THE AUSTRALIAN POST OFFICE

COURSE OF TECHNICAL INSTRUCTION

Engineering Training Section, Headquarters, Postmaster-General's Department, Melbourne C.2.

TELEPHONY II.

(Reissued 1950.)

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COMMONWEALTH OF AUSTRALIA.

Chief Engineer's Branch,
Postmaster-General's Department,
Treasury Gardens,
Melbourne, C.2.

COURSE OF TECHNICAL INSTRUCTION.

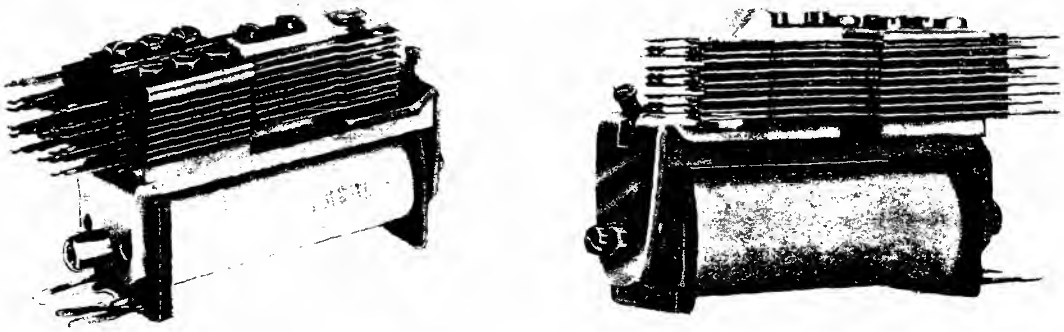
RELAYS.

CONTENTS:

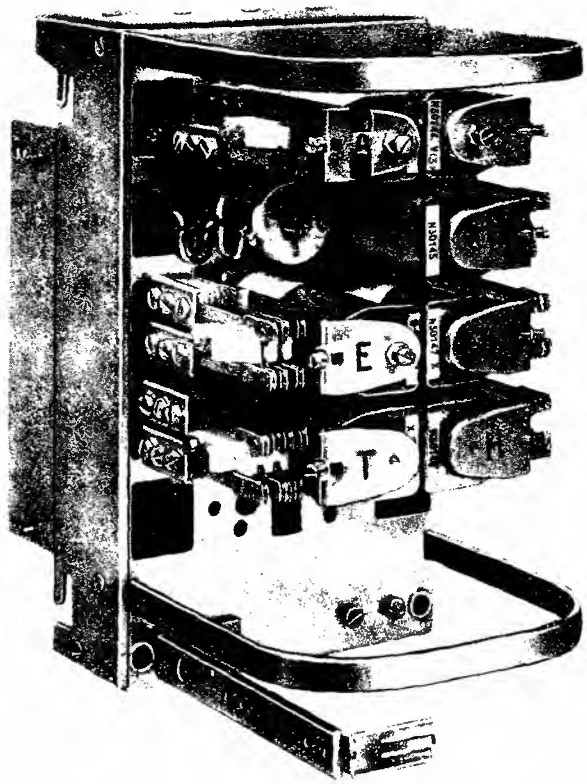
1. INTRODUCTION.

1.1 Most circuits used in Telecommunication include one or more relays. Some circuits include one relay only, whilst others depend on many relays for their correct operation. There are many thousands of relays in a large automatic exchange. Relays are used in some types of telephones, switchboards, radio apparatus, telegraph circuits, light and power installations and innumerable other instances. Relays are very important units in Telecommunication and will be covered in greater detail later in this series of books.

The principle of the telephone relay was discussed in Telephony I and some simple circuits employing such relays were dealt with in Paper No. 12 of the same book. The relays dealt with operate immediately the circuit of which they form a part is closed, and release immediately the circuit is opened. In this and subsequent books of the course, many other applications of such relays will be dealt with.



Two Views of a Typical 3,000 Type Relay.



Typical Relay Mounting Equipped with 3,000 Type Relays.

RELAYS, THE LETTERS OF THE ALPHABET USED
TO WRITE THE BOOK OF TELECOMMUNICATION.

1.2 Some of the circuits dealt with in this book require a relay whose operation takes place a little time after the circuit is closed, or one whose release takes place a little time after the circuit is opened. The former type is known as a "slow operating" relay, whilst the latter is known as a "slow releasing" relay. Again, a relay is sometimes required which is slow to both operate and release.

1.3 In this Paper, the factors which effect the operate and release times of a telephone relay will be discussed, and the types of delayed action relays encountered in this book will be dealt with, together with certain other relays.

2. OPERATE TIME.

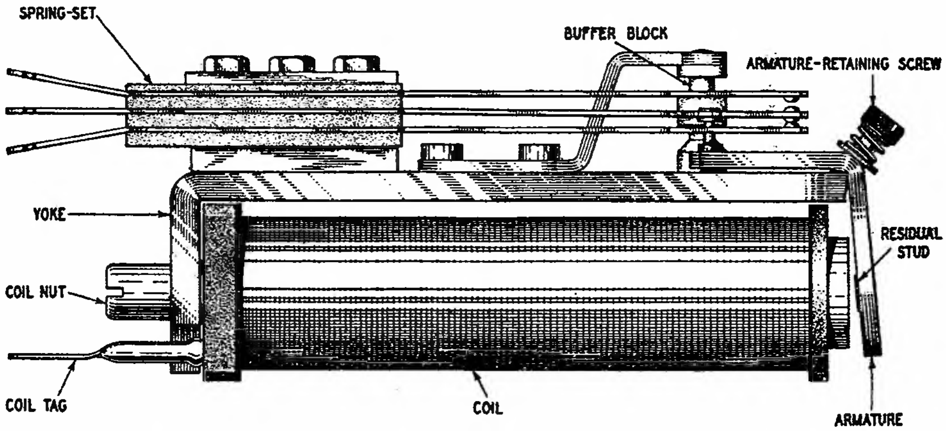
2.1 A relay does not operate immediately its circuit is closed. This delay in operation is called the operate lag and is due to four main factors -

(i) Inductance of the relay winding.

(ii) Tension on the springs, particularly the lever springs.

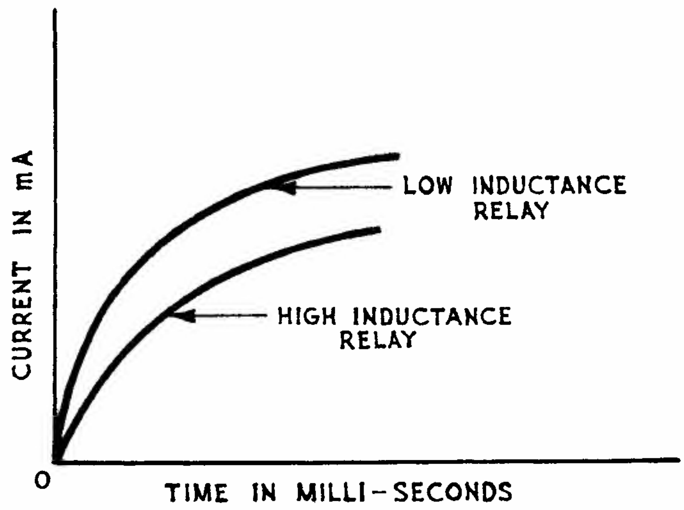
(iii) Eddy currents produced in the core of the relay.

(iv) Distance of the armature from the core in the unoperated condition of the relay.



600 TYPE RELAY.

2.2 Inductance. When the circuit to a relay is closed, the current through the relay winding does not rise to its Ohm's Law value immediately, but rises gradually, as shown in Fig. 1.



RISE OF CURRENT THROUGH RELAY.

FIG. 1.

The reason for this gradual rise is that when the circuit is closed, current starts to flow through the relay coil and this current produces a rising flux which cuts the turns of the coil. A voltage of self-induction, therefore, is produced across the coil and this voltage will oppose the applied voltage. The current through the coil, therefore, will be due to the difference between the applied voltage and the voltage of self-induction. The current will not reach its Ohm's Law value until the voltage of self-induction has disappeared. As the flux is proportional to the ampere-turns, this flux will rise gradually with the current as in Fig. 1. Should the inductance of the relay be increased, for example, by improving the magnetic circuit or increasing the number of turns, the voltage of self-induction will be increased and the current and flux will rise still more gradually. This is shown also in Fig. 1. This gradual rise of flux causes the armature of the relay to be gradually attracted to the core, so that the armature does not move to the core and operate the relay immediately the circuit is closed.

/ 2.3

2.3 Tension. As the flux rises gradually, a gradually increasing attractive force is built up between the armature and the coil. When this attractive force is great enough to overcome the tension of the lever springs, which tension is holding the armature away from the core when the relay is unoperated, the relay will operate. If the lever spring tension is increased, a greater flux is necessary to produce the extra attractive force required between the armature and the core to overcome this extra tension. As the rise of flux is gradual, the greater amount of flux required takes a longer time for its production so that large lever spring tensions further delay the operation of the relay.

2.4 Eddy Currents. The rising coil flux cuts not only the coil turns but also the core, armature and heelpiece or yoke. Voltages, therefore, are induced across these components and as these components are made of conducting material, usually soft iron, eddy currents flow therein. These eddy currents produce a flux which, according to Lenz's Law, will oppose and weaken the coil flux. Thus, the total amount of flux in the magnetic circuit of the relay, whilst the current is rising, will be the difference between the coil flux and the eddy current flux. This makes the rise of the flux in the operating magnetic circuit of the relay even more gradual than that due to the inductance of the winding alone, thus further delaying the operate time of the relay.

The effect of the eddy current flux is shown in Fig. 2.

2.5 Armature Gap. An air-gap in the magnetic circuit is formed by the armature and core and the smaller this air-gap, the greater will be the operating flux available to operate the relay. Thus, the distance of the armature from the core, in the unoperated condition of the relay, is a factor affecting the operate lag.

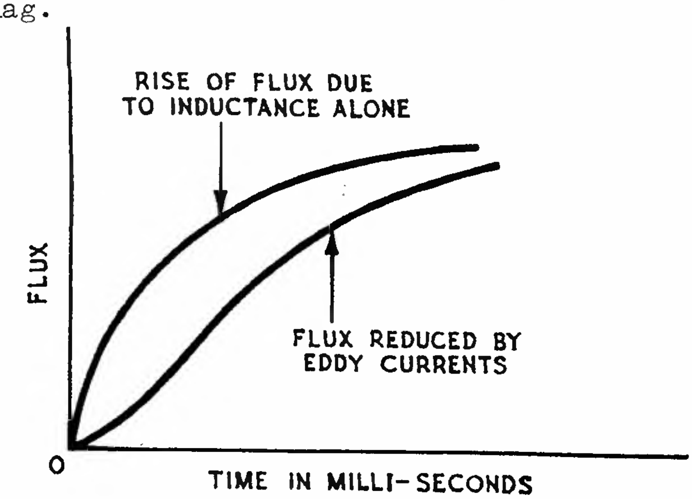


FIG. 2. EFFECT OF EDDY CURRENTS.

3. RELEASE TIME.

3.1 A relay will not release immediately its circuit is opened. This delay in release is called the release lag and is due to four main factors -

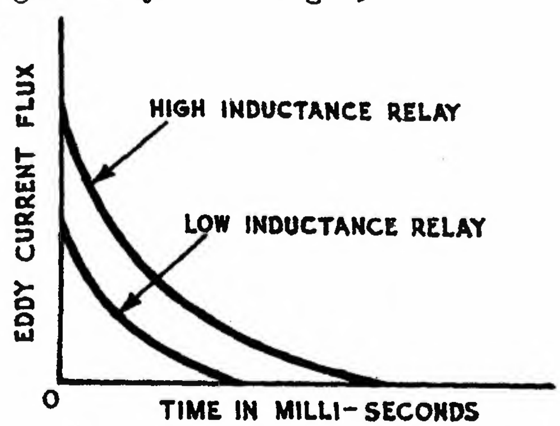
(i) Inductance of the relay winding.

(ii) Tension on the springs.

(iii) Eddy currents in the core.

(iv) Distance of the armature from the core when the relay is operated.

3.2 Inductance. When the circuit to a relay is opened, the current decays to zero practically instantly, as will the coil flux. This decaying coil flux cuts the core, armature and heelpiece and induces a voltage across those components. As a result, eddy currents flow in those components and these eddy currents decay to zero gradually as in Fig. 3.



DECAY OF EDDY CURRENTS AND FLUX.

FIG. 3.

Thus, immediately the coil flux is removed, its place is taken by a gradually decaying eddy current flux. This means that the armature will not move from the core and release the relay until the eddy current flux has decayed to a value low enough to allow the tension of the springs to force the armature away from the core, thus delaying the release of the relay.

3.3 Tension. The spring tension also plays a part in that the greater the tension on the springs, the shorter will be the time taken by the eddy current flux to fall to a value low enough to allow

/ the

the spring tension to take control and force the armature away from the core.

3.4 Eddy Currents. A high inductance relay will produce more flux when the circuit is closed. This means that when the circuit to such a relay is opened, a higher voltage will be induced across the core, armature and heelpiece of such a relay, and the eddy currents and their flux will be correspondingly greater. This is illustrated in Fig. 3, from which it will be seen that a high inductance relay releases more slowly than a low inductance relay because the flux will take a longer time to decay to a value low enough to allow the spring tension to force the armature away from the core.

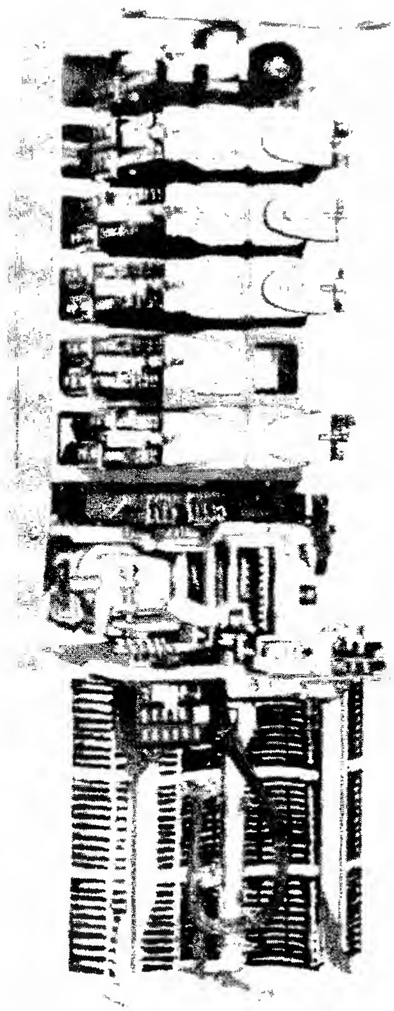
3.5 Armature Gap. The closer the armature is to the core when the relay is operated, the higher will be the inductance of the relay because the magnetic circuit will be improved. Thus, the closer the armature is to the core of a relay when operated, the longer will be the release time.

4. FAST ACTING.

4.1 By a fast acting relay is meant one which operates and releases in a minimum of time. The inductance of the winding cannot be eliminated because a relay must be inductive in order to produce magnetic flux. Eddy currents, however, can be eliminated by making the core (which is responsible for most of the eddy current effect) of a magnetic material which has a high resistivity. Such a material is nickel-iron, and some fast acting relays employ a core of nickel-iron.

4.2 In most fast acting relays, advantage is taken of the fact that the core eddy currents are concentrated in the outer layers of the core. This is because the coil flux, in cutting the core, induces across the core a voltage which results in the eddy currents. The eddy current flux opposes the coil flux and, due to this opposition, the coil flux can penetrate the core to only a slight depth. Nickel-iron sleeves, therefore, are employed on many relays which must be fast acting, the sleeve, or sleeves, acting as a magnetic core layer with a high resistivity.

/ Relays



Relays are used in this automatic telephone switch, the Final Selector. This switch is directed by the dial of the calling telephone to select one telephone from 200, ring the bells of the selected telephone and charge the call to the calling telephone. If the called telephone is "busy" the switch will send a "busy signal" to the calling telephone. Automatic telephony has been described as "the high-water-mark of human creative effort."

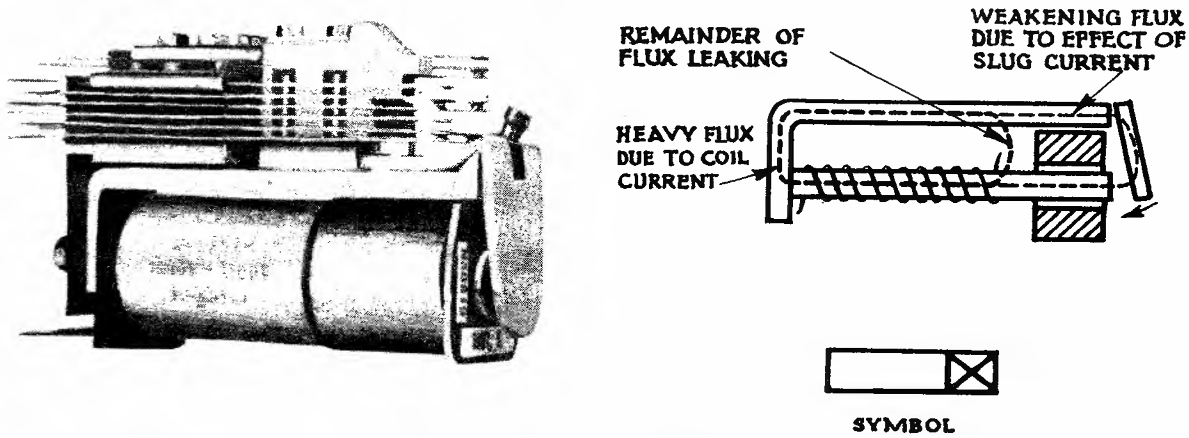
A large automatic exchange will have many final selectors and other switches and many thousands of relays.

RELAYS IN ACTION.

5. SLOW ACTING.

5.1 A slow acting relay is one which is purposely designed to operate and release slowly. One way of achieving this effect is to decrease the resistivity of the outer layers of the core, so that the eddy current effect is increased. This is done by fitting a copper sleeve over the soft iron core or winding a single layer of bare copper wire over the core. Satisfactory operate and release times up to about 500 milliseconds can be obtained by this method.

5.2 The usual method, however, is to fit a mass of copper called a "slug" over the armature end of the core, as in Fig. 4.



SLOW ACTING RELAY.

FIG. 4.

When the circuit to the coil of such a relay is completed, the majority of the flux passes through the core, heelpiece, armature and the air-gap between the armature and the core. The remainder leaks across the space between the core and heelpiece. This is the leakage flux shown in Fig. 4. This leakage flux cuts the copper slug and induces a voltage across it, and eddy currents flow in the slug as a result of that voltage. Because of the large mass of slug and the material of which the slug is made, these eddy currents will reach an appreciable value. The eddy current flux passes through the core and heelpiece and opposes the coil flux passing through that circuit, so delaying the operation of the relay until the eddy currents have died down. As these currents are of appreciable value, the operation of the relay is delayed up to 500 milliseconds, depending on the length of the slug. On the circuit to the

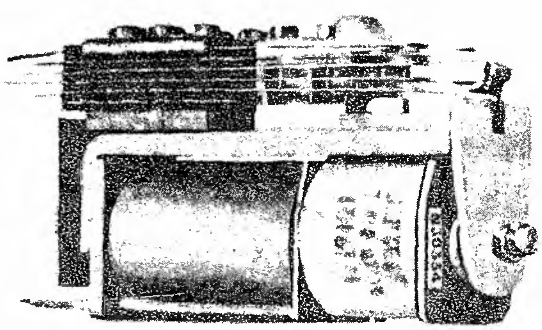
/ coil

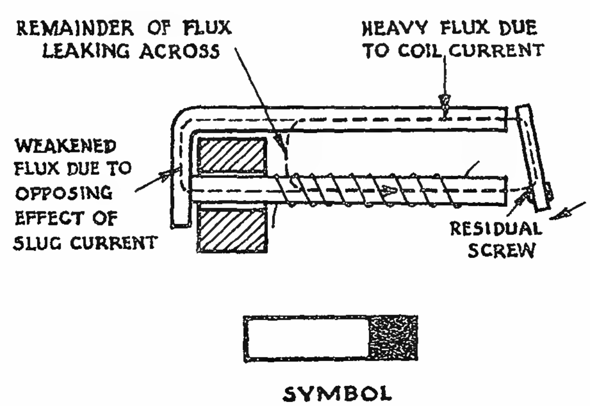
coil being opened, the coil current and flux decay to zero immediately. The decaying coil flux cuts the slug, inducing a voltage across it and producing eddy currents again of appreciable magnitude. The flux produced by these eddy currents holds the relay operated until the flux has fallen to a value low enough to allow the spring tension to take control and restore the armature. As with the operate time, so the release time of the relay is appreciably prolonged.

6. SLOW RELEASING.

6.1 A slow releasing relay is one which is purposely designed to be fast in operation, but whose release time is prolonged. This effect can be achieved by employing a copper slug on the heel end of the core as in Fig. 5.

6.2 When the circuit to the coil of such a relay is closed, eddy currents are produced in the slug by the leakage flux, just as in the case of the armature end slug. The tendency will be for the coil flux to avoid entering the slug, due to the slug flux opposing the coil flux. The coil flux, therefore, will build up in a local circuit in front of the slug and as this circuit contains the armature, the effect on the operate time is negligible. The release time is prolonged, the explanation here being the same as that given above for the relay with an armature end slug.





SLOW RELEASING RELAY.

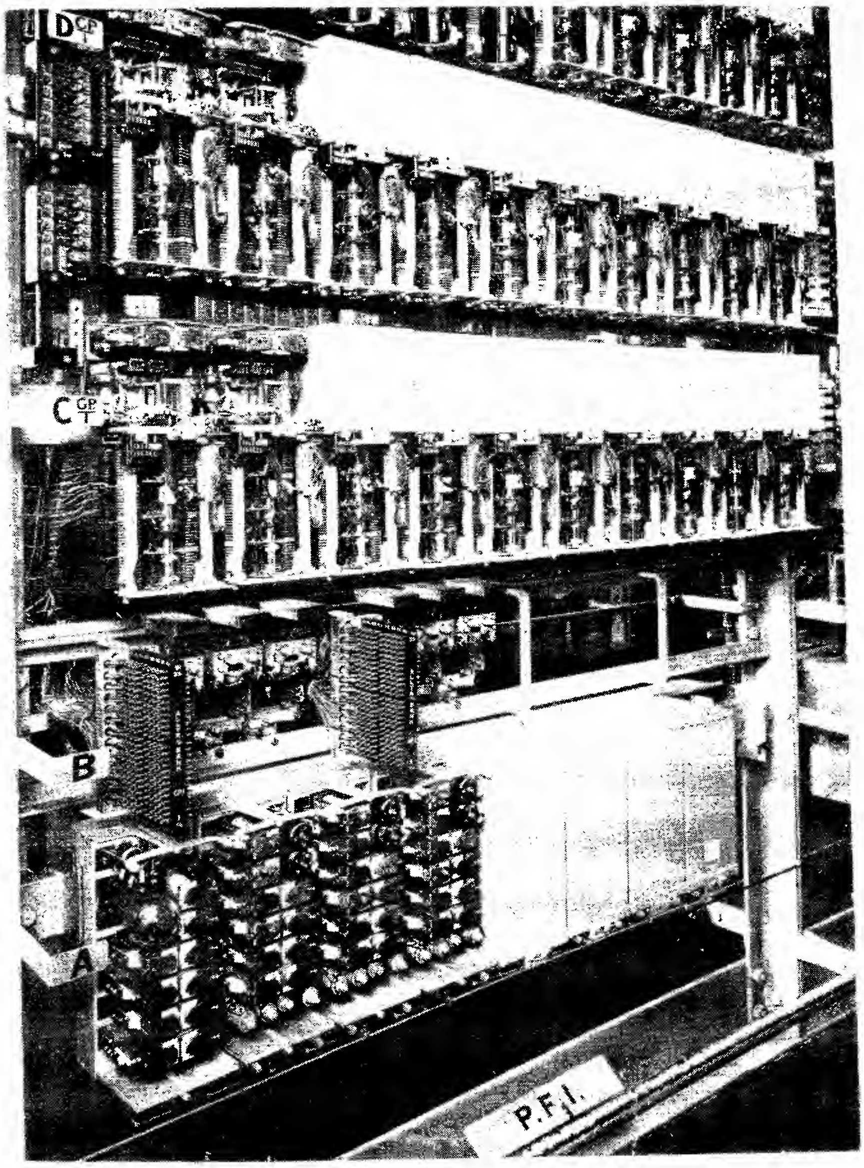
FIG. 5.

7. IMPEDANCE EFFECT OF SLEEVES AND SLUGS.

7.1 A relay can be likened to a transformer, the primary winding being the coil and the secondary winding and load combined being provided by the core, sleeves, slugs, etc., across which voltages are induced when the current in the coil changes in value.

7.2 As is shown in Telephony I, Paper No. 5, the primary winding of a transformer offers its maximum impedance when the secondary winding is on open circuit. Under this condition, no secondary current flows and, therefore, no secondary flux is provided. When a load is connected to the secondary winding, a current flows through the secondary winding and load and this secondary current produces a flux. This secondary flux opposes and reduces the primary flux, thus reducing the voltage of self-induction across the primary and reducing the impedance of the primary. This reduction in the primary impedance allows the primary source of supply to send more current through the primary winding to meet the demands for power placed on that source by the secondary load.

7.3 Relays behave in much the same way. When nickel-iron cores or core sleeves are employed, a voltage is induced across them from the coil, but, due to the high resistance of those sleeves or cores, negligible current flows. This condition is the equivalent of a transformer with the secondary on open circuit, so that relays with a nickel-iron core, or employing nickel-iron core sleeves, possess a high impedance. When a copper sleeve or slug, or a soft iron core without a sleeve, is employed, the eddy currents are the equivalent of the secondary current produced when a load is connected to the secondary of a transformer. Such relays, therefore, possess a lower impedance than relays with a nickel-iron core or core sleeves.

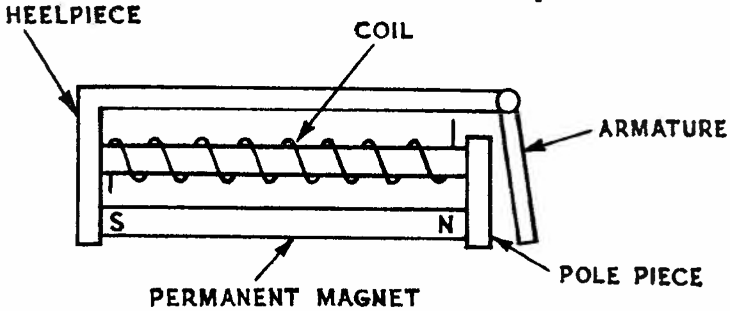


Relays are used in this automatic telephone apparatus which automatically connects the exchange apparatus to the calling telephone when the receiver of the telephone is lifted. This apparatus serves 200 telephones, is duplicated many times in some automatic telephone exchanges, and can select one calling telephone from 200.

RELAYS IN LINE FINDERS.

8. POLARISED.

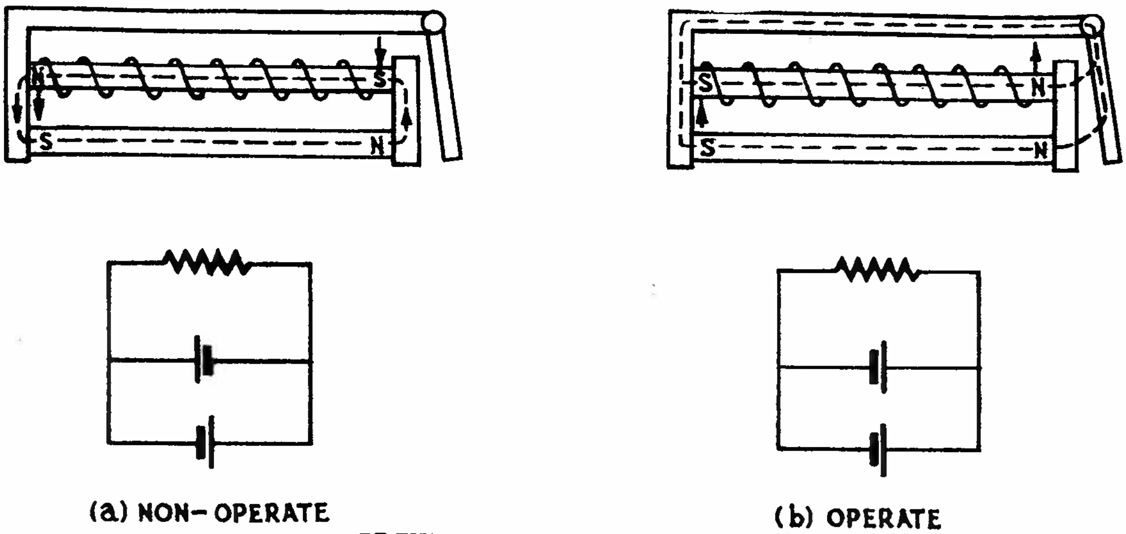
8.1 In some telephones to be dealt with in this book, a relay is required which will not operate when current flows in one direction through the winding but will operate when the direction of current flow is reversed. A polarised relay is frequently used under such circumstances. Fig. 6 shows the construction of a typical polarised relay.



POLARISED RELAY (SIMPLIFIED SKETCH).

FIG. 6.

The relay consists of a permanent magnet and a coil wound on a soft iron core mounted parallel to one another. One end of each is attached to the heelpiece of the relay and the other end is attached to a soft iron pole piece. Two magnetic circuits thus exist, an internal or closed circuit consisting of the magnet and coil core in series and completed via the heelpiece and pole piece, and an open or external circuit consisting of the magnet and coil core in parallel and completed via the air-gap, armature and heelpiece. Fig. 7 shows the non-operate and operate conditions.



PRINCIPLE OF POLARISED RELAY.

FIG. 7.

In Fig. 7a the magnetomotive forces produced by the permanent magnet and the current flowing through the coil, in the direction indicated, act in series, the external magnetic circuit being short-circuited by the pole pieces and heelpiece. Fig. 7a also shows the equivalent electrical condition and, as the batteries are in series and act in a circuit of zero resistance, no current flows through the resistance. No flux, therefore, will pass through the external magnetic circuit of Fig. 7a.

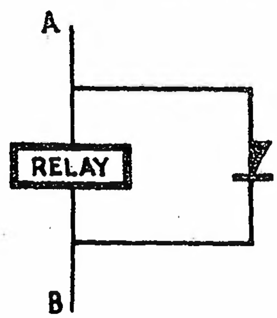
In Fig. 7b, the direction in which the current flows through the coil is reversed, so that the magnetomotive forces act in parallel to cause flux to pass through the external circuit, so attracting the armature and operating the relay. In the equivalent electrical circuit, the batteries are in parallel and current flows through the resistance.

8.2 There are many different types of polarised relays, but, in general, the principle stated applies to these various types.

9. METAL RECTIFIERS AND RELAYS.

9.1 Metal type rectifiers are extensively used with telephone relays to achieve certain results. A typical metal rectifier is the copper oxide type which consists of a number of discs of copper. On one side of each disc cuprous oxide is formed at a high temperature and the junction of the metal and the oxide is found to conduct electricity in only one direction, from oxide to copper. The current flow in the direction copper to oxide is so small that the junction may be regarded as an open circuit in that direction.

9.2 Fig. 8 shows how a standard telephone relay can be made to behave as a polarised relay by shunting a metal rectifier across it.

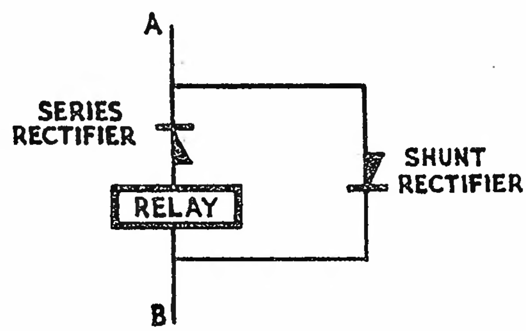


METAL RECTIFIER ACROSS RELAY.
FIG. 8.

When current is sent through the circuit in the direction A to B, the rectifier shunts the relay of all but only a very small percentage of the current. (Current flows only in the direction of the ~~half arrow rectifier symbol.~~) When the direction of the current flow is reversed, the rectifier offers an open circuit to this reverse

/ current

current so that all of this current flows through the relay which operates. The forward resistance of rectifiers varies and, to prevent any current flowing through the relay in the non-operate direction, a series rectifier connected as in Fig. 9 is frequently used.



METAL RECTIFIERS ASSOCIATED WITH RELAY.

FIG. 9.

10. A.C.

10.1 On some C.B. P.B.X. switchboards, the 17 c/s ringing current from the exchange operates a relay to display a lamp signal. A normal telephone relay will not operate satisfactorily on 17 c/s ringing current as each time the A.C. falls to zero, from a maximum in either direction, the relay releases. This behaviour is overcome by shunting the relay with a metal type rectifier, as in Fig.8 above. The half cycle in the A to B direction passes through the relay and operates it. During the next half cycle, the rectifier shunts the relay which, therefore, receives very little of the 17 c/s supply current. However, the decay of the first half cycle of current in the relay winding induces a voltage of self-induction across that winding. The direction of this induced voltage will, of course, be such as to maintain the current in the relay winding in the original direction, that is, in the direction of the first half cycle. This induced voltage, therefore, sends a current through the rectifier and relay winding, this current circulating in a clockwise direction in Fig. 8. This current produces a flux which holds the relay operated during the half cycles which pass through the rectifier until the arrival of the succeeding half cycles which pass through the relay.

11. TEST QUESTIONS.

1. State the four main factors that affect the operate time of a relay.

2. What is a slow acting relay?

3. How is the slow release feature obtained on a relay?

4. What is the function of a polarised relay?

5. Describe, with sketch, the operation of a polarised relay.

END OF PAPER.

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COURSE OF TECHNICAL INSTRUCTION.

TELEPHONY II.

C.B. PRINCIPLES AND TELEPHONES.

CONTENTS:

1. INTRODUCTION.

1.1 The Local Battery or Magneto System requires a transmitter battery and a signalling generator at each subscriber's telephone. These introduce high maintenance costs and, in addition, the telephone is cumbersome, particularly when used as a table telephone.

These disadvantages led to the development of a system termed the Common Battery System, wherein one "common" battery located at the exchange is used for both signalling and transmission purposes. This system obviates the necessity for primary batteries and signalling generators at the subscribers' telephones, thus reducing external maintenance costs and allowing a compact telephone to be used.

2. TRANSMITTER BATTERY SUPPLY.

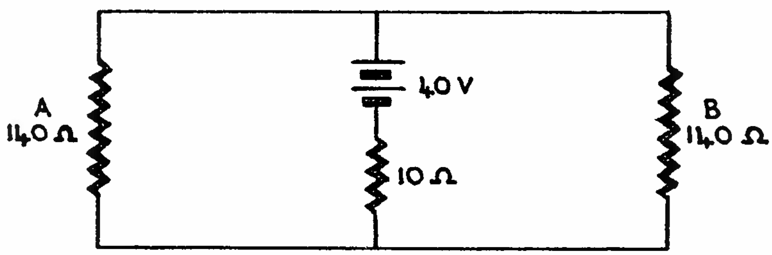
2.1 Telephone transmitters require a battery supply only when the telephone is being used, and the logical place for the transmitter battery feed in C.B. manual exchanges is in the cord circuits used for answering and connecting subscribers. As a "common" battery is used to supply the transmitter battery feed current to all cord circuits in the exchange, the battery must -

(i) Be capable of supplying large currents for long periods.

(ii) Have an extremely low internal resistance (approximately 0.0002 ohm) in order to prevent noise and crosstalk.

The size of the battery depends on several factors, among which are the number of cord circuits in the exchange and the calling rate of the subscribers. The second point, the necessity for a low resistance battery, can be proved by considering the following case.

2.2 Battery with Internal Resistance. Fig. 1 shows the equivalent of two subscribers' lines connected to the exchange battery of a C.B. manual exchange, the internal resistance of the battery, for purposes of this example, being 10 ohms (which is about 5,000 times the resistance of a telephone exchange battery).



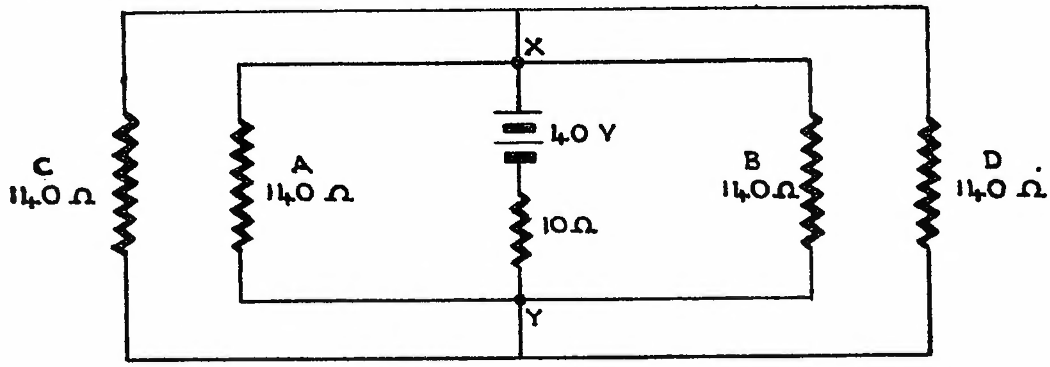
EQUIVALENT CIRCUIT FOR TWO SUBSCRIBERS' LINES CONNECTED TOGETHER.
(0.25 ampere of current in each line.)

FIG. 1.

The joint resistance of the two lines will be 70 ohms, so that the current output from the battery will be 0.5 ampere. Thus, 0.25 ampere flows in each telephone.

/ Assume

Assume now that two other subscribers, C and D, having lines of the same resistance as A and B above, are now connected to the battery as in Fig. 2.



FOUR SUBSCRIBERS' LINES CONNECTED TOGETHER.
(0.225 ampere of current in each line.)

FIG. 2.

The joint resistance of the four subscribers' lines will be 35 ohms, and the current output from the battery will be 0.9 ampere. Thus, 0.225 ampere flows in each telephone.

From this example, it will be seen that, as circuits are connected to, and disconnected from, the battery, the transmitter battery feed current flowing in each circuit changes. In a large exchange, circuits will be connected to, and disconnected from, the battery continuously, and the resultant continuous change in current will be heard as noise in the receivers of the telephones in use.

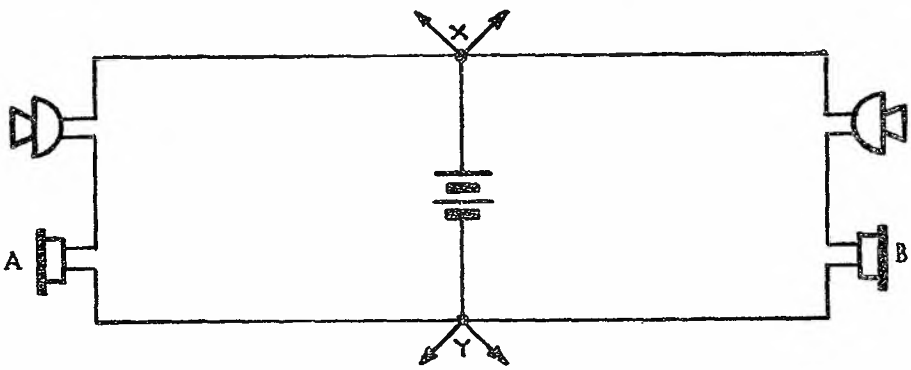
Further, the conditions shown in Fig. 2 assume that the A and B subscribers are connected together for a conversation as are the C and D subscribers. The alternating speech currents from the transmitter at A will divide at points X and Y, the common points via which all cord circuits are connected to the battery. These currents divide proportionately between the internal resistance of the battery and the lines to B, C and D, thus causing crosstalk.

Another adverse feature is that, as the number of circuits connected to the exchange battery in Figs. 1 and 2 increases, the amount of transmitter battery feed current supplied to each transmitter decreases, as will be seen by comparing the results of the calculations made above in connection with Figs. 1 and 2. This will mean that the transmission efficiency of the system will vary as the load on the battery varies.

2.3 Battery with Zero Resistance. When a battery possessing zero internal resistance is used, the difficulties outlined above disappear. This can be shown by a consideration of Figs. 1 and 2 with a zero resistance battery. In the case of Fig. 1, the load on the battery is 70 ohms and the current output is 0.57 ampere, of which 0.285 ampere flows through each telephone. In the case of Fig. 2, the load on the battery will be 35 ohms and the current output 1.14 amperes, of which 0.285 ampere flows through each telephone. This eliminates the noise caused by the connection and disconnection of circuits to and from the battery, eliminates crosstalk because the battery acts as a complete short-circuit across each subscriber's line and causes the transmission efficiency of the system to be independent of the load on the battery.

2.4 Types of Batteries. Primary batteries are unsuitable for the conditions outlined above, because they possess too great an internal resistance and must be replaced when exhausted. Secondary batteries, therefore, are used as, with correct manufacture and maintenance, the internal resistance of a secondary battery can be kept extremely low, for example, 0.0002 ohm. Further, when exhausted, a secondary battery can be made serviceable again by passing through it a current from some source, such as a D.C. generator, this current being passed through the battery in the opposite direction to that in which current is taken from the battery.

2.5 The transmitter battery feed at present stands as shown in Fig. 3, the battery having zero internal resistance and being connected across the cord circuits, other cord circuits in the exchange being connected to the battery at points X and Y.



TRANSMITTER BATTERY FEED EMPLOYING ZERO RESISTANCE BATTERY ONLY.

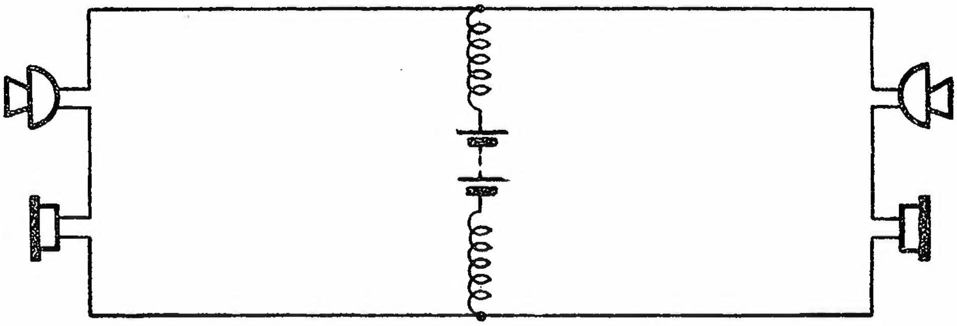
FIG. 3.

As mentioned above, the battery of zero internal resistance acts as a short-circuit across each subscriber's line. This means that, when A in Fig. 3 speaks, the alternating speech currents

/ generated

generated by the transmitter at A will not reach the telephone at B, due to the complete short-circuit provided by the battery.

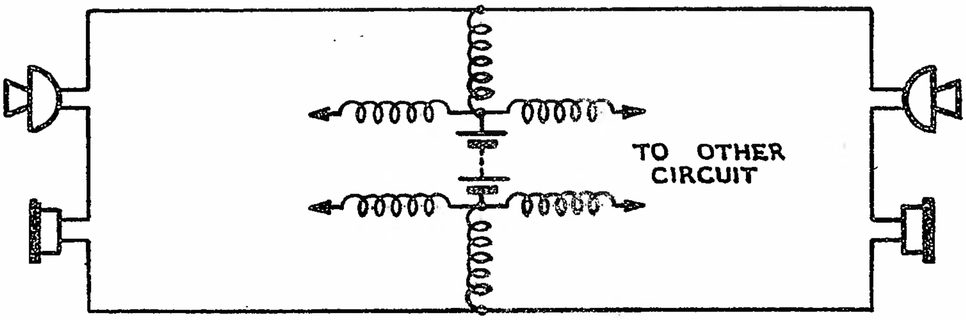
It is necessary, therefore, to place in series with the battery some arrangement which allows the passage of direct current for the subscribers' transmitters but prevents the alternating speech currents generated by the transmitters from passing through the battery. This could be arranged as in Fig. 4, where two retards are connected in series with the battery feed to each pair of telephones connected together.



PRACTICAL TRANSMITTER FEED.

FIG. 4.

These retards allow the passage of the direct current necessary to operate the transmitters, but they are of such an impedance that alternating speech currents generated by the transmitters will not pass through them and, therefore, through the battery This arrangement also successfully prevents crosstalk between the different pairs of telephones simultaneously connected to the battery, as speech currents from one circuit cannot affect another circuit owing to the impedance of the coils. Fig. 5 will make this clearer. Remember that the speech currents cannot traverse the coils, that is, they have no common point with other circuits.



MULTIPLE TRANSMITTER FEEDS.

FIG. 5.

2.6 This method of providing transmitter battery feed current to telephones is efficient only when the circuits are of approximately equal resistance. The following case is worked out to illustrate this point.

In Fig. 4, the retards are assumed to have a resistance of 80 ohms each and each line and telephone has a resistance of 80 ohms each, the battery voltage being 40 volts. The joint resistance of the two telephones, therefore, will be 40 ohms, which means that the total resistance connected to the battery in that case will be 160 ohms (the resistance of the two retards in series) plus the joint resistance of the two 80 ohm lines, which is 40 ohms. Thus, the total resistance connected to the battery will be 200 ohms. The current output from the battery will be -

$$I = \frac{E}{R}$$

$$= \frac{40 \text{ Volts}}{200 \text{ Ohms.}}$$

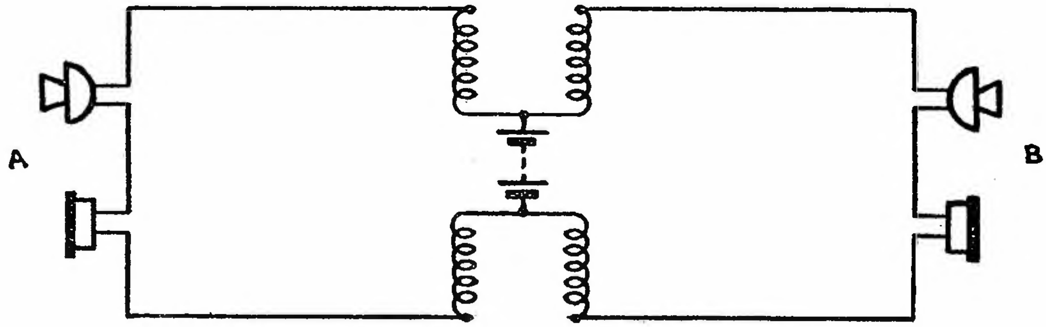
$$= 200 \text{ mA.}$$

This 200 mA will divide, half flowing through each line and telephone, which means that each telephone receives 100 mA to operate the transmitter there.

Assume, now, that the resistance of one line and telephone is increased to 120 ohms. The joint resistance of the two lines will now be 48 ohms, and the total resistance connected to the battery will be 208 ohms. The current output from the battery will be 192 mA, of which 115 mA will flow through the 80 ohm line and telephone and 77 mA through the 120 ohm line and telephone. Thus, when lines of unequal resistance are connected to the battery feed shown in Fig. 4, the line of lower resistance will shunt that of higher resistance, causing much less transmitter battery feed current to pass through the transmitter in the high resistance line than through that in the low resistance line. The transmitter in the low resistance line, therefore, will operate far more efficiently than that in the high resistance line. For this reason, the type of transmitter battery feed illustrated in Figs. 4 and 5 is used only where all lines are of approximately the same length and resistance, for example, on C.B. cordless type P.B.X. switchboards dealt with in Paper No. 5.

/ 2.7

2.7 The difficulty of a high resistance line shunting a low resistance line can be overcome by employing separate retards for each line as in Fig. 6.



SEPARATE TRANSMITTER FEEDS.

FIG. 6.

To illustrate the advantage gained over Fig. 4, the cases worked out in connection with Fig. 4 are here reworked for Fig. 6.

(i) Lines of Equal Resistance, say, 80 ohms each.

The current supplied to each line will be -

$$\frac{40}{80 + 160} = \frac{40}{240} = 167 \text{ mA.}$$

(ii) Lines of Unequal Resistance, say, 80 ohms and 120 ohms respectively.

The 80 ohm line will still receive 167 mA, as the current supplied to it will be independent of the presence of the 120 ohm line.

The current supplied to the 120 ohm line will be -

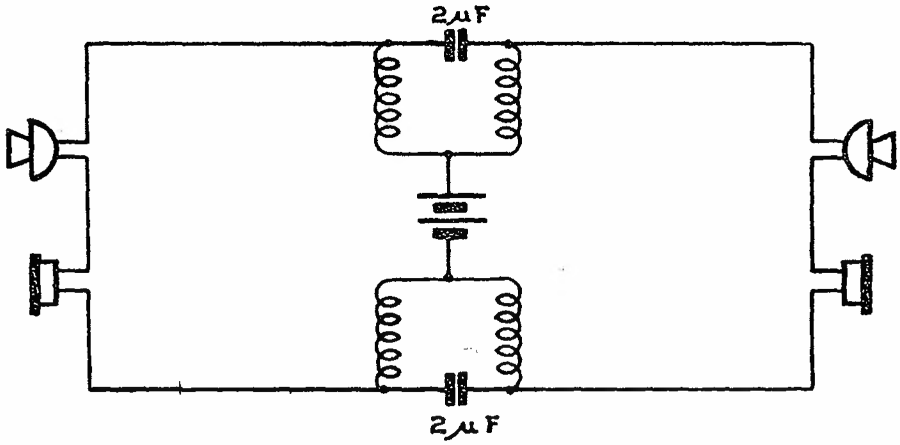
$$\frac{40}{120 + 160} = \frac{40}{280} = 145 \text{ mA.}$$

Thus, in the arrangement shown in Fig. 6, the amount of transmitter battery feed current supplied to each line is independent of the joint resistance of the two lines and the ratio of their individual resistances, but is dependent on the individual resistance of each line.

2.8 The arrangement of Fig. 6 will not permit speech currents to pass from one telephone to the other, as such speech currents have to traverse the four windings of the retards in series, and these retards, as explained in paragraph 2.5, are included for the specific purpose of preventing the passage of speech currents.

/ 2.9

2.9 Stone Transmission. One method of retaining the individual battery feed employed in Fig. 6, whilst permitting the passage of alternating speech currents between the two telephones, is shown in Fig. 7.

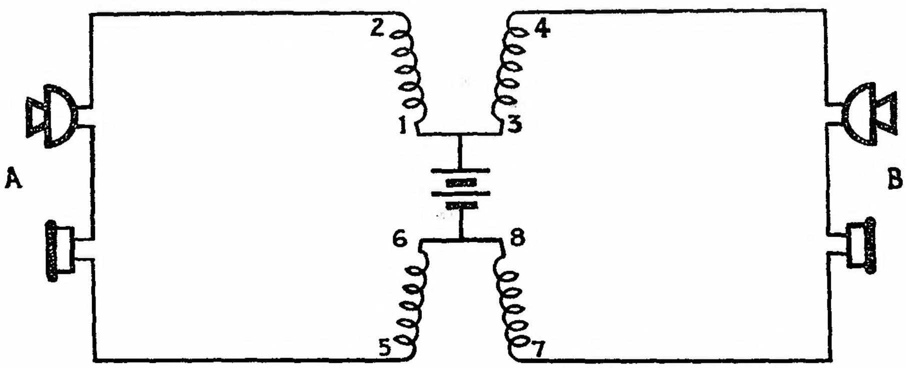


STONE TRANSMISSION SYSTEM USES RETARDS AND CONDENSERS.

FIG. 7.

The 2 μF condensers permit the passage of alternating speech currents from one telephone to the other, whilst retaining the independent battery feed to the two lines. This arrangement is due to J.S. Stone and is called the "Bridged Impedance", Stone, or "Inductor-Capacitor" type of transmitter battery feed.

2.10 Hayes Transmission. Another method of retaining the individual battery feed, whilst permitting the passage of alternating speech currents between the two telephones, is to arrange the retard coil as transformer windings. Fig. 8 illustrates the idea.



HAYES TRANSMISSION SYSTEM USES TRANSFORMERS.

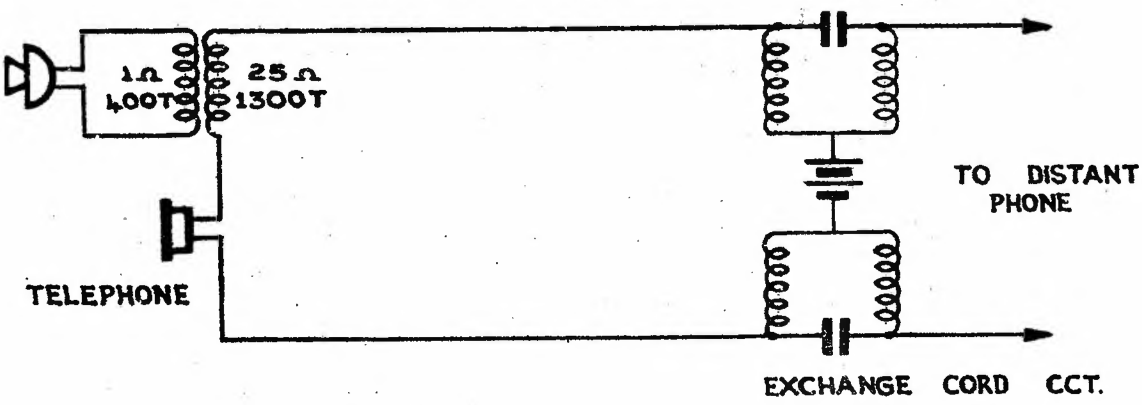
FIG. 8.

Windings 1-2 and 5-6 form a winding 2-5 of a transformer, whilst windings 3-4 and 7-8 form another winding. Alternating speech currents from the transmitter at A pass through windings 1-2 and 5-6 and the battery, which acts as a short-circuit across the line to B. These alternating currents, in passing through windings 1-2 and 5-6, induce alternating voltages across windings 3-4 and 7-8. These alternating voltages cause alternating currents to flow through the telephone at B. Although the alternating speech currents from all telephones simultaneously connected to the exchange battery pass through that battery in this system, no crosstalk results because of the negligible internal resistance of the battery. This system is called the Hayes System after its inventor, or the "Repeating Coil" system, as repeating coils, that is, transformers, are used in the circuit.

2.11 The advantage of the Stone System is that the battery feed retards in each cord circuit can be used as relays for supervisory purposes. The advantage of the Hayes System is that efficient transformers can be wound having a low resistance, so that the battery voltage necessary for this system is somewhat lower than that required for the Stone System. In practice, both systems are used, as will be seen later in this book.

3. PRINCIPLE OF THE C.B. TELEPHONE.

3.1 In Telephony I, the speaking circuit of a magneto telephone was developed. This circuit is shown in Fig. 9 connected to a bridged impedance type of transmitter battery feed located in the cord circuit of a C.B. Manual Exchange.

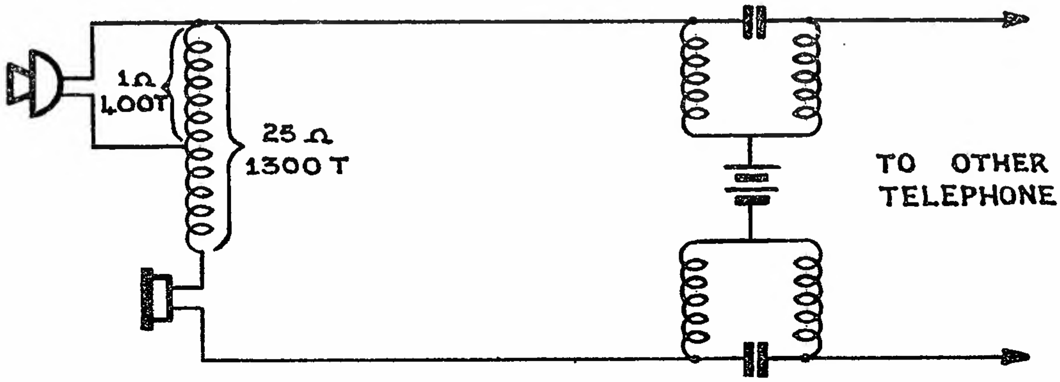


MAGNETO TELEPHONE AND BRIDGED IMPEDANCE BATTERY FEED
A CIRCUIT THAT WON'T TRANSMIT.

FIG. 9.

The local battery has been omitted from the telephone of Fig. 9, as one of the objects of the common battery system is tc eliminate the batteries at each telephone. It will be apparent that the transmitter in Fig. 9 will not transmit, because the D.C. necessary for its operation does not pass through it.

3.2 This is remedied in Fig. 10 by employing an "auto transformer" for the induction coil.

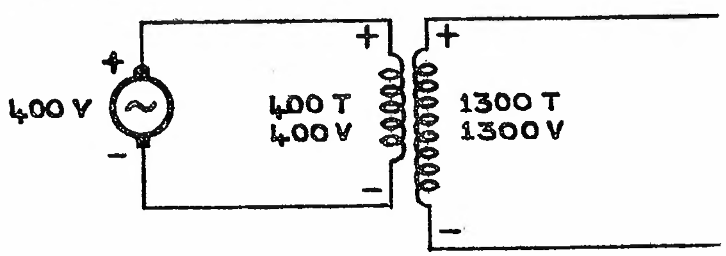


TELEPHONE WITH AUTO TRANSFORMER.

FIG. 10.

In an auto transformer, the primary winding is merely part of the secondary winding. Thus, in Fig. 9, a primary winding of 400 turns and a secondary winding of 1,300 turns are required. In Fig. 10, this is provided by an auto transformer having a single winding of 1,300 turns - the secondary winding - 400 turns of which form the primary winding.

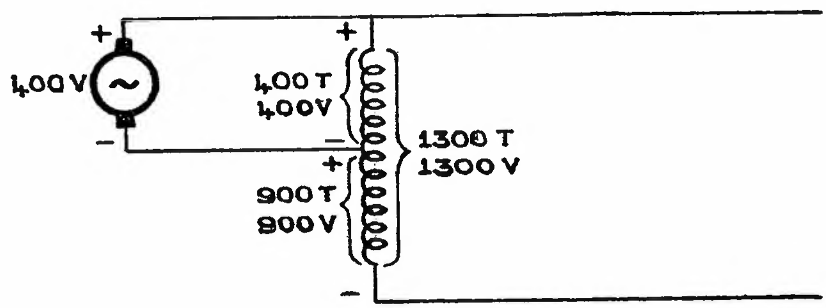
3.3 The auto transformer principle can be understood by considering the directions of the voltages of self and mutual induction produced across the windings of a transformer with separate primary and secondary windings. Fig. 11 shows the position for the transformer of Fig. 9.



TRANSFORMER WITH SEPARATE WINDINGS.

FIG. 11.

In Fig. 11, an alternating voltage of 400 volts is applied to the primary winding. In the case of a perfect transformer, a voltage of self-induction of 400 volts will appear across the primary winding and, as with all voltages of self-induction, will oppose the applied voltage. The directions for some instant are indicated in Fig. 11 by + and - signs. The flux which links the primary winding and induces a voltage of self-induction of 1 volt per turn across that winding also links the secondary winding. Thus, a voltage of mutual induction of 1 volt per turn will be induced across the secondary winding. As the same flux produces the voltages of self and mutual induction, the directions of these two voltages must be the same as indicated in Fig. 11. Thus, the voltage of mutual induction across any 400 secondary turns will be equal to, and in the same direction as, the voltage of self-induction across the 400 primary turns. There is, therefore, no reason against 400 of the secondary turns being used as the primary winding. This is done in Fig. 12.



AUTO TRANSFORMER.

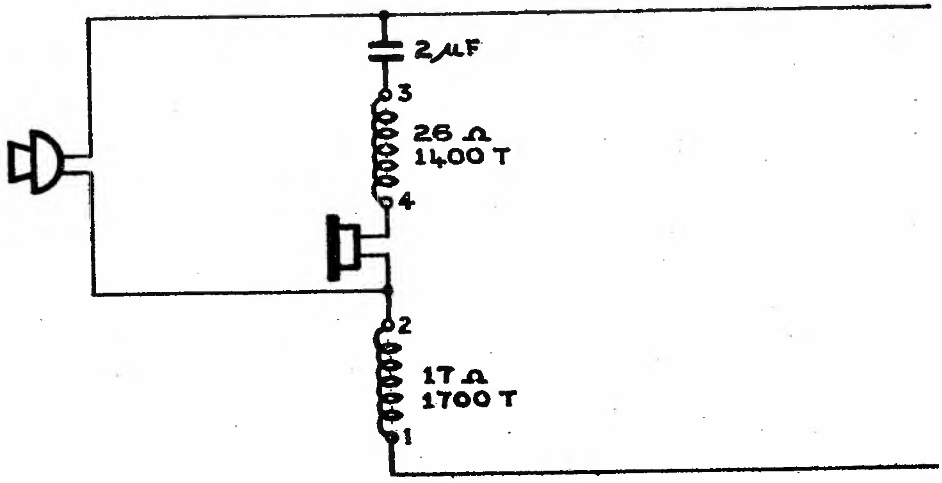
FIG. 12.

In Fig. 12, a voltage of self-induction of 400 volts is induced across the 400 turn primary section and a voltage of mutual induction of 900 volts is induced across the remaining 900 turns, these voltages acting in the directions indicated in Fig. 12 at some instant. Thus, a total of 1,300 volts is applied across the load connected to the secondary winding of Fig. 12 and, as the magnitudes and directions indicated in Figs. 11 and 12 are identical, the auto transformer can be used for exactly the same purposes as the separate winding transformer, that is, for voltage, current and impedance transformation.

3.4 Turning now to the circuit shown in Fig. 10, it will be seen that the primary winding of the auto transformer shunts the transmitter of some of its operating D.C. and that the receiver is in a D.C. circuit. It is not desirable that the receiver

/ be

be connected in a D.C. circuit, as the magnetism produced by the D.C. flowing through the receiver coils would oppose and weaken the permanent magnetism if in the appropriate direction, or saturate the magnetic circuit of the receiver if in the opposite direction. The two difficulties outlined above are remedied by arranging the circuit as in Fig. 13.



PRINCIPLE OF C.B. TELEPHONE.

FIG. 13.

The 2 µF condenser in Fig. 13 prevents the primary (26 ohms) winding of the induction coil from shunting the transmitter of some of its operating D.C. The connection of the receiver in this primary circuit removes the receiver from a D.C. circuit.

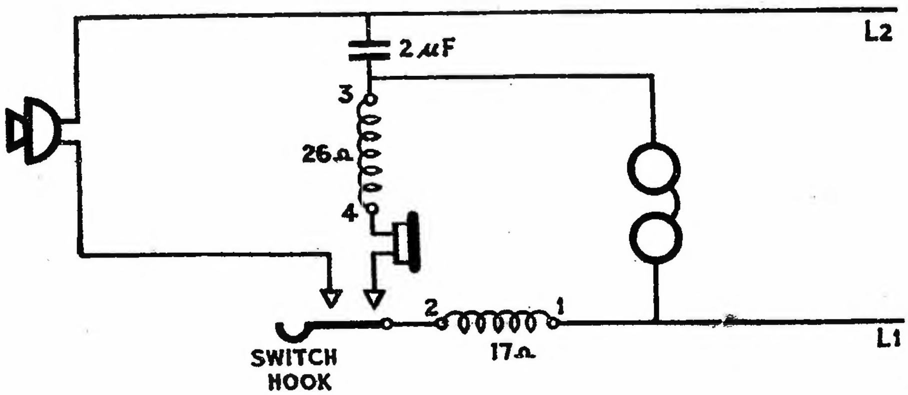
The turns and resistance values shown in Fig. 13 refer to the induction coil used on many C.B. telephones, so that this induction coil has a primary winding of 26 ohms and 1,400 turns and a secondary winding of 26 + 17 ohms = 43 ohms and 1,400 + 1,700 = 3,100 turns. The position of the receiver and the impedance relations existing in Fig. 13 mean that incoming speech does not pass directly through the receiver.

Incoming speech passes through the transmitter and 1,700 turn section of the induction coil rather than directly through the receiver, because the transmitter acts as a low resistance, non-reactive shunt across the circuit consisting of the condenser, primary winding of the induction coil and the receiver. The incoming speech currents flowing through the 1,700 turn section of the induction coil induce voltages across the 1,400 turn primary winding, thus causing speech currents to flow in a local circuit consisting of the 1,400 turn primary winding, the receiver, transmitter and condenser.

/ 3.5

3.5 The circuit of Fig. 13 is the basic speaking circuit of all C.B. telephones without anti-sidetone arrangements and is an important circuit. In some circuits, the resistances and number of turns on the coils differ, but the principle remains the same. These circuits will be dealt with in Section 4 of this Paper.

3.6 Fig. 13 must have additions made to it for signalling purposes. The exchange signals the subscriber using 17 c/s ringing current, so that a magneto bell is necessary. A switch hook is necessary, so that the speaking circuit will not shunt the bell when the telephone is not in use. Further, as the exchange is signalled by a D.C. circuit provided by the telephone when the receiver is lifted from the hook, the circuit arrangements must be such that a D.C. circuit or loop is not provided when the receiver is on the hook. Fig. 14 shows the schematic circuit of the basic C.B. telephone and the methods of providing for the above three features.



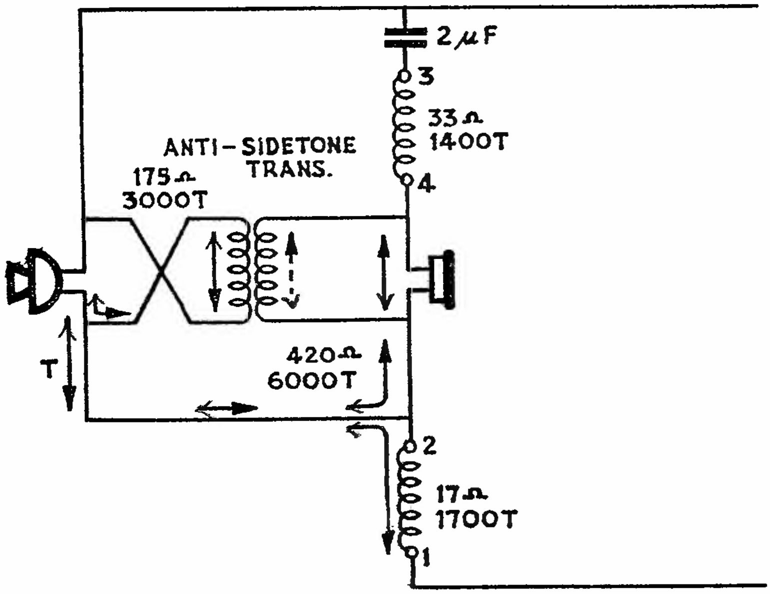
BASIC C.B. TELEPHONE CIRCUIT.

FIG. 14.

4. ANTI-SIDETONE CIRCUITS.

4.1 The receiver of C.B. telephones is in series with the primary winding of the induction coil, and sidetone becomes excessive when modern hand conversers are employed. This Section will deal with the principles of the anti-sidetone arrangements employed on C.B. telephones.

4.2 Early Anti-sidetone Device. Fig. 15 shows the circuit of the first C.B. telephone using anti-sidetone arrangements. This telephone is the 162 type, formerly known as the 566 telephone. A special anti-sidetone transformer was used in this telephone.



PART CIRCUIT OF TYPE 162 TELEPHONE.

FIG. 15.

Considering that the A.C. current generated by the transmitter flows in the direction shown by arrow T, then this current will divide, portion flowing through the primary winding of the A.S.T. transformer, portion flowing to line through the 17 ohm winding, and the remainder flowing through the receiver, the directions being indicated by the full arrows.

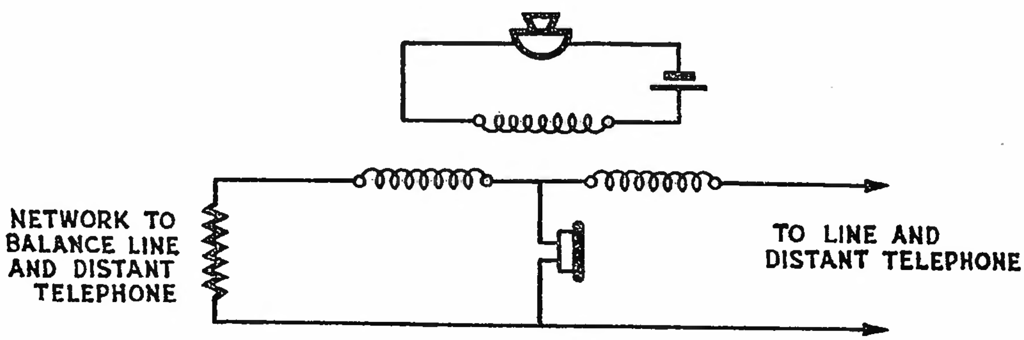
The current flowing through the primary winding of the A.S.T. transformer will induce an e.m.f. across the secondary winding in the direction shown by the dotted arrow. The resultant current flows through the receiver in the opposite direction to the current from the transmitter, with the result that the current through the receiver is reduced with a corresponding reduction in sidetone.

/ The

The action during the reception of speech is similar to that previously described for the fundamental C.B. telephone.

4.3 The circuit described above does not provide for a large reduction in sidetone. When it was introduced, sidetone suppression to a greater degree was thought to be inadvisable, and it was considered that the public had learned to regard sidetone as a measure of the efficiency of the telephone. Experience, however, has shown that this is not so, and that a much greater reduction of sidetone than that provided for in this circuit is greatly appreciated by the user and is of definite advantage. This is provided for in the circuits to be described later.

4.4 The type of anti-sidetone circuit employed in the Type 162 telephone has been displaced by a circuit similar in principle to that employed in local battery telephones and dealt with in Telephony I, Paper No. 5, Section 6, which should be studied in full again at this stage. Fig. 16 shows the principle of the anti-sidetone circuit employed in local battery telephones.



ANTI-SIDETONE CIRCUIT OF LOCAL BATTERY TELEPHONE.

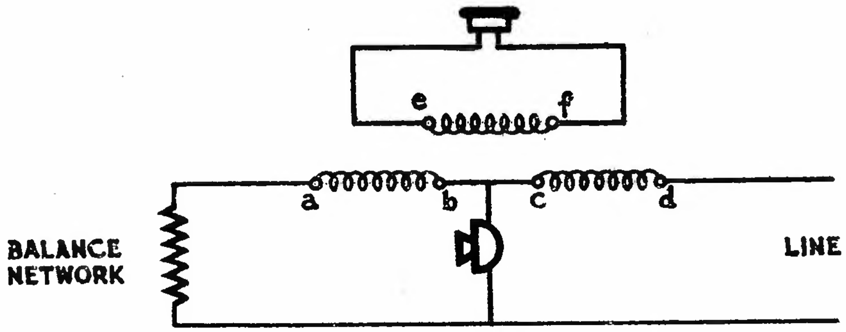
FIG. 16.

As discussed in the reference quoted above, when the impedance of the network equals that of the line and distant telephone, no voltage will be developed across the receiver when the transmitter is actuated, and, therefore, no current passes through the receiver in the transmitting condition.

As the transmitter battery feed for a C.B. telephone is supplied from the exchange battery via the line to the telephone, the transmitter must be placed in a position in the circuit so that the battery feed current from the exchange

/ can

can pass through it. This is done in Fig. 17 by interchanging the positions of the transmitter and receiver of Fig. 16, the local battery being eliminated.



PRINCIPLE OF ANTI-SIDETONE CIRCUIT OF C.B. TELEPHONES.

FIG. 17.

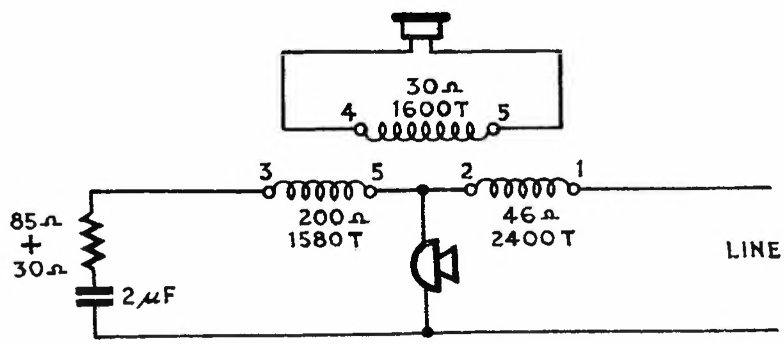
When the transmitter of Fig. 17 is actuated, that transmitter will supply A.C. power to two circuits in parallel - the line and the balance network. When the impedance of the balance network equals that of the line and distant telephone, the transmitter will supply equal amounts of power to the line and network. As equal currents will flow in opposite directions through the windings a-b and c-d of Fig. 17 under this balanced condition, then windings a-b and c-d will produce equal and opposite fluxes. The resultant flux in the core of the induction coil of Fig. 17 will, therefore, be zero when the transmitter is actuated, so that no voltage will be induced across winding e-f. Thus, sidetone is completely eliminated. This means that one half of the power output of the transmitter of Fig. 17 is absorbed by the balance network, the other half being sent to the line and distant telephone.

As described in connection with the local battery anti-sidetone circuit in Telephony I, one half of the power input from the line of Fig. 17 will be absorbed by the transmitter when a perfect balance exists, the other half being absorbed by the receiver and the balance network absorbing none of the input power.

Under this condition of perfect balance and with an equal number of turns on windings a-b and c-d of Fig. 17, it is found that the sending efficiency is raised to well above standard, whilst the receiving efficiency is lowered to well below standard. (The standard adopted by the Australian Post Office for C.B. and Automatic telephones is a Type 162

/ telephone

telephone supplied from a 22 volt repeating coil type of transmitter battery feed and having a 300 ohm line connected between the battery feed and telephone. All C.B. and Automatic telephones are compared with this telephone for performance data.) The circuit actually employed does not preserve a strict balance with regard to either the number of turns on the induction coil or the balancing impedance. This raises the receiving efficiency to nearer standard whilst reducing the sending efficiency, the raising of one being inseparable from the reduction of the other. Fig. 18 shows the principle applied to anti-sidetone induction coil No. 20 (A.S.T.I.C. No. 20) employed in Type 232 telephones.



PRINCIPLE OF A.S.T.I.C. NO. 20.

FIG. 18.

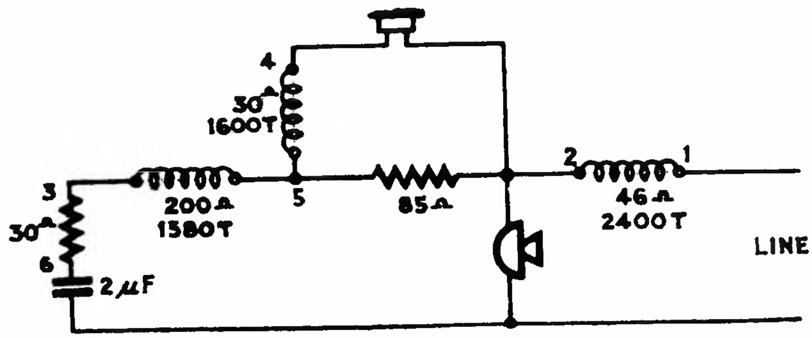
In Fig. 18, the unbalance between the number of turns on windings 1-2 and 3-5 and between the line impedance and network impedances (which should be regarded as containing the resis tances of windings 1-2 and 3-5 respectively) will mean that the power output from the transmitter will not divide equally between line and network, and that unequal currents will flow in windings 1-2 and 3-5 when the transmitter is actuated. A resultant flux will, therefore, be produced in the core of the coil, which will induce a voltage across winding 4-5 and produce sidetone. As the power output from the transmitter now divides between the line, network and receiver in Fig. 18, instead of merely between the line and network as in Fig. 17, less power is sent to line, thus lowering the sending efficiency.

As regards the receiving efficiency, this is raised as the power input to the telephone from the line will divide between the receiver, transmitter and network in the unbalanced circuit of Fig. 18, instead of between the transmitter and receiver only in the balanced circuits of Figs. 16 and 17.

/ As

As explained in Paper No. 5 of Telephony I, the perfectly balanced circuit of Fig. 17 results in equal voltages being produced across the transmitter of Fig. 17 and windings a-b and c-d when a signal is applied across the telephone from the line. As the balance network connects points at the same potential, no current will flow through the balance network of Fig. 17. When the number of turns on the a-b winding of Fig. 17 does not equal that on the c-d winding (as in Fig. 18), unequal voltages are produced across these, and the voltage across the a-b winding will not equal that across the transmitter. Under these circumstances, the balance network will not connect points at the same potential, so that the power input to the telephone divides between the transmitter, receiver and balance network. As the receiver is coupled to both the a-b and c-d windings of the induction coil, power is transferred to the receiver from both of these windings. This produces the result of raising the receiving efficiency, because more of the input power is transferred to the receiver in this unbalanced circuit than in the balanced circuit of Fig. 17.

Whilst correct numbers of turns and a correct value of balance network can raise the receiving efficiency to near standard whilst reducing the sending efficiency to nearer standard, the unbalance, as described above, produces sidetone. Sidetone is reduced by arranging the circuit as in Fig. 19.



CONNECTIONS OF A.S.T.I.C. NO. 20.

FIG. 19.

In Fig. 19, a portion of the voltage dropped across the resistance in the balance network is injected into the receiver circuit in opposition to the resultant voltage induced across winding 4-5 by the difference in the flux produced by windings 1-2 and 3-5 when the transmitter is actuated. Correct phasing of these voltages is ensured by care in the connection of the various windings.

4.8 There have been a number of developments in the design of anti-sidetone induction coils over the years, and some types are

/ summarised

summarised in circuit form in Fig. 20. The values shown for the A.S.T.I.C. No. 27 are the maximum values allowed by the specification of manufacture, and may differ slightly from those shown on some telephone circuits. The winding between terminals 3 and 5, for example, may be shown as 30 ohms, comprising both inductive and non-inductive turns.

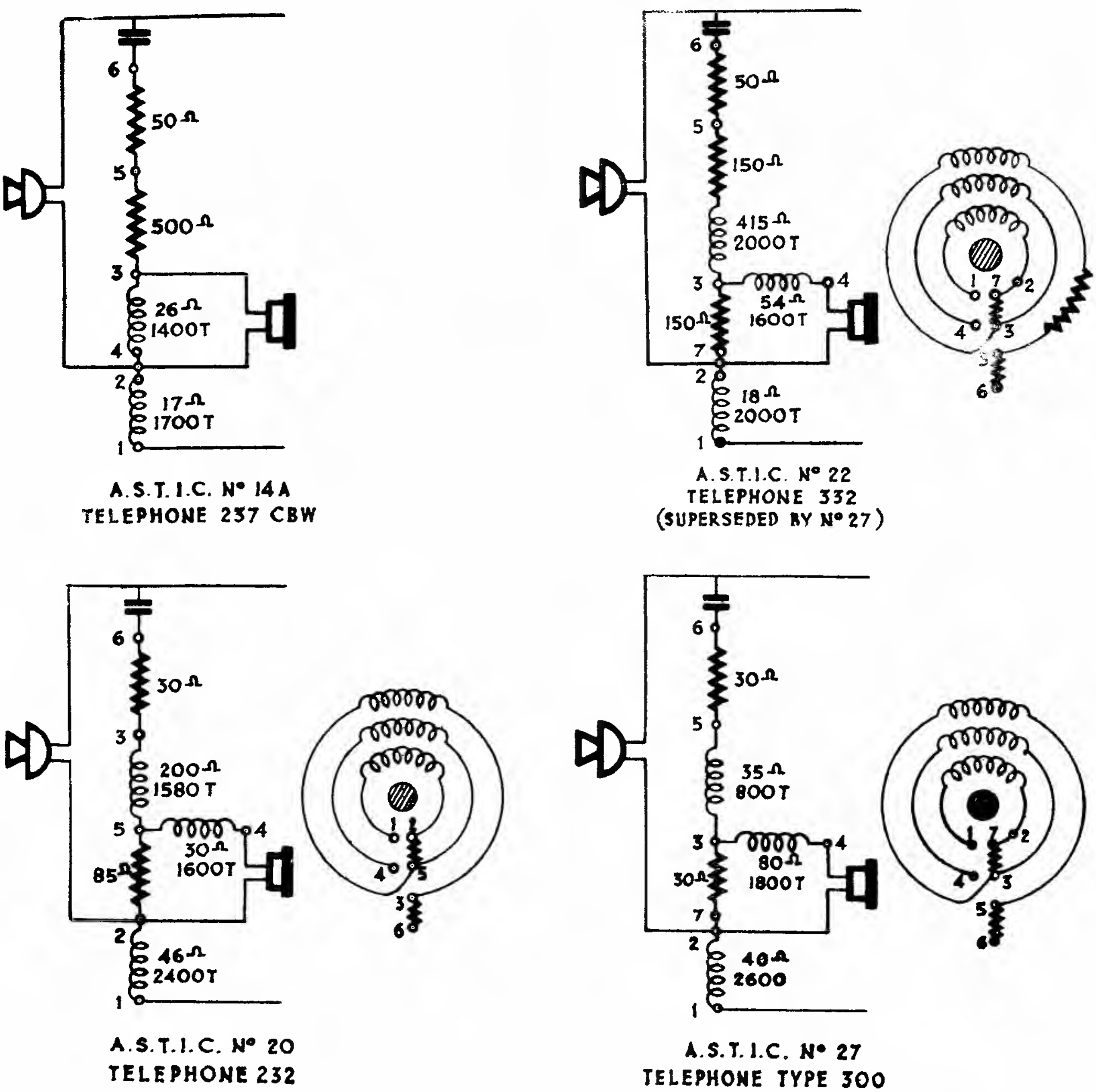


FIG. 20. ANTI-SIDETONE INDUCTION COILS.

5. TELEPHONES.

5.1 As with the magneto telephone, the C.B. telephones in use at present represent a continuous development to improve performance standards and appearance. The most frequently used C.B. telephones are described in this Section.

5.2 Telephones 37 C.B.W. and 38 C.B.T. These telephones use the basic circuit shown in Fig. 14, telephone 37 C.B.W. being the wall telephone and telephone 38 C.B.T. being the equivalent table telephone. Fig. 21 shows the wall telephone and wiring and schematic diagrams. The terminals designated R and TR in Fig. 21b are not utilised by the Australian Post Office. The British Post Office, which also employs this instrument, utilises terminals R and TR to provide a particular type of extension service.

The table instrument uses two units - a pedestal and a bell box. A solid back transmitter and a switch hook are mounted on a pedestal and a bell receiver is connected thereto, whilst the bell box contains the bell, condenser and induction coil. A cord 3600 connects the bell box and pedestal. Fig. 22 shows the telephone and wiring and schematic diagrams.

5.3 Telephone 162 C.B.T. This table telephone, the first moulded handset telephone to be used in Australia (previously known as Type 566), employs the anti-sidetone arrangements discussed in paragraph 4.2 of this Paper. A picture and circuits of the telephone are shown in Fig. 23. The instrument consists of three parts - a bell set containing the bell, induction coil and condenser; a pedestal containing the switch hook and anti-sidetone transformer; and a handset containing the transmitter and receiver. A cord 3306 connects the handset to the pedestal. A cord 3009 connects the pedestal to the bell set external to the instrument, and a cord 3600 connects the bell set to a terminal strip on which the exchange line terminates. Terminals 1 and 2 of this strip, which correspond with L1 and E of Fig. 21b, are strapped when extension bell facilities are not required.

5.4 Telephone 237 C.B.W. The 237 C.B.W. telephone was introduced to meet the demands of subscribers requiring a handset wall telephone. The telephone employs a moulded handset and an A.S.T.I.C. No. 14A. A picture of this telephone and a schematic diagram are shown in Fig. 24.

5.5 Telephone 232 C.B.T. This telephone is similar in appearance to the 162 C.B.T. shown in Fig. 23. The only differences are the elimination of the moulded and weighted base plate supplied with the 162 telephone, and the connection of the bell set to the pedestal by an internally run cord in the 232 telephone,

/ instead

instead of the external cord of the 162 telephone shown in Fig. 23a. As with the 162 telephone, the three parts of the instrument are the bell set, pedestal and handset. The exchange line terminates on a terminal strip which is connected to the bell set by a cord 3600. The strap for extension bell facilities is provided on this strip. The bell set contains the bell and condenser and is connected to the pedestal by a cord 3009. This pedestal contains the switch hook and anti-sidetone induction coil and is connected to the handset by a cord 3306. For a picture, Fig. 23a applies, whilst Fig. 25 shows a wiring-schematic diagram of the telephone.

5.6 Telephone 332 C.B.T. As mentioned previously, this telephone succeeded the Type 232. It differs from the Types 162 and 232 in that only two units are employed - a moulded handset containing the transmitter and receiver and a moulded case containing the bell, condenser, induction coil and switch hook. Fig. 26 shows a picture of the instrument and a wiring-schematic diagram of the instrument when equipped with A.S.T.I.C. No. 27. When alternative A.S.T.I.C's. Nos. 22 or 4c are used, the diagram is identical, except for the resistances and turns on the coil windings. A radio suppression unit of an 0.1 μF condenser is provided across the transmitter to prevent radio programmes being detected by the coherer action of the carbon granules and heard as music and speech in the receiver. The condenser by-passes the radio signals around the transmitter.

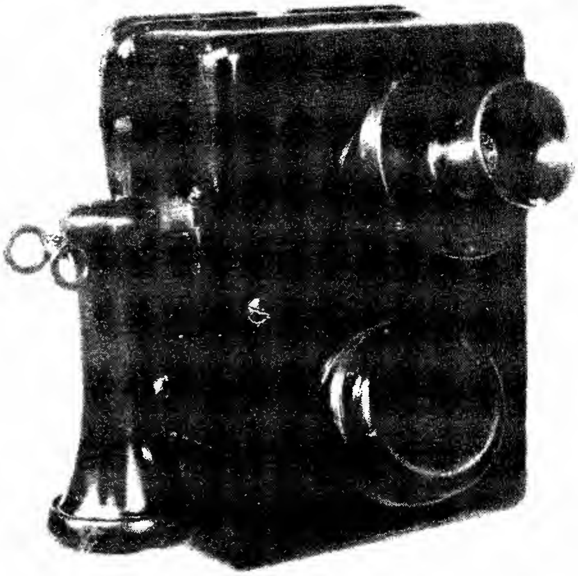
5.7 Telephones 300 C.B.W. and 300 C.B.T. These are the C.B. wall and table models of the universal 300 telephone developed by the Australian Post Office. Fig. 27 shows the telephones and a schematic diagram. The wiring-schematic diagram is the same for both telephones. Both wall and table instruments are made up of two units - the moulded handset containing the transmitter and receiver and a moulded case containing the bell, condenser, switch hook and induction coil. The table instrument is connected to a terminal strip on which the exchange line terminates by a cord 2406, whilst the exchange line terminates directly on the wall instrument. Terminals 14, 15, 16, 17 and 18 are provided for the dial connections when the telephone is used as an Automatic telephone. Slight variations in the A.S.T.I.C. No. 27 may be found in some of these telephones.

The extension bell, if required, is connected to terminals 1 and 2 of terminal strip No. 20/4, a three conductor cord is fitted between the strip and telephone, and the strap between terminals 1 and 2 in the telephone is removed.

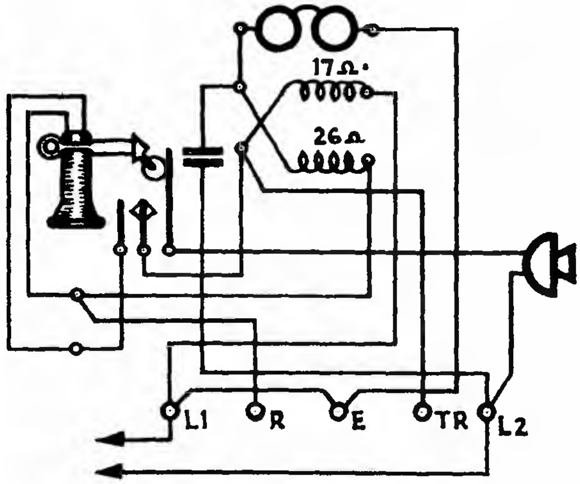
When used as a wall telephone, cords 2406 and terminal strip No. 20/4 are omitted.

The 0.1 μF condenser by-passes radio signals around the transmitter to prevent their reception as music and speech in the telephone receiver.

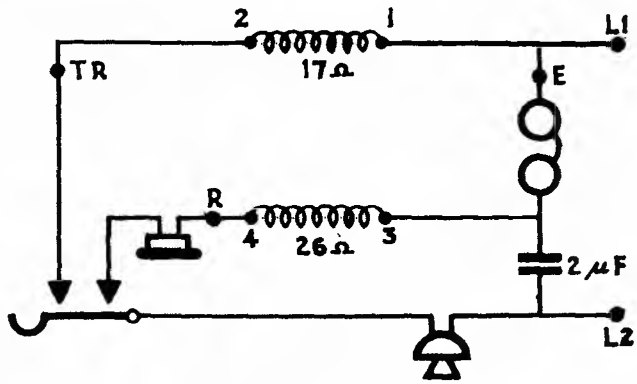
/ Fig. 21



(a) Telephone.



(b) Wiring Diagram.



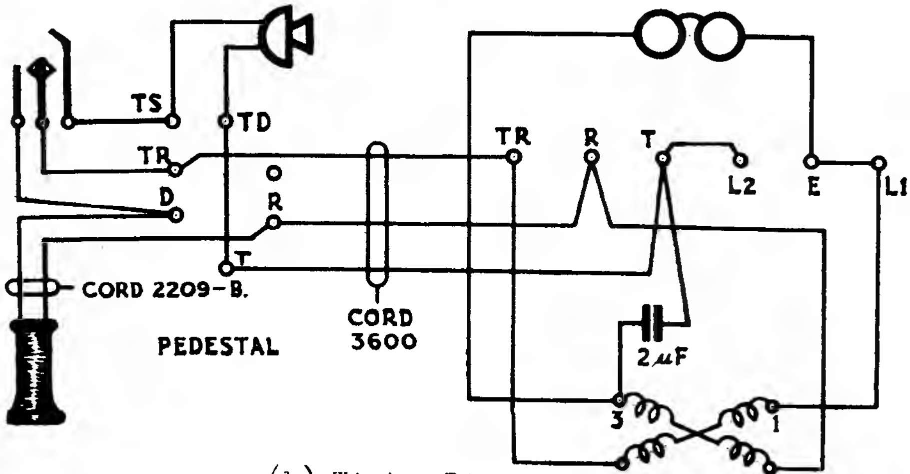
(c) Schematic Circuit.

C.B. WALL TELEPHONE.

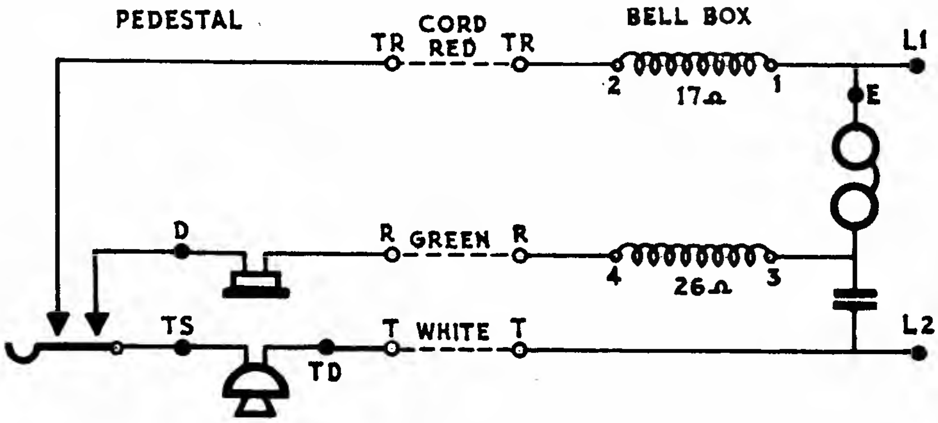
(37 C.B.W.)

FIG. 21.

(a) TELEPHONE



(b) Wiring Diagram.

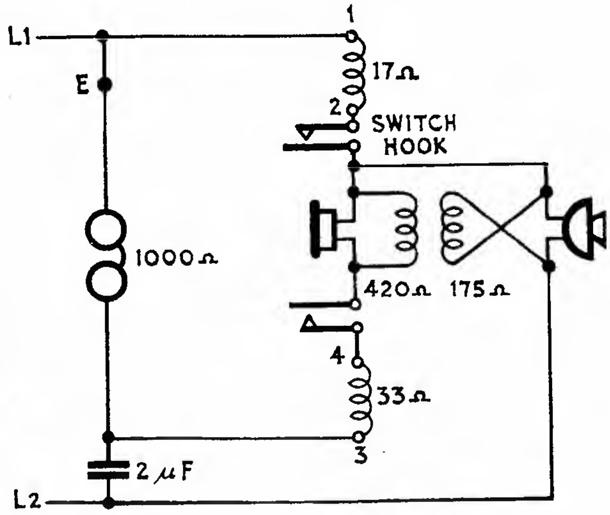


(c) Schematic Circuit.

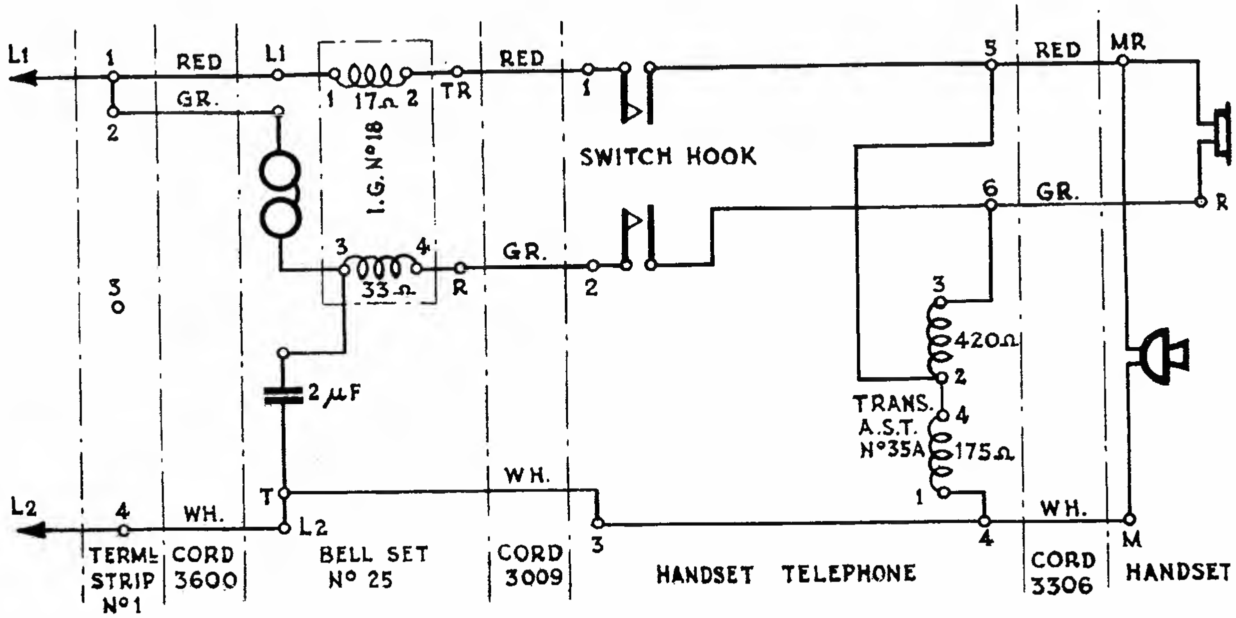
C.B. TABLE TELEPHONE.
(38 C.B.T.)

FIG. 22.

(a) Telephone.



(b) Schematic Circuit.

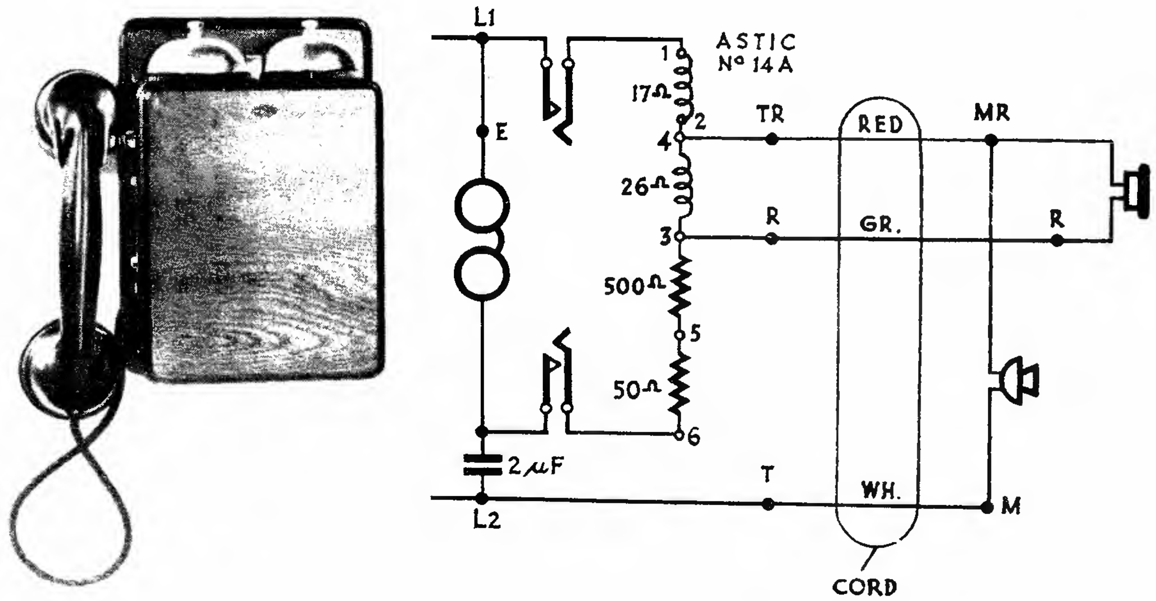


(c) Circuit.

HANDSET TELEPHONE.

(162 C.B.T.)

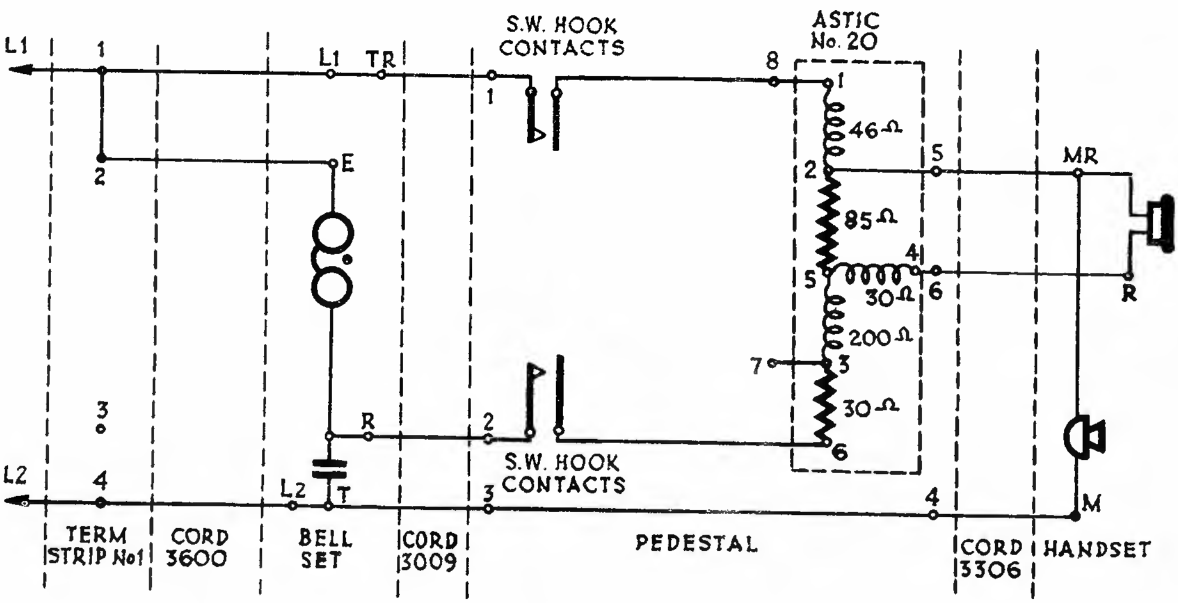
FIG. 23.



(a) Telephone.   (b) Circuit.

WALL TELEPHONE (237 C.B.W.)
(WITH HANDSET).

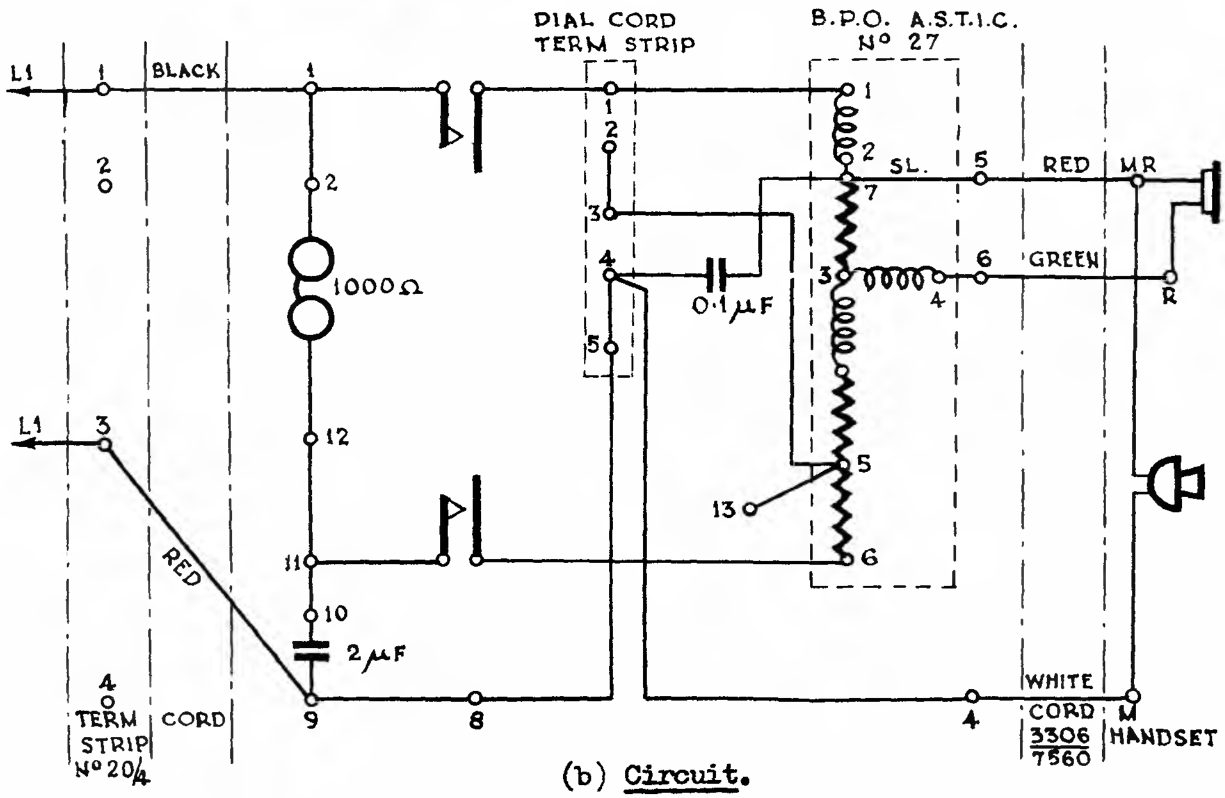
FIG. 24.



HANDSET TELEPHONE (C.B.T. 232).

FIG. 25.

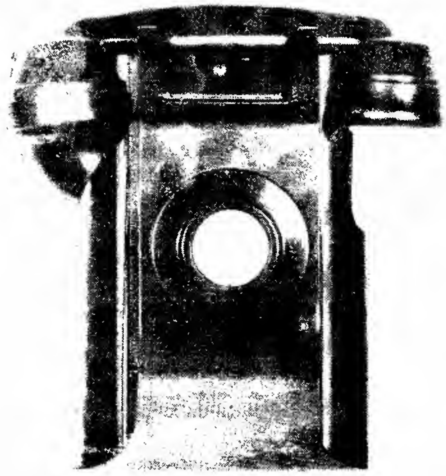
(a) Telephone.



(b) Circuit.

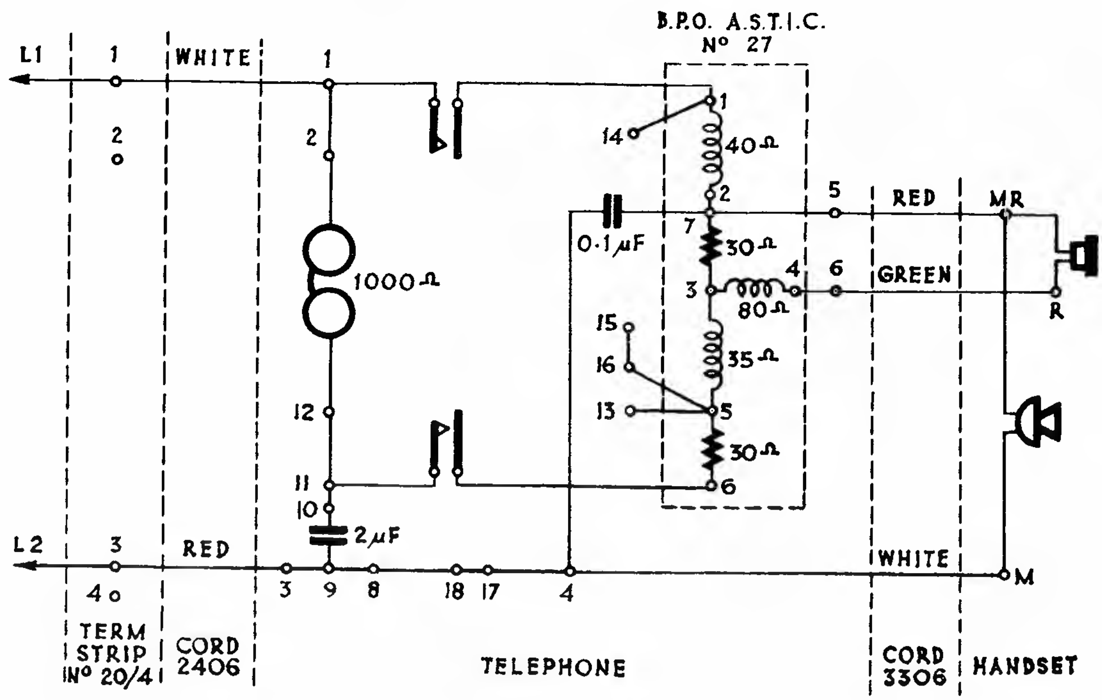
HANDSET TELEPHONE.
(332 C.B.T.)

FIG. 26.



(a) Wall Telephone.

(c) Table Telephone.



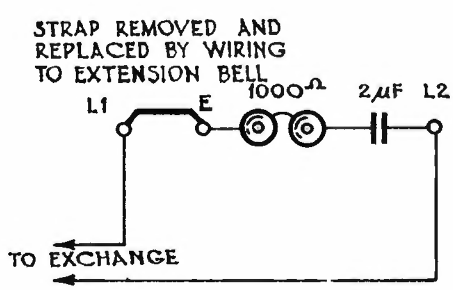
(c) Circuit.

C.B. TELEPHONES.
300 C.B.W. AND C.B.T.

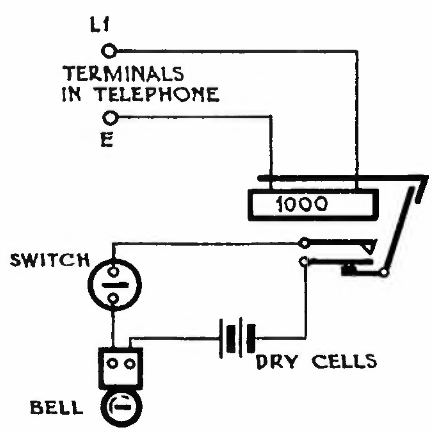
FIG. 27.

6. EXTENSION BELLS.

6.1 When a subscriber wishes to be advised at a position away from his telephone instrument when a call is incoming, but does not desire to make calls from that distant point, then an extension bell can be wired from the telephone. In C.B. working, the extension bell circuit is placed in series with the ordinary bell of the telephone. To allow this, an additional terminal (sometimes marked "E") is usually fitted near the line terminals as shown in Fig. 28a. This terminal is normally strapped to the terminal to which the incoming line wire connects. When an extension bell is required, the strap is removed and the extension bell connected in place. In Fig. 28a, the normal bell is shown,and reference to earlier information will show the remaining connections of the telephone. Extension bells are of two types, that is, Magneto or Trembler Bells. Magneto extension bells range from 2-1/2" to 6" gongs, while trembler bells range from 2-1/2" to 10" gongs. Trembler Bells operate from a local battery, the circuit being completed by indicator contacts as shown in Fig. 28b.



(a) Magneto Extension Bell.



(b) Trembler Extension Bell.

EXTENSION BELLS.

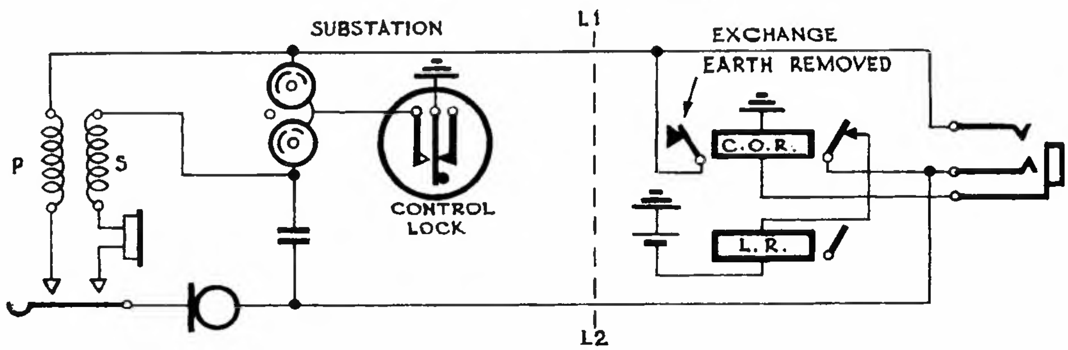
FIG. 28.

7. KEY CONTROL SERVICES.

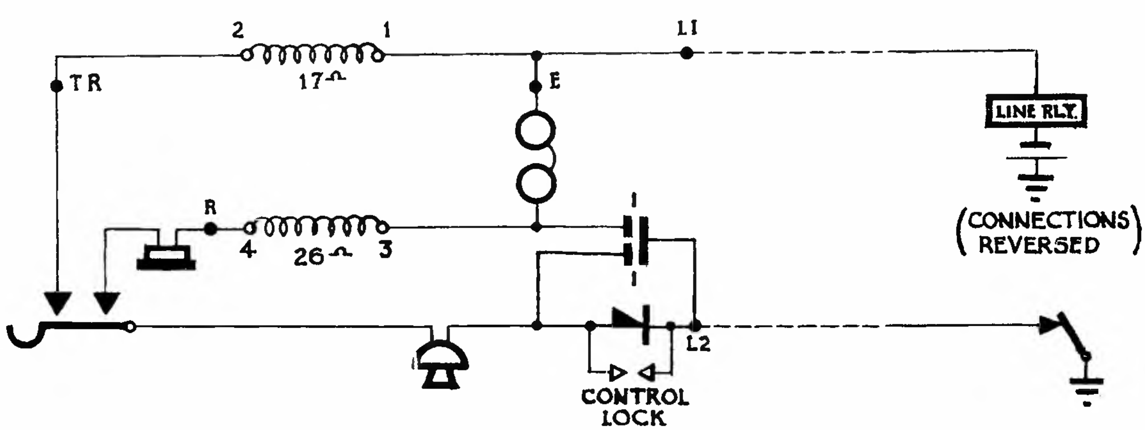
7.1 When a subscriber desires that outward calls, that is, chargeable calls, will not be made from the telephone, except by an authorised person, a control lock is fitted, the keys of which are held by the subscriber. A single lock unit, consisting of a small lock complete with one set of change-over springs, is used for all types of telephones.

7.2 In the early circuit of Fig. 29a, the earth at the exchange, which normally completes the circuit of the line relay over the subscriber's loop, is removed and, in place thereof, the control lock, when operated, connects an earth via one of the bell coils. If, therefore, the control lock is normal, removal of the subscriber's receiver will not cause operation of the line relay at the exchange.

7.3 The later circuit in Fig. 29b uses a metal rectifier and the connections to the line relay and earth are reversed in the exchange. When the receiver is lifted, the metal rectifier prevents the earth from completing the circuit to the line relay until the control lock contacts are operated by the key.



(a) Early Circuit.

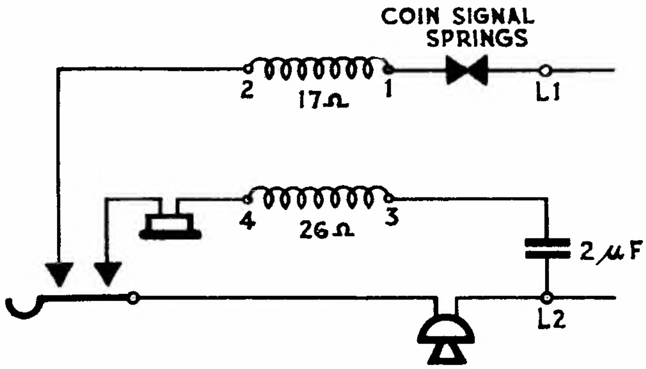


(b) Improved Circuit.

FIG. 29. CONTROL LOCK FOR C.B. TELEPHONES.

8. PUBLIC TELEPHONES.

8.1 On unit fee public telephones, the insertion of the two pennies in the coin chute (described in Telephony I, Paper No. 7) causes the coin signal springs, which are in series with the line, to make and break a number of times for each penny. This rapid making and breaking of the line circuit causes a signal in the telephonist's receiver, indicating that the pennies have been inserted. Fig. 30 shows the basic circuit.

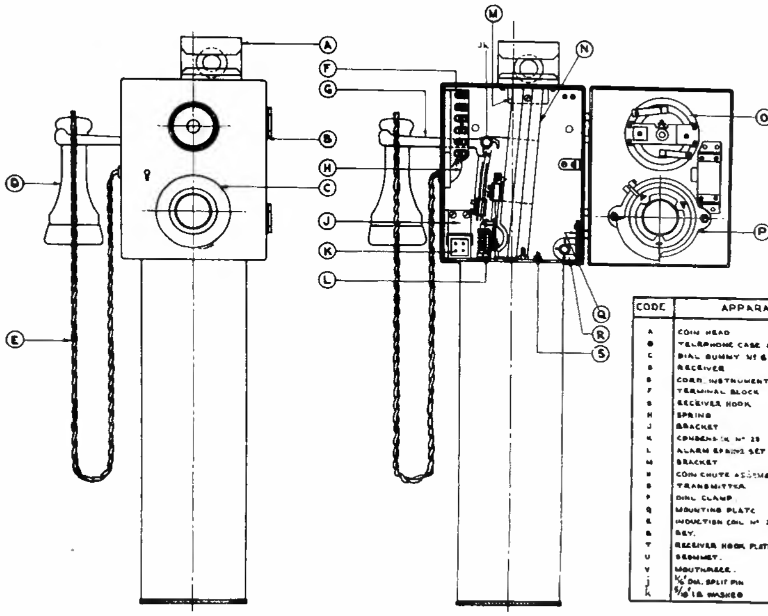


PRINCIPLE OF C.B. PUBLIC TELEPHONE.

FIG. 30.

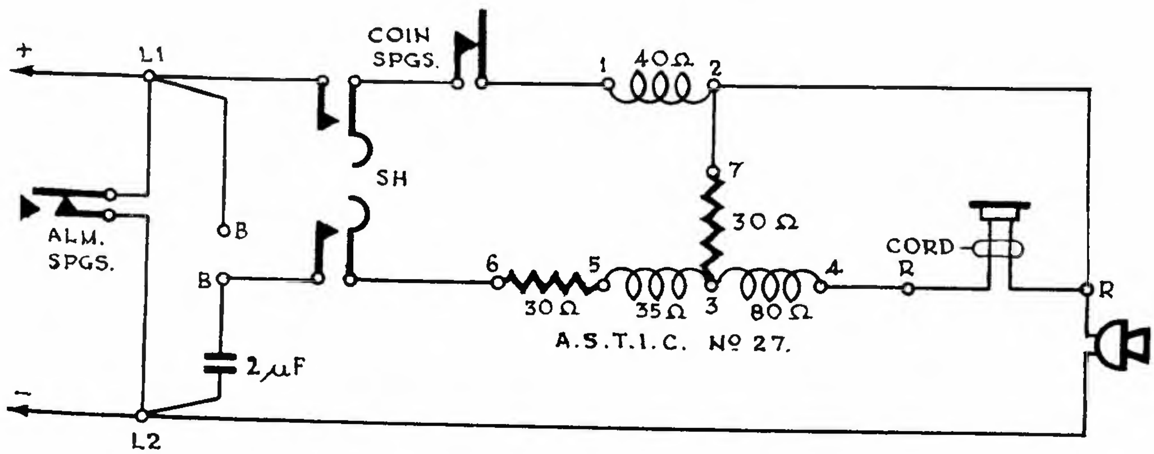
The coin chute and coin tin may be separate from the telephone or combined in a special public telephone as shown in Fig. 31. Fig. 31 also includes the circuit of this telephone. The alarm springs shown are opened when the coin tin is in situ, but closed when the coin tin is withdrawn from the telephone. This provides an alarm feature to the exchange.

/ Fig. 31.



CODE	APPARATUS
A	COIN HEAD
B	TELEPHONE CASE ASSEMBLY
C	DIAL DUMMY Nº 6.
D	RECEIVER
E	CORD, INSTRUMENT
F	TERMINAL BLOCK
G	RECEIVER HOOK
H	SPRING
J	BRACKET
K	CONDENSER Nº 23
L	ALARM SPRING SET
M	BRACKET
N	COIN CHUTE ASSEMBLY
O	TRANSMITTER
P	DIAL CLAMP
Q	MOUNTING PLATE
R	INDUCTION COIL Nº 27.
S	KEY.
T	RECEIVER HOOK PLATE
U	GROMMET.
V	MOUTHPIECE.
j	1/16" DIA. SPLIT PIN
k	5/16" I.D. WASHER

(a) Manual C.B. Public Telephone.
(Improved Type)



NOTE:– ALARM SPRINGS ARE OPENED WHEN COIN TIN IS IN STITU.

(b) Circuit.

C.B. PUBLIC TELEPHONE.

FIG. 31.

9. TEST QUESTIONS.

1. Why is a battery with a low internal resistance essential for C.B. operation?

2. Give sketches and describe two methods of supplying transmitter battery to subscribers from a common battery exchange.

3. Explain the operation of an auto transformer.

4. Sketch and describe the basic circuit for a C.B. telephone.

5. With a sketch, describe the operation of an anti-sidetone device.

6. How is an extension bell connected to a telephone?

7. Give a circuit and describe the principle of the C.B. Key Control Telephone.

8. Explain how the fee is collected on a C.B. Public telephone.

END OF PAPER.

COMMONWEALTH OF AUSTRALIA.

Chief Engineer's Branch,
Postmaster-General's Department,
Treasury Gardens,
Melbourne, C.2.

COURSE OF TECHNICAL INSTRUCTION.

C.B. EXCHANGES.

CONTENTS:

---

1. INTRODUCTION.

1.1 C.B. exchange switchboard circuits, like the Magneto exchange switchboard circuits, can be divided into two parts -

(i) The Line Circuit on which the subscriber's line terminates and which contains the signalling apparatus necessary for initiating a call and the subscriber's register.

(ii) The Cord Circuit which contains the transmitter battery feed, the speaking and ringing key, supervisory signals and facilities for registering calls against a calling subscriber at the end of an effective call. The cord circuit employs either the Hayes or the Stone type of transmitter battery feed.

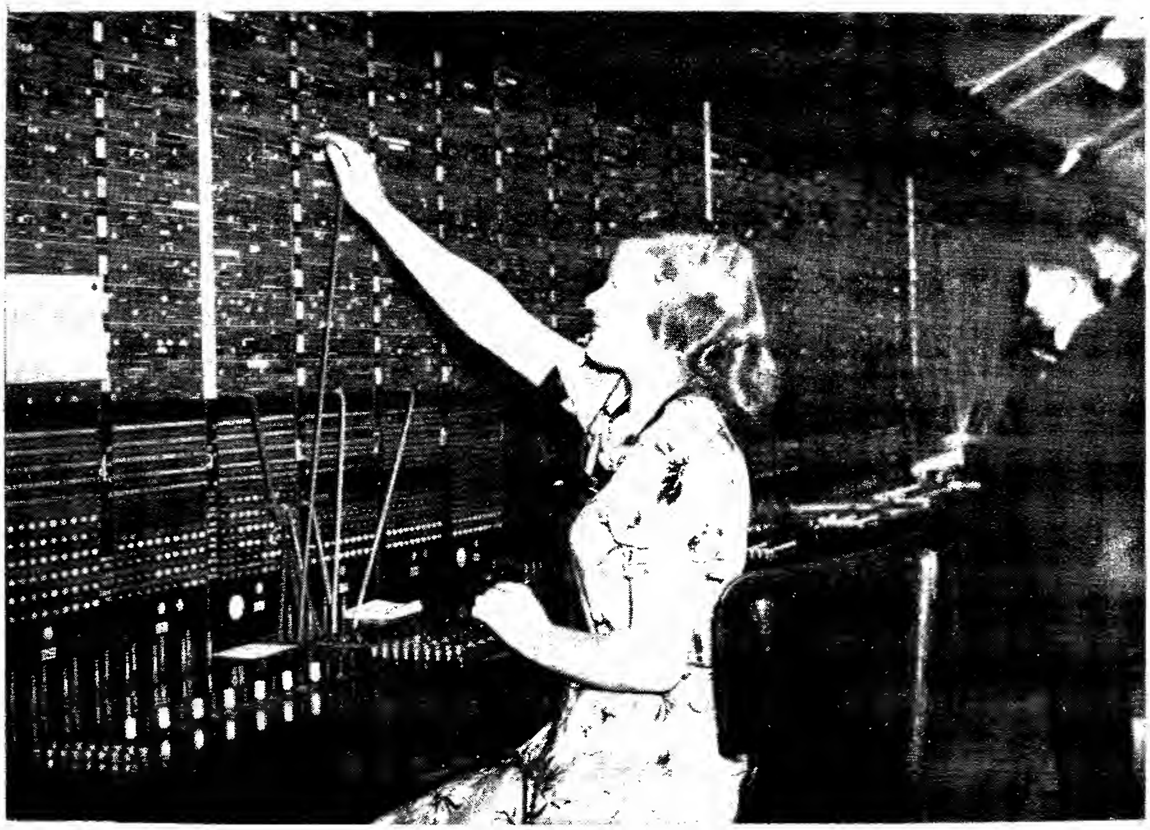
2. SUBSCRIBER'S LINE CIRCUIT.

2.1 Fig. 1 shows the circuit details of a C.B. subscriber's line circuit. The main points to be noted are -

(i) The use of a branching multiple for the multiple appearances of subscriber's lines.

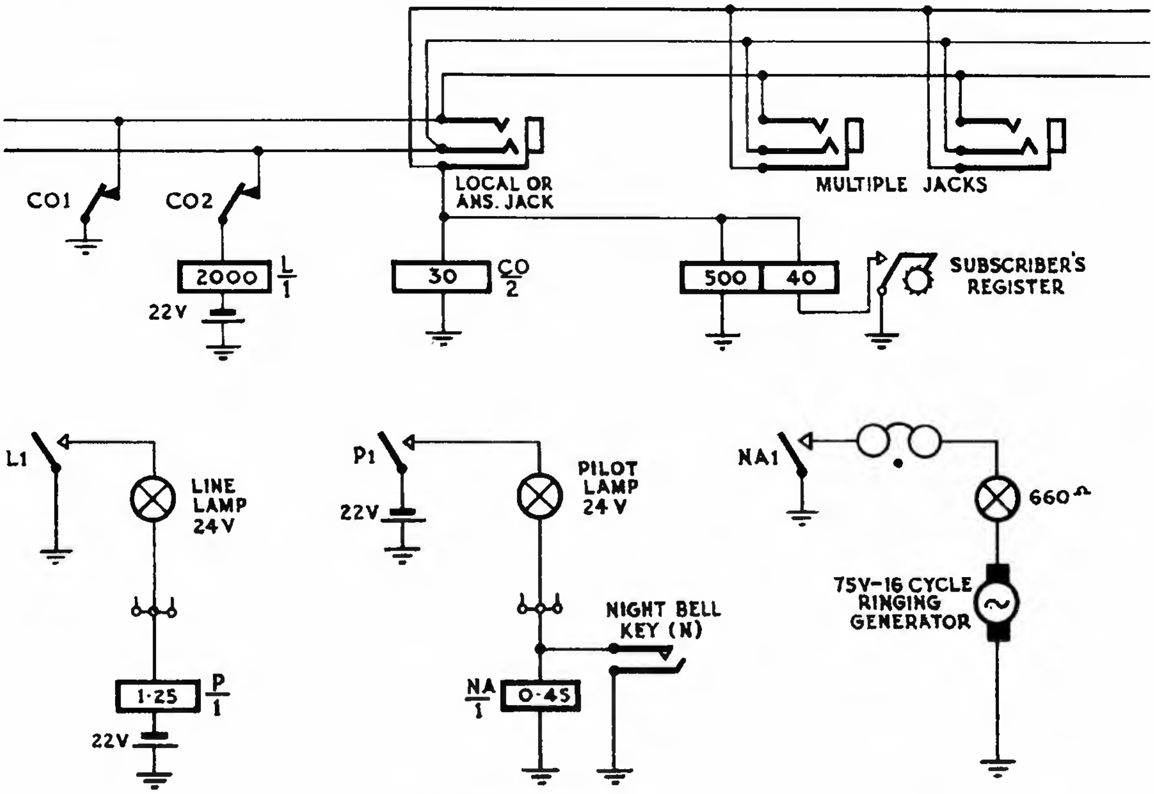
(ii) The use of a low resistance pilot relay common to the line lamps on a position. The low resistance of this pilot relay prevents any appreciable drop over the relay when a number of line lamps are being simultaneously displayed.

(iii) The use of a night alarm circuit common to all or a number of the positions in the exchange.

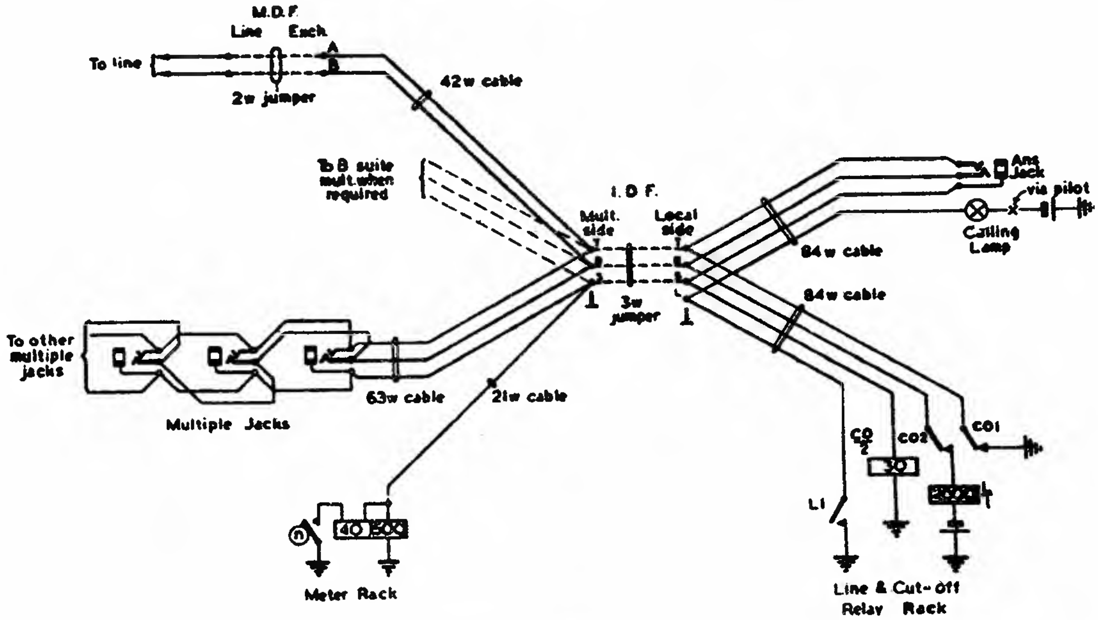


TESTING THE CALLED LINE.

C.B. Telephone Exchange. A POSITION. Note the extent of the multiple, order wire keys, line lamps and R and L keys.



(a) Schematic Circuit.



(b) Cabling Diagram.

FIG. 1. TYPICAL C.B. SUBSCRIBER'S LINE CIRCUIT.

2.2 Circuit Operation.

Outgoing Calls. As discussed in Paper No. 2, when the receiver of a C.B. telephone is on the hook, the bell and condenser in the subscriber's telephone are in series across the line. On the receiver being lifted from the hook a loop is provided by the transmitter, winding of the induction coil and switch hook contacts. This loop operates relay L in the line circuit at the exchange, as shown in Fig. 1. The operated contacts L1 display the line lamp and operate the pilot relay P. Operated contacts P1 display the pilot lamp and operate the night alarm relay NA (if the night bell key is operated). Operated contacts NA1 complete a circuit to operate a magneto bell from the exchange ringer.

On the operator plugging up to answer a call, relay CO in the calling subscriber's line circuit operates to earthed battery on the sleeve of the cord circuit used (see Fig. 3 and succeeding circuits). Operated contacts CO1 and CO2 disconnect relay L from across the calling subscriber's line. Relay L releases, extinguishing the line lamp and releasing relays P and NA.

As in the circuit of the branching multiple magneto switchboard, the subscriber's register is connected to the sleeve circuit. The operation of this register is dealt with in the descriptions of the cord circuits.

Incoming Calls. On incoming calls to a subscriber, it is necessary to disconnect relay L from across the subscriber's line to prevent that relay from shunting the ringing current away from the subscriber's line and bell, and to prevent the line lamp from falsely displaying when the subscriber answers. This is done by operating relay CO on the line being plugged up, the operating battery being connected to the sleeve of the cord circuits, as in Fig. 2.

2.3 M.D.F. and I.D.F. As with the magneto branching multiple line circuit, subscriber's lines are connected to the multiple and local circuits in the exchange via a Main Distributing Frame and an Intermediate Distributing Frame. These frames perform the same functions as those described for the magneto installation, and typical cabling arrangements from these are shown in Fig. 1.

/3.

3. CORD CIRCUIT (HAYES TRANSMISSION).

3.1 Any C.B. cord circuit should provide the following facilities -

(i) Transmitter battery feed to the calling and called subscribers.
(ii) Means of operating the CO relays connected in the calling and called subscriber's line circuits.
(iii) Individual supervision on each cord.
(iv) Facilities for registering effective calls against the calling subscribers.
(v) The usual speaking and ringing facilities required on exchange cord circuits.

3.2 Battery Supply. Fig. 2 shows how a cord circuit could be arranged to provide a transmitter battery feed to calling and called subscribers, the system employed being the Hayes or repeating coil system.

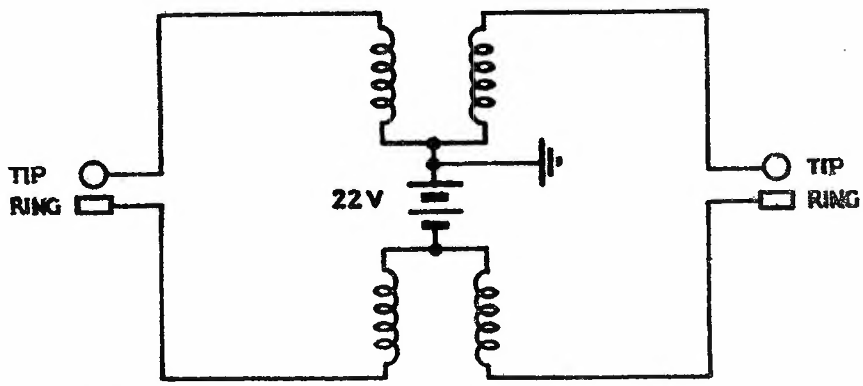


FIG. 2. CORD CIRCUIT EMPLOYING REPEATING COIL BATTERY FEED.

3.3 Operating the C.O. Relay. The CO relays in the calling and called subscriber's line circuits would be operated by connecting earthed battery to the sleeves of the plugs, as shown in Fig. 3.

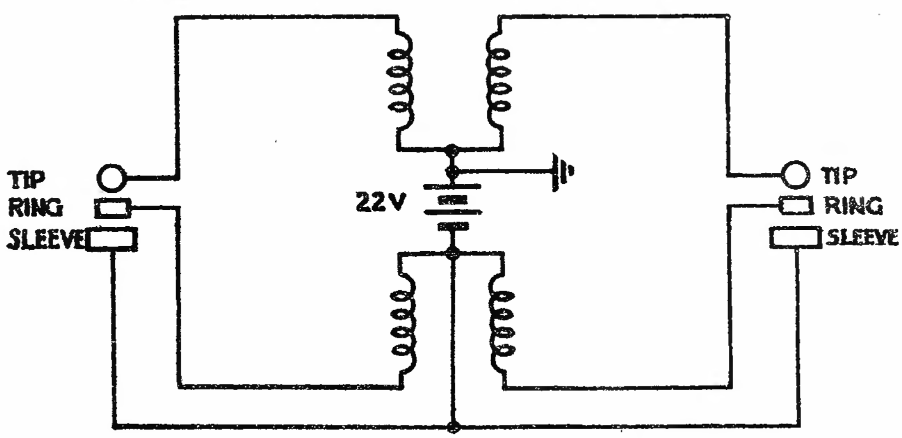
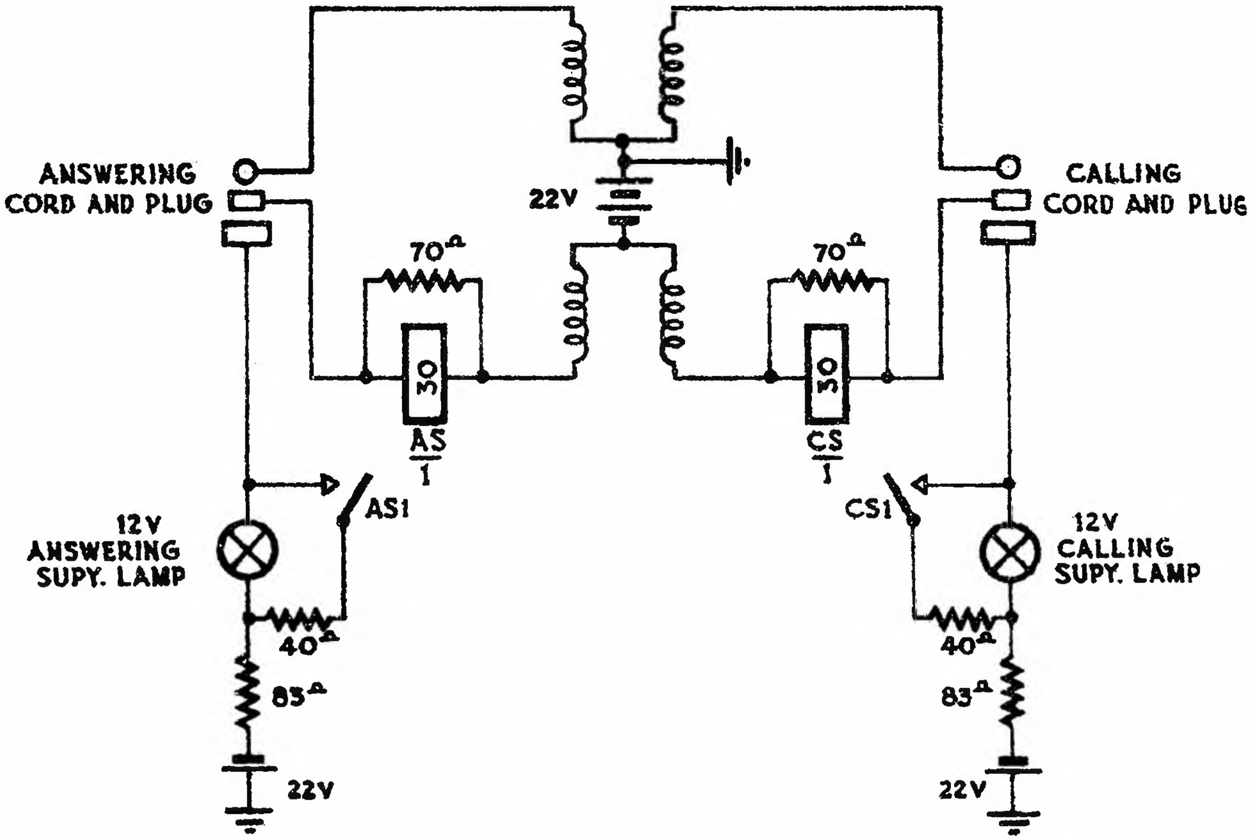


FIG. 3. METHOD OF OPERATING CO RELAYS.

3.4 Supervisory Relays. Individual supervision on each cord is arranged by the means shown in Fig. 4.



SUPERVISORY ARRANGEMENTS ON CORD CIRCUITS.

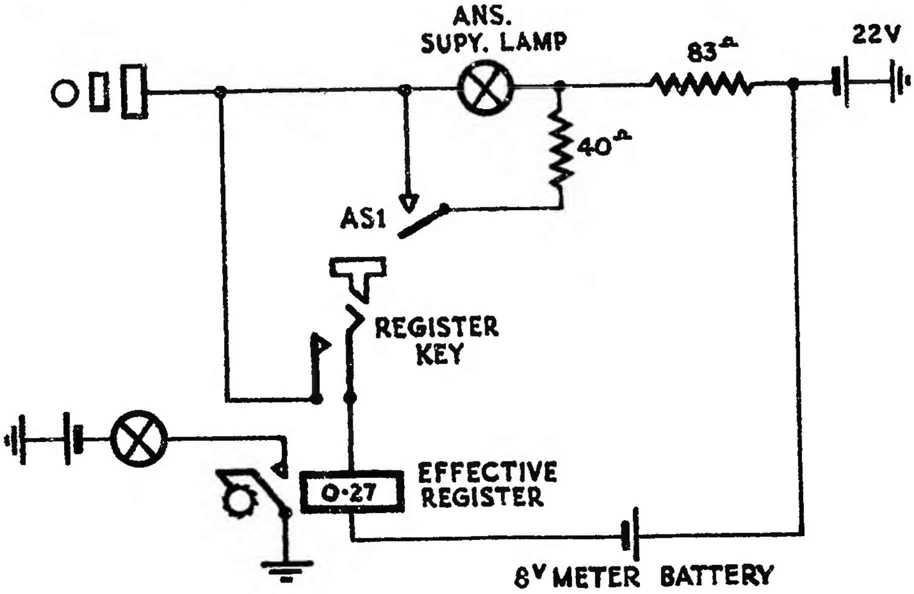
FIG. 4.

Individual supervisory relays are connected in the ring side of each cord, and contacts of these relays control the circuits of supervisory lamps connected in the sleeve circuit. Thus, whilst the subscriber connected to the answering cord has the receiver off the hook, the answering supervisory relay AS is operated and operated contacts AS1 are maintaining a shunt on the answering supervisory lamp, so preventing that lamp from displaying. On the subscriber hanging up, relay AS releases, the shunt is removed from the answering supervisory lamp and that lamp displays. Thus, whilst both calling and called subscribers connected together by the cord circuit of Fig. 4 have the receivers off the hook, both supervisory relays are operated and neither supervisory lamp is displaying. On either subscriber hanging up, the

/appropriate

appropriate supervisory relay releases to display the corresponding supervisory lamp. The relays are shunted by 70 ohms non-inductive resistors to allow the passage of speech currents through the cord circuit clear of the high impedance of the relays. The Hayes type of battery feed employs a 22 volt battery. This battery is used for both speaking and signalling. To economise in power, 12 volt lamps are used in the supervisory circuits and the 83 ohm resistance, together with the 30 ohm CO relay in the subscriber's line circuits, reduce the voltage applied to the lamps to 12 volts.

3.5 Metering Calls. As effective calls are registered against the calling subscriber only, it is necessary to arrange the answering cord only for operating calling subscribers' registers. The subscribers' registers are connected to the sleeve of the line circuits so that the register circuit must be connected to the sleeve of the answering cord, which is, therefore, arranged as in Fig. 5.



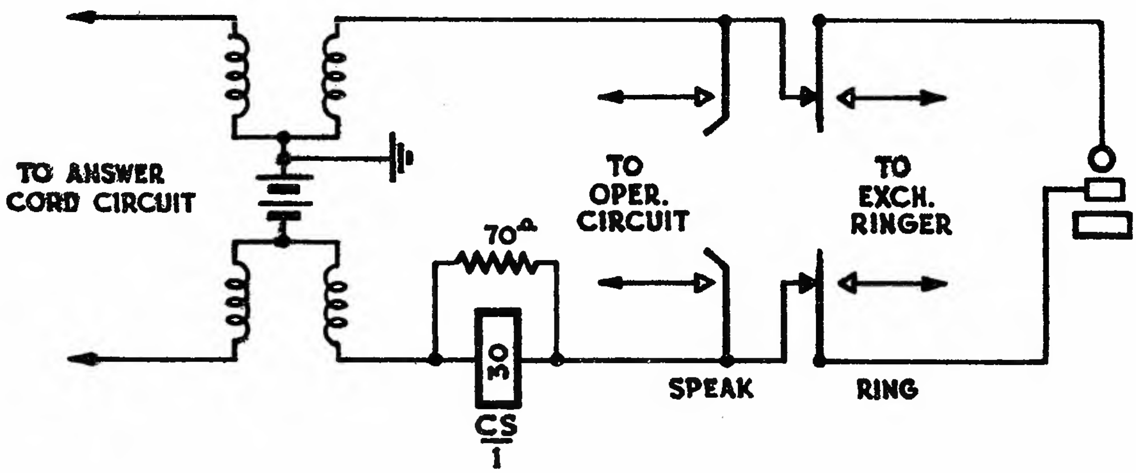
CIRCUIT FOR REGISTERING CALLS.

FIG. 5.

An examination of Fig. 5 will show that the circuit is essentially the same as that in Fig. 9, Paper No. 11 of Telephony I, and that the description included in Section 7 of that Paper is applicable to Fig. 5.

/3.6

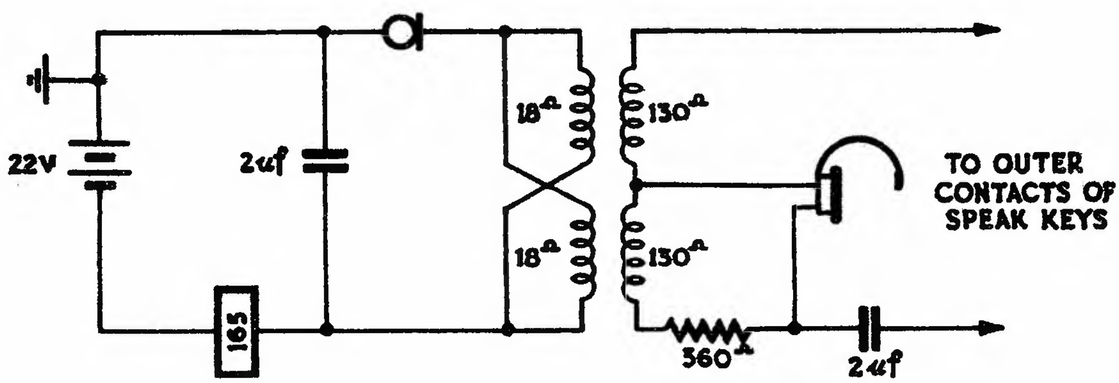
3.6 Speaking and Ringing Keys. A speaking and ringing key is connected in the calling cord circuit, the connections being indicated in Fig. 6.



CONNECTION OF SPEAKING AND RINGING KEY.

FIG. 6.

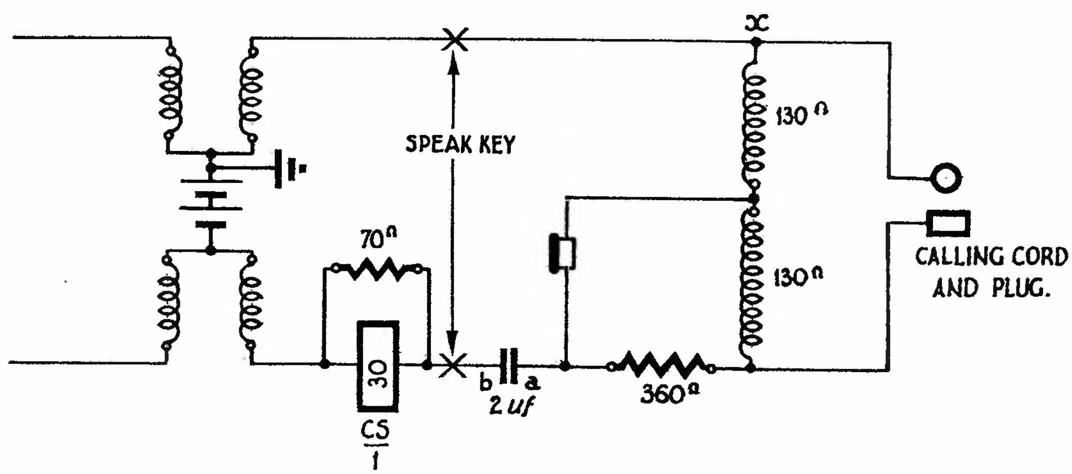
3.7 Operator's Circuit and Engaged Test. The operator's telephone circuit is shown in Fig. 7.



OPERATOR'S TELEPHONE CIRCUIT.

FIG. 7.

The arrangements employed to reduce sidetone are identical with those employed in the circuit and description of Fig. 4, Paper No. 11, Telephony I. The resistance of the retard in the primary circuit is increased to 165 ohms because a 22 volt battery is employed. A 2 µF condenser is connected in series with the secondary circuit to prevent false operation of the calling supervisory relay on a cord circuit when a speaking key is operated. This condenser also supplies the engaged test. This engaged test is carried out in the manner previously described, that is, with the speaking key operated on the cord circuit being used, the operator touches the tip of the calling plug on the sleeve of the jack of the called line. When the speaking key is operated, the condenser in series with the operator's secondary circuit charges to the voltage of the exchange battery. This circuit will be connected across the transmitter battery feed to the calling cord. Fig. 8 shows the circuit conditions.



OPERATOR'S SECONDARY CIRCUIT WITH SPEAK KEY OPERATED.

FIG. 8.

Plate a of the condenser in Fig. 8, therefore, will be at earth potential and plate b at a potential of -22 volts. If, now, the operator touches the tip of the calling plug on the sleeve of a disengaged jack, the tip of the plug will encounter an earth potential via the CO relay and register in the tested subscriber's line circuit (see Fig. 1). The tip of the plug is merely an extension of point x in Fig. 8, and, under this condition, that is, the tested line disengaged, there is no alteration of the potential on the plates of the condenser.

/Should

Should the tested line be engaged, the circuit conditions of the sleeve circuit will be as in Fig. 9.

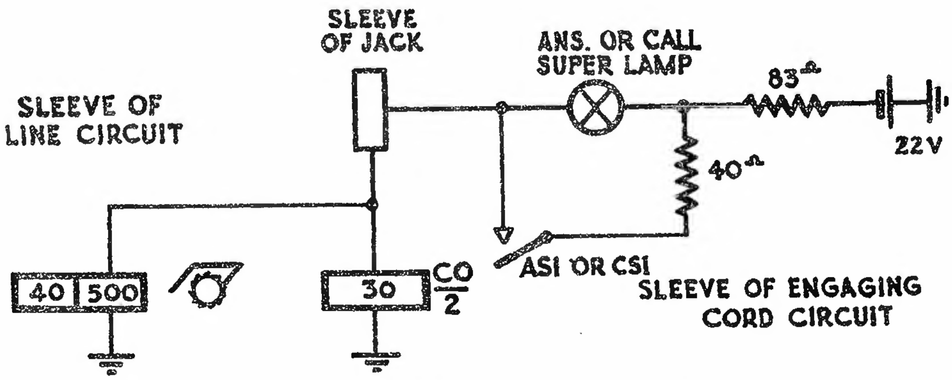


FIG. 9. CONDITION OF ENGAGED LINE.

Under these circumstances the sleeve of the jack being tested will not be at earth potential but at a potential below earth potential, and of an amount equal to the voltage drop across the windings of relay CO and the subscriber's register in parallel. When the tip of the testing plug of Fig. 8 is touched on the sleeve of the jack of Fig. 9, the potential on plate a of the condenser of Fig. 8 is reduced and a partial discharge of the condenser takes place. Some of this discharge current passes through the receiver to produce a distinct "click" which indicates that the line is engaged.

3.8 Alternative Operator's Circuit. An alternative telephonist's telephone circuit is shown in Fig. 10. The induction coil has a primary winding of 11 ohms resistance and has two other windings of 58 ohm resistance and 240 ohm resistance respectively. The latter winding is connected across the receiver, and the arrangement tends to reduce sidetone.

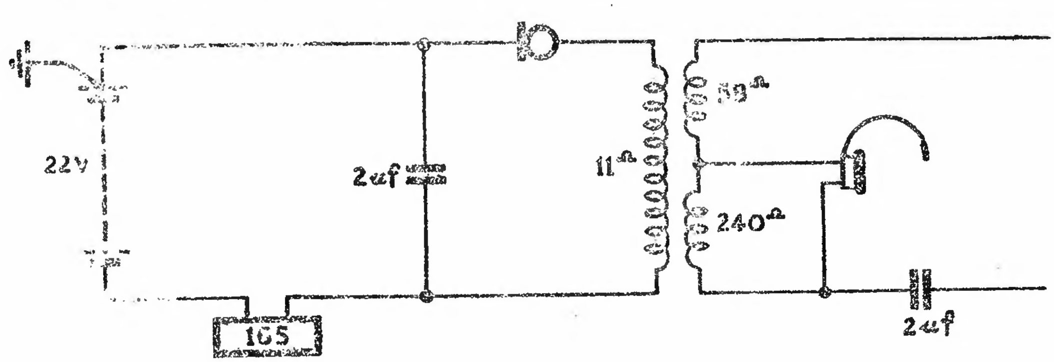
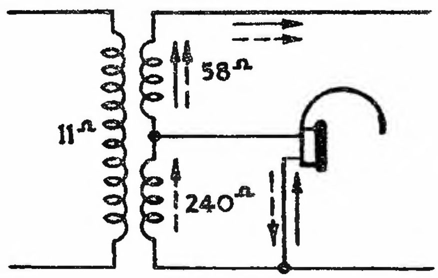


FIG. 10. "A" POSITION. TELEPHONIST'S CIRCUIT.

Fig. 11 shows the manner in which the induction coil functions to reduce sidetone. The currents produced by the voltages induced from the primary are shown by means of normal arrows for the 58 ohm winding and by dotted arrows for the 240 ohm winding. The current in the latter winding divides and a portion passes via the receiver coils in the opposite direction to the current, due to the 58 ohm winding. This minimises the effect in the receiver.

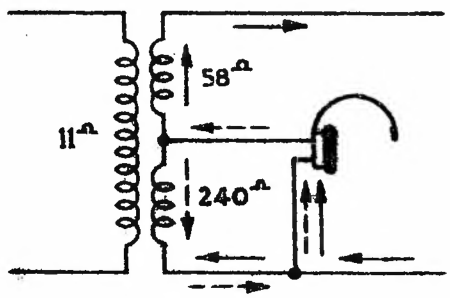


TRANSMITTING.

FIG. 11.

Fig. 12 shows the operation of the circuit for received speech.

The whole of the received currents traverses the 58 ohm winding, but only a small portion passes via the 240 ohm winding as this is bridged by the receiver. In the 240 ohm coil, however, the winding is such that current is induced from the 58 ohm winding in an opposite direction to the inducing current. The currents due to the two sources, therefore, assist each other in the receiver circuit itself. The thick arrows represent an incoming line current and the dotted arrows the induced currents in the 240 ohm winding.



RECEIVING

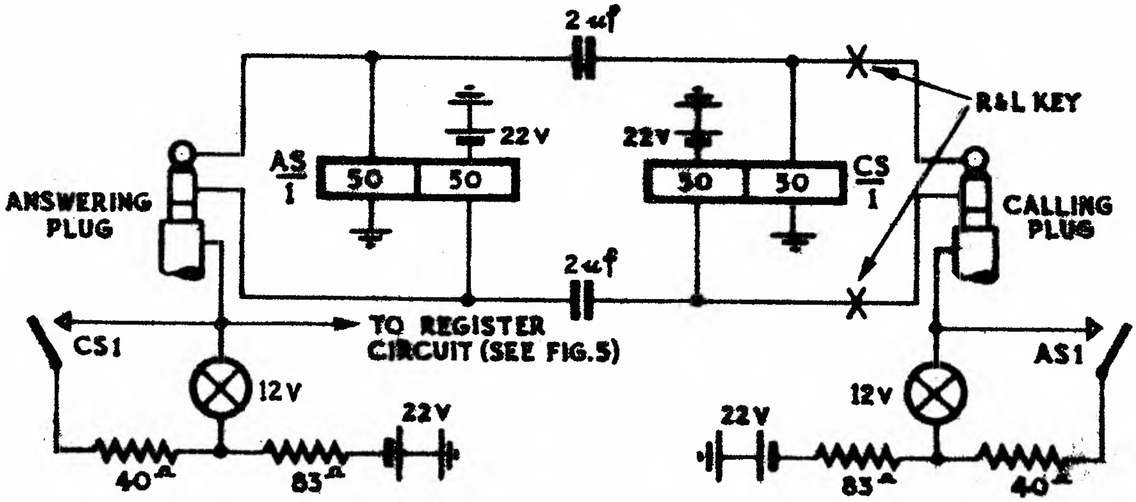
FIG. 12.

The condenser in the secondary circuit performs the same functions as those described in paragraph 3.7 above.

/4.

4. CORD CIRCUIT (STONE TRANSMISSION).

4.1 Fig. 13 shows a cord circuit using the Stone or Bridged impedance type of transmitter battery feed.



C.B. "A" POSITION CORD CIRCUIT (USING STONE SYSTEM OF TRANSMISSION).

FIG. 13.

It will be noted that the circuit is somewhat simpler than that of Fig. 4, because the retards perform the dual functions of transmitter battery feed and supervisory relays. The operation of the circuit is similar to that described in Section 3 above.

5. JUNCTION SYSTEMS.

5.1 Several exchanges, each serving a comparatively small section, is a less costly arrangement than providing one large exchange for the whole of the area. Many points must be considered when the provision of an exchange or exchanges is being decided.

The cost of the line plant, however, is the chief factor. By providing several exchanges in an area, the exchange lines will become much shorter, therefore the size of the aerial or underground cable wires for the subscriber's circuits may be reduced and still be within the permissible resistance and transmission limits. A saving is thus effected by the use of smaller cables, fewer ducts, etc.

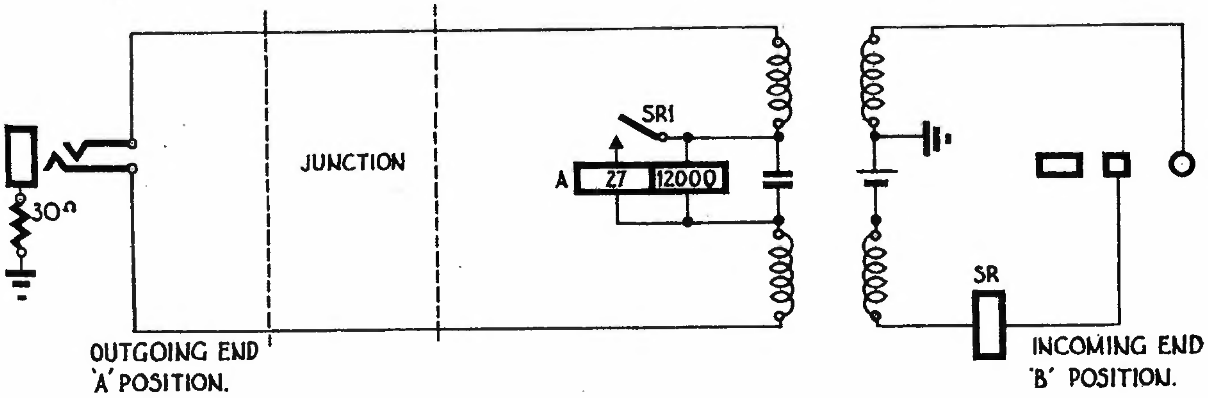
Against this it will be realised that one exchange serving a large area would be less costly to operate, supervise and maintain than several exchanges containing the same total number of lines. Other considerations, such as the cost of large buildings, risk of disarranging the whole service when a fire occurs, etc., have also to be taken into account, as well as the anticipated development.

Typical junction circuits will be described in the next Sections.

/6.

6. C.B. TO C.B. JUNCTION.

6.1 These junctions are necessary to allow subscribers on one C.B. exchange to be connected to subscribers on another C.B. exchange. Junctions between two such exchanges may be in sufficient numbers to warrant order wire working when a group of one-way junctions is provided in each direction. At the outgoing end the junctions on "A" positions are jack ended, and at the incoming end the junctions are plug ended on the "B" positions. Ringing is automatically started when the "B" telephonist plugs into the wanted subscriber's multiple jack, but only if the junction is plugged up at the outgoing end. The elements of the junction circuit are given in Fig. 14.



ELEMENTS OF JUNCTION CIRCUIT.

FIG. 14.

The outgoing jack has a 30 ohm sleeve resistance in place of the relay on the subscriber's multiple jack. This completes the circuit of the supervisory relay in the cord circuit and provides the engaged test potential.

At the incoming end, a repeating coil is connected in the line circuit, forming a dividing line between the signalling circuits of the A and B telephonists' positions respectively. A condenser is inserted between the inner ends of the incoming side of the transformer. This condenser allows speech currents to pass clear of relay A and allows the two sides of the junction to be used separately, as required, for signalling purposes.

/6.2

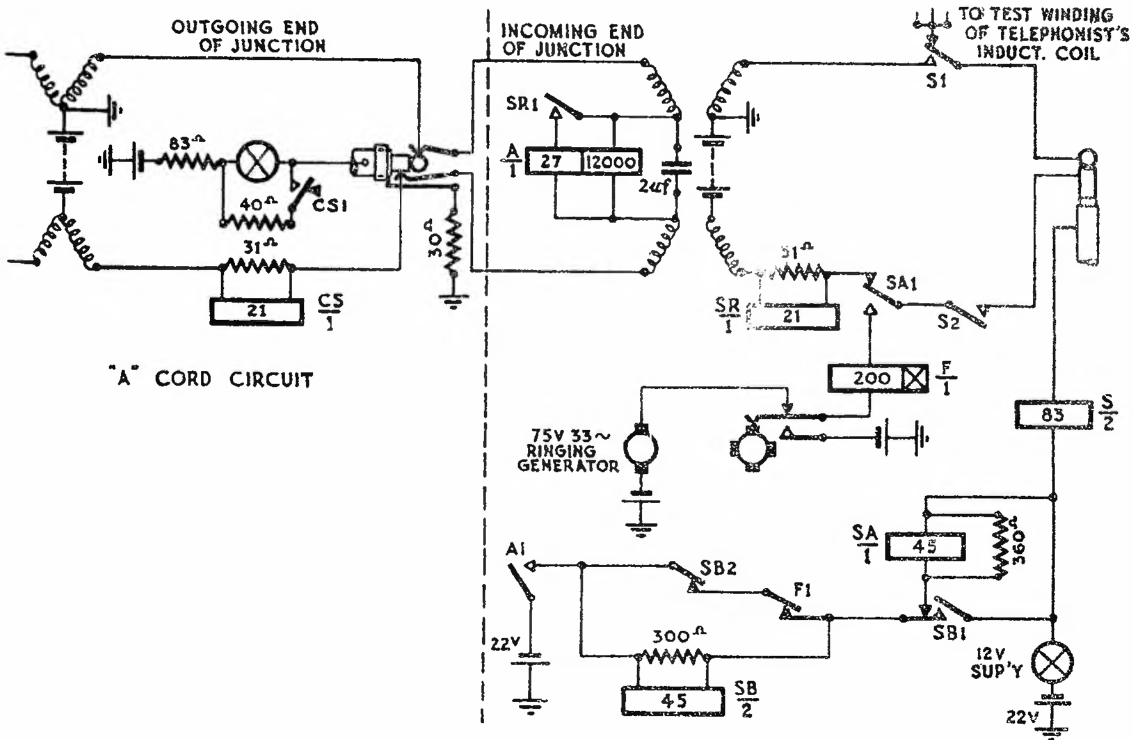
6.2 Circuit Operation. Fig. 15 shows details of the circuit. When the B telephonist allots a junction over the order wire, the A telephonist at the distant exchange plugs into the appropriate outgoing junction jack. Current flows from earth at the "A" cord circuit via the repeating coil and junction to the repeating coil and 12,000 ohm winding of relay A, repeating coil, the other side of the junction, the supervisory relay, the repeating coil to negative.

Relay A (12,000 ohms) operates and closes contact A1. Meanwhile, if the wanted line is disengaged, the B telephonist has inserted the plug in the called subscriber's line, and the sleeve circuit is completed through the 30 ohm CO relay of the called subscriber's line. The 12 volt supervisory lamp does not display as, owing to contact A1 being closed, it is shunted by SA relay (45 ohm and 360 ohm non-inductive shunt, the joint resistance being 40 ohms). Relay S operates and at contacts S1 and S2 closes the line circuit. Relay SA also operates and contacts SA1 connects the ringing machine cam to supply ringing current and 22 volt negative alternately to the ring side of the line via the slow acting 200 ohm F relay. Relay F is made slow acting so that it will not be operated by the 17 c/s ringing current passing through it. The ringing current passes through the called subscriber's bell and returns via the tip of the cord circuit to earth.

The current which operates the 12,000 ohm A relay also passes through the calling supervisory relay CS in the A telephonist's cord circuit, but is insufficient to attract the armature of that relay and operate it. Therefore, the A telephonist's supervisory lamp displays.

The telephonist's circuit on the "B" positions is usually similar to that shown in Fig. 4 of Telephony I, Paper No. 11, but, instead of the 500/500 ohms impedance, there is an induction coil 37/250 ohm, the higher resistance winding being across the receiver, and the 37 ohm winding being connected to the earth and the back contact of S1 in Fig.15. If the wanted subscriber had been engaged then there would be negative potential on the sleeve of the jack which would cause a flow of current through the 37 ohm winding to be induced in the 250 ohm circuit to give the engaged click.

/Fig. 15



C.B.-C.B. JUNCTION CIRCUIT. (KEYLESS RINGING.)

FIG. 15.

The position now is that the supervisory lamp in the A telephonist's cord circuit is glowing. The supervisory lamp in the B telephonist's cord circuit is not glowing and relays A, S and SA are operated. It will be seen that if the junction is not taken at the distant end, the contacts of relay A will be open and, in consequence, the circuit for SA relay will not be completed. The object of this arrangement is to ensure that the called subscriber is not rung until connection is made to the junction by the A telephonist.

The removal of the called subscriber's receiver from the switch hook enables direct current to flow through the F relay via the called subscriber's loop, so operating relay F. Relay SB, which was short-circuited by the contacts F1 of the ring trip relay F, will now operate as it is momentarily placed in series with the winding of relay SA. The closing of the make-before-break contacts SB1 of the SB relay disconnects SA relay but simultaneously connects SB across the supervisory lamp, thus maintaining the 40 ohm

/shunt

shunt across that lamp. Contacts SB2 break the circuit so that the release of relay F will not result in SB being short-circuited.

The SA relay releases and disconnects the ringing current at SA1 and, at the same time, extends the ring side of the junction cord circuit to the rest of the circuit and so allows the 31 ohm + 21 ohm SR supervisory relay to operate. SR1 closes the circuit of the 27 ohm winding of the 12,000 + 27 ohm relay, thus allowing sufficient current to flow over the junction to operate relay CS in the A position cord circuit.

The SB relay which replaces the SA relay as a shunt to the supervisory lamp remains operated until the telephonist at the distant end disconnects and causes the contacts A1 of the 12,000 ohm A relay to open. The removal of the lamp shunt gives the clearing signal to the B telephonist.

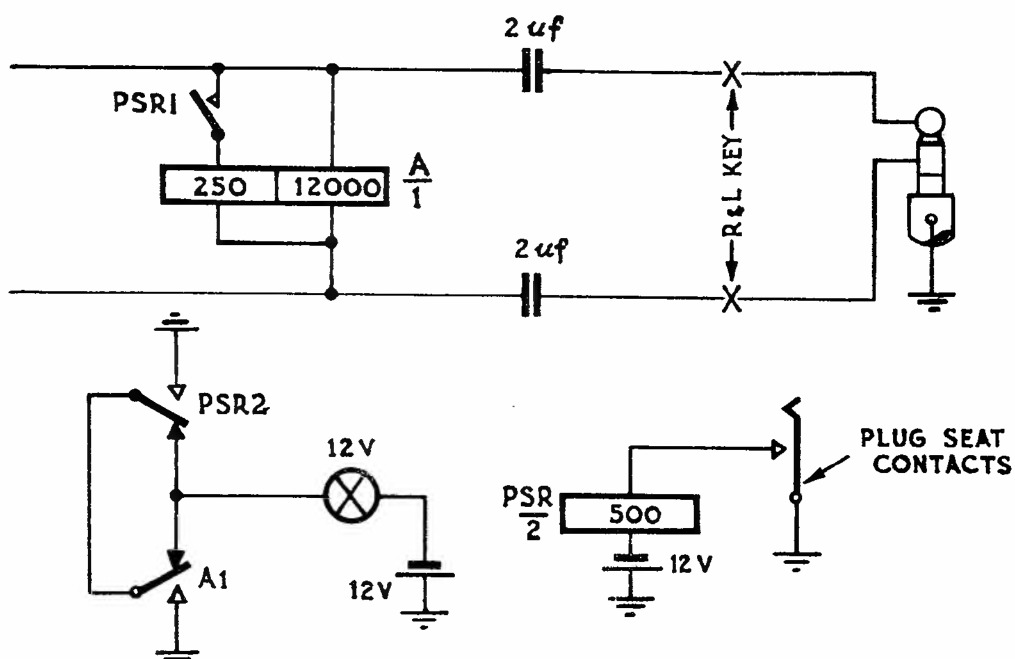
The called subscriber, upon restoring his receiver to the switch hook, breaks the circuit of relay SR which removes the 27 ohm shunt from the 12,000 ohm winding of relay A, thereby increasing the resistance in the circuit containing relay CS. Relay CS releases and the A telephonist's supervisory lamp glows.

The A telephonist takes down the connection and relay A releases, thus breaking the circuit of relay SB which was in shunt with the supervisory lamp. The supervisory lamp displays and gives the clearing signal to the B telephonist. The B telephonist withdraws the junction plug, and the circuit is restored to normal by the releasing of relay S. The 360 ohm non-inductive shunts to relay SA and SB are provided to reduce the inductance in the local circuit containing this relay and so prevents sparking at the A1 contacts when that relay releases.

7. C.B. TO MAGNETO JUNCTION.

7.1 The connections at the outgoing or C.B. end of the C.B. Magneto junction circuit are similar to those described for the C.B. to C.B. junction circuit (see left-hand side of Fig. 15). At the incoming end a number of different arrangements are in use chiefly because these Magneto manual exchanges have been established for many years, and it has been necessary to adopt in each case a junction circuit which, while fulfilling service requirements, is at the same time readily installed in conjunction with existing equipment.

At the incoming end the two line wires pass through two 2 μF condensers, as shown in Fig. 16, and thence via the ringing and listening key to the tip and ring conductors of the plug. The sleeve of the plug is earthed in order to provide an engaged test.



C.B.-MAGNETO JUNCTION CIRCUIT (PLUG ENDED). INCOMING END.

FIG. 16.

Across the junction side of the line the 12,000 ohm winding of relay A is connected. This relay operates on the insertion of a plug at the C.B. end, and contact A1 closes the circuit of the lamp associated with the junction cord. The B telephonist at the magneto exchange now raises the junction plug and inserts it in the line of the called subscriber. As soon as the plug is lifted, the plug seat switch operates, thus closing the circuit of relay PSR.

When PSR operates, a 250 ohm winding of relay A is connected across the junction circuit by means of contact PSR1. This reduces the loop resistance and so operates the supervisory relay in the cord circuit at the C.B. exchange, thus shunting the supervisory lamp at that exchange. It might be observed that the A relay used in this case has windings of 12,000 ohms and 250 ohms respectively, instead of windings of 12,000 ohms and 27 ohms respectively, as in the case of the C.B. to C.B. junction. The reason for the 250 ohm winding in this case is that this winding is bridged across the speaking wires, and it is necessary that this winding should present a high impedance to the speech currents. In the case of the C.B. to C.B. junction circuit, the 27 ohm winding is simply connected across a condenser connected between the inner terminals of a transformer, and it is therefore not necessary that this winding should present a high impedance to speech currents. Any current passing through the 27 ohm winding also passes through the transformer.

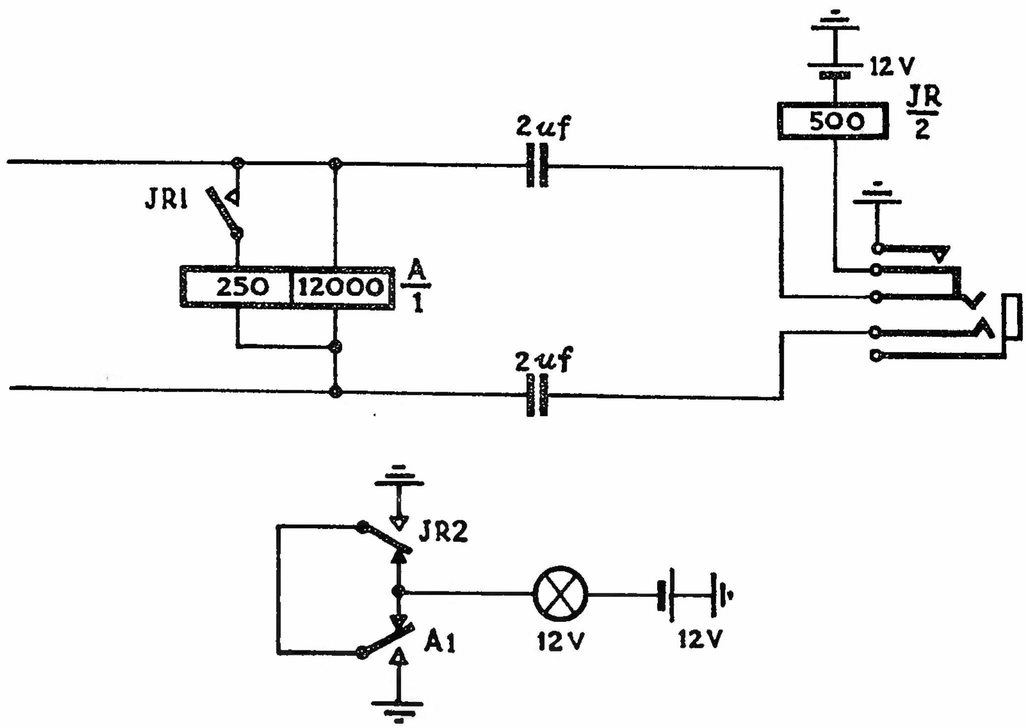
On the operation of PSR relay, contact PSR2 is also operated, and the junction lamp circuit is opened at the back contact of this springset.

When the calling subscriber at the C.B. exchange replaces the handset, the A telephonist supervises the connection and then disconnects the cords. When the calling plug is withdrawn from the outgoing junction jack, A relay (12,000 + 250 ohms) at the magneto exchange releases so closing the junction lamp circuit as follows - from earth via the front contact of PSR2, back contact of A1, junction lamp to negative battery. This lamp, therefore, displays and indicates to the B telephonist at the magneto exchange that the connection should be disconnected.

/When

When the call is disconnected and the junction plug restored to the plug seat, the plug seat switch operates and the circuit of relay PSR is opened. PSR releases and the junction line lamp circuit is now opened at the front contact of PSR2.

The circuit described above is of the plug ended type, and is used in conjunction with order wire working. In some cases, the traffic to a magneto exchange is not sufficient to justify the installation of a B position and the introduction of order wire working. In such cases a jack ended junction, arranged as shown in Fig. 17, is adopted. It will be seen that the circuit is similar to that described, except that, instead of a plug seat switch, an additional contact on the junction jack is provided for closing the circuit of PSR relay, termed JR in this case.

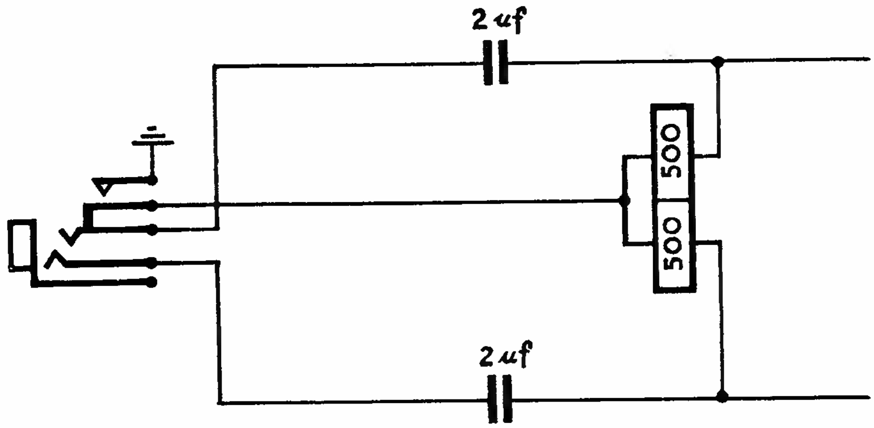


C.B.-MAGNETO JUNCTION CIRCUIT (JACK ENDED). INCOMING END.

FIG. 17.

8. MAGNETO TO C.B. JUNCTION.

8.1 The connections of the outgoing junction line at the magneto end are shown in Fig. 18.



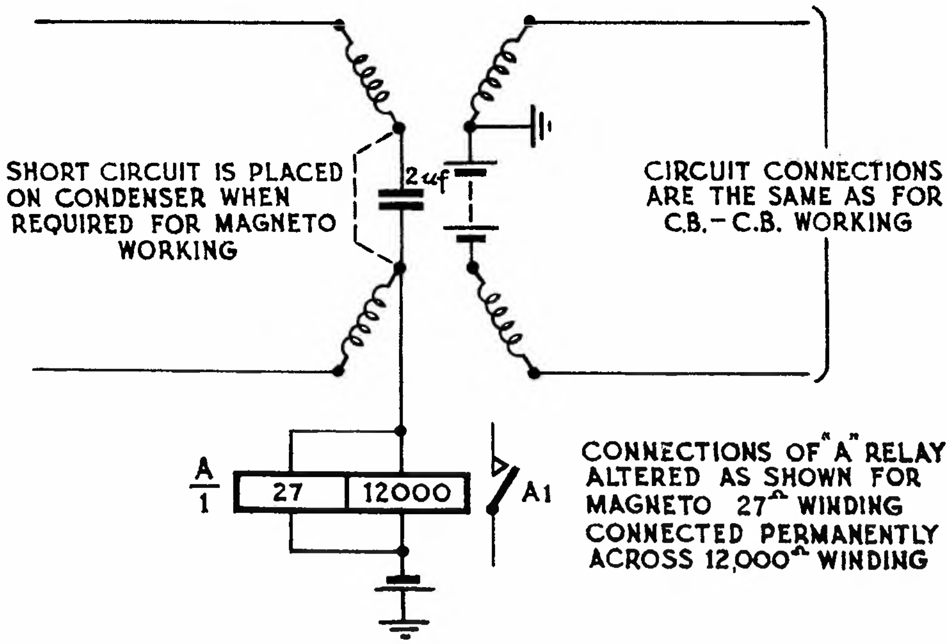
MAGNETO-C.B. JUNCTION CIRCUIT. OUTGOING END AT MAGNETO EXCHANGE.

FIG. 18.

The insertion of the plug of standard magneto cord circuit in the outgoing junction jack places an earth on the centre point of a 500 ohms + 500 ohms retard by means of the auxiliary springs on the outgoing junction jack. A 2 μF condenser is placed in series with each of the line wires, so that the clearing indicator in the magneto cord circuit is isolated from the battery on the junction circuit at the C.B. end. Where this is not done, the clearing indicator frequently receives a brief current impulse while the plug is being inserted in the jack, and this is sufficient to drop the indicator.

/8.2

8.2 The connections of the incoming side of this junction circuit are similar to those described in the case of the C.B. to C.B. keyless ringing junction. An alteration, however, is made on the line side of the transformer in that the 12,000 ohm relay, instead of being connected across a 2µF condenser in the split of the transformer, is connected from the centre point of this transformer to negative battery. The 27 ohm winding of this relay is connected in parallel with the 12,000 ohm winding. It will be apparent, therefore, that when an earth is placed on the centre point of the 500 ohms + 500 ohms retard at the magneto exchange, a circuit is closed for this 12,000 + 27 ohm relay. The modifications necessary to the standard C.B. to C.B. junction circuit are indicated in Fig. 19. The parts of the circuit similar to those used in the C.B. case are omitted.

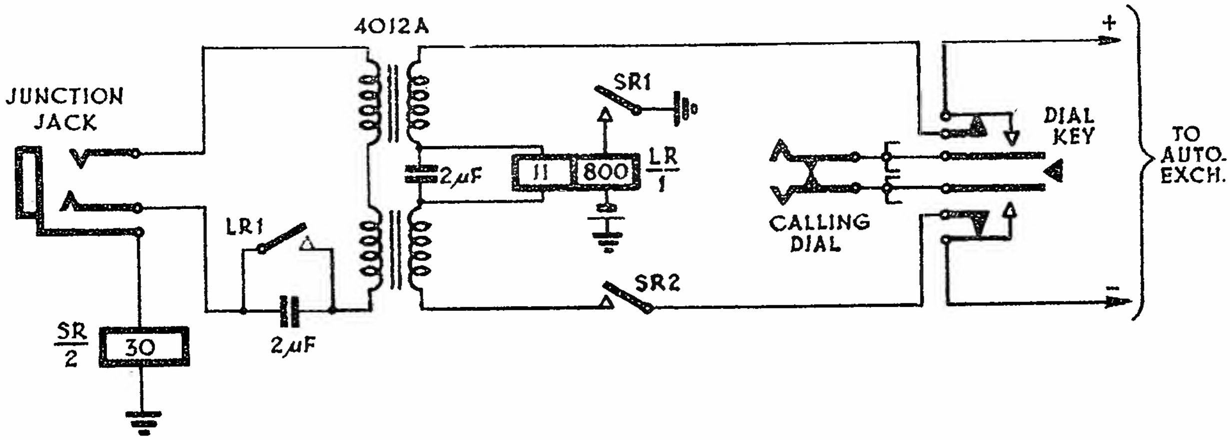


MAGNETO-C.B. JUNCTION CIRCUIT. SKETCH SHOWING MODIFICATIONS AT C.B. END FOR WORKING FROM MAGNETO.

FIG. 19.

9. C.B. TO AUTOMATIC JUNCTION.

9.1 A typical C.B. to automatic junction circuit for small C.B. exchanges is shown in Fig. 20. A junction jack and dialling key is provided at the C.B. position for each junction, and the dial is common to the junctions.



C.B.-AUTOMATIC JUNCTION.

FIG. 20.

On receipt of a call for an automatic exchange, the telephonist plugs the calling cord into a junction jack, operates the dial key and dials the required number.

Relay SR operates when the operator plugs into the junction jack and SR1 completes the circuit of the 800 ohm winding of LR. SR2 completes the loop circuit to the automatic exchange. LR does not operate until the called automatic subscriber answers, when the direction of battery current through the 11 ohm winding is reversed. When LR operates LR1 short-circuits the condenser, and this provides a loop for the calling supervisory lamp in the cord circuit, and the calling supervisory lamp is dimmed to indicate to the telephonist that the called number has answered.

9.2 Keyboard Senders. When more than twenty junctions are involved, the above method becomes unwieldy and expensive because -

/(i)

(i) The time to operate a dial is too long for a busy telephonist.

(ii) The associated apparatus cannot be accommodated on the face of the A positions.

(iii) The maintenance of a large number of dials is expensive due to the increased fault liability with increased use.

One method of overcoming these difficulties is with "Keyboard Senders." A keyboard sender consists of a desk and associated apparatus. On these desks the required automatic number is "set up" by depressing push keys with which are associated a machine which will send out dialling impulses to the automatic equipment in accordance with the number set up.

TO AUTO. EXCH.

The method of operation is as follows -

(i) The A telephonist presses an order-wire key and passes the required automatic number to the B operator at the keyboard sender desk.

(ii) The B telephonist allots a junction to the A telephonist and "sets up" the required number on digit keys of the sender desk, and then presses the junction key which connects the automatic sender to the allotted junction.

(iii) The A telephonist in the interim plugs the calling cord of a pair into the allotted junction jack. These jacks are in the junction multiple on each board.

10. TEST QUESTIONS.

1. Explain the functions of the M.D.F. installed in a typical C.B. exchange.

2. Draw a cabling diagram of the subscriber's line circuit in a C.B. exchange, and indicate thereon the sizes of the cables used.

3. Describe the engaged test on a B position in a C.B. Manual exchange.

4. Describe from the circuit the operation of a C.B.-C.B. junction circuit keyless ringing.

5. Sketch and describe a typical C.B.-Magneto junction circuit.

6. Sketch and describe the outgoing junction circuit of a magneto exchange for working to a C.B. exchange.

7. Explain the functions of an I.D.F. in a C.B. exchange.

8. Name eight of the different types of apparatus from the picture on page 2.

END OF PAPER.

COMMONWEALTH OF AUSTRALIA.

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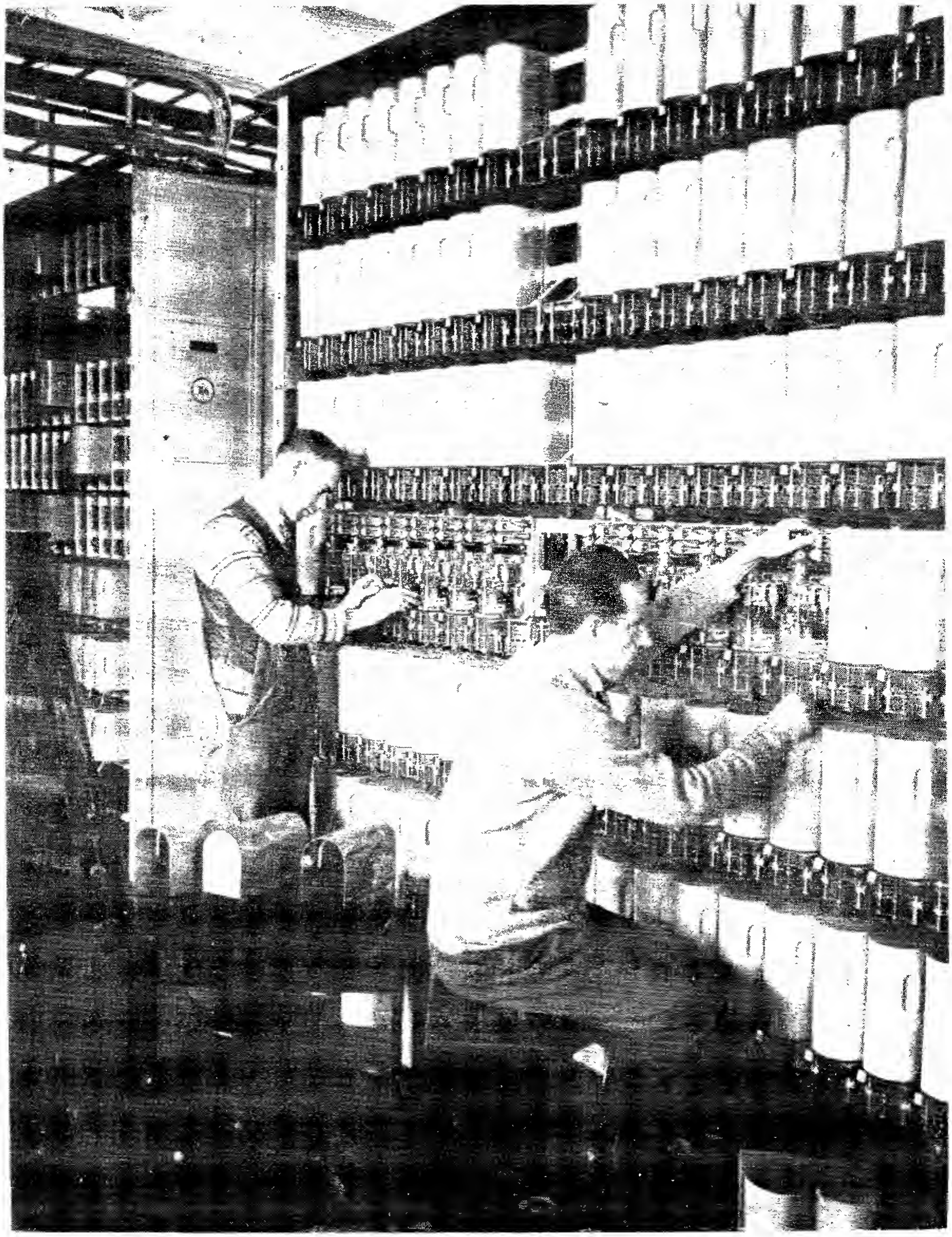
COURSE OF TECHNICAL INSTRUCTION.

AUTOMATIC PRINCIPLES AND TELEPHONES.

CONTENTS.

1. INTRODUCTION.

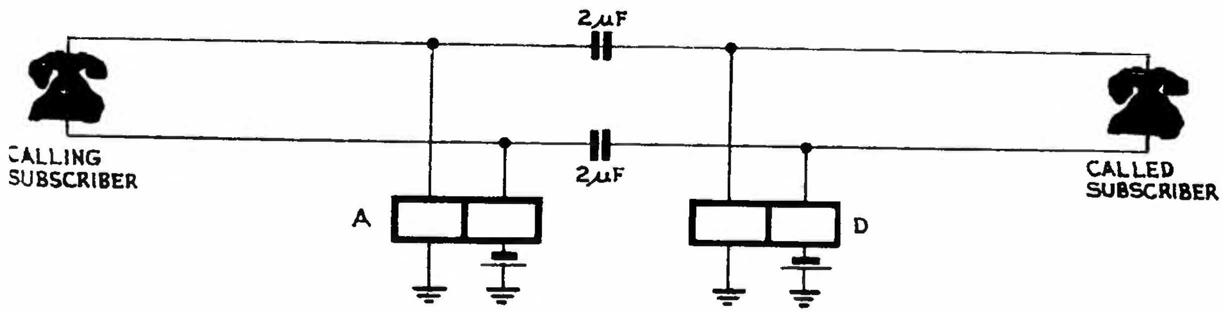
1.1 Automatic Telephony is a common battery system in which calls are directed to called subscribers by mechanisms in the calling subscribers' telephones and at the exchanges. As in the C.B. manual system, a "common" battery at the exchange is used to supply transmitter current to subscribers' telephones. The battery also supplies power to operate the exchange equipment used to route calls to the called subscribers' lines and telephones.



TECHNICIANS MAKING FINAL ADJUSTMENTS TO SELECTORS IN AN AUTOMATIC EXCHANGE PRIOR TO THE "CUT-OVER".

2. TRANSMITTER BATTERY FEED.

2.1 The transmitter battery feed used in most automatic systems is the Stone or Bridged Impedance type. Fig. 1 is a through speaking circuit. The battery feed retards are the windings of relays designated A and D in the items of exchange equipment of which these relays form a part. These relays perform the dual functions of relays and retards.



TRANSMITTER BATTERY FEED FOR AUTOMATIC SYSTEM.

FIG. 1.

3. STROWGER AUTOMATIC SYSTEM.

3.1 The Strowger System of automatic telephony is used almost exclusively in the A.P.O. The system is named for its inventor whose first patent is dated 10th March, 1891. Although many modifications and refinements have been introduced, the present Strowger System does not differ in principle from the original system.

3.2 The system is a decimal system with a 100 line exchange as the basic unit. For the purposes of this Paper, only the general principles of the basic 100 line unit will be discussed. Perhaps the easiest approach to this basic 100 line unit is via a 100 line manual switchboard. Fig. 2 shows the jack field of such a switchboard, together with No. 1 cord circuit whose position in the cord shelf is slightly to the left of the jack field.

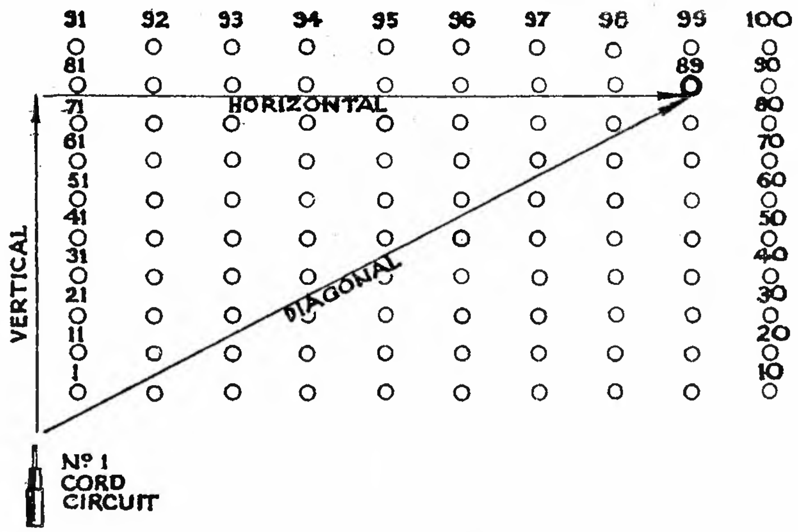
Assume, now, that the operator answers a calling subscriber, with the answering plug of No. 1 cord circuit, and that the subscriber requires subscriber Number 89. The operator plugs the calling plug of No. 1 cord circuit into jack 89 and rings. The movement of No. 1 calling plug from its position in the

/ plug

plug shelf to jack 89 is a diagonal movement, as shown in Fig. 2. This diagonal movement can be resolved into two movements -

(i) A vertical movement, which selects the particular tens row of jacks required, and

(ii) A horizontal movement, which selects the unit required in that row.



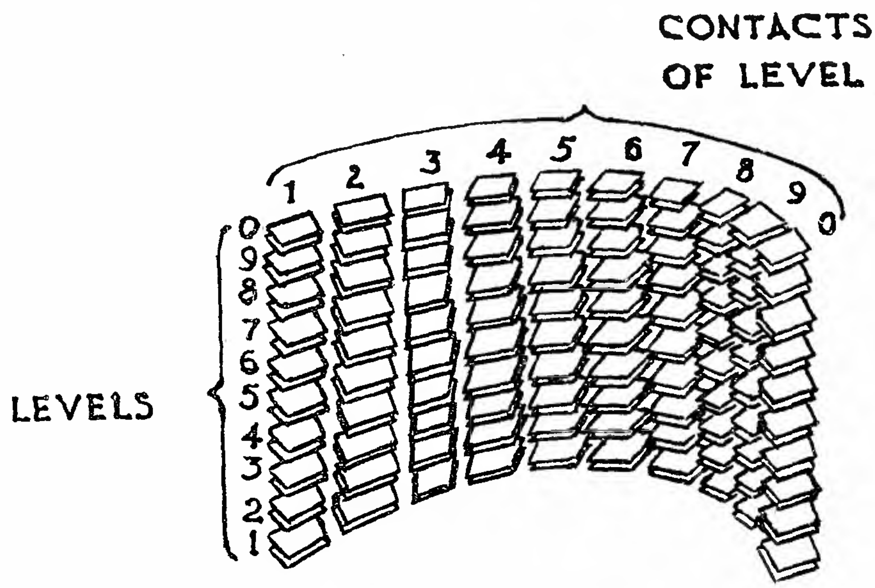
SELECTING ONE JACK FROM 100 JACKS.

FIG. 2.

3.3 This selection principle is used in an automatic selecting mechanism termed a "Selector", so called because it "selects". The jack field of Fig. 2 consists of 100 jacks, each jack containing two springs to which the two sides of a subscriber's line are connected. These 100 jacks are arranged in 10 rows, each row containing 10 jacks. What could be regarded as the "Contact Field" of a 100 line selector is similarly arranged. The contact field is termed a contact "bank" and consists of 100 sets of contacts, each set containing two contacts to which the two sides of a subscriber's line are connected.

/ These

These 100 sets of contacts are arranged in 10 rows, each row containing 10 sets of contacts. This contact bank is arranged in the arc of a circle as shown in Fig. 3. Fig. 3 merely illustrates the principle of a selector contact bank, such features as insulation, the method of holding the bank together and so on being unnecessary at present. (The picture on page 6 provides more information about the contact bank.)



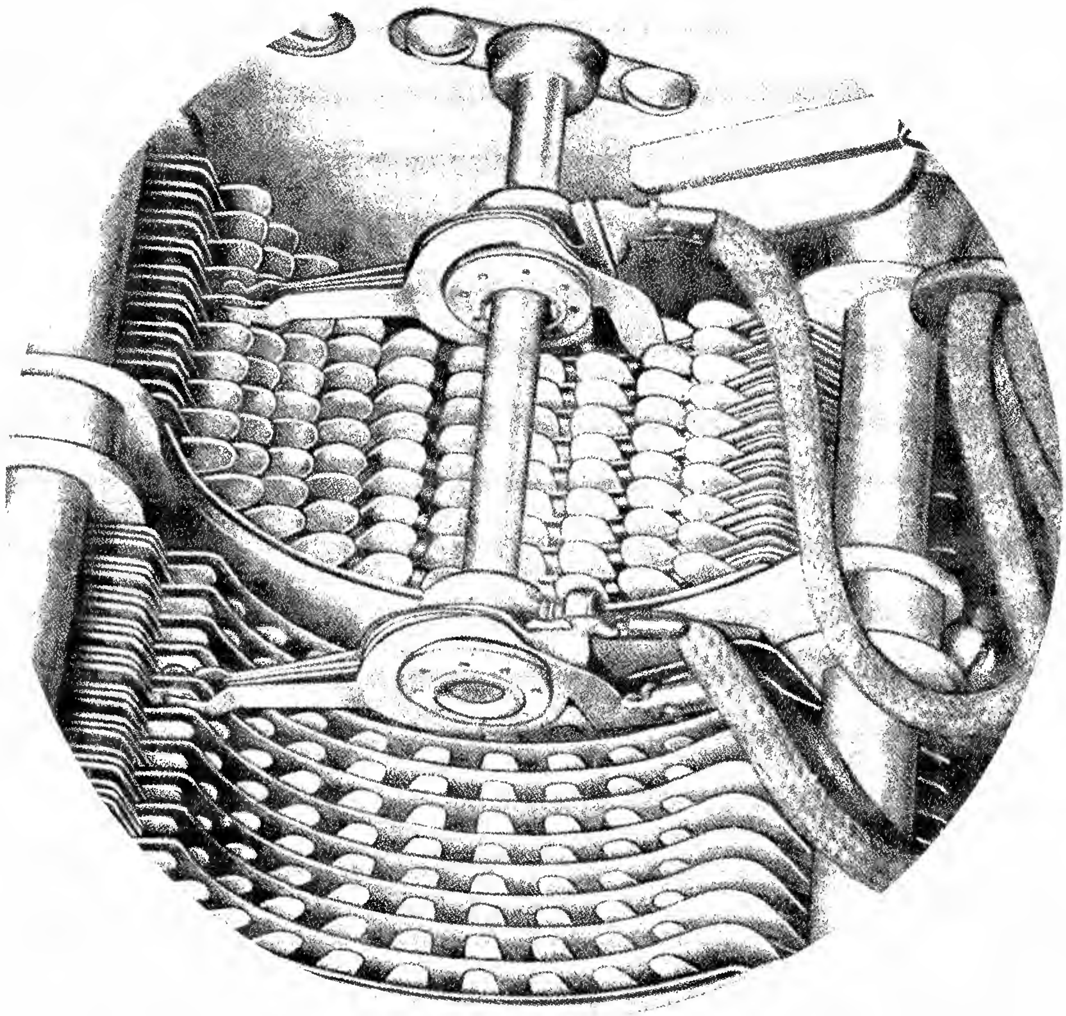
SELECTOR CONTACT BANK.

FIG. 3.

3.4 The equivalent of the calling plug in Fig. 2 is provided by a pair of insulated contact brushes called "wipers" which are attached to a spindle, generally called a shaft. The normal position of these wipers is to the left and below the lowest row of contacts. This shaft is capable of a vertical and a rotary movement. The vertical movement carries the wipers up the side of the bank in just the same way as the vertical component of Fig. 2 carries the calling plug up the side of the jack field. The rotary movement carries the wipers over the sets of bank contacts in the row reached by the vertical movement in just the same way as the horizontal component of Fig. 2 carries the calling plug across the row of jacks reached by that vertical movement. The rows of contacts in the bank are termed "levels" and, hereafter, will be referred to as such.

's

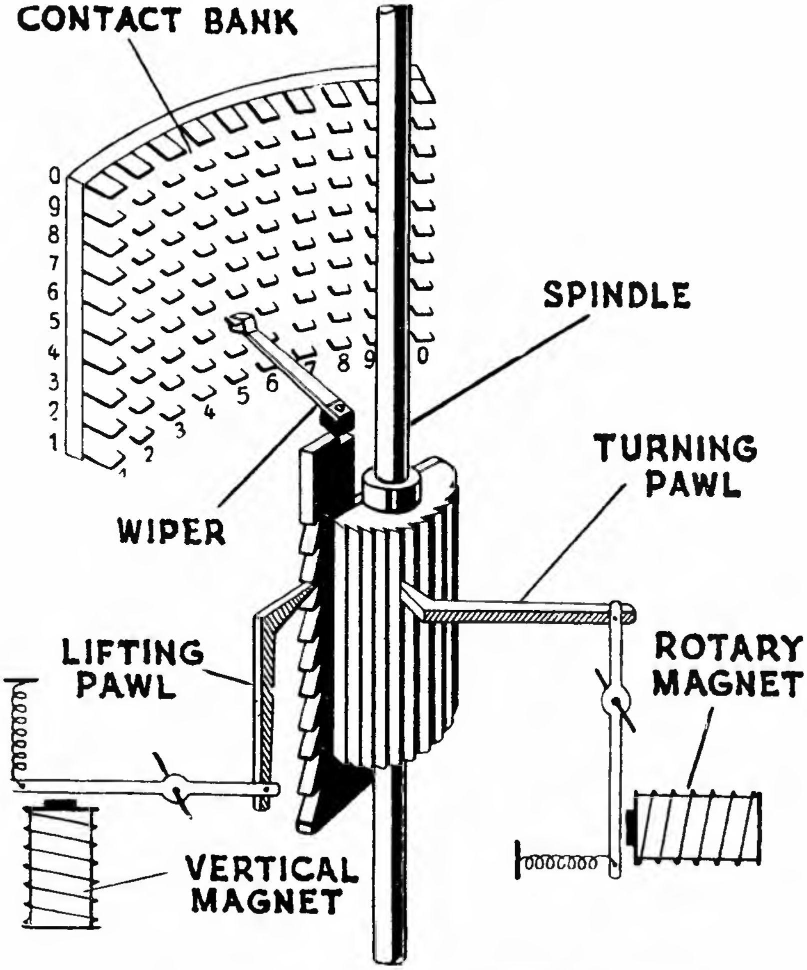
/ Close-up



CLOSE-UP OF CONTACT BANK.

Note the Shaft and Wipers. To what Subscriber's Number are the Wipers Connected?

3.5 The shaft and wipers are moved vertically by the armature of an electromagnet called the "vertical magnet". When the armature of this vertical magnet is attracted on current flowing through the winding of the magnet, a pawl carried by the armature engages the underside of teeth attached to the spindle or shaft, as shown in Fig. 4. The design and adjustment of the mechanism is such that each attraction of the armature lifts the shaft and wipers a distance equal to that between two levels.



METHOD OF MOVING SHAFT AND WIPERS.

FIG. 4.

3.6 Thus, in order to raise the wipers to the third level, the circuit to the vertical magnet must be closed and opened three times. The first closure of the circuit attracts the armature, the pawl engages the underside of the appropriate vertical tooth and the shaft moves to lift the wipers from their normal position to a position opposite the first level. When the

/ circuit

circuit to the vertical magnet is opened after this operation, the armature resumes its normal position under spring tension. On the circuit to the vertical magnet being closed again, the armature is attracted once more and the shaft is moved to lift the wipers from the first to the second level. Thus, the operation of selecting the particular level or row of bank contacts required depends on the circuit to the vertical magnet being closed and opened a number of times corresponding to the level required. (The wipers are normally attached to the bottom of the spindle or shaft and not as shown in Fig. 4.)

3.7 The operation of selecting the particular set of contacts in the level reached by the vertical movement is carried out by closing and opening the circuit to another magnet called the "rotary magnet". Each operation of the rotary magnet attracts the armature of that magnet and causes a pawl carried by that armature to engage in one of a number of teeth cut longitudinally around a hub on the shaft, as shown in Fig. 4. This action rotates the shaft and wipers step by step to the set of bank contacts corresponding with the number of times the circuit to the rotary magnet is closed.

3.8 For the purposes of this book, it is necessary to have some knowledge of the principles only of the operation of automatic selectors, as described above, so that the operation of automatic telephones can be followed. In so far as the automatic telephone is concerned, the above discussion shows that Strowger automatic selectors are operated by closing and opening the circuit to a vertical or a rotary magnet a number of times corresponding with the number of vertical or rotary steps the wipers are to make. As these steps must be made under the control of the calling subscriber, a device is necessary at automatic telephones which will permit the subscriber to step the selector.

4. HOW SUBSCRIBERS SIGNAL.

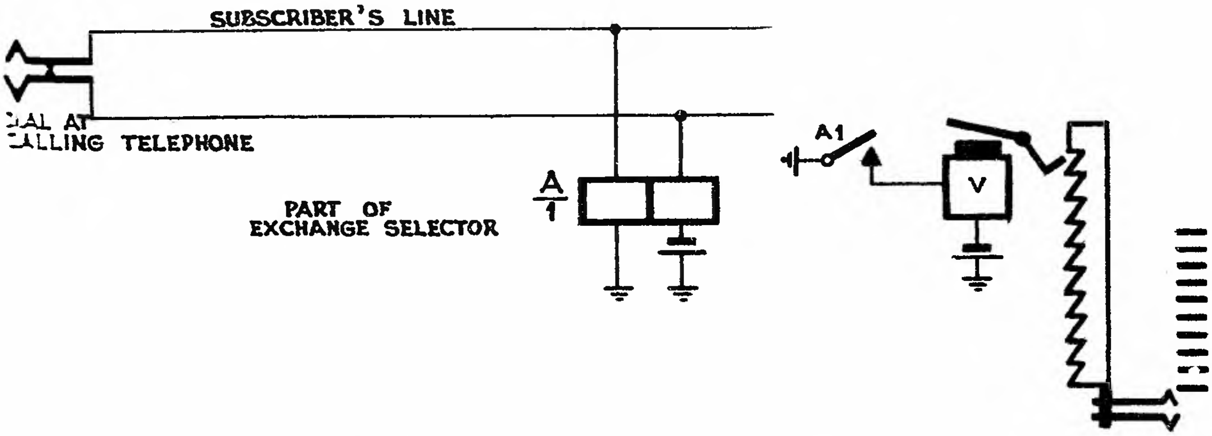
4.1 For reasons of economy, it is desirable that the two wires used for the transmission of speech should be used to carry the signals originated at a calling telephone for operating the vertical and rotary magnets of selectors. This can be done conveniently by employing the battery feed retard for the calling line as a relay which repeats interruptions to its own circuit on to the magnets in the selector. This necessitates a device at each telephone by means of which calling subscribers can interrupt the circuit to their battery feed retard a number of times corresponding with the number of vertical steps the shaft and wipers are required to make. This device is the Dial in an automatic telephone. In the case of Fig. 1, the dial at the calling subscriber's telephone would interrupt the circuit to relay A under the control of the calling subscriber.

/ 5.

5. BASIC IMPULSING CIRCUIT.

5.1 When interrupting the circuit to the A relay of Fig. 1, or the A relay of any automatic selector, the dial contacts open for a certain definite length of time and close for another definite length of time. When installing and maintaining automatic telephones, it is necessary to test subscribers' dials. In order to appreciate the reason for this, the basic circuit for stepping a selector is developed from first principles.

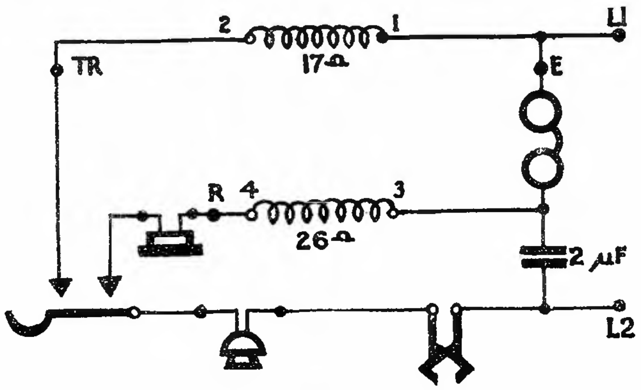
5.2 Fig. 5 shows an elementary circuit for stepping the vertical electromagnet (usually marked V on circuits) of a selector from a calling telephone.



ELEMENTARY CIRCUIT FOR VERTICAL STEPPING OF SELECTOR.

FIG. 5.

The telephone used is a C.B. telephone of the type described in Paper No. 2 of this book in so far as speech transmission is concerned. The only addition required for present purposes is the dial, the contacts of which are connected as shown in Fig. 6.

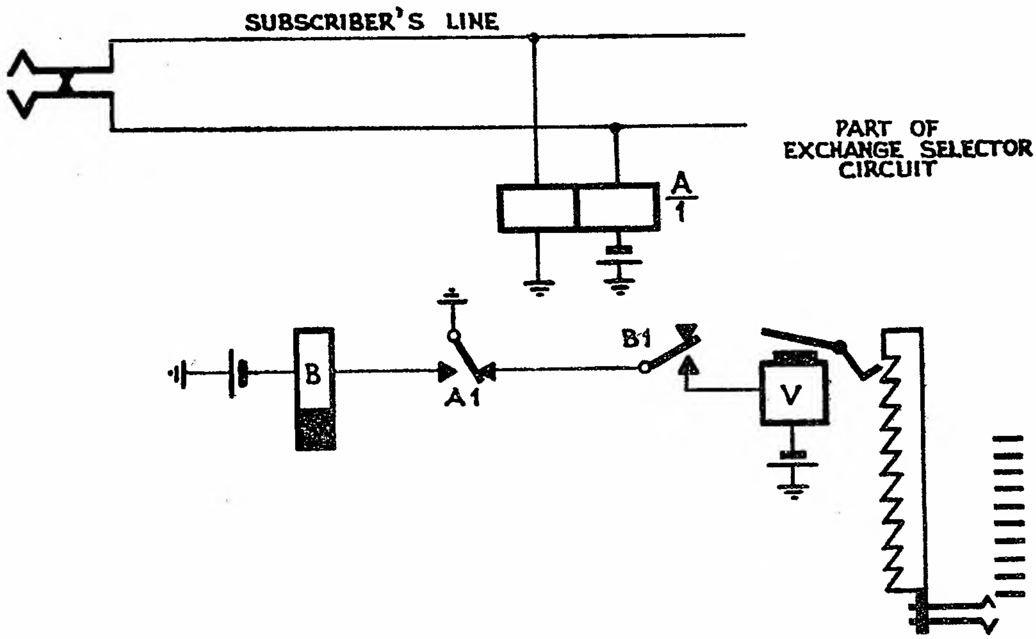


BASIC C.B. TELEPHONE WITH DIAL.

FIG. 6.

In Fig. 5, the lifting of the receiver at the calling subscriber's telephone would operate relay A. Operated contacts A1 (see Fig. 5) would complete a circuit to the vertical magnet V, the armature of which would be attracted to lift the shaft and wipers to the first level. The elementary circuit of Fig. 5, therefore, is unsatisfactory because the action of lifting the receiver preparatory to making a call produces the same effect as one operation of the vertical magnet.

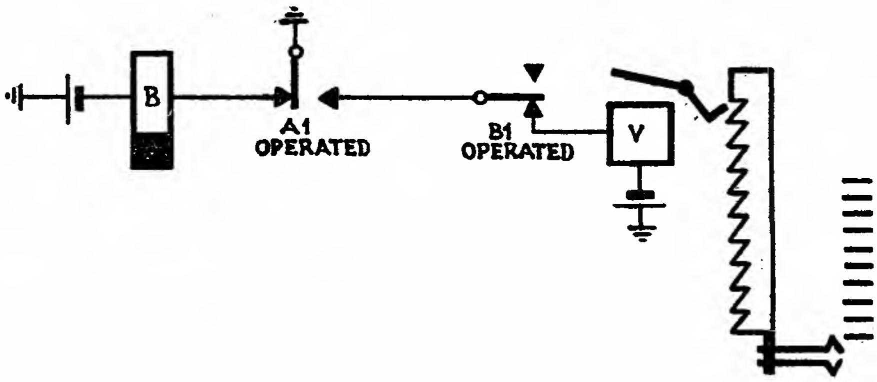
5.3 This difficulty is overcome by including a slow releasing relay and its associated contacts in the exchange selector circuit, as in Fig. 7, and arranging for the vertical magnet to operate each time the dial contacts open under the control of the calling subscriber to release relay A.



VERTICAL STEPPING OF SELECTOR.

FIG. 7.

The action of lifting the receiver at the calling telephone preparatory to making a call operates relay A. Operated contacts A1 (see Fig. 8) complete a circuit to operate the slow releasing relay B. The operated contacts B1 merely prepare a circuit for the vertical magnet, the circuit to which is open at operated contacts A1.

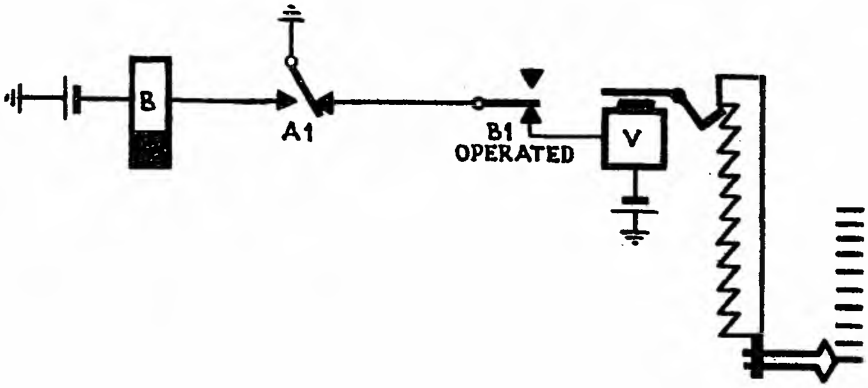


CONDITION OF FIG. 7 WHEN CALLER REMOVES RECEIVER.

Relay A and Relay B operated.

FIG. 8.

5.4 When the dial contacts open to step the wipers from normal to the first level, relay A releases and opens the circuit to relay B. Because of the slow releasing characteristics of relay B, that relay remains operated and a circuit is completed to operate V via A1 normal and B1 operated, as shown in Fig. 9. The armature of V is attracted and lifts the shaft and wipers from the normal to the first level.



CONDITION OF FIG. 7 WHEN DIAL CONTACTS OPEN.

Relay A releases, Relay B holds operated, vertical magnet operates, and shaft and wipers lifted to first level.

FIG. 9.

When the dial contacts close again, relay A reoperates. The circuit to relay B, therefore, is closed again whilst that to the vertical magnet V is opened at operated contacts A1. V, therefore, will release in preparation for any following step. Thus, in Fig. 7, each time the dial contacts open, the vertical magnet of the exchange selector is energised to lift the wipers from one level to the next.

/ 6.

6. IMPULSES.

6.1 The dial contacts must open for a definite time and close for a definite time when interrupting the A relay of exchange selectors. The reasons for this are -

(i) If the dial contacts are open for too long a time, relay A will be released for a time long enough to release relay B. The release of B will interfere with other parts of the circuit not shown in Fig. 7, and connected to the break contact of relay B.

(ii) If the dial contacts are open for too short a time, the vertical magnet will not receive current for a time long enough for the magnetic circuit of that magnet to saturate and lift the shaft and wipers.

(iii) The dial contacts must close for a time long enough to saturate relay B so that relay B will hold satisfactorily over the next period of time during which the dial contacts are open.

6.2 Considerations such as these necessitate definite periods of time for the dial contacts to open or close. The time during which the dial contacts are open has been fixed at 66-2/3 milliseconds, whilst the time during which they are closed has been fixed at 33-1/3 milliseconds. The former time is called the "break period" of the dial contacts and the latter the "make period". The total time, that is, 100 milliseconds, covers an "impulse", this being the name given to a break period and the following make period. This impulse time of 100 milliseconds produces an impulse speed of 10 impulses per second. The ratio of the break period of the dial contacts to the make period, that is, 66-2/3 milliseconds to 33-1/3 milliseconds or 2 to 1 is called the "impulse ratio". As will be seen from the above discussion, both the ratio and speed of dials must be correct to ensure satisfactory operation of the exchange equipment.

/ 7.

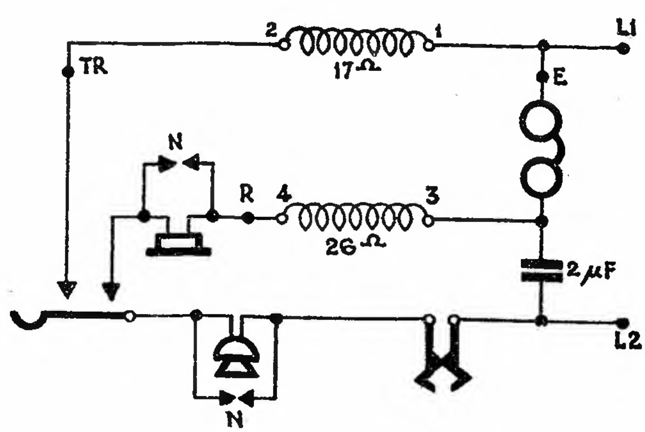
7. DIAL OFF-NORMAL SPRINGS.

7.1 An examination of Fig. 6 will show that -

(i) The variable resistance of the transmitter is in series with the dialling circuit.

(ii) When the dial contacts are closed, the condenser is charged to the voltage drop existing across the transmitter. When the dial contacts are open, the condenser is connected via the subscriber's line and battery feed retards across the exchange battery. Thus, when the dial contacts open, the condenser charges to the exchange battery voltage and when the dial contacts close the condenser discharges until the voltage across it equals that across the transmitter. These charge and discharge currents pass through the receiver, causing the receiver to produce undesirable clicks during dialling.

7.2 The variable resistance of the transmitter is removed from the dialling circuit and the charge and discharge currents of the condenser are prevented from passing through the receiver by means of additional spring contacts on the dial. These additional spring contacts are termed "off-normal" springs as they are operated only when the dial is turned off-normal preparatory to impulsing. Fig. 10 shows the position of these off-normal springs (marked N) in the telephone circuit of Fig. 6. It will be noticed that, during dialling, the off-normal springs short-circuit the transmitter to remove its variable resistance from the dialling circuit, and short-circuit the receiver to prevent the condenser charge and discharge currents from passing through it.



CONNECTION OF DIAL "OFF-NORMAL" SPRINGS (N).

FIG. 10.

8. AUTOMATIC DIALS.

8.1 There are various types of dials, but the Dial Auto. No. 10 (B.P.O. type) has been adopted for general use by the A.P.O. However, there are many Dials Auto. No. 24 (an American type) in use, and both these dials will be described.

8.2 Functions of the Dial No. 10 -

(i) To open the line circuit, that is, transmit impulses, when the moving portion of the dial is returning to normal after having been displaced from its normal position. The number of opens, or impulses, depending on the position at which the moving portion is released.

(ii) To transmit the impulses at a constant speed.

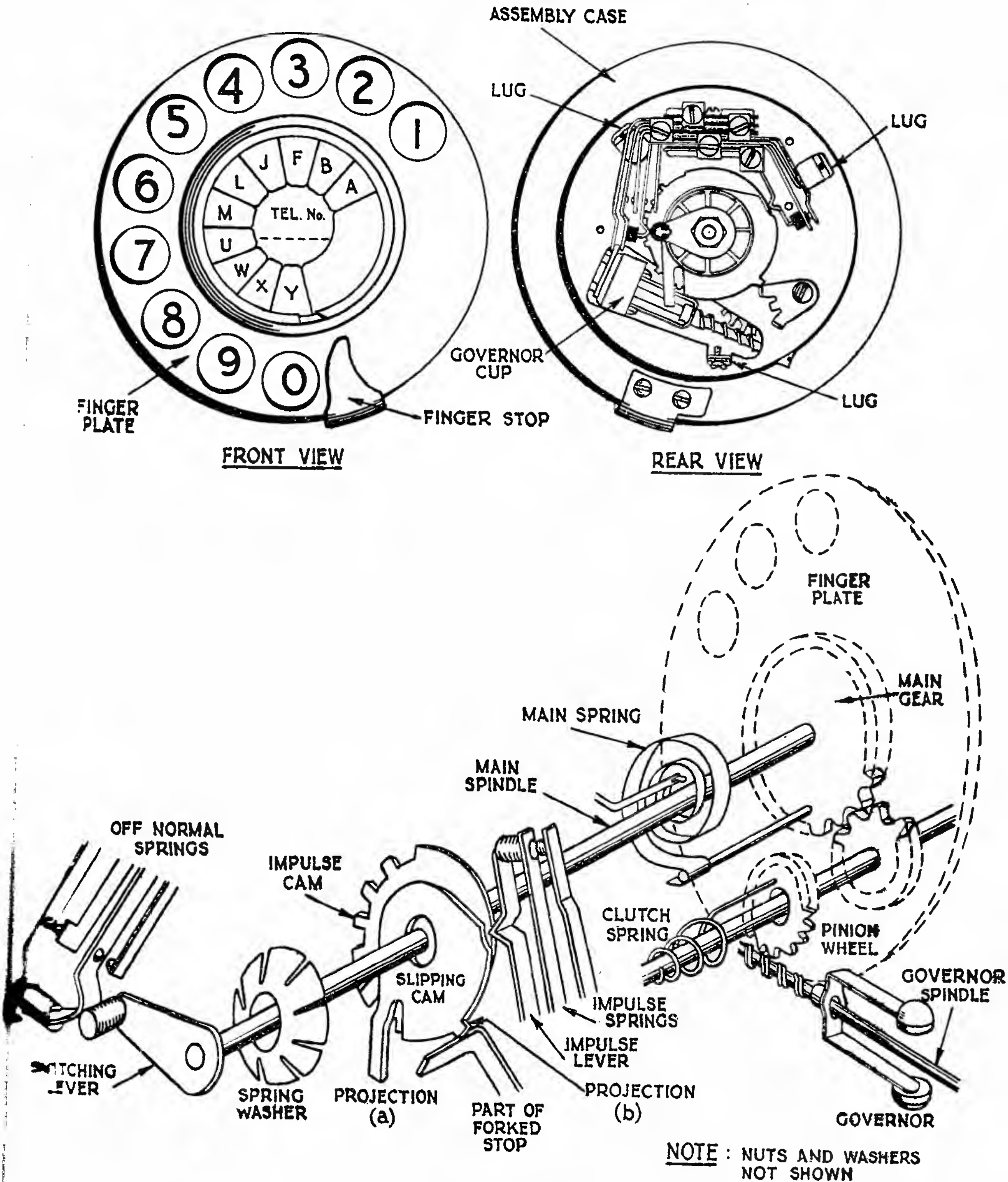
(iii) To prepare an impulsing circuit within the telephone. (Circuit changes are made by means of "off-normal" springs which close contact when the finger-plate of the dial is displaced from its normal position.)

(iv) To provide a minimum period equivalent to the length of two impulses between the last impulse of one train and the first impulse of the succeeding train. (The "lost motion" or "slipping" cam provides this feature. The lost motion period is required by the switch mechanisms for "hunting", that is, for searching for a free circuit. The necessity for this will be explained in later Papers dealing with the circuit operation of switches.)

8.3 Details of the Dial Auto No. 10 (England). Fig. 11 shows details of the standard dial (Dial Auto. No. 10). It consists of a circular pressed brass assembly case which is secured by means of three lugs to a suitable mounting. To ensure rigidity, the lower lug is furnished with a fixing screw. In the centre of the case, but out of view, is a bearing which carries the main spindle. A spring, similar to the main spring of a watch, is arranged with one of its ends fastened to the dial case and the other to the main spindle. The spring is situated behind the impulse wheel. When the main spindle is rotated and released, the spring returns it to its normal position.

In the front of the dial is a plate, termed the finger-plate, provided with ten holes. This plate is fixed to the main spindle and can, therefore, be rotated relatively to the dial case. The numbers that can be seen through the holes in the finger-plate are enamelled upon a number ring which is fixed to the dial case by means of a brass wire spring.

/ Fig. 11.



DIAL AUTO NO. 10.

FIG. 11.

The impulse arrangements are such that if a finger be placed in any hole, say, the hole through which the figure fiv is visible, and the finger-plate rotated until the finger is stopped by the finger-stop, then released, the line circuit will be broken five times, that is, a train of five impulses, as the finger-plate is returned to its normal position by the main spring.

Behind the instruction label in the centre of the dial is a screw which, when fully tightened, "fouls" at one point a projection on the dial case, thus forming a normal position beyond which the finger-plate cannot be rotated in a counter clockwise direction.

The screw also provides a means of applying an initial tension to the main spring. To set the spring, the instruction label is removed and the screw is turned until it clears the projection. The finger-plate is now turned in a clockwise direction until the main spring is felt to tighten, the finger-plate is allowed to return through one complete revolution when the screw is tightened.

Impulsing and Lost Motion Features. Fixed rigidly to the main spindle and located at the back of the dial may be seen the impulse cam, sometimes called impulse wheel, and the switching lever. The latter keeps the "off-normal" springs separated when the dial is normal, and allows the springs to make contact when the finger-plate is rotated. The impulse springs, which are connected directly in the line circuit of the telephone, normally remain in contact due to the pressure applied by the impulse lever, which is a hinged strip (insulated) provided with a bulge that rests against the impulse cam. The cam is provided with a number of indentations and during rotation the bulge on the impulse lever drops into those indentations, thus permitting the impulse contacts to open. Therefore, as the impulse cam rotates, the springs open and close rapidly, and from this source a series of impulses are produced. The impulse cam indentations are so dimensioned that, during one impulse, the ratio of the time during which the impulse spring contacts are open, to the time when they are closed, is 2 : 1, that is, the break period is 66-2/3 per cent. of the total time. A manufacturing tolerance of 63 per cent. to 70 per cent. is allowable but slight adjustment of the impulsing spring assembly enables a 66-2/3 per cent. break to be obtained. The ratio is adjusted before installation of the dial and should not be altered on a subscriber's premises.

A slipping cam mounted upon the main spindle immediately next to the impulse cam serves -

/ (i)

(i) To prevent the impulse springs from opening when the finger-plate is being rotated from its normal position, but permits impulsing when the finger-plate is returning to normal under the influence of the main spring.

(ii) To provide a minimum time interval between impulse trains.

The slipping cam is not fixed to the spindle, but is pressed towards the impulse wheel by the spring washer. Steel washers (not shown in Fig. 11) between the spring washer and the slipping cam and between the slipping cam and the impulse cam, serve as a friction clutch and keep the retarding force constant. As the finger-plate is turned in a clockwise direction, the impulse cam and slipping cam will move round, the direction will be counter-clockwise if the dial is viewed from the back, until the projection (a) on the slipping cam encounters the forked stop, when the cam is stopped and commences to slip in relation to the impulse cam. During the whole of this forward movement, the cam, by bearing against the bulge on the impulse lever, serves to screen the impulse lever from the indentations on the impulse cam, thus preventing the transmission of impulses. When the finger-plate is released, the slipping cam will move with the impulse cam until the projection (b) encounters the forked stop, when slipping takes place during the remainder of the motion. With the slipping cam in this position, the impulse lever is not screened and consequently the impulse lever will engage the indentations and there will be making and breaking of the impulse contacts. The portion of the return movement prior to this slipping, during which the cam screens the indentations, is termed the lost motion period and provides the minimum time period necessary between impulse trains. The dial is so designed that the impulse cam is screened while two indentations pass the impulse lever, thus the lost motion period has a duration of about 0.2 seconds. The time interval between successive trains of impulses, therefore, is equal to the time occupied by the subscriber in turning the finger-plate and releasing it, plus 200 milliseconds.

By releasing a screw, the position of the forked stop can be altered so that the projection (b) lies within the fork, and, if secured in this position, the scope of the slipping cam is materially reduced being only sufficient, under these conditions, to allow such movement as will prevent impulsing during the forward operations of the finger-plate, but is insufficient to cause lost motion during the return of the finger-plate. This feature is introduced so that the dial may be used on automatic systems where the lost motion feature is not required (the Western Electric Company's Rotary system for example). As the elimination of the lost motion feature

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will introduce two additional impulses per train, owing to the fact that the impulse cam is unscreened during the whole of the time that the finger-plate is returning to normal, a compensating arrangement must be provided. This is effected by moving the finger-stop to an alternative position such that the travel of the finger-plate is reduced by an amount equal to two impulses.

Impulse Speed Control. This is effected by means of a spring controlled friction governor. Immediately behind the finger-plate, and like it secured to the main shaft, is a toothed wheel. This meshes into a pinion wheel, which in turn meshes into a worm on the governor spindle.

The governor spindle carries the flat springs having brass weights at their ends. These pass inside a casing (governor cup) against which they are pressed by centrifugal force as the spindle rotates. The faster the dial tends to move, the more the weights try to fly out and the greater is the friction between them and the inside of the casing, thus tending to slow down the dial speed. By this means, the speed of rotation is kept constant at a value depending upon the initial "set" or tension given to the governor springs. The normal speed of impulsing is ten impulses per second, but this will vary, of course, as the main spring loses tension or as the friction of the governor alters with use. Although most automatic switches are capable of working with speeds of from 7 to 14 impulses per second, the dial speed should be kept as near as possible to 10 impulses per second in order to allow a working margin. The speed can readily be corrected by an adjustment of the governor springs.

Further Information. Additional information on the Dial No. 10 is to be found in Telephone Engineering Instruction, Exchanges Automatic AD 1103.

8.4 Dial Auto. No. 24 (U.S.A.). The Dial Auto No. 24 has the following distinctive features -

(i) Includes a ratchet.

(ii) Governor rotates in one direction only.

(iii) Lost motion is at end of a train of impulses.

(iv) Impulses by means of a two-lobed cam.

(v) Spiral spring controls return motion.

(vi) Slipping cam or friction washers not used.

/ Fig. 12

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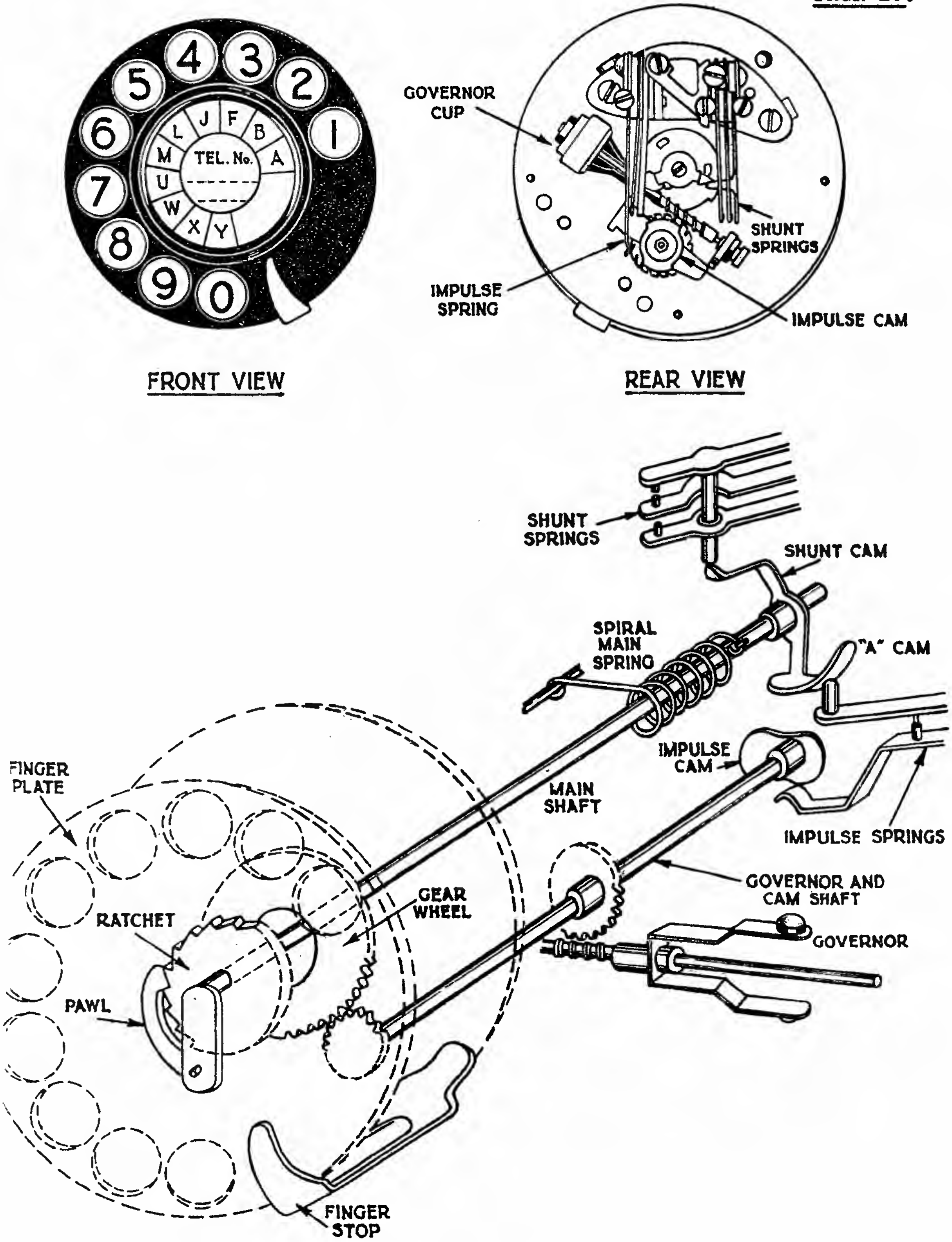


DIAL AUTO NO. 24.

FIG. 12.

Fig. 12 shows some details of this dial. The shunt cam which controls the operation of the off-normal springs is fastened to the main shaft which is attached to the pressed metal finger-plate. On the forward dialling motion, the shunt cam and cam "A" move, one end allowing the make springs of the off-normal assembly to operate, cam "A" allowing the impulse springs to come to a position so that the longer spring is in the path of the impulsing cam. The forward motion of the finger-plate also winds up the spiral spring on the main shaft and moves the ratchet pawl around the teeth to the desired position.

On the return motion of the finger-plate, the pawl engages the ratchet to operate the governor and impulse cam which rotates to transmit the desired number of breaks. Two more impulses than the number pulled would be sent if it were not for the cam on the shunt cam assembly, which comes into contact with the impulse springs before the final impulse is sent and pushes both springs away to continue the make period and put the long spring out of engagement with the impulse cam. The lost motion time period is thereby given at the end of each train. A governor is included which acts in the same manner as described for the Dial Auto. No. 10. Earlier dials of this type provided a lost motion equal to one impulse.

The above descriptions deal with two typical dials. Slight variations are made by the different manufacturers, but the information given above will serve as a basis for appreciating the action and construction of any make.

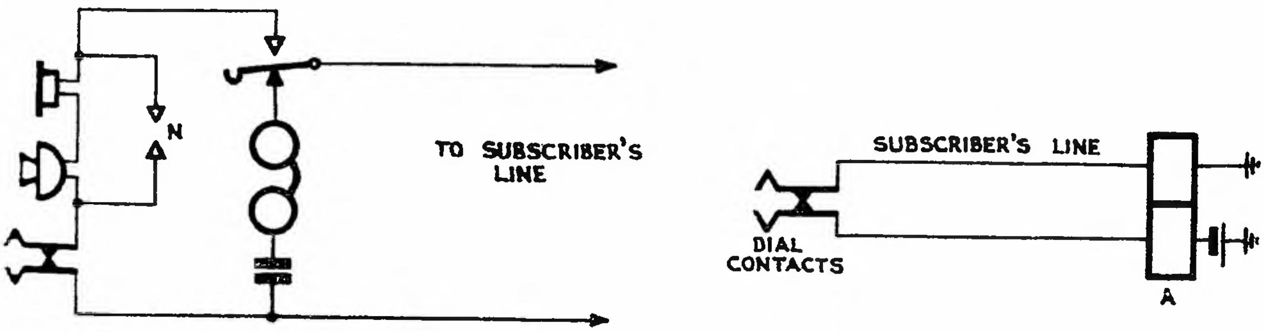
8.5 Dial No. 11. Some public telephone circuits used with the prepayment type of coin collecting boxes are designed so that the caller cannot operate the exchange apparatus without prepayment, except when making calls to an operator at a parent exchange or special services. To provide this feature of access to an operator without prepayment, a special dial, the Dial No. 11, is fitted to the telephone. This dial differs from the Dial No. 10 only in the provision of an additional cam and spring-set. This spring-set is operated when a predetermined digit is dialled (usually 0) and allows access to an operator at the exchange without payment. A telephone using this dial is described later in this Paper.

/ 9.

9. DEVELOPMENT OF DIALLING CIRCUIT.

9.1 The automatic telephones in use at the present time represent a continuous development from the early circuits. It is important to trace the development of the present day dialling circuit from these early telephones.

9.2 The first automatic telephone circuit used in Australia was wired to the circuit shown in Fig. 13.



(a) Schematic Circuit.   (b) Dialling Circuit.

EARLY AUTOMATIC TELEPHONE CIRCUIT.

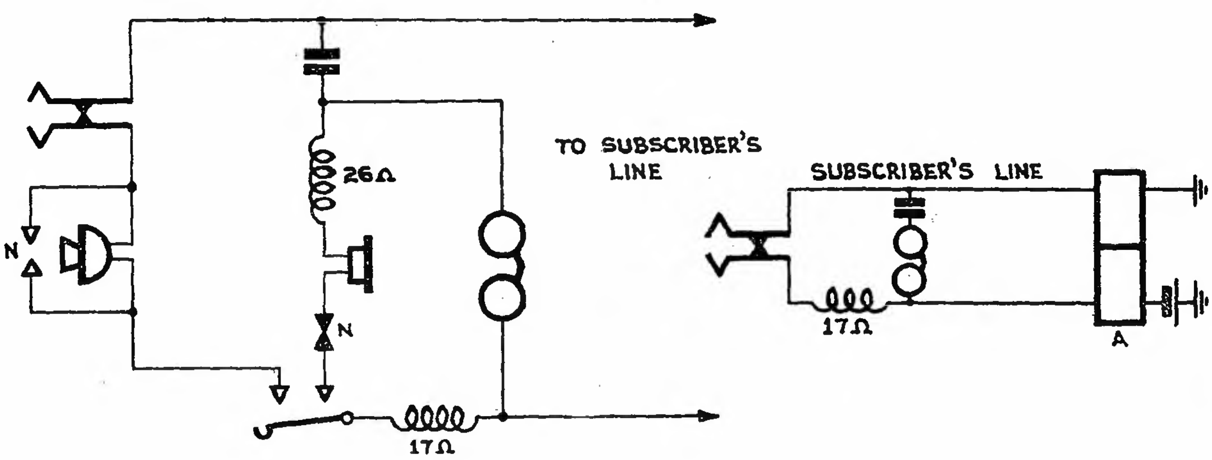
FIG. 13.

In this telephone, no attempt is made to improve impedance conditions and sending and receiving efficiencies by means of an induction coil. The dialling circuit shown in Fig. 13b also has a decided objection in that when the dial contacts open, a voltage of about 700 volts is induced across the windings of the selector A relay each time the dial contacts open. This high voltage is due to the fact that when the dial contacts open, the current through, and, therefore, the flux about the windings of, relay A decay to zero almost instantly. The flux in so doing cuts the turns of

/ the

the relay windings and, for average length lines, the voltage of self-induction produced across the windings is about 900 volts. Such a voltage unduly strains the insulation of the lines and equipment and introduces a danger to staff working on the plant.

9.3 The next automatic telephone to be introduced used the basic C.B. telephone circuit of Fig. 6, the dial off-normal springs short-circuiting the transmitter and opening the receiver circuit for the reasons given previously. This circuit is shown in Fig. 14 in schematic form.



(a) Schematic Circuit.   (b) Dialling Circuit.

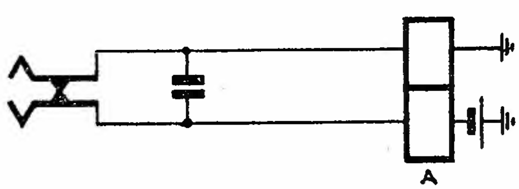
EARLY AUTOMATIC TELEPHONE CIRCUIT.

FIG. 14.

In this circuit an effort is made to use the condenser in the telephone to reduce the voltage of self-induction produced across the windings of the A relay at the moment the dial contacts open.

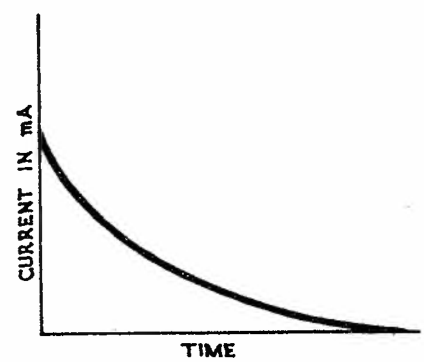
/ The

The condenser will reduce this voltage as follows, Fig. 15 shows a condenser alone connected across the impulsing contacts of a dial. Whilst the dial contacts are closed, they short-circuit the condenser and, therefore, the condenser is uncharged. On the dial contacts opening, the short circuit is removed from the condenser which will charge up to the exchange battery voltage via the windings of the A relay. As discussed in Paper No. 2 of Telephony I, a condenser charging current is a gradually decaying current, being initially high and gradually falling to zero with time, as shown in Fig. 16. The presence of the condenser across the dial contacts of Fig. 15, therefore, means that when the dial contacts open, the current decays to zero gradually instead of suddenly. The flux about the windings of the A relay will decay correspondingly gradually so that the voltage induced across the windings of that relay will not be so high. With a line of zero resistance between the dial and A relay, this induced voltage is about 150 volts, a considerable reduction from the 900 volts produced when no condenser is present.



CONDENSER ACROSS DIAL CONTACTS.

FIG. 15.



CHARGING CURRENT OF FIG. 15.

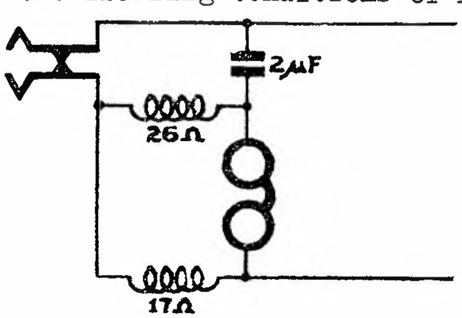
FIG. 16.

Whilst the condenser considerably reduces the voltage induced across the winding of the A relay at the instant the dial contacts open, a condenser alone across the dial contacts introduces trouble. This is due to the fact that when the dial contacts close again, the condenser is short-circuited by these contacts. The condenser, therefore, will discharge through the dial contacts on these contacts closing. As these contacts represent a short circuit and the condenser is charged to the exchange battery voltage, 48 volts for automatic exchanges, the discharge current will be fairly high. As time goes on, the heavy discharge current, carried by the dial contacts each time they close, causes these contacts to deteriorate. To limit the discharge current and prevent deterioration of the dial contacts, a resistance is connected in series with the condenser. In the circuit of Fig. 14a, the connection of the dial off-normal springs is such that the bell is in series with the condenser across the dial impulsing contacts during dialling, as shown in

/ Fig. 14b.

Fig. 14b. The resistance of the bell is too high and, whilst limiting the discharge current, the high resistance affects little reduction of the voltage induced across the windings of the A relay when the dial contacts open. The reason for this can be understood by considering a typical case. In Fig. 14b, assume that each winding of relay A has a resistance of 200 ohms, the line resistance is 200 ohms and the exchange battery voltage is 48 volts. When the dial contacts are closed, the current flowing through the line and windings of relay A is, therefore, 48 volts/600 ohms or 80 mA. On the dial contacts opening an additional 1,000 ohms (the resistance of the bell) is added and the resistance in the circuit for charging the condenser is, therefore, 1,600 ohms. Thus, the initial charging current into the condenser is 48 volts/1,600 ohms or 30 mA. Thus, when the dial contacts open, the current through the windings of relay A drops instantly from 80 to 30 mA in the case used for illustration, and the gradual decay of the current as the condenser charges commences from 30 mA. The instantaneous drop in current from 80 to 30 mA quoted above means that the flux about the windings of the A relay drops instantly by a corresponding amount, causing a fairly high voltage of self-induction to be produced across the windings of that relay. This voltage is about 700 volts, which is still too high for safety although lower than that produced when no condenser is present.

9.4 By short-circuiting the receiver, as in Fig. 10, during dialling, the dialling conditions of Fig. 10 become those shown in Fig. 17.



DIALLING CIRCUIT OF FIG. 10.

FIG. 17.

It will be noticed that the bell is shunted by the two windings of the induction coil in series. When the dial contacts open, this low resistance shunt across the bell allows the charging currents into the condenser to pass through the shunt rather than through the bell. As the circuit resistance is practically the same when the dial contacts are open or closed under these circumstances, there is not the large sudden drop of current mentioned above when the dial contacts open. The voltage induced across the windings of the A relay will, therefore, be much less than in the case of Fig. 14, being about 180 volts for average length lines. Further, as the 26 ohm winding of the induction coil is in the discharge path on the dial contacts closing, the discharge current is limited and deterioration of the impulsing contacts of the dial by high discharge currents is prevented.

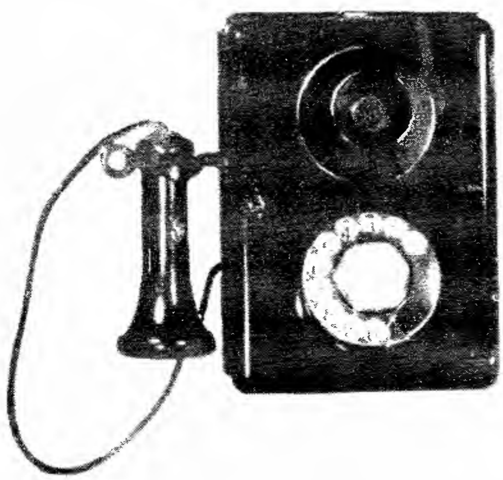
/ 10.

10. AUTOMATIC TELEPHONES.

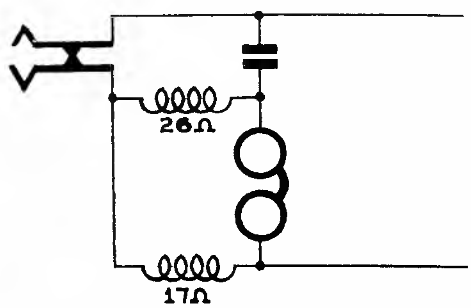
10.1 Telephones 37AW and 38AT. These two telephones, wall and table instruments respectively, use the basic schematic circuit of Fig. 10.

A typical wall telephone is shown in Fig. 18, with schematic diagram and the dialling conditions. The telephone shown has a metal case. The usual wall telephone of this type, however, generally has a wooden case.

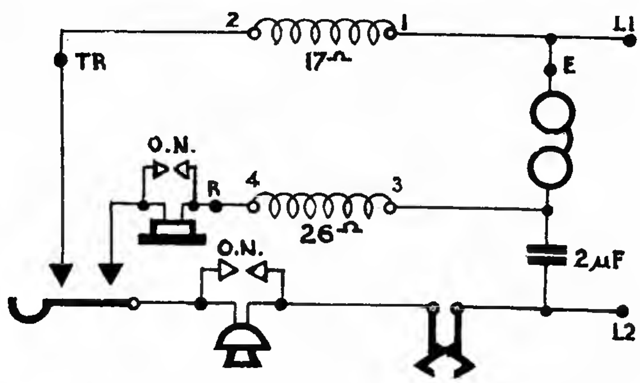
The terminals designated R and TR in Fig. 18b are not utilised by the Australian Post Office. The British Post Office, which also uses this instrument, utilises terminals R and TR to provide a particular type of extension service.



(a) Wall Telephone.



(c) Dialling Circuit.

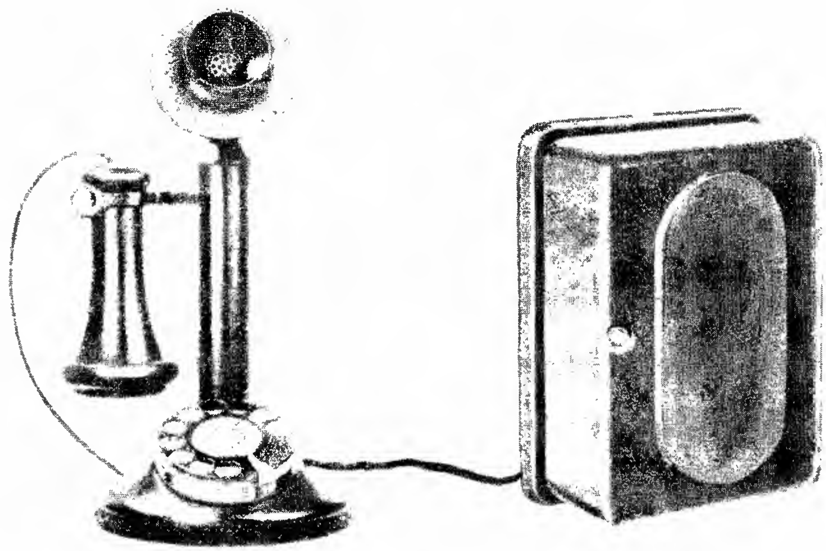


(b) Schematic Circuit.

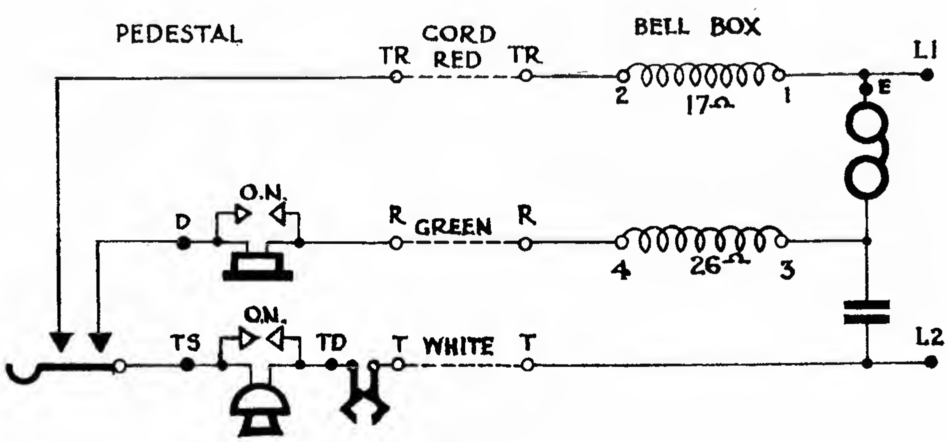
WALL TELEPHONE (37AW).

FIG. 18.

The table instrument and circuit are shown in Fig. 19. This instrument employs two units, a pedestal and a bell set. A solid back transmitter and a switch hook are mounted on the pedestal and a bell receiver is connected thereto. The bell set contains the bell, 2 μF condenser and induction coil. A cord 3600 connects the bell box and pedestal. The dialling conditions are those shown in Fig. 18c. The bell box in Fig. 19 is of metal, and a Dial No. 24 is in the pedestal. The usual bell box is of wood, and the dial is usually the Dial No. 10.



(a) Automatic Table Telephone.



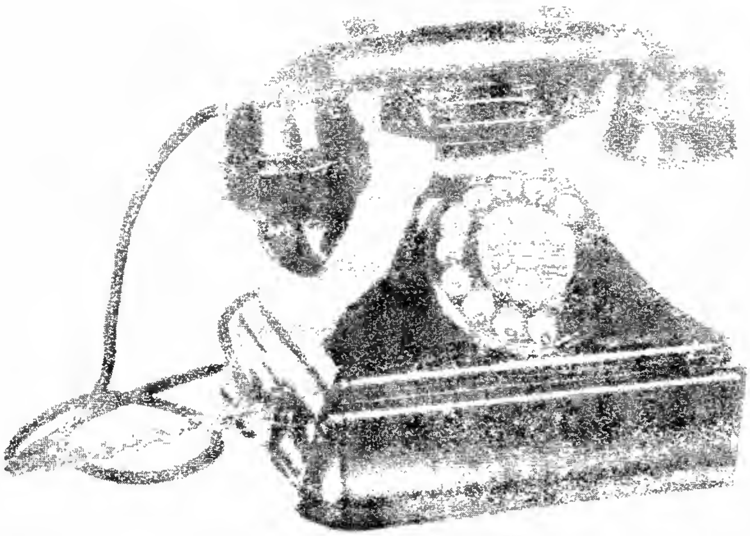
(b) Circuit.

TABLE TELEPHONE (38AT).

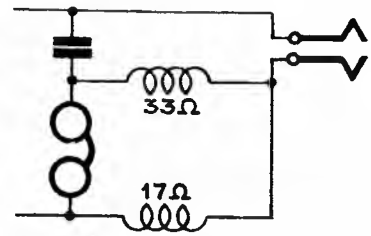
FIG. 19.

10.2 Telephone 162AT. This table telephone, previously known as the Type 566, was the first moulded handset telephone to be introduced into Australia and uses the anti-sidetone arrangements described in paragraph 4.2 of Paper No. 2 of this book. The telephone and schematic and dialling circuits are shown in Fig. 20.

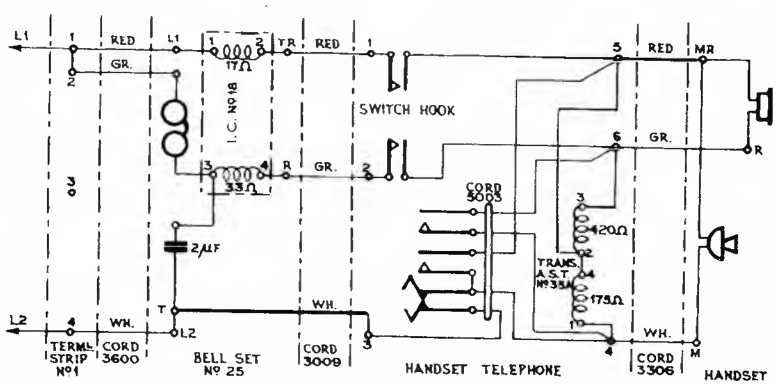
The telephone consists of three parts, a bell set containing the bell, induction coil and condenser; a pedestal containing the switch hook, anti-sidetone transformer and dial; and a hand converser containing the transmitter and receiver. A cord 3306 connects the handset to the pedestal, a cord 3009 connects the pedestal to the bell set external to the instrument, and a cord 3600 connects the bell set to a terminal strip on which the exchange line terminates. Terminals 1 and 2 of this strip, which correspond with L1 and E of Figs. 18b and 19b, are strapped when extension bell facilities are not required.



(a) Telephone.



(c) Dialling Conditions.

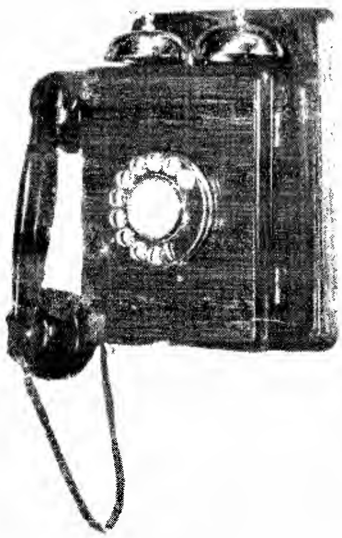


(b) Schematic Circuit.

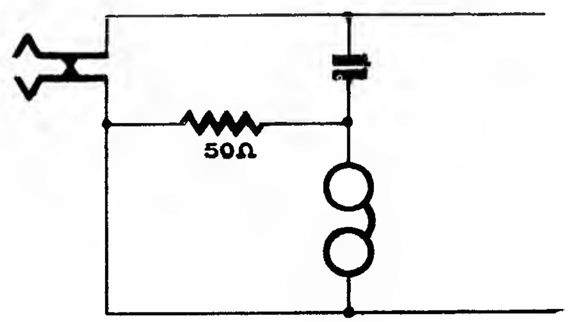
HANDSET TELEPHONE (162AT).

FIG. 20.

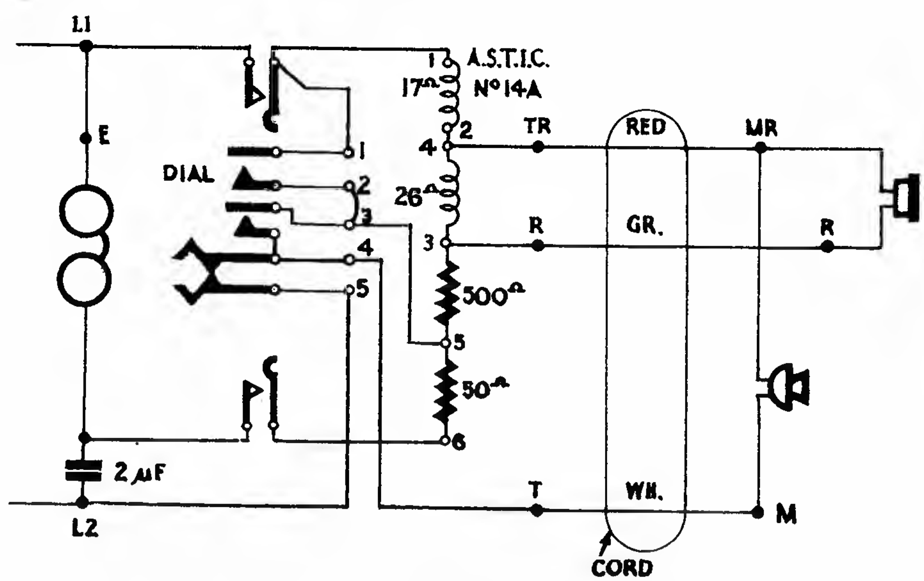
10.3 Telephone 237AW. This telephone, as stated previously, was developed to meet the needs of subscribers requiring a wall handset telephone and to obviate the use of moulded handset table telephones mounted on brackets for such purposes. Fig. 21 shows a picture of the telephone, a schematic diagram and the dialling circuit. It will be noticed that the 50 ohm resistance provided on A.S.T.I.C. No. 14A used in this telephone provides the necessary resistance in series with the condenser when dialling.



a) Telephone.



(c) Dialling Conditions.

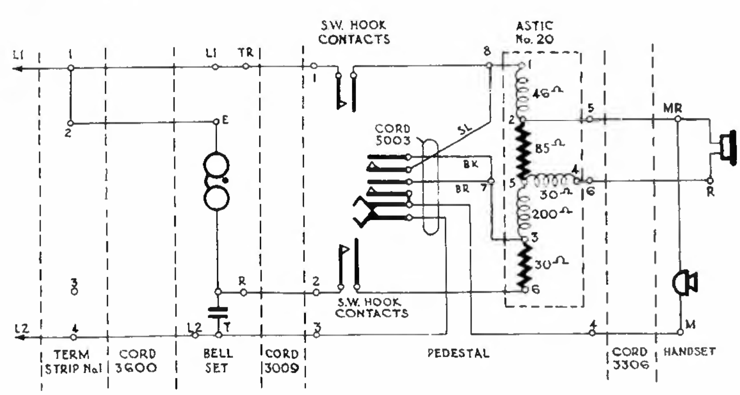


(b) Circuit.

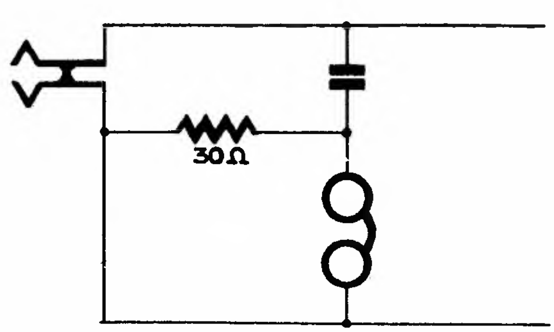
WALL TELEPHONE (237AW).

FIG. 21.

10.4 Telephone 232AT. This telephone is similar in appearance to the 162AT shown in Fig. 20a. The only differences are the elimination of the moulded and weighted base plate supplied with the 162 telephone, and the connection of the bell set to the pedestal by an internally run cord in the 232 telephone, instead of the external cord of the 162 telephone shown in Fig. 20a. As with the 162 telephone, the three parts of the instrument are the bell set, pedestal and handset. The bell set contains the bell and condenser and is connected to the pedestal by a cord 3009. The pedestal contains the dial, switch hook and anti-sidetone induction coil, and is connected to the handset by a cord 3306. The handset contains the transmitter and receiver. The exchange line terminates on a terminal strip which is connected to the bell set by a cord 3600. The strap for extension bell facilities is provided on this terminal strip. For a picture, Fig. 20a applies, whilst Fig. 22 shows a wiring-schematic diagram and the dialling circuit.



(a) Schematic.



(b) Dialling Conditions.

HANDSET TELEPHONE (232AT).

FIG. 22.

10.5 Telephone 332AT. This telephone differs from the Types 162 and 232 in that only two units are employed; a moulded handset containing the transmitter and receiver, and a moulded case containing the bell, condenser, dial, induction coil and switch hook. Fig. 23 shows the telephone, a wiring-schematic diagram of the telephone when equipped with A.S.T.I.C. No. 27 and the dialling conditions. As with the 237AW, the 232, 332 and 300 Automatic Telephones employ a non-inductive resistance in series with the condenser when dialling.

Two points of interest in this telephone are -

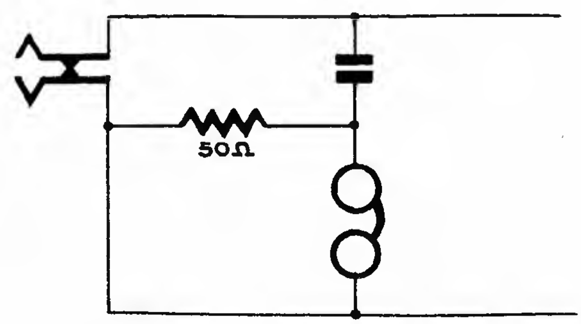
(i) The provision of a 0.1 μF condenser across the transmitter, to prevent radio programmes being detected by the coherer action of the carbon granules and heard as music and speech in the receiver. The condenser by-passes the radio signals around the transmitter.

(ii) The provision of a radio interference suppressor (condenser and inductance), the condenser of which is connected across the inductance in series with the impulse springs. This suppressor is not normally connected, but is used when the operation of the dial causes clicks in the loud-speaker of nearby radio sets.

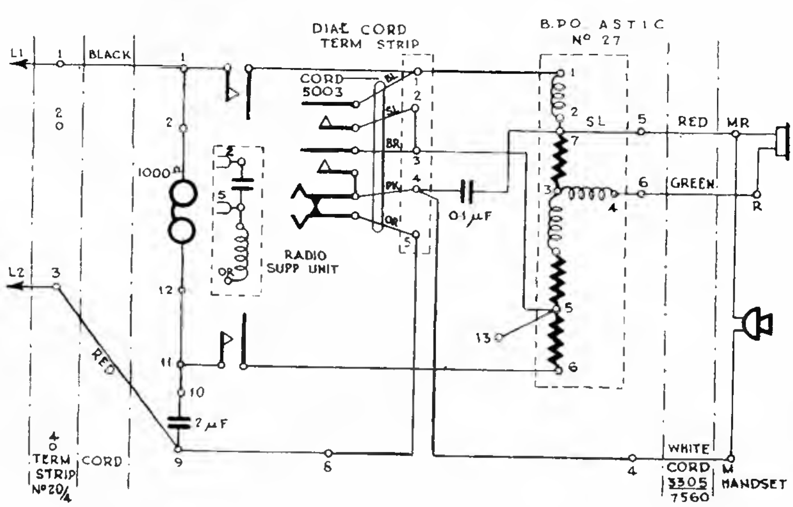
The terminals marked 2 and 5 on the suppression unit are fitted to terminals 2 and 5 of the dial cord terminal strip, and the OR wire of cord 5003 is removed from terminal 5 and connected to the OR terminal of the suppression unit.

/ Fig. 23.

(a) Telephone.



(c) Dialling Conditions.

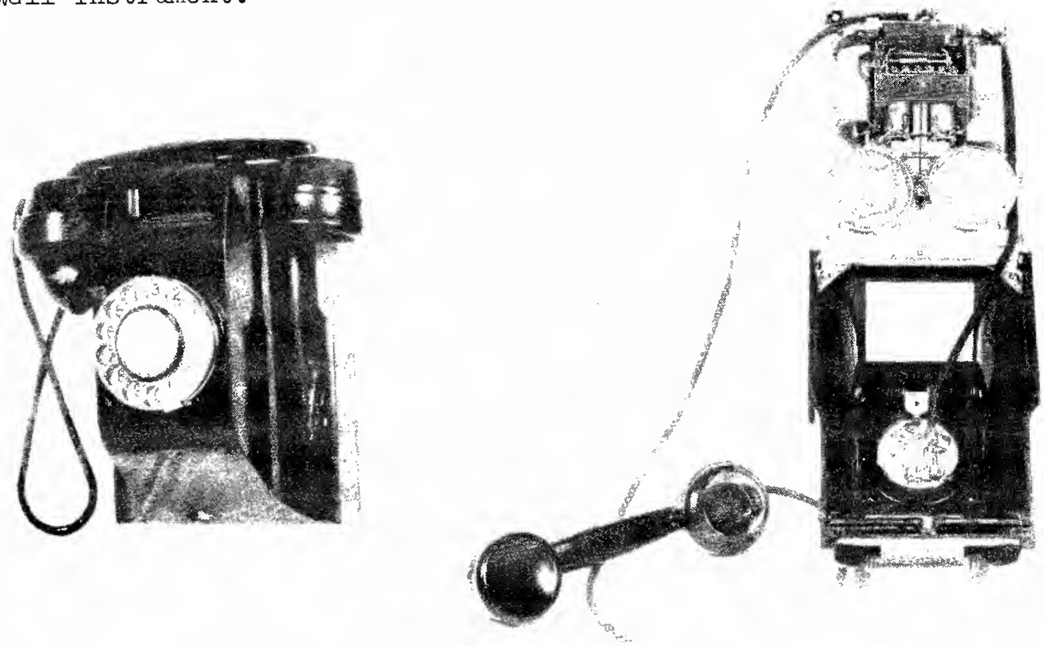


(b) Circuit.

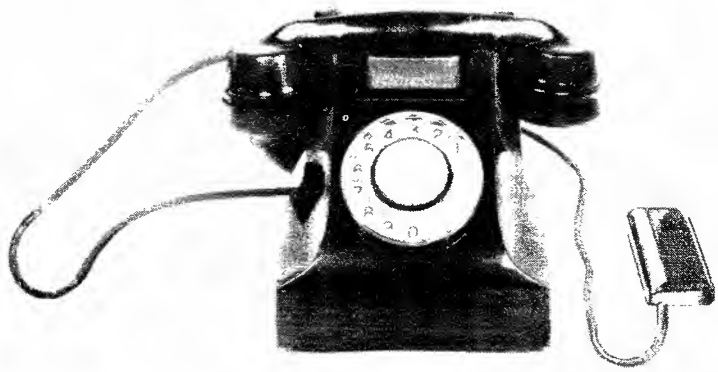
HANDSET TELEPHONE (332AT).

FIG. 23.

10.6 Telephones 300AW and 300AT. These telephones are the auto. wall and table models of the universal 300 telephone developed by the Australian Post Office. Fig. 24 shows pictures of the wall and table telephones. Fig. 25 shows the circuit, the wiring-schematic diagram being the same for both telephones. Both wall and table instruments are made up of two units, the moulded handset, and the case containing the bell, condenser, dial, induction coil and switch hook. The table instrument is connected to a terminal strip on which the exchange line terminates by a cord 2406, whilst the exchange line terminates directly on the wall instrument.



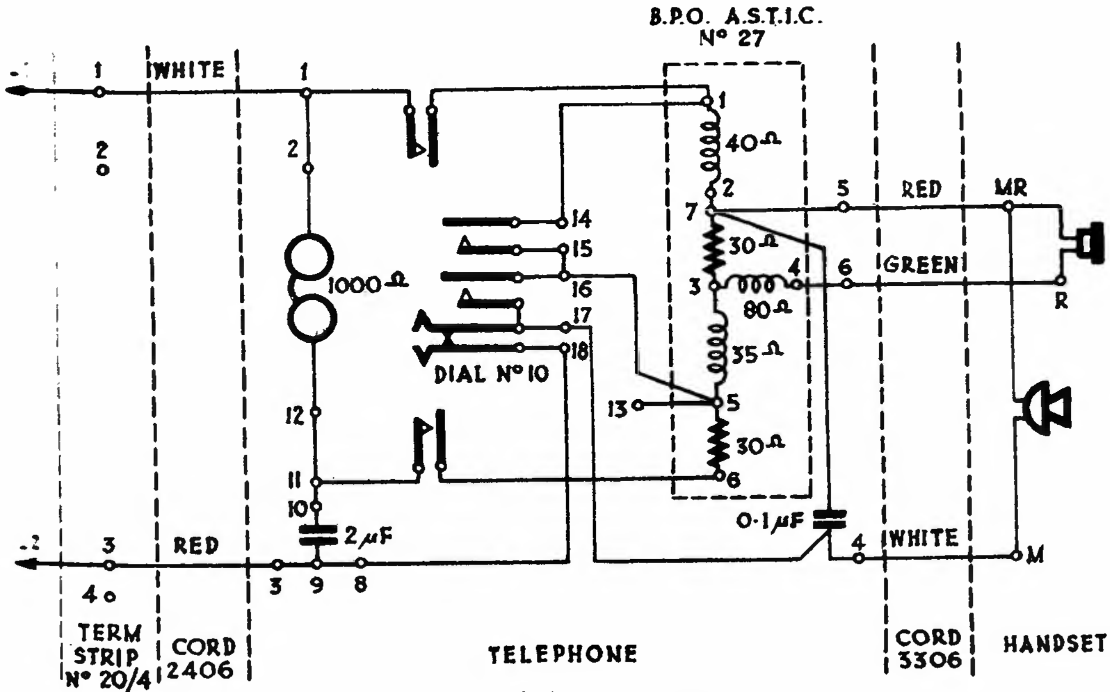
(a) Wall Telephone (300AW).



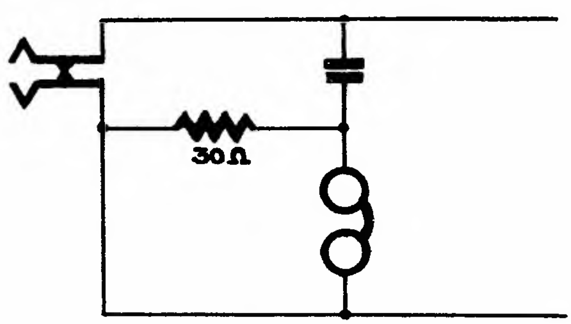
(b) Table Telephone (300 AT).

TYPE 300 HANDSET TELEPHONES.

FIG. 24.



(a) Circuit.



(b) Dialling Conditions.

HANDSET TELEPHONE (300AW AND 300AT).

Notes.

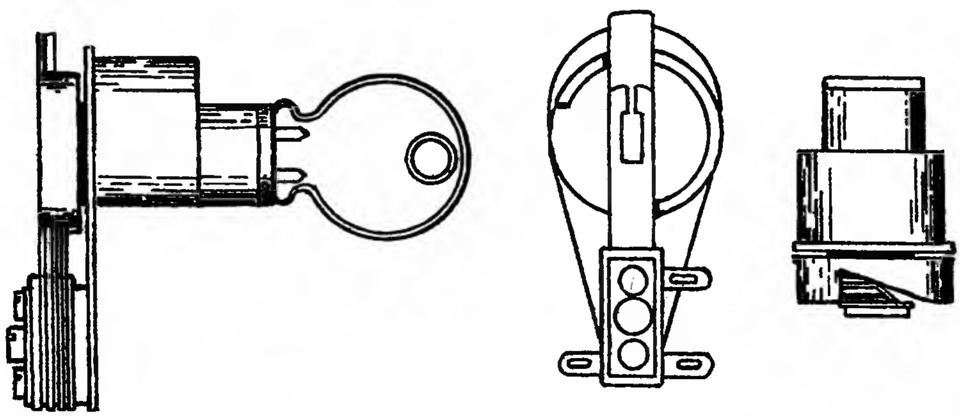
1. When used as a wall telephone, cord 2406 and terminal strip No. 20/4 are omitted.
2. Extension bell connected to 1 and 2 in place of strap if on wall telephone.
   For table telephone, fit three conductor cord in place of cord 2406, remove strap from 1 and 2 of telephone and connect bell to terminals 1 and 2 of terminal strip No. 20/4.

FIG. 25.

11. KEY CONTROL SERVICES.

11.1 A key control service on an automatic telephone is provided by connecting the springs of the control lock across the impulsing springs of the dial. Fig. 26 shows the schematic circuit of a Telephone 37AW with a control lock.

The control lock is operated by the Yale type of key and, in the unoperated position, prevents unauthorised persons from using the telephone. The insertion of the key in the lock removes the short-circuit from the dial. Incoming calls are answered in the usual manner.



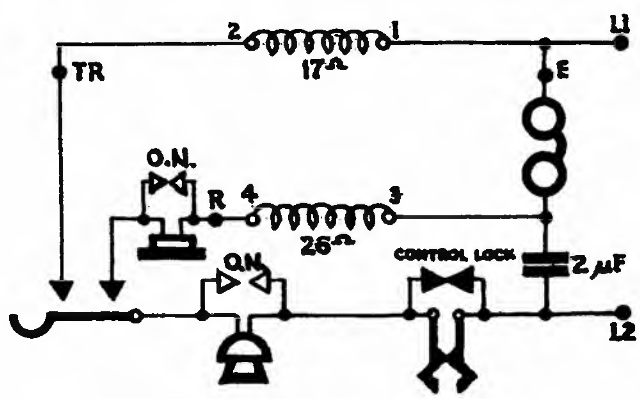
Side

Rear

Plan

(Key not shown.)

(a) Views of Control Lock.



(b) Circuit.

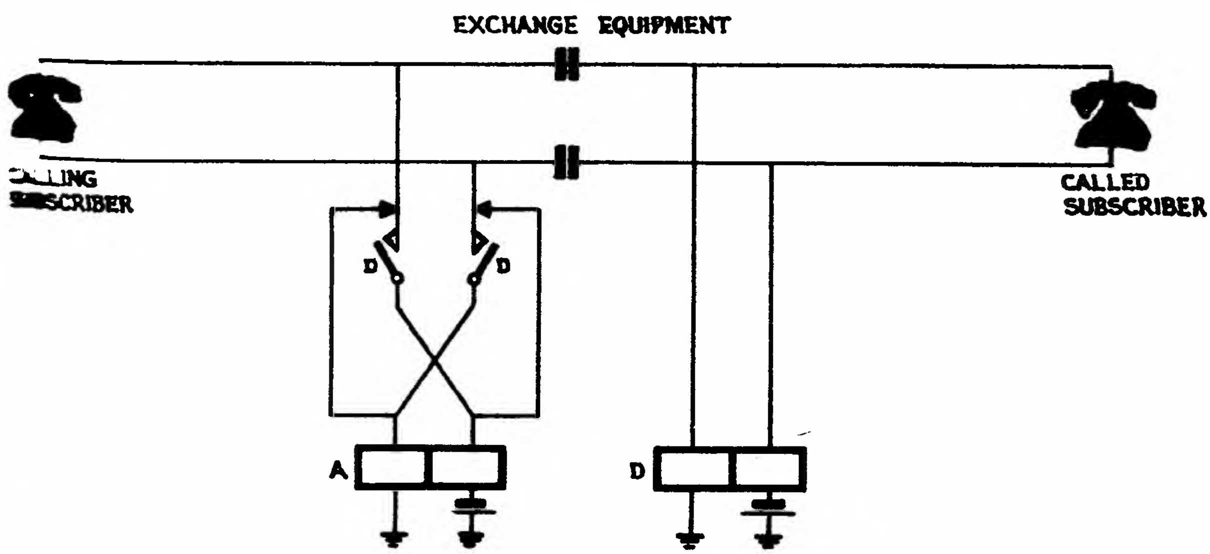
TELEPHONE 37AW FITTED WITH CONTROL LOCK.

FIG. 26.

12. PUBLIC TELEPHONES.

12.1 Manual public telephones provide audible signals to the exchange operator on the insertion of the necessary fee by the caller. When these signals are received, the operator connects the caller at the public telephone (who is answered on the answering cord of one cord circuit) to the called party, who is waiting on the calling cord of another cord circuit. In an automatic system some other method of collecting the necessary fee is required because calls are completed without the aid of operators.

12.2 In automatic systems a reversal in the direction of the transmitter current to calling subscribers takes place when the called subscriber answers. This reversal of battery is provided for a number of reasons with which this Paper is not concerned; for the present purpose it is sufficient to know that such a reversal takes place and that the reversal is used to enable the fee to be collected on automatic public telephones. Fig. 27 shows the method of providing the reversal using the transmitter battery feed circuit described in Fig. 1 of this Paper.



PROVISION OF REVERSAL IN AN AUTOMATIC EXCHANGE.

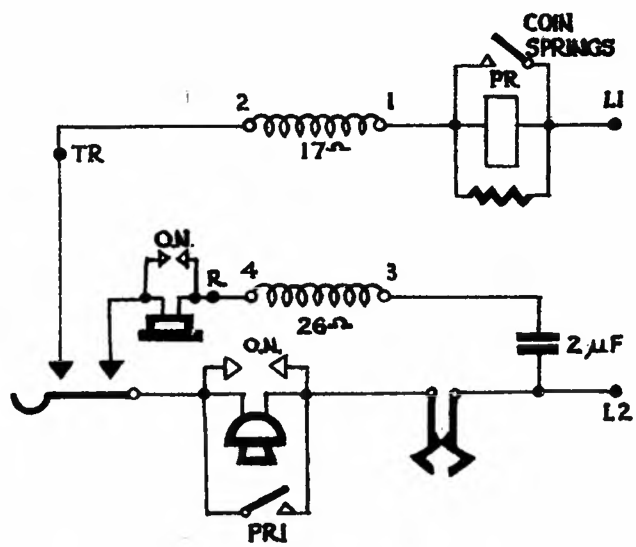
FIG. 27.

When the called subscriber answers, relay D operates to the loop provided by the called telephone and the D relay contacts (shown normal in Fig. 27) are operated. These operated contacts reverse the direction in which the transmitter battery feed current flows through the calling telephone. When the called subscriber is connected to a C.B. Manual

/ Exchange,

Exchange, the reversal to a calling subscriber connected to an automatic exchange takes place on the called subscriber answering, as in the auto. to auto. call. When the called subscriber is connected to a Magneto Exchange, the reversal to a caller connected to an automatic exchange takes place on the magneto exchange operator operating the ringing key to ring the called subscriber.

12.3 This reversal is used to operate a polarised relay of the type described in Paper No. 1 of this book, this relay being part of the public telephone circuit. Fig. 28 shows the principle applied to the circuit of Fig. 10.



PRINCIPLE OF AUTOMATIC PUBLIC TELEPHONE.

FIG. 28.

The connections of the polarised relay PR of Fig. 28 are such that the relay is unoperated until the reversal takes place. As the reversal takes place on the called subscriber answering (in the case of automatic and C.B. manual exchanges and on the operator ringing in the case of most magneto exchanges), callers from automatic telephones can speak to manual exchange operators without the insertion of the necessary fee. On the reversal occurring, relay PR operates to place a short circuit across the transmitter at operated contacts PR1. This prevents speech from the telephone. On the insertion of the necessary fee, the coins close a pair of coin springs which short-circuit relay PR, so releasing it. The release of relay PR removes the short circuit from the transmitter and allows a conversation to proceed. Relay PR is shunted by a resistor to allow speech currents to pass

/ clear

clear of the high impedance of the relay winding where speech is necessary before relay PR operates, for example, on calls to manual exchanges.

12.4 An automatic public telephone and typical circuits in extensive use are shown in Fig. 29. The coin collecting mechanism is shown in Fig. 30.

Circuit Operation. (See Fig. 29b.) Two pennies are placed in the coin rest and are held there under control of a button until required. The receiver is lifted from the hook and the caller dials in the usual way. The polarised relay PR does not operate, if the line wires are correctly connected, until the called subscriber answers, when the direction of current flow through the telephone is reversed and PR operates.

PR1-2 short-circuit the transmitter and PR2-3 connect a low non-inductive resistance across the receiver. The calling party cannot speak to the called party by means of the short circuited transmitter, and the shunt across the receiver prevents its effective use as a transmitter. This shunt does not prevent the calling party from hearing, and, when the called party speaks, the caller presses the button holding the coins. The pennies pass via the chute and operate the coin springs. These springs short-circuit the relay PR which releases. The transmitter and receiver are restored to normal, and conversation may proceed. When the receiver is replaced on the hook at the end of the call, the coins are allowed to continue their journey to the coin tin.

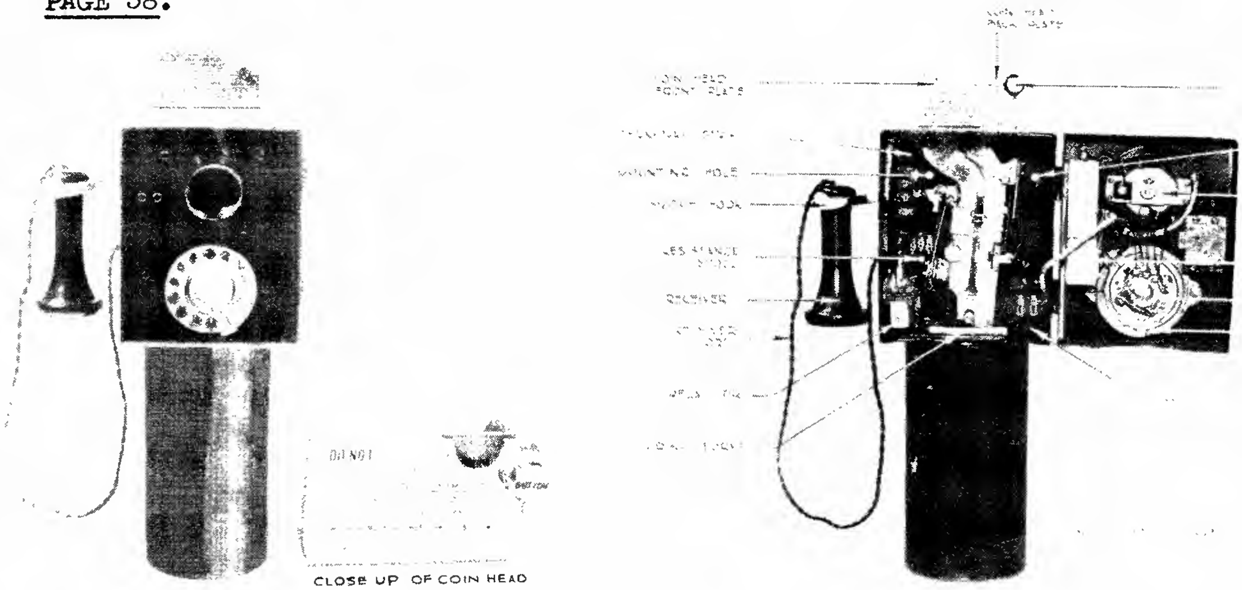
As the shunt across the receiver reduces its efficiency, it is necessary that the resistance of this shunt be such that the caller will be able to hear the called party answer under varying line conditions. The efficiency of the receiver is increased with a decrease of line resistance, and thus the resistance of the shunt may be reduced when the resistance of the line is low.

The resistance of the shunt is 15 ohms for lines under 200 ohms resistance and 25 ohms for lines over this value. The resistance is made up as shown in Fig. 29b with a short circuit across the 10 ohms, which is cut if the full 25 ohms is required.

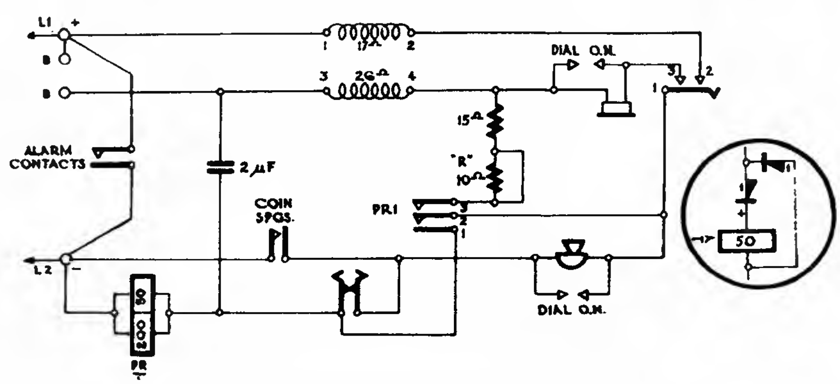
If the lines to this telephone are reversed, the relay PR operates when the receiver is taken off the hook and short-circuits the dial and the transmitter.

If the pennies should block in the coin chute, the operation of the coin springs will prevent any further calls by short-circuiting the dial.

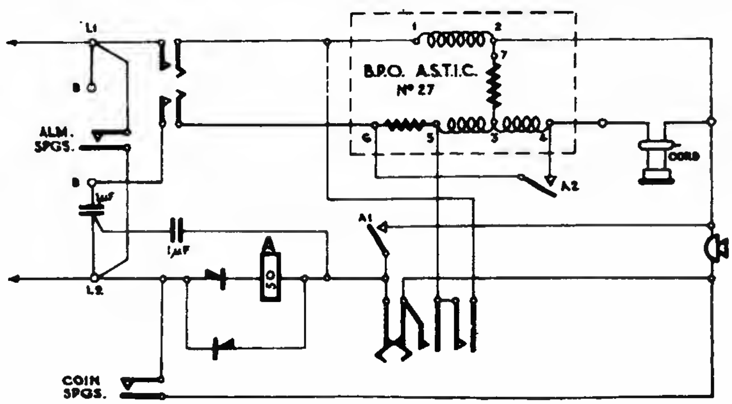
/ Fig. 29.



(a) Telephone.



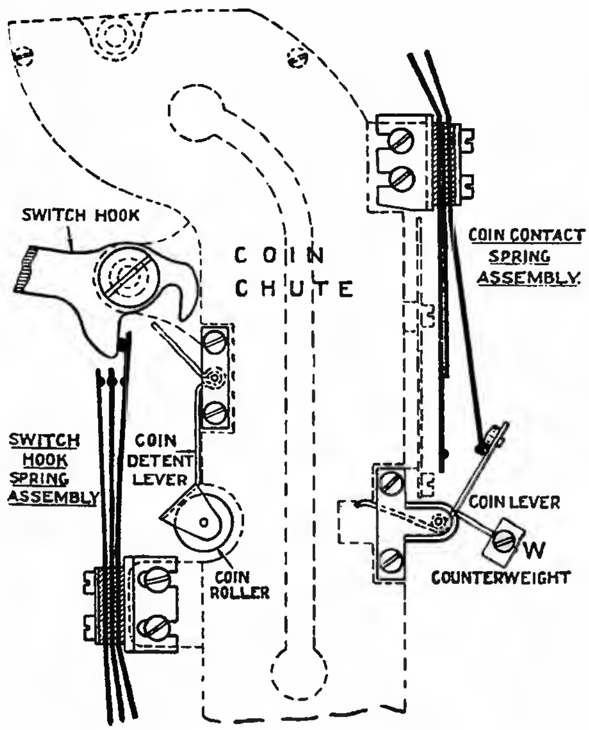
(b) Typical Circuit.
(The apparatus in circle may replace the relay PR.)



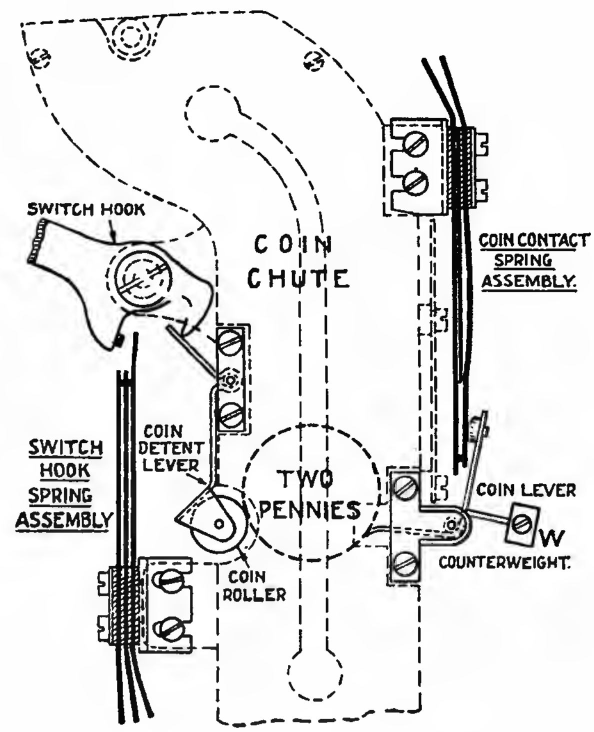
(c) Alternative Circuit.

AUTOMATIC PUBLIC TELEPHONE.

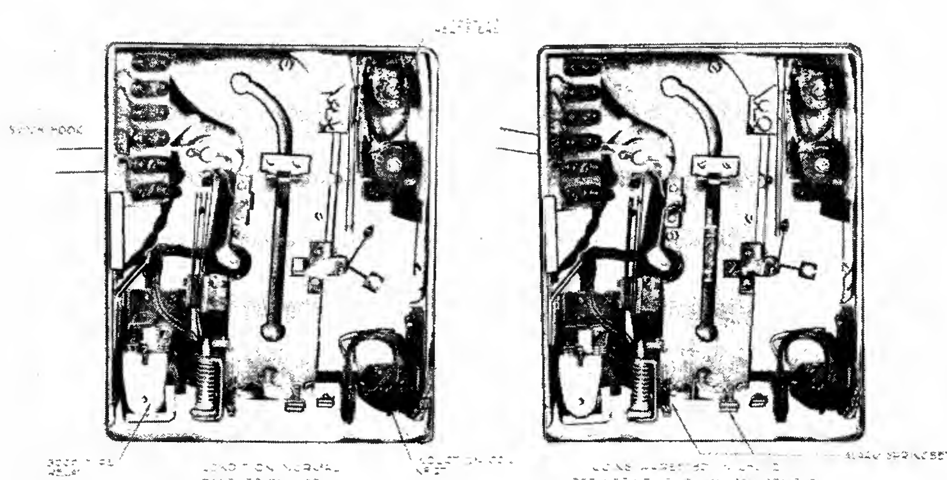
FIG. 29.



(a) Chute With Receiver on Hook and Without Pennies.



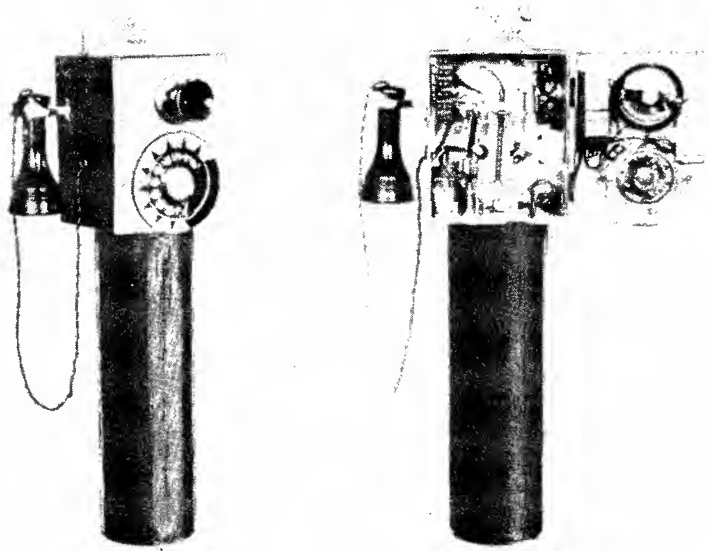
(b) Chute With Receiver Off Hook and Two Pennies.



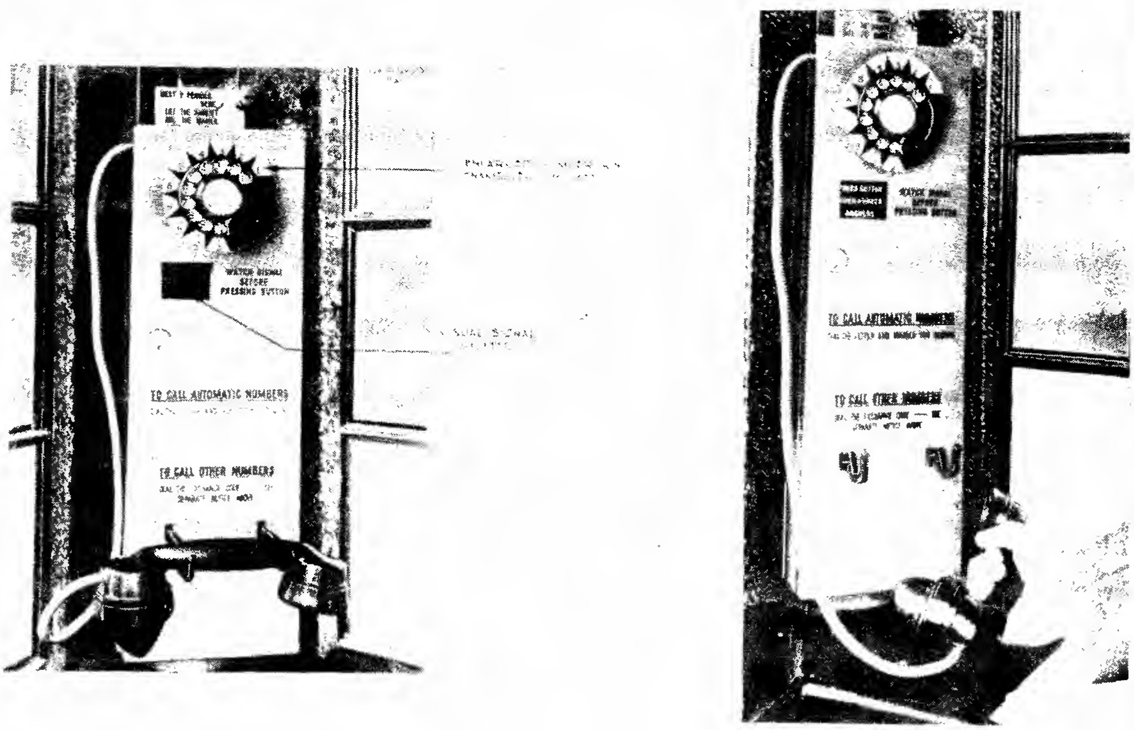
(c) Chute for improved Type of Public Telephone in Fig. 31a.

COIN CHUTE FOR AUTOMATIC PUBLIC TELEPHONE.

FIG. 30.



(a) Improved Type Automatic Public Telephone.



(b) Views of Public Telephone 1AW.

AUTOMATIC PUBLIC TELEPHONES, ALTERNATIVE TYPES.

FIG. 31.

PUBLIC TELEPHONE CABINETS.

Fig. 29c is an alternative circuit of the public telephone in which a relay and rectifiers replace the polarised relays, and Fig. 31a shows the improved type of automatic public telephone, in which this circuit is generally used.

Fig. 31b shows the Public Telephone 1AW or Handset Public Telephone. This is a unit fee post-payment type, which incorporates a handset and other new features. It is a self-contained corner mounting unit and is shown mounted in a public telephone cabinet. In the coin chute used with the public telephones previously described, a projection on the switch hook prevents the coin detent lever and roller from moving. Thus, the pennies are held in the chute and operate the coin lever and springs until the receiver is replaced, when the pennies continue their journey to the coin tin. In the Public Telephone 1AW, the coin lever or stop is not held by the switch hook, but by an extension on the armature of a magnet which operates when current flows through the telephone circuit. When the called subscriber answers, a relay operates and performs the functions of short-circuiting the transmitter and displaying a notice (in a small window) on which is printed "Press button when number answers." Thus, a visual, as well as an aural, indication that the called party has answered is given.

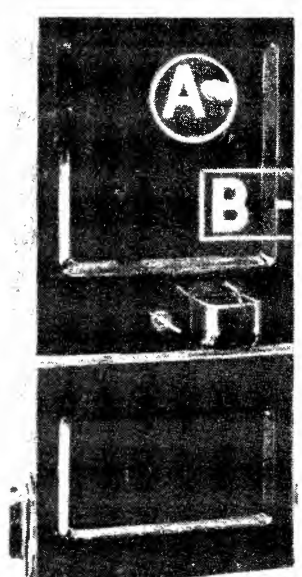
13. MULTI-COIN PUBLIC TELEPHONE.

13.1 This public telephone consists of a telephone with the addition of a multi-coin collecting attachment, and was introduced principally to allow the general public to make Trunk Line and Phonogram calls from unattended locations. It is suitable for use on all classes of exchanges, but it is not proposed to use it on manual C.B. exchanges as special line and cord circuits are necessary.

When used on automatic exchanges for local calls, or magneto exchanges for local and trunk line calls, this telephone functions as a prepayment type. When used on automatic exchanges for Trunk Line calls, it functions as a post-payment type.

/ 13.2

13.2 Multi-Coin Attachment. The multi-coin attachment is shown in Fig. 32, and an exploded view, including the self-sealing coin tin, is shown in Fig. 33. The outer case is constructed from pressed sheet steel with welded joints and is divided into two compartments. The upper contains the mechanism and wiring terminals, the lower the coin tin. The lower compartment is reinforced, and underneath the coin tin, holding it in position, is an iron plate which slides in a slot from the right-hand side. At the right-hand side, a recessed casting welded to the case contains a removable combination lock, which secures the iron plate by means of a projection or tongue entering the recess through a slot.



MULTI-COIN ATTACHMENT.

FIG. 32.

COMPONENT PARTS OF ATTACHMENT.

FIG. 33.

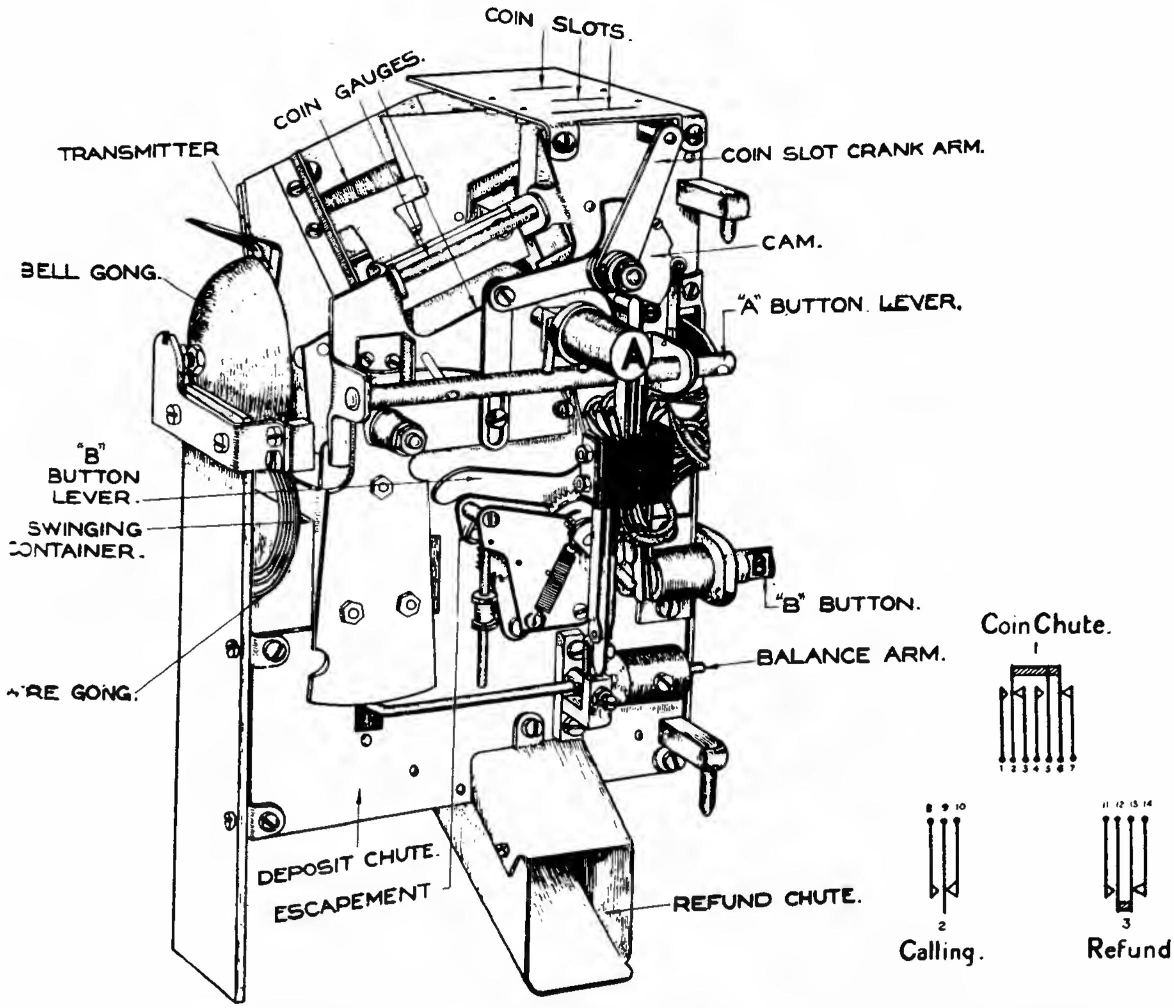
13.3 Mechanism. (See Fig. 34.) At the top of the mechanism are three coin slots which line up with a sloped casting on the case marked in raised letters from front to rear, "Penny", "Sixpence", "Shilling". The slots are accurately cut and serve as gauges to prevent the entry of coins larger than the correct denomination and also mis-shapen coins.

Immediately beneath the slots are the coin guides, and included in each of these is a coin gauge which rejects coins of smaller diameter than the standard of the correct denomination. Fig. 35 shows a coin guide and gauge. The rejected coins are returned to the user via the refund chute and receptacle. To do this, the coin guides are given a downward slope of approximately 25° and a sideways slope or tilt of approximately 15° so that a coin is supported by its flat side at this angle as it rolls down the coin guide. On the section comprising the coin gauge, the side wall is punched out to form a flap which is given a further slope of about 33°. Across the top of the punched-out portion, an adjustable flat metal piece is fixed by two screws at such height that coins of correct diameter are supported at the upper edge by the metal piece and are prevented from falling sideways on to the flap. The upper edges of coins of smaller diameter miss the metal gauge piece and falling on to the flap, slide from this over the narrow ledge, which forms the bottom of the coin guides, into an opening leading to the refund chute. Fig. 35 shows a coin being rejected.

After passing the gauges, the coins strike a signal gong and then fall into a swinging coin container which is mechanically controlled by two press buttons marked "A" and "B". These buttons are operated by the caller. The operation of button "A" moves the container to the left and deposits the coins in the coin tin, and the operation of button "B" moves the container to the right and returns the coins to the caller via the refund chute and receptacle.

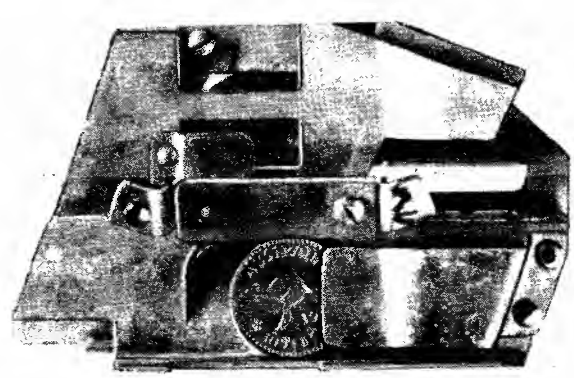
The signal gongs mounted at the left of the coin guides are a telephone type bell and a coiled wire. A penny strikes the wire gong once, a sixpence strikes the bell gong once, and a shilling, by means of a double guide, strikes the bell twice. The wire gong emits a low note and the bell gong a high note. These "tones" are rendered audible to a telephonist by means of the Coin Signal Transmitter which is mounted on a heavy "U" shaped spring inside the bell. The transmitter is the button type, modified by having the usual mica diaphragm replaced by a thin ebonite diaphragm and the carbon chamber tightly packed with carbon granules. The ebonite diaphragm carries a central ebonite stud which is held in close contact with the bell by the mounting spring, and by this means the transmitter is made to respond to the vibrations of the gongs. The gongs are rigidly fixed to the same mounting plate and this communicates the vibration of the wire gong to the bell and transmitter.

/ Fig. 34.



COIN COLLECTING MECHANISM AND DETAILS OF THE SPRING-SETS.

FIG. 34.

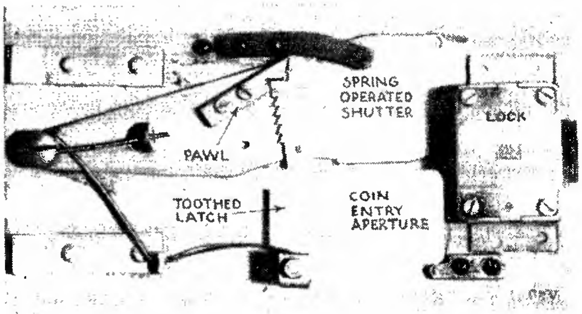


COIN GUIDE AND GAUGE.

FIG. 35.

The transmitter is unresponsive to speech, but to prevent the vibration of the case caused by the caller's voice being picked up by the transmitter, it was found necessary to mechanically insulate the gong assembly from the rest of the mechanism by means of soft rubber pads.
The capacities of the three sections or compartments of the swinging coin container are 10 pennies, 8 sixpences, and 10 shillings, respectively. When the fee to be inserted by the caller contains more than eight coins of the same denomination, the telephonist instructs the caller to insert eight only, then press button "A" before inserting the remainder.
The mechanism is hinged at the right-hand side of the case and can be swung clear by simply pressing a latch, or the mechanism can be removed entirely by lifting it off the hinges which are of the pin and socket type. The electrical connections between the spring-sets on the mechanism and the terminals on the back of the case are made by means of a 16 point plug and jack of the automatic switch type.

13.4 Coin Tin. The self-sealing coin tin shown to the right of Fig. 33 is constructed from sheet steel with welded seams. The lid, shown in Fig. 36, is also of sheet steel. In the bottom of the coin tin a keyhole shaped hole is cut so that the coin compartment key can be inserted to assist in the withdrawal of the coin tin if necessary. Mounted on the lid is a spring operated shutter which automatically closes the coin entry aperture when the coin tin is drawn from its compartment. The shutter is retained in the open position by a toothed latch engaging a pawl screwed to the shutter, the latch being held against the pawl under the pressure of a spring. The automatic closing of the shutter is accomplished by a steel pin with a tapered point fitted inside the coin compartment in such a position that it passes through a 1/4" diameter hole in the lid when the coin tin is placed in position. The pin pushes the latch aside and out of contact with the pawl and at the same time allows just sufficient closing movement of the shutter to prevent the pawl re-engaging when the coin tin is withdrawn. When the shutter is fully closed, it is locked by the latch and pawl.

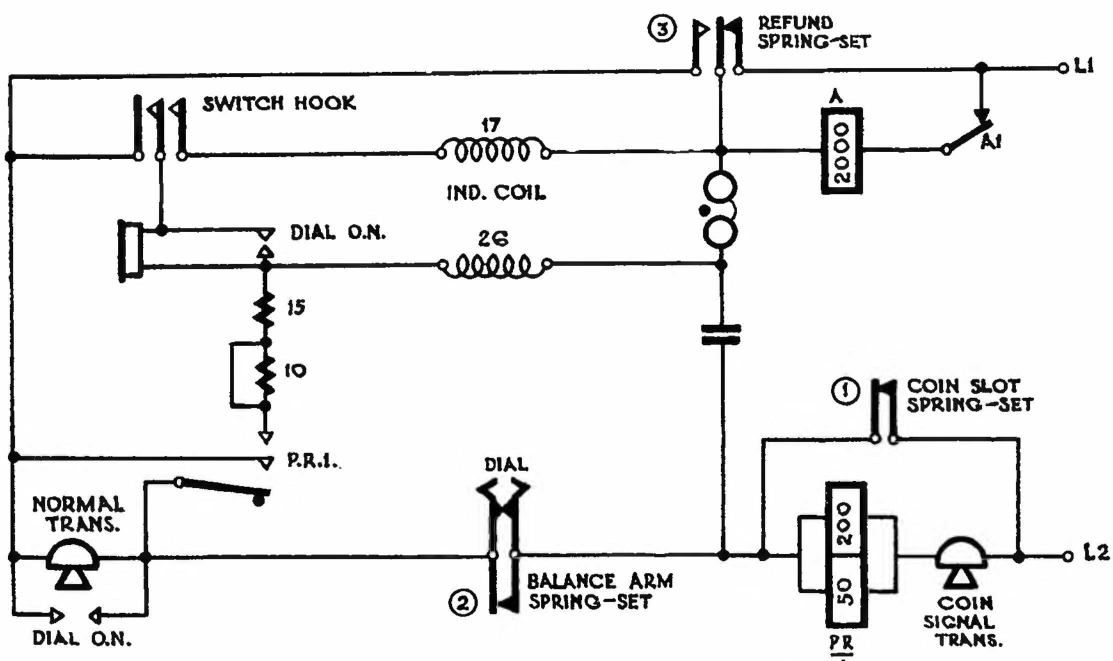


LID OF SELF-SEALING COIN TIN.

FIG. 36.

13.5 Circuits for Multi-Coin Public Telephones.

Automatic Area - Local Call (see Fig. 37). To originate a local call on this public telephone, the caller inserts two pennies in the "penny" slot. The first coin moves the coin slot crank arm which operates the coin slot spring-set (1) by means of an ebonite stud fixed to the cam. The cam locks in position by the semi-circular slots in its periphery engaging a roller fitted to the end of a flat steel spring. Spring-set (1) removes a short circuit from the coin signal transmitter and polarised relay PR. The two pennies come to rest on the balance arm which extends across the bottom of the penny compartment of the swinging coin container. The balance arm which is adjusted by a sliding weight to just operate with the weight of two well-worn pennies, operates spring-set (2) which removes a short circuit from the dial. The number can now be dialled.



MULTI-COIN ATTACHMENT PUBLIC TELEPHONE FOR METROPOLITAN AUTOMATIC AREAS.

FIG. 37.

If the call is to an automatic exchange subscriber, the battery reversal, which takes place when the call is answered, operates the polarised relay PR. Contacts of this relay short-circuit the telephone transmitter and place a non-inductive resistance across the receiver to prevent its use as a transmitter. Upon hearing the called subscriber answer, the caller depresses button "A". This action deposits the pennies in the coin tin and restores the coin slot crank-arm to normal. The

/ PR

PR relay and coin signal transmitter are again short-circuited by spring-set (1) and the relay in releasing removes the short circuit from the telephone transmitter and the shunt from the receiver and allows the call to proceed.

If the call is to a manual exchange subscriber, the battery reversal takes place when the called subscriber answers or when the telephonist rings the called subscriber, according to the type of exchange or circuit arrangements. PR is included in the circuit to enable the caller to speak to manual exchange or "service" telephonists. If this were not necessary, the function of the PR relay could be performed by the coin slot spring-set (1), which operates when the first coin is inserted and restores when button "A" is depressed.

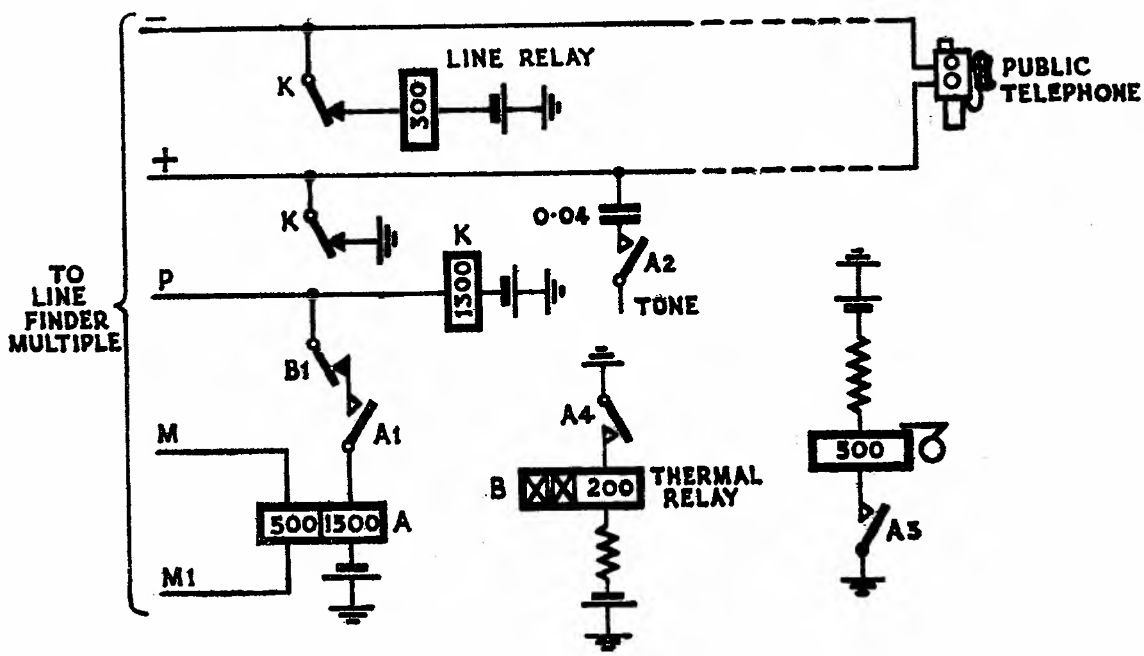
If the call is ineffective, the caller depresses button "B" and the pennies are refunded. Button "B" also operates the refund spring-set (3), which opens the line circuit and allows the automatic switches to release. To ensure that the switches have ample time to release, the refund spring-set is held operated for seven seconds by an escapement mechanism which is adjusted by means of a pendulum bob. The further functions of the refund spring-set will be explained later.

Automatic Area - Trunk or Phonogram Call. (See Fig. 37.) The caller inserts two pennies, as on a local call, and dials the special number allotted. If the call is for trunk service, the trunk operator obtains the number of the P.T. cabinet from the caller, takes particulars of the call and instructs the caller to press button "B" to recover the two pennies and wait outside the cabinet for the call to mature. When the call matures, the trunk telephonist dials the P.T. switch number and, after ascertaining that the correct caller answers, the telephonist instructs the caller to insert the fee in the correct slots. The telephonist checks the fee inserted by means of the tones transmitted by the coin signal transmitter. When satisfied that the correct fee has been inserted, the caller is instructed to press button "A". This deposits the coins and the call proceeds as for a local call. If the caller presses button "B", the coins will be refunded and spring-set (3) operated. Reference to Fig. 37 shows that this spring-set also introduces the self-interrupting 2,000 ohm relay A into the circuit. The buzzer action of relay A transmits a tone to line which is heard by the trunk telephonist, and a seven seconds clearing signal is received on the supervisory lamp. These signals warn the telephonist that the wrong button has been depressed and the caller is instructed to redeposit the fee. The refund spring-set also short-circuits the switch hook of the telephone, so that the caller cannot mask the buzzer tone by temporarily operating the switch hook.

/ Phonogram

Phonogram calls are similarly treated except that, when the caller asks for "telegrams," the call is reverted immediately after the refund button is depressed by the caller, and the call is routed to phonograms over special junctions. The battery reversal for the operation of the polarised relay on reverted calls to the public telephone is obtained by reversing the normal wires to the final selector bank contacts. The relays PR and A and the 15 + 10 ohm non-inductive resistance are standard serial items and are supplied separately to the multi-coin attachment.

Automatic Area - Calls to Demand Trunk Lines. To enable Trunk Line telephonists to identify calls from coin attachment telephones, in connection with Demand Calls for trunk line service, the normal line relay circuit in the automatic exchange is altered, as shown in Fig. 38. The circuit given is for use in a 2,000 type Line Finder exchange.



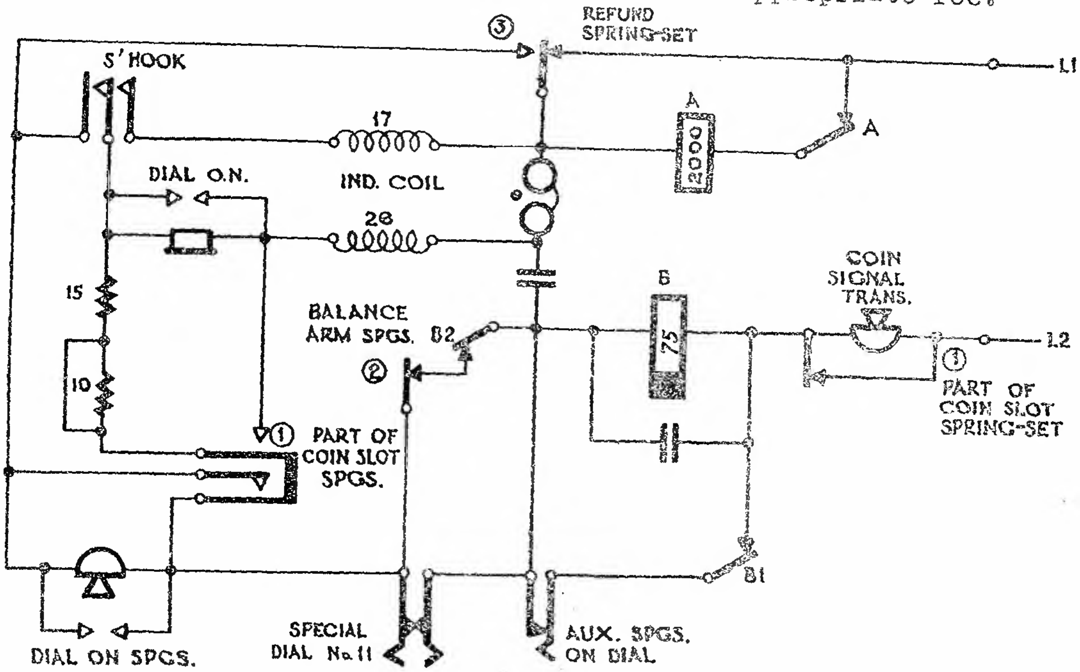
LINE CIRCUIT FOR MULTI-COIN PUBLIC TELEPHONES.

FIG. 38.

When a call to the Trunk Line Demand Service is made via this circuit, A relay operates and locks when the telephonist answers the call. A2 connects a 400 cycle tone interrupted at 1-1/2 second intervals to the line and this indicates to the telephonist that the call is from a public telephone. The tone signal is disconnected at the end of 15 seconds by the operation of the thermal relay B which operates and releases relay A at B1.

/ Calls

Calls from an R.A.X. Area (see Fig. 39). Local calls from a multi-coin attachment connected to an R.A.X. are made in a similar way as when connected to an automatic exchange in the metropolitan area. The circuit operation is different, however, as the functions performed by relay PR in Fig. 37 are performed by the coin slot spring-set. Trunk or Phonogram calls are lodged with the telephonist at an R.A.X. parent exchange. Trunks to these are grouped on the "0" level and are reached by dialling 01, 04, etc., depending on the number of trunks in each group; the selection of an idle trunk in each group is automatic as in P.B.X. groups. All calls on the "0" level, therefore, are under the control of an operator. It is convenient to allow such calls to be set up without prepayment as they will not be allowed to proceed without the appropriate fee.



MULTI-COIN ATTACHMENT PUBLIC TELEPHONE FOR R.A.X. AREAS.

FIG. 39.

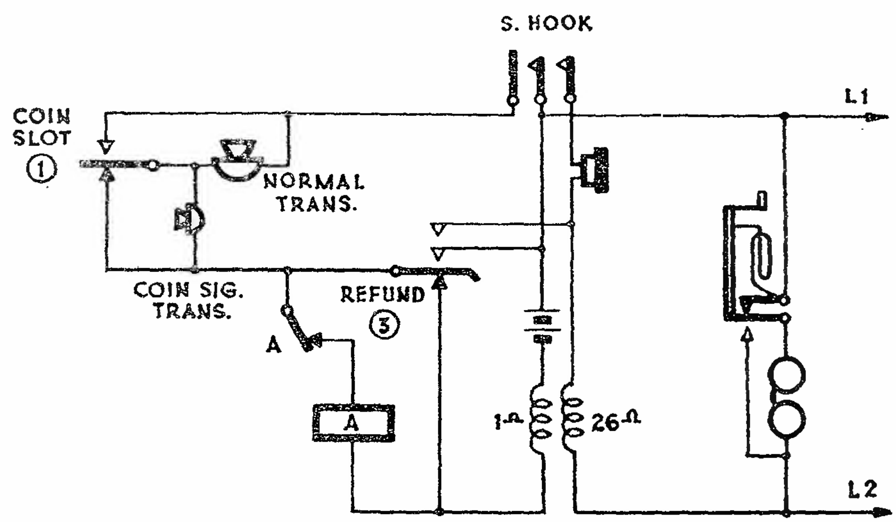
To enable a parent exchange to be called without the "prepayment" of twopence, the telephone is fitted with a special dial having an auxiliary cam which operates when the dial is pulled to the full extent on dialling "0". The special dial is known as Dial No. 11, and differs from Dial No. 10 only in the provision of the auxiliary cam. The cam removes the short circuit from relay B which operates in series with the line. Contact B1 opens the auxiliary cam circuit to prevent the relay being again short-circuited when the cam springs close on the dial returning to normal. Contact B2 removes the short circuit from the dial and allows the "0" and subsequent impulses to be dialled. The relay remains operated during dialling due to its slow release feature. The remainder of the circuit functions are the same as given for Fig. 37 except that,

/ as

as previously mentioned, the coin slot spring-set is arranged to short-circuit the telephone transmitter and shunt the receiver with the non-inductive resistance. In Fig. 39 the coin slot spring-set is shown in two parts for simplicity, but actually these are mechanically coupled. It is unnecessary to revert Trunk and Phonogram calls unless demand service cannot be given, as there is no polarised relay in the circuit and the circuit arrangements of the R.A.X. provide for a special indication to the parent exchange telephonist when calls are originated from a public telephone fitted with a multi-coin attachment.

It will be observed that a multi-coin attachment connected to an R.A.X. works on the "prepayment" principle for local calls, but on the "post-payment" principle for Trunk calls.

Magneto Area - Local and Trunk Calls. Typical circuit arrangements for this type of service are shown in Fig. 40.



MULTI-COIN ATTACHMENT PUBLIC TELEPHONE FOR MAGNETO AREAS.

FIG. 40.

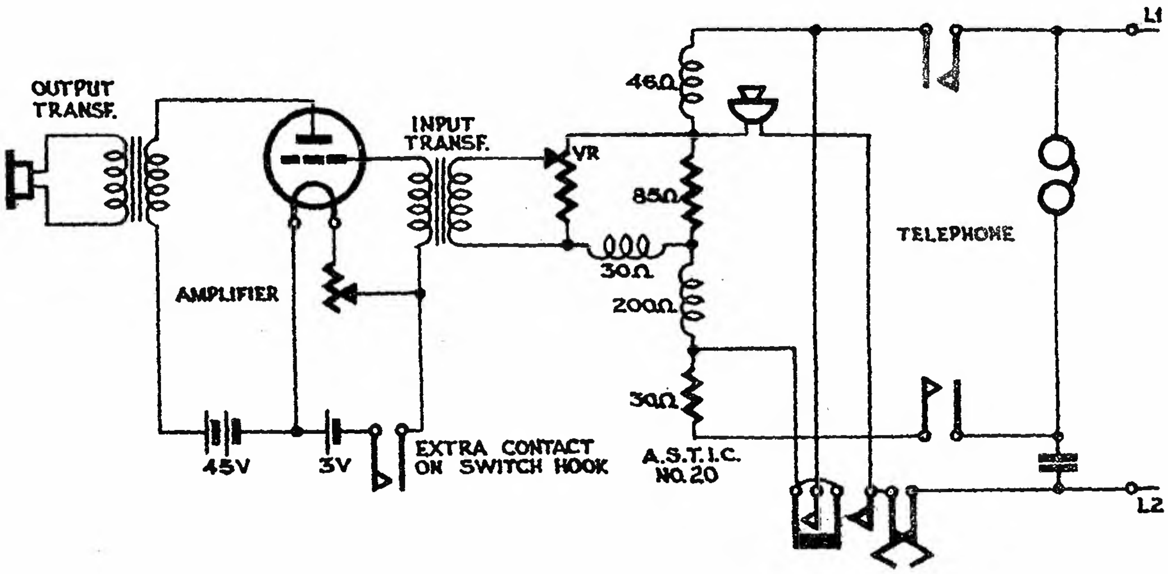
The exchange is signalled in the normal way and, for local or trunk calls, the caller is requested to insert the appropriate fee, which is checked on entering by the aid of the coin signal transmitter and deposited by the "A" button. If the refund button "B" is depressed, the 30 ohm self-interrupting relay A is brought into circuit. The A relay is operated from the speaking battery and develops a tone in the primary circuit, which is induced in the line circuit by the secondary winding of the induction coil. The refund spring-set (3) also short-circuits the local receiver and switch hook. Trunk calls are only reverted where demand service cannot be given.

/ 14.

14. TELEPHONE WITH AMPLIFIER.

14.1 A telephone circuit has been developed to amplify incoming voice currents. This enables partially deaf people to use a telephone, but may also be installed when the telephone must be placed where there is considerable noise, as in a workshop.

The circuit shown in Fig. 41 is that of an automatic handset type telephone to which has been added an amplifier. A variable resistance takes the usual place of the receiver and a transformer is connected to this resistance. The receiver is connected to an output transformer. An extra pair of springs fitted to the switch hook complete the circuit to the filament of the valve.



AUTOMATIC TELEPHONE WITH AMPLIFIER.

FIG. 41.

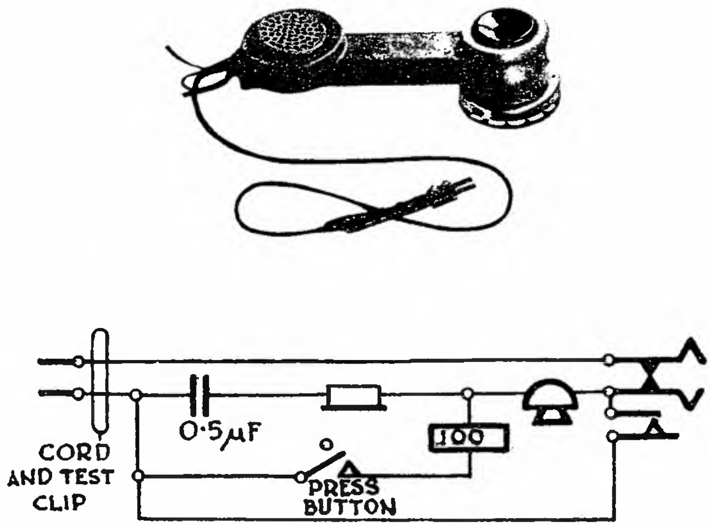
The incoming voice circuits, which in the normal circuit pass through the receiver, pass through the variable resistance VR and the primary of a step-up transformer in parallel in this circuit. The resistance VR may be adjusted to vary the current through the input transformer.

The secondary of the input transformer is connected across the grid and filament of a triode amplifier valve. The output of this valve is fed through a step-down transformer to the receiver.

/ 15.

15. BUTTINSKI OR HANDSET NO. 3.

15.1 The Buttinski or Handset No. 3 is a portable assembly of receiver, transmitter and dial, etc., for the use of faultsmen. The circuits of the handsets in use vary considerably, but a typical circuit is shown in Fig. 42, together with a sketch of the instrument.



TYPICAL BUTTINSKI AND CIRCUIT.

FIG. 42.

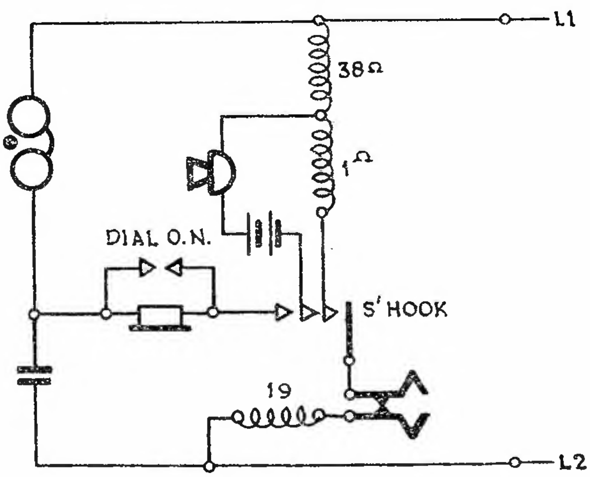
15.2 The A and B wires are terminated on a test plug or clips suitable for the work to be performed. In the normal condition, the Buttinski provides a supervisory or listening facility. A condenser in series with the receiver, transmitter and dial allows voice frequency currents to pass via the receiver, but prevents the flow of direct current. The operation of the press button completes the speaking and dialling circuits by providing a direct current loop via the press button, retard, transmitter and dial. This retard allows direct current to flow through the transmitter but effectively prevents voice frequency currents from taking this path. The voice frequency currents, therefore, flow via the receiver.

/ 16.

16. TELEPHONES FOR HIGH RESISTANCE LINES.

16.1 In a large network some subscribers will have a much higher line resistance than others. For purposes of good transmission there should be a minimum current of 50 mA through the transmitter for a standard telephone. Where it is not possible to give good transmission with a normal telephone a special telephone may be provided.

16.2 If the transmission is below standard but dialling, signalling or supervision is within working limits a telephone with a circuit similar to that shown in Fig. 43 is provided. The main feature is the inclusion of a local battery in an automatic telephone set. This telephone circuit provides for an improvement in transmission when compared with a standard telephone. A generator may be fitted if necessary. The three windings of the induction coil are in inductive agreement and the auto. transformer effect of this coil improves the reception and transmission.

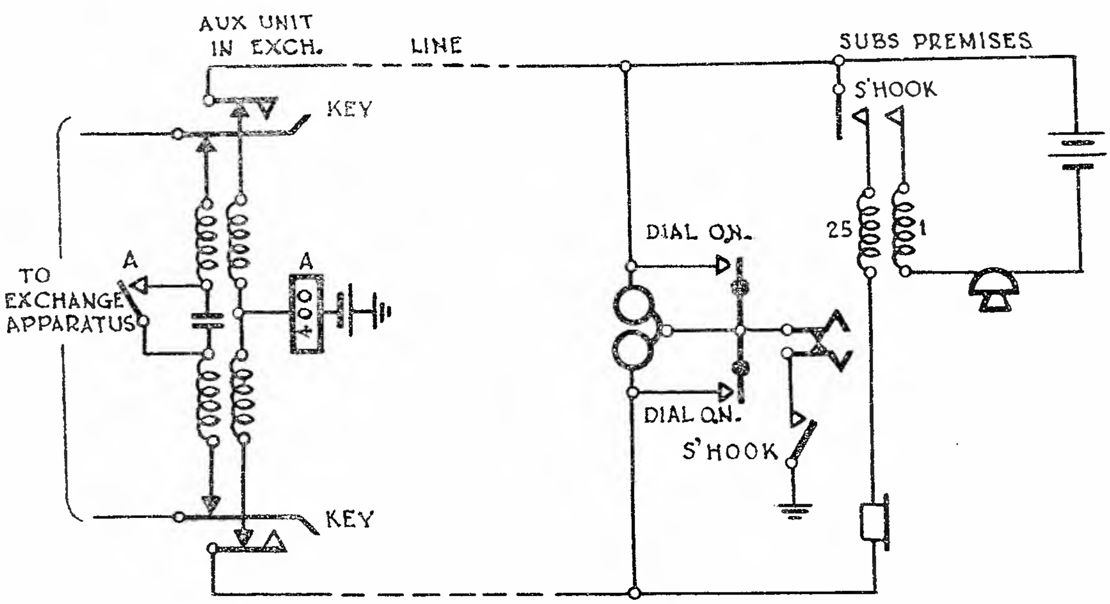


TELEPHONE FOR LONG LINES.

FIG. 43.

16.3 When the transmitter current is below standard and the resistance of the line also interferes with dialling, signalling or supervision, the auxiliary unit shown in Fig. 44 is fitted at the exchange in addition to a special telephone at the subscriber's premises.

As dialling and/or signalling is over both sides of a pair in parallel the line resistance is reduced to 1/4 of the series loop. The A relay at the exchange repeats the impulses or loop condition to the exchange apparatus. The dialling and signalling is carried out from the split of the magneto bells and the transformer thus maintaining an inductive balance and reducing noise during transmission. A generator is required when the telephone is an extension from an interswitch. The operation of the key in the auxiliary unit at the exchange allows a test to be made to the subscriber without the transformer in circuit.



TELEPHONE AND AUXILIARY UNIT FOR LONG TELEPHONE LINES.

FIG. 44.

17. TEST QUESTIONS.

1. Sketch the transmitter battery feed used at automatic exchanges.

2. Describe the mechanical operation of the automatic switch, the selector.

3. State the functions of the dial.

4. Sketch the basic automatic telephone circuit.

5. How does the key control on an automatic telephone prevent unauthorised persons from using the telephone?

6. Draw a circuit of the basic automatic public telephone.

7. Describe the mechanical operation of the coin chute mechanism used on automatic public telephones.

8. How does the automatic public telephone coin chute mechanism differ from that used on manual public telephones?

9. Briefly describe the operation of the multi-coin public telephone.

10. In the contact bank on page 6 mark the contacts of lines numbers 11, 10, 01, 57 and 88.

11. When is the line battery reversed on -

    (a) Automatic to Automatic call.

    (b) Automatic to C.B. Manual call.

    (c) Automatic to Magneto call.

12. Write a description of the operation of the Public Telephone circuit in Fig. 29c.

END OF PAPER.

COMMONWEALTH OF AUSTRALIA.

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COURSE OF TECHNICAL INSTRUCTION.

EXTENSION SWITCH AND CORDLESS P.B.X.

CONTENTS.

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1. EXTENSION WORKING.

1.1 As explained in Telephony I, Paper No. 7, one telephone in a fixed location may not meet the requirements of some subscribers, and various standard arrangements are used to meet these conditions. The arrangements are -

Two Telephones with a Change-over Switch. This service allows calls to be made and answered on one of two telephones. Normally, the exchange line connects through the switch to one of the telephones. Operation of the switch connects the other telephone to the exchange line after disconnecting the first telephone. The switch is of the rotary snap type and has no "off" position, so that there is always one telephone connected to the exchange line. See Plan No. 5, Paper No. 6, Telephony I.

Telephones in Parallel. A maximum of three telephones in parallel is permitted on exchange lines. A maximum of two telephones is permitted on extension lines from extension switches or P.B.X's. The bell of one telephone is left in circuit; the bell circuits of the remaining telephones being opened. While these bell circuits would not affect C.B. working, they cause dial impulse distortion should the service be ultimately changed over to automatic working.

Calls can be answered from, or originated at, any of the telephones, which must all be within 20 feet of each other and in the same room. See Plans Nos. 6 and 7 in Paper No. 6 of Telephony I. A further extension of this system involves a press button at the location of the telephone where the bell is left in circuit. This press button controls a trembling bell at each of the other telephones, which may then be called by Morse code signals. As all calls are answered on one telephone, the press button is used to notify the other telephones that an incoming call is to be answered on one of the telephones. If press button service is not provided, it may be necessary to speak or shout across a room in order to inform the person at the other telephone that a call is to be answered. When a press button service is provided, the distance between telephones may range to 40 feet and the telephones may be in separate partitioned-off enclosures, an arrangement not allowable where the separate code calling feature is not employed.

Portable Telephone. (See Plan No. 8 in Paper No. 6 of Telephony I.) This facility is afforded by connecting the pedestal of a table telephone set to a plug. The subscriber can then obtain connection to the line by plugging the pedestal into a plug socket. A number of plug sockets may be provided at points desired by the subscriber. The bell set is fixed in position and suitable cable is then connected from the bell set to the plug sockets around the subscriber's premises. If the bell cannot be heard at any point, an extension bell of the magneto type is also installed.

Extensions with Intercommunication. None of these systems provide for intercommunication between the main telephone connected to the exchange line and the extension points. Parallel telephones with a separate code calling feature provide a measure of intercommunication, but the distance between the telephones is so limited that this feature is of little use. Subscribers, however, frequently desire to speak between various telephones in their own premises, but find that a limited number of exchange lines concentrated at one convenient point will meet their requirements for communication with the exchange network. To meet such requirements the following equipment is used -

(i) Extension Switch.
(ii) Intercommunication System, or
(iii) Private Branch Exchange Switchboards.

A description of the Extension Switch follows. Details about switchboards for Private Branch Exchanges are given later in this Paper and also in Paper No. 6. Information on Intercommunications Systems is given in Paper No. 7.

2. EXTENSION SWITCH (C.B. AND AUTOMATIC).

2.1 The extension switch allows an exchange line, which normally terminates on the main telephone, to be extended to an extension telephone. The switch also allows the extension telephone to signal and speak to the main telephone or the exchange. A typical switch, switching key and circuit are shown in Fig. 1.

The extension switch, which is installed at the main telephone, thus provides for intercommunication between the main and extension. To provide this facility a more or less complex switch is required. The extension switch shown in Fig. 1 provides for four switching conditions, viz -

(1) Main Telephone Connected to the Exchange. With the switch in this position, the extension telephone is terminated on a magneto bell and a generator is provided to call the extension if required.

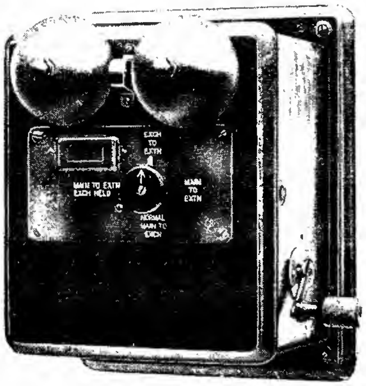
(2) Main Telephone Connected to the Extension. The exchange line is connected to a magneto bell to receive an incoming call.

(3) Main Telephone Connected to the Extension Telephone and the Exchange Line Held. This condition is required so that an outgoing exchange call from the main telephone can be held whilst an inquiry is made to the extension.

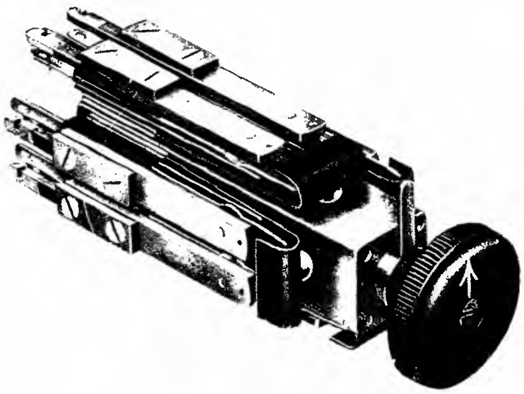
(4) Exchange Connected to the Extension Telephone. The circuit provides for secrecy from the main instrument, if required, and a supervisory indicator in the bell set shows when an extension to exchange call is in progress.

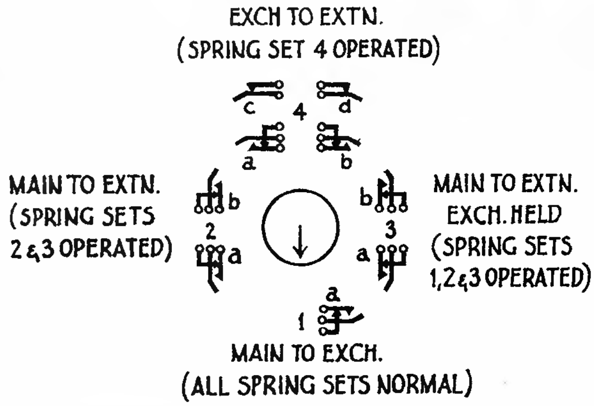
2.2 If the loop of a C.B. line to the exchange is opened, a clearing signal is given at the exchange, or, if the exchange is automatic, the automatic switches restore to normal. To avoid such disconnection at the exchange when the extension switch is in the "Main to Extension, Exchange Held" position, the loop to the exchange is closed through one of the bell coils. In the "Exchange to Extension" position, a 50 ohm slow release relay, which is a combined relay and indicator, is in circuit. This relay-indicator provides supervision at the extension switch on through connections. As the switch may be used for both C.B. and Automatic exchanges, the relay is made slow releasing to prevent chattering when dialling from the extension

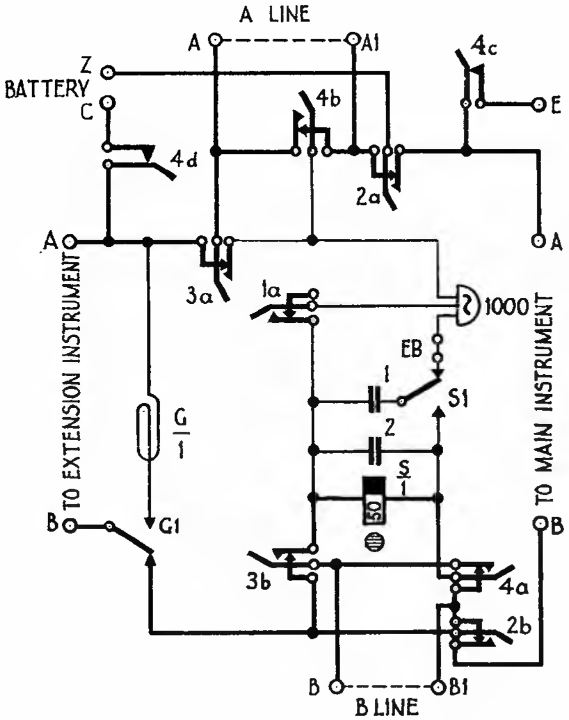
/ Fig. 1.



(a) Extension Switch.







(b) Circuit.

Key Position	Condition	Springs Operated
1	Main to Exchange Extension on Switch Bell.	
2	Main to Extension Exchange on Switch Bell.	2 and 3
3	Main to Extension Exchange Held.	1-2 and 3
4	Exchange to Extension.	4

(c) Switching Key.

EXTENSION SWITCH (C.B. AND AUTOMATIC).

FIG. 1.

to an Automatic exchange. Similarly, to prevent impulse distortion under the same conditions, the relay, when operated, removes the bell and condenser of the extension switch from across the connection. The bell is open-circuited and the condenser is placed in the speaking circuit in parallel with the 2 μF condenser already bridged across the 50 ohm relay. The condensers then form a path for the alternating speech currents clear of the impedance of the relay.

On "Main to Extension" calls, exchange battery is not available and a local battery is installed to supply the necessary current for the operation of the transmitters. A generator and 2 μF condenser are provided at the extension telephone to enable the main to be called. Similarly, the extension telephone is called by the main by means of the generator in the extension switch.

If dialling facilities are not required from the extension, a telephone, with a generator mounted in the position normally occupied by the dial, is fitted.

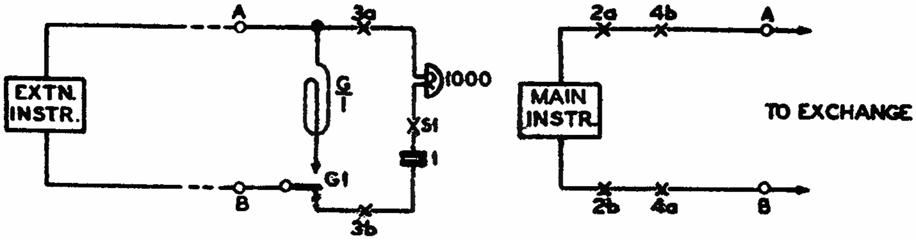
2.3 Simplified circuits of the connections are shown in Fig. 2, in which circuit 2a is self-explanatory.

The point of interest in Fig. 2b is the introduction of a local 3 volt battery to provide transmitter current on main to extension calls.

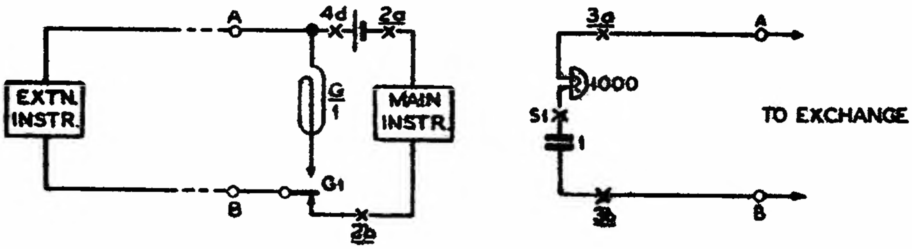
In Fig. 2c, the exchange is held with the switch in Position 3 by one 500 ohm winding of the magneto bell. The use of the bell as a hold coil enables the subscriber to be rung if he should accidentally leave the switch in the "Exchange Hold" position.

The supervisory relay S (Fig. 2d, switch Position 4) is connected in series with one line and operates from the normal line current to the extension. During conversation, S1 disconnects the magneto bell in the bell set and places a 1 μF condenser in parallel with the existing 2 μF condenser across the S relay, thereby providing a very low impedance path for the speech currents. S also acts as a supervisory indicator by showing a white disc when operated. When the extension hangs up at the end of the conversation, S releases and at S1 places a magneto bell in series with a 1 μF condenser across the exchange line. This provides for any incoming call received before the switch is restored.

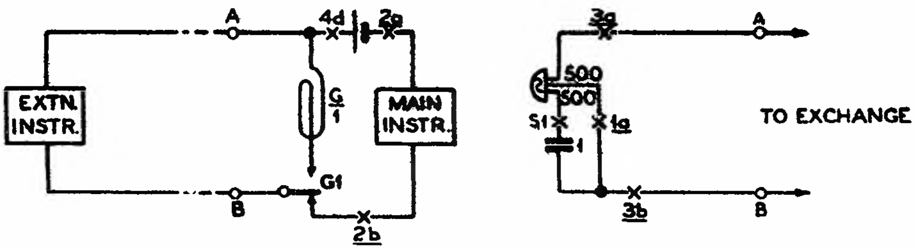
/ Fig. 2.



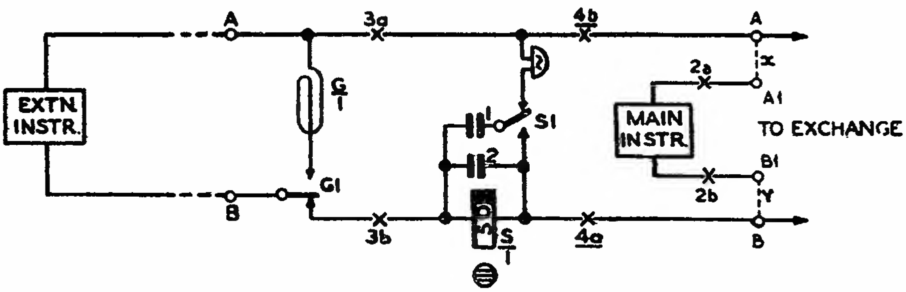
(a) Main to Exchange. Position 1.



(b) Main to Extension. Position 2.



(c) Main to Extension - Exchange Held. Position 3.



(d) Exchange to Extension. (Straps x and y Removed When Secrecy is Required.) Position 4.

EXTENSION SWITCH (SIMPLIFIED CONNECTIONS).

Spring-sets are shown as x.
Spring-sets in operated position are shown with underline, for example, 3a.

FIG. 2.

3. PRIVATE BRANCH EXCHANGE SWITCHBOARDS (P.B.X's.).

3.1 Private Branch Exchange Switchboards for Manual (C.B.) exchanges, usually called P.B.X's., are divided into two classes, that is, "Cordless" and "Cord" types.

Each cordless switchboard is fully equipped, and should the subscriber's requirements ultimately exceed the capacity, the switchboard is replaced by a larger one.

The cord type switchboards are made in two main divisions of ultimate 40 lines capacity and ultimate 100 lines capacity. In each case the ultimate capacity is determined by the size of the carcase of the switchboard. Each size of cord board may be supplied partially equipped, that is, switchboards initially equipped for a certain number of lines but capable of increase to the ultimate capacity as the requirements of the subscriber increase.

3.2 The cord type switchboard (see Paper No. 6), like the ordinary C.B. telephone, is provided with an opening for connection of a dial when such is required. The hold coil associated with each exchange line must be replaced by one of higher resistance if the switchboard is transferred from a C.B. to an automatic exchange area. The cordless switchboards are suitable for use in connection with either a C.B. manual or an Automatic exchange.

4. CORDLESS TYPE P.B.X. SWITCHBOARDS.

4.1 This type of switchboard is supplied in three sizes -

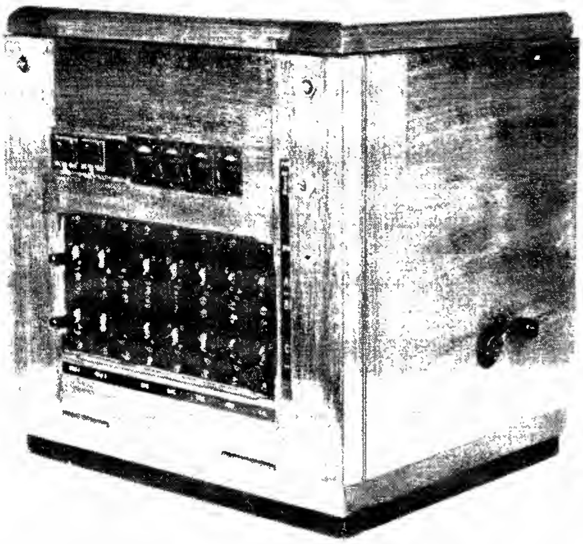
$$\frac{1 + 3}{4}$$

$$\frac{2 + 4}{6} \text{ and}$$

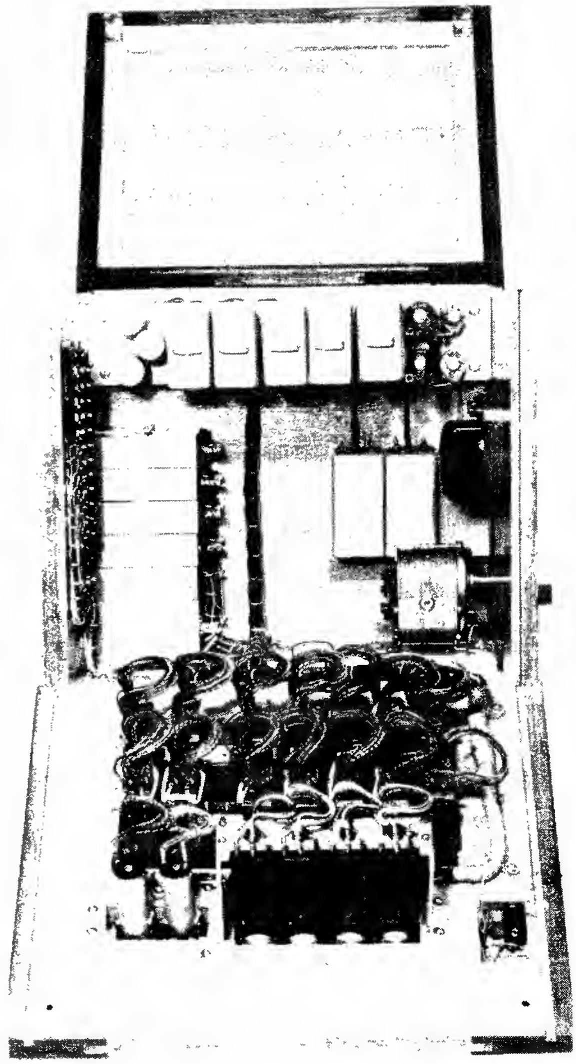
$$\frac{3 + 9}{12}$$

The first figure indicates the number of exchange lines, the next figure indicates the local or extension lines and the figure below the line denotes the ultimate capacity. The calling indicators (see also paragraph 4.9) for the exchange lines are 1,000 ohm tubular type and those for the extension lines are 500 ohm "eye-ball" type. The eye-ball type serves as both calling and clearing signals for the same extension line and is provided with alarm contacts to give an audible, as well as a visual, alarm. Pictures of a typical $\frac{2 + 4}{6}$ cordless P.B.X. are shown in Fig. 3.

/ Fig. 3.



(a) Exterior View.



(b) Interior View.

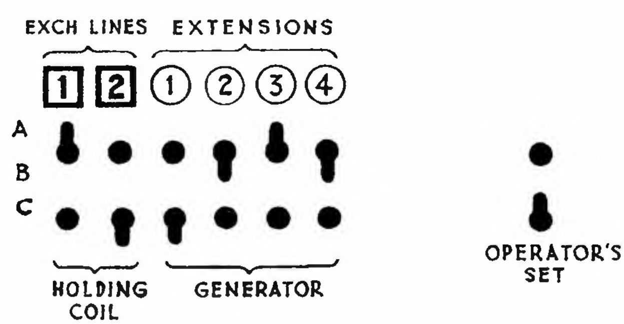
TYPICAL CORDLESS P.B.X.

FIG. 3.

4.2 Key Arrangement. On the smaller boards two rows of keys, similar to double listening keys, are used to make the connections. The upper positions and the lower positions of the upper row of keys are used for making the connections, whilst the lower positions of the lower row are used for signalling. The exchange is signalled by the loop of the operator's telephone or an extension telephone. Extensions are signalled from the switchboard by a magneto generator. A 750 ohm retard coil is used as a hold coil for "holding" an exchange line when required.

The connecting keys for each line are directly below the signal or indicator for that line to facilitate switching operations. Any keys in the same horizontal row operated to the same relative position, top or bottom, will cause the lines connected to those keys to be joined together. Thus, with two rows of keys, there is provision for three pairs of lines to be connected, viz., the upper and lower positions of the top row of keys and the upper positions of the second row of keys. The keys on the extreme right-hand side are used for connecting the operator's telephone to incoming calls, either exchange or extension. The clearing signal is positive, and always appears vertically above the connecting key on which the call is set up.

Fig. 4 is a simplified picture of the key arrangement for the $\frac{2+4}{6}$ P.B.X. What connections are represented by the keys shown operated?



WHAT CONNECTIONS ARE ESTABLISHED ON THIS KEYBOARD?

FIG. 4.

A simplified circuit on one exchange line and one extension line is given in Fig. 5a.

4.3 Supervisory Relays. As cordless switchboards are designed for use in either an Automatic or a C.B. exchange area, provision is made on all boards to prevent chattering of the supervisory

/ or

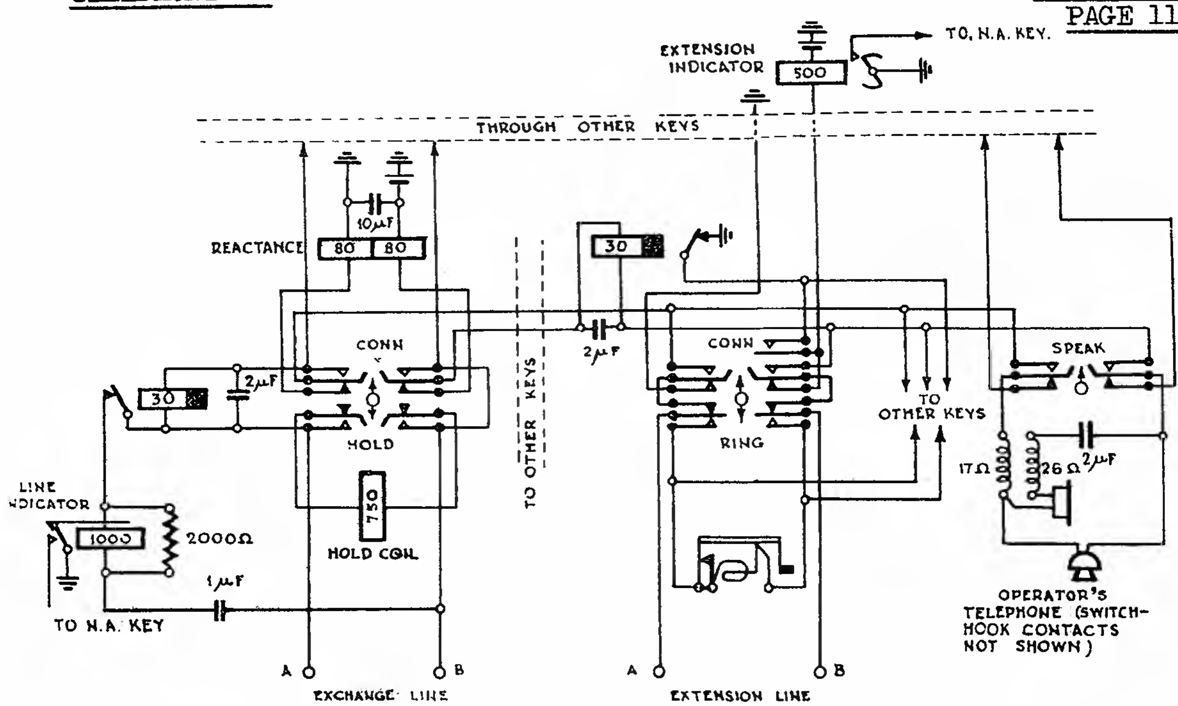
or exchange line indicators during standard automatic operation. The relay in each connecting circuit controls the operation of the supervisory indicator by open-circuiting that indicator during the period an extension telephone line is looped. This relay is a 30 ohm slugged (slow releasing) relay and chattering of the supervisory indicator, when an extension breaks the loop during dialling, is prevented.
This supervisory relay is shunted by a 2 μF condenser to allow the speech current to pass without being affected by the impedance of the supervisory relay.
The exchange line indicator is similarly protected by a 30 ohm slow releasing relay as indicated in Fig. 5.

4.4 <u>2,000 Ohm Resistance</u>. It will be observed also that the indicator is bridged by a 2,000 ohm non-inductive resistance. This is provided to prevent false operation of the exchange line indicator when, at the end of a call, the associated key at the P.B.X., or the receiver at an extension of the P.B.X., is restored. When either of these operations takes place, the 30 ohm relay in the exchange line circuit is released, and the line indicator circuit is restored to normal. When the 1 μF condenser in the line indicator circuit is connected back to the line, the potential on its plates must readjust itself to the line potential. The resultant surge may be sufficient to operate the line indicator, which is in series with the condenser, and give a false calling signal. The 2,000 ohm non-inductive resistance is bridged across the <u>inductive</u> line indicator to by-pass this surge and thus prevent the false operation of the indicator. (A metal rectifier is sometimes wired in parallel with this resistance to further prevent the false operation of the indicator.)

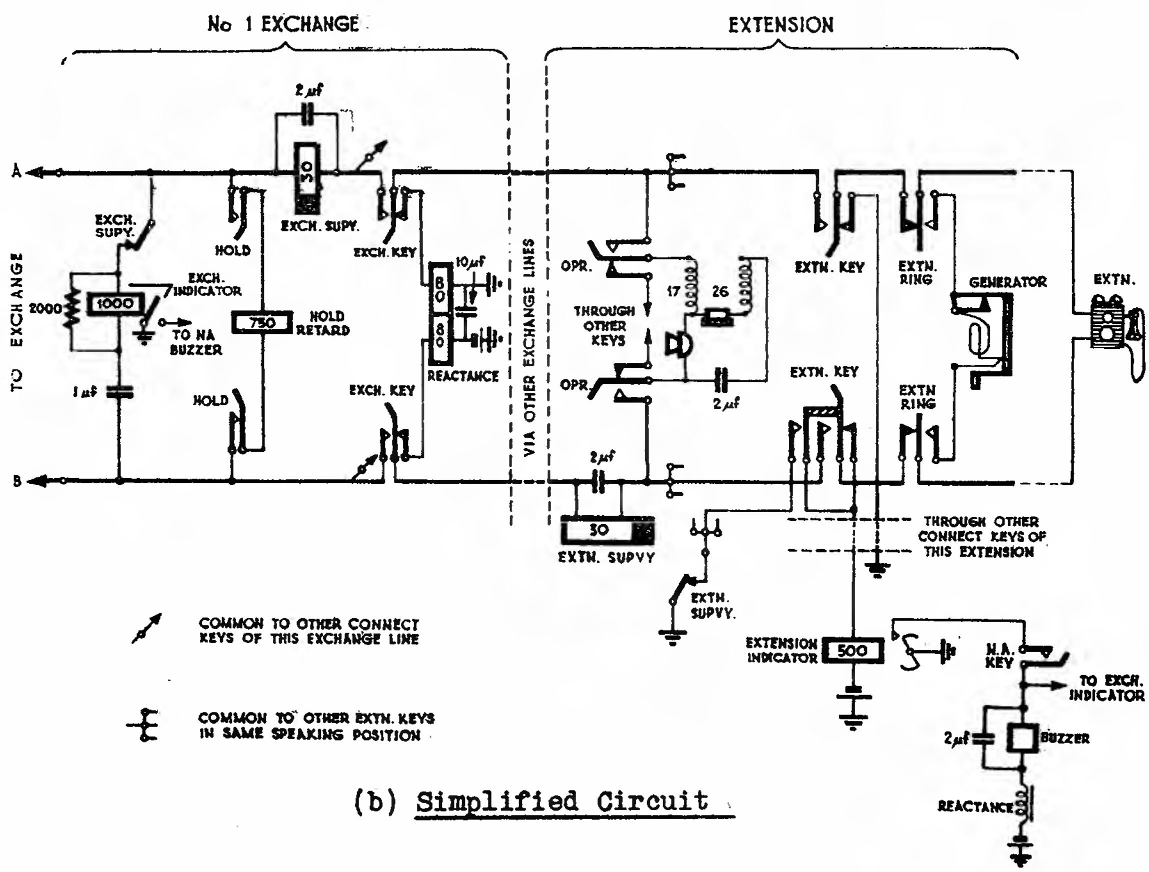
4.5 <u>Circuits</u>. In the operation of the switchboard, the keys appropriate to the two services to be connected are thrown in the same direction. Fig. 5a shows the means by which the connection is then established. Fig. 5b is a further simplified circuit of an exchange to extension connection. The keys are shown in the normal position.

4.6 <u>Power Supply and Night-switching</u>. The power supply to the switchboard is connected through an ordinary rotary snap switch (or toggle switch on some boards) which disconnects the battery feed when required. Any one extension line may be switched through to any exchange line for night service by means of the ordinary switching keys when the board is unattended and, as in these circumstances, the power switch should be in the "off" position; the absence of a power supply will prevent the unnecessary operation of the supervisory indicators.

/ Fig. 5.



(a) Schematic Circuit.



(b) Simplified Circuit

CORDLESS P.B.X.

FIG. 5.

4.7 Telephonist's Circuit. The telephonist's circuit is usually the pedestal of the table type telephone and the induction coil is mounted in the switchboard. Handsets may replace this arrangement on later boards.

4.8 Circuit Operation. (See Fig. 5.)

Exchange Line Calls. When the exchange calls, ringing current passes through line A, normal contacts of exchange line relay, 1,000 ohm indicator, 1 μF condenser and exchange line B, operating the indicator.

Telephonist Answers Exchange. The exchange line and operator's keys in the same row are operated in similar positions.
The exchange line is connected to the operator's telephone via exchange line A, 30 ohm exchange line relay, operated exchange line key, speaking common, operated telephonist's key, speaking common, 30 ohm supervisory relay, operated exchange key, to exchange line B.
Operation of the exchange line key disconnects the P.B.X. speaking battery to economise in battery drain over the power lead.
The exchange line relay operates on a direct current loop and disconnects the exchange line indicator. This relay is slow releasing and will hold up during dialling, preventing false operation of the indicator and excessive impulse distortion.

Extension Calling. When the extension receiver is lifted, a circuit is completed from earth via normal contacts of extension connecting and ringing keys, extension loop, ringing and connecting keys normal, 500 ohm eye-ball indicator, to negative battery. The indicator operates and provides a calling signal. Night alarm contacts on the indicator complete the circuit of the night alarm buzzer if the N.A. key is operated.

Telephonist Answers Extension. The telephonist answers the call by operating the extension connecting key and the operator's key in the same row in similar positions. Operation of the extension connecting key transfers the indicator from the calling circuit and places it under the control of the supervisory relay associated with the key position (that is, speaking common).

(Sufficient speaking commons, or key positions, are provided to enable the maximum possible number of simultaneous conversations to occur on the switchboard.)

/ The

The extension battery feed circuit is from earth via an 80 ohm winding of the reactance coil, normal contacts of exchange line key, speaking common, operated extension connecting key, normal contacts of ring key, extension loop, normal contacts of ring key, operated contacts of connecting key, speaking common, 30 ohm supervisory relay, normal contacts of exchange line key, second 80 ohm winding of reactance coil, to negative battery. The telephonist's circuit is connected in parallel with the calling extension (Stone undivided system of transmission coupling).

Calling Required Extension. The ring key associated with the required extension is operated to connect the hand generator to the extension line, and disconnect the extension indicator.

Extension to Extension Call. The called extension is connected in parallel with the calling extension by operating the called extension connecting key in the same row in a similar position to the operated calling extension key. This operation also places the called extension indicator in parallel with the calling extension indicator under control of the supervisory relay.

When both extensions clear the supervisory relay will restore, and the extension indicators are operated from earth via normal contacts of supervisory relay, operated springs of respective extension connecting keys, extension indicators, to negative battery, giving a positive clearing signal. This is known as double supervision; that is, both parties must clear before a supervisory signal is given.

Extension to Exchange Call. Extension connecting key and exchange line key in the same row are operated in similar positions. The extension loop is connected to the exchange line via the speaking common and the supervisory and exchange line relays. Transmission battery for the extension is fed from the exchange over the exchange line.

An extension may originate outgoing calls if it is switched to an exchange line. The slug on the supervisory relay holds the armature operated during dialling from an extension to prevent false operation of the extension indicator.

Night Alarm Circuit. Exchange line indicators are normally connected direct to the N.A. circuit independent of the N.A. key (see Fig. 5b). A 400 ohm reactance coil in series with the buzzer reduces the current to the buzzer to a normal value, and prevents variations in current produced by the operation

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of the buzzer from passing back to the power lead and causing interference in other circuits. The 2 µF condenser assists the reactance, providing a reservoir effect to the buzzer, by permitting its operation at high speeds with a minimum of sparking at the contacts.

10 µF Condenser. This is connected across the power leads to slow up the rate of change of potential at the P.B.X. when circuits are connected or disconnected. This prevents inductive clicks in the receivers of conversing extensions drawing battery through the reactance coils.

4.9 False Operation of Drop Indicators. As mentioned, difficulties are experienced with switchboards of the cordless type, due to false operation of the exchange line indicators. A slow releasing relay and contact are included in the circuit to prevent the exchange line indicator dropping during dialling over the line, and the 2,000 ohm non-inductive resistance across the indicator prevents its false operation during switching operations.

In some switchboards a special indicator which is insensitive to impulsing and momentary surges of current may be fitted to obviate these false operations. The armature of this special indicator is of the rotary type similar to that of the eye-ball indicator, and a projection engages with the trip lever when the armature is almost fully operated. The construction is such that, whilst the shutter is released by a sustained energisation of the magnet coil, very short current pulses do not cause false operation. When this type of indicator is used the slow releasing relay is not required.

4.10 Battery Feed. It will be observed that the "Battery Feed" is on the bridged impedance principle using 80 ohm/80 ohm retards. The connecting circuit is, therefore customarily referred to as "Undivided". A simple bridged impedance battery feed is satisfactory where extension lines concerned are of approximately similar resistance, which is the case, generally speaking, where a cordless switchboard will meet the subscriber's requirements. Where these conditions do not obtain, that is, where long and short extension lines may be connected for speech purposes, the line of lower resistance absorbs most of the available current, thus preventing satisfactory operation of the transmitter associated with the longer line. In such cases, combined bridged impedance and condenser transmission are employed in connection with the battery feed. An example of this will be seen in the cord type switchboard, the cord circuits of which are spoken of as "Divided".

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5. TEST QUESTIONS.

1. Sketch and describe the exchange line circuit on a C.B. cordless switchboard to be used in a C.B. or Automatic network.

2. Explain why the battery feed arrangement of the cordless switchboard limits the length of the extensions.

3. Explain the reasons for the 2,000 ohm shunt across the indicator in a cordless board.

4. Give simple sketches showing the two transmission feed systems adopted for C.B. switchboards.

5. Name the items of apparatus on the relay mounting plate shown in Fig. 3b.

6. One important item is missing from the interior view of Fig. 3b. What is it?

END OF PAPER.

COMMONWEALTH OF AUSTRALIA.

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COURSE OF TECHNICAL INSTRUCTION.

TELEPHONY II.

CORD TYPE P.B.X's. AND POWER LEADS.

CONTENTS:

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1. CORD TYPE C.B. P.B.X's.

1.1 Cord type switchboards (C.B. working) are designed for use either in manual C.B. or automatic areas, provision being made on the board for a dial to be fitted if the board is installed in an automatic area. Figs. 1 and 2 show front and rear views of a typical modern cord switchboard.

1.2 The number of exchange lines, extension lines and cord circuits on some of the earlier type switchboards is as follows. (The

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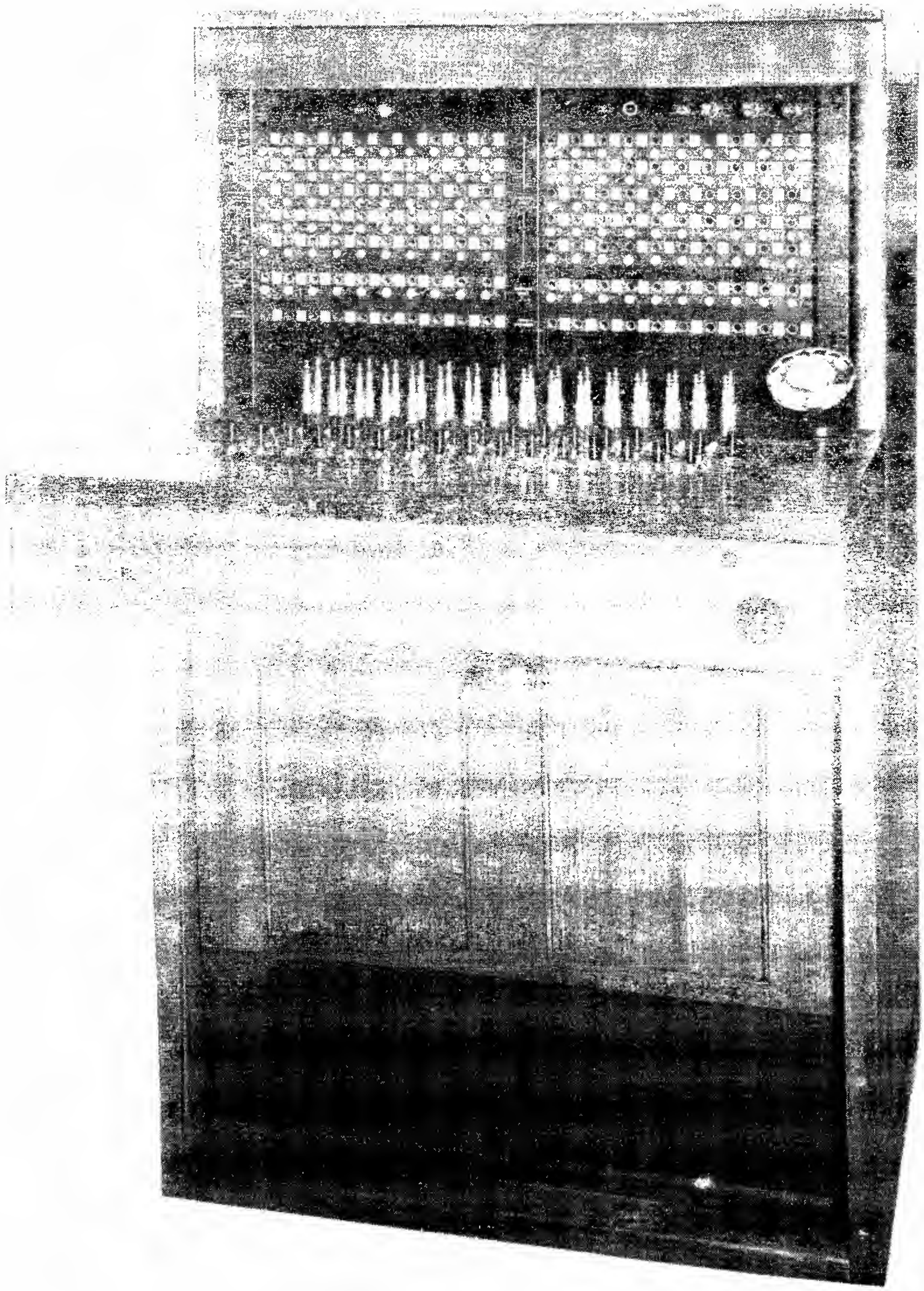
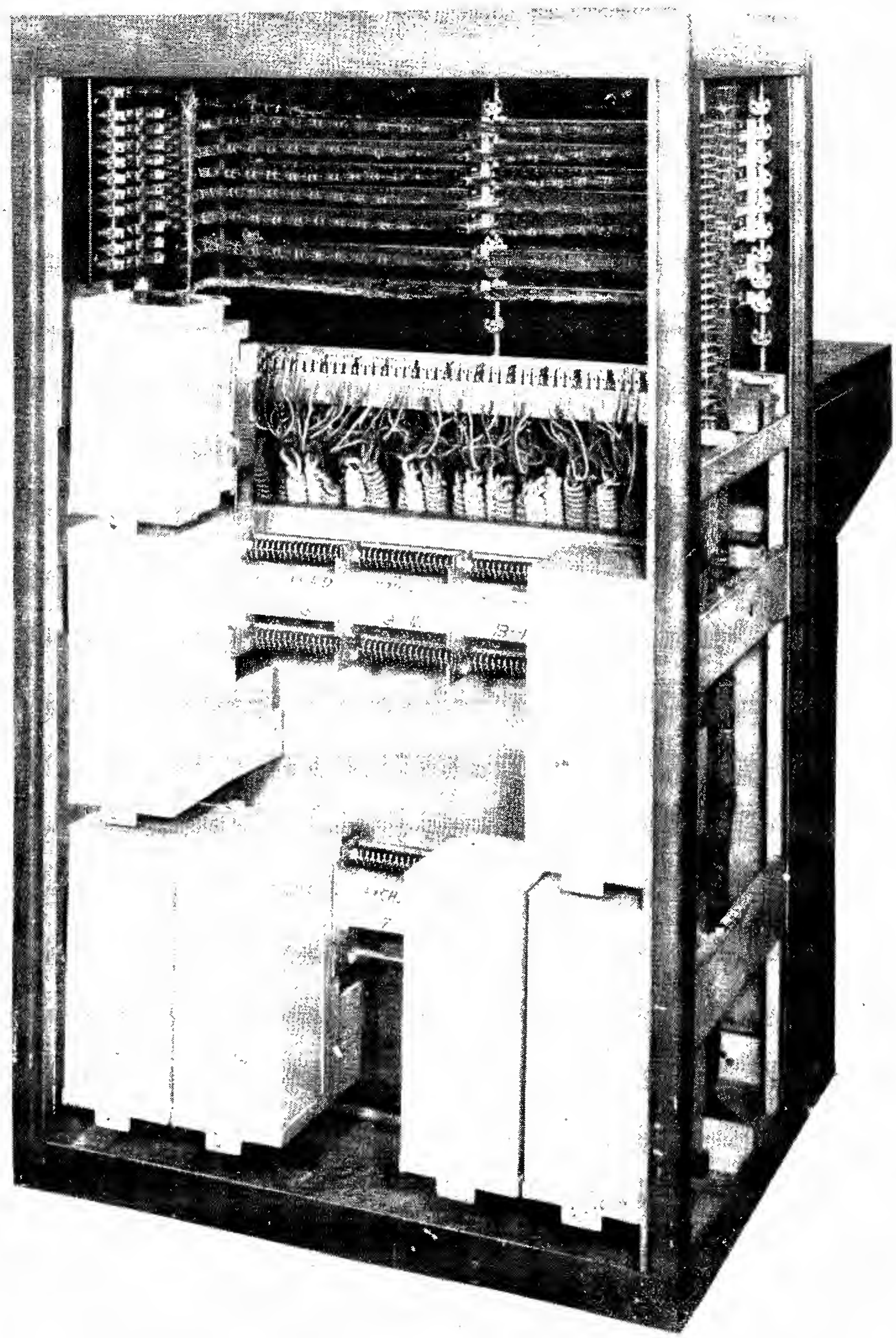


MODERN PRIVATE BRANCH EXCHANGE (P.B.X.).

Cord Type (Front View).

FIG. 1.



MODERN PRIVATE BRANCH EXCHANGE (P.B.X.).

Cord Type (Rear View).

FIG. 2.

first figure is the number of exchange lines, the second figure the number of extension lines and the denominator is the capacity of exchange and extension lines.)

$\frac{5 + 10}{40}$ lines (6 cord circuits) $\frac{10 + 40}{100}$ lines (13 cord circuits)

$\frac{6 + 20}{40}$ lines (8 cord circuits) $\frac{10 + 60}{100}$ lines (15 cord circuits)

$\frac{8 + 30}{40}$ lines (10 cord circuits) $\frac{15 + 80}{100}$ lines (17 cord circuits)

The ultimate capacity of each of the smaller sizes is -

10 exchange lines, 30 extension lines and 10 cord circuits.

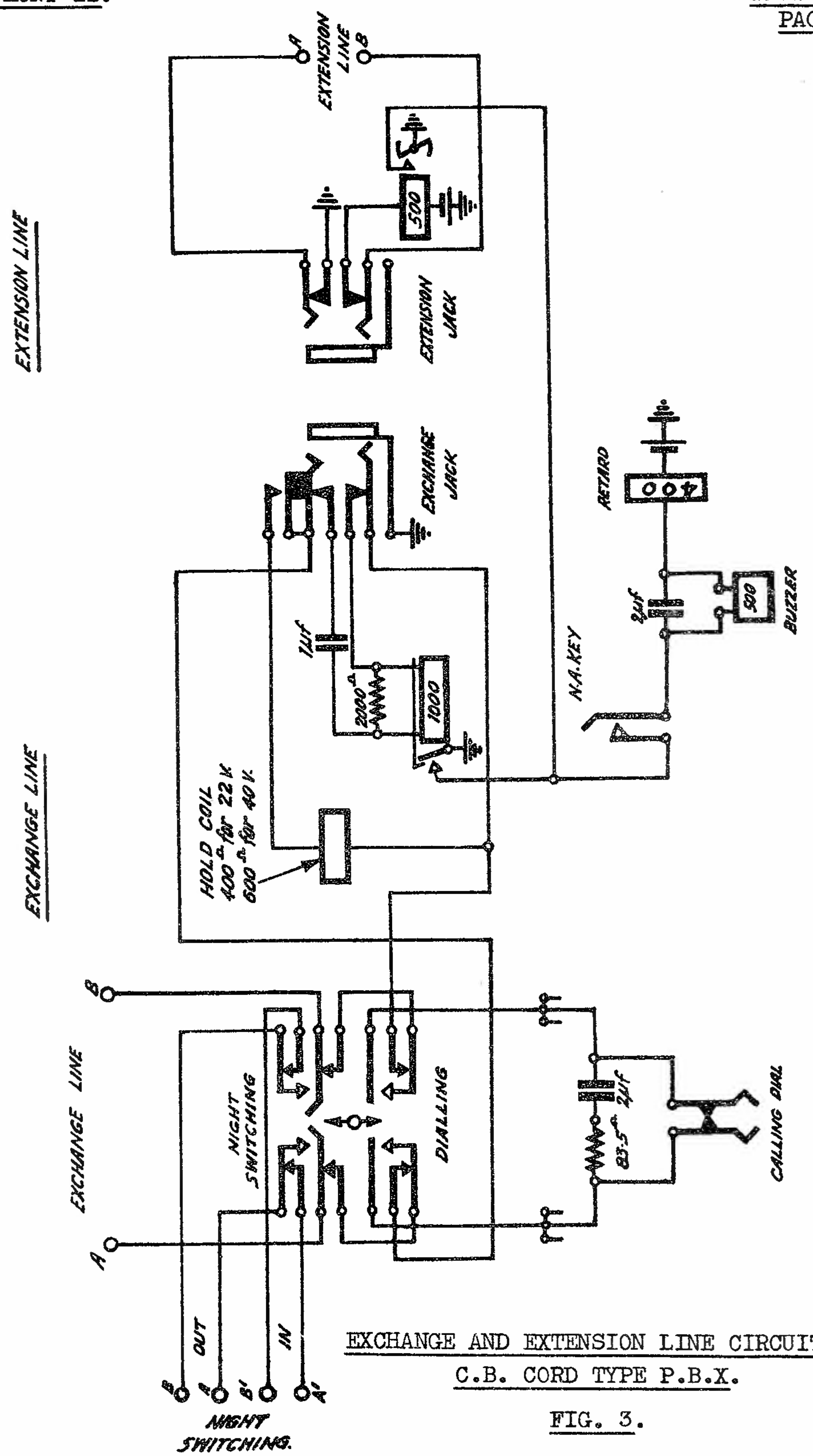
The ultimate capacity of each of the larger sizes is -

20 exchange lines, 80 extension lines and 17 cord circuits.

Cord type switchboards employ either indicator or lamp signalling. Of the former, the present standard is a through dialling board, that is, extensions can dial numbers direct through the board. A number of earlier boards with no through dialling facilities is still in use, and these will be dealt with first. Figs. 3 and 4 show the exchange line, extension line and cord circuits for a cord type board employing indicator signalling and having no through dialling facilities, that is, extensions cannot dial numbers through the board, the operator dialling all numbers required.

1.3 Exchange and Extension Circuits. Fig. 3 is the exchange line and extension line circuits of an early type of board. The exchange line indicator arrangement is the same as that adopted for the cordless board, except that, when these switchboards are used in an automatic exchange area, dialling is arranged by means of a dialling key per exchange line. This allows the telephonist to bring the dialling circuit across the switchboard side of the exchange line, and, therefore, the 30 ohm relay used in the cordless board is unnecessary. Moreover, when an exchange line is taken into use, the answering plug disconnects the indicator at the inner springs of the exchange line jack. It will also be seen that, when a plug is inserted in an exchange line jack, the hold coil is bridged across the exchange line, and thus a clearing signal cannot be given to the exchange until the plug is withdrawn. As the dialling key is make-before-break, that is, the connection of the dialling circuit to the exchange line is completed before the hold coil loop is disconnected and, conversely, the hold coil loop is

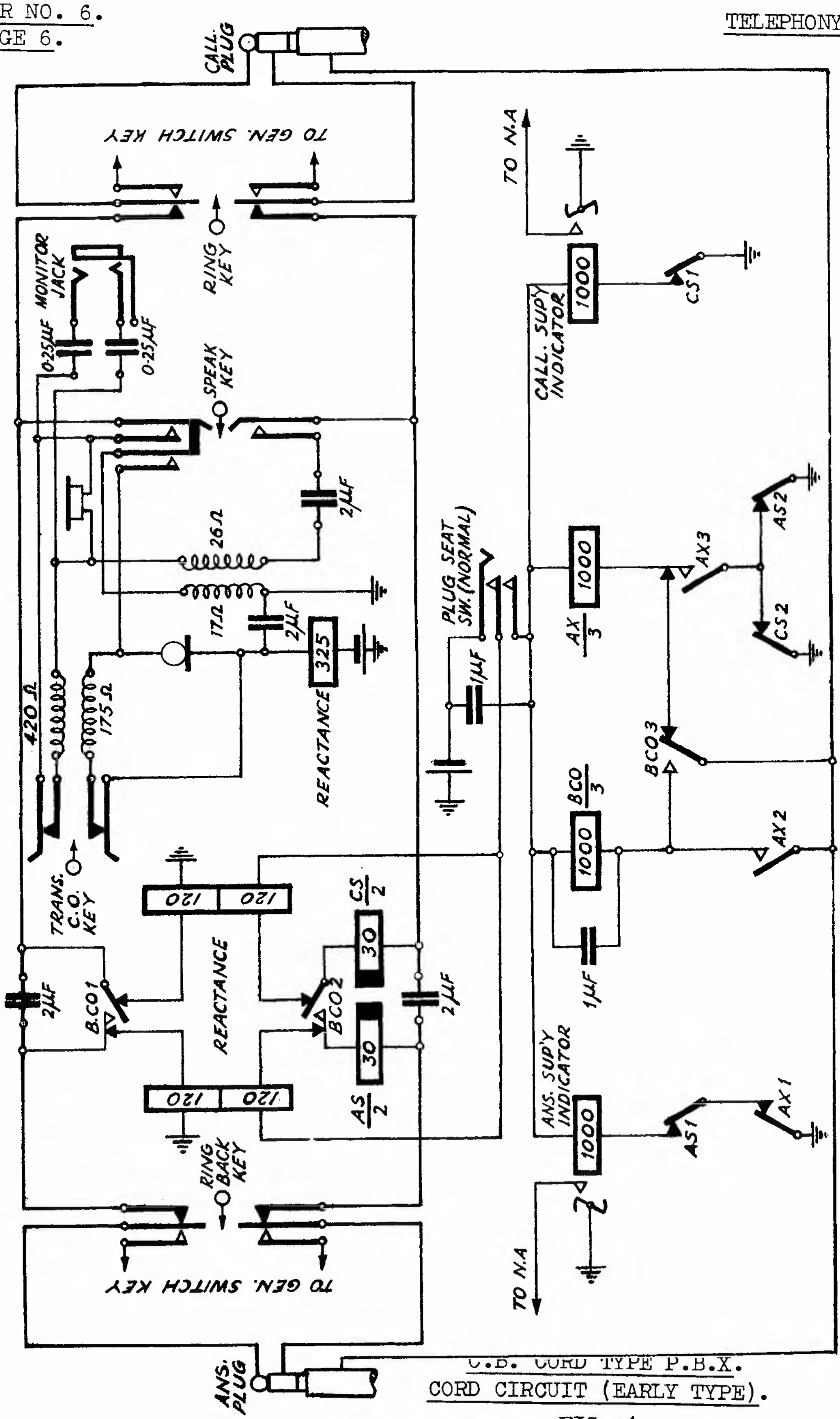
/ Fig. 3.



EXCHANGE AND EXTENSION LINE CIRCUIT.

C.B. CORD TYPE P.B.X.

FIG. 3.



C.B. CORD TYPE P.B.X.
CORD CIRCUIT (EARLY TYPE).

FIG. 4.

restored before the loop of the dial is disconnected, it will be seen that, when the P.B.X. is associated with an automatic exchange, the loop is still maintained until the telephonist unplugs.

Reference to the dialling circuit will show that the dial impulse springs are bridged by a 2 μF condenser in series with 83 ohms. This is to reduce the e.m.f. of self-induction produced across the A relay (dialling relay of 200 + 200 ohms or 50 + 50 ohms) at the exchange at the moment when the dial contacts open. Fig. 5a shows the circuit, together with a graph of the decay of the current and flux when a condenser is not present. As the current and, therefore, the magnetic flux about the relay windings decay to zero immediately the dial contacts open, the e.m.f. induced across the windings by this rapidly decaying flux will be high, about 800 volts on average length lines. Such a high voltage unduly strains the insulation, breaks down carbon arresters and introduces a danger to staff working on the plant. By placing a condenser across the dial contacts, the decay of current and, therefore, of flux is retarded as shown in Fig. 5b.

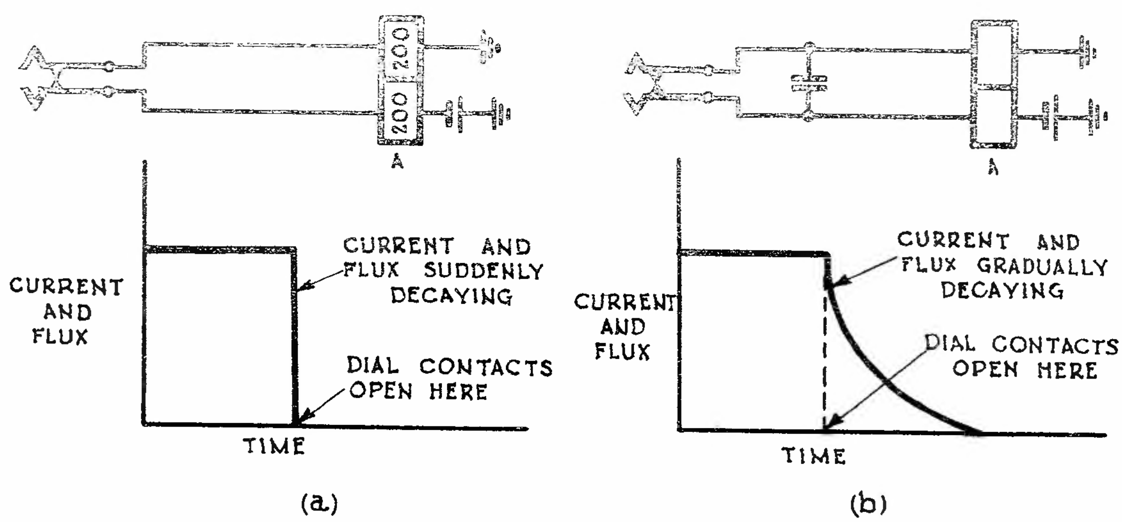


FIG. 5. OPERATION OF DIALLING CIRCUIT WITH AND WITHOUT CONDENSER.

Whilst the dial contacts are closed, the condenser is short-circuited and, therefore, uncharged. On the dial contacts opening, the condenser charges to the exchange battery voltage, 48 volts in automatic exchanges of the Strowger type. As the condenser charges via the windings of the A relay, the charging current is limited, meaning that some time elapses between the dial contacts opening and the condenser becoming charged to the battery voltage. Further, as the condenser charges, it develops an increasing voltage opposing the charging voltage

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which further limits the current as time goes on. When the condenser voltage equals that of the battery, no further charging current can flow and the current, therefore, is zero. This gradually decreasing current into the condenser through the windings of the A relay is shown in Fig. 5b, and, as the magnetic flux decays with the current, the decay of this flux is correspondingly gradual. The magnetic flux gradually, rather than suddenly, decaying means that the e.m.f. of self-induction produced across the windings of the A relay will not be so high, about 150 volts on average length lines. The 83.5 ohm resistor limits the discharge current as, on the dial contacts closing, these contacts alone would present almost a short circuit across the condenser which is, of course, charged to 48 volts.

1.4 In Paper No. 5 on Cordless P.B.X's., it was explained that dialling from extensions to the exchange is possible over the connecting circuits of the P.B.X. In the cord type P.B.X. of Figs. 3 and 4, direct signalling or dialling from the extensions to the exchange is not possible via the cord circuit.

The insertion of a plug in an exchange line jack bridges the hold coil across the exchange line, and thus an extension cannot directly signal a manual C.B. exchange or directly dial to an automatic exchange. In certain cases, however, where the user of an extension telephone works during hours when the P.B.X. is unattended, direct exchange service to the extension is necessary, and this is arranged by means of the Night Switching Key included in any exchange line. An extension line to be provided with night switching facilities is terminated on the terminals marked "Out" associated with the night switching key, while the terminals marked "In" are jumpered to the terminals associated with the extension line jack and indicator. Thus, the extension line is wired to the extension line apparatus on the P.B.X., so long as the night switching key is normal, and functions as a normal extension line. When the night switching key is operated, the extension line concerned is connected direct to the exchange line clear of the P.B.X. equipment other than the night switching key. The extension may call the exchange direct by lifting the receiver in the case of C.B., or lifting the receiver and dialling in the case of automatic working.

1.5 The extension line calling signal is the same as for the C.B. Cordless P.B.X. and operates in a similar manner, but, in this type of board, the extension line indicator is not required to function as a supervisory signal also and, consequently, it is disconnected when a plug is inserted in the jack of an extension line.

1.6 Cord Circuit. An examination of Fig. 4 will show that the cord circuit employs the Bridged Impedance type of transmitter / battery

battery feed already dealt with in connection with exchange cord circuits in Paper No. 3, Fig. 13. In Fig. 4, the impedances, or reactances as they are termed there, have a resistance of 120 ohms each. In order that the student may appreciate the development of the cord circuit up to Fig. 4, a step by step explanation will be made.

Fig. 6 shows the answering and calling cords provided with only the transmitter battery feed, the position of the speaking and ringing and ring-back keys in Fig. 4 being merely indicated in Fig. 6.

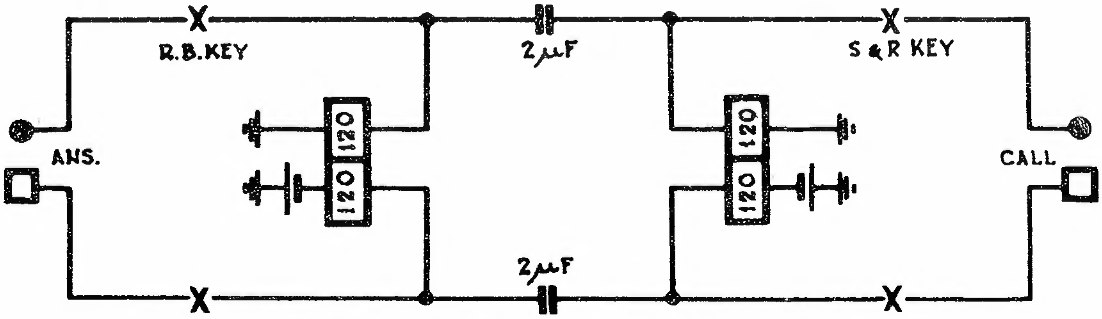


FIG. 6. CORD CIRCUIT BATTERY FEED.

Whilst one extension is connected to another, transmitter current is supplied from the P.B.X. power supply via the battery feed in the P.B.X. cord circuit. On calls involving the use of an exchange line, however, advantage can be taken of the fact that the exchange cord circuit supplies current to the exchange line, and this can be used to operate the transmitter of the extension telephone. On extension to exchange connections, therefore, the P.B.X. cord circuit battery feed can be disconnected, but it must be retained for extension to extension connections. This is done by earthing the sleeve of exchange line jacks only, as in Fig. 3, and connecting a battery cut-off relay BCO in Fig. 7, to the sleeve of each cord circuit. Contacts of this relay control the supply of battery feed current to the P.B.X. cord circuit.

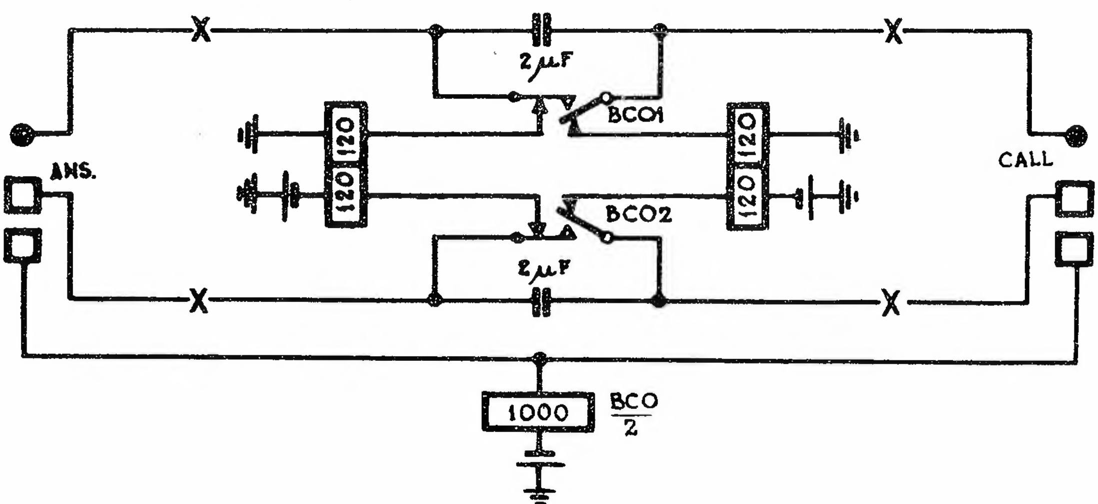
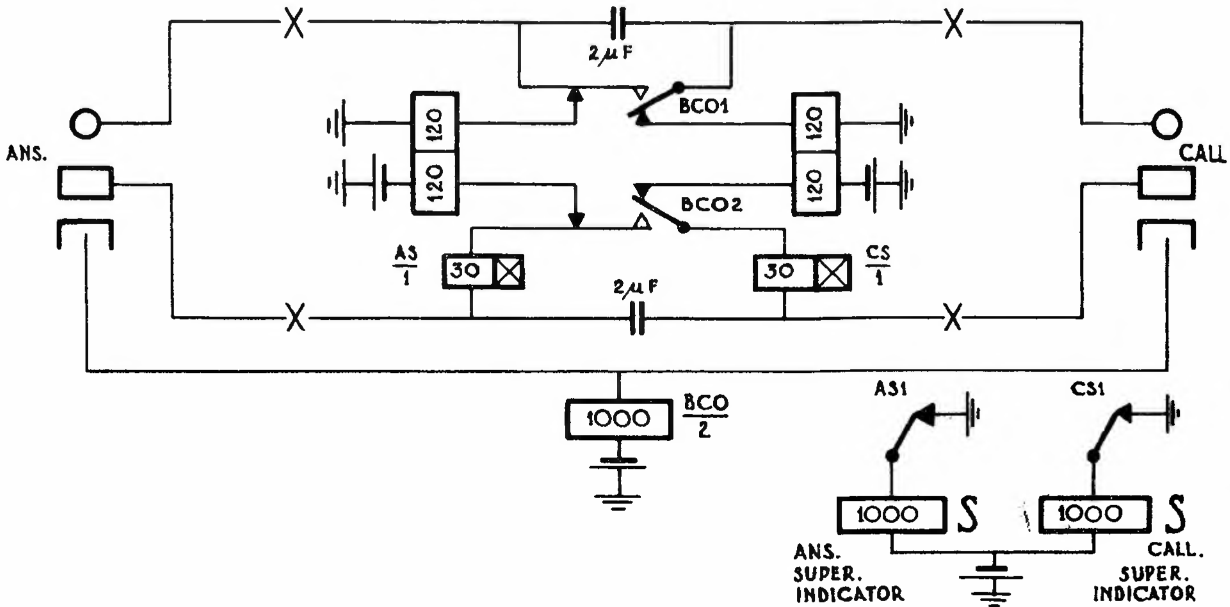


FIG. 7. MAIN FUNCTION OF BCO RELAY.

Thus, when either plug of a cord circuit is plugged into an exchange line jack, relay BCO in that cord circuit operates to the earth on the sleeve of the exchange line jack to disconnect the battery feed from the cord circuit and short-circuit the feed condensers at BCO1 and 2 operated. When extension lines are involved, BCO does not operate, as there is no operating earth on the sleeve of extension line jacks.

For supervisory purposes, eyeball indicators controlled by supervisory relays AS and CS are provided as in Fig. 8.



PROVISION OF SUPERVISORY RELAYS.

FIG. 8.

Individual supervision is given on extension to extension calls, as each indicator is in a circuit controlled by the extension connected to the answering cord only or the calling cord only. Double supervision, however, is provided on exchange to extension calls, that is, when an exchange line is connected to an extension line, both indicators remain displayed until the extension answers, the two supervisory relays operating to the exchange battery in series with the extension telephone. On the extension clearing again, both indicators again display, as both relays release on the extension loop being removed. This causes confusion, as the operator cannot distinguish between an exchange line call unanswered by the extension and such a call being finished. For this reason, relay AX in Fig. 4 is added. Relay AX provides single supervision on exchange to extension calls unanswered by the extension, and double supervision on the finish of such calls.

/ Further,

Further, in Fig. 8, the supervisory indicators on all cord circuits will be displayed when the circuits are not in use. This has been overcome in Fig. 4 by connecting the battery to the supervisory indicators, and also to the cord circuit reactances, through a plug seat switch controlled by the answering plug. When the answering plug of a cord circuit is in the plug shelf, its base rests in the barrel of a plug seat switch, forcing the springs apart and so disconnecting the battery supply to the cord circuit.

As relays AX and BCO in Fig. 4 are controlled by the sleeve circuit, the operation of Fig. 4 for extension to extension calls is as described above. For exchange calls, the operation is as follows. On lifting the answering cord to answer an incoming exchange call, the plug seat switch supplies battery to the cord circuit and both supervisory indicators display. On plugging up the exchange line, relay AX operates over the sleeve circuit via AX3 and BCO^{2} normal, locking via AX3 operated. Relay BCO now operates via AX2 operated and locks via BCO3 operated. The answering supervisory indicator also restores, its circuit being opened at AX1 operated. On the extension answering, relays AS and CS operate to the exchange battery via the extension telephone. The calling supervisory indicator now restores and relay AX is released. On the extension clearing, relays AS and CS release, completing circuits to the appropriate indicators which display.

The supervisory relays in Figs. 4 and 8 are slow acting. This prevents false operation of the relays when the operator throws a speaking key on plugging up an exchange line. The condenser in the operator's circuit of Fig. 4 will charge via the supervisory relays, the charging current being often high enough to momentarily operate the relays. On plugging-up extension lines, the charging current does not reach such a high value due to the presence of the battery feed retards.

1.7 Telephonist's Circuit. The Telephonist's Circuit contains an anti-sidetone transformer similar to that described in Section 4 of Paper No. 2. This transformer is required when a handset is used by the telephonist, but is disconnected by the operation of the Transformer Cut-Out Key when the telephonist uses a head and breast set.

The Monitoring Jack is provided to allow a telephonist to wait on an exchange line call and, whilst waiting, answer other calls without giving a clearing signal on the first call if to a manual exchange, or possibly releasing the call if to an automatic exchange. The calling cord of the first call is plugged into the Monitoring Jack and the Speak Key is restored. Other calls may then be answered, the first call being connected to the telephonist's receiver via 0.25 μF condensers.

/ 2.

2. CORD TYPE C.B. P.B.X. (MODIFIED TO ALLOW THROUGH CALLING).

2.1 The circuits described and shown in Figs. 3 and 4 place the control of a call between the exchange and an extension telephone in the hands of the telephonist at the switchboard. The hold coil associated with the exchange line jack holds the exchange line call while a plug is in the jack. When the board is connected to an automatic exchange, this hold coil prevents extensions from dialling via the cord circuit to the automatic exchange, and the telephonist must dial all numbers.

The circuits shown in Figs. 9 and 10 have been designed to allow through calling and/or dialling, and thus place the control of the call with the extension telephone. Modification of the circuits previously described was also necessary, in order to prevent coupling between cord circuits when two or more speaking keys were operated simultaneously. In the circuit shown in Fig. 4, if the telephonist operated the Speak Key on another call whilst across an exchange line connection, outward calls from the P.B.X. may be released if the board is connected to an automatic exchange, or a clearing signal may be given if the board is connected to a manual exchange.

2.2 Advantages. The main advantages of this circuit are -

(i) Reduced holding time of exchange switching plant.
(ii) Improved accuracy in timing trunk line calls.
(iii) If the P.B.X. is connected to a manual exchange, the extension may recall the operator at the exchange without the aid of the P.B.X. operator.
(iv) If the P.B.X. is connected to an automatic exchange, extensions fitted with dials may make successive outgoing calls without intervention of the P.B.X. operator.
(v) The operator, when dialling a number, receives an indication of the progress of the call.
(vi) The operation of the Called Subscriber Held Alarm at automatic exchanges, due to delayed clearing by the P.B.X. operator, is avoided.

2.3 Disadvantages. The disadvantage of through clearing are -

(i) An incoming call arriving on an exchange line before the P.B.X. operator has disconnected the line from an extension with which it has just been associated will not operate the switchboard indicator, but will be received at the extension.

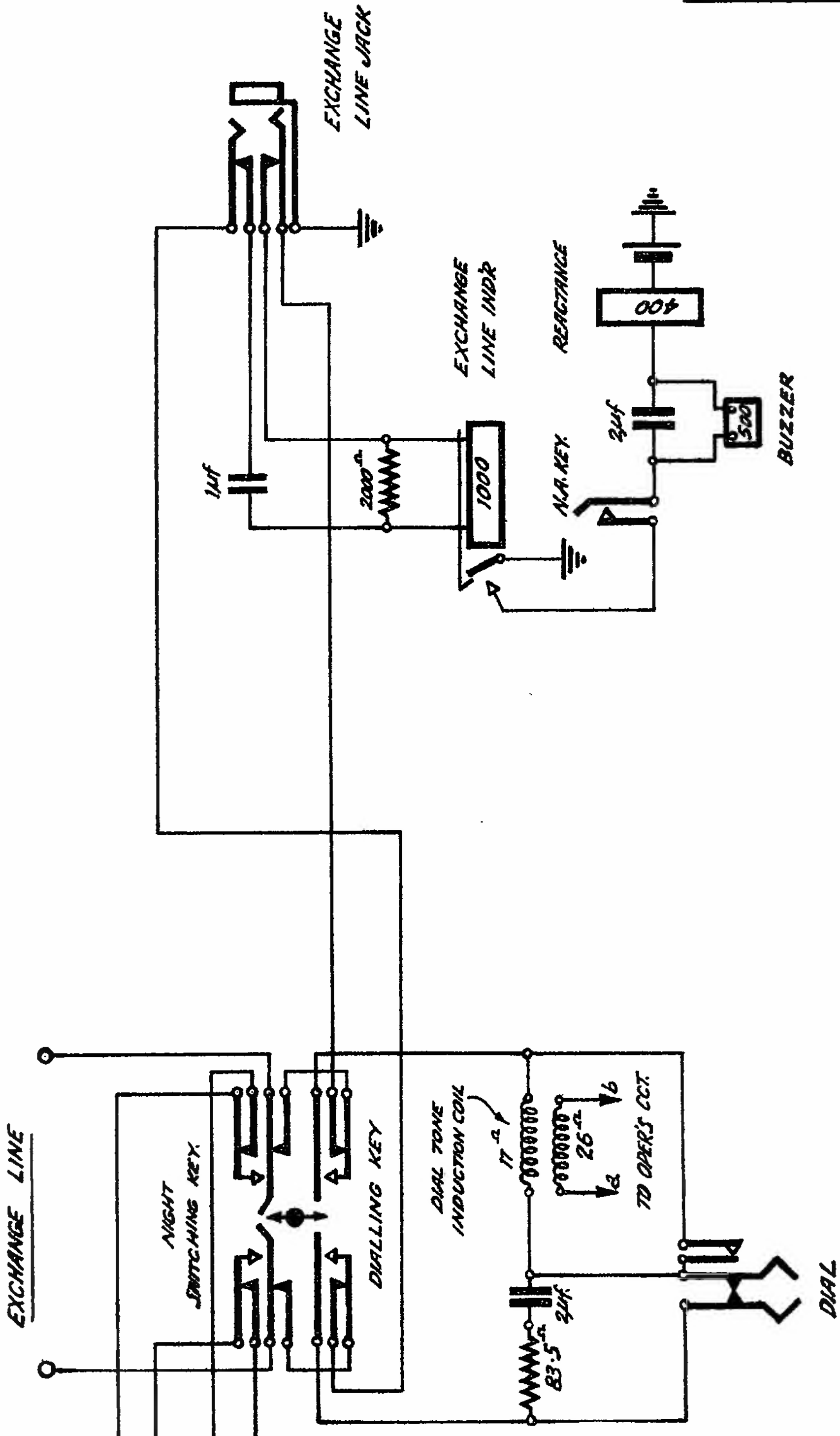
(ii) On outgoing calls set up via automatic equipment, the extension cannot flash the P.B.X. operator unless the extensions are specially wired and equipped with a press button for this purpose.

2.4 Circuit Explanation. Exchange Line Circuit (see Fig. 9). The incoming ring displays the indicator. The indicator completes the circuit of the Night Alarm Buzzer, provided the N.A. key is operated. The insertion of a plug disconnects the indicator from the line. Provision is made on each exchange line to night switch it to an extension by means of a locking type key. This key disconnects the signalling apparatus on the exchange and extension lines and extends the extension direct to the exchange.

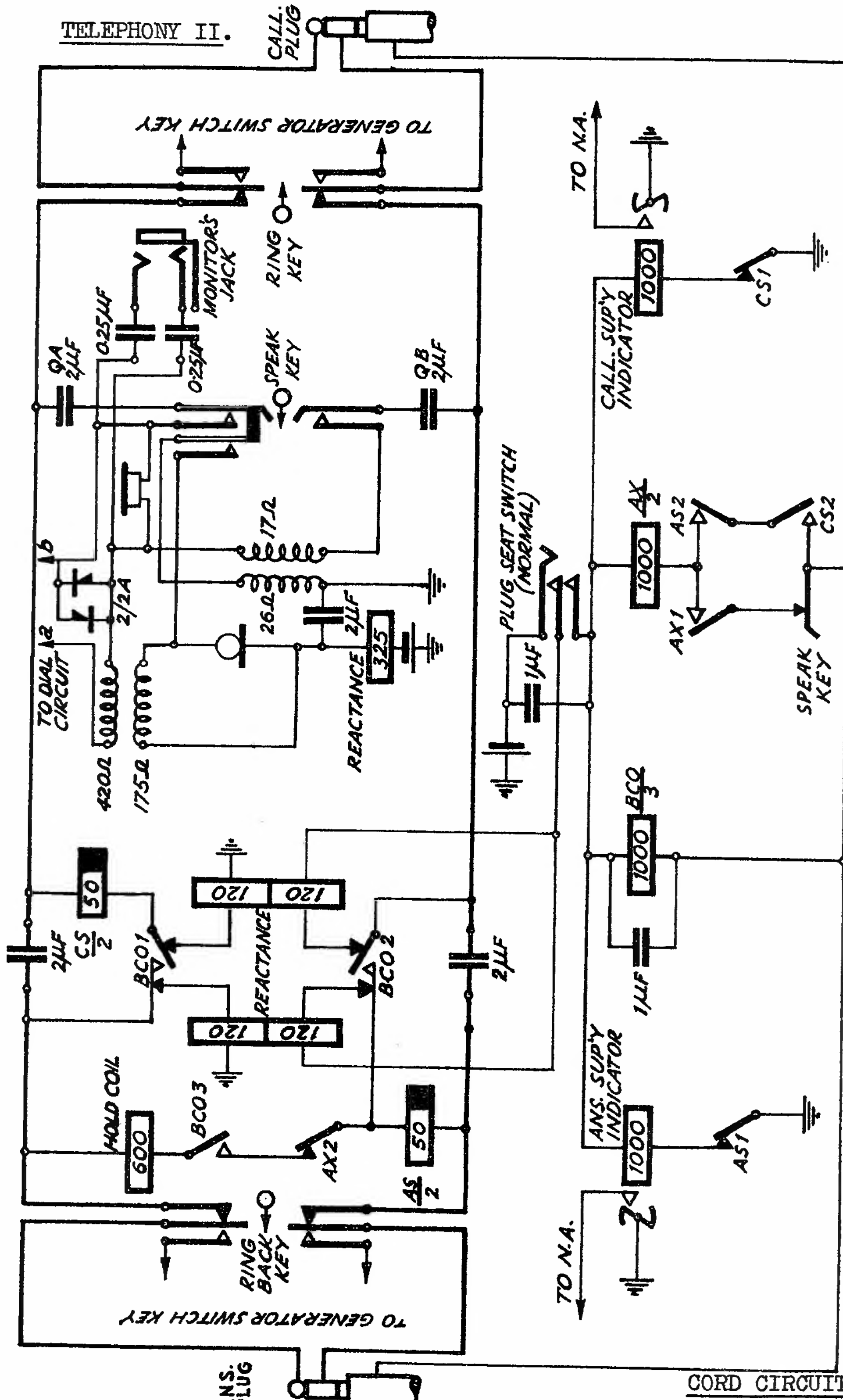
A dialling key is provided per exchange line to enable the operator to dial on exchange lines. The operator may supervise the progress of the call by means of the 17-26 ohm induction coil.

2.5 Cord Circuit. Incoming Exchange Line Call (see Fig. 10). When the answering plug is lifted, the plug seat switch completes circuit to both supervisory indicators which display. The answering plug is inserted in the calling exchange line jack, and earth on the sleeve of this jack operates the BCO. BCO1 and BCO2 disconnect the battery feed retards, and BCO3 connects the 600 ohm retard in series with AS relay across the cord circuit. The loop provided by these coils trips the incoming ring, and the operator connects the operator's telephone circuit to the line by the operation of the Speak Key. It will be noted that the condensers QA and QB in each cord circuit prevent direct current coupling between cord circuits when two or more keys are operated together. AS operates over this loop circuit and AS1 opens the circuit of the answering supervisory indicator. To extend the call to an extension, the operator plugs the calling cord in an extension jack and operates the Ring Key. The calling supervisory indicator is still displayed. When the extension answers, CS relay operates via the extension loop and CS1 opens circuit to the calling supervisory indicator. CS2 completes a circuit to AX from earth on the sleeve of the cord circuit, CS2, AS2, AS relay to battery via the plug seat switch. AX operates and locks via AX1. AX2 removes the 600 ohm retard from across the line and the exchange line is held by the extension telephone loop. Thus, the extension may call or dial directly to the exchange and control the release of the call from the extension telephone switch hook.

/ Fig. 9.



EXCHANGE LINE CIRCUIT.
CORD TYPE C.B. P.B.X.
(MODIFIED FOR THROUGH CALLING).
FIG. 9.



CORD CIRCUIT.
(C.B. CORD TYPE P.B.X.
MODIFIED FOR THROUGH CALLING).
FIG. 10.

When the extension handset is replaced, both supervisory relays release and both supervisory indicators show. AX remains locked until the plugs are removed from the jacks.

2.6 Extension to Extension Call. When the answering plug is lifted, both supervisory indicators display until the plug is inserted in the jack of the calling extension, when AS operates from earth at 120 ohm coil of retard, BC01, Ring-back Key, calling extension loop, Ring-back Key, AS relay, BC02, 120 ohm coil of retard to battery at the plug seat switch. AS1 releases the answering supervisory indicator. The operator extends the call to the required extension with the calling cord and operates the Ring Key.

When the extension answers, CS operates in series with the extension loop and the battery feed retard. CS1 opens the circuit of the calling supervisory indicator. When an extension handset is replaced, either AS or CS releases and the appropriate supervisory indicator displays.

2.7 Extension to Exchange Call. The calling extension is answered as usual, AS operating via the extension loop and AS1 restoring the answering supervisory indicator. The calling extension is extended to an exchange line jack via the calling plug, and the BCO operates from earth at the sleeve of the exchange jack. BC01 and BC02 disconnect the battery feed retards, and BC03 completes a loop from battery at the exchange. CS2 and AS2 complete the operating circuit of AX, which locks via AX1 to earth at the sleeve of the exchange line jack. AX2 disconnects the loop provided by the 600 ohm retard, and the exchange line is now held by the extension line loop.

When the extension handset is replaced, both supervisory relays release and both supervisory indicators display until the plugs are removed from the jacks.

AS and CS are slugged to prevent their release during dialling from the extension.

2.8 General Notes on P.B.X. Circuits.

(i) After an exchange line call, the circuit to relay BCO is maintained until the telephonist unplugs the exchange line. The opening of the circuit to relay BCO causes its current and flux to decay to zero instantly, this sudden decay of flux inducing a high voltage across the relay. At this stage, relay BCO has not had time to release, so its contacts will still be operated. Referring to Fig. 4,

/ it

it will be seen that this voltage is applied across sleeve and earth for the release time of BCO, as the sleeve is merely an extension of the lower terminal of BCO via BCO3 operated, and the upper terminal is connected to earth via the supervisory indicators. If the operator is touching the sleeve and some earthed object at the moment of unplugging the exchange line, a severe shock results. The value of this induced voltage and, therefore, the liability to shock is reduced by shunting relay BCO with a condenser as in Fig. 4. Whilst the sleeve connection is maintained, the condenser is charged to the voltage drop produced across relay BCO by the current flowing through it. On the connection being broken by unplugging the exchange line, the current ceases and the condenser discharges through relay BCO. As with a charging current, a condenser discharge current is initially high and gradually decays to zero. The flux decays correspondingly, so reducing the voltage induced across BCO at the moment its circuit is opened.

(ii) On the return of an answering cord to the plug shelf, the circuit to the supervisory indicators is opened at the plug seat switch contacts. Again a high voltage will be induced across the indicators, due to the rapid decay of the current and flux. In many cases, the lower plug seat switch contacts of Fig. 4 open before the upper contacts, so that the circuit to the indicators is opened before the battery is disconnected from the battery feed retards in the ring side of the cord circuit. For the time interval between the lower and upper spring-sets opening, the high voltage will be applied across ring and sleeve of the cord circuit. This is because the sleeve is merely an extension of the upper terminals of the indicators via relay AX, AX3 normal and BCO3 normal, whilst the ring is an extension of the lower terminals via the earth common, battery supply, upper plug seat switch contacts operated, 120 ohm retards, supervisory relays to the ring side of the cords and plugs. This high voltage unduly strains the insulation between ring and sleeve, and severely shocks the operator should that person be touching the ring and sleeve simultaneously on returning the answering cord to the plug shelf. Once again the value of the induced e.m.f. is reduced by the use of a condenser. In this case, the condenser is connected across the contacts of the plug seat switch. Whilst the answering cord is out of the plug shelf, the condenser is short-circuited and, therefore, uncharged. On the plug being returned to the plug shelf, the condenser charges to the battery supply voltage via the indicators. As this charging current gradually falls to zero, the flux falls correspondingly, so reducing the e.m.f. induced across the indicators.

/ (iii)

(iii) The provision of power, direct current and alternating current for operation of the switchboard is discussed later in this Paper. The direct current supply is connected to the board and hence to the various circuits via a power switch. A large capacity condenser (10 or 250 μF) is connected across this direct current power lead. The principal function of this condenser is to prevent crosstalk when several pairs of extensions are connected at the board.

Paper No. 2 explained the necessity for keeping the resistance of the battery circuit at a negligible figure, but, owing to the resistance of the cable pair or pairs over which the current from the exchange is conveyed, this is not possible with a P.B.X. battery supply. The provision of the condenser, however, by providing a low impedance path for any voice or high frequency currents which may pass the battery feed coils, maintaining the potential at the power leads at a constant figure, and by providing a reservoir for a small amount of power, prevents crosstalk between extensions.

(iv) If the ringing supply is from the exchange, it is wired via a change-over key, which provides for ringing current from a hand generator in the event of failure of ringing current from the exchange.

2.9 Cord Test. Two Cord Test Jacks are provided. These jacks provide for rapid testing by the telephonist of the cords on the position. The circuit is shown in Fig. 11. The tests are given below, and should be studied in conjunction with Fig. 4.

C.B. P.B.X's. - Cord Circuits. The test should be performed as indicated hereunder. (See Fig. 11.)

(i) Raise the answering plug from the plug seat switch. Both supervisory indicators should operate completely.

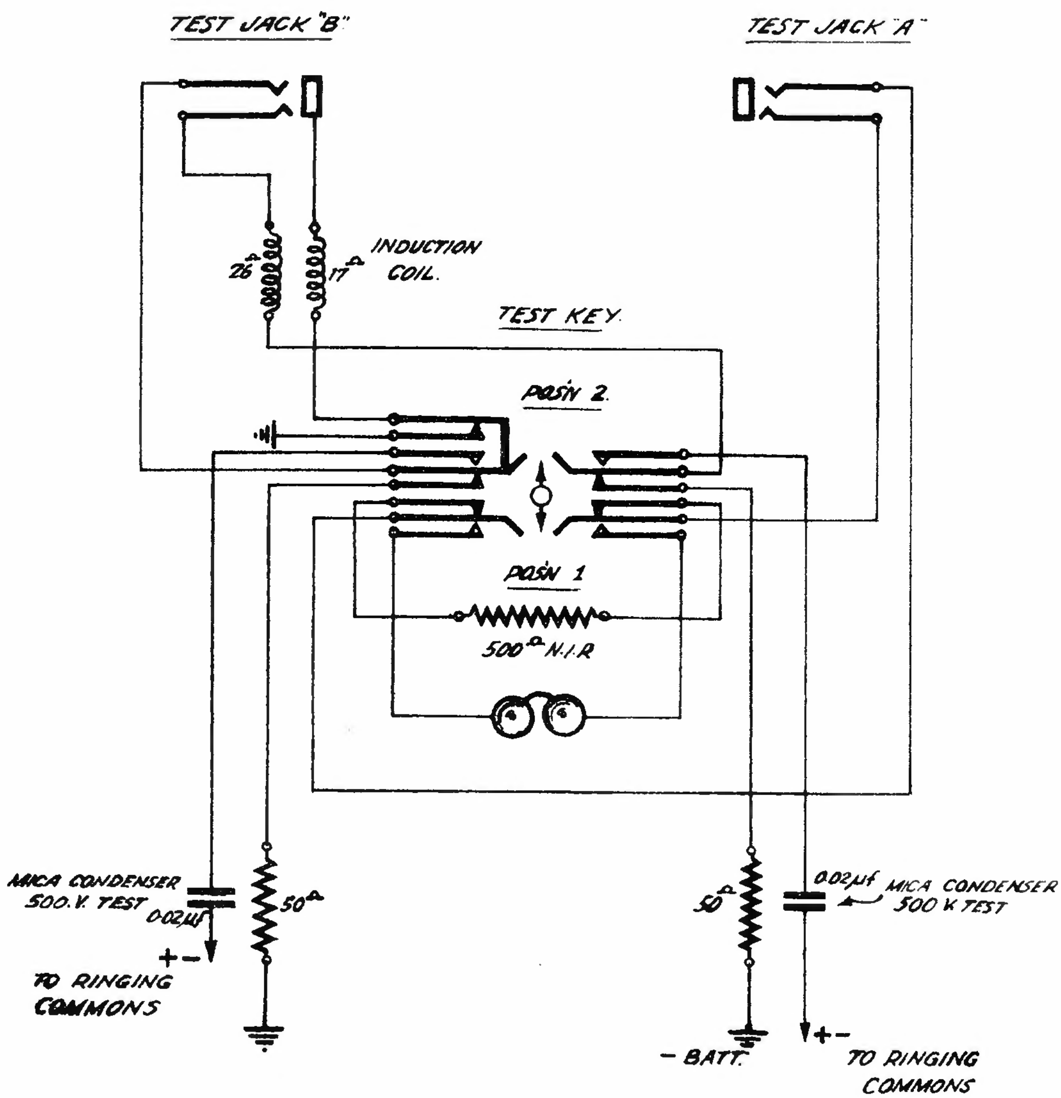
(ii) Insert the answering plug of the cord under test in Test Jack "A". The answering supervisory relay should operate and the answering supervisory indicator should restore promptly.

(iii) Operate the test key to Position 1 and operate the ringback key; a ring should be heard on the test bell. Withdraw the plug and restore the test key.

/ (iv)

(iv) With the answering plug raised from the plug seat, insert the calling plug in Test Jack "A". The calling supervisory relay should operate and the calling supervisory indicator should restore promptly.

(v) The operation of the night alarm buzzer should be observed for each indicator.



CORD TEST CIRCUIT. C. B. CORD TYPE P. B. X.

FIG. 11.

(vi) Insert the answering plug in Test Jack "B". Relay AX operates opening the circuit to the answering supervisory indicator which should restore. Relay AX also closes the circuit to the BCO relay, which operates and removes battery from the cord circuit under test. For cord circuits not equipped with AX relays, the answering supervisory indicator will not restore.

(vii) Insert the calling plug in Test Jack "A". Both supervisory relays should operate in series and the calling supervisory indicator and the AX relay should restore, proving the continuity of the "A" and "B" sides of the cord circuit.

(viii) With the speaking key operated, hold the answering plug and shake the cord. Fractured cord conductor strands will be indicated by a scraping noise heard in the telephonist's receiver.

(ix) Check the telephonist's circuit by testing for sidetone. Withdraw the calling plug; both supervisory indicators should be displayed.

(x) Operate the test key to Position 2. Ringing tone should be heard clearly in the telephonist's receiver, proving the transmission condensers in the cord circuit. Restore the answering plug.

(xi) Insert the calling plug in Test Jack "B" and the answering plug in Test Jack "A" and repeat test indicated in paragraph (viii) hereof.

(xii) Repeat the tests on each cord circuit.

2.9 An induction coil is inserted in the cord test circuit to enable the cord test for broken tinsel strands in the cord conductor to be carried out at full efficiency. This test is made by plugging-up the cord to be tested in Test Jack "B", operating the speaking key of the cord circuit concerned and shaking the cord.

Broken strands are indicated by noise in the telephonist's receiver. In the cord test circuit, it will be seen that, if the induction coil is not included, the tip and ring conductors will be satisfactorily tested, but the sleeve conductor will not be associated in any way with the operator's receiver. The introduction of the induction coil accomplishes such an association. The current variations, due to open or partial

/ open

open circuits in the sleeve conductor when the cord is shaken, cause, through the induction coil, induced effects in the tip ring circuit which are communicated to the listening operator via the receiver in the operator's circuit.

3. CORD TYPE C.B. P.B.X. (LAMP SIGNALLING AND THROUGH CALLING).

3.1 The Lamp Signalling Switchboard (Figs. 1 and 2 are pictures of this switchboard) to be described here includes many features not normally associated with cord type switchboards. The frame of the switchboard, for example, is made of steel, and the top and sides have removable panels in addition to the usual back and front panels. The relays, with their associated condensers and resistances, are mounted on jack-type relay bases, each accommodating 16 relays.

The switchboard has an ultimate capacity of 80 Extension Lines and provides for fifteen Exchange Lines (5 bases with 3 exchange lines per base), three Tie Lines (on one base) and sixteen Cord Circuits (4 bases with 4 cord circuits per base). One 10 relay base provides for the Operator's and Miscellaneous Circuits.

This switchboard, in addition to the improvements stated in paragraph 2.2, includes the following -

Lamps associated with each exchange or extension jack are used instead of drop or eyeball indicators, thus reducing the cabinet space needed. The association of the calling lamp with the jack facilitates the operation of the switchboard.

An audio frequency termination ensures balanced conditions for trunk lines equipped with amplifiers, when connected to extensions.

Incoming calls, arriving on an exchange line before the P.B.X. operator has disconnected the line from an extension with which it has just been associated, flash the supervisory lamps.

Plug seat switches are eliminated.

3.2 Special Features. The lamp signalling switchboard includes the following features -

Lamps (six volt) are used for exchange line, extension line and supervisory signals. An audible alarm is provided on exchange and extension signals.

/"Through

"Through dialling" from extensions is provided. The telephonist can monitor on a through call, but cannot interfere with through dialling.

"Follow-on" calls (exchange or tie line) are trapped.

Provision is made for holding and transferring inward or outward exchange calls.

Night switching of any line by normal cord circuits is provided.

"Call-back" is available with inward or outward exchange calls.

Provision is made for tie lines from P.A.B.X's. or C.B. or magneto P.B.X's. Positive supervision is provided on tie lines.

Connection of an exchange line to another exchange line or to a tie line is electrically prevented. Cord circuits are not electrically coupled when two speak keys are operated at the same time.

Voice frequency termination is provided during switching to prevent unbalancing of repeater amplifiers when connected to trunk lines.

When cords are normal, battery is disconnected from cords or plugs.

Independent battery feed coils with positive lamp supervision are provided for each side of cord circuit.

3.3 Operating the Switchboard. The operation of the Lamp Signalling Switchboard differs from the operation of the switchboards previously described and is as follows -

(i) The front cord is used for answering or calling exchange or tie lines, but the rear cord is used to answer extension calls.

(ii) When connecting extensions to exchange or tie lines, the connection must be completed before closing the speak key.

/ (iii)

(iii) When transferring exchange calls to another extension, the hold key must be operated before the plug is removed and restored only when the required extension is connected. The supervisory lamp will glow until extension answers.

(iv) When answering "follow-on" calls, both hold and speak keys are operated before plug is withdrawn from extension. The hold and speak keys are restored when the required extension is connected.

(v) When calling tie line, speak key must be operated before ringing.

(vi) To test cords, insert rear cord half-way in rear cord test jack and check that rear supervisory lamp glows, then insert plug fully into jack and see that lamp is extinguished. With rear cord still in rear cord test jack, insert front cord half-way in front cord test jack and check that front supervisory lamp glows, then with plug fully in test jack the front lamp is extinguished. With key KS operated, shake both cords and listen for fault indicating noise in receiver. (It is necessary to operate key KDH to test the sleeve conductor of the front cord.)

(vii) To prevent overhearing by caller when transferring calls, hold dial in off-normal position.

(viii) ~~To night switch an exchange to an extension line, connect with any pair of cords and switch the BCO (battery cut-off) key to the "off" position.~~

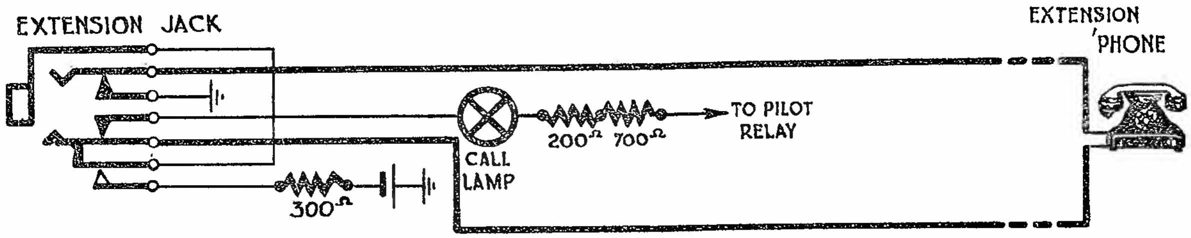
(ix) To night switch AT ALL TIMES ~~whilst still operating switchboard~~, connect the lines to be night switched with reversed cords, that is, extension (rear) cord in night switch jack. The front lamp will glow as each connection is set up and will go out when the battery is cut off at the BCO switch.

(x) To test extension telephones from test desk in exchange, request telephonist to night switch as above to extension telephone to be tested. (Do not operate speak key.)

3.4 Extension Line Circuit. A six volt line lamp (in series with limiting resistances and a 30 ohm pilot relay) placed directly

/ in

in the extension line circuit, as shown in Fig. 12, is used as an extension calling signal. The 200 ohm limiting resistance is short-circuited, if the resistance of the extension line is above the normal resistance value of extension lines.



EXTENSION LINE.

FIG. 12.

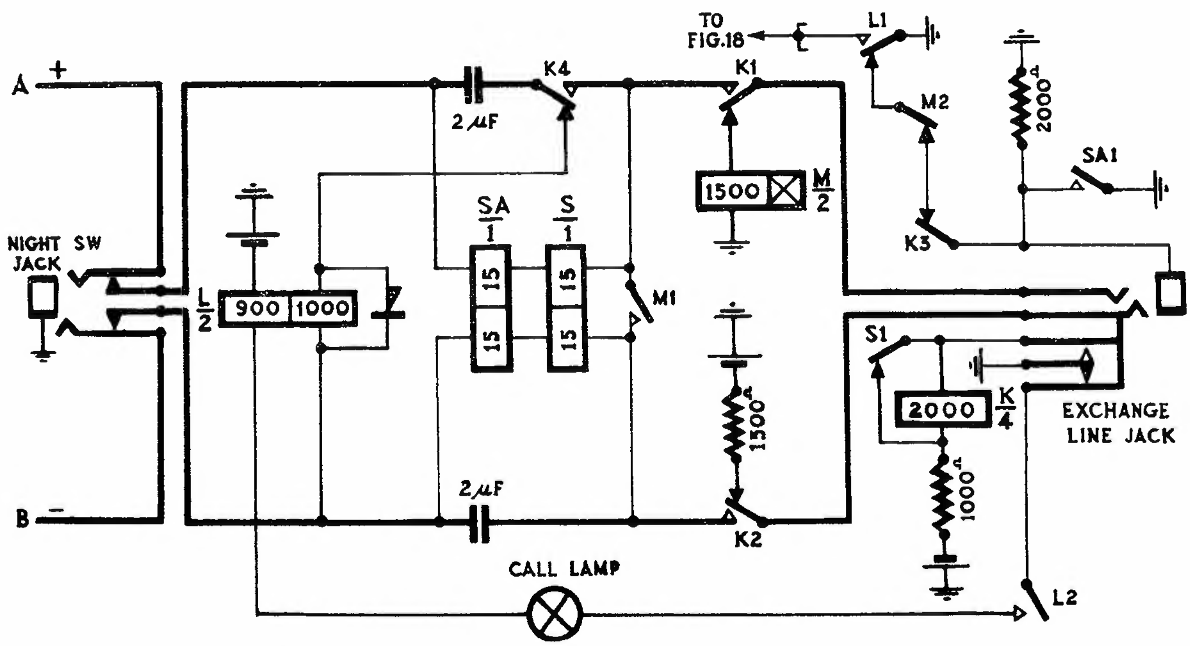
When the handset is removed at the extension telephone, a lamp signal is given at the switchboard and the operator inserts a rear plug in the extension jack to answer the call. The insertion of a plug in an extension jack disconnects the lamp and connects negative battery (via 300 ohms) to the sleeve of the jack.

3.5 Exchange Line Circuit. On an incoming exchange line call (see Fig. 13), ringing current from the exchange operates L over the negative line via springs of the night switching jack, 1,000 ohm winding of L relay (shunted by a metal rectifier), K4, 2 μF condenser, springs of the night switching jack to the positive line. L2 closes a locking winding circuit of L relay through the calling lamp (which glows) to earth at the springs of the exchange line jack. L1 operates the pilot relay (shown in Fig. 18) and the pilot lamp glows. The operator commences to answer the call by inserting a front plug into the jack of the calling exchange line. The plug operates the extra springs of the line jack, thus disconnecting the call lamp and releasing relay L. This change-over spring-set, operated by the insertion of the plug, also prepares for the later operation of the K relay.

The operator now operates the speaking key associated with the cord circuit being used. Relay M in the exchange line circuit operates from negative battery via 1,500 ohm resistor, K2, exchange jack spring, through cord circuit as explained later, exchange jack spring, K1, to earth via M relay. M relay is

/ slow

slow to operate to ensure that it is sufficiently fluxed to have an adequate release lag to trip the incoming ring at M1. M1 loops the exchange line and trips the incoming ring via the windings of relays SA and S (in series). Contact M2 disconnects the direct earth from the sleeve of the exchange line jack. Relay S operates to battery from the exchange over the exchange line, but SA, being differentially connected, does not operate. Contact S1 removes the short circuit from relay K which operates to earth at the exchange line jack. K1, K2 and K4 extend the exchange line to the cord circuit via the exchange line jack. K1 also opens circuit of M, and K4 also disconnects L relay. K3 prevents the direct earth being restored to the sleeve of the exchange line jack, when M releases (slowly) after its circuit is opened at K1.



EXCHANGE LINE CIRCUIT.

FIG. 13.

Relay S will hold for the duration of the call, as the windings are in series with the two sides of the line and provide, with the windings of SA, a direct current path across the two condensers in the exchange line circuit. For the duration of the call, earth is supplied to the sleeve of the exchange line jack via a 2,000 ohm resistor.

/ When

When the call is completed, the handset of the extension telephone is replaced, thus opening the direct current loop to the exchange line and releasing relay S. S1 restores to normal and short-circuits relay K which also releases.

K1 and K2 disconnect the exchange line from the extension, and K4 reconnects the 1,000 ohm winding of relay L in series with the condenser across the exchange line. K3 reconnects a direct earth, via L1 and M2, to the sleeve of the jack and cord circuit to cause the supervisory lamps to glow, as explained later, as a clearing signal to the switchboard operator.

Relay SA, as explained later also, is used only when an extension engaged on a call requires to recall the switchboard operator without releasing the exchange line.

3.6 Cord Circuit Operation.

Incoming Exchange Line Call to Extension. The operator answers the incoming exchange call by inserting a front plug in the exchange line jack and operating the speaking key. The speaking key is designated KS in the cord circuit of Fig. 14. L relay in the exchange line circuit (Fig. 13) is released by the operation of the extra springs on the exchange line jack. The direct earth, via L1, M2 and K3 and the sleeve of the jack in the exchange line circuit, operates relay C (Fig. 14) via KS1 operated, D7, 1,400 ohm winding of C to negative battery.

C1 extends the direct earth from the sleeve of the exchange line jack via KS5 to relay D which operates. C2 and C3 connect relay B across the rear cord, but, as the loop is not complete, B does not operate. C4 and C6 connect A relay to the answering (exchange) side of the cord circuit. C7 prepares a locking circuit for the 1,400 ohm winding of relay C, and C5 prepares a circuit for the 750 ohm winding of C and (after D operates) opens the circuit of front supervisory lamp.

Relay D, which operated via C1 and KS5, locks via D1 to earth on the sleeve of the exchange line jack.

D2 closes the loop through A relay windings to operate relay M (see Fig. 13) in the exchange line circuit. M2 (Fig. 13) removes direct earth from the sleeve, but earth via 2,000 ohm N.I.R. is still connected. Relay D holds for the duration of the call through this 2,000 ohm resistance. Contact D2 opens the negative battery feed to A, and D6 opens the positive

/ Fig. 14

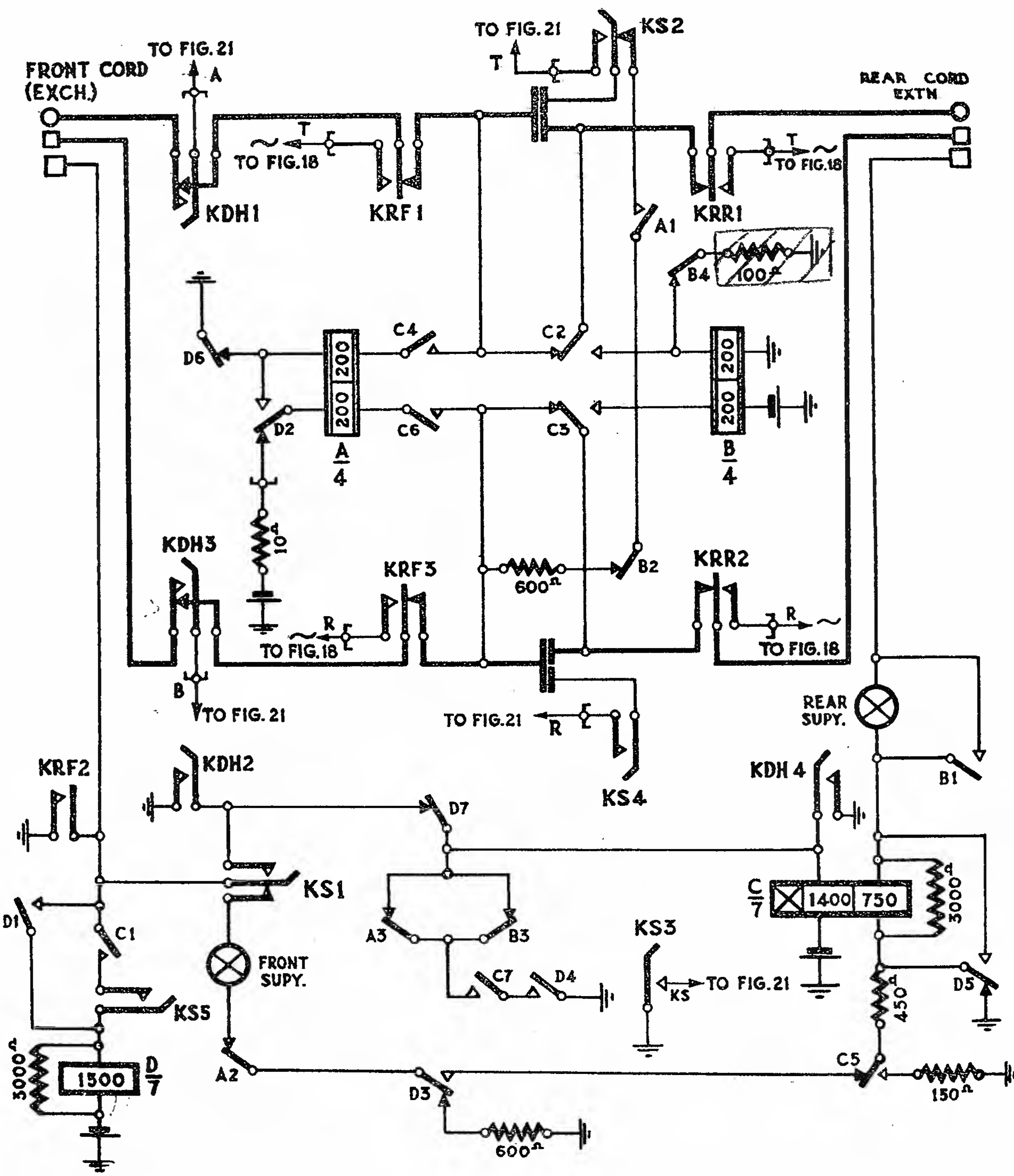
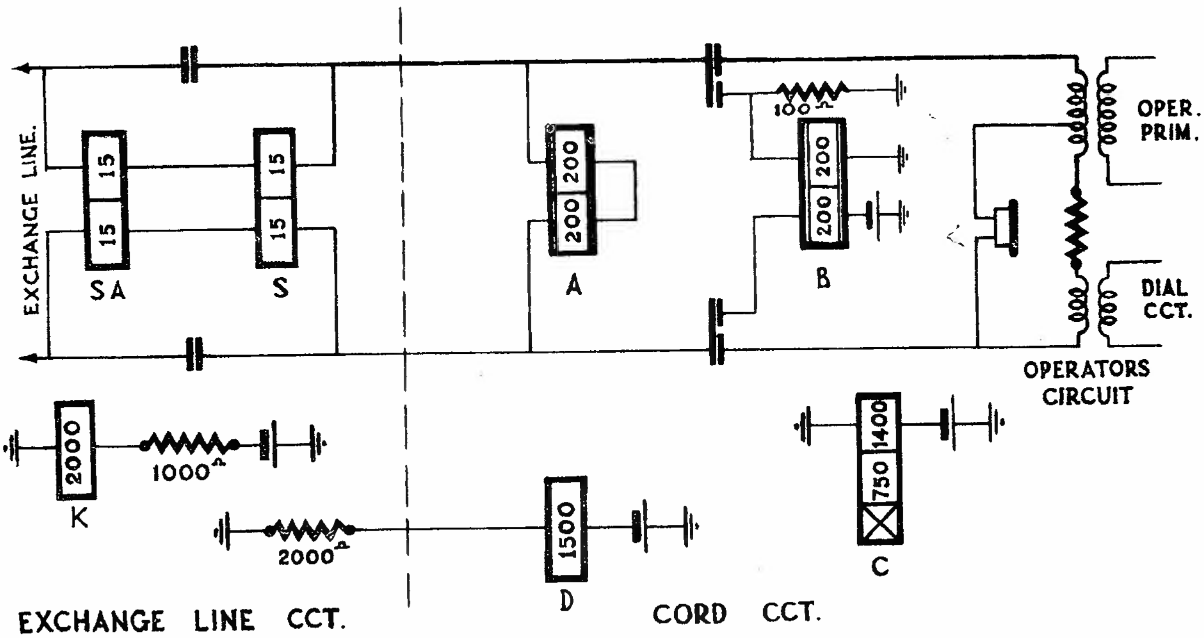


FIG. 14. CORD CIRCUIT.

battery feed to A. D3 connects the supervisory lamps in series in the through sleeve circuit for later operation. D4 completes a locking circuit for the 1,400 ohm winding of C, and D5 short-circuits the 750 ohm winding of C relay.

Relay A, now across the tip and ring of the cord circuit, operates in series with M relay in the exchange line circuit. If the speaking key is restored, A1 provides a circuit for a voice frequency termination (600 ohm N.I.R. and condenser) across the line. A2 further opens the circuit of the front supervisory lamp, and A3 prepares for the later release of C relay. At this stage, the operator can speak to the caller on the exchange line and schematic conditions are as shown in Fig. 15.



EXCHANGE TO OPERATOR.

FIG. 15.

The operator now ascertains the required extension number from the calling subscriber and extends the call by inserting the rear plug into the appropriate extension jack. When the plug / is is inserted, battery via 300 ohms (see Fig. 12) is connected to the sleeve of the rear cord. The supervisory lamp (in Fig. 14) glows, the circuit being from the sleeve of the plug via supervisory lamp, D5, 450 ohm resistance, C5, 150 ohm resistance to earth.

Ringing current is connected to the extension telephone line when the rear ringing key (KRR) is operated. When the called extension answers, relay B operates from battery via 200 ohm winding of B, C3, KRR2 (normal), ring of cord, loop of extension telephone, tip of cord, KRR1 (normal), C2, to earth via the other 200 ohm winding of B, in parallel with earth via B4 and 100 ohm resistance. (The 100 ohm shunt across the 200 ohm winding makes B slow to operate, and thus prevents the operation of B to a possible fleeting negative battery connection should a plug, being inserted in an extension jack, bridge the tip of the plug and ring of the jack. If B should operate at this stage, B3 would open the locking circuit of C relay, which would release and remove the loop from across the exchange line at contacts C4 and C6 before the extension had answered. C could not reoperate when B released, as C's holding circuit at this stage is via C7.)

OMIT

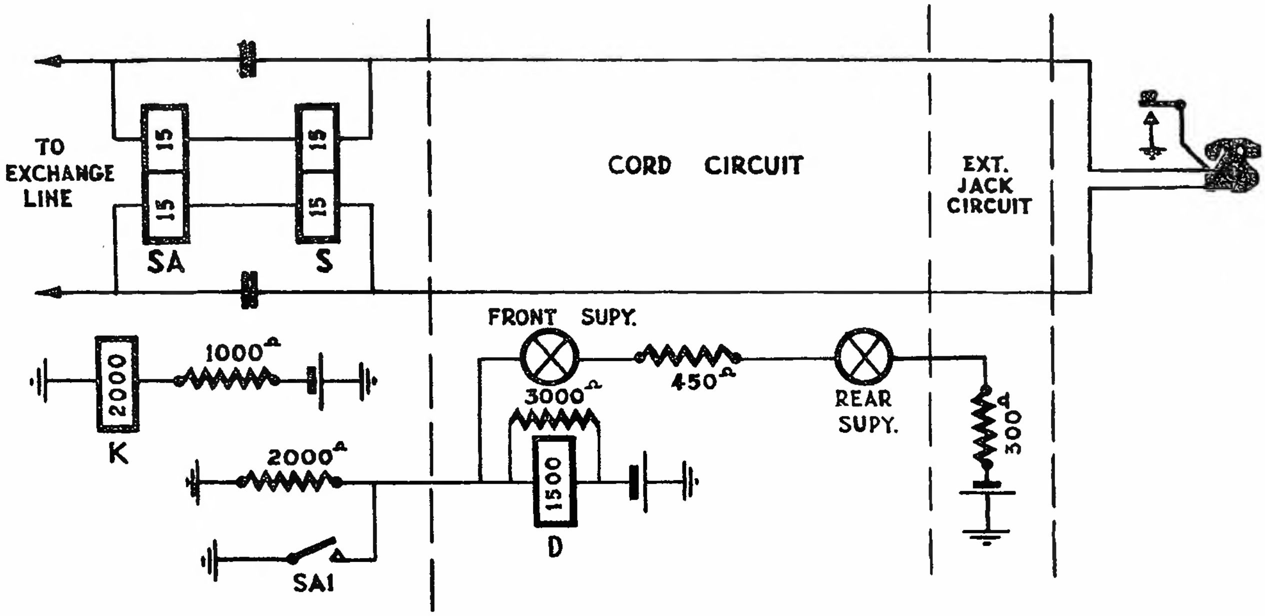
B1 short-circuits and thus extinguishes the rear supervisory lamp, B3 causes the release of C relay and B4 removes the shunt from the winding of B.

Relay C, in releasing, short-circuits the transmission condensers in the cord circuit and opens the circuits of the A and B relays which release. C7 prevents the reoperation of C on the release of B. C1 does not affect the circuit for this condition. C5 places both supervisory lamps in series in the sleeve circuit as follows.

Negative battery via 300 ohms on the sleeve of the extension jack (Fig. 12), sleeve of the rear cord (Fig. 14), rear supervisory lamp, contact D5 operated, 450 ohm resistance, C5 normal, D3 operated, A2 normal, front supervisory lamp, KS1 normal, sleeve of the front cord, sleeve of the exchange jack (Fig. 13) to earth via 2,000 ohm resistance. The current flow in this circuit is insufficient to cause the lamps to glow under this condition. The voice frequency termination is disconnected at A1, and B1 removes the short circuit from the rear supervisory lamp. Thus, for the duration of the call, the loop is held across the exchange line by the extension and only the D relay in the cord circuit is operated. D holds via D1 to earth through 2,000 ohms on the sleeve of the exchange line jack.

/ The

The simplified circuit of this condition is shown in Fig. 16.



EXCHANGE TO EXTENSION (SIMPLIFIED CIRCUIT).

FIG. 16.

Recalling the Operator. A press button fitted to extension telephones allows the extension, if engaged on an exchange line call, to recall the switchboard operator without releasing the exchange line. This button, when pressed, applies an earth to one side of the line. The earth, as shown in Fig. 16, shunts one winding of SA to the exchange line battery, upsetting the differential balance and allowing SA to operate. SA1 applies a direct earth to the sleeve of the exchange line jack and causes both supervisory lamps in the cord circuit to glow. The extension can flash the supervisory lamps, and thus attract the attention of the operator, by alternately pressing and releasing the special button on the telephone. When the call is completed, the extension handset is replaced. This opens the exchange line loop, relay S in the exchange line circuit (Fig. 13) releases and S1 short-circuits relay K, which also releases. A direct earth is supplied to the sleeve of the exchange line jack and both supervisory lamps glow.

/ Follow-on

Follow-on Exchange Line Calls. Should an incoming ring from an exchange line be received before the connection is taken down by the operator of the P.B.X., relay L will operate in synchronism with the ringing periods of the incoming ringing current. L relay, however, cannot lock or light the exchange line lamp, as this is open at the springs of the exchange line jack. At each operation of L, contact L1 removes the direct earth from the sleeve circuit of the jack, and both supervisory lamps in the cord circuit are dimmed during the ringing periods. The make contact of L1 will also cause the pilot lamp (see Figs. 13 and 18) to glow in synchronism with the received ring.

For the operator to answer the incoming exchange line under these conditions, it is necessary to operate the speaking key (KS) and also the dialling key (KDH). Earth via KDH4 operates relay C, which will lock via B3, C7 and D4. Spring-sets KDH1 and KDH3 and impulsing circuit (Fig. 21) operate relay M (Fig. 13), which loops the incoming call via the exchange line relays (SA and S). The operator can remove the plug from the extension jack and the call then functions as before. (KDH must be operated until flashing loop is removed.) When the dialling key is released, the loop of the dial is replaced with A relay windings via C4, C6 and D2 operated. A 3,000 ohm non-inductive resistance is placed across relays D and C. D and C relay windings are in the sleeve circuit, and these shunting resistances prevent the telephonist receiving electric shocks when handling plugs.

If the handset of the extension telephone is removed to make a second call before the cord circuit is restored to normal, the extension telephone will be extended to the exchange line as follows. The extension loop will operate relay M in the exchange line circuit via K1 and K2. Contact M2 will remove the direct earth from the sleeve circuit to extinguish the cord circuit supervisory lamps again, and M1 will loop the exchange line via the windings of relays SA and S. Relay S will operate to the exchange line battery and, at S1, will remove the short circuit from K relay, which will operate as the plug is still in the exchange line jack.

K1 and K2 reconnect the exchange line to the extension line and release relay M. K4 disconnects the L relay from the line and closes the voice frequency shunt (the 2 μF condenser) across the windings of SA and S. K3 prevents the direct earth being replaced (at contact M2) on the sleeve of the exchange line jack on the release of M.

/ M1

M1, when normal, removes the loop in the exchange line circuit from across the line. Relays S and K remain operated for the duration of a call from an exchange line to an extension.

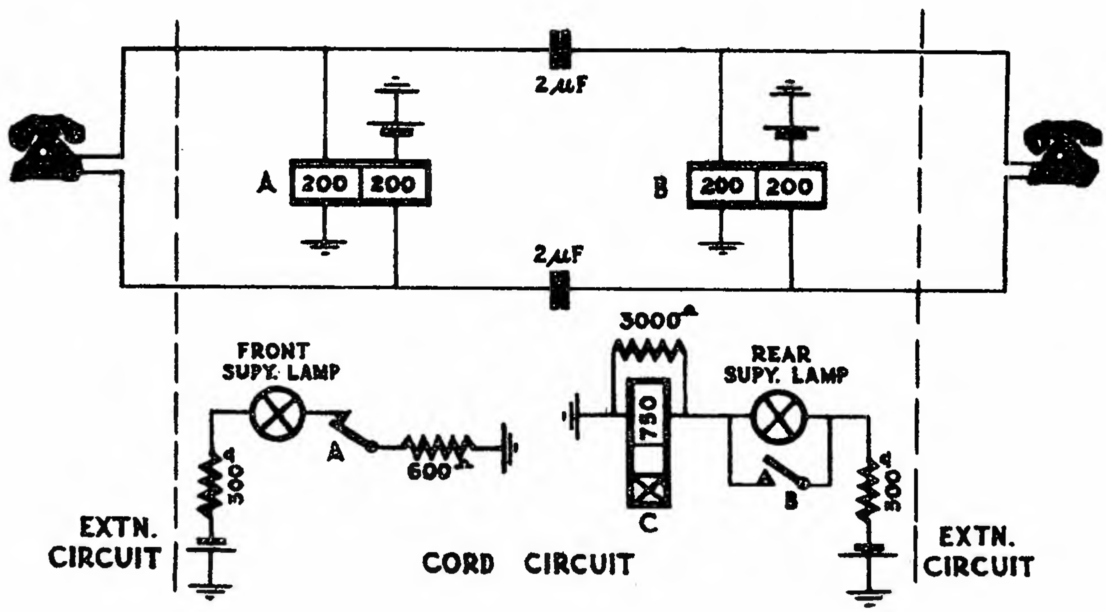
Extension to Extension Calls. The operator answers the calling extension by inserting the rear (extension) plug into the appropriate extension jack. This operation extinguishes the extension's line lamp (see Fig. 12) by disconnecting it at the jack, and connects negative battery (via 300 ohms) to the sleeve of the extension line jack and thus to the sleeve of the rear plug. Relay C (see Fig. 14) operates from this battery on the sleeve of the plug and jack via the supervisory lamp, 750 ohm winding of C and contact D5 normal to earth. C2, C3, C4 and C6 connect the battery feed retards (relays A and B) to the cord circuit. Relay B operates from negative battery, 200 ohm winding of B, C3, KRR2, ring of plug and jack, loop of extension telephone, tip of jack and plug, KRR1, C2, 200 ohm winding of B to earth, ~~and the parallel path via B4 and a 100 ohm resistance to earth.~~

B1 short-circuits the rear supervisory lamp which is thus extinguished, and B4 removes the shunt across the positive winding of B, but other contacts of B play no part at this stage. The operator now operates the speaking key (KS) and speaks to the extension. The operation of this key connects the operator's circuit to the cord circuit via condensers and KS2 and KS4. KS3 closes the primary of the operator's circuit. Having ascertained the number of the required extension, the operator completes the connection by inserting the front plug in the extension jack and rings the extension telephone's bell by the operation of the ringing key (KRF). KRF1 and KRF3 disconnect the answering side of the cord circuit and connect ringing current, from hand magneto generator or ringing power leads (see Fig. 19), to the front cord. Negative battery (via 300 ohm N.I.R.) connected to the sleeve of the cord when the plug is inserted in the extension jack causes the front supervisory lamp to glow via KS1 normal, supervisory lamp, A2 normal, D3 normal and 600 ohm resistance to earth.

When the called extension answers, relay A operates from negative battery, 10 ohm non-inductive resistance (this is a 15 watt resistance and guards against contact between D2 and D6), D2 normal, 200 ohm winding of A, C6 operated, KRF3, KDH3, ring of plug and jack, loop of extension, tip of jack and

/ plug

plug, KDH1, KRF1, C4 operated, 200 ohm winding of A, D6 to earth. A2 opens the circuit of the front supervisory lamp which is extinguished. Transmission between extensions is via a standard Stone Bridge arrangement, the two sides of the cord circuit being electrostatically coupled. While the conversation is proceeding, relays A, B and C remain operated. A and B act as supervisory relays as well as battery feed retards. The impedance of A and B relays to voice frequency currents is increased by nickel iron sleeves. Independent supervision is given with this circuit and, when the handset of either extension is replaced, the appropriate relay is released, causing the appropriate supervisory lamp to glow. A simplified circuit of an extension to extension call is shown in Fig. 17.



EXTENSION TO EXTENSION (SIMPLIFIED CIRCUIT).

Note:

The 300 ohm resistors are in the extension jack circuits (see Fig. 12).

FIG. 17.

Extension to Exchange Call. The operator answers a calling extension by inserting the rear (extension) cord in the appropriate jack, and, as shown in Fig. 12, negative battery via 300 ohms from the sleeve of the extension's jack operates C relay in Fig. 14. C2 and C3 in Fig. 14 complete the circuit of B via the calling extension's loop and B operates. B1 extinguishes the rear supervisory lamp. C4 and C6 prepare for the later operation of A relay. C1 prepares for the later operation of D relay, and C7 prepares a locking circuit for the 1,400 ohm winding of C. C5 switches a total of 600 ohms in series with the rear supervisory lamp to limit the current, should the extension replace the handset and release B relay after D has operated. The operator operates the speaking key (KS) and ascertains that an exchange line call is required. The operator now inserts the front exchange line plug into the jack of a free exchange line. This operates D relay, via C1 and KS5 from the earth on the sleeve of the exchange line jack. D1 locks relay D independent of its operating circuit. D2 and D6 disconnect the positive and negative battery feeds from the exchange side of the cord circuit, and, in addition, D2 provides a loop via the windings of A relay to operate relay M in the exchange line circuit. D5 short-circuits the 750 ohm winding of C, and C will release after its slow release period. (C will not hold on the 1,400 ohm winding via A3 or B3, C7 and D4, because A relay operates immediately it is placed across the exchange line.) D3 places both supervisory lamps in series in the sleeve circuit. D7 prevents the reoperation of C on the 1,400 ohm winding. Relay C releases as above, and C2 and C3 short-circuit the transmission condensers in the cord circuit and open the circuit of both A and B relays. The release of A and B replaces both supervisory lamps in the sleeve circuit. The loop of the extension at this stage is the loop holding the exchange line. The operator at the switchboard is connected across the line via condensers and the speaking key. If the extension telephone is fitted with a dial, the operator may close the key and allow the extension to dial. If the operator leaves the key open, however, the extension may still dial, as the operator's circuit does not provide a shunt path across the connection for direct current. The acoustic shock absorber in the operator's circuit (see Fig. 21) prevents the operator hearing the dialled impulses at too loud a volume, should the speaking key be left open or inadvertently opened when an extension is dialling.

If the number required by the calling extension is to be obtained by the operator of the switchboard, the dialling key (KDH) must be operated. Spring-sets KDH1 and KDH3, two change-over make-before-break spring-sets, replace the

/ extension

extension loop with the impulsing springs of the switchboard dial. An induction coil winding in series with these springs allows the operator to supervise the call between impulse trains without releasing the dialling key.

A spring-set KDH4 operates relay C while dialling is taking place, and C2 and C3 reconnect relay B across the extension line. B operates to the extension loop, and B1 short-circuits the rear supervisory lamp to prevent it glowing. After dialling is finished, the dialling key is released and A relay operates to the exchange line battery. The earth is removed from the 1,400 ohm winding of C at KDH4, and, on the operation of A relay, C releases as its locking circuit is opened at A3. On the release of C, the exchange line is again extended through to the extension and relays A and B release.

3.7 Night Alarm Circuit. In the exchange line circuit (Fig. 13), L1, when operated, closes a circuit to the Pilot Relay. This pilot relay is shown in Fig. 18.

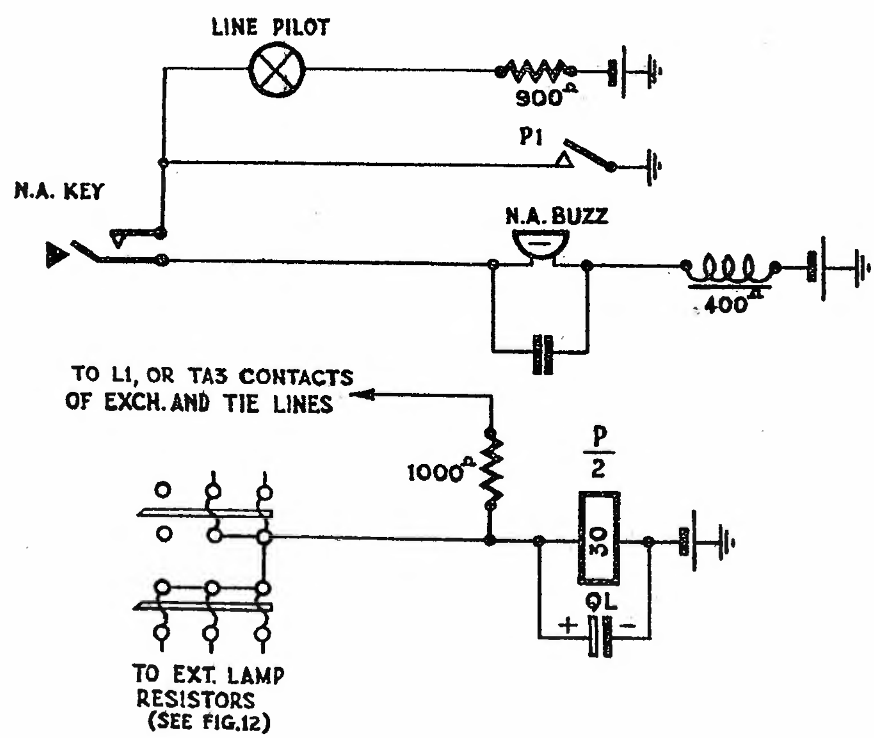


FIG. 18. NIGHT ALARM CIRCUIT.

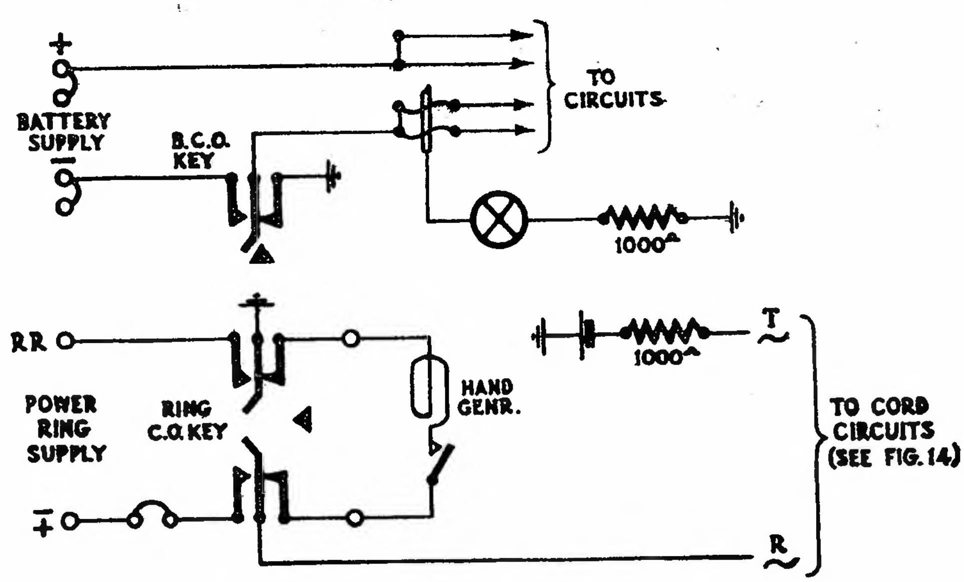
A 1,000 ohm resistance is in series with the 30 ohm pilot relay winding, which is connected to negative battery. The battery supply to the pilot relay does not pass through the fuse panel, so that, even if the fuse supplying battery to

/ the

the line lamps should operate, the switchboard operator will receive a signal for an incoming exchange line call on the pilot lamp. The pilot lamp is operated by P1 contacts. This contact P1 also controls the night alarm circuit through the night alarm switch for the audible signal. A 400 ohm retard is placed in series with the buzzer to act as a choke in the common power lead. The pilot relay is shunted by a 100 µF electrolytic condenser. This is included in the circuit to prevent coupling of calling extensions via this common impedance in the power lead.

3.8 Power Circuit. A visible lamp signal to indicate the operation of a fuse is included in this switchboard. This lamp, as shown in Fig. 19, will continue to glow until the fuse is removed or replaced. The lamp signal is not connected to the pilot or night alarm circuit. Ringing current is supplied either from a hand generator or the local telephone exchange. When a hand generator is used, earth is connected through the armature of the generator to one side with a return path via 1,000 ohms and negative battery.

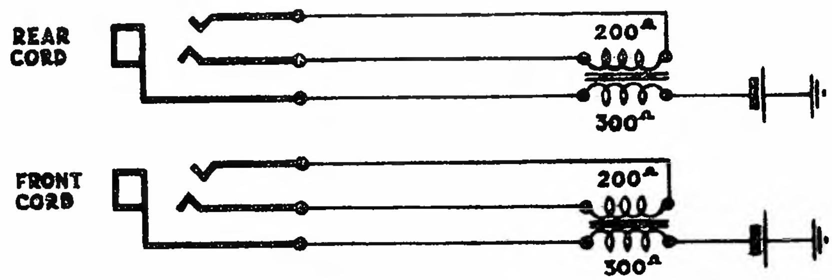
The battery cut-off key is arranged to earth the negative commons inside the switchboard to prevent any possible rise of potential under night switched conditions. The power lead requirements for this board are 2.5 times the present allowance shown in General Engineering Circular No. 13.



POWER CIRCUIT.

FIG. 19.

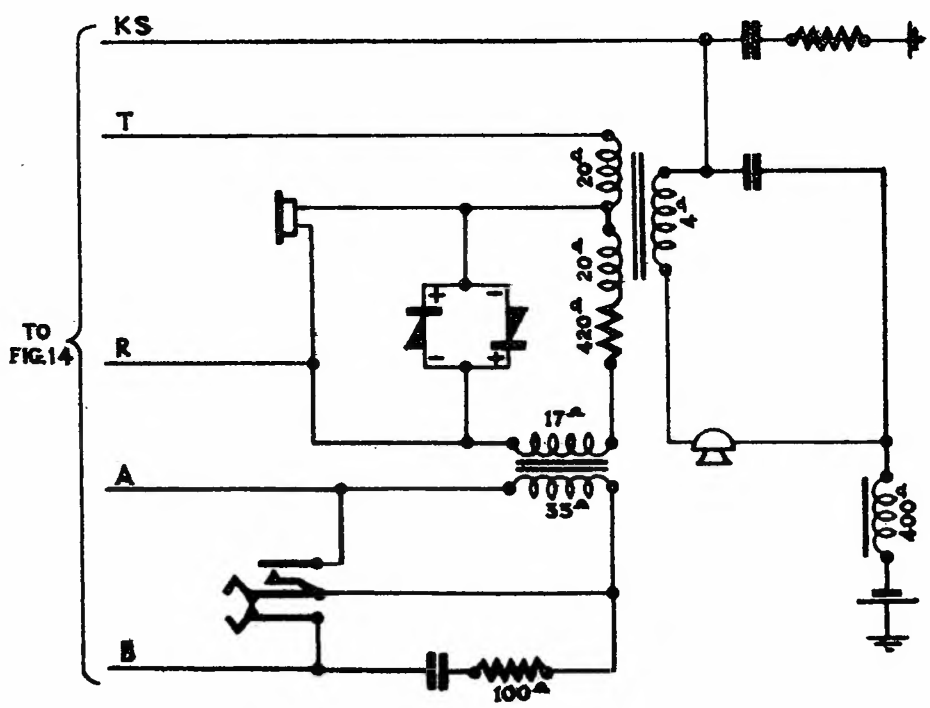
3.9 Cord Test Circuit. Cords are tested as explained previously. Two test jacks are provided in the cord test circuit, as shown in Fig. 20. When plugs are inserted in the jacks, a loop of 200 ohms is placed across the tip and ring, and negative battery via 300 ohms on the sleeve of each cord. The sleeve is inductively coupled to the loop to enable faulty conductors in either tip, ring or sleeve to be detected by noise in the receiver when the cord is moved.



CORD TEST CIRCUIT.

FIG. 20.

3.10 Telephonist's Circuit. The telephonist's circuit, as shown in Fig. 21, is similar to other operators' circuits.



TELEPHONIST'S CIRCUIT.

FIG. 21.

The primary winding of the induction coil is a separate circuit closed only when a speaking key is operated. The 400 ohm retard in the transmitter battery supply is to reduce the P.D. across the transmitter and to act as a choke in the common power circuit. The receiver is connected in the secondary winding of the induction coil across a bridge arrangement to reduce sidetone. The two metal rectifiers act as an acoustic shock absorber at the receiver. A coupling key is fitted when two switchboards are installed.

Tie Lines. P.A.B.X. Tie Line. Tie lines are lines connecting switchboards together for purposes of direct communication between extensions connected to the switchboards. The Exchange Line Circuits of this switchboard, when connected to a Private Automatic Branch Exchange (usually abbreviated to P.A.B.X.), may be used as Tie Lines. The switchboard operator may dial over the tie line to the P.A.B.X. to obtain the required extension telephone at the P.A.B.X. The operator cannot gain access to an exchange line via the tie line circuit to the P.A.B.X.

Extensions of the P.A.B.X. may connect to the switchboard over the tie line by dialling the appropriate extension number allotted to the tie line. The operator of the manual position at the P.A.B.X. is prevented from extending one of the exchange lines via the tie line to the switchboard. Exchange access over tie lines is not given, as they are designed solely to allow extensions of one switchboard to be connected direct to extensions of the other switchboard.

C.B. or Magneto Tie Line. The circuit of the Tie Line for C.B. or Magneto working is shown in Fig. 22.

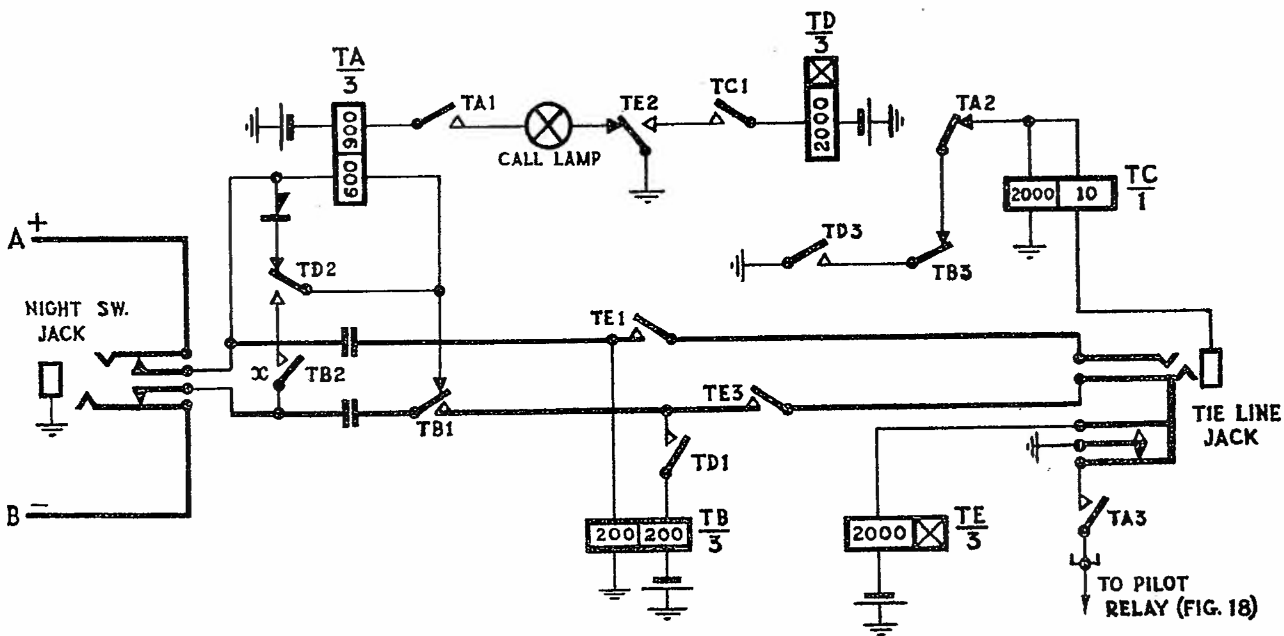
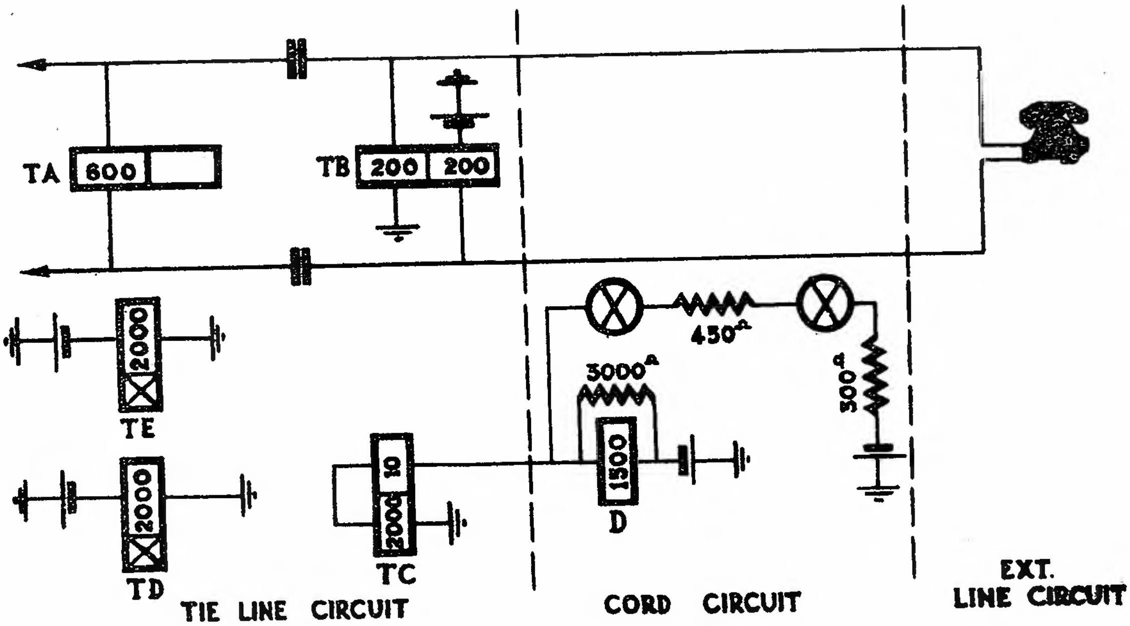


FIG. 22. TIE LINE (C.B. OR MAGNETO) WITH RESTRICTED ACCESS.

The front plug and cord are used to answer or originate a call. On an incoming call to the switchboard, ringing current is received over the positive line, top and inner springs of the night switching jack, 600 ohm winding of TA (shunted by a metal rectifier), TB1 normal, 2 uF condenser, inner and ring springs of the night switching jack back to the negative line. The incoming ring, whether from a magneto or C.B. switchboard, will cause TA to operate. TA1 closes the locking winding circuit via the tie line call lamp (which glows) and TE2. TA2 operates and thus allows the 2,000 ohm winding of TC to be in series with the 10 ohm winding of TC for later operation. TA3 extends an earth from the normally making extra springs of the tie line jack to the pilot relay (Fig. 18). The pilot relay operates and lights the pilot lamp. The operator answers the calling tie line by inserting an exchange line plug in the jack and operating the speaking key. The extra spring-set of the tie line jack operates, disconnecting the pilot relay and operating TE. Negative battery via the 1,400 ohm winding of C (see Fig. 14), D7 and KS1 in the cord circuit is also applied to the sleeve to operate TC (in Fig. 22) via the 10 and 2,000 ohm windings in series. Relay C in the cord circuit (Fig. 14) will not operate with this current value. TE1 and TE3 (Fig. 22) partly extend the tie line, and TE2 opens the line lamp and locking winding of TA which releases. TD operates via TE2 operated and TC1. TD1 connects the battery feed relay TB across the tie line. TD2 prepares to loop the tie line.

TD3 short-circuits the 2,000 ohm winding of TC and increases the sleeve current to cause the operation of relay C (Fig. 14) in the cord circuit. This is followed by the operation of relay D, and the A relay is then connected across the tip and ring of the tie line. Relay TB (Fig. 22) operates to this loop. TB2 places the 600 ohm winding of TA across the incoming tie line to provide a loop in the case of a tie line from a C.B. switchboard. TB1 connects the B side through, and TB3 removes the short-circuit from the 2,000 ohm winding of TC. The D relay in the cord circuit (Fig. 14) will hold through this resistance. (If the tie line is from a C.B. switchboard, relay TA (Fig. 22) will operate on its 600 ohm winding and remain operated for the duration of the call. If the tie line is from a magneto switchboard, TA will not operate.) The operator speaks to the caller on the tie line, ascertains the extension required and extends the call, the operation of the cord circuit being as for an exchange to extension call. The simplified conditions, when the call is proceeding, are as shown in Fig. 23. When the call is completed, the extension handset is replaced, and relay TB (Fig. 22) releases and disconnects TA from the line at TB2. TB1 however, opens one side of the line and reconnects TA in series with a condenser across the line. TB3 connects earth through the 10 ohm winding only of relay TC to the sleeve. This causes both supervisory lamps in the cord circuit to glow as a clearing signal.



EXTENSION TO TIE LINE (C.B. OR MAGNETO) (SIMPLIFIED CIRCUIT).

Note: The 300 ohm resistor is in the extension jack circuit (see Fig. 12).

FIG. 23.

If another incoming call is received before the operator has cleared the connection, TA will operate on its 600 ohm winding via the condenser and contacts TB1. Contact TA2 will replace the 2,000 ohm winding of TC in the sleeve circuit, and the cord circuit supervisory lamps will be extinguished. As the locking winding circuit of TA is open at TE2, the tie line lamp

/ cannot

cannot glow, and the only signal received by the operator is the extinguishing of the cord circuit supervisory lamps in synchronism with the received ring.

If, on answering a tie line, an attempt should be made to connect the tie line to an exchange line by inserting the rear plug into an exchange line jack, neither B relay in the cord circuit nor M relay in the exchange line circuit can operate as their battery feeds oppose one another. The exchange line could not, therefore, be looped and the call could not proceed. For an outgoing call from an extension to the tie line, the operator answers a calling extension as detailed in the circuit description for extension to extension call. Relays B and C in the cord circuit are operated at this stage. To call the tie line, the front (exchange) plug is inserted in the jack. This operates relay TC via the 1,400 ohm winding of C in the cord circuit. C is already operated on its 750 ohm winding. Relay TE operates from the extra springs of the jack as the plug is inserted.

TC1 prepares for the operation of TD. TE1 and TE3 extend the A and B sides of the line in preparation for the later operation of TB. TE2 causes TD to operate. TD3 short-circuits the 2,000 ohm winding of TC, increasing the sleeve current and allowing relay D in the cord circuit to operate at this stage.

TD2 prepares to loop the outgoing line to give a signal to the operator of the distant switchboard in the case of a C.B. line. TD1 closes the circuit of TB relay, and this relay operates to the loop of relay A in the cord circuit. This causes the release of C relay in the cord circuit, and TB holds now to the loop of the calling extension.

TB2 completes the loop to the distant switchboard, and TB1 completes the through circuit. TB3 reconnects the 2,000 ohm winding of C in the sleeve circuit. Relay TA will now operate on its 600 ohm winding to the battery feed from the distant C.B. switchboard and remain operated for the duration of the call.

If it is necessary to ring on a tie line, for example, to a magneto exchange or to another lamp signalling switchboard, this is done by operating the front ringing key KRF (Fig. 14).

/ Spring-set

Spring-set KRF2 applies an earth to the sleeve of the front cord. This keeps relay D in the cord circuit operated, but allows TC in the tie line to release. TC1 releases TD. TD1 opens the negative winding of TB relay, but this does not release as the ringing key at KRF1 applies negative battery through 1,000 ohms to hold TB on its positive winding. TD2 opens the loop of the 600 ohm winding of TA, and the ring is applied direct without any shunt paths over the ring side of the tie line. On the release of the ringing key, TC reoperates on its 10 ohm and 2,000 ohm windings, followed by relay TD. Relays TD and TE are slow to operate, so that TC will operate fully on its 2,000 ohm winding when the plug is inserted and the speak key operated.

Note that, when a call is made by the switchboard operator to a tie line, it is essential for the operator to open the speaking key before operating the ring key. This is to allow relay TC to operate via KS1, D7 and 1,400 ohms of C relay in the cord circuit.

4. ADDITIONAL APPARATUS ON EXTENSION LINE OF P.B.X.

4.1 For both cordless and cord type C.B. P.B.X. switchboards, additional apparatus is not permitted on any exchange line, but the facilities already indicated for extension working with straight line telephones are permitted on extension lines associated with such switchboards, with the following reservations -

4.2 Where alternative telephones with a change-over switch are installed, telephones in parallel with either of the telephones controlled by the change-over switch are not allowed. This restriction applies also to an extension line operating from an extension switch.

4.3 Telephones in parallel are restricted to two, as previously indicated.

4.4 Where portable telephone facilities are installed on an extension line, no additional facilities, other than an extension bell and an extra portable telephone, are permitted on that extension line.

4.5 Each cordless or cord type P.B.X. switchboard is equipped with a generator for ringing the various extension telephones.

/ Where

Where it is desired, however, power ringing from the exchange ringing apparatus is connected to the P.B.X. over conductors in the network cables, and is then available for use by the P.B.X. telephonist in place of the generator forming portion of the P.B.X. switchboard equipment.

4.6 Cord type P.B.X. switchboards are also equipped with a head and breast telephone set where such is desired by the subscriber, that is, where a telephonist is continuously engaged at the switchboard. The normal speaking point, that is, a bell receiver and fixed transmitter, is not removed from the P.B.X. when a head and breast telephone is provided. A handset with anti-sidetone coil may be fitted in place of the bell receiver and fixed transmitter.

4.7 A non-switching unit, as described in the next section, is also permitted on an extension line associated with a P.B.X.

5. THE NON-SWITCHING UNIT.

5.1 The P.B.X. switchboards already described provide for intercommunication between the various lines connected to the switchboard. Occasionally, however, a subscriber desires to have access from one telephone instrument to various lines without intercommunication between such lines. To meet such requirements, a special type of equipment known as the Non-Switching Unit is employed. This unit is similar in appearance to a cordless type P.B.X. The circuit of such a unit is shown in Fig. 24.

5.2 These units are available in the following sizes -

$$\frac{1+1}{2}, \qquad \frac{1+3}{4}, \qquad \frac{2+4}{6}, \qquad \frac{2+6}{8}.$$

The first number in the numerator represents the number of lines connected to the exchange or P.B.X., the second number in the numerator represents the number of direct lines to which access is desired, and the denominator represents the total number of lines.

5.3 The exchange lines or P.B.X. lines are equipped with a drop indicator circuit similar to that used for cord or cordless type P.B.X. switchboards. The holding and calling arrangements (exchange or P.B.X.) are similar to those for the

/ cordless

cordless P.B.X. As the subscriber, when speaking to an exchange or P.B.X., will receive speaking battery over the line concerned from the exchange or P.B.X., a battery feed is not associated with an extension line from a P.B.X.

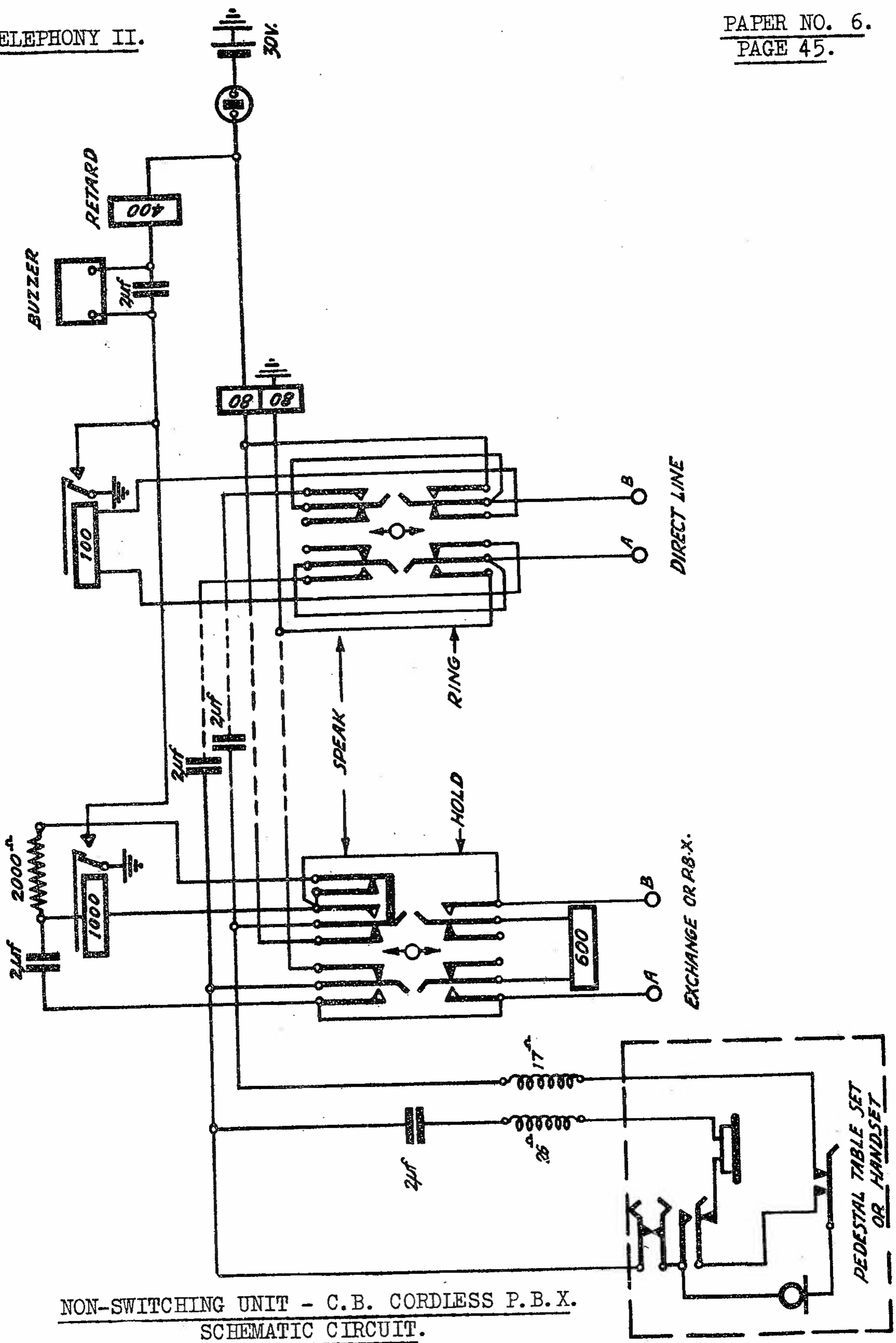
The dial is not fitted unless the extension line is one with night switching facilities to an automatic exchange. Outward calling on direct lines is effected by applying battery and earth to the direct lines through the 80 ohm/80 ohm retard and the ringing key. The direct line, terminating on another similar N.S.U., will be connected direct to a 100 ohm drop indicator as shown, and this indicator will drop.

Similarly, operation of the speaking key brings the subscriber's telephone across the direct line through the 2 µF condensers indicated, battery feed being to the subscriber's telephone from the 80 ohm/80 ohm retard via the inner springs of the speaking key on the exchange or P.B.X. line.

A similar arrangement prevails at the N.S.U. at the other end of the direct line. The circuit arrangements indicated do not provide for the termination of the direct lines on telephones, since battery is not connected to the direct line for speaking purposes and an ordinary telephone cannot be called from the N.S.U.

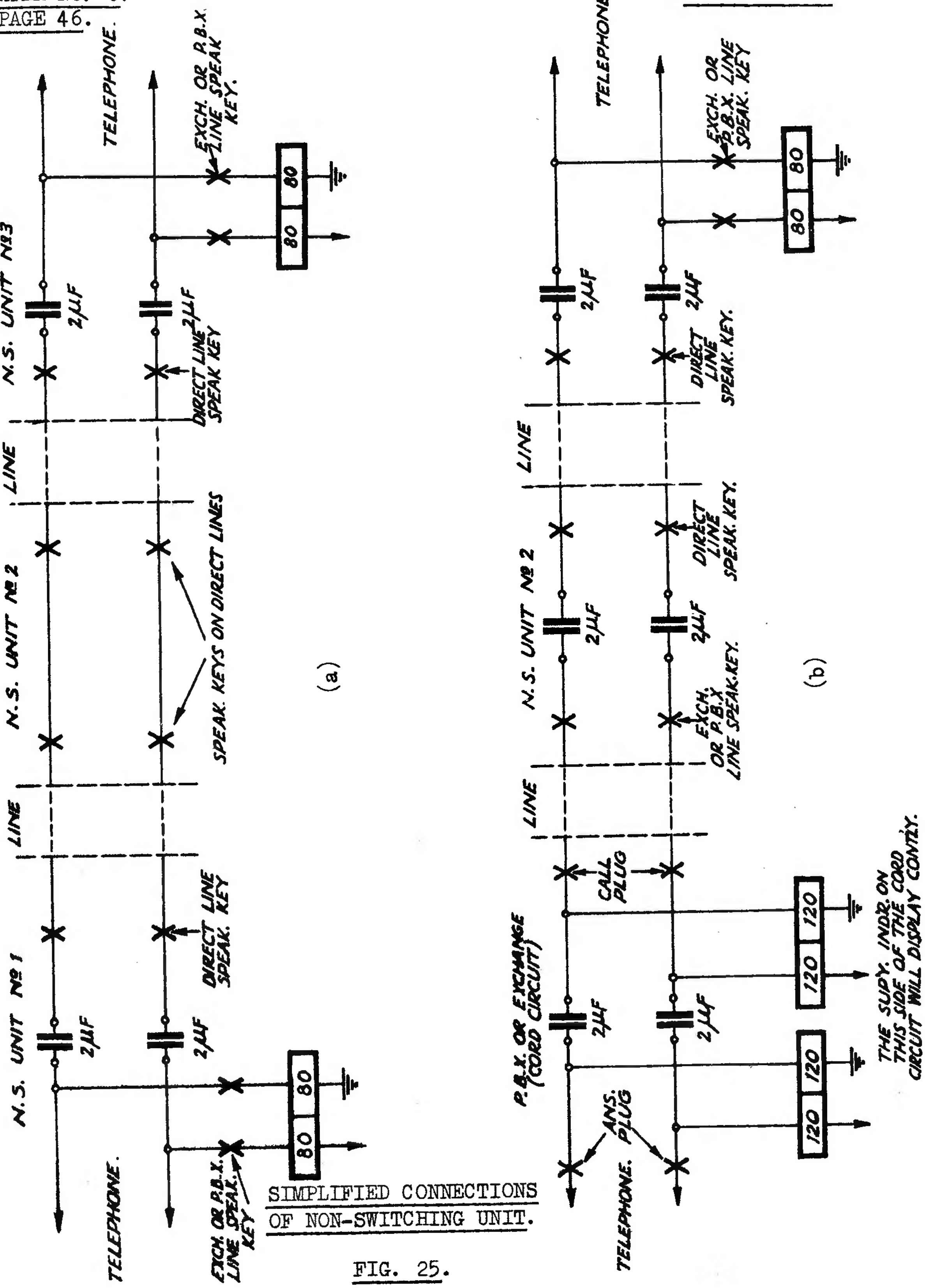
5.4 The unit, as its name implies, is not designed to allow the switching together of direct lines or direct lines to P.B.X. (or exchange) lines. Such switching can be done over the speaking common, however, and the resultant connections are as indicated in Figs. 25a and 25b. It will be seen, however, that a clearing signal is not available at the N.S.U. at which the irregular switching is performed and, moreover, as long as such a switched conversation is in progress, the N.S.U. at which the switching is done cannot be used for any other purpose without upsetting the switched conversation. In the circumstances, it will be appreciated that the name given to the unit does not mean that lines cannot be switched together, but rather that the unit is not designed to permit such switching as a regular function.

/ Fig. 24



NON-SWITCHING UNIT - C.B. CORDLESS P.B.X.
SCHEMATIC CIRCUIT.

FIG. 24.



SIMPLIFIED CONNECTIONS OF NON-SWITCHING UNIT.

FIG. 25.

6. P.B.X. POWER LEADS.

6.1 It has been explained that, for extension to extension connections at cordless or cord type P.B.X. switchboards, or for direct line working at non-switching units, battery feed must be supplied by the P.B.X. or N.S.U. circuits. The simplest manner of supplying such battery feed is by a battery associated with the P.B.X. or N.S.U. The use of a primary battery is expensive both in maintenance and renewal of the cells. The cost of the necessary charging facilities for a secondary battery installation is also high, and thus a more economical arrangement than either of these is desirable (except in special circumstances which will be referred to later, see paragraph 7.1). This more economical method is by the use of Power Leads. A power lead is a group of conductors in parallel, which serves to join the negative busbar at the exchange to the negative busbar of the power panel of the P.B.X., the positive busbar at the P.B.X. being earthed. As the positive busbar at the exchange is earthed also, it will be seen that power lead working is single or earth circuit.

Certain cases may occur where small cordless P.B.X's. are installed on the outskirts of an exchange network, and the provision of power leads would involve tying up long cable pairs and probably also a certain amount of open wire construction. In these cases, it may prove economical to provide primary cells (dry cells) in preference to power leads. Such cases are determined on the results of an economic study made of the particular case.

6.2 The reason for placing several conductors in parallel to form the power lead is to reduce the resistance thereof, so that the "Potential Drop" over the power lead will be reduced to a certain fixed maximum value which depends primarily on the exchange voltage. The principle of joining the conductors in parallel should be readily appreciated, as, if N (exactly similar) conductors be so paralleled, the joint resistance of the group is $\frac{R}{N}$, where R is the resistance of any one of them. The potential drop over the power lead for a given current (I) will be $\frac{I \times R}{N}$, as against $I \times R$ where only one conductor is used. In certain circumstances, that is, where the P.B.X. is close to the exchange, only one conductor may be necessary in the power lead and the potential at the P.B.X. may still be over the allowable minimum. The greater the current demand at the P.B.X. and the greater the distance of the P.B.X. from the exchange, the greater will be the number of conductors required in the power lead.

/ 6.3

6.3 The minimum and maximum permissible busbar potentials for P.B.X. switchboards, as already described, are 21 and 46 volts respectively. Main exchange batteries used on power leads are generally one of three values, namely, 30, 40 and 46 volts respectively. Where the main exchange battery is below 30 volts, it is increased to this figure for power leads by the addition of the meter battery (or other suitable battery) in series. Where the voltage is over 46 (for example, Siemens' exchanges), it is reduced to 46 volts by the use of C.E.M.F. cells. The maximum potential drop allowable over a power lead is, therefore, 9, 19 or 25 volts respectively for each of the exchange voltages mentioned.

6.4 To simplify the determination of the number of cable conductors required in any power lead, tables have been prepared showing the number of cable conductors required per mile under different load conditions at the P.B.X. Tables 1 and 2 for exchanges of 30 and 46 volts respectively are included in this Paper.

6.5 On an exchange to extension call, the drain on a power lead is small, as current is only required to operate the supervisory signal in the case of cordless P.B.X. switchboards, or to operate the BCO relay and supervisory signals in the case of cord type P.B.X. switchboards. For extension to extension calls, the total current demand for the operation of both extensions in parallel is from the power lead. It has been found that an approximate figure indicative of the average current demand is 50 mA per cord or switching circuit of the P.B.X. at a minimum busbar potential of 21 volts. The current demand may, therefore, be calculated for all general cases by multiplying the number of cord or equivalent switching circuits by 50 and dividing by 1,000 to get the resultant product in amperes. This figure of 50 mA forms the basis of the tables previously referred to, which include particulars relevant to 6-1/2, 10, 12-1/2 and 20 lb. cable conductors.

6.6 The tables are based on the following equation derived from Ohm's Law -

$$N = \frac{M}{20} \times \frac{R}{(X - 21)}$$

where N = Number of single wire conductors per mile,
M = Number of cord or equivalent switching circuits on the P.B.X.,
X = Exchange power lead busbar voltage, and
R = Resistance per mile of a single cable conductor.

/ Table 1.

LENGTH OF U.G. CABLE PAIRS. (IN YARDS)	LOOP RESISTANCE IN OHMS OF UNDERGROUND CABLE PAIRS. (Resistance of paralleled pair is one-quarter of value shown.)				MAXIMUM NO. OF SWITCHING CIRCUITS.			
	6-1/2 lb.	10 lb.	12-1/2 lb.	20 lb.	6-1/2 lb.	10 lb.	12-1/2 lb.	20 lb.
A	B	C	D	E	F	G	H	J
100	15.5	10	8	5	46.4			
150	23.25	15	12	7.5	30.9	48		
200	31	20	16	10	23.2	36	45	
300	46.5	30	24	15	15.5	24	30	48
400	62	40	32	20	11.6	18	22.5	36
440	68	44	35	22	10.6	16.3	20.6	32.7
500	77.5	50	40	25	9.3	14.4	18	28.8
600	93	60	48	30	7.7	12	15	24
700	108.5	70	56	35	6.6	10.3	12.9	20.6
800	124	80	64	40	5.8	9	11.2	18
880	136	88	70	44	5.3	8.2	10.3	16.3
900	139.5	90	72	45	5.2	8	10	16
1,000	155	100	80	50	4.8	7.2	9	14.4
1,100	170.5	110	88	55	4.2	6.5	8.2	13
1,200	186	120	96	60	3.9	6	7.5	12
1,300	201.5	130	104	65	3.6	5.5	6.9	11
1,320	204	132	106	66	3.5	5.4	6.8	10.9
1,400	217	140	112	70	3.3	5.1	6.4	10.3
1,500	232.5	150	120	75	3.1	4.8	6	9.6
1,600	248	160	128	80	2.9	4.5	5.6	9
1,700	263.5	170	136	85	2.7	4.2	5.3	8.4
1,760	273	176	141	88	2.6	4.1	5.1	8.2
1,800	279	180	144	90	2.6	4	5	8
1,900	294.5	190	152	95	2.4	3.8	4.7	7.6
2,000	310	200	160	100	2.3	3.6	4.5	7.2
2,200	340	220	176	110	2.1	3.3	4.1	6.5
2,400	372	240	192	120	1.9	3	3.7	6
2,600	403	260	208	130	1.8	2.8	3.5	5.5
2,640	408	264	211	132	1.8	2.7	3.4	5.45
2,800	434	280	224	140	1.7	2.6	3.2	5.1
3,000	465	300	240	150	1.6	2.4	3	4.8
3,080	476	308	246	154	1.5	2.3	2.9	4.7
3,200	496	320	256	160	1.45	2.25	2.8	4.5
3,400	527	340	272	170	1.4	2.1	2.7	4.2
3,520	546	352	282	176	1.3	2.05	2.6	4.1
3,960	612	396	317	198	1.2	1.8	2.3	3.6
4,400	680	440	350	220	1.05	1.6	2.06	3.3
4,840	748	484	387	242	0.96	1.5	1.9	3
5,280	816	528	422	264	0.88	1.4	1.7	2.7
6,160	952	616	493	308	0.75	1.2	1.5	2.3
7,040	1088	704	563	352	0.66	1.02	1.3	2.05

POWER LEADS FROM EXCHANGES (30 VOLT BATTERY) TO PRIVATE BRANCH EXCHANGES.

Columns "F" to "J" show the Number of Switching Circuits which may be connected to One Cable Pair of Length shown in Column "A" and Resistance shown in Columns "B" to "E".

TABLE 1.

LENGTH OF U.G. CABLE PAIRS. (IN YARDS)	LOOP RESISTANCE IN OHMS OF UNDERGROUND CABLE PAIRS. (Resistance of paralleled pair is one-quarter of value shown.)				MAXIMUM NO. OF SWITCHING CIRCUITS.			
	6-1/2 lb.	10 lb.	12-1/2 lb.	20 lb.	6-1/2 lb.	10 lb.	12-1/2 lb.	20 lb.
A	B	C	D	E	F	G	H	J
100	15.5	10	8	5				
150	23.25	15	12	7.5				
200	31	20	16	10				
300	46.5	30	24	15	43.01			
400	62	40	32	20	32.3	50		
440	68	44	35	22	29.4	45.5	57.1	
500	77.5	50	40	25	25.8	40	50	
600	93	60	48	30	21.5	33.3	41.7	
700	108.5	70	56	35	18.4	28.6	35.7	57.2
800	124	80	64	40	16.1	25	31.2	50
880	136	88	70	44	14.7	22.7	28.6	45.5
900	139.5	90	72	45	14.3	22.2	27.8	44.4
1,000	155	100	80	50	12.9	20	25	40
1,100	170.5	110	88	55	11.7	18.2	22.7	36.4
1,200	186	120	96	60	10.7	16.7	20.8	33.4
1,300	201.5	130	104	65	9.9	15.4	19.2	30.8
1,320	204	132	106	66	9.8	15.1	18.8	30.3
1,400	217	140	112	70	9.2	14.3	17.9	28.6
1,500	232.5	150	120	75	8.6	13.3	16.7	26.6
1,600	248	160	128	80	8.1	12.5	15.6	25
1,700	263.5	170	136	85	7.6	11.8	14.7	23.6
1,760	273	176	141	88	7.3	11.4	14.2	22.7
1,800	279	180	144	90	7.2	11.1	13.9	22.2
1,900	294.5	190	152	95	6.8	10.5	13.2	21
2,000	310	200	160	100	6.5	10	12.5	20
2,200	340	220	176	110	5.9	9.1	11.4	18.2
2,400	372	240	192	120	5.4	8.3	10.4	16.6
2,600	403	260	208	130	5.0	7.7	9.6	15.4
2,640	408	264	211	132	4.9	7.6	9.5	15.1
2,800	434	280	224	140	4.6	7.1	8.9	14.3
3,000	465	300	240	150	4.3	6.7	8.3	13.4
3,080	476	308	246	154	4.2	6.5	8.2	13.0
3,200	496	320	256	160	4	6.2	7.8	12.5
3,400	527	340	272	170	3.8	5.9	7.3	11.8
3,520	546	352	282	176	3.7	5.7	7.1	11.4
3,960	612	396	317	198	3.3	5.05	6.3	10.1
4,400	680	440	350	220	2.9	4.5	5.7	9.1
4,840	748	484	387	242	2.7	4.1	5.2	8.3
5,280	816	528	422	264	2.5	3.8	4.8	7.6
6,160	952	616	493	308	2.1	3.2	4.1	6.5
7,040	1,088	704	563	352	1.8	2.8	3.6	5.7

POWER LEADS FROM EXCHANGES (46 VOLT BATTERY) TO PRIVATE BRANCH EXCHANGES.

Columns "F" to "J" show the Number of Switching Circuits which may be connected to One Cable Pair of Length shown in Column "A" and Resistance shown in Columns "B" to "E".

TABLE 2.

Some typical resistance values of cable conductors are -

135 ohms for 6-1/2 lb. cable conductors.
88 ohms for 10 lb. cable conductors.
70 ohms for 12-1/2 lb. cable conductors.
44 ohms for 20 lb. cable conductors.

The formula is derived in the following manner -

(a) Since X = Exchange power lead busbar voltage, and

21 = Minimum allowable potential at the P.B.X. busbar,

(X - 21) = Maximum allowable potential drop over the power lead.

(b) Then $X - 21 = I \times R_\ell$

where I = Current demand over the power lead at period of heaviest current demand, that is, the busiest time of the day (or hour), and

R_ℓ = Resistance of the power lead.

From what has already been stated -

$$I = M \times 50 \text{ mA}$$

$$= \frac{M \times 50}{1,000} = \frac{M}{20} \text{ amperes}$$

also $$R_\ell = \frac{R \times D}{N_c}$$

where R = Resistance per cable conductor per mile,

D = Distance in miles between P.B.X. and the exchange, and

N_c = Number of cable conductors.

/ (c)

(c) In consequence -

$$X - 21 = \frac{M}{20} \times \frac{R \times D}{N_c}$$

Cross multiplying -

$$N_c \; (X - 21) = \frac{M \times (R \times D)}{20}$$

$$\text{and } N_c = \frac{R \times D}{(X - 21)} \times \frac{M}{20}$$

$$\text{then } \frac{N_c}{D} = \frac{M}{20} \times \frac{R}{X - 21}$$

But N = Number of cable conductors per mile

$$= \frac{N_c}{D}$$

$$\therefore N = \frac{M}{20} \times \frac{R}{X - 21}$$

The number of cable conductors per mile can, therefore, be calculated.

6.7 The maximum permissible resistance of a power lead is given by the formula -

$$R = \frac{X - 21.}{I}$$

This formula is used where abnormal traffic conditions cause a heavier current drain than the 50 mA per cord circuit approximation used for the tables previously referred to. I, in this case, is the measured normal maximum current demand in amperes.

6.8 Examples to illustrate the use of the tables are as follows -

Example 1. A 10 lb. cable pair, 1,300 yards long, is available from a 46 volt exchange for power supply to a subscriber's building. What number of switching circuits will it supply under the prescribed conditions?

/ Reading

Reading horizontally along the line in which 1,300 yards appears in Table 2, Column "A", the figure in Column "G" is 15.4. Therefore, 15 switching circuits would be the capacity of the pair, and additional pairs would not be connected to the group until, say, 16 switching circuits were exceeded.

Example 2. The table may be used to ascertain the number of pairs required for a given load (in switching circuits) as follows -

A $\frac{6 + 20}{40}$ floor pattern cord type switchboard and two $\frac{3 + 9}{12}$ cordless switchboards to be installed in a building at a distance of 1,800 yards (10 lb. conductors from a 46 volt exchange) require to be provided with direct current power supply. Reading horizontally along the line in which 1,800 yards appears in Table 2, Column "A", the figure in Column "G" is 11.1. This represents the carrying capacity of 1 cable pair. For 18 switching circuits, 2 pairs would be necessary. This number of switching circuits is the maximum of the units to be installed.

Example 3. Where a circuit consists of lengths of different weights of cable conductors jointed together, it will be necessary to obtain the loop resistance of the cable pair from the exchange to the premises. If it is necessary to calculate the loop resistance - knowing the length of each weight of conductor - columns "A" to "E" should be used. Add together the value for the length of each weight. When the loop resistance of the circuit is known, locate this value (or the nearest value to it) in any of the columns "B" to "E" of the table for the appropriate exchange voltage. The number of switching circuits will be shown in that one of columns "F" to "J" which is headed with the same weight of conductor as the column in which the resistance value was found.

A practical example for a 46 volt exchange area is as follows -

A cable pair is composed of 200 yards of 10 lb. conductor (loop resistance 20 ohms) jointed to 880 yards of 12-1/2 lb. conductor (loop resistance 70 ohms) as shown in Table 2. The total loop resistance is, therefore, 20 + 70 ohms, and this value is found in Table 2, Column "C". The number of switching circuits, which can be connected on one pair of conductors having this total resistance, is shown in Column "G" as 22.2

/ It

It should be specially noted that the columns from which the resistance value and switching circuit figures, respectively, are selected must each be headed by the same conductor weight. For example, if the resistance value nearest to that of the circuit in question is found in Column "B" (6-1/2 lb.), the figure for switching circuits must be read from Column "F" which refers to 6-1/2 lb. conductors.

6.9 The foregoing information is arranged primarily for use with standard cord and cordless type P.B.X. switchboards. Standard data for cable conductors for power leads to older type P.B.X. switchboards is difficult to compile, but it may be taken that the data as set out is applicable to all indicator signalling P.B.X. switchboards. For Lamp Signalling Switchboards of approximately the same capacity as the standard types of switchboards already detailed, it may be accepted that, if the conductors provided for a standard switchboard of the same size are multiplied by $\frac{4}{3}$, power lead provision should be satisfactory.

On some installations, however, it may be necessary to multiply the conductors by 2. New installations should be examined, in order to determine whether the higher factor is necessary.

7. METHODS OF GROUPING AND CONNECTING CONDUCTORS FOR POWER LEADS.

7.1 The method employed in the distribution of energy and the grouping of conductors is shown in Fig. 26. The grouping of conductors to serve one P.B.X. is such that no limit is placed on the maximum number of conductors in the group, but, where these groups become large, consideration is given to the installation of a secondary battery floating on a smaller group of power lead conductors, or charged by independent means. Consideration is given to the economic aspect of any such proposal on the basis of the annual charges relative to cable conductors, as against those charges incurred if a secondary battery or a secondary battery and charging plant is provided.

7.2 Although it is advantageous from the viewpoint of economy to group P.B.X's. in the same vicinity on one power lead, it is necessary that extreme care be exercised in order to avoid incurring difficult maintenance conditions.

/ Where

Where the "block" system of distribution is employed, there is no objection to the grouping of installations on one power lead, provided that the independent leads to the various P.B.X's. are "commoned" at one readily accessible distribution point only, as shown in Fig. 26b. If several installations in the one vicinity are supplied from an overhead system of distribution, "tees" are made on the distribution pole only. However, if two or more switchboards are located in the same building, the power supply leads may be "commoned" in the building.

7.3 The following factors govern the maximum size of any power lead group -

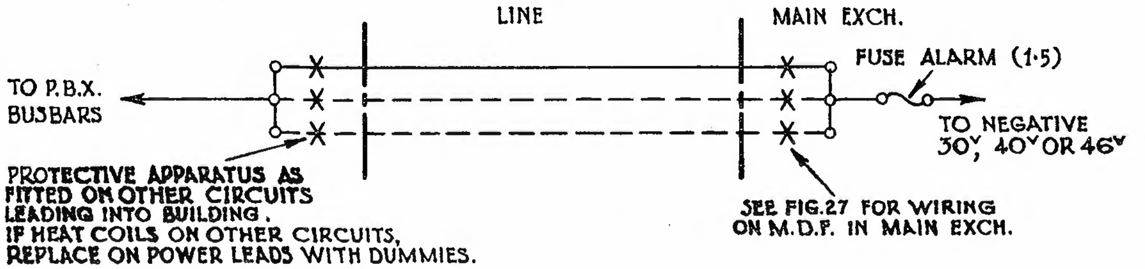
(i) The maximum number of conductors in any power lead group serving two or more P.B.X's. is six, as indicated in Fig. 26b.

(ii) The number of switching circuits connected to any group must not exceed 24. In this regard, P.B.X's. of the size $\frac{10 + 40}{100}$ and larger are generally connected to individual power lead groups and, consequently, to fuses on the distribution panel in the exchange.

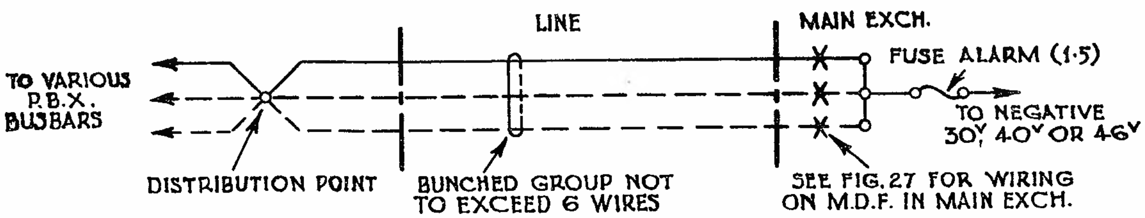
(iii) For multi-position P.B.X's., the minimum size of any position being $\frac{10 + 40}{100}$, the method of distribution is as shown in Fig. 26c.

7.4 Whenever possible, where underground cables are in full or part multiple in more than one building, separate groups of conductors are utilised for power leads for each building. Further, in instances where part multipling is in use, it is arranged that each group appears at a minimum number of points.

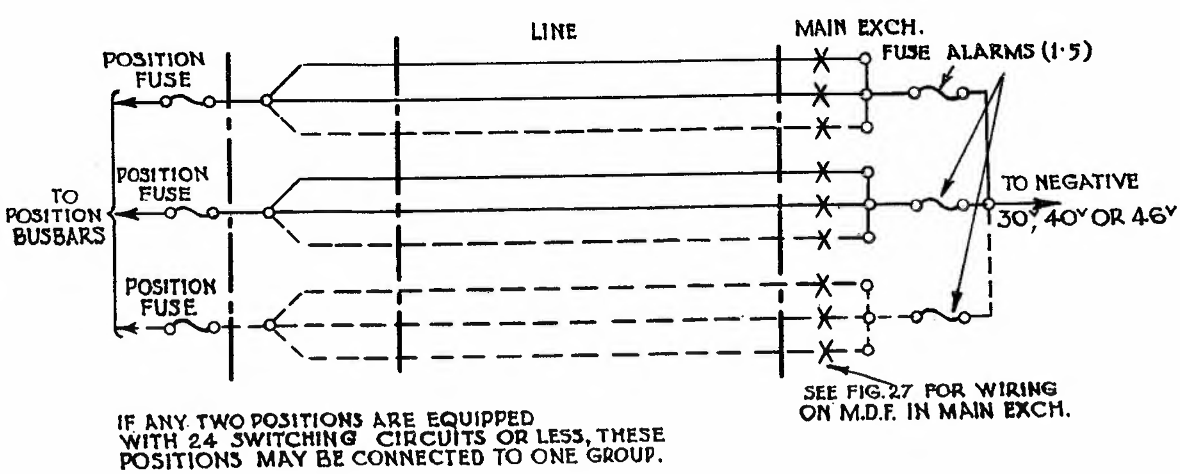
/ Fig. 26



(a) One P.B.X. served by a bunched group of cable conductors where maximum current demand does not exceed 1.5 amperes.



(b) Two or more P.B.X's. connected to a group of power lead conductors. Maximum number of switching circuits = 24.



(c) One multi-position P.B.X. where maximum number of switching circuits on any two positions exceeds 24.

GENERAL METHODS OF POWER DISTRIBUTION TO P.B.X's.

FIG. 26.

8. FUSING ARRANGEMENTS FOR POWER LEADS.

8.1 The present standard fuse for power lead distribution, as shown in Figs. 26b and 27, is 1.5 amperes, and, with fuses of this capacity in use, the maximum number of switching circuits shall not exceed 24 per fuse. The figures above the horizontal lines (that is, those exceeding 24) in the "Number of Switching Circuits" columns "F" to "J" of Tables 1 and 2 apply only to non-standard distribution methods, where fuses have a rating of 1.2 to 3 amperes. In these instances, care should be taken to ensure that the total number of switching circuits connected in any one group does not exceed the rated carrying capacity of the fuse in milliamperes divided by 50. For example, if 1.2 ampere fuses are installed, the maximum number of switching circuits allowed is -

$$\frac{1.2 \times 1{,}000}{50} = \frac{1{,}200}{50} = 24 \text{ circuits.}$$

9. CONNECTION OF POWER LEADS AT EXCHANGES.

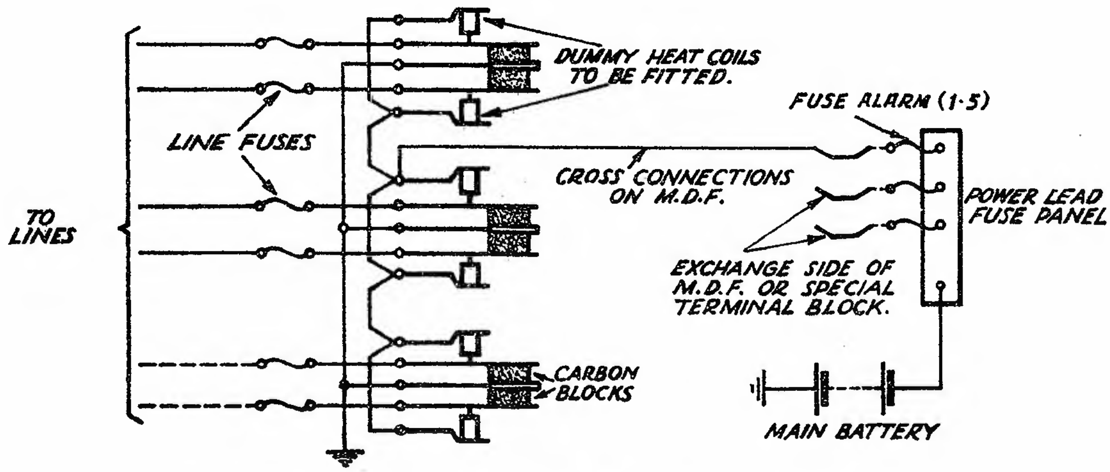
9.1 The jumpering methods of connecting P.B.X. power leads at exchanges are indicated in Fig. 27. The methods shown include those used for exchanges having standard main distributing frames, for exchanges having all the protective apparatus on the exchange side, and for exchanges in which all the protective apparatus is provided on the external line side of the M.D.F.

10. POWER LEADS FOR RINGING PURPOSES.

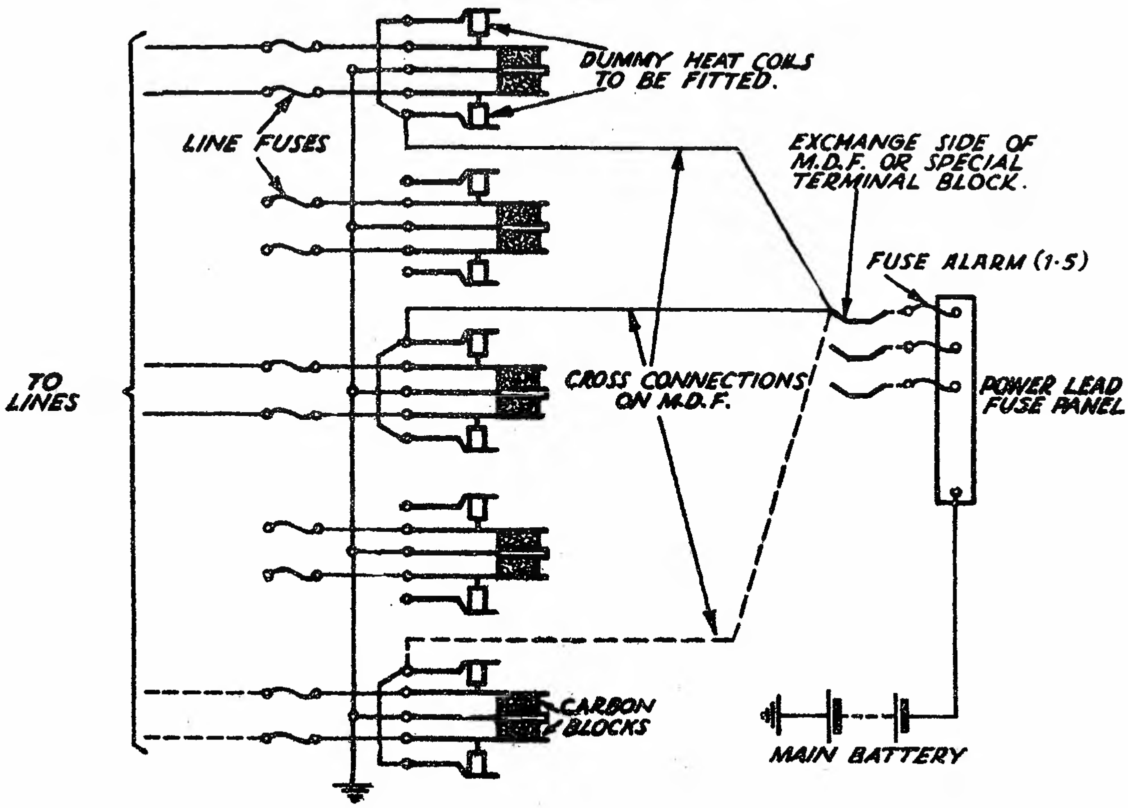
10.1 Circuits to be Metallic (that is, Two-Wire Lines). Power leads used for the purpose of supplying ringing current from the exchange to P.B.X. switchboards should be two-wire lines.

10.2 Loading. Except for very large multi-position P.B.X. installations, only one cable pair will be required for ringing power leads. Installations requiring a number of pairs of wires are exceptional. In these cases, special tests should be made under normal load conditions to ascertain if more than one pair of wires is essential. Where two ringing leads are required, they should be arranged to feed alternate positions of the multi-position switchboard.

/ Fig. 27.



(a) Method of "Commoning" when the conductors are on adjacent protectors.



(b) Method of "Commoning" when the conductors are not on adjacent protectors.

FIG. 27. CONNECTIONS OF P.B.X. LEADS AT MAIN EXCHANGES.

11. POWER LEAD RECORDS AND ALTERATIONS.

11.1 The power lead record is kept on Form E.M. 19 (buff colour), a facsimile of which is shown in Fig. 28. The card referred to is of standard dimensions, that is, 6" × 5", but, for certain cabinets now in use which accommodate cards that differ in size from this standard, supplies of cards of unstandard sizes are arranged. The complete particulars of service recorded on a card may then be utilised to facilitate the location of faults, determine the capacity of the power lead group to accommodate further switching circuits and the suitability for the ready connection of additional cable conductors.

11.2 Special attention is drawn to the note at the bottom of the lower portion of the front of the card. This note is included in order that the "total number of switching circuits connected" may be converted into terms of standard type switching circuits, so that the difference between -

(i) total capacity of group, and

(ii) total connected,

may be read in terms of standard switching circuits without the need for conversion after reference to the information contained on the back of the card.

11.3 Members of the Subscriber's Installation Staff, therefore, take steps to notify the Exchange Foreman or the Controlling Officer when any switchboard service has been removed from the power lead group, in order that the power lead records may be appropriately amended.

11.4 Accurate records for the main frame and distribution boxes in the subscribers' premises are also kept.

* RINGING
* BATTERY

POWER LEAD CARD

E.M. 19

POWER LEAD FUSE No. .... VOLTAGE AT FUSE PANEL ....

LOCATION OF DISTRIBUTION POINT ....

....

....

ROUTE DISTANCE .... WEIGHT OF CONDUCTORS .... LBS.

No. OF SWITCHING CIRCUITS
(IN TERMS OF STANDARD TYPE CIRCUITS) (*a*) TOTAL CAPACITY OF GROUP ....
(*b*) TOTAL CONNECTED (SEE NOTE) ....

* RULE OUT THAT WHICH DOES NOT APPLY

PARTICULARS OF CABLE PAIRS CONNECTED IN GROUP

CABLE NO.	PAIRS NO.	M.D.F. SWBD. SIDE VERT.	M.D.F. SWBD. SIDE TERML.	M.D.F. CABLE SIDE VERT.	M.D.F. CABLE SIDE TERML.	CONDUCTOR RESISTANCE OF BUNCHED GROUP TO EARTH	DATE PAIR TAKEN INTO USE

NOTE.—IN SUMMARIZING TOTAL SWITCHING CIRCUITS, THOSE ON LAMP SIGNALLING BOARDS SHOULD BE MULTIPLIED BY ½ BEFORE BEING ADDED TO BALANCE TO SHOW TOTAL CONNECTED

Sch. C. 5299—3/1947

(a) Front of Card.

PARTICULARS OF SWITCHBOARDS CONNECTED

LINE No.	SUBSCRIBER'S NAME	SUBSCRIBER'S ADDRESS	SIZE & TYPE OF SWITCHB'D	SWITCHING CIRCUITS ON INDICATOR TYPE BOARDS	SWITCHING CIRCUITS ON LAMP TYPE BOARDS	DATE CON-NECTED

(b) Back of Card.

FIG. 28. POWER LEAD RECORD CARD.

12. TEST QUESTIONS.

1. State the function of the AX relay in a cord circuit.

2. State the purpose of the Transformer Cut-Off Key in a cord circuit.

3. Give five advantages of Through Calling as applied to a Cord Type P.B.X.

4. State the disadvantages of Through Calling on a Cord Type P.B.X.

5. Why is an induction coil included in the Cord Type C.B. P.B.X. Cord Test Circuit?

6. State the advantages possessed by the Cord Type C.B. P.B.X. (Lamp Signalling, Through Calling) over an early type of cord board.

7. What lamps are used for signalling purposes in the above board? Draw a typical circuit diagram of the arrangement for extension lines.

8. A copper oxide rectifier is fitted in the line relay circuit of the Lamp Signalling Switchboard. State the reason for this rectifier.

9. In the Lamp Signalling board, battery is connected to spring-set C2 via a 10 ohm resistance. What is the necessity for this resistance?

10. (a) In what circumstances is a Non-Switching Unit installed?
    (b) What range of sizes is available?
    (c) Sketch and describe the circuit connections of a direct line between the two non-switching units.

11. Write a note on power lead provision for P.B.X's. under the following headings -

    (a) What is a power lead?
    (b) What power lead voltages are used in exchanges from which power leads distribute?
    (c) What voltage should be maintained at the P.B.X., and how could this be checked up with a voltmeter?

12. Why is a condenser connected across the power lead at a P.B.X.?

END OF PAPER.

COMMONWEALTH OF AUSTRALIA.

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COURSE OF TECHNICAL INSTRUCTION.

INTERCOMMUNICATION TELEPHONE SYSTEMS. (TYPES A5 AND A10).

CONTENTS:

1. INTRODUCTION.

1.1 As a means of communication between a number of telephones in the same building, Intercommunication or House Telephone Systems possess certain important advantages over P.B.X's. These advantages include the ease and rapidity of connection afforded and the ability to obtain connections without the aid of an operator. Intercommunication systems have been in use for many years and, even with the disadvantage of having no connection to the public exchange, have achieved considerable popularity. An Intercommunication Telephone System has now been developed, however, which gives access to the public exchange. This system provides facilities for direct intercommunication between a number of stations or extensions in the same building, called Internal Extensions, and, in addition, allows direct access, if desired, from these extensions to the public exchange. One extension, called an External Extension, may be situated in a building other than the one where the intercommunication system is installed. The combination of facilities afforded by this system is peculiarly suitable for installation in private residences and small offices, where it is important that operating attendance be reduced to a minimum.

FIG. 1. INTERCOMMUNICATION TELEPHONE.

1.2 Internal extensions are each provided with a special telephone similar to that shown in Fig. 1. One internal extension is also provided with an additional unit called a Transfer Unit as in Fig. 2.

This unit provides means of indicating to the internal extension that an incoming exchange or an external extension call is to be answered. This particular internal extension is called the Main Station. The external extension is a two-wire extension equipped with a standard telephone. To facilitate installation and subsequent maintenance, the internal extension telephones and the Transfer Units are fitted with plugs and cords. The incoming cable to the telephones or units is terminated on jacks.

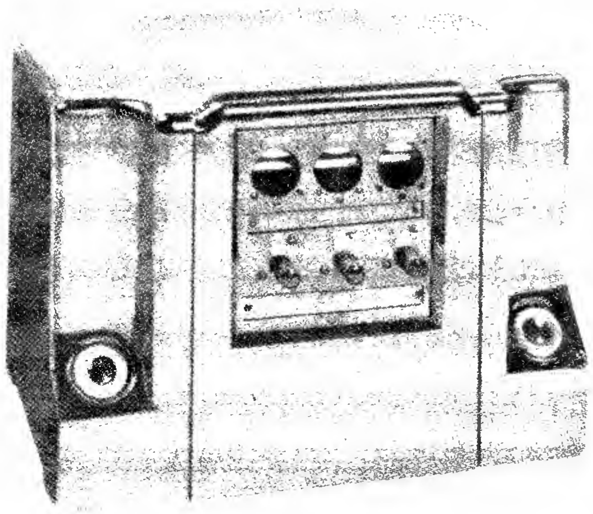


FIG. 2. TRANSFER UNIT.

/ 2.

2. FACILITIES PROVIDED.

2.1 The facilities provided by this system are -

(i) Direct calling between all internal extensions. (Secrecy is not provided on these calls, although a busy test is provided if an extension is busy on an exchange call.)

(ii) Internal extensions may call the external extension direct.

(iii) The external extension may call the main station and request that an internal extension be notified to call the external extension.

(iv) Conference facilities which allow any internal extension to speak to all or any number of extensions simultaneously.

(v) Direct access to the exchange from any internal extension, if desired.

(vi) Internal extensions may be denied access to the exchange or, alternatively, allowed access through the main station.

(vii) External extension may call the exchange via main station.

(viii) Incoming calls are answered at the main station.

(ix) Exchange calls may be transferred from one extension to another.

(x) An internal extension may hold an exchange line and make a call to any other extension. If two exchange lines are provided, an internal extension may hold one exchange line and make a call on the other.

(xi) Secrecy on exchange calls.

(xii) Any internal extension with full facilities may be equipped with an extension trembler bell to enable incoming exchange or external extension calls to be answered at that point.

2.2 Two sizes of installations are available, the small size called the Type A5, providing for one exchange line and five extensions (including one external extension), and the large size, called the Type A10, providing for two exchange lines and ten extensions (including one external extension). It is possible to accommodate one additional internal extension on each of the above sizes by a slight modification of the wiring.

/ 3.

3. INTERCOMMUNICATION TELEPHONE.

3.1 The special telephone supplied for an internal extension in the A10 System (shown in Fig. 1) is known as the Intercommunication Telephone No. 2. The telephone used in the A5 system is known as the Intercommunication Telephone No. 1. This telephone is similar to the Intercommunication Telephone No. 2 but has less push buttons. Three types and colours of push buttons or keys are provided on each telephone -

(i) A red push button is provided for each exchange line,
(ii) a black push button is provided for each extension line, and
(iii) a green push button is provided to allow conference facilities.

The mechanical arrangement of the keys is such that, when depressed consecutively, except when the green conference key is depressed first, only one key may remain operated at any time. If an extension key is in the operated position, the depression of a second key completely restores the first key.

If an exchange key is operated, the depression of the second exchange key or of an extension key will partially restore the first key to a position known as the hold position.

3.2 Exchange Line Keys have three rest or locking positions -

(i) Fully Operated.
(ii) Intermediate.
(iii) Normal.

The first position is the calling and speaking position. The intermediate position is the "hold" position, which the key automatically assumes from the fully operated position when an extension or second exchange key is depressed. In the fully operated position, two sets of springs are operated, one set being released when the key is restored to the hold position. The key is fully restored when the handset is replaced on the switch hook.

In the A10 system, the intermediate position is indicated by a trigger but a visible indication of this position is not given in the A5 system.

3.3 Extension Keys have three positions -

(i) Signalling.
(ii) Speaking.
(iii) Normal.

When fully depressed to the non-locking signalling position, common spring-sets (CB) are operated as well as the spring-sets

/ necessary

necessary to connect to a particular extension. When the pressure is released, the key partially restores to the speaking position, and the CB spring-sets restore but the extension spring-sets remain operated. The key is fully restored when the handset is replaced on the switch hook.

3.4 The Conference Key, when depressed, brings into operation a locking bar, which allows any number of extension keys to be depressed consecutively and to remain in the speaking position when pressure is released. All keys are restored to normal when the handset is replaced.

3.5 Two special triggers are provided above the exchange keys on telephones for the A10 system (see Fig. 1), in order to allow the complete release of either exchange key when holding both exchange lines. Without these triggers, the exchange keys could only be restored to normal from the hold position by replacing the handset and, if both exchange lines are in use, the result of replacing the handset would be to clear both lines. The triggers, therefore, provide individual release from the hold position for exchange line keys.

4. TRANSFER UNIT.

4.1 Fig. 2 shows a typical transfer unit for use at the internal extension (the main station), where incoming calls are to be normally answered. This transfer unit contains signalling, clearing and switching apparatus used in connection with incoming calls from exchange and external extension lines. A press button may be fitted at either side or both sides of the cabinet for use when an extension, with restricted access to the exchange, requires an exchange call.

Another internal extension may be selected to act as a second choice main station when required.

The operation of a key at the Transfer Unit transfers its functions to another unit fitted at the internal extension, which is selected to act as the second choice main station.

5. SIGNALLING METHODS.

5.1 The external extension and exchange lines are provided with eyeball indicators as a means of signalling to the Transfer Unit. Internal extensions are signalled by means of a buzzer. To allow easy access for adjustment, this buzzer is mounted on the outside of the terminal block shown in Fig. 1.

6. MULTIPLE CABLING AND JUNCTION-BOXES.

6.1 Internal extensions are connected via a multiple cable scheme, and multiple cables are connected to Junction-boxes. The telephones or auxiliary units are also cabled to terminal strips in the junction-boxes, so that the terminals may be strapped as desired. In the case of the A5 system, 12-pair L.C. 10 enamel

/ cable

cable is used, between the junction-boxes, whilst for A10 installations 20-pair cable is needed.

6.2 Junction-boxes are made up of four terminal strips enclosed in a moulded bakelite case (see Fig. 3). The terminals are staggered and the front portions drilled and fitted with a clamping screw, so that cross-connections can be made by means of bare wire of square cross-section. This construction also allows jumpers to be run, if necessary, with switchboard wire on the front of the strips. The backs of the terminals have screw connections for terminating the cable wires.

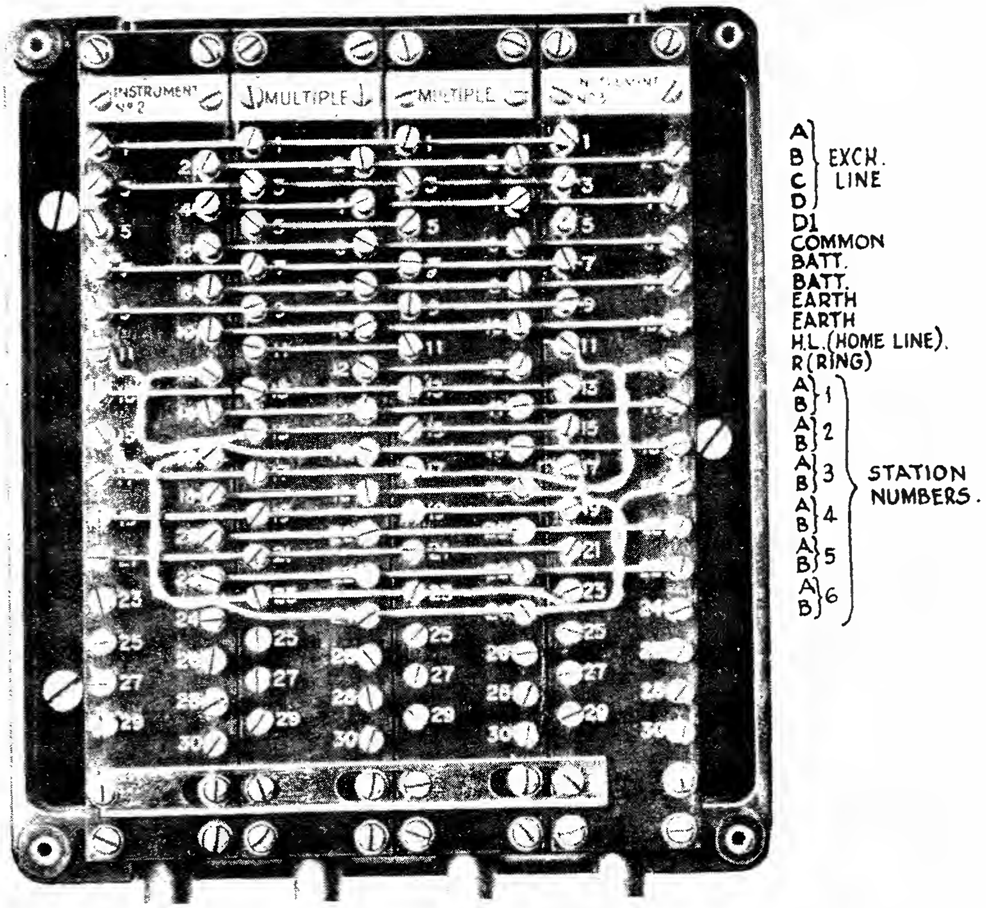
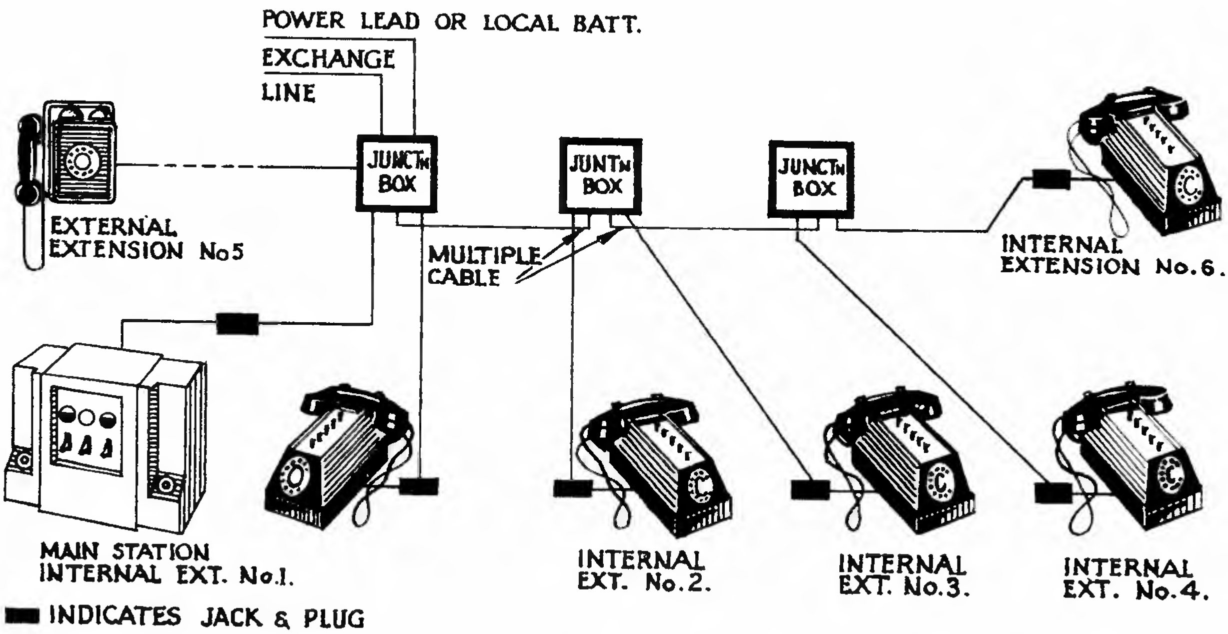


FIG. 3. TYPICAL JUNCTION-BOX.

The junction-boxes are so designed that four cable connections can be made and, if the box is used in an intermediate position to connect an incoming and an outgoing multiple cable, then two internal extensions can be connected to this box. But where it is a terminal box with only one incoming multiple cable, then three internal extension telephones can be connected. Fig. 3 is an intermediate box. Rubber spacers are provided to assist in preventing undue strain when the boxes are mounted on uneven surfaces. / 6.3

6.3 Fig. 4 shows a typical A5 system with the maximum number of extensions, that is, 5 internal extensions and one external extension. Fig. 3 is a typical junction-box connection for extensions 2 and 3 at the centre junction-box shown in Fig. 4.



TYPICAL CONNECTIONS FOR A5 SYSTEM.

FIG. 4.

The incoming multiple cable terminates on the left-hand multiple strip, that is, the second strip from the left in the junction-box, and the outgoing multiple cable terminates on the right-hand multiple strip. Instruments 2 and 3 are cabled, as shown, to terminal strips on either side of the multiple cable strips.

Each internal extension has a multiple connection to every other extension and exchange line. At each internal extension, the key corresponding to the particular extension's number is not normally used. For example, at extension 3 the No. 3 key will not be required. When a 6th or 11th extension is required in the A5 or A10 type respectively, however, the key at each extension corresponding to the extension's number is used in conjunction with a spare multiple pair to provide the additional extension.

7. OPERATION OF SYSTEM.

7.1 Call to Internal Extension. When an internal extension requires another extension, the handset is lifted and the appropriate key pressed. The buzzer at the distant internal extension, or the bell at the external extension as the case may be, rings only whilst the key is fully depressed. When the finger is removed from the key, the key locks in a speaking position. To answer an incoming call, it is only necessary to lift the handset.

Conference Call. To make a conference call, the internal extension calls the required stations separately and advises each extension that a conference call is about to be made. The separate conference key is then depressed and, subsequently, the keys of all the stations taking part in the call. Conference facilities are not available on exchange calls.

Exchange Call. To make an exchange call, the exchange key is pressed. If the exchange line is busy, the pressing of the key, irrespective of whether the handset is lifted or not, will cause the local buzzer to operate, thus indicating a busy condition.

Replacing the handset restores all keys to normal.

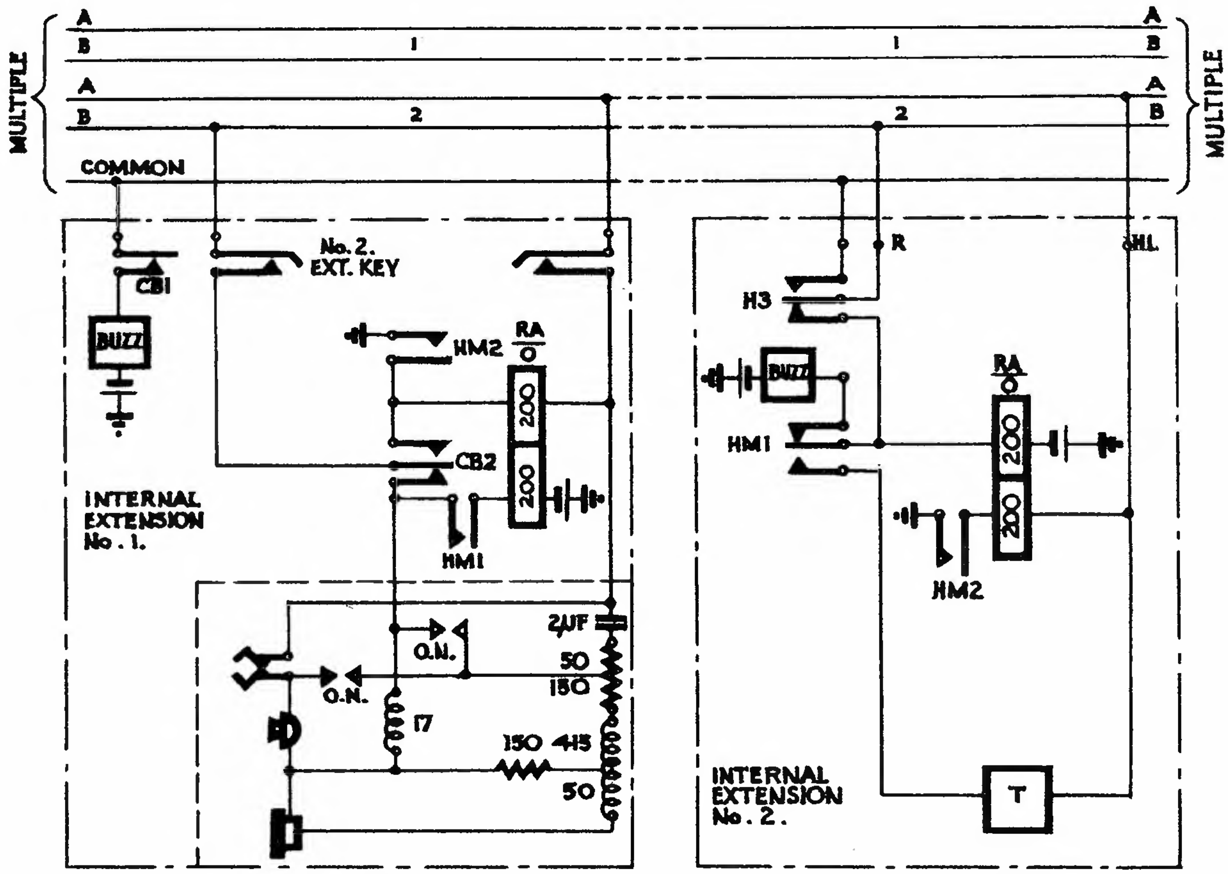
7.2 Call from External Extension. When the external extension lifts the handset, the calling indicator on the Transfer Unit at the main station operates. To answer the call, the main station operator presses the external extension key on the telephone. If an extension is required, the main station calls the required extension and asks that extension to pick up the external extension by pressing the appropriate key. If an exchange call is required by the external extension, the main station tests the exchange line and, if free, operates a key on the transfer unit to extend the external extension to the exchange.

7.3 Incoming Exchange Calls. Incoming exchange calls are normally received at the main station. The exchange line indicator on the Transfer Unit operates to the ringing current on the calling exchange line. The call is answered by pressing the exchange key on the telephone. If the call is for another extension, the main station presses the appropriate extension key and requests that extension to pick up the exchange line. The exchange line is held by the exchange key (in the hold position) on the main telephone, so that, when the notified extension presses the exchange key, the buzzer on that telephone will operate. The operator at the main station hears a tone from this buzzer and then replaces the handset. This releases the exchange line from the telephone at the main station and allows it to be picked up by the extension. It is possible for any extension to answer an incoming exchange call and to transfer it to another station, if necessary.

/ 8.

8. CIRCUIT OPERATION.

8.1 Extension calling Extension. For the purpose of this circuit description, it will be assumed that extension 1 is calling extension 2, as shown in Fig. 5.



EXTENSION TO EXTENSION CALL.

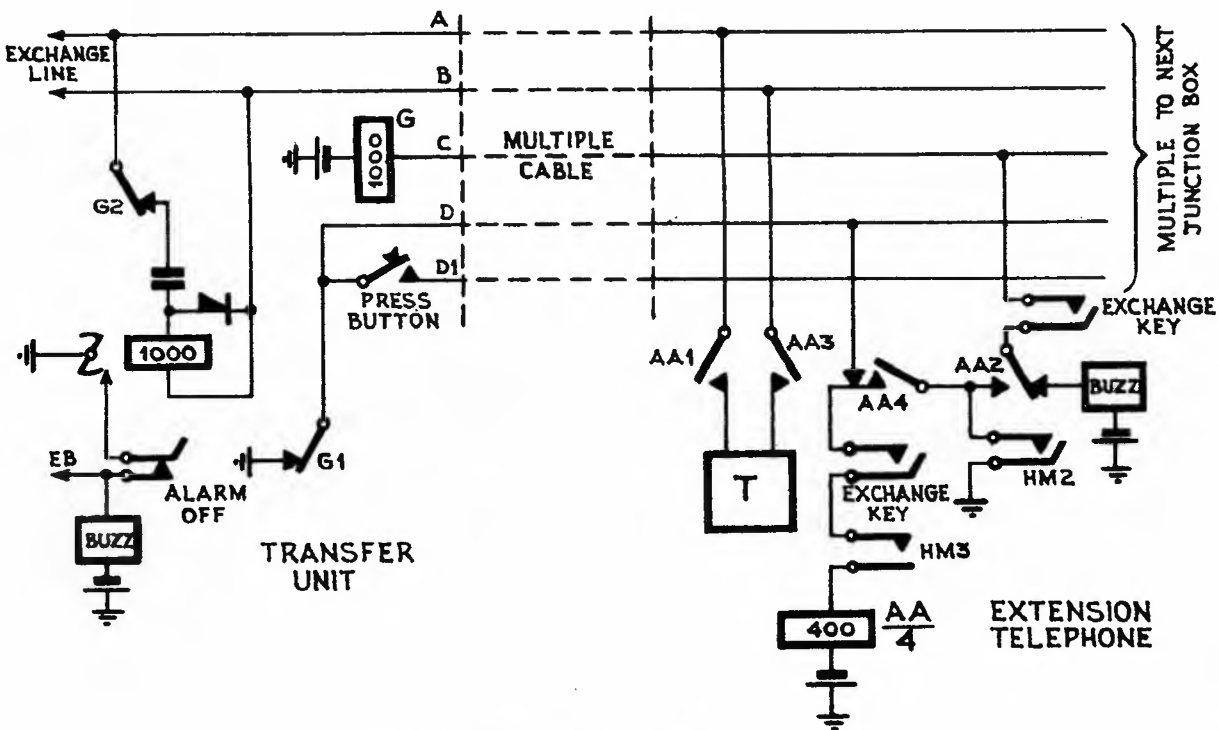
FIG. 5.

The handset, when lifted at extension 1, operates HM spring-sets. (The simplified connections of the handset and associated apparatus are enclosed by the dotted lines in the circuit of the internal extension No. 1 in Fig. 5.) Key No. 2, when fully depressed, also operates contacts CB. Earth is extended via HM2, CB2, key No. 2 to the "B" wire of pair 2 in the multiple cable. This earth operates the buzzer at extension 2. When the key at extension 1 is released, CB restores, but the springs of extension key 2 remain operated. When the handset, / which

which is represented by the square marked T in internal extension 2 and in subsequent figures, is lifted at extension 2, the buzzer is disconnected at HM and the two stations are in communication. It will be seen that each telephone has a separate battery feed via the coil RA. Thus, on conference calls, there is negligible loss in transmission.

If the called extension is busy with an exchange line call, the B wire of that extension will be connected to the common via the operated spring-set H. The earth connected to the B side of the called extension's pair will, therefore, be returned over the common to operate the buzzer at the calling extension via CB1.

8.2 Internal Extension Calling Exchange (or Answering an Incoming Exchange Call). This circuit is shown in simplified form in Fig. 6.



INTERNAL EXTENSION TO EXCHANGE.

FIG. 6.

When the exchange key is pressed, the relay AA in the intercommunication telephone is extended to the D wire of the multiple cable. If the exchange line is free, there will be an earth on

/ the

the D wire via the contact G1 in the transfer unit at the main station. Relay AA will operate and lock via AA4 and HM2. (All HM contacts are operated when the handset is lifted.) Contacts AA1 and AA3 extend the telephone to the wires A and B, which are connected to the exchange, and contact AA2 extends an earth to the C wire to operate relay G in the transfer unit. The operation of relay G disconnects the earth from the D wire, thereby preventing other extensions using the exchange line whilst this call is in progress. Contact G2 disconnects the calling indicator and condenser from the line. If the extension has restricted facilities, the AA relay is extended to the D1 wire and will not operate until the press button is operated at the main station. This modification is made on the junction-box to which the telephone is connected. If the exchange line is busy when the exchange key is operated, the buzzer at the extension will operate via the exchange key contacts and AA2 as the C wire is earthed by the extension using the exchange line.

8.3 External Extension Circuit. The main features of the external extension circuit are shown in Fig. 7. The external extension is a two-wire extension equipped with a normal wall or table telephone.

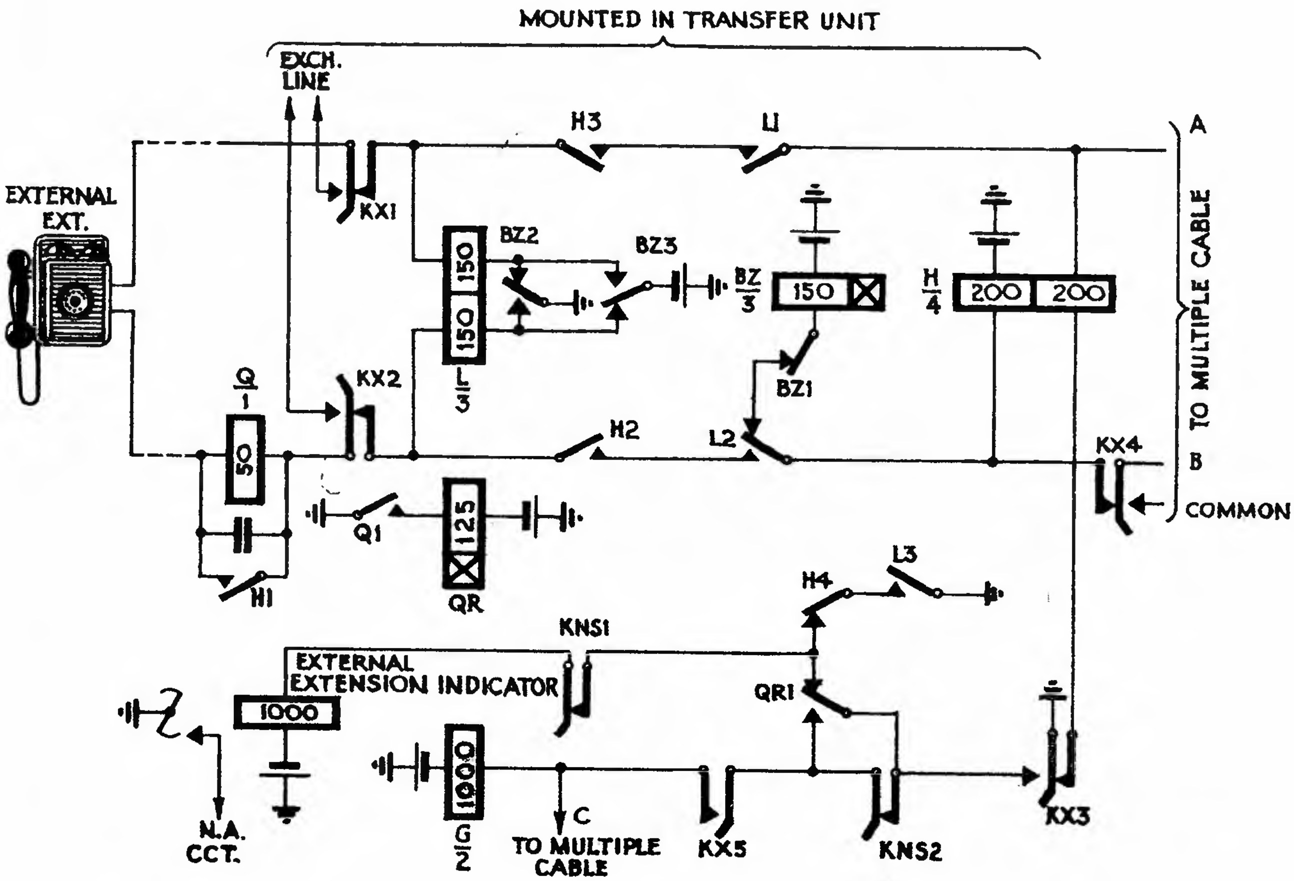


FIG. 7. EXTERNAL EXTENSION.

When the external extension calls, relays L and Q operate. L3 completes a circuit for the calling indicator. When the main station answers by pressing the appropriate extension key (not shown in Fig. 7), the intercommunication telephone at the main station is connected across the A and B wires in the multiple cable and relay H operates. H4 disconnects the calling indicator, and a speaking circuit is completed between the extension and the main telephone via contacts L1, H3, H2 and L2. If the external extension requires the exchange, the main station tests the exchange line to ascertain if free, then exchange key KX is operated. Relay L restores and the external extension is connected to the exchange line. G relay operates via KX5, KNS2 and KX3 to remove the earth from the D wire in the multiple and to prevent any internal extension using the exchange line. When the external extension replaces the handset, relays Q and QR release. QR1 completes a circuit to the indicator, which operates to inform the main station that the call has been released, thus giving supervision. When an internal extension calls the external extension, an earth is placed on the B wire of the multiple cable in a similar manner to the calling of an internal station. Relay BZ is thus operated, but breaks its own circuit at BZ1 and restores. While the earth is maintained on the B wire, relay BZ will operate and release continually, that is, BZ will "buzz" and the slug ensures a timing of about 16 c/s. Contacts BZ2 and BZ3, in series with the L relay, will oscillate and cause rapid reversals of battery polarity on the extension lines, and the bell at the extension will ring.

9. NIGHT SWITCHING FACILITIES.

9.1 If desired, the external extension may be switched permanently to an exchange line by the operation of keys on the unit at the main station. When the external extension is thus switched, internal extensions may use the night switched exchange line, when this is not in use by the external extension, but exchange calls made by internal extensions are non-secret to the external extension. Under night service conditions, incoming exchange calls will give a signal at the external extension and also at the main station. The main station signal may be extended by means of a bell to any other point on the installation. Under these conditions, the first extension to answer will engage the exchange line.

10. POWER SUPPLY.

10.1 Power Supply is normally obtained via a power lead from the exchange battery. The system operates efficiently between voltage limits of 18 and 28 volts, and the maximum current required for a system with 5 extensions is 0.6 ampere and for 10 extensions is approximately 1.3 ampere. A 10 µF condenser should be connected across the power lead at the subscriber's premises. The Intercommunication Telephone System may be connected with manual / C.B.

C.B., magneto exchanges or automatic public exchanges, a standard type of instrument being used at all internal extensions and a standard type "Unit" fitted at main stations irrespective of the type of public exchange (see also paragraphs 11.2 and 11.3).

11. IMPROVED SYSTEM.

11.1 Later installations of intercommunication telephones will differ in some respects from those just described.

The main differences are -

(i) The telephones will be connected in "series" instead of in "parallel" and junction-boxes will not be used.

(ii) Transfer units for services with internal extensions only have been designed for wall mounting, and on all transfer units the switching arrangements for connecting a second main station have been deleted.

(iii) For A10 systems with an external extension, a new transfer unit, No. 3A, has been designed to replace the transfer unit previously described.

11.2 The telephones used are similar to those shown in Fig. 1 but the instrument cord is terminated on a terminal strip mounted in a wooden case, in which the buzzer is also fitted. The terminal box replaces the plug and jack used in earlier installations. The variations to the telephone circuits are -

(i) A normally short-circuited 150 ohm resistance is wired in the buzzer circuit. If the voltage of the battery supply at the subscriber's premises is 28 volts or more, the strap is removed.

(ii) Terminals can be fitted to provide for extensions calling the main station whilst the latter is holding an exchange call.

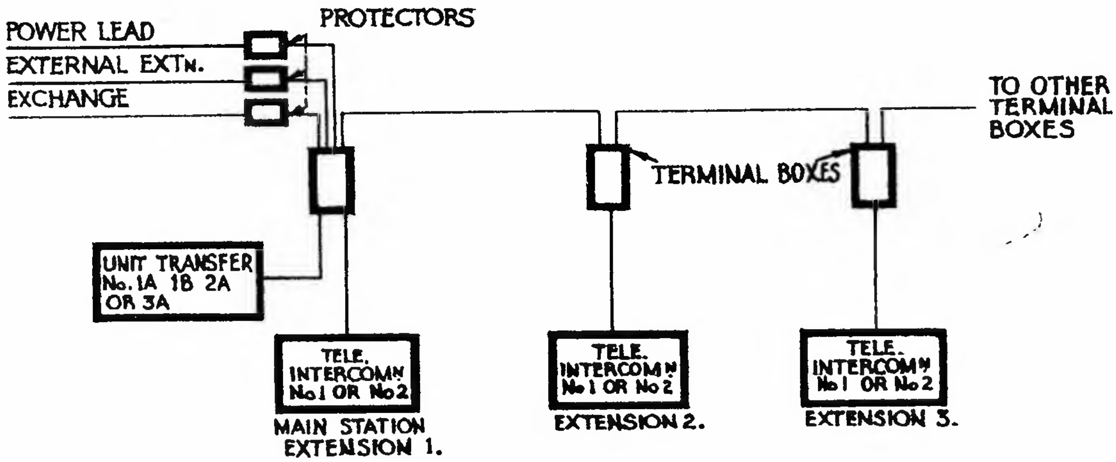
(iii) The connections of the instrument cord are suitable for either a plug or a terminal box.

11.3 The Transfer Units, Nos. 1 and 2, described earlier in this Paper were designed for table mounting but, as switching operations performed on these units are infrequent, the allocation of space on a table is not essential. Therefore, Wall Mounting Units, Nos. 1B and 2A, have been designed. These new units are housed in wooden cases similar to those used for extension switches. The only circuit modification is the provision of a 50 ohm resistance in the battery feed to relays BZ and QR. Keys have not been provided, however, for connecting incoming calls to a second main station. This

/ resistance

resistance is normally short-circuited, but, if the voltage is 28 volts or more, this short circuit is removed.

11.4 Method of Cabling and Terminal Box Connections. The general method of cabling is shown in Fig. 8. It is essential to plan the lay out carefully, in order to ensure that the minimum length of cable is used.



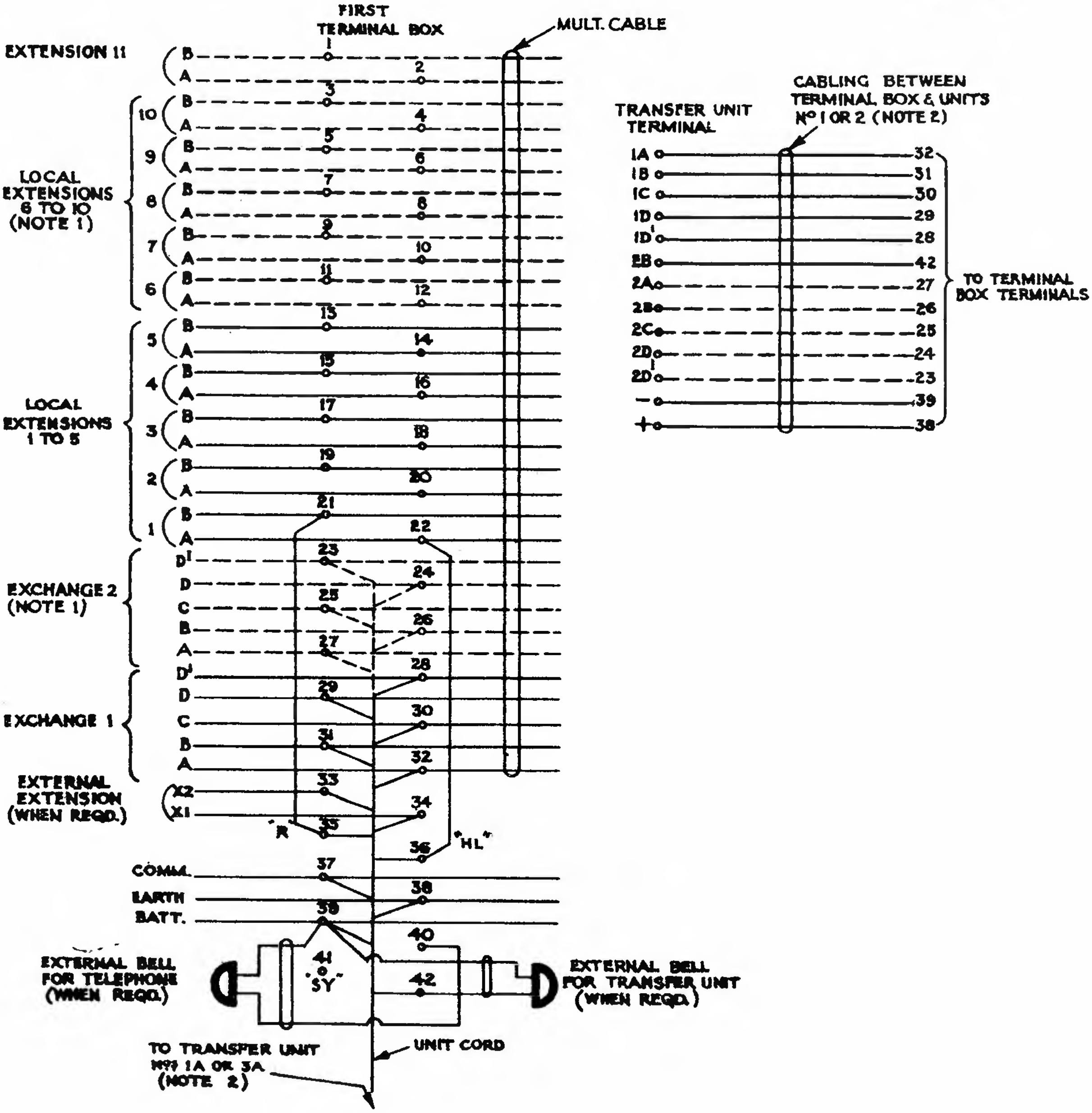
GENERAL METHOD OF SERIES CABLING.

FIG. 8.

The power lead, exchange and external extension lines and the cord or cable from the transfer unit, are terminated on the main station terminal box. The multiple cable also commences from this box and is connected to the boxes of other telephones in "series", that is, at telephone No. 2 the cable from telephone No. 1 is led in and another cable is led out to telephone No. 3. At each telephone, the relative in and out wires for each circuit are connected to the same terminal, that is, the telephone connection is teed off the multiple cable. Thus, the term "series" is not strictly correct, but it is used to differentiate between this method of cabling and the "parallel" method, in which up to three telephones are teed off the multiple cable from each junction-box. The sizes of the lead covered multiple cable used are 15 pairs for an A5 system, and 20 pairs for an A10 system.

The terminal boxes associated with A10 telephones are fully equipped with 42 terminals, but boxes associated with A5 telephones are fitted with 27 terminals only, although the same strip and numbering are used. The cord connections are in the same relative position on each type. Fig. 9 shows the connections for a typical terminal box for both A5 and A10 systems.

/ Fig. 9



TERMINAL BOX CONNECTIONS.

NOTES:

1. Dotted Wiring required on A10 System only.
2. Transfer Units fitted on Main Station only

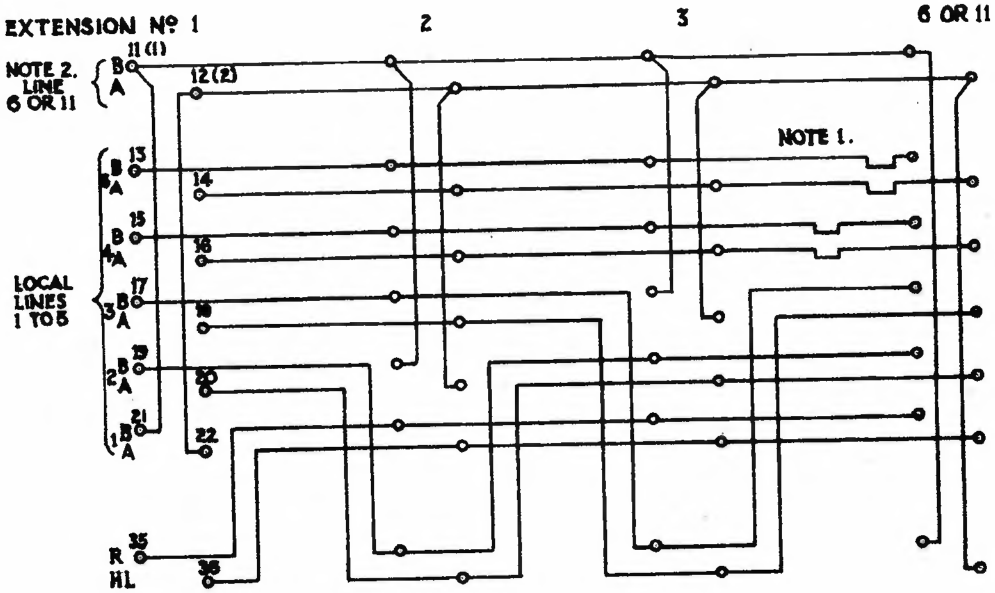
FIG. 9.

The connections shown in full line are required for an A5 system, whilst the connections shown in broken line are required, in addition to the connections shown in full line, for an A10 system.

The cords from the telephone and from transfer unit No. 1A or No. 3A should be connected to the underside of the terminal strip, whilst multiple cables and cable from transfer unit No. 1B or No. 2A should be terminated on the front of the terminal strip. Transfer units are connected to the main station terminal strip only.

At each telephone the HL and R wires should be connected to the multiple pair corresponding to the extension number of the instrument. Switchboard wire should be used for this purpose.

When a 6th extension on an A5 system or an 11th extension on an A10 system is required, the extension is connected to terminals 11 and 12 and 1 and 2 respectively. The strapping arrangements are shown in Fig. 10.



TERMINAL BOX CONNECTIONS FOR 6 OR 11 EXTENSIONS.

NOTES:
1. Multiple connections on terminal box 4-5 or 4-10 are carried out in similar manner to boxes 1-3.
2. Line 11 on A10 system is connected to terminals 1 and 2. Line 6 on A5 is connected to 11 and 12.

FIG. 10.

On telephones 1-10, in an A10 system, the relative A and B terminals are strapped to terminals 1 and 2, and the multiple cable wires, which would normally connect to the A and B terminals of each telephone, are connected to the R and HL terminals. On extension 11, the multiple cable is straight and terminals 1 and 2 are strapped to the R and HL terminals respectively. A similar arrangement is adopted for an A5 system, except that connections are made to terminals 11 and 12 instead of 1 and 2. Apart from these modifications, the connections are as shown in Fig. 9.

When an external extension is connected, the line wires are terminated on terminals 33 and 34 of the main station terminal box. The cord from transfer unit No. 1A or No. 3A is connected to terminals 33 and 34 also. The R and HL conductors in the transfer unit are connected to terminals 35 and 36, and these terminals are strapped to the A and B terminals of the extension number allotted to the external extension. A typical strapping is shown in Fig. 9. The main station A and B conductors should be insulated and tied back, and the HL and R conductors should be connected direct to the A and B terminals.

If an external extension is included in the maximum number of six extensions of an A5 system, or in the maximum number of eleven extensions of an A10 system, the R and HL terminals are in use (see Fig. 10) but, if an extension bell is not required, terminals 40 and 42 can be used as R and HL leads for the external extension. When this modification is necessary, the terminals should be designated specially. This congestion is confined to the main station terminal box, and occurs only in cases where all facilities are required.

When an extension is barred exchange service, the C conductor in the instrument cord should be connected to earth (terminal 38) and the other conductors should be insulated and not connected to the terminal strip.

When it is desired to bar an extension from making exchange calls (except under the control of the main station), the D conductors from the telephone should be connected to the D1 terminals (Nos. 28 and 23) in the terminal box and not to the D terminals.

/ 11.5

11.5 Circuit Operation. The circuit operation is generally similar to that of the telephones described earlier in this Paper, and a more complete circuit is shown in Fig. 11. The following brief description applies to this circuit.

Exchange Line Supervision. If exchange line supervision is required from an intercommunication telephone, that is, connection to the exchange line irrespective of whether it is in use or not, the strapping on terminals 1 and 2 in the intercommunication telephone is removed and placed between terminals 2 and 3 (see Fig. 11). (These terminals are individual to each exchange line.) The alteration of this strap allows the operation of the AA relay direct from earth at HM2 when an exchange line key is pressed. AA1 and AA3 connect the telephone to the exchange line. The busy exchange line test will still operate, provided the handset is not lifted from its normal position.

Signalling Extensions Busy with Exchange Line Calls. The facility of being able to signal an extension, even if the extension is busy on, or holding, an exchange line call, is given by means of the CM terminals. This facility is provided by removing the strap between the CM terminals 1 and 2 and bridging the CM terminals 2 and 3 in the intercommunication telephone. When the telephone is busy with an exchange line, the R wire is thus extended to the buzzer. If another extension calls an extension which is busy on an exchange line, the earth connected to B, which is the R terminal of the called telephone, by the operation of CB in the calling telephone will cause the buzzer of the called telephone to operate via 1H3 (operated) and CM2-3. A tone, induced from the buzzer, will be heard in the calling extension's receiver.

Transfer of Exchange Line Call. To transfer an exchange line call to another internal extension, after the exchange line call has been answered, the appropriate extension key on the intercommunication telephone is pressed. This operation restores the exchange line key to the "hold" position indicated by the trigger. The X spring-sets restore to normal, but the H spring-sets remain operated. At 1X1 and 1X2 in the intercommunication telephone circuit in Fig. 11, a 600 ohm hold coil is connected across the exchange line, the calling intercommunication telephone being transferred via 1X3 to the A side

/ Fig. 11

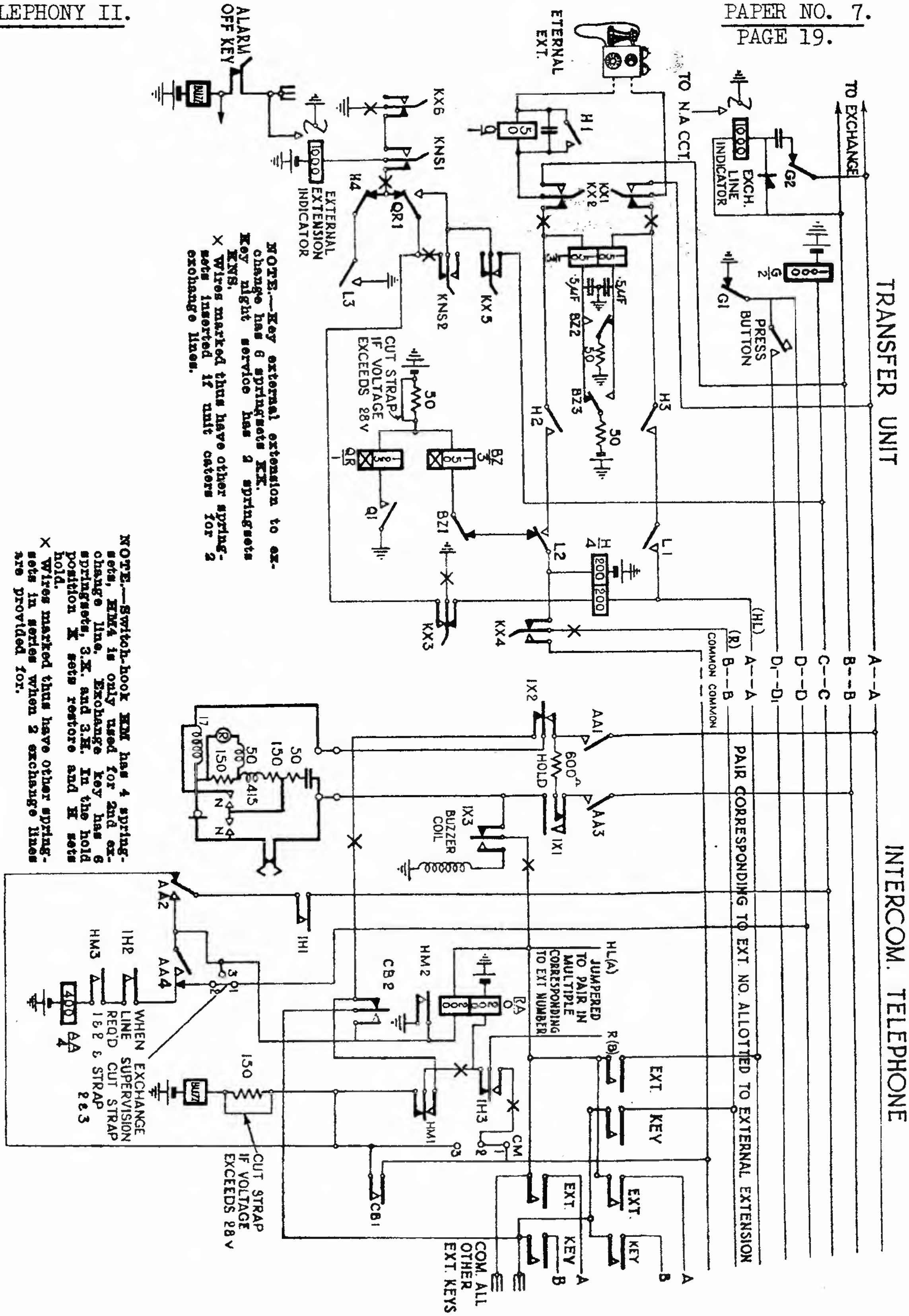


FIG. 11. INTERCOMMUNICATION SYSTEM (SIMPLIFIED CIRCUIT).

of the called extension and via 1X2 and CB2 to the B side of the called extension. By fully depressing the extension key and thus operating the CB spring-sets, a signal is given to the called extension. The called extension, on answering, is informed of the exchange line call and asked to take it over. When the called extension presses the exchange line key to take the exchange call, the buzzer will operate as the exchange line is still held by the calling telephone (see busy exchange line test). By means of a coil inductively coupled to the buzzer of the called extension, a signal tone is given via 1X3 to the calling extension to indicate that the called extension has pressed the exchange line key. This tone is extended via 1X3 to HL. HL is connected to the A wire of the pair in the multiple, across which the calling extension is connected via the appropriate extension button. The tone is heard in the receiver of the calling telephone via multiple wire A, internal extension key, 1X3, telephone loop, 1X2 and HM1 operated, to negative battery via 200 ohm RA. The calling telephone on receiving this tone replaces the handset, and, by opening 1H1, releases G in the transfer unit. The earth is restored on D by contacts G1. This causes the AA relay of the called extension to operate, as the circuit is already extended to the D wire. When AA operates, an earth via HM2, AA2 and 1H1 is extended to the C wire to immediately reoperate G. The call is then taken over by the called extension telephone. Calls may be transferred to the external extension via the main station.

<u>External Extension</u>. When the external extension calls the main station by lifting the handset, L and Q relays operate. L3 operates the external extension eyeball indicator. L1 and L2 prepare the circuit for the main station to answer, and Q1 operates QR. QR1 prepares a circuit for a clearing signal, if the call is extended to an exchange line. The main station answers the external extension by pressing the extension key appropriate to the external extension. This operation places the main station telephone loop and battery feed retard across A and B in the multiple. Relay H in the transfer unit operates via negative battery, 200 ohm winding of H, KX4 normal, B wire of multiple, B terminal of main station, contacts of external extension button, CB2 normal, 1X2 normal, telephone circuit, 1X3 normal, other pair of contacts of external extension button, A terminal of external extension pair in multiple, other 200 ohm winding of H in transfer unit to earth via KX3 normal.

/ H4

H4 releases the indicator. H1 short-circuits Q which releases and, in turn, releases QR. H2 and H3 extend the loop of the main station to the external extension and conversation may take place. Under this condition, battery feed is obtained from RA retard of the main station telephone in parallel with relays L and H in the transfer unit.

If the external extension requires another internal extension, the main station calls and advises the required extension to press the external extension key in order to connect to the external extension.

11.6 For additional information about A5 and A10 Intercommunication Systems, refer to Installation Circular No. 10 and Telephone Engineering Instruction, Substation, I 4110.

12. TEST QUESTIONS.

1. What is the difference between the A5 and an A10 telephone used by an internal extension?

2. How is a sixth extension provided for on the A5 system?

3. What method of signalling is used on the intercommunication system for -

   (a) Extension to extension calls, and

   (b) Incoming exchange calls?

4. Draw a block diagram of a typical A5 Intercommunication System.

END OF PAPER.

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COURSE OF TECHNICAL INSTRUCTION.

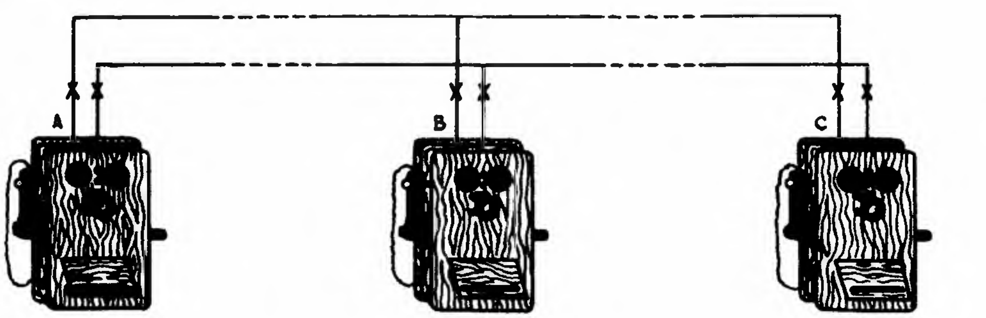
TELEPHONY II.

TRUNK LINES.

CONTENTS:

1. INTRODUCTION.

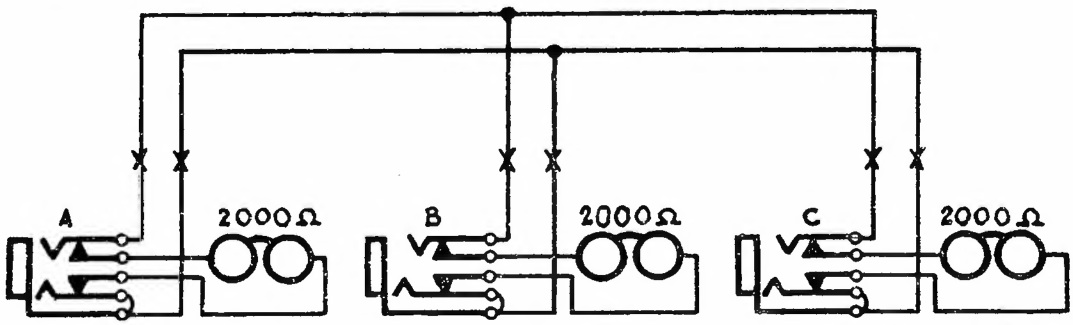
1.1 Trunk lines may be defined as long junction lines between two or more exchanges. At each exchange, the trunk line may be connected to a telephone, a normal switchboard or a specially designed trunk line switchboard. The basic form of trunk line working is shown in Fig. 1, which represents three stations connected to a trunk line on a long country route. At each station, the equipment consists simply of a telephone. Magneto telephones with 2,000 ohm bells are used. These bells ensure effective ringing conditions when several stations are connected to a line. Section switches, or testing jacks, may be included for convenience in testing.



BASIC TRUNK LINE.
(Telephones with 2,000 ohm bells. x indicates test jack or equivalent.)
FIG. 1.

In addition to providing 2,000 ohm bells in telephones used for this type of trunk line working, it is also usual to insert a 2 μF condenser in series with the receiver. The magneto telephone is usually wired to allow this addition to be made easily. The 2 μF condenser ensures that ringing on the trunk line is not unduly affected by a station leaving the receiver off the hook. The 2 μF condenser has a low impedance to the voice frequencies, and a comparatively high impedance to the ringing current of 16 c/s.

1.2 If switchboards are installed at the trunk line stations, the trunk line is connected to a specially allotted jack on the switchboard. The basic case of this type is shown in Fig. 2. The line contacts of the jacks at each station are connected in parallel, while the indicator springs are wired to 2,000 ohm bells.



MAGNETO TRUNK LINE BETWEEN SMALL SWITCHBOARD TYPE EXCHANGES.

(x indicates test jack or equivalent.)

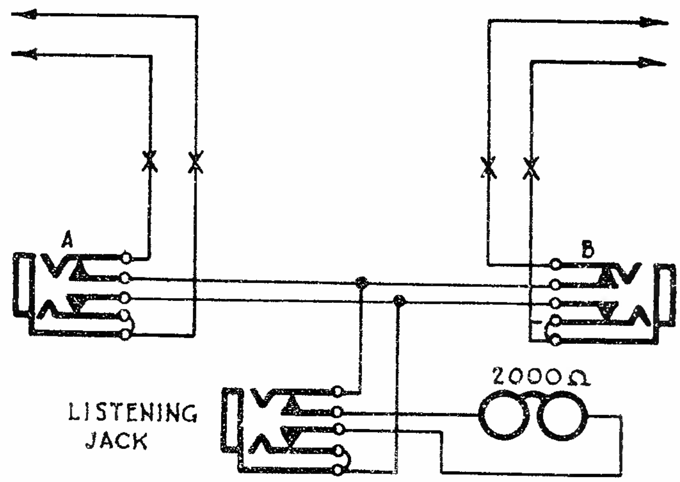
FIG. 2.

At the offices where there is a continuous attendance at the switchboard, trunk lines are connected to 2,000 ohm indicators instead of 2,000 ohm bells. This obviates the noise and inconvenience associated with the ringing of bells. The code call can be picked up from the fluttering of the indicator armature.

1.3 On a long trunk line, it is sometimes desirable that a conversation between two stations, separated by a comparatively short distance, should not busy the entire trunk line. In such circumstances, a Divided Working principle is provided. At a station equipped with these facilities, it is possible to switch a call through to a section of the trunk line and, at the same time, leave the remainder of the trunk line terminated on a 2,000 ohm indicator or bell in readiness for traffic on that particular section.

/The

The Divided Working Circuit is shown in Fig. 3.



DIVIDED WORKING ON MAGNETO TRUNK LINES.

(x indicates test jack or equivalent.)

FIG. 3.

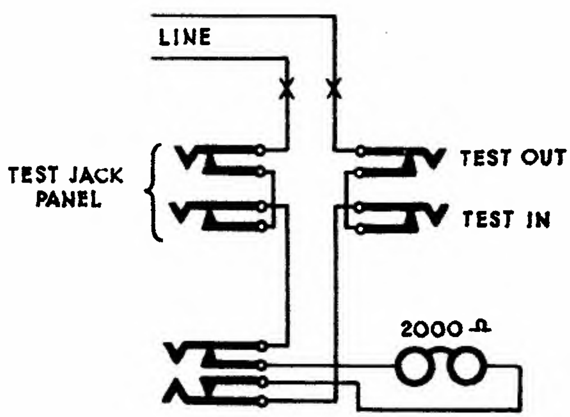
When a call is received for a particular station on the trunk line, the telephonist inserts a plug in the listening jack and ascertains whether the trunk line is engaged by a conversation over the entire line. If the trunk line is free, the telephonist then inserts the plug in the jack associated with the side of the trunk on which it is desired to make the call. Assume jack A is used, then it will be seen that, while the telephonist rings on one section of the line from this jack, the remainder of the trunk line is available at jack B or at the listening jack. The disconnection between the two sections of line is made at the indicator springs on jack A. The B section of the trunk line is terminated on a 2,000 ohm indicator or bell and can be called when the A section is in use.

1.4 At stations connected to an important trunk line, over which tests are made from a main testing centre, a 2 μF condenser is usually inserted in series with the bells. This enables the testing station to make a general test of the trunk line

/without

without calling all intermediate stations and having them disconnected. It is, of course, possible to open the loop caused by the bell circuit by inserting an open-circuit plug in the listening jack or, alternatively, by disconnecting the exchange equipment at the trunk test panel or section switches provided for testing purposes.

1.5 Trunk Test Panel. Snap switches or section switches are provided at small offices, so that the equipment in any particular station can be readily disconnected from the trunk line for testing purposes. At large offices, a Trunk Test Panel is installed and the trunk line is connected through test jacks in the manner shown in Fig. 4. These jacks enable the trunk line to be opened, short-circuited, earthed or "connected through" clear of the exchange equipment. Alternatively, a section of one trunk line can be patched or cross-connected to a section of another trunk line to minimise the interruption to service caused by a fault on any particular trunk line section.



TEST JACK PANEL.

(x indicates protection items.)

FIG. 4.

2. TRUNK SWITCHBOARDS.

2.1 Special switchboards are provided in large country exchanges and special trunk exchanges in capital cities to handle trunk line traffic. Ordinary subscribers' lines are not connected to these trunk exchanges or special switchboards. In consequence, special circuit arrangements are adopted.

In a C.B. or magneto manual exchange, the large number of subscribers' lines necessitates the use of minimum equipment per line for economic and accommodation reasons. The signalling and transmission apparatus, therefore, is located in the cord circuits, which are comparatively few in number. As the circuit conditions met on each line are the same, this arrangement is efficient and economical.

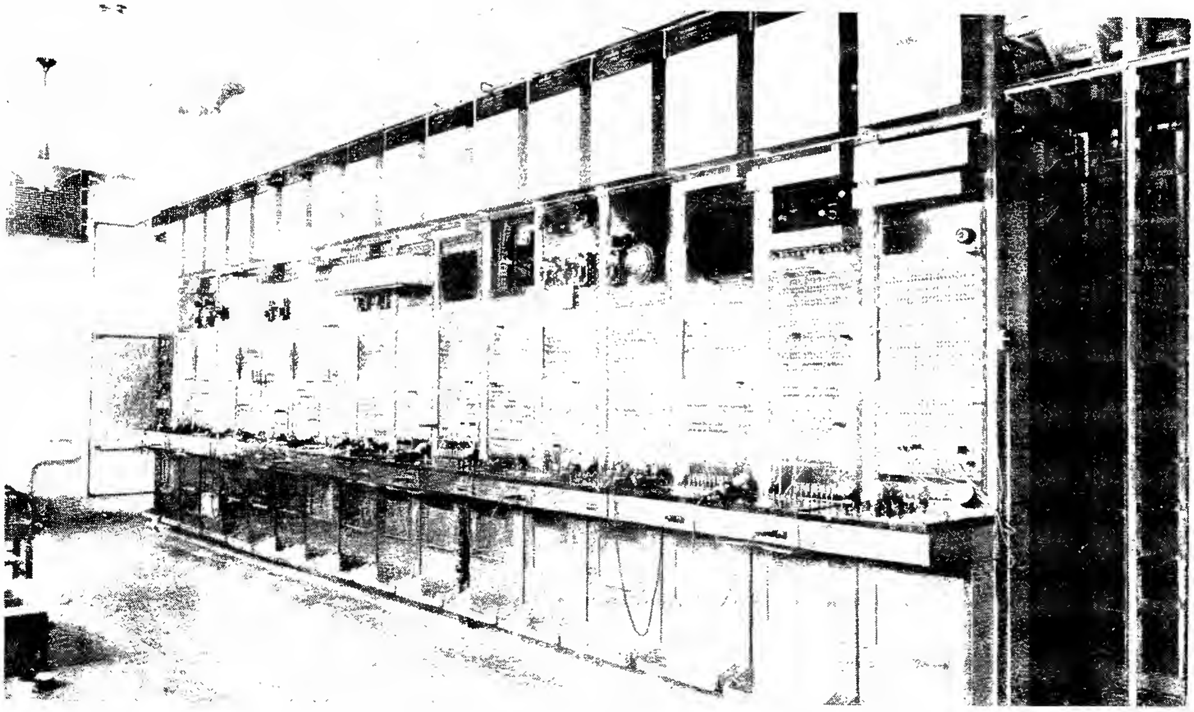
In trunk exchanges, or at trunk switchboards, the conditions are different. The number of trunk lines connected to the switchboard or trunk exchange is much less than the number of subscribers' lines on a manual exchange with the same number of operators' positions. Further, the type of service given on the different circuits varies considerably. Many signalling and supervisory facilities are required on trunk and junction calls which are unnecessary on direct calls to subscribers.

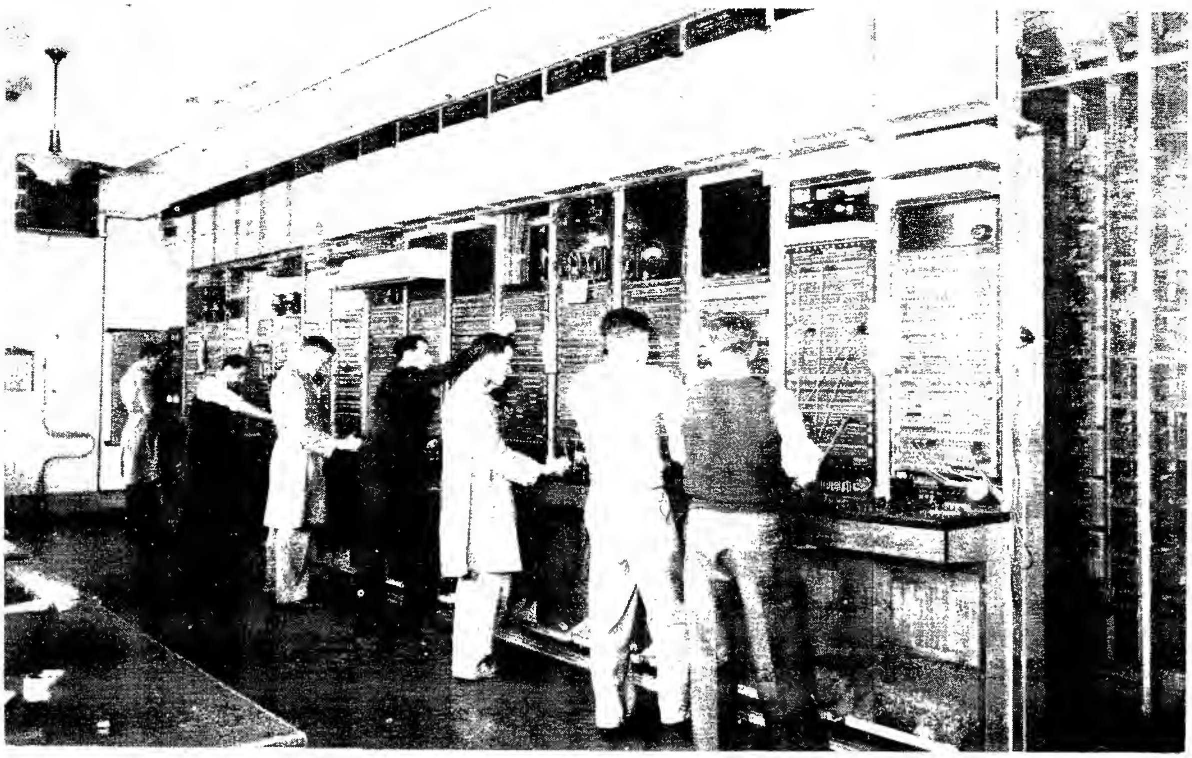
On account of these features, and in view of the non-uniformity of the different types of line connected, trunk exchanges are equipped with cord circuits which contain the minimum of apparatus. All the signalling and supervisory equipment is accommodated in the line terminations, of which different types are provided for the various classes of circuit in use.

The cord circuits simply connect the tip and ring conductors of two circuits straight through; the individual sleeve connections being joined to the cord circuit supervisory lamps.

Thus, all supervisory signals are received on the position via the sleeve conductors, and the uniformity of the cord circuit equipment allows full flexibility in staffing. Since the outgoing and incoming circuits are multipled over many positions, calls may be dealt with by any operator.

/Trunk





TRUNK TEST BOARD AT A TRUNK EXCHANGE.

2.2 Sleeve Control System. Since the cord circuit supervisory signals are associated with the cord circuit and not with the line termination, it becomes necessary to pass the clearing signal from the line termination to the cord circuit via the third conductor of the connecting plug and jack. Thus, the method is known as the Sleeve Control System. The principle is shown in Fig. 5, where the tip and ring conductors of the cord circuit are free from supervisory relays and merely connect the called and calling jacks together. Relay LA is operated while the calling loop is maintained, but, at the end of the conversation, LA releases and LA1 completes the circuit via the sleeve of the jack and the sleeve of the plug to operate the answering supervisory signal. Similar arrangements exist on the calling side of the cord circuit.

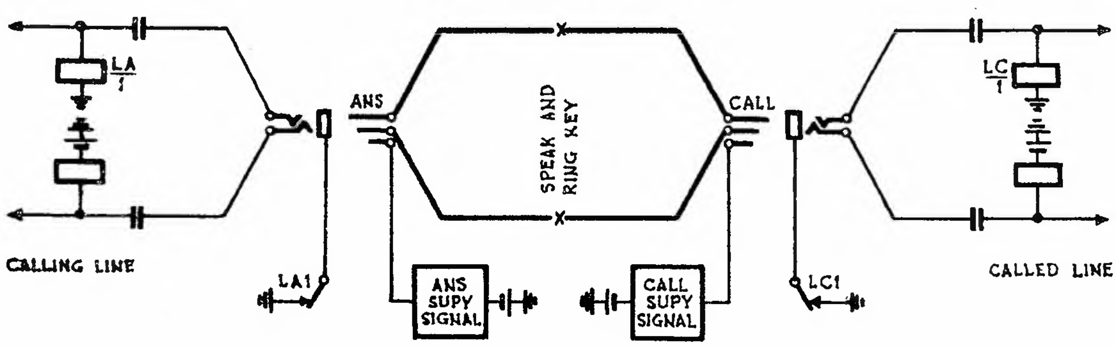


FIG. 5. BASIC SLEEVE CONTROL CORD CIRCUIT.

It will be noted that two transmission bridges are now required for each call, as compared with the single bridge in the cord circuit of the Bridge Control System. This is a slight disadvantage from an economics point of view, but the benefits of permanently associating the supervisory relay with the line instead of the cord circuit, and the simple and universal cord circuit, more than outweigh the small additional cost. The association of the transmission bridge with the line termination has also some transmission advantages on amplified trunk and junction circuits.

2.3 The normal cord circuit in a manual exchange is operated on the Bridge Control method. The terms "Bridge Control" and "Sleeve Control" may be confusing. It is apparent from the foregoing considerations that the supervisory signals are, in both cases, controlled from relays associated with the transmission bridge. Moreover, the sleeve connection is an essential link for the control of the positive clearing signal of the bridge control system. The reader should therefore realise that the sole difference between the two systems is that, in the bridge control system, the supervisory relays are in the cord circuit, whereas in the sleeve control system, the supervisory relays

/are

are in the line termination and the cord circuit supervisory signal is controlled from the line termination via the sleeve conductor of the plug.

2.4 The circuits given in this Paper are indicative of modern trunk practice, and provide a guide to the principle of manual trunk line operation. Automatic trunk line operation is covered in Telephony V.

3. TRUNK LINE CIRCUIT (TWO-WIRE) AND CORD CIRCUIT.

3.1 Incoming Calls. Fig. 6a is a typical termination for a trunk line. Ringing current from the trunk line operates relay L via the transformer. Relay S operates from earth via L1 and locks via S1. S2 completes the line lamp circuit.

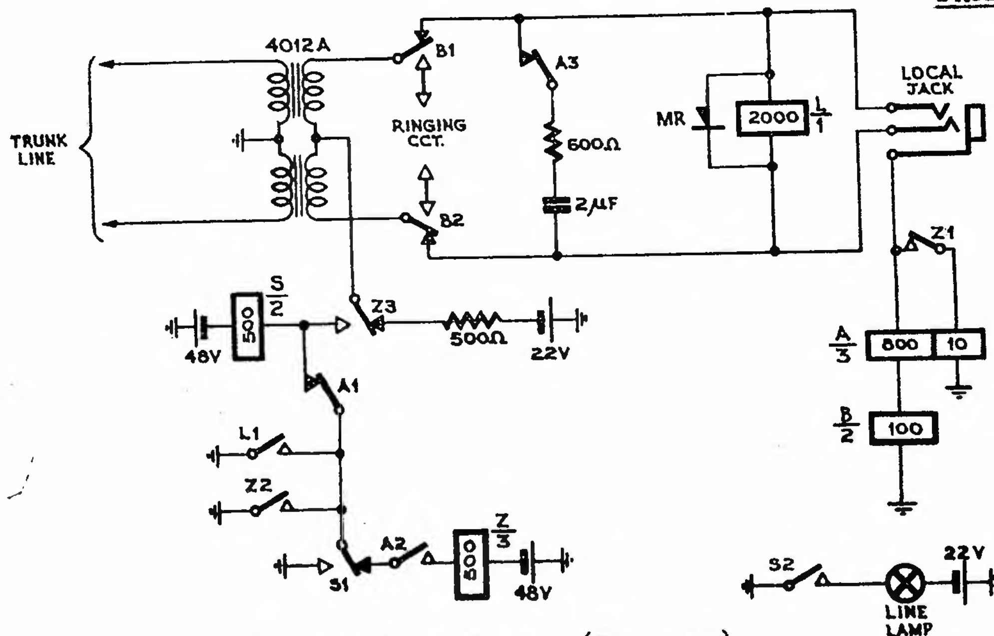
The operator answers the call by inserting the answering plug of a cord circuit into the line jack. (Fig. 6b is a typical cord circuit. The operation of this cord circuit is covered by the descriptions of the following typical trunk circuits.) A circuit is completed over the sleeve, for the operation of relay A, in series with relay B in the line circuit, and the answering supervisory lamp in the cord circuit. Relay B does not operate, nor does the supervisory lamp glow under these conditions. A1 (Fig. 6a) opens the circuit of relay S, which releases and extinguishes the line lamp at S2. A2 prepares the circuit for the operation of relay Z. A3 removes the V.F. termination from the line, as this is now supplied via the cord circuit.

Clearing Signal. A ring-off from the trunk line reoperates relay L. Relay Z operates from earth via L1 and locks via Z2. Z1 shunts the 800 ohm winding of relay A with its 10 ohm winding. The increase in sleeve current allows the answering supervisory lamp in the cord circuit to glow.

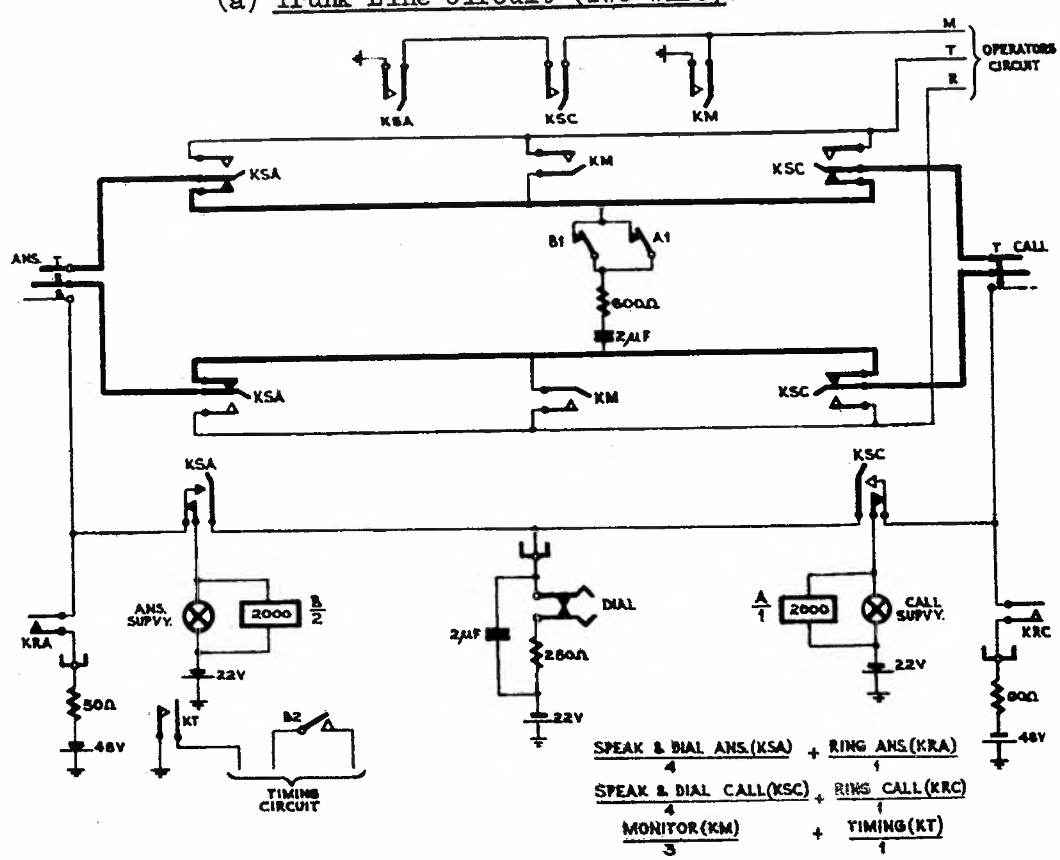
When the operator monitors the cord circuit, earth via the operator's circuit (via retard R in Fig. 7) completes the circuit of relay S in the line circuit over a cailho circuit and Z3. S1 opens circuit of relay Z which restores. Z3 restoring, releases relay S. Z1 restoring, dims answering supervisory lamp. The operator then disconnects the cords.

3.2 Outgoing Calls. To make a call on the trunk line, the operator plugs a calling cord into the line jack and relay A operates. The current flowing is insufficient to operate relay B, which is in series with relay A. When the Ring Call Key in the cord circuit (Fig. 6b) is operated, 48 volts is applied to the sleeve circuit via a 50 ohm protective resistance. This increased current causes the operation of relay B (Fig. 6a). The contacts of relay B disconnect relay L and apply ringing current to the trunk line. Relay B releases when the ringing key is restored.

/Fig. 6.



(a) Trunk Line Circuit (Two-wire).



(b) Trunk Line Cord Circuit.

FIG. 6. TYPICAL LINE AND CORD CIRCUITS.

4. OPERATOR'S CIRCUIT.

4.1 The operator's circuit of Fig. 7 is typical of modern trend in design. This circuit includes an anti-sidetone circuit. An observation induction coil is also included in the circuit.

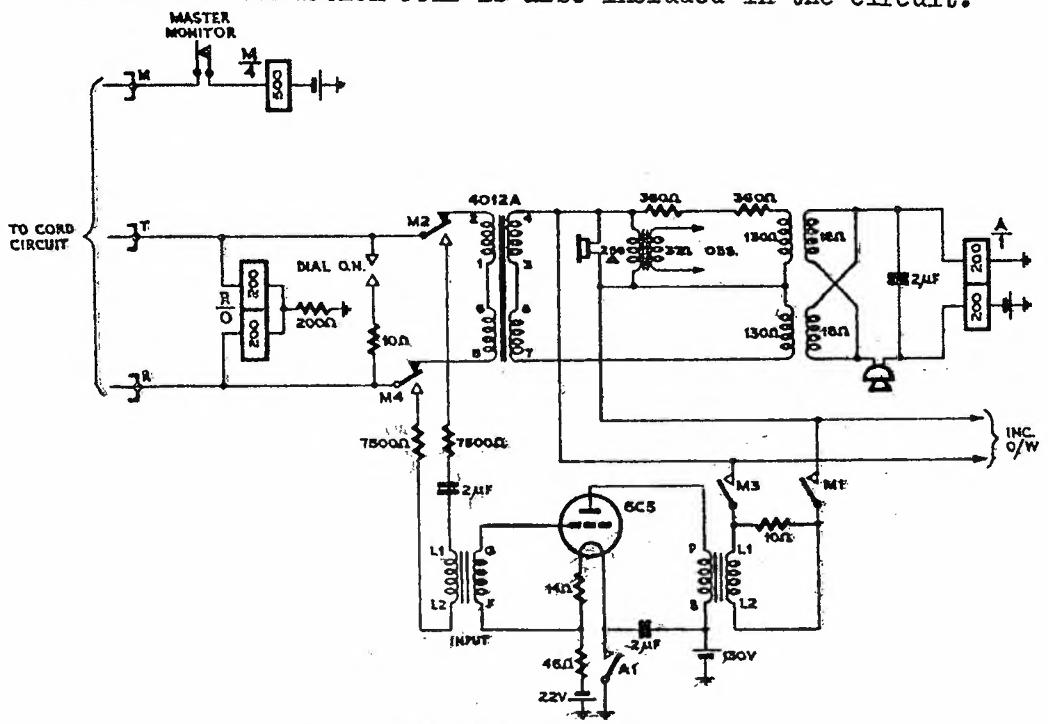


FIG. 7. OPERATOR'S CIRCUIT.

Incoming order wires from other positions terminate directly across the operator's receiver. The busy test is obtained by the balanced retard R, which is also used to operate relay S in a two-wire trunk line circuit when monitoring after receiving a clearing signal.

Monitoring. When the monitoring relay M is operated, an amplifier is connected in the operator's circuit and a monitoring shunt of high impedance is formed. This high impedance shunt prevents appreciable loss on the through conversation.

Relay M may be operated by the monitoring key contacts KM in Fig. 6b.

Speaking is not possible in the monitoring condition, and a "Master Monitor" key is provided which releases relay M and reverts the circuit to normal.

The filament supply to the monitoring valve is controlled by contacts A1. Relay A serves as a reactance in the transmitter battery supply, and is operated whenever an operator's outfit is being used on the position.

/5.

5. JUNCTIONS FOR TRUNK EXCHANGES.

5.1 Various types of junctions are used at trunk exchanges. The incoming junctions to the trunk exchange allow subscribers in the normal telephone network to call the trunk exchange. The outgoing junctions from the trunk exchange enable trunk telephonists to extend trunk line calls to subscribers in that network. The following are typical of these.

5.2 Junction from Automatic Exchange.

Incoming Call. Access to the trunk exchange is available to automatic subscribers by dialling a specially allotted number. When the junction is seized by the automatic subscriber, relay A is operated by negative battery on the positive leg of junction. (See Fig. 8.)

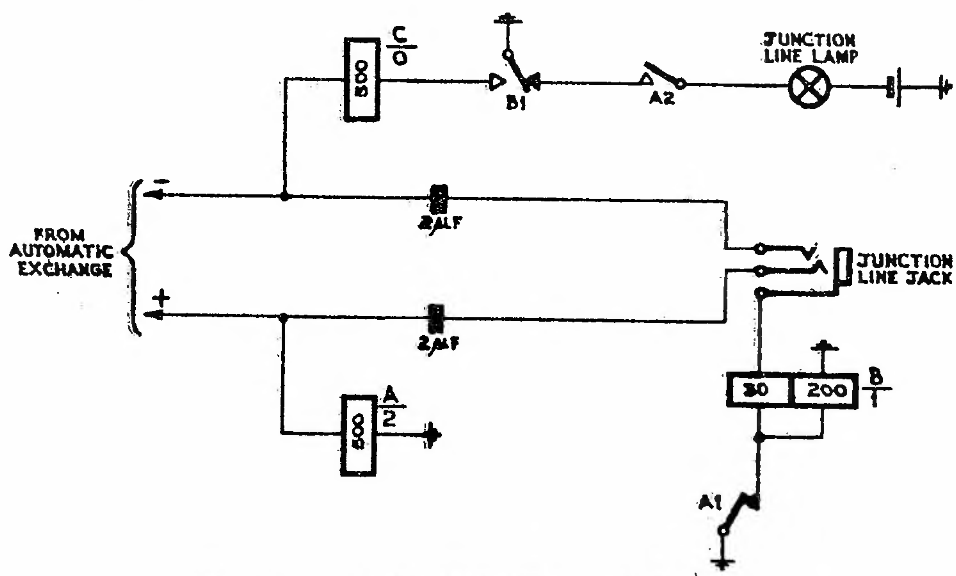


FIG. 8. AUTOMATIC-TRUNK JUNCTION.

A2 closes the circuit of the junction line lamp. A1 removes a shunt on 200 ohm winding of relay B.

Operator answers by placing an answering plug in line jack. Relay B, 200 ohms and 30 ohms in series, operates in series with cord circuit answering supervisory lamp, which will not glow under these conditions.

B1 opens the circuit of the junction line lamp and connects a balancing earth through retard C to the negative leg of the junction line. This earth causes the operation of the supervisory relay in the repeater at the Automatic exchange.

Clearing Signal. When the automatic subscriber clears, the negative battery is removed from the positive trunk, allowing relay A to release.

/A1

A1 shunts the 200 ohm winding of relay B in the sleeve circuit, and the increased current produces a glow in the answering supervisory lamp.

The earth, through operated contact B1 and retard C to the negative leg of the junction, maintains the busy condition on the repeater. When the operator clears the connection, relay B restores and the junction is free to receive the next call.

5.3 Outgoing Junction to Automatic Exchange. (Fig. 9.)

These junctions allow trunk telephonists to dial automatic numbers in the network.

Outgoing Call. When calling plug of cord circuit (see Fig. 6b) is placed in a junction jack, relay A (30 ohms) (Fig. 9) operates in series with cord circuit supervisory lamp which glows.

A1 closes circuit of relay B, which operates.

A2 completes junction loop circuit and automatic selector is seized from negative line, B1 operated, C1 normal, 400 ohm winding of relay F (shunted by metal rectifier), F2 normal, 250 ohm winding of retard E, A2 operated to positive line.

B2 energises 2,000 ohm winding of polarised relay F, which does not operate under these conditions.

The operator dials after operating the Speak and Dial Call Cord Key (KSC) in Fig. 6b. The dialled impulses are repeated by relay A to the Automatic exchange.

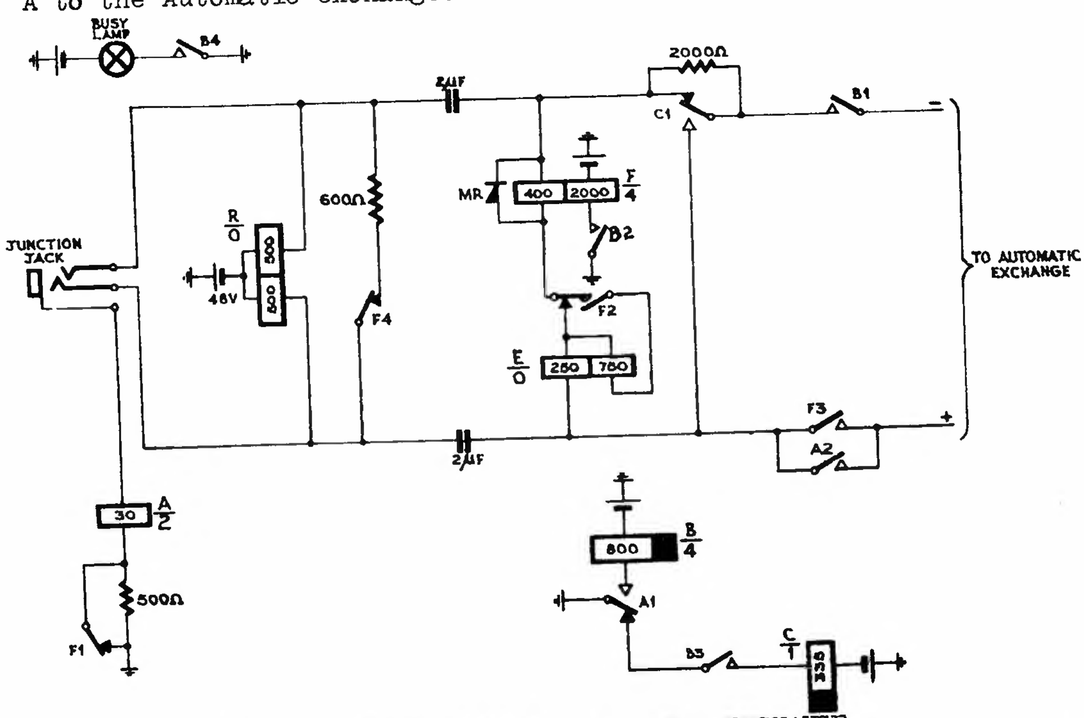


FIG. 9. TRUNK JUNCTION TO AUTO. EXCHANGE.

Relay C operates on the first impulse of each train to give optimum impulsing conditions. The 2,000 ohm resistance around contacts C1 prevents a false impulse being given by the release of relay C after each impulse train.

Called Party Answers. When the called party answers, the current on the junction is reversed and relay F operates, both windings now assisting.

F1 connects 500 ohm resistance in series with sleeve circuit, causing cord circuit supervisory lamp to be dimmed.

F2 inserts 750 ohm winding of retard E in series with its 250 ohm to increase the impedance of the holding loop.

F3 shunts A2 contacts preventing further impulsing.

V.F. Termination. F4 disconnects V.F. termination, as this is now supplied by called subscriber's telephone.

If this termination were not provided on amplifier trunks, oscillation (which is fed back to the trunk) would occur.

Called Party Clears. When the called party clears, the line current again reverses and relay F restores.

F1 shunts 500 ohm resistance in sleeve circuit, and cord circuit supervisory lamp glows.

F4 reconnects V.F. termination.

Operator removes plug from junction jack and relay A restores.

A2 contacts open junction loop.

A1 opens circuit of relay B, which releases.

6. TEST QUESTIONS.

1. Draw a typical Trunk Line Circuit.

2. Why are special cord circuits used at trunk exchanges?

3. What are the main differences between Bridge Control and Sleeve Control cord circuits?

4. Describe from Fig. 6b the operation of the Trunk Cord Circuit.

END OF PAPER.

COMMONWEALTH OF AUSTRALIA.

Chief Engineer's Branch,
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Treasury Gardens,
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COURSE OF TECHNICAL INSTRUCTION.

TELEPHONY II.

C.B. EXCHANGES, SPECIAL FACILITIES.

CONTENTS.

1. INTRODUCTION.

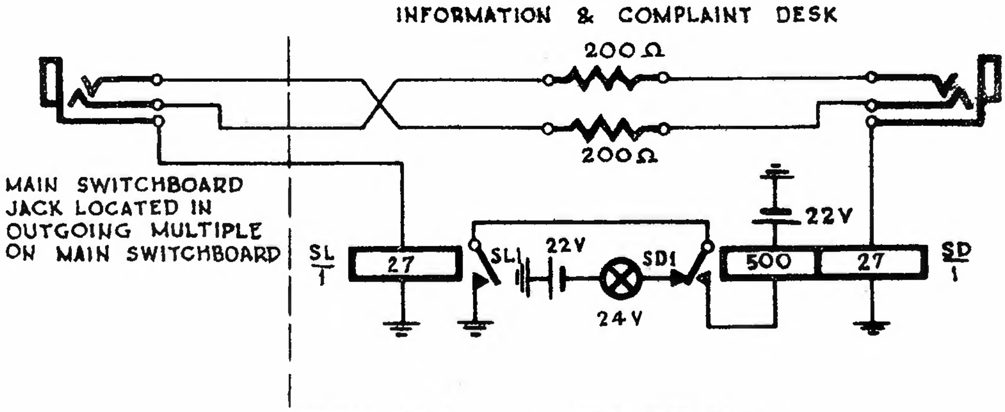
1.1 In large manual exchanges special auxiliary services are provided on the following separate desks -

(i) Information and Complaint Desks,
(ii) Observation Desks,
(iii) Interception Positions,
(iv) Monitors' Desks,
(v) Traffic Officer's Desk.

1.2 The facilities are generally combined in one small switchboard mounted on the monitor's table at small manual exchanges. Where possible, these desks consist simply of an office table of standard size with a cabinet fitted thereon to accommodate the necessary equipment. The arrangements described hereunder should be regarded as typical of circuits for providing the facilities usually required in a large manual exchange. In manual exchanges in capital cities, the services are often centralised, that is, routed to a central desk serving a number of exchanges.

2. INFORMATION AND COMPLAINT DESKS.

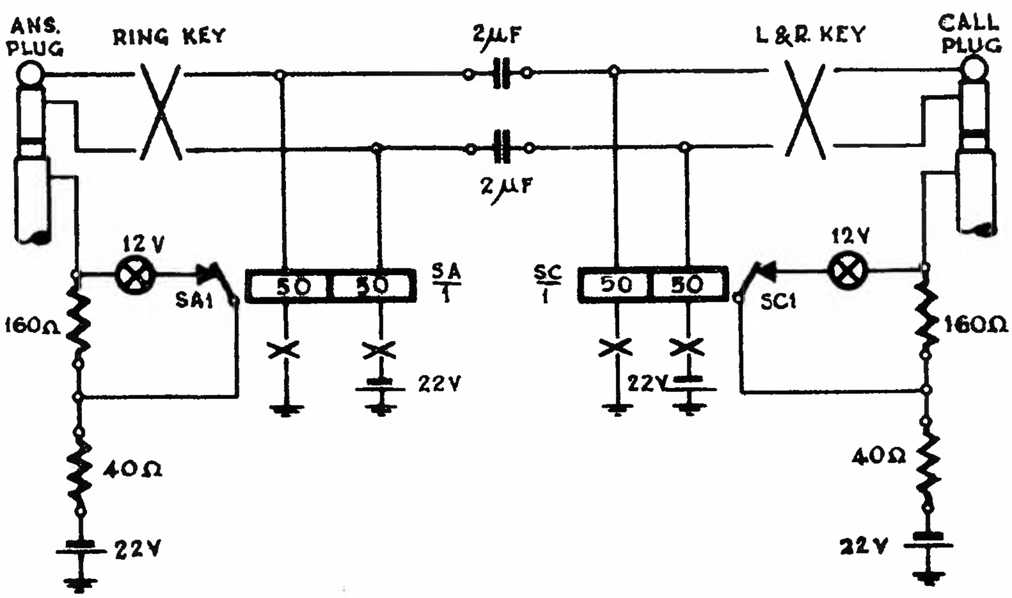
2.1 Enquiries or complaints regarding the telephone service are connected by the A telephonist to the Information and Complaint Desk. A typical circuit is shown in Fig. 1.



INFORMATION AND COMPLAINT DESK.
(INFORMATION LINES FROM MAIN SWITCHBOARD.)

FIG. 1.

When the calling plug of the A position cord circuit is plugged in the jack of a line to the information desk, relay SL operates. SL1 lights the line lamp on the information desk. The information telephonist plugs into the jack of the information line with the answering plug of a connecting cord circuit, as shown in Fig. 2.



INFORMATION AND COMPLAINT DESK. (CONNECTING CORD CIRCUIT.)

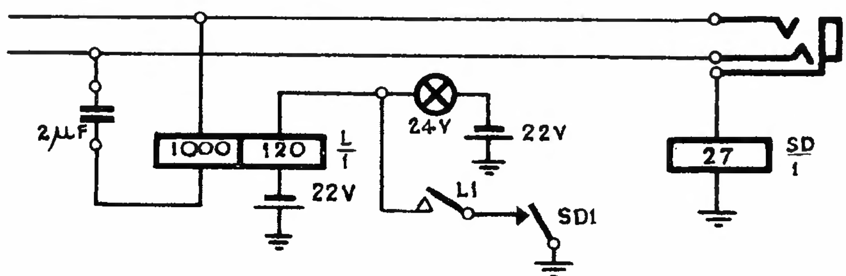
FIG. 2.

Owing to the transposal of the tip and ring conductors (see Fig. 1) the supervisory relay in the A position cord circuit operates and extinguishes the supervisory lamp on the A position. Relay SD operates over the sleeve circuit of the information cord and locks up via contact SD1.

SD1 opens the circuit of the line lamp which cannot again light until the connection has been cleared both at the information desk and at the A position.

The information cord circuit is provided with facilities for ringing on either the answering or the calling side. A call incoming over an information line circuit may be extended to any of the other circuits terminating on the desk. In these cases supervision is obtained by means of the lamps shown in Fig. 2.

2.2 Lines to other desks are of the ring down type with connections at each end as shown in Fig. 3. On a call from or to the Information and Complaint Desk, L relay operates due to the ringing current through the 1,000 ohm winding, L1 closes the circuit of the line lamp and also the circuit of the 120 ohm holding winding of L. When a plug is inserted in the line jack, the sleeve circuit is completed and the 27 ohm SD relay is operated. This opens the circuit of the line lamp and the holding winding of the L relay.



INFORMATION AND COMPLAINT DESK.
(LINES TO AND FROM OTHER DESKS.)

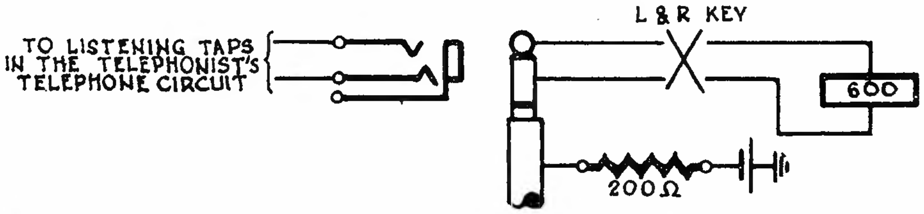
FIG. 3.

To extinguish the supervisory lamps in the cord circuits at the manual desks, it is necessary that a transposal of the tip and ring conductors be made between the desks. If the circuit is used between desks located in the same exchange, it is also desirable to insert 200 ohm non-inductive resistances in the tip and ring conductor shown in Fig. 1.

/ 3.

3. OBSERVATION DESK.

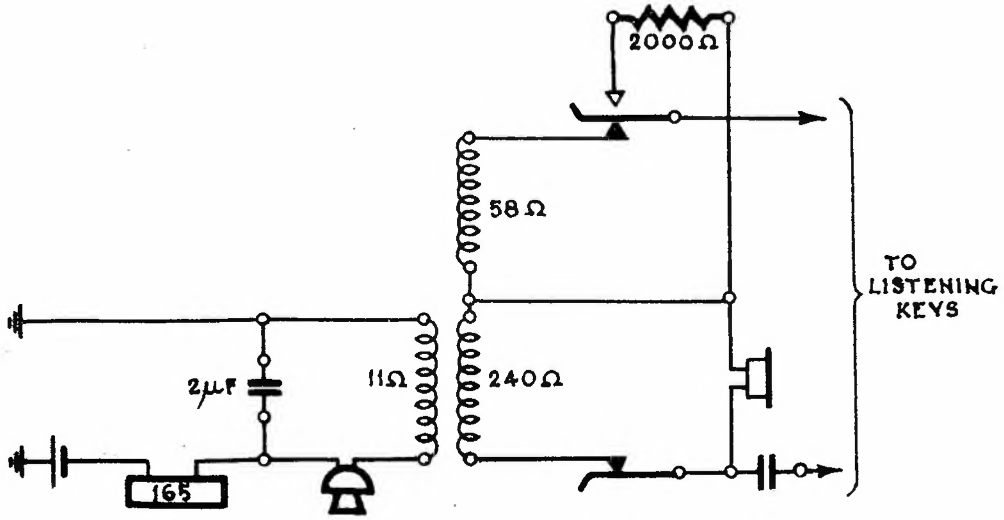
3.1 The Observation Desk is provided to allow a supervising officer to observe the grade of service given by the telephonist on any position or on any subscriber's line. Listening taps from each A and B position are extended to the observation desk which has cord circuits as shown in Fig. 4.



OBSERVATION DESK - POSITION CIRCUITS.

FIG. 4.

3.2 Typical connections of the observation desk telephone circuit are shown in Fig. 5. It will be observed that facilities are provided for opening the secondary winding of the induction coil and connecting the receiver in series with a 2,000 ohm non-inductive resistance across the line under observation. This arrangement is necessary in order that observations may be made without seriously impairing the transmission on the line under observation. It also enables the presence of the observing telephonist on the circuit to remain undetected.

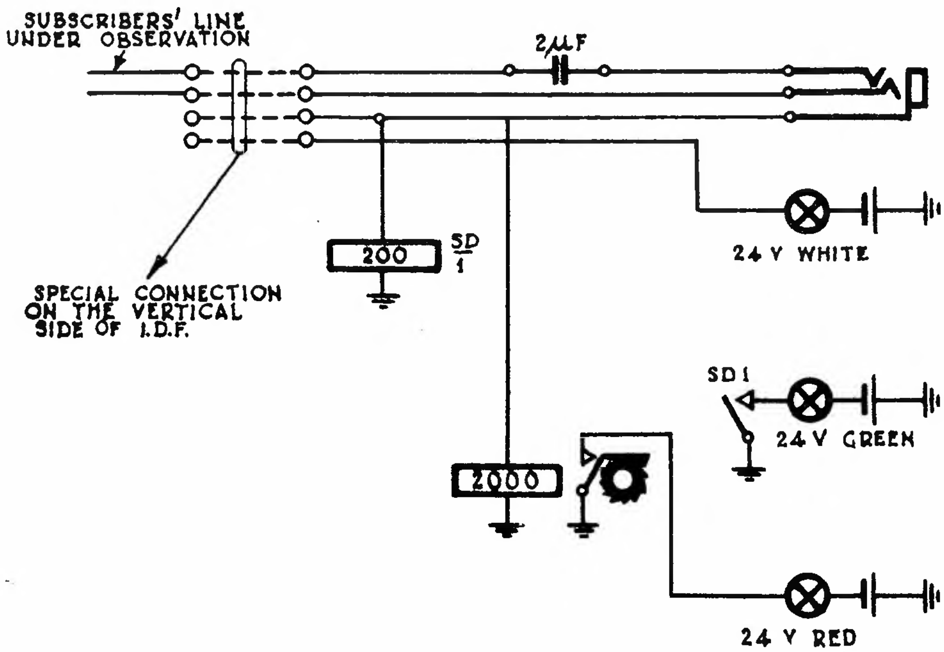


OBSERVATION DESK - TELEPHONE CIRCUIT.

FIG. 5.

3.3 Facilities for observing subscribers' lines are given by the circuit shown in Fig. 6. The connection to the subscriber's line to be placed under observation is made by means of a flexible cord and special connection block on the vertical side of the I.D.F. When a subscriber under observation makes a call, the white line lamp on the observation desk will light in parallel with the subscriber's line lamp on the A position. If a call is made to a subscriber under observation, the insertion of the calling plug in the subscriber's multiple jack operates the 200 ohm SD relay connected to the sleeve of the line. This relay operates and lights the green observation lamp.

The registration of calls on the subscriber's line under observation is checked by means of a 2,000 ohm register and also by an associated red lamp.



OBSERVATION DESK.
CIRCUIT FOR OBSERVING SUBSCRIBERS' LINES.

FIG. 6.

4. INTERCEPTION POSITION.

4.1 When a subscriber's number is changed, it is advisable to check incoming calls to the old and new numbers until the issue of the next directory. Special stops are placed in the multiple field in lines of this type and the A telephonist then switches calls for these numbers through to the interception position which is similar to an A position and located as part of the main switchboard. After requirements are ascertained and checked, the call is switched through in the ordinary way by means of the subscribers' multiple or the outgoing junction multiple.

A circuit of the general type shown in Fig. 1 is suitable for the junctions from the main switchboard to the interception position.

5. MONITORS' DESKS.

5.1 In the event of a complaint concerning service or traffic, the telephonist will route the call to the monitor who will then ascertain the subscriber's requirements. The desk has a telephone and compartments for fault dockets which can be prepared, if necessary, without extension to the Information and Complaint Desk.

6. TRAFFIC OFFICER'S DESK.

6.1 The officer in charge of a large manual exchange is usually provided with a switchboard of the cordless type on which are terminated lines from the various desks in the exchange and also lines to and from the main switchboard.

7. ROUTINE TESTS.

7.1 The efficiency of a telephone system, as far as the exchange plant is concerned, is largely dependent on the efficiency of the routine tests made periodically on that plant. The ideal to be aimed at, is that the service should not be interrupted by faults on any part of the equipment or apparatus. In a modern telephone system this ideal condition cannot be always maintained, but it is possible to approach closely to this condition if the plant is properly tested and adjusted at sufficiently frequent intervals.

All sections of the plant are subjected to tests from time to time but the frequency of the tests that are necessary vary for different portions of the equipment. For example, the switchboard cords, owing to the constant handling they receive and being necessarily of a flexible nature, need testing more frequently, whilst other apparatus such as multiple jacks and wires require to be tested comparatively infrequently.

/ The

The testing arrangements outlined hereunder refer more particularly to C.B. exchanges, but similar systems are in use in magneto exchanges of the multiple type, the facilities provided being specially designed to meet the particular requirements of the equipment in use.

7.2 Routine Tests for C.B. Manual Exchanges. Seventeen routine tests are made by the traffic staff in a C.B. manual exchange at frequencies ranging from daily to annually. These seventeen tests cover the various types of plant in C.B. manual exchanges.

A schedule of the routine tests and the frequency at which they are performed is given hereunder -

		Frequency.
1.	Examination of switchboard.	Daily
2.	Examination of telephonists' sets.	Daily
3.	Examination of cord circuits "A".	Daily
4.	Examination of cord circuits keyless.	Daily
5.	Examination of cord circuits manual.	Daily
6.	Examination of cord circuits automatic A positions.	Daily
7.	Examination of semi-automatic desk junctions.	Daily
8.	Examination of outgoing junctions.	Daily
9.	Examination of calling equipment auto. junctions.	Daily
10.	Examination of alarm signals.	Daily
11.	Examination of calling equipment subscribers' lines.	Weekly
12.	Examination of insulation tests subscribers' lines.	Monthly
13.	Examination of sleeve circuits subscribers' lines.	Quarterly
14.	Examination of ringing key contacts of A position cord circuits.	Monthly
15.	Examination of subscribers' registers.	Half-Yearly.
16.	Examination of subscribers' and junction multiple, end to end.	Quarterly
17.	Examination of subscribers' and junction multiple point to point.	Subs.' 2 years, Junc. Quarterly.

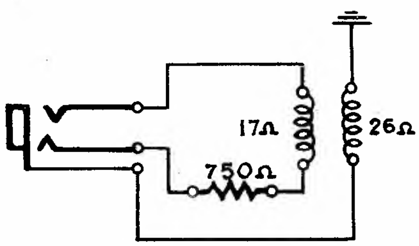
/ 8.

8. DETAILS OF ROUTINE TESTS.

8.1 Examination of Switchboard. Each position is examined daily by a telephonist, and any missing or defective parts, such as designations, lamp caps, key tops, etc., are reported. This test also discloses frayed cords.

8.2 Telephonists' Sets. Each telephonist tests daily the efficiency of her telephone set by speaking through an artificial line to another officer. Additional tests are made of telephonists' sets when any particular set appears to be inefficient.

8.3 Cord Circuit A Position. Circuit arrangements are established in each exchange to enable cord circuits of the various types to be tested readily by the traffic staff. The primary object of the arrangements is to furnish the telephonist with a rapid means of testing all cords on the positions for faults, including intermittent disconnections. This is effected by the provision of special circuits terminating on switchboard jacks, see Fig. 7, and so arranged that, when the plug of the cord to be tested is inserted in the jack, a current flows through each conductor of the cord and, at the same time, suitable arrangements are provided for detecting in the receiver of the telephonist any variations in these currents. The circuits in use are not necessarily intended to provide a severe test for the relays in the cord circuits, but their use enables many relay and other faults to be detected by the telephonist. The resistances provided permit a current, slightly in excess of the minimum operating current for the type of relay in use, to flow through the coils of the supervisory relay.



CORD TEST A POSITIONS.

FIG. 7.

The circuit of Fig. 7 is suitable for use in a C.B. exchange. A test is made by inserting the answering plug in the test jack. As the plug is inserted, the supervisory lamp lights, owing to the sleeve circuit of the plug being completed by means of the 26 ohm winding of the induction coil connected to the sleeve of the jack. When the plug is fully inserted in the jack, the supervisory relay is operated by a loop across the tip and ring springs of the jack. This loop consists of the 750 ohm non-inductive resistance and the 17 ohm winding of the induction coil in series.
The speaking and ringing key is now operated to the speaking position and the telephonist holds the plug and shakes the cord.

/ A

A scraping noise is heard if the cord conductors are not in good order.

8.4 The engaged test is checked by withdrawing the answering plug, operating the speaking key, and then touching the tip of the calling plug on the sleeve of another plug. If the cord circuit is in good order, a click is heard. The calling plug is now inserted in the jack and tested for signalling and intermittent troubles in a similar manner to that described for the answering cord. The ringing and speaking key is then thrown into the ringing position and, if the ringing circuit is in order, the ringing pilot lamp will glow.

8.5 Cord circuits on the various types of B positions and on incoming automatic A positions are tested in a similar manner. It is necessary, however, to modify the circuit described above, in order to make it suitable for use on B positions. For instance, on some B positions, it is necessary to test a keyless ringing feature and to check that the ringing relay, controlling the trip of this keyless ringing, is operating satisfactorily.

8.6 <u>Semi-automatic desk junctions and outgoing junctions</u> are tested to ensure that the transmission and signalling over these lines is satisfactory.

8.7 <u>Alarm Signals</u> are checked by the telephonist inserting a plug with a 750 ohm resistance across the tip and ring into a local jack on each panel. This operates the line relay which in turn causes the pilot relay to operate. The pilot lamp circuit is then closed and the night bell relay operates, thus closing the night alarm bell circuit and causing the bell to ring.

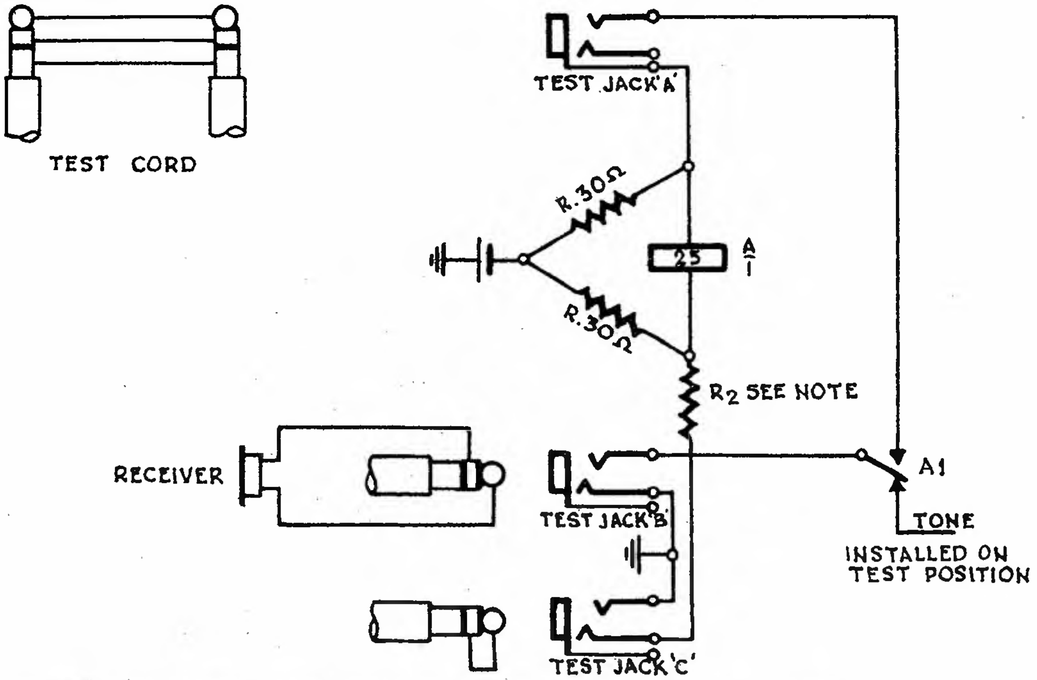
8.8 <u>The calling equipment on subscribers' lines</u> is tested by the telephonist inserting a 750 ohm test plug with a resistance of 750 ohms connected across the tip and ring in the multiple jack of each subscriber's line. The telephonist verifies that the correct line lamp and pilot lamp glow.

8.9 Insulation tests are made by the telephonist inserting a test cord on a position located at the end of the switchboard in the multiple jack of each subscriber's line. A voltmeter and battery are connected in this test cord circuit and a mark is made on the voltmeter scale to indicate to the telephonist the point at which the insulation should be regarded as being defective. All lines failing to pass this test are reported to the engineering staff for attention.

/ 8.10

8.10 Sleeve Circuits. The sleeve circuits of the various subscribers' lines are tested quarterly by the telephonist using the special test cords and circuit shown in Fig. 8, these being located on a testing position. One plug of the test cord is inserted in jack A, the head receiver is plugged into jack B and the short-circuited plug into jack C. Relay A should operate. The tip of the other test plug is touched on the sleeve of each multiple jack in turn. If the line is busy, the engaged click is heard and the test on this circuit can be made later. If the circuit is free, the test plug is pushed into the jack. It will be observed that the circuit is arranged on the Wheatstone Bridge principle. As long as the impedance of the sleeve circuit under test is approximately the same as the impedance of R2, relay A will then restore and a tone is heard by the telephonist in her receiver.

The object of the test is to detect abnormal conditions in the sleeve circuit.



NOTE THE RESISTANCE R_2 SHOULD BE EQUIVALENT TO THAT NORMALLY CONNECTED IN THE SLEEVE CIRCUIT OF THE LINES UNDER TEST

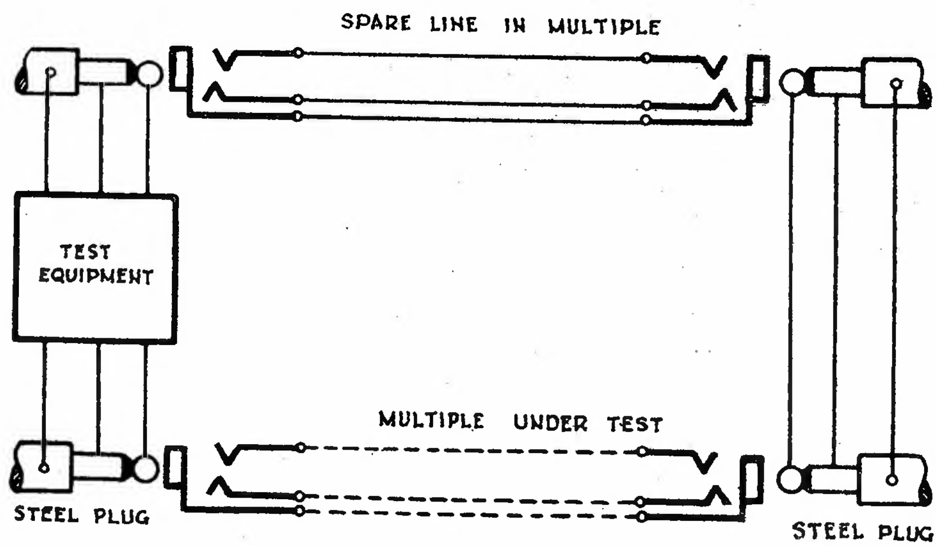
TEST CIRCUIT FOR SLEEVES OF SUBSCRIBERS' LINES.

FIG. 8.

8.11 Ringing Key Contacts of A Position Cord Circuits. The telephonist inserts the answering plug of an A position cord in the test jack and moves the ringing key slowly to the ringing position. No click or ring should be heard in the receiver.

8.12 Subscribers' Registers. Half-yearly tests of all subscribers' registers are made. Details of the circuit used are not given, but the arrangement is that a telephonist inserts a testing plug in the jack of the line on which it is desired to test the register. This telephonist is in telephonic communication with another telephonist stationed at the register rack. The circuit arrangement is such that 10 calls are metered and these registrations are checked on the subscriber's register by the girl at the register rack. Each time the subscriber's register operates, it causes a special register on the testing position in front of the girl on the switchboard to operate. The registration is, therefore, checked by the telephonist in the switchroom and, on completion of 10 registrations, the testing plug is moved to the next line. Defective registers are reported to the engineering staff for attention.

8.13 Subscribers' and Junction Multiple. End to End Test. The special test circuit is situated at one end of the multiple which can be connected by a plug into the multiple jack of each line in turn. In order to pick up the other end of the multiple, a spare line in the multiple is used, one end being plugged to the test set and the other end plugged by a double ended cord which can pick up the multiple line under test. The circuit is shown in Fig. 9.



MULTIPLE TEST.

FIG. 9.

The plugs shown at the top of each pair are kept in the jacks, but the bottom ones are moved over the jacks in the multiple in sequence. If the tip, ring, and sleeve conductors are in order, the buzzer will operate. For very long multiples, a communication circuit is provided between the testing telephonists. The plugs shown at the bottom of each pair are made of steel to stand up to the wear they are subjected to by the continued plugging during a test.

Point to Point. In addition to the test right through the multiple, made at quarterly intervals and described above, another test is made annually so that every subscriber's multiple jack is tested in the course of the year. The procedure is similar to that described for the multiple end to end test, but the test covers the multiple between two adjoining sections.

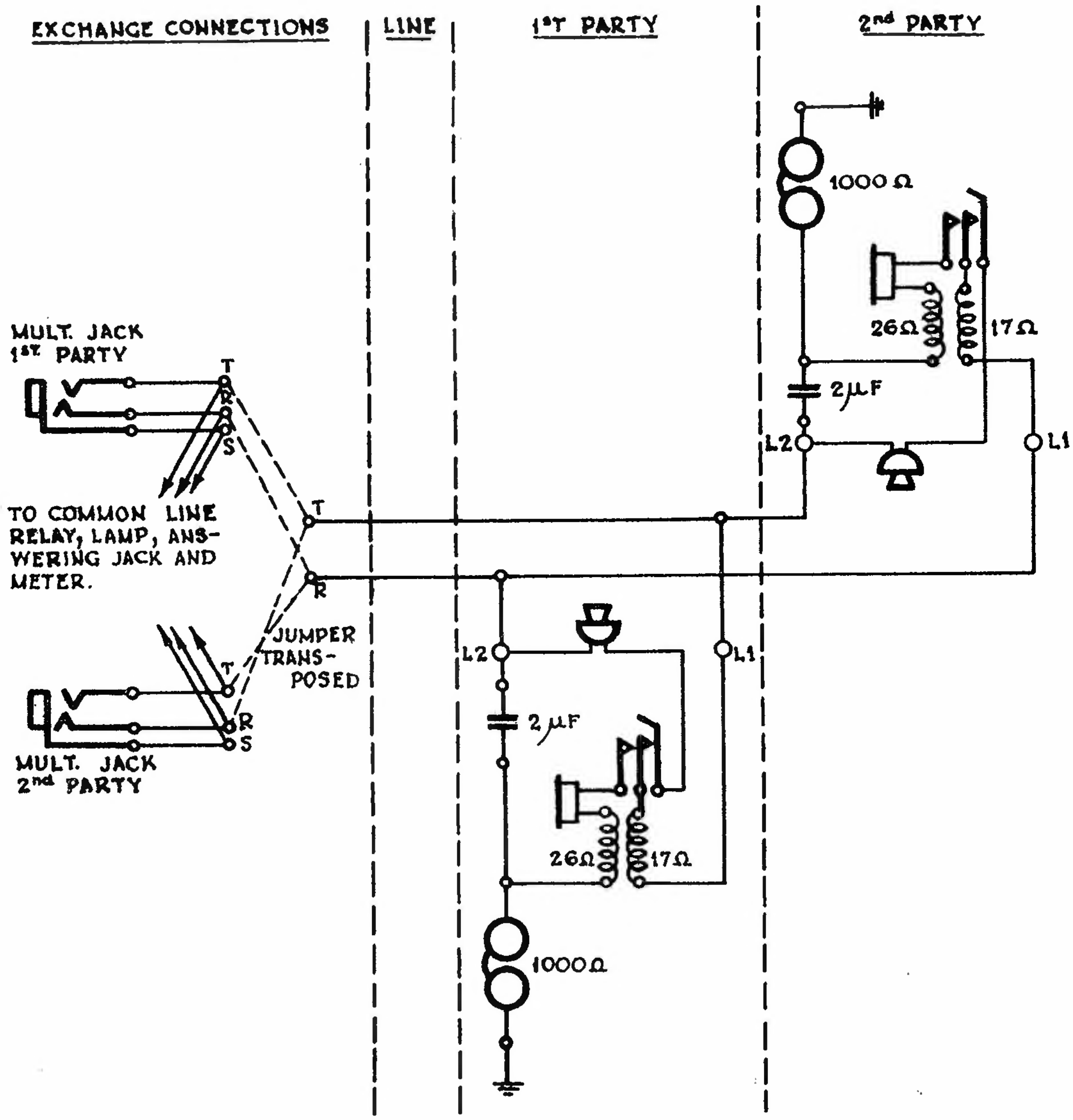
9. C.B. PARTY LINE SERVICE.

9.1 The demand for party line service to C.B. manual exchanges in the Commonwealth is very limited. Fig. 10 gives details of a 2-party line system used in such cases. The subscribers' telephones are connected in parallel across the line for speaking purposes, but a slight alteration is made in the bell circuit, so that, in the case of the first party, the bells in series with a 2 μF condenser are connected between the ring side of the line and earth. In the case of the second party, the bells are connected in series with a 2 μF condenser between the tip side of the line and earth.

9.2 In the exchange two numbers are allotted, one for the first party and one for the second party. Both these numbers are jumpered through on the M.D.F. to the party line, but in one case the tip and ring conductors of the jumper are transposed. When the exchange is ringing the first party, ringing current is placed on the ring side of the cord circuit and this ringing current flows by means of the ring spring of the jack to the party line and operates the bells of the first party. When a call is made to the number associated with the transposed jumper, the ringing current passes via the ring spring of the jack, but, owing to the transposal in a jumper, this ringing current passes out on the tip side of the line, thus operating the bells of the second party.

9.3 Although a separate number in the multiple is allotted to each party, one line relay, lamp, answering jack and register is shared by the two parties. The recording of calls is effected by "Tally Cards", the telephonist ascertaining which party is calling and then entering the particular number on a special card provided.

/ Fig. 10.



C.B. PARTY LINE CIRCUIT.

FIG. 10.

10. TEST QUESTIONS.

1. Sketch and describe a typical Information Circuit from a manual switchboard to an information desk located in the same room as the main switchboard.

2. State the facilities provided on an Observation Desk in a C.B. manual exchange.

3. Write a note on Routine Testing in manual exchanges, and describe three typical routine tests conducted in a typical C.B. exchange.

4. Sketch and describe the C.B. party line circuit.

5. Describe the Routine Test performed on subscribers' registers.

6. State the special auxiliary services provided at a C.B. manual exchange.

7. State the advantages and disadvantages of the C.B. party line service.

8. Why is an Interception Desk necessary?

END OF PAPER.

COMMONWEALTH OF AUSTRALIA.

Chief Engineer's Branch,
Postmaster-General's Department,
Treasury Gardens,
Melbourne, C.2.

COURSE OF TECHNICAL INSTRUCTION.

TELEPHONY II.

TESTING AT C.B. (MANUAL) EXCHANGES.

CONTENTS:

1. INTRODUCTION.

1.1 Telephone faults may be located in some cases as a result of a visual examination. A broken wire or a relay contact spring out of adjustment, for example, may be located in this manner. In other cases, the cause of a fault may be less apparent and may involve both functional and electrical tests to diagnose. If the fault is not located at the preliminary examination, it is usually necessary to carry out functional tests of the equipment to determine the exact nature of the failure. To facilitate such functional tests, it is a common practice to provide specially designed test boxes or routiners, which are arranged to apply test conditions somewhat more onerous than the conditions normally encountered in practice. Having determined, from functional tests, the particular phase of the circuit operation which is at fault, it is then necessary to locate the circuit elements concerned on the appropriate diagram of the apparatus. A further visual examination at this stage will often reveal the cause of failure, but, if this is unsuccessful, it may be necessary to carry out electrical tests of the portion of the circuit under consideration.

By far the greater proportion of telephone exchange and subscribers' line and apparatus faults can be found by means of simple direct current tests. Such tests will, in most cases, reveal not only faults on the signalling and switching circuits, but also a high proportion of faults which would affect speech transmission. In general, the most common defects are -

(i) Disconnection or lack of continuity of the circuit, usually called an "open".
(ii) Short circuit either in the wiring or in one of the components, usually called a "short circuit".
(iii) Low insulation, called L.I.R.
(iv) Earth fault, called "earth".

In all of these tests, it is necessary to have some device which will indicate or measure the presence of an e.m.f. or current. The moving coil type of milliammeter or voltmeter is highly suitable for the circuit testing of telephone equipment and forms the basis of most testing instruments. A voltmeter of suitable sensitivity can be used in a wide variety of ways for the location of faults, but it is not possible in this book to give more than a few of the more common and simpler uses.

This Section will provide the basic principles of testing, more information is in Telephony V.

2. TESTING PRINCIPLES.

2.1 High resistance voltmeters are used extensively in exchanges for making rapid tests of conductor resistance and insulation resistance of lines. A typical voltmeter for use in an exchange is of the permanent magnet moving coil type. A description of the moving coil instrument is in Paper No. 5 of Heat, Magnetism and Electricity. The voltmeter is usually mounted in a wall or floor type test desk, together with testing keys and other facilities. The principles of the more usual tests are given below.

2.2 Conductor Resistance or Loop Tests. The resistance of a subscriber's line and/or telephone or other apparatus is often required for reference or comparison purposes. This test determines the resistance value of a subscriber's line or apparatus connected, as shown in Fig. 1. To make the test on a subscriber's line for example, the lines are looped at the distant end and the voltmeter and battery are connected as in Fig. 1 by the operation of appropriate keys on the test desk. / The

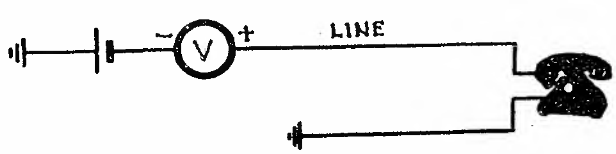


FIG. 1. TESTING RESISTANCE OF A LINE.

The resistance of the line may be calculated as follows -

Let D1 = e.m.f. of testing battery,
D2 = Deflection in volts obtained as in Fig. 1,
r = External resistance,
R = Resistance of voltmeter system and
I = Current in the circuit.

$$\text{Then, } I = \frac{D2}{R}$$

$$\text{also, } I = \frac{D1 - D2}{r}$$

$$\therefore \frac{D2}{R} = \frac{D1 - D2}{r}$$

$$\therefore r = \frac{R(D1 - D2)}{D2}$$

$$\text{or } r = \frac{RD1}{D2} - R$$

$$\text{or } r = R\left(\frac{D1}{D2} - 1\right)$$

This formula, therefore, gives the conductor resistance (r) of the loop.

It is not necessary to make this calculation for each test, as a test chart is usually prepared for all deflections at various voltages and the conductor resistance of the loop is read directly from this chart. (Note: For accurate measurement of resistance, value R should be approximately equal to r.)

Before making conductor or insulation tests by this method, it is necessary to ascertain whether any stray current, called "foreign battery", exists on the line. To do this, one terminal of the voltmeter is earthed and the other connected to the line which is open at the distant end and a deflection will then indicate a stray current.

If a deflection is obtained when the voltmeter is connected as in Fig. 2, the stray current will be aiding the testing battery when the latter is connected.

TEST FOR AIDING FOREIGN BATTERY ON ONE SIDE OF LINE.

FIG. 2.

Therefore, the deflection obtained must be subtracted from the test reading and the formula modified thus -

$$r = \frac{RD1}{D2 - d} - R$$

where d = deflection due to stray current.

If a deflection is obtained when the voltmeter is connected as in Fig. 3, that is, the positive and negative connections are reversed, the deflection obtained must be added because the stray current will oppose the testing battery.

TEST FOR OPPOSING FOREIGN BATTERY ON ONE SIDE OF LINE.

FIG. 3.

The modified formula is as follows -

$$r = \frac{RD1}{D2 + d} - R$$

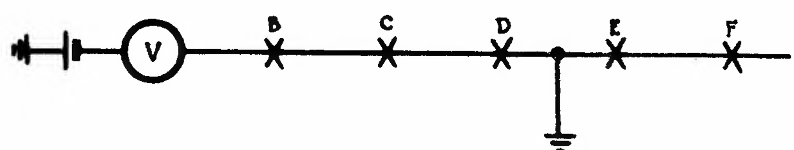
2.3 Insulation Resistance. The insulation resistance value of subscribers' lines must be kept as high as possible to prevent leakage of current and loss of transmission efficiency.

When making insulation tests, the wires are opened at the distant end and insulated from earth. The test is then applied to each wire in turn. The potential is connected as in Fig. 1 but is usually 400 volts to give a measurable deflection, and the resistance of the voltmeter should be of the order of 100,000 ohms. The voltage is usually obtained from a rectifier connected to the A.C. power supply. Any leakage to earth along the line will give a deflection which is a measure of the voltage drop across the resistance of the voltmeter. The resistance to earth is calculated as in paragraph 2.2 above, the resistance of the line being negligible in comparison to the resistance to earth unless there is a faulty condition. As in the loop resistance test, a test chart is prepared to facilitate this test and insulation resistance values are read direct from the chart.

2.4 Localisation of Faults.

Earths. Earth faults, caused by direct contact between lines and the earth or between lines and other lines connected to earth, are one type of fault frequently detected on subscribers' lines.

In order to localise an earth fault on an aerial line for example, the circuit is connected as for a conductor resistance test and each line is successively disconnected at the various testing points, and it is then ascertained up to which point the circuit is O.K. and beyond which point it is defective. For this purpose, an earthed battery and voltmeter are joined to the wire, as shown in Fig. 4. Since current will flow through the fault, a deflection of the same order as for a conductor resistance test will show. When the circuit is first disconnected at F, it is noted whether the deflection changes on the A or the B wire. If not, the faulty circuit is then disconnected at E and the line tested again. If the fault is between D and E, as shown in Fig. 4, the circuit is next disconnected at D and another test is made. If no deflection is obtained, then the fault exists between D and E.



LOCATING EARTH FAULT.

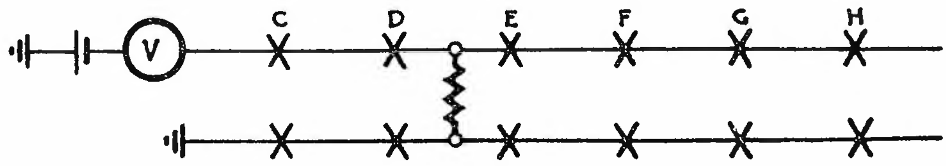
FIG. 4.

Location of earth faults, by calculating the resistance value to the fault and then converting this value into yards of line, is explained in Long Line Equipment III.

Contacts. Aerial lines are prone to "short-circuit" faults, particularly in windy weather. To test for this short-circuit or contact fault, an earth is connected to one line and earthed battery via the voltmeter to the other. (See Fig. 5.) If the two wires are in contact, the voltmeter is deflected. A battery and voltmeter joined in series without an earth connection is not satisfactory for this test, for the reason that an earth fault upon each of the lines would give the same result as a

/ contact

contact, and an incorrect test could very easily be given. To avoid this error it is advisable, when testing for contacts, to test each line for earth fault.

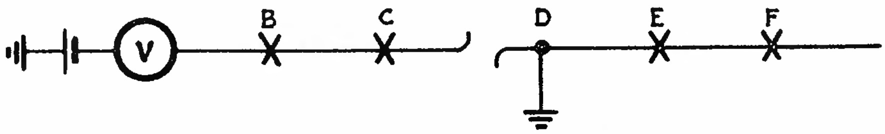


LOCATING A CONTACT FAULT.

FIG. 5.

In Fig. 5, if the lines are successively disconnected at H, G, F and E, a deflection on the voltmeter will indicate that the fault still exists in the part of the line in circuit. After disconnecting at D there will be no deflection, thus indicating that the contact is between D and E.

Disconnections. "Open-circuit" faults may be due to a variety of reasons which include broken line wires, operated fuses or faulty joints in wires. When an "open" fault is to be tested on a long line for example, the various offices en route are successively requested to loop the circuit and the testing battery and voltmeter applied, as in the case of a contact. A deflection then proves the continuity of the circuit between the two testing points, whilst the absence of a deflection denotes that the disconnection is in the last section to be added to the circuit being tested. When it is required to prove whether the A or B line is concerned, both wires should be earthed successively at the various testing points, and the test made as indicated in Fig. 6.



LOCATING AN OPEN CIRCUIT.

FIG. 6.

3. TEST DESKS.

3.1 To facilitate the performance of the many tests required on lines, a test desk, equipped with a voltmeter and other testing apparatus and means for connecting lines to be tested, is installed in exchanges. These test desks have testing keys to enable the circuit changes necessary for the various tests to be made rapidly. Test desks for manual C.B. exchanges are described here, and those for Automatic exchanges in Telephony V.

3.2 In a C.B. exchange, tests of a preliminary nature may be made by the switchroom technician at the exchange Test or Plugging-up Position,which is generally installed adjacent to the last A position so that by plugging into the subscribers' multiple jack, tests made pass through the entire multiple. The general nature of the fault may be ascertained from this testing position and, if necessary, the matter is referred to the test desk officer for a more comprehensive examination.

3.3 Test Desk Equipment. In addition to lines to the exchange and the information desk, which facilitate the work of the testing technician, the following equipment is provided on a test desk position in a typical C.B. exchange -

(i) Test extension circuits to the plugging-up position;

(ii) Test extension circuits from the plugging-up position;

(iii) M.D.F. test and interception circuit;

(iv) Outgoing order wire to plugging-up position;

(v) Test cord circuit;

(vi) Interrupted earthing plug circuit;

(vii) Sounder plug circuit;

(viii) Speaking cord and connecting cord circuit.

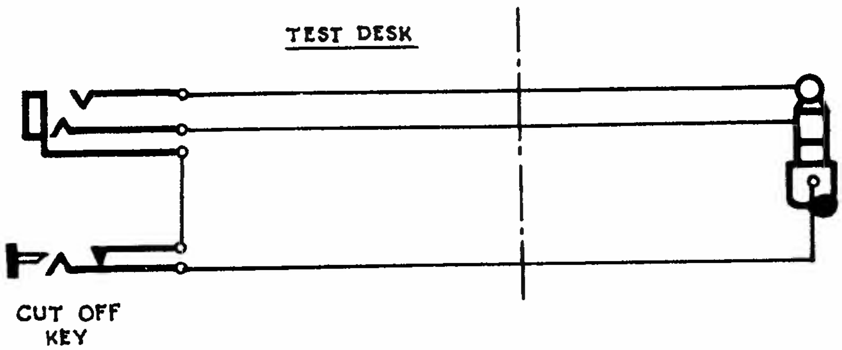
3.4 Sufficient test desk positions are provided to deal expeditiously with the testing work during the busy periods of the day.

/ 4.

4. TEST EXTENSION CIRCUITS.

4.1 The majority of the tests from a test desk at a manual exchange are made through the subscriber's multiple. The testing technician stationed at the test desk is connected to the line to be tested by means of a test extension circuit which terminates on a jack at the test desk and on a plug at the plugging-up position. The testing technician inserts the plug of the test cord in the jack of the test extension circuit, and carries out the tests by operating the various keys.

4.2 Test Extension Circuit to the Plugging-up Position. The circuit is given in Fig. 7. After the plug is inserted in the multiple jack the operation of the cut-off key at the test desk releases the B.C.O. relay of the subscriber's line under test. The complete circuit of such a connection is given in Fig. 9. This connects the line relay and calls the attention of the telephonist on the A position on which the circuit under test terminates. This enables the testing technician to obtain connection with any line by communicating over the order wire with the telephonist at the plugging-up position.



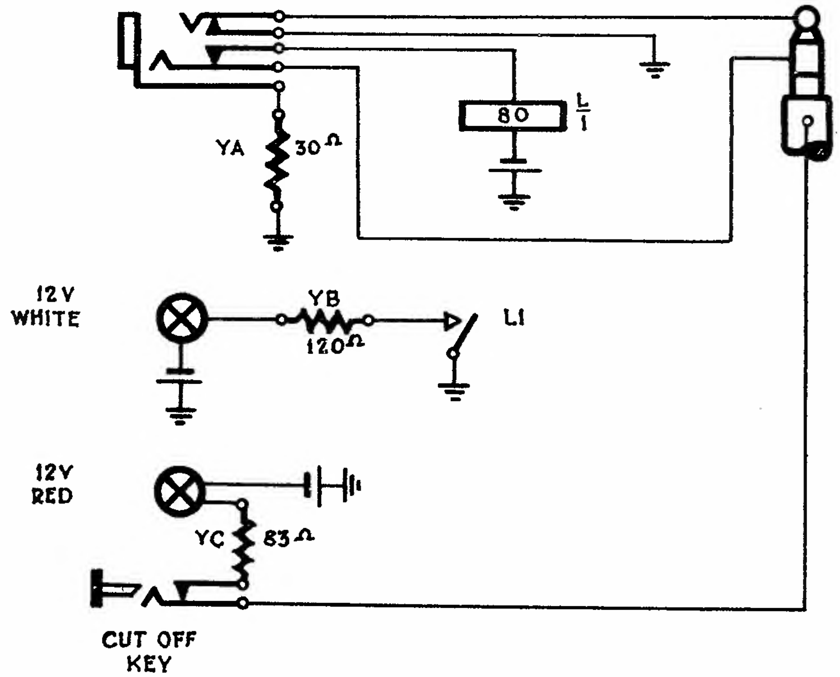
TEST EXTENSION CIRCUIT.
FROM TEST DESK TO PLUGGING-UP POSITION.

FIG. 7.

The insertion of a test extension plug into a multiple jack on the switchboard will not "busy" a line. The engaged test is not given until the test cord is inserted at the test desk.

/ 4.3

4.3 Test Extension from the Plugging-up Position. This circuit (see Fig. 8) is installed at exchanges where a test technician is constantly in attendance during ordinary hours of duty.



TEST EXTENSION CIRCUIT.
FROM PLUGGING-UP POSITION TO TEST DESK.

FIG. 8.

When a fault lineman or technician desires to communicate with the test technician, he asks the "A" telephonist for "Test Desk No. ." Particulars of the call are passed by means of an order wire to the telephonist at the plugging-up position who inserts a disengaged test extension plug allocated for the use of the test desk specified into the multiple jack of the line to be tested. The "A" telephonist then withdraws the answering plug.

The insertion of the test extension plug in a jack of the switchboard will cause the relevant red and white lamps on the test desk to glow. The red lamp indicates that the sleeve circuit is continuous, and the white lamp that the tip and ring of the line are looped.

/ An

An engaged test is given immediately the test extension plug is inserted into the multiple jack. Calls after ordinary hours are completed over direct exchange lines from the exchange switchboard to the test desk.

4.4 Order Wire to the Plugging-up Position. The order wire to the plugging-up position circuit enables the testing technician, by pressing an order-wire key, to communicate with the officer on the plugging-up position for the purpose of having test extension circuit plugs inserted in, or withdrawn from, lines under test.

5. M.D.F. TEST AND INTERCEPTION CIRCUITS.

5.1 Circuit facilities are provided for testing from the M.D.F. and for intercepting lines on which there are intermittent faults.

5.2 Tests to Arrester Side of M.D.F. A test shoe is inserted in the line at the arrester and heat coil side of the M.D.F., and the line is then extended by means of a four-wire circuit to the test desk. The testing technician can test either the exchange or the switchboard side of the line separately.

5.3 Tests to Line Side of M.D.F. Where necessary, the fuses may be withdrawn on the line side of the M.D.F., and testing clips, consisting of brass caps on a bakelite mounting, may be inserted in place of the fuses. By this means, a four-wire circuit to the test desk is given, with facilities for testing either the exchange or the subscriber's side of the line. This feature is useful in testing lines from the cable head or line side of the M.D.F.

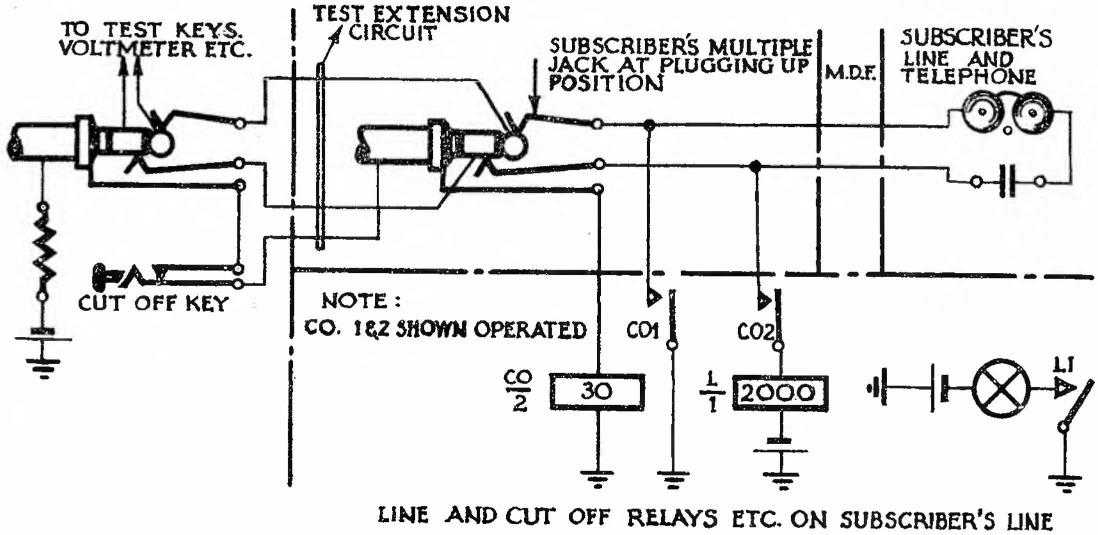
6. TEST CORD CIRCUIT.

6.1 The method of obtaining connection to the subscriber's line is shown in Fig. 9, where a clear circuit over the tip and ring conductors to the test keys is provided. A typical test desk cord test circuit consists essentially of a number of keys and a voltmeter, and provides the following test conditions. The principles of these tests were explained earlier in this Paper.

6.2 Tests. Insulation Resistance Test of subscriber's line, as shown schematically in Fig. 10. A high voltage battery or rectifier is sometimes used in place of the 60 volt battery.

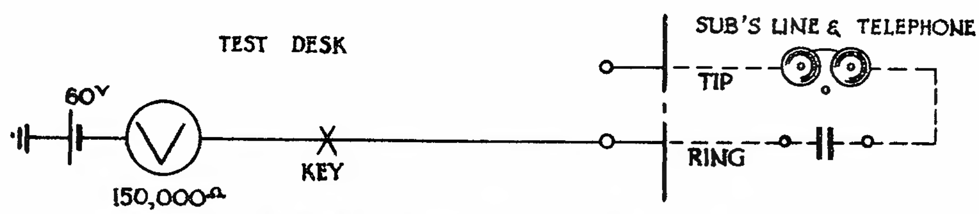
Capacity Test. When the line is connected to the voltmeter, the rapid operation of a line reversing key will give an approximate indication of the capacity of the line. This capacity or ballistic test will indicate an open line if a condenser discharge is not obtained.

/ Fig. 9.

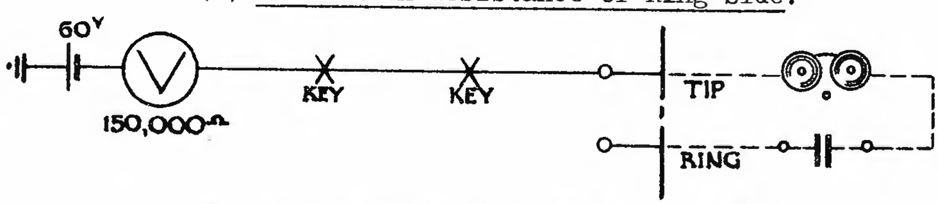


CONNECTIONS WHEN TESTING A LINE VIA A TEST EXTENSION CIRCUIT TO PLUGGING-UP POSITION.

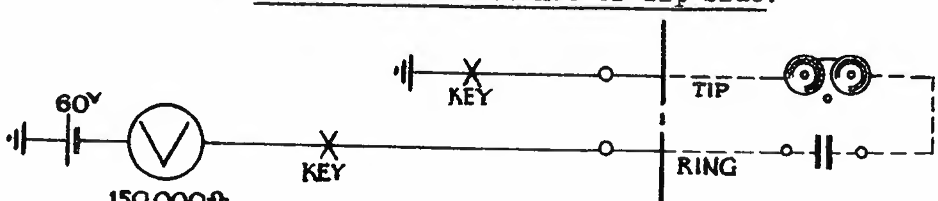
FIG. 9.



(a) Insulation Resistance of Ring Side.



(b) Insulation Resistance of Tip Side.

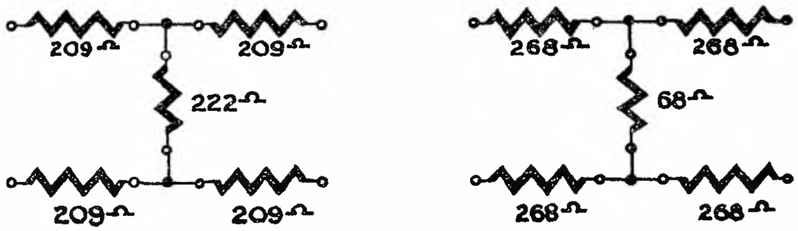


(c) Insulation Resistance Between Tip and Ring.

INSULATION RESISTANCE TEST.

FIG. 10.

Transmission Test. An attenuating network, as shown in Fig. 11, may be connected in circuit to test the transmission qualities of the subscriber's line and instrument. The "decibel" is the name adopted to denote transmission loss or gain and is discussed in Telephony III and Long Line Equipment I.



TRANSMISSION NETWORK USED ON TEST DESKS.

The transmission test is normally made through 25 db network by operating key. The 15 db network is placed in series with the 25 db network, thus giving a transmission test through an artificial line having a total equivalent of 40 db.

FIG. 11.

Resistance Test. The resistance of the line and/or instrument can be determined by connecting the voltmeter to the line as shown in Fig. 1.

Foreign Battery Test. The voltmeter is connected directly to the line to detect the presence of "foreign" battery.

Sounder Test, used by the testing technician when he is required to leave the test desk to prove the line to the M.D.F. By operating a key, and earthing the ring side of the subscriber's line at the cable head on the M.D.F., the testing technician can satisfy himself that the ring side is not open in the exchange. By using the reversing key as well as the sounder key, the tip side may be verified. Similarly, by using the earthing key and sounder key, a short circuit may be placed on the subscriber's line at the M.D.F., and the loop verified.

Howler Key used for calling attention of a subscriber who has left the receiver off the hook. The operation of this key transmits a loud "howl" to the line and telephone.

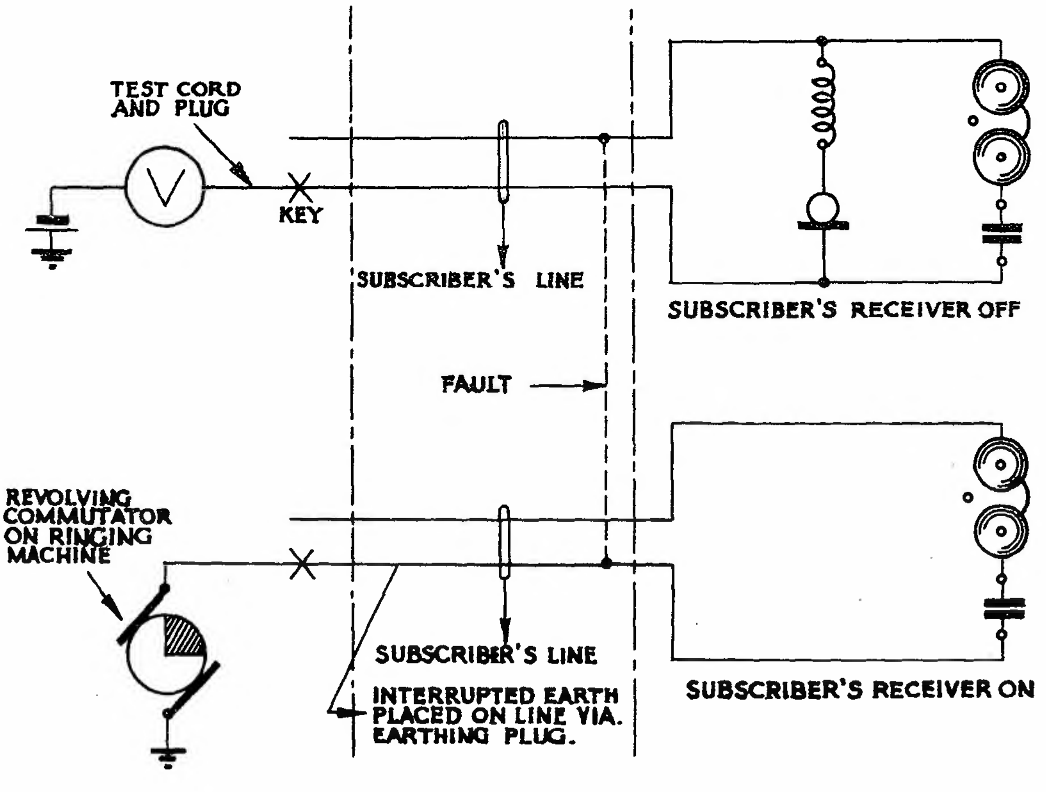
A number of other tests and associated keys is provided in the testing circuit such as Ringing Key, Operator's Telephone Key.

/ 6.3

6.3 Other Facilities Provided on Test Desks. In addition to the test cord circuit described in paragraph 6 above, a number of other cords are provided on the test desk to facilitate the technician's work.

The sounder plug is used when it is desired to use the sounder without holding up the testing work conducted from the test desk by means of the test cord.

The earthing plug is useful in making tests for crosses between lines. The earthing plug is plugged into one of the lines concerned and the testing plug connected to the other line. The voltmeter will then indicate the presence of a cross between the wires. The connections can be followed from the circuit given in Fig. 12.



TEST FOR CROSS, USING EARTHING PLUG.

FIG. 12.

Cord circuits are also provided for connecting and speaking. On some occasions, it is necessary for the testing technician to connect a line under test through to an exchange line to enable an urgent call to be made. A pair of cords are provided for this purpose. Ringing and Listening Keys are associated with these cords.

The speaking cord circuit is used when the testing technician desires to speak to a fault technician or lineman, etc., without utilising his test cord for this purpose.

7. TEST QUESTIONS.

1. (a) Give the formula for calculating the value of an unknown resistance when measured with a testing voltmeter.

   (b) If a voltmeter of 150,000 ohms resistance gives a deflection of 10 when connected in series with an unknown resistance and a testing battery of 59 volts, calculate the value of the unknown resistance.

2. Show the elements of a circuit arrangement for testing the loop resistance of a subscriber's line and instrument in a typical C.B. exchange. State the voltmeter scale and value of shunt used, and give reasons.

3. Draw a diagram of a typical test trunk circuit from the test desk to the plugging-up position in a typical C.B. exchange. For what purpose is the cut-off key provided?

4. A subscriber's line, when tested from the test desk, proves to be open. Indicate how you would prove whether the fault was in the exchange or not, assuming that no other officer was available to assist in making tests to the M.D.F.

END OF PAPER.