LOCAL BATTERY AND CENTRAL BATTERY TELEPHONES

CONTENTS

Introduction

This pamphlet describes the operating principles of the common types of telephone that can be installed at a customer's premises. Later pamphlets in this series will deal with extension plan numbers and private branch exchanges.

To transmit sound from one place to another, other than directly through air or similar sound conducting media, an arrangement is required consisting of:-

(a) An instrument to convert the energy of the sound waves into energy of a different form.

(b) A medium through which the energy can travel.

(c) A second instrument which re-converts the energy received into sound waves similar to those originally produced.

The instruments required in (a) and (c) are known as a transmitter and receiver respectively. It will be found that the term 'transducer', i.e. a power transforming device for insertion between electrical, mechanical or acoustic parts of systems of communication, is sometimes used for the transmitter or receiver. The transmitter consists essentially of a quantity of carbon granules packed between two carbon electrodes. One electrode is fixed while the other is firmly attached to a diaphragm. The receiver consists essentially of a permanent magnet together with an electro-magnet mounted in close proximity to a diaphragm. These instruments are described in detail in Eductional Pamphlet - Draft Series - General 4/1. The transmitting medium, as far as this aspect of telephony is concerned is a pair of wires.

The design of the telephone circuit, must satisfy the following conditions:-

(a) The signalling path through the telephone must have a low resistance to allow the majority of the permissible signalling path resistance to be in the line. The transmitter is usually in the signalling path, consequently it must have a resistance which is low compared with that of the line.

(b) The circuit must work efficiently in an existing network which consists of lines having a wide range of impedances.

(c) The circuit must work efficiently when connected to a telephone circuit of earlier design.

(d) The circuit must include a device which will respond to the incoming alternating current ringing signal; in practice the device is usually a magneto bell.

Principle of Operation

General

Fig. 1(a) shows a simple circuit which enables one person to talk to another. The battery may be considered as being positioned midway between the transmitter and the receiver. Under no signal conditions a steady current flows, the magnitude of which is determined by the total circuit resistance presented to the battery. When a sound wave impinges on the transmitter diaphragm however, the resulting vibrations of the diaphragm vary the pressure on the carbon granules, thus causing the resistance of the transmitter to vary about its mean value. The current changes in the circuit also vary about the mean value in accordance with the changes of resistance of the transmitter. In the absence of a sound being applied to the transmitter, the steady current flowing through the receiver determines the mean pull on its diaphragm. When the current commences to vary about its mean value, the pull on the diaphragm also varies. The sudden changes of position of the receiver diaphragm produce changes of air pressure in the immediate vicinity of the receiver. These changes of pressure are heard and the sound reproduced is the same as the original sound applied to the transmitter. Bothway conversation is possible with the simple circuit shown in Fig. 1(b).

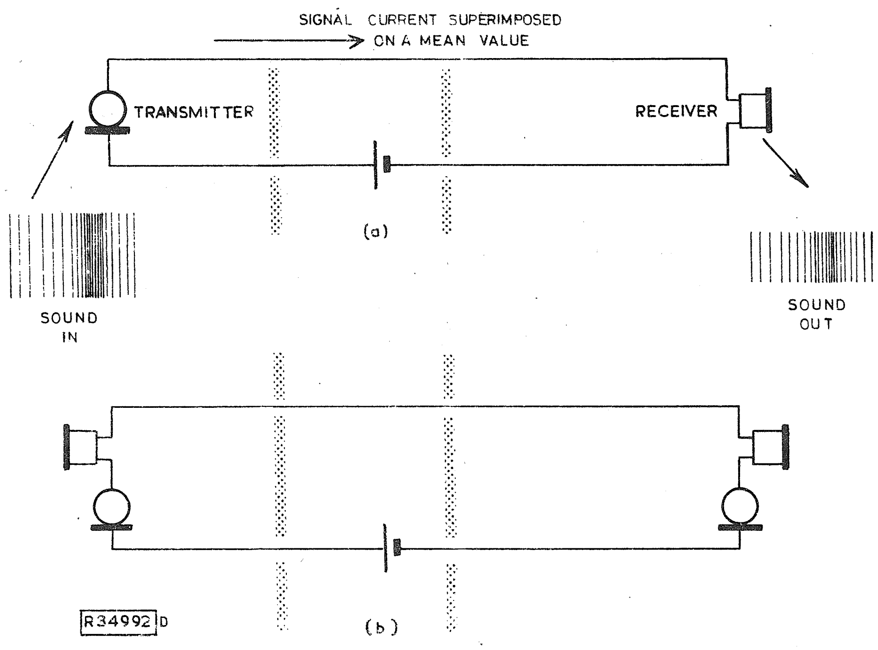

Fig. 1

The circuits shown in Fig. 1 have certain disadvantages. As the distance between the two stations is increased, so also will the resistance of the connecting line be increased. Consequently, to maintain the same transmitter output the e.m.f. of the battery must be increased in order to keep the transmitter energizing current at the same value. Apart from the difficulty of adjusting the battery voltage for each individual line, a limit is soon reached when it becomes uneconomical to provide the required number of cells. There are two solutions to the problem, namely:-

(a) Provision of a local circuit at each station for the transmitter and battery, the resistance of this circuit being independent of the length of the line; this is referred to as a *Local Battery System.*

(b) Provision of a high voltage battery at some central point to serve all the transmitters on an exchange; this is known as a *Central Battery System.*

Local Battery System (LB)

A simple circuit diagram of two local battery telephones connected by a pair of wires is shown in Fig. 2.

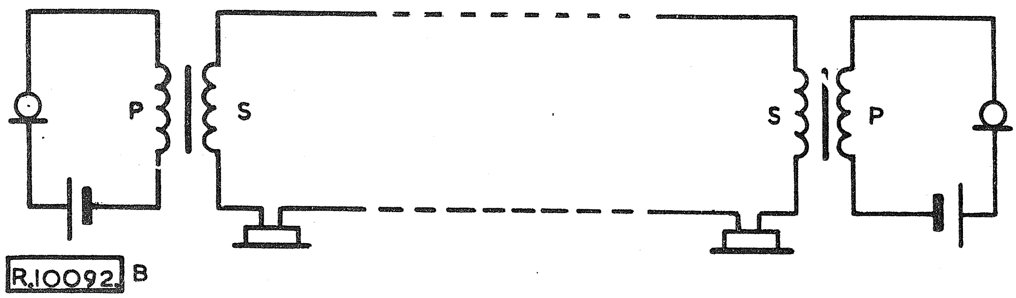

Fig. 2

The transformer, generally termed an induction coil, performs the following functions:-

(a) Provides a local circuit of low resistance for the transmitter, thus enabling adequate feeding current to be obtained from a low voltage battery. In practice it is usual to employ two primary cells connected in series, i.e. 3 volts.

(b) Isolates the receiver from the path of the transmitter feeding current. It is undesirable to have direct current flowing through the receiver because it may produce a magnetic field in opposition to that of the permanent magnet.

(c) Matches the impedance of the transmitter circuit with that of the line to ensure maximum sending efficiency. The theory of impedance matching is not considered in this pamphlet, but the following may be accepted without proof. When a direct or alternating source of e.m.f. is used to supply current to an external load, the power dissipated in the load will be a maximum when the load impedance is equal to the internal impedance of the source. The source and external load are then said to be "matched". If this condition does not arise naturally, the load impedance presented to a source of alternating e.m.f. may be varied by means of a matching transformer, since primary impedance $= \left(\frac{\text{primary turns}}{\text{secondary turns}}\right)^2 \times$ secondary impedance.

The required load impedance may therefore be obtained by a transformer with a suitable turns ratio.

The circuit arrangement of a type of local battery telephone in use is shown in Fig. 3. The induction coil has three windings and acts as an auto transformer when speech is both transmitted and received.

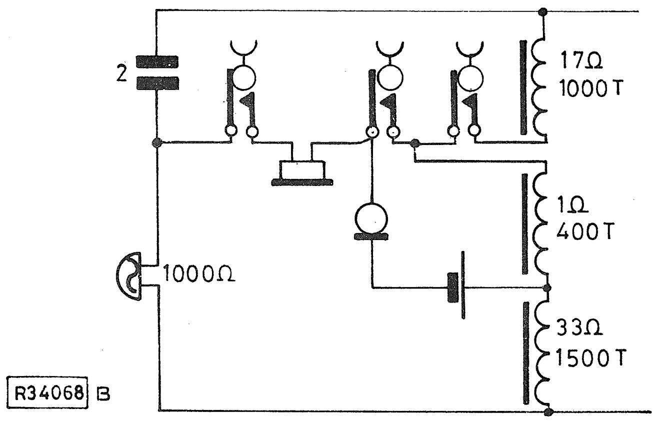

Fig. 3

The spring-sets disconnect the local battery circuit and ensure that only the bell coils in series with the capacitor bridge the line when the telephone is normal. The spring-sets make when the telephone handset is removed from its rest. The capacitor is included in the bell circuit to comply with the 'loop-calling' 'disconnexion-clearing' line signalling conditions. For consideration of the transmission of speech the circuit of Fig. 3 can be rearranged as shown in Fig. 4. When the transmitter is spoken into, the resultant alternating currents that flow in the coil which is directly associated with the transmitter, i.e. the 1 ohm 400 turn winding, induce aiding voltages in each of the three windings. Thus, because of the auto transformer action of the induction coil, the voltage developed across the 400 turn winding is stepped up by the ratio 1000 + 400 + 1500 to 400, i.e. 7.25 to 1, before being applied to the line.

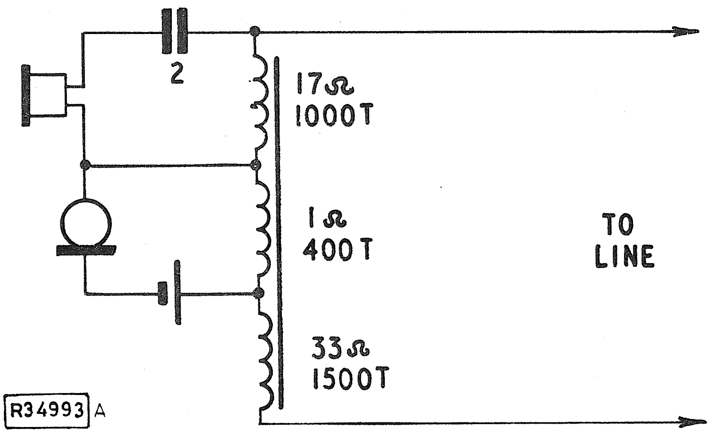

Fig. 4

The impedance ratio is equal to the square of the turns ratio, consequently there is a 52.5 to 1 step up impedance ratio between the transmitter circuit and the line. Such a high ratio is required because the transmitter circuit contains only the impedance of the transmitter.

Received speech currents flow in all the windings but the receiver is actuated by currents caused by the voltage induced in the 1000 turn windings. Thus the voltage developed across the three windings by the received currents is stepped down by the ratio 1000 + 400 + 1500 to 1000, i.e. 2.9 to 1 before being applied to the receiver. The 2.9 to 1 voltage ratio means that there is an 8.4 to 1 impedance step down ratio between the line and receiver circuit.

Central Battery System (CB)

The elementary circuit of the connexion between two central battery telephones is shown in Fig. 5. The coil and battery are situated at the telephone exchange, the coil is particular to the connecting circuit but the battery is shared by all the circuits on the exchange. If the transmitter, A, of circuit 1 is spoken into, the greater portion of the alternating currents so generated will flow through the receiver of circuit 2. Similarly alternating currents generated by the transmitter, B, in circuit 2 will flow through the receiver of circuit 1. If the coil, which has a high impedance to speech frequency alternating currents, is not included in the circuit by far the greater proportion of the alternating currents generated by each of the transmitters would flow through the low resistance path offered by the battery instead of the appropriate receiver. A battery of 50 volts is standard for automatic systems.

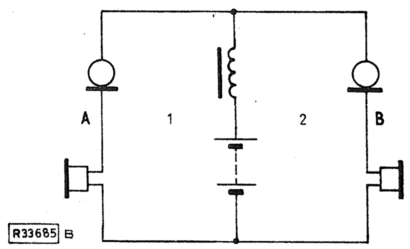

Fig. 5

The circuit of an early type of CB telephone is shown in Fig. 6. The circuit is different from the LB telephone, Fig. 3, because provision has to be made for connecting the transmitter in series with the central battery and isolating the receiver from the direct current.

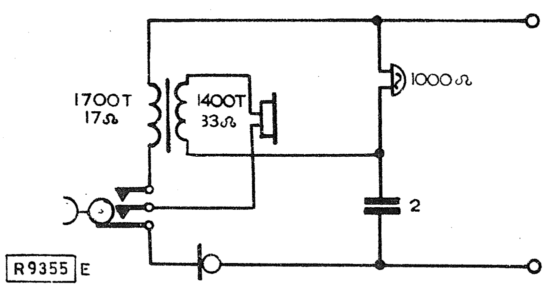

Fig. 6

For the purpose of considering the transmission of speech, the circuits can be drawn as shown in Fig. 7. The capacitor can also be neglected because of its low reactance at speech frequencies, but is included to show how it isolates the receiver from direct current. The presence of the capacitor is, however, still necessary to ensure that there is the maximum possible flow of direct current through the transmitter and consequently the maximum possible alternating current output. In modern telephone circuits it can be considered that the main purpose of the capacitor is to block any path for direct current other than that through the transmitter.

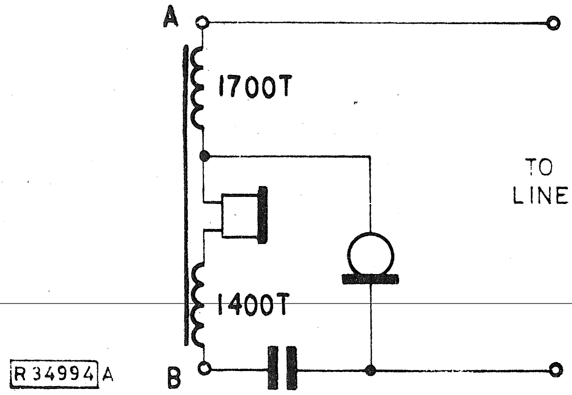

Fig. 7

When the transmitter is spoken into, alternating voltages are developed across it, and consequently alternating currents are caused to flow in the 1700 and 1400 turn windings of the induction coil. The currents in the 1700 turn winding however are small and for the purpose of this simple explanation may be neglected. The windings of the induction coil are connected in series aiding, and consequently the voltage induced between the points A and B by the alternating current in the 1400 turn winding is in the ratio 1.4 to (1.4 + 1.7). Thus the induction coil acts as an autotransformer, and the voltage applied to line is approximately 2.2 times that developed by the transmitter in the 1400 turn winding. It follows that the impedance matching ratio between the transmitter and line circuits is approximately 1 to 4.8.

When speech currents are received the induction coil acts as a simple transformer having a 1.7 to 1.4 step down turns ratio. The low impedance path offered by the transmitter to the received currents effectively short circuits the 1400 turn winding and receiver. Consequently the speech currents which actuate the receiver are caused by the voltage induced in the 1400 turn winding by the received current in the 1700 turn winding. The impedance matching ratio between the line and the receiver circuits is 1.48 to 1.

Principle of the Anti-Sidetone Induction Coil Circuit

Introduction

Sidetone, which may be defined as the reproduction in a telephone receiver of sounds picked up by the associated transmitter, causes the customer to lower his voice; presumably this is because by hearing himself well in his own receiver he has the subconscious impression that the distant customer can hear him well also. Although it is certainly not desirable for a customer to shout into the transmitter, a tendency to speak in a voice lower than normal is to be avoided.

Sidetone has the following bad effects:-

(a) It lowers the transmitting efficiency of the instrument by wasting power in the receiver circuit.

(b) It lowers the apparent transmitting efficiency by causing the speaker to lower his voice.

(c) It lowers the overall receiving efficiency by producing ear fatigue.

On the other hand a small amount of sidetone is desirable in order to avoid the impression of speaking into a 'dead' telephone.

Room noise sidetone may be reduced by stopping extraneous noise and reducing reverberation in the room containing the telephone. The circuit arrangement of the telephones already described in this pamphlet are such that a portion of the output from the transmitter is reproduced in the associated receiver. Thus the production of sidetone is inherent in these circuits.

The method that became standard to suppress the sidetone inherent in the early type of CB telephone circuit is shown in Fig. 8

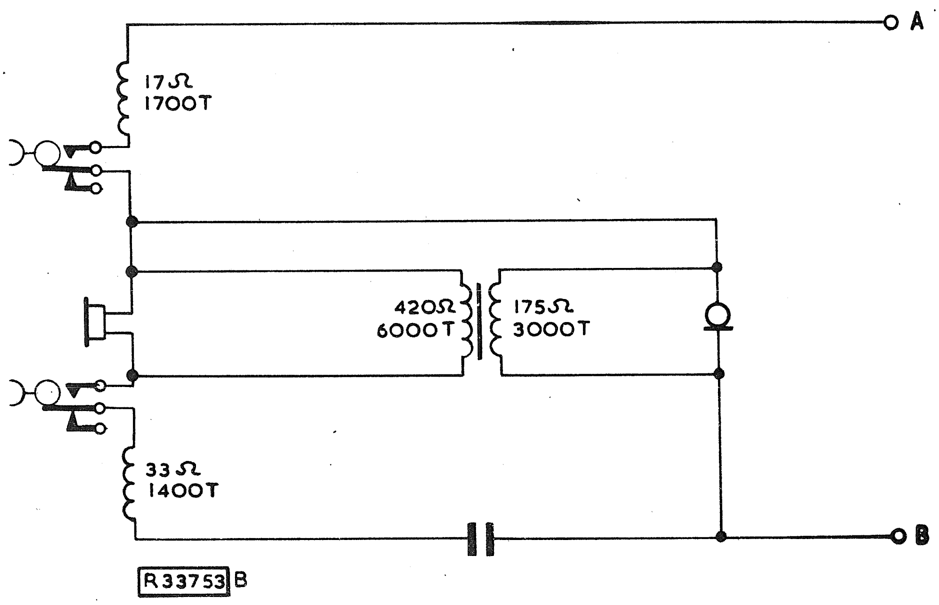

Fig. 8

An additional induction coil is introduced into the circuit and connected so that it introduces speech currents in the receiver which oppose those caused directly by the transmitter. With average line conditions the opposing currents reduce the sidetone to a tolerable level.

In telephone circuits of modern design the separate anti-sidetone coil has been abolished and additional windings added to the original induction coil. The new coil is termed an "anti-sidetone induction coil", and telephones so fitted are consequently referred to as ASTIC telephones. It should be noted that the induction coil itself does not possess anti-sidetone qualities, these properties are established by the circuit which includes such an induction coil.

The modern customer's telephone used by the BPO has a transmission **circuit** based on the following observed fact:-

It is only possible for the transmitter, receiver and line of a telephone circuit to be interconnected so that each is electrically matched to the remainder when an additional power consuming impedance is included in the circuit. The power consuming impedance is termed a 'balance'. This matching ensures maximum transfer between power sent and power received.

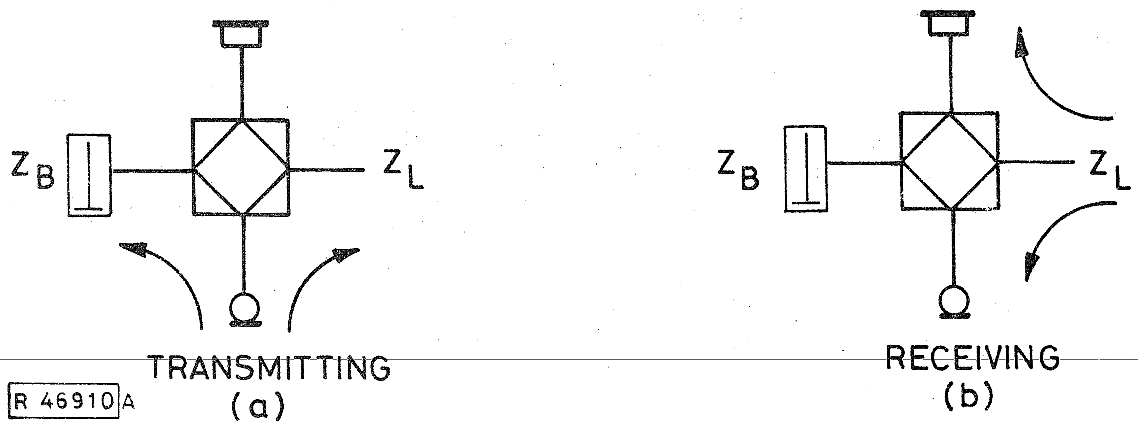

Fig. 9

The anti-sidetone circuit provides for:-

(a) When transmitting, the output power is shared only between the line and the balance, (Fig. 9(a)).

(b) When receiving, the output power from the line is shared only between the receiver and the transmitter, (Fig. 9(b)).

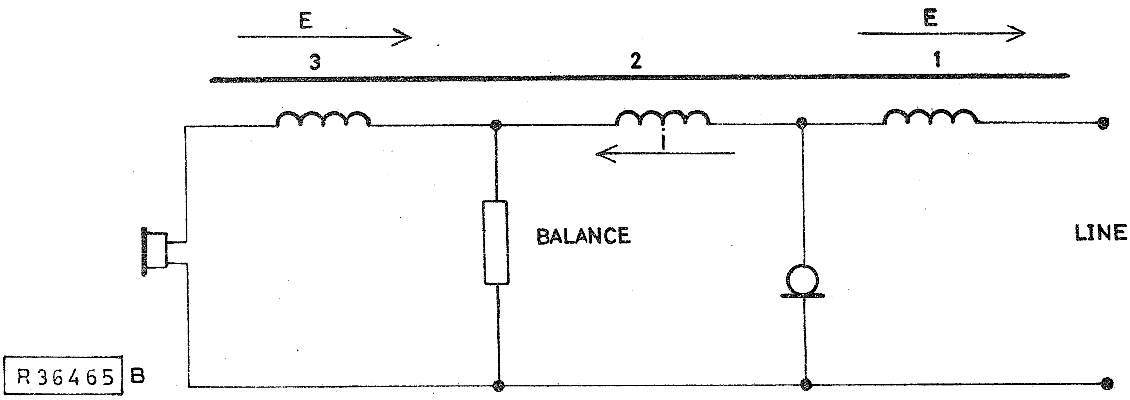

Fig. 10

The basic circuit arrangement of the induction coil is shown in Fig. 10. The coil is wound such that a current flowing in one winding will induce voltages in the other two windings as indicated.

Transmitting

When the customer speaks into the transmitter, alternating voltages are developed across it causing alternating currents to flow as indicated in Fig. 11. The balance impedance, Z_B, is a lower impedance than that of the line, Z_L, and therefore i_B produces a greater ampere-turns product in winding 2 than i_L produces in winding 1. The result of this is to produce induced e.m.f.s in windings 1 and 3 in the direction shown.

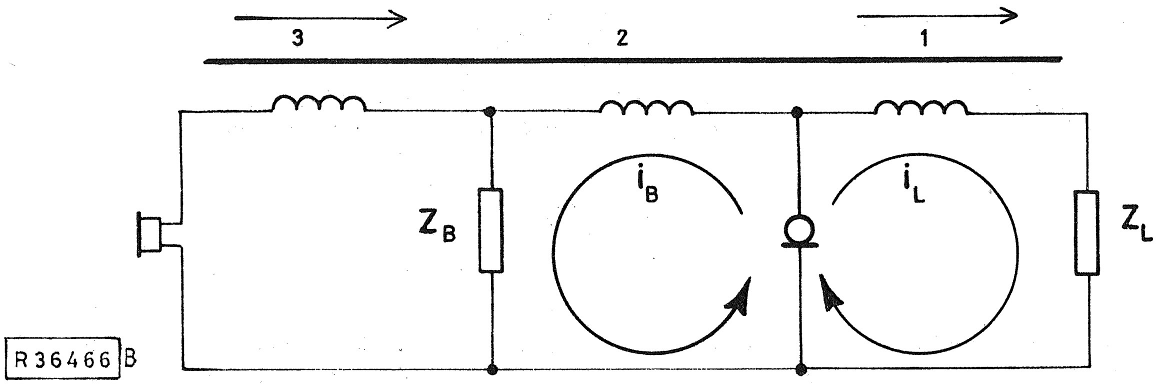

Fig. 11

For the condition of 'no sidetone' there must be no flow of alternating current in the receiver. The condition is obtained by arranging that the turns ratio of winding 3 to the other windings results in an induced voltage across winding 3 which is equal and opposite to that developed across the balance impedance by i_B. The receiver is then subjected to two equal and opposite alternating voltages, hence there is no flow of current in the receiver. See Fig. 12.

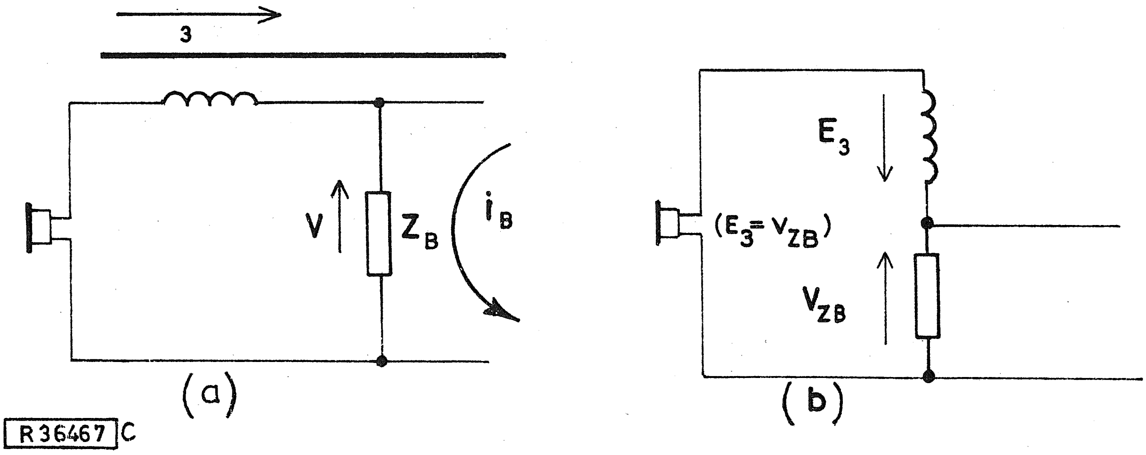

Fig. 12

The voltage now applied to the line is the voltage across winding 1, which aids the speech current flow produced in the transmitter. The output from the transmitter is therefore shared between the balance and the line, see Fig. 13, the division of power will be considered later in this pamphlet.

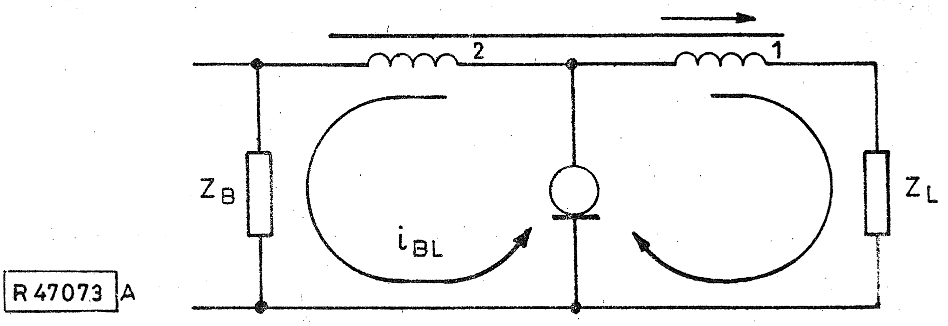

Fig. 13

Receiving

The source of received speech can be considered as an alternating voltage in series with the impedance of the line as shown in Fig. 14. The current, i_L, which is caused to flow through winding 1 and the transmitter by the alternating voltage, induces aiding voltages in windings 2 and 3 as indicated.

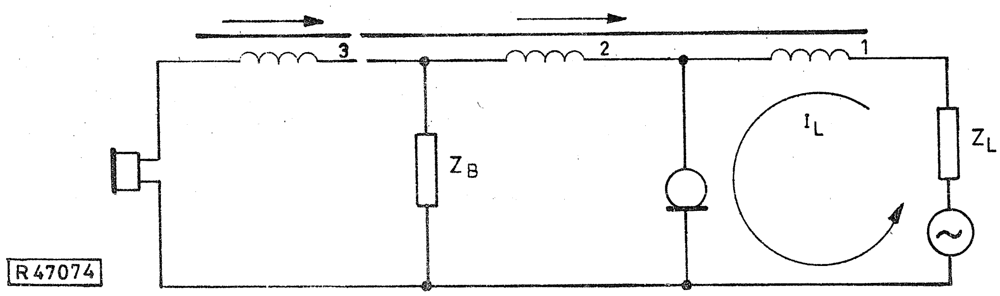

Fig. 14

The induced voltages across windings 2 and 3 result in two currents, i_R and i_T, as shown in Fig. 15(a). It is a feature of the circuit however, that when it is balanced for no sidetone and the receiver is of a suitable impedance, $i_R = i_T$. The current in the balance impedance is, therefore, cancelled out leaving a flow of current through the receiver and transmitter, Fig. 15(b).

The power received from line is therefore shared only between the receiver and transmitter.

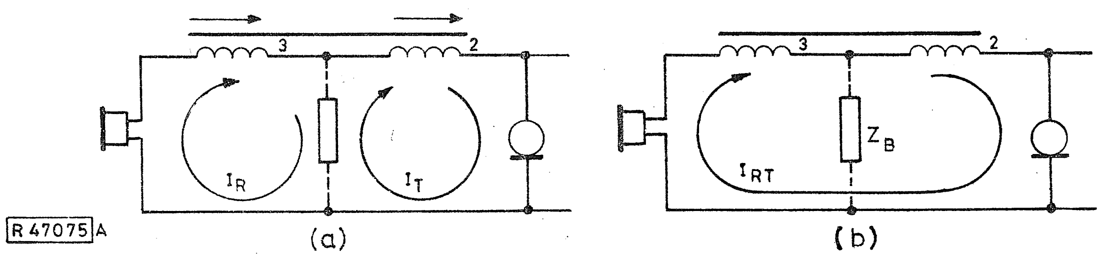

Fig. 15

Design Considerations

In practice a telephone has to work in an existing network of lines, the impedances of which range over widely spaced limits. Consequently as the condition of no sidetone or a fixed value of sidetone requires a fixed relationship between the impedances of the line and the balance, it is not practicable to design the circuit to have a predetermined sidetone condition on all lines. Thus one problem in the design of the circuit is to keep the sidetone within tolerable limits over the usual range of speech frequencies for the line conditions met in practice.

For the tlephone circuit to have a high transmission efficiency it must be designed so that the transmitter circuit impedance is matched to its load impedance, and the ratio of the power expended in the line to that expended in the balance is high. The ratio is known as the Y ratio. It is a basic property of the ASTIC telephone circuit, however, that if the no-sidetone and receive conditions exist, then

$$Y = \frac{\text{Trans. power to line}}{\text{Trans. power to balance}} = \frac{\text{Received power to transmitter}}{\text{Received power to receiver}}$$

The optimum Y ratio is 1, and if it is increased beyond this figure the receiving efficiency is decreased. Consequently unless the physical design of the receiver is an improvement on that used in existing telephones, any improvement in the transmitting efficiency caused by the circuit arrangements results in a descreased receiving efficiency.

If it is assumed that there is no saving in the manufacturing costs of a new telephone, economic advantage is gained only if the existing maximum permissible length of a line can be increased. Such a condition can exist only when both the transmit and receive features of the telephone are improved. Consider a new type of telephone which has a transmitting and receiving performance x and y units respectively better than the existing standard instrument.

The transmission improvements over an existing connexion are,

new telephone transmitting to existing	=	$+x$ units
new telephone receiving from existing	=	$+y$ units
new telephone transmitting to new	=	$xx + y$ units
new telephone receiving from new	=	$x + y$ units.

Assuming that the lower limit of transmission performance allowable on a connexion between existing telephones is 0 units, then the length of the connexion when using new instruments at each station can be increased to introduce an additional loss of $x + y$ units. However, when the new telephone is to work with an existing instrument, the loss introduced by an increase in the length of the line must not be greater than the lesser of x and y. Thus there is no economic advantage if only the transmitting or receiving circuit is improved, but maximum advantage is gained when both circuits are improved by the same amount.

The Telephone No. 746

General

In 1955 the BPO decided to proceed with the design of a new telephone, the 700 type, using the rocking armature receiver but retaining the existing standard type of carbon granule transmitter, and obtaining a balanced increase in transmission by re-design of the circuit. Because of the superior transmission performance on long lines, it meant that calls over short distances tended to be uncomfortably loud. To overcome this problem, a device known as the regulator was fitted to limit line current on short lines yet allow full power on longer lines. A more detailed explanation of this is given later.

The original 700 type telephone was contained within a 300 type telephone case but had a handset of new design. Subsequently an instrument of a new physical design and shaped to satisfy modern tastes was introduced, and designated the Telephone No. 706. A further development of the 700 type telephone has resulted in the Telephone No. 746, a photograph of which is shown in Fig. 16.

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Fig. 16

The telephone has a new design of cover which incorporates a carrying handle. The dial is mounted on the chassis of the telephone and has numbers only printed on a silver background. Figs. 17 and 18 show the telephone No. 746 with the cover removed and from these it is possible to see the printed circuit board which has miniaturised components, including the regulator, mounted on it. A micro-switch, to the left of C1 (Fig. 18), is used instead of the gravity springsets employed in earlier 700 type telephones and is operated by a lever when the handset is on the rest.

To obtain an improved transmission performance, the induction coil has a closed magnetic circuit, and the balance circuit resistors are not wound on the core as in earlier types of coil. The use of separate resistors in the balance circuit is convenient because it gives flexibility to the design of the circuit pattern. As will be explained later, the values of the capacitors are a compromise to meet transmission and signalling requirements.

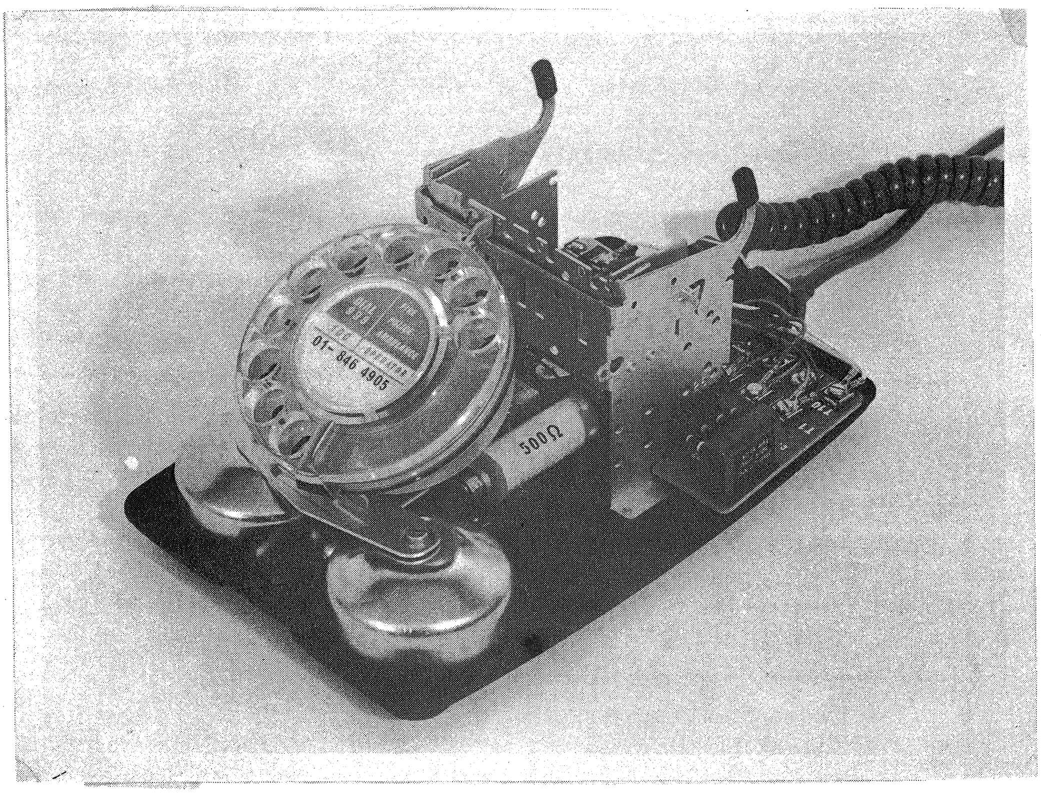

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Fig. 17

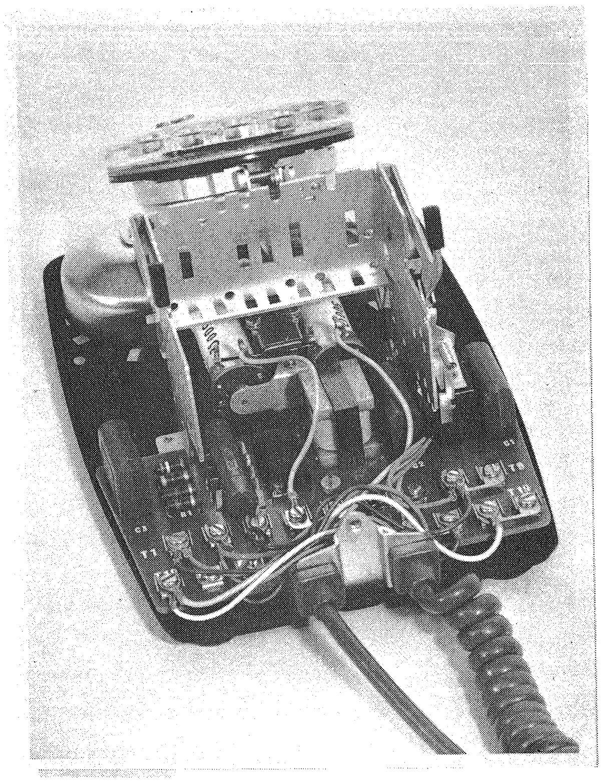

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Fig. 18

A simplified circuit of a telephone 746, without the regulator shown, is given in Fig. 19.

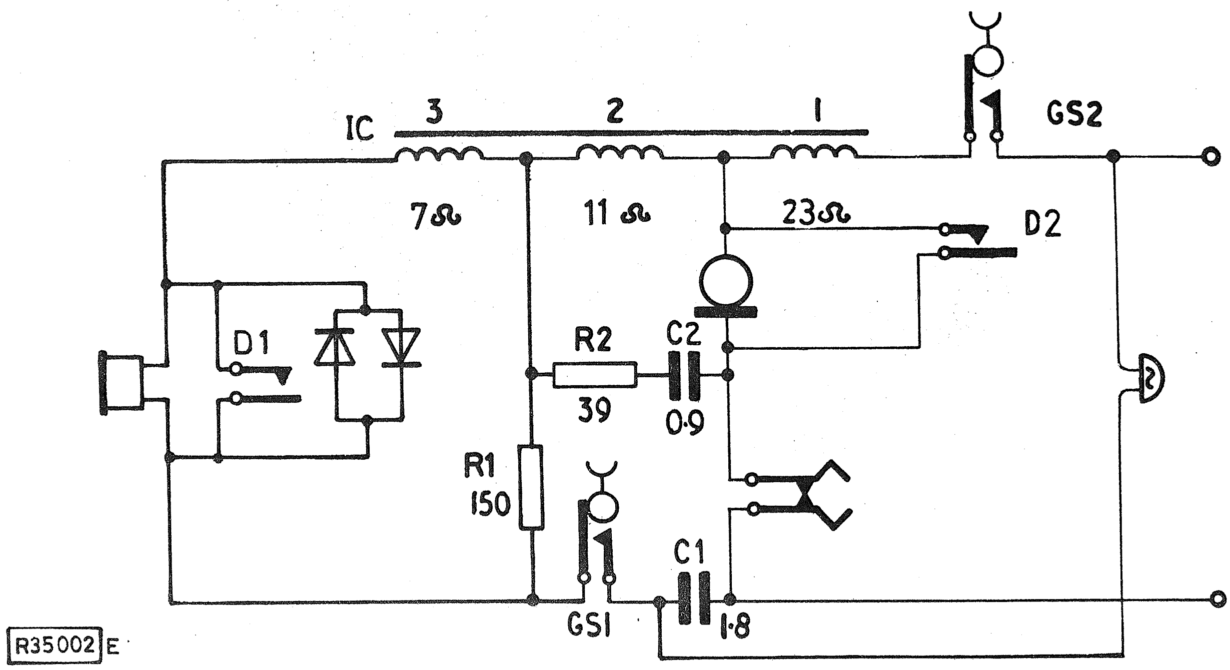


Fig. 19

Signalling Circuit

The ringing signal circuit is formed by the 1000 ohm magneto bell connected in series with the 1.8 μF capacitor directly between the A and B wires. It should be noted that in order to use the 1.8 μF capacitor in both the ringing signal and transmission circuits direct current flows through the receiver when the telephone is in use. The direct current path includes the 1000 ohm resistance of the bell, consequently the value of the current is very small and its effect on the receiver sensitivity can be ignored. The current does, however, 'wet' the micro-switch contacts GS1, which otherwise would carry only speech currents and possibly give rise to faults.

The loop calling signal is completed by the micro-switch contacts and is formed by the contact GS2, winding 1, the transmitter and dial pulse springs. When the handset is lifted contact GS1 operates first to complete a discharge path for the 1.8 μF capacitor.

The disconnexion clearing signal is created by contact GS2 when the handset is replaced.

Dialling Circuitt

The dial off normal contact D2 (Fig. 19), short circuits the transmitter and off normal contact D1 short circuits the receiver. The two diodes suppress any surge voltage which could cause acoustic shock.

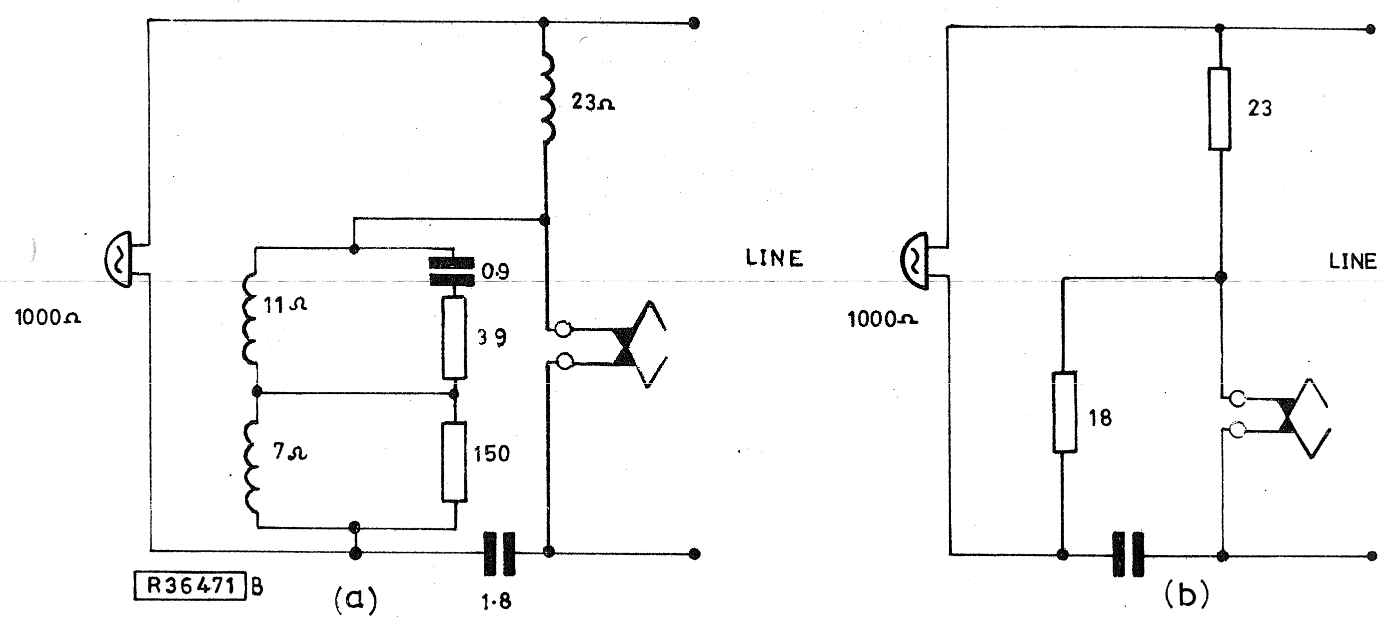


Fig. 20

It can be seen from Fig. 20 that the dialling loop in this telephone contains resistance. This resistance is that of the line winding of the induction coil, which has been included in the dialling loop to improve the spark quench circuit. Its resistance value of 23 ohms is low compared to the line resistance, and therefore, makes minimal difference to the line current. Bell tinkle during dialling is prevented by the shunting effect of the equivalent 18 ohm resistance across the pulsing springs.

Transmission Circuitt

The transmission circuit is shown in Fig. 21. It has already been shown that to gain an economic advantage from a new telephone both the receiving and transmitting characteristics must be improved, and that maximum advantage is gained when both characteristics are equally improved. Only the receiver of the 700 type telephone has been improved, consequently if the circuit had been designed to have a Y ratio of 1, only the receive characteristic would be improved and no economic advantage gained. If, however, the Y ratio is increased the transmitting characteristic is improved but the gain due to the improved receiver is reduced; this feature of the ASTIC circuit has already been discussed in this pamphlet. In the transmission circuit of this telephone the Y ratio has been increased to 3.3, thereby reducing approximately by a half the maximum gain in receive performance possible with the new receiver, but increasing the transmitting characteristic. The overall result is that the increase in Y ratio, in conjunction wi. . other circuit improvements, causes an equal improvement in both the receiving and transmitting characteristics thereby giving the maximum economic advantage.

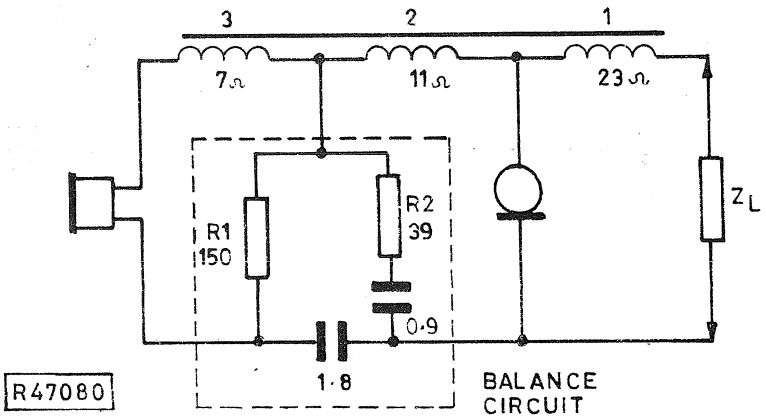


Fig. 21

The improved efficiency of the transmitting and receiving features increases the level of the sidetone, and it is likely that this will cause a customer to lower his voice and consequently offset the transmission improvements. The circuit is therefore designed to have a high degree of sidetone suppression over a wide range of line conditions. The complexity of the balance network necessary to give the required suppression is largely governed by the quality of of the induction coil. In the 700 type telephone the quality of the coil is improved by the use of a closed magnetic path formed from laminations of high grade silicon-iron, and this allows the use of the relatively simple resistance-capacitance balance shown in Fig. 21. It should be noted that the d.c. blocking capacitor is included in the balance.

Regulator Circuitt

The increased sensitivity of the 700 type telephone allows it to be used on longer lines than earlier types. It is however so sensitive on short lines that without modification the loud reception would cause discomfort to the customer. There is also the danger of acoustic shock caused by line surges during switching operations and a possible nuisance due tooĉrosstalk (overhearing between circuits) when a large number of these telephones are in service.

As well as these points other involved engineering reasons make it necessary to consider either:-

(i) Providing the telephones connected to short lines with a unit designed to reduce the sensitivity by a predetermined amount,

(ii) Providing all telephones with a regulator which reduces the sensitivity by an amount governed by the value of the line current, i.e. an automatic regulator.

The method given inn(i) is not practicable because of the additional work involved in the provision of each telephone. In practice each telephone is fitted with an automatic regulator operating as outlined in (ii).

Basically the regulator is a network of resistors and selenium rectifiers which effectively introduces a low d.c. resistance in series with the transmitter, an a.c. shunt path across the transmitter, and an a.c. shunt path across winding 2.

An appreciation of the operation of the regulator may be obtained by first considering the circuit element shown in Fig. 22. The potential developed across RU1 by the transmitter feed current will have a polarity as indicated, and its magnitude will increase as the resistance of the line R_L decreases. If it is assumed that all lines have the same gauge conductor, the value of the positive bias potential on the rectifier increases as the length of the line decreases. Therefore as the length of the line decreases the forward resistance of the rectifier decreases and the impedance of the circuit MR1 and C in shunt with the transmitter also decreases. The effect of the shunt is to divert a portion of the transmitter output from winding 2 and therefore to decrease the output to line. The rectifier has a non-linear voltage/resistance characteristic and there is partial rectification of that part of the transmitter output which flows via the shunt, so giving rise to appreciable distortion.

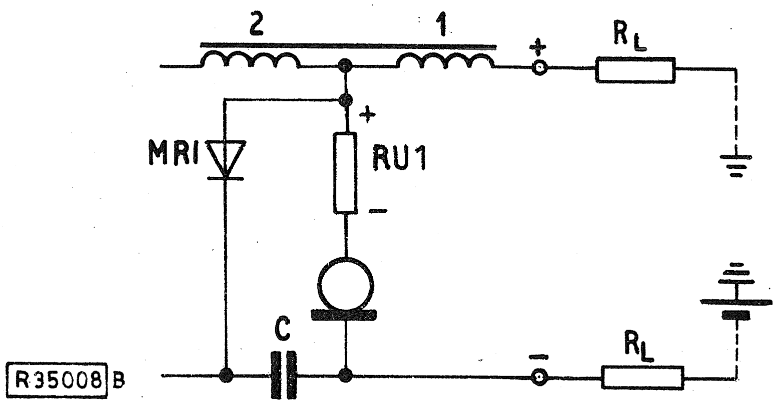


Fig. 22

The inclusion of a second rectifier, MR2, similarly biassed and connected as shown in Fig. 23, obviates the noticeable distortion by causing both the positive and negative half cycles of the alternating component in the shunt to be equally distorted.

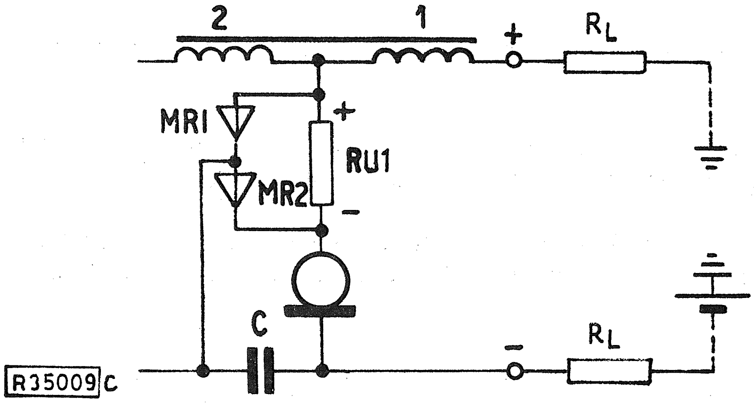


Fig. 23

The basic circuit developed in the foregoing has several disadvantages, the more important being:-

(i) The value of RU1 is independent of line current and must be of such a value that it does not seriously reduce the transmission efficiency when the value of R_L is high.

(ii) There is a linear relation between line current and the voltage drop across RU1, thus the bias potential will vary by the same ratio as the line current. In practice, however, a higher ratio of voltage change than current change is required to produce the necessary decrease in transmitting efficiency on short lines.

(iii) If direct current paths exist within the telephone circuit such that unequal currents flow in MR1 and MR2, distortion will be caused by the resultant unequal characteristics of the rectifiers.

(iv) The regulator is made ineffective if there is a reversal of bias potential as would occur if there was a change of line polarity.

Taken in order, the disadvantages are overcome in practice as follows:-

(i) The resistance RU1 is in the form of a tungsten filament lamp which has a resistance/current characteristic such that its resistance increases as the current through it increases. Thus on long lines the resistance of RU1 is low and has negligible effect on the transmission.

(ii) The characteristic of the lamp is such that when the line current is 76 mA the lamp resistance is 36 ohm, when the current falls to 30 mA however, the resistance is only 10 ohm. Therefore a bias voltage change of approximately 9 to 1 is obtained with a current change of about 2.5 to 1.

(iii) The resistance RU1 is in two equal sections and the rectifiers are connected so that a Wheatstone bridge is formed as shown in Fig. 24. If it is assumed that when equal currents flow in each arm the bridge is balanced, there will be no flow of direct current in the shunt path. The shunt path consists of the receiver circuit of the telephone and certain additional components.

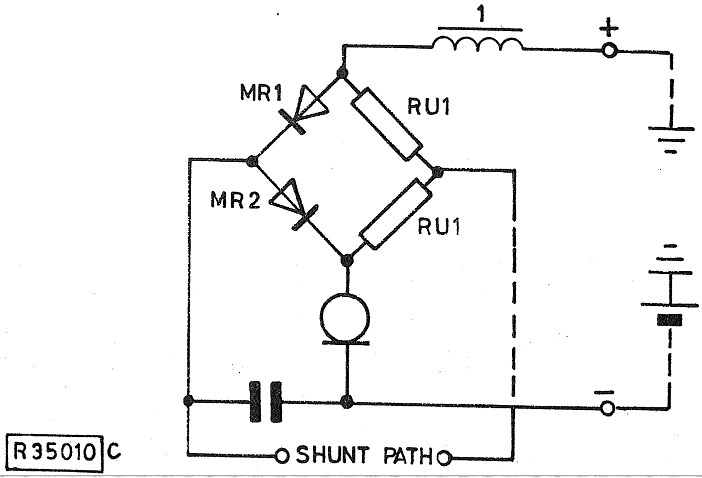


Fig. 24

(iv) An additional pair of rectifiers are connected in parallel with MR1 and MR2 as shown in Fig. 25 which also shows RU1 as a resistance lamp. With the line polarity shown in the figure, MR1 and MR2 are effective and MR3 and MR4 are subject to a negative bias such that they may be considered as a disconnexion. A reversal of line polarity causes a reversal of bias conditions on the rectifiers and MR3 and MR4 are then effective and MR1 and 2 are biassed negatively.

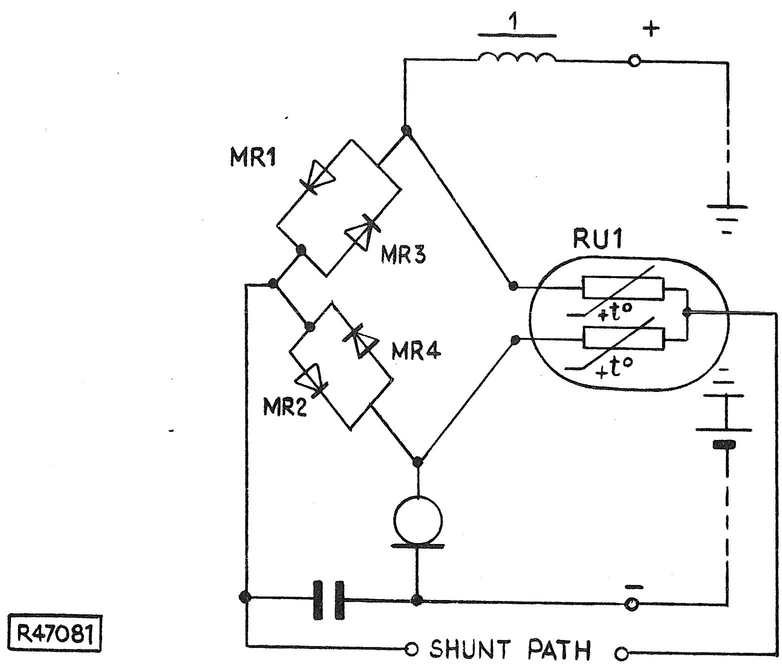


Fig. 25

The full circuit of the regulator is shown in Fig. 26.

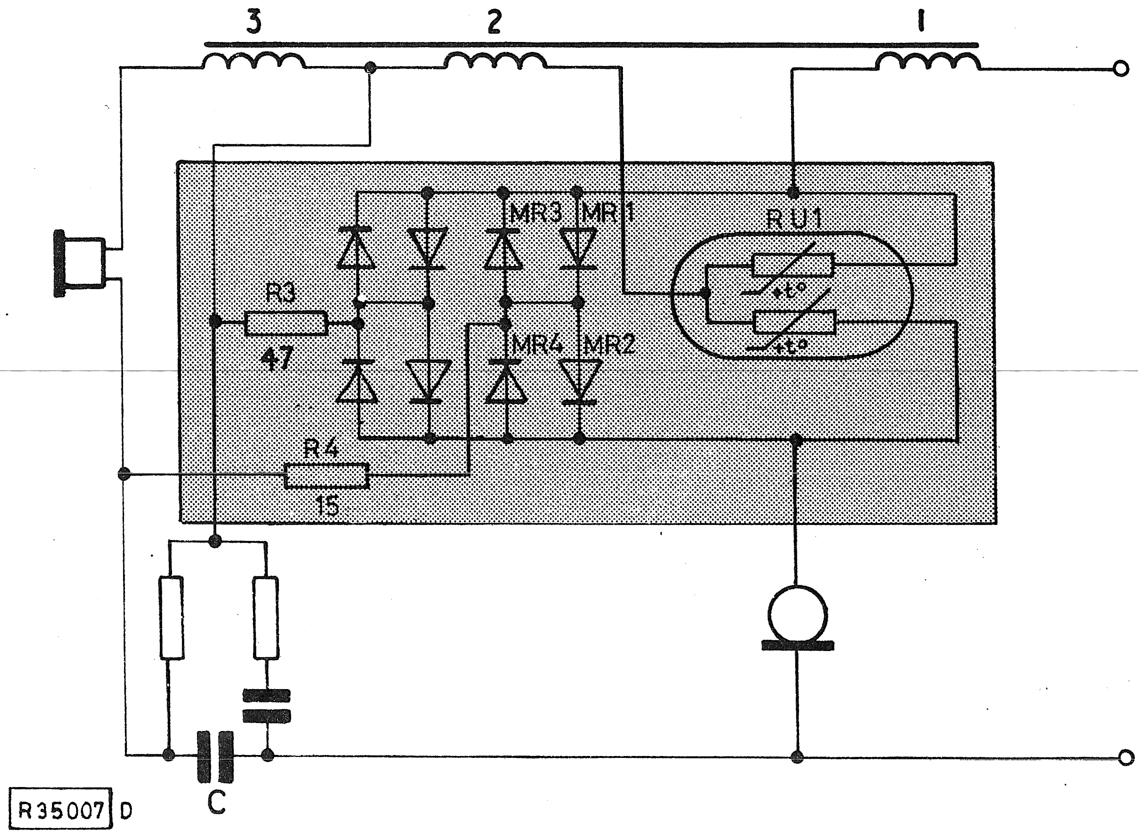


Fig. 26

The four additional rectifiers are in fact shunting winding 2 of the induction coil to give a loss on the receive side of the circuit. Resistors R3 and R4 bias the rectifiers and also provide series resistance. The rectifiers and RU1 can be seen in Fig. 18, behind the left hand bell coil.

Shared Service Telephones

General

Shared service working is a method of providing telephone service to two customers, each having a separate telephone number, by utilizing a common pair of wires over which signalling and speech currents are transmitted. One customer of a pair is known as the X customer and the other as the Y customer. Originally, shared service customers on automatic exchanges shared a common line, exchange equipment and meter, but later an additional facility of separate metering, i.e. the calls proper to each customer are recorded on individual meters, was introduced. There is no secrecy between two sharing customers.

Automatic Exchange Areas

The method of originating a call differs from normal practice and a simplified diagram of the arrangement is shown in Fig. 27. In practice the circuit is so arranged that the X and Y customers cannot originate a call unless the exchange equipment is normal, but for simplicity this is not shown in the diagram. Consider the X customer; the depression of the button and lifting of the handset causes an earth to be extended via the telephone loop to the B wire, which causes relay L in the X customer's line equipment to operate. Similarly, when the Y customer originates a call, earth is extended over the A wire to operate relay L in the Y customer's line equipment. In both cases, on receipt of dial tone the customer releases the button, and dials in the normal manner.

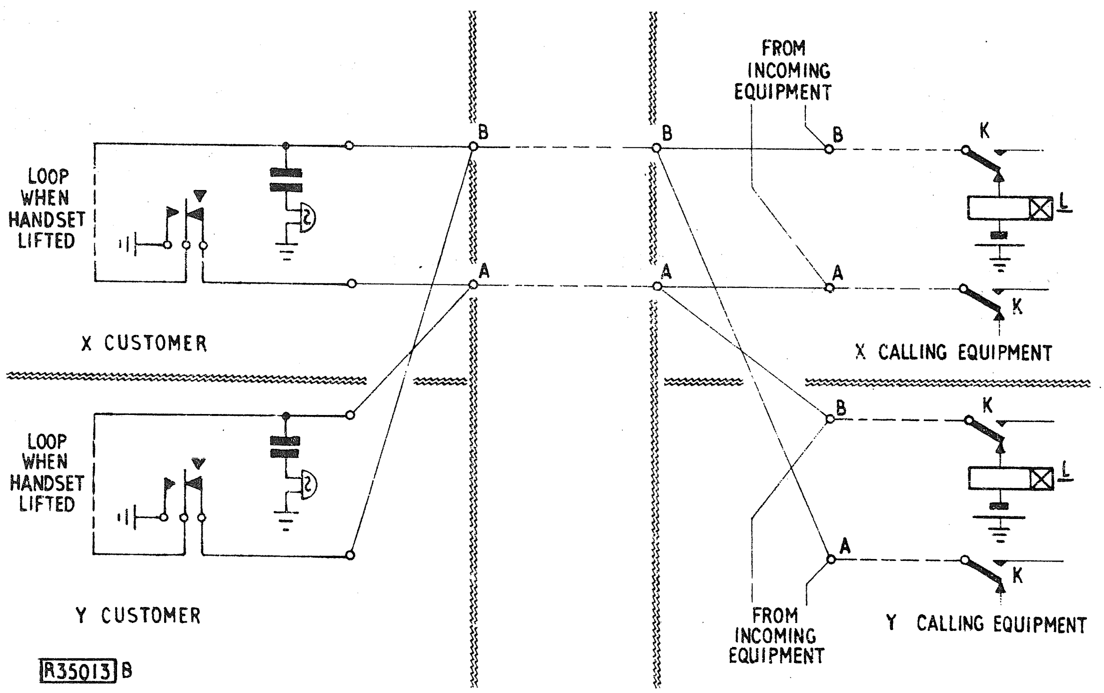


Fig. 27

To signal an incoming call, ringing current is fed over the appropriate wire to earth return via the bell and the capacitor. When the customer lifts his handset, the A and B wires are looped to complete an operate circuit for relay F in the exchange final selector and so trips the ringing in the normal way. The exchange equipment is designed to extend ringing current to the B wire of a customer's line, consequently to obtain party line signalling conditions the Y customer's connexion is reversed in the exchange as indicated in the elementary circuit connexion diagram, Fig. 28.

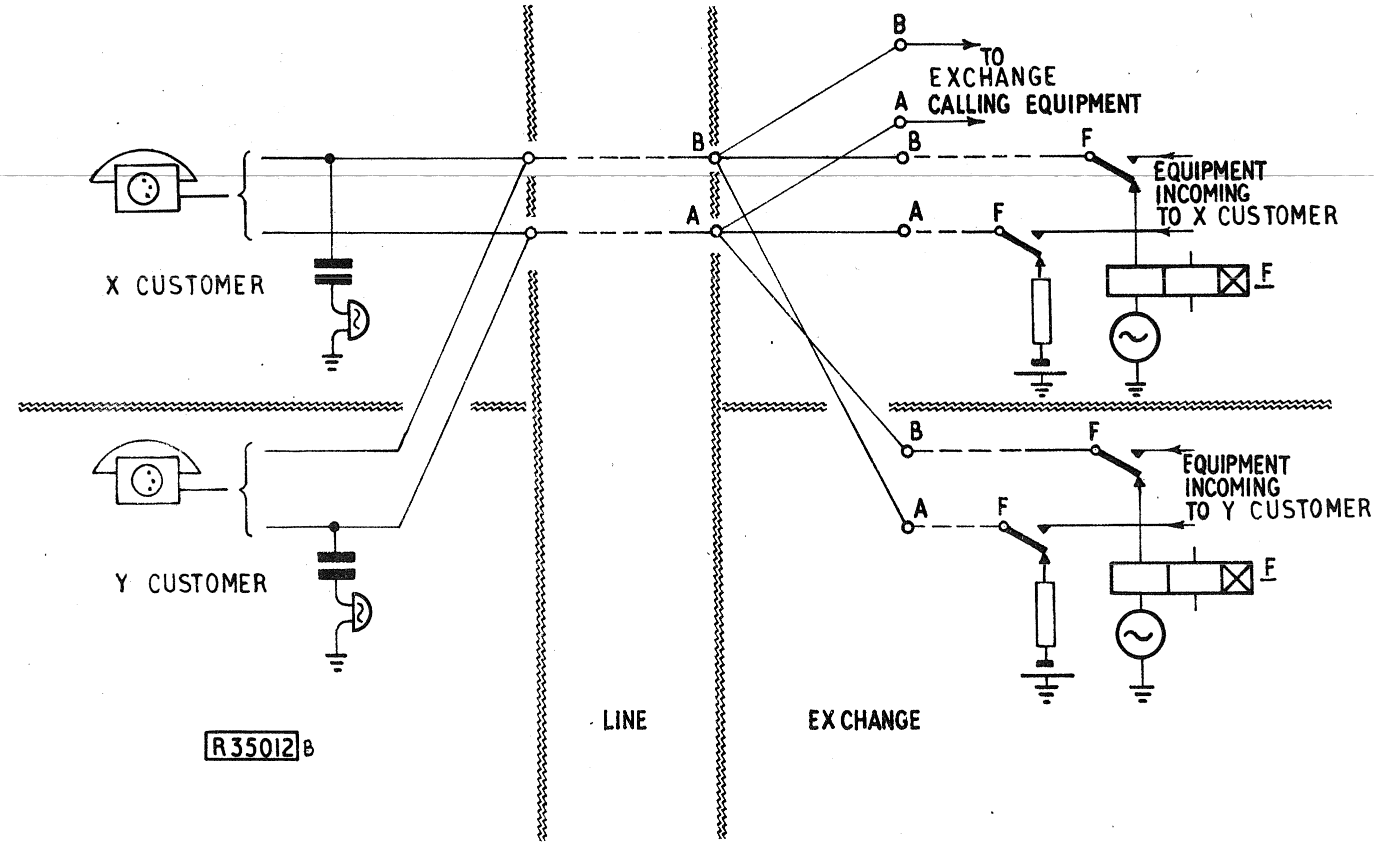


Fig. 28

Practical Circuits

The transmission circuit of a telephone suitable for shared service working is the same as that for a normal telephone, special consideration must be given to the bell circuit, however, when the telephone is used in automatic areas.

Consider the circuit element shown in Fig. 29, which shows the conditions which exist when the X customer is dialling. The two bell circuits effectively form a series circuit between the A and B wires, and are, therefore, subject to the voltage surges caused by the loop disconnect pulses during dialling. Such a condition causes the bell to tinkle at both installations when either customer is dialling, and consequently is not acceptable.

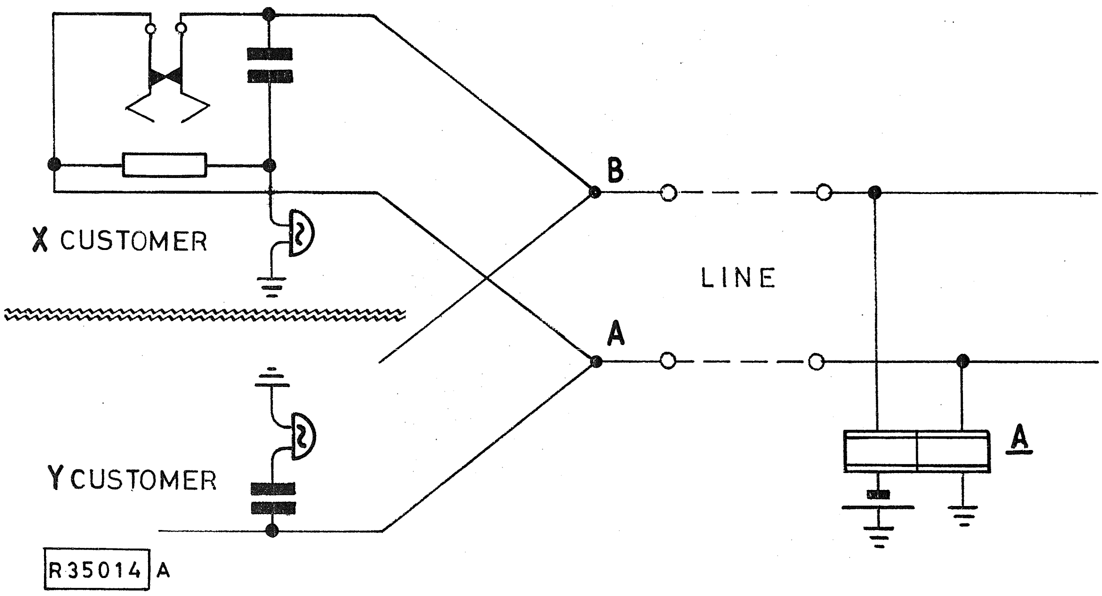


Fig. 29

The present standard method of preventing bell tinkle is to connect a thermistor in series with the bell coils. A thermistor is a special type of resistor with a high negative temperature coefficient; in this instance it has a nominal resistance of 200 000 ohms when no current is flowing through it, and the resistance drops to less than 500 ohms when it is passing a steady current of 14 mA. The duration of the surge voltages caused by dialling or other signalling conditions are too short to lower the thermistor resistance appreciably, so that insufficient current will pass to operate the bell. When the ringing signal conditions are applied, however, the resistance falls sufficiently to allow the bell to operate, and the time lag of the fall in resistance is insufficient to appreciably upset the duration of the ringing periods.

The 700 type telephone can be "adapted" for shared service working by the addition of a switch and thermistor, as shown in Fig. 30.

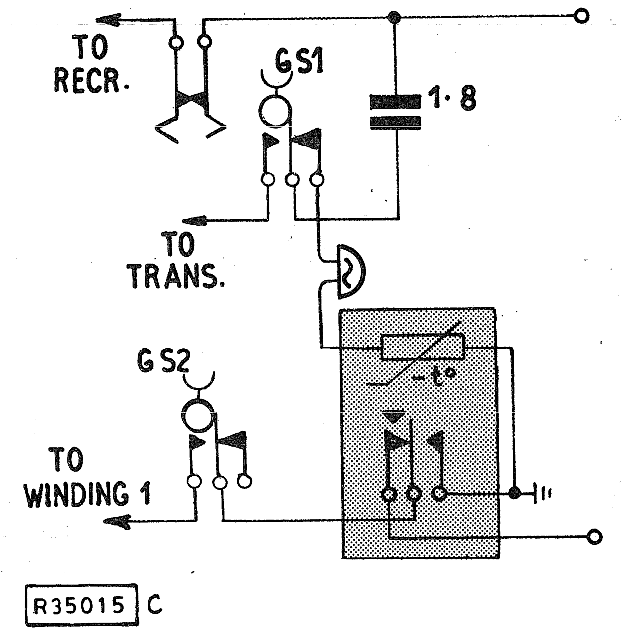


Fig. 30

Other Types of Modern Telephone

Telephone No. 740

This telephone has identical circuitry to the Telephone No. 746, with facilities to provide up to four push buttons on the top of the case for use on plan numbers. This telephone is shown in Fig. 31.

R 47082

Fig. 31

Telephone No. 741

This is a wall mounted version of the Telephone No. 746 and as such has identical circuitry. It can be provided with up to four push buttons. Fig. 32 shows the telephone without the push buttons fitted.

R47083

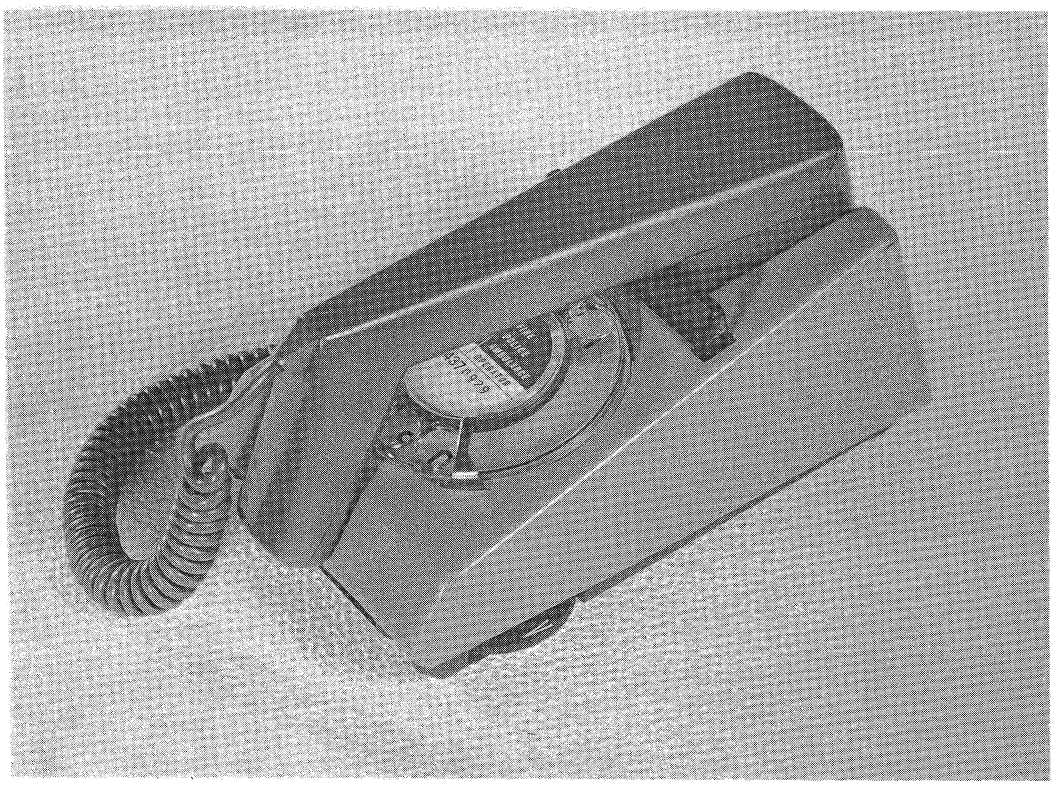
Fig. 32

Telephone No. 722

This is commonly referred to as the "Trimphone", derived from Tone Ringing Illuminated Model, and is shown in Fig. 33.

The dial is illuminated by a fluorescent tube mounted beneath a transparant finger plate. This tube is filled with a small quantity of tritium, a radioactive gas, which energizes the fluorescent coating of the tube to produce the necessary level of illumination. As the tube is self energized by the tritium, no separate power supply is required.

Instead of a bell there is a transistorised tone ringer which has a volume control to adjust the level of sound to suit the surroundings. The tone ringer consists of a single stage oscillator and a separate delay stage, both of which derive power from the 25 Hz ringing current which is rectified before being applied to the transistors. The delay stage consists of a transistor switch and is provided to ensure that the circuit will only operate to genuine ringing and not to spurious line pulses. The oscillator output produces a distinctive "warble" in a modified rocking armature receiver mounted in the base of the telephone. The volume control has a soft and loud position with a build up position in between. If set to the build up position, the applied ringing current gradually biasses the transistor, via a capacitor or thermistor circuit, so that the oscillator output increases to a maximum over a given period of time.

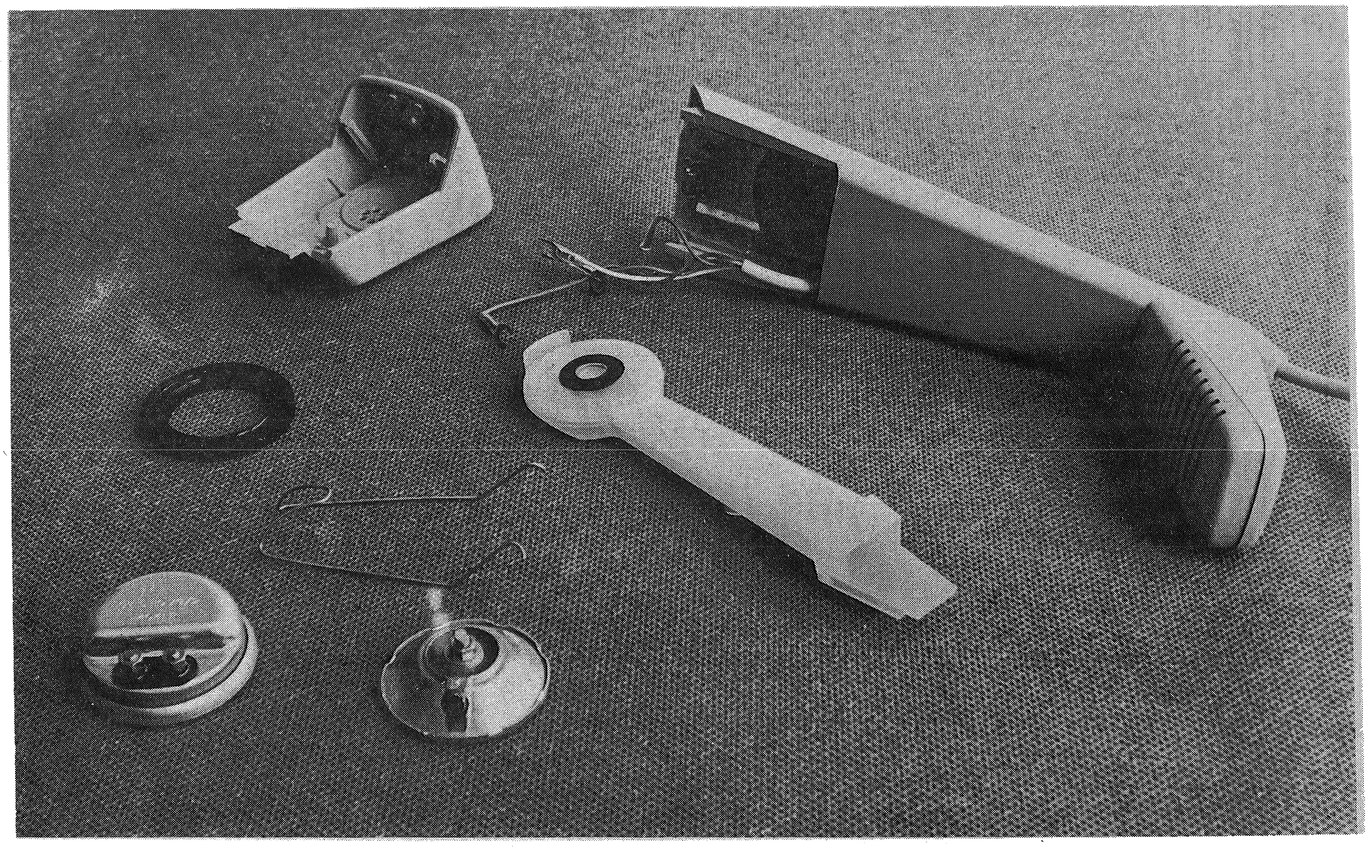


R47084

Fig. 33

The receiver and transmitter are both contained at the receiver end of the handset, see Fig. 34. An acoustic horn transfers the sound from the mouthpiece to the transmitter. The acoustic horn fits inside the handset with the transmitter placed face down over the circular base so that the transmitter will be activated by the sound entering the mouthpiece. A spring clip is used to retain the transmitter in position. A gasket is fitted between the receiver and the plastic case to give an improved acoustic seal. The internal wiring runs alongside the acoustic horn and leaves the handset at the base of the stem.

The transmitter has been found in practice to have a reduced life if excessive line current is allowed to flow through it. Recent production models have included a special regulator across the transmitter which shunts current on a short line but has little effect on long lines. This reduces the maximum current in the actual transmitter to a level which ensures an increased life. Apart from this modification, the transmission circuit is identical to that of a Telephone No. 746



R47085

Fig. 34

Telephone No. 745

This telephone is for installations where the circuitry is likely to be exposed to abnormal weather conditions. The transmission circuit is identical to that used on the Telephone No. 746, but a different layout is used for the printed circuit board to enable it to fit in the case. Certain components, such as the induction coil and bell coils have additional protection against moisture as well as the complete printed circuit board having a second coating of protective varnish. The telephone is enclosed in a protective cabinet, with a door, a picture of this appears in Fig. 35.

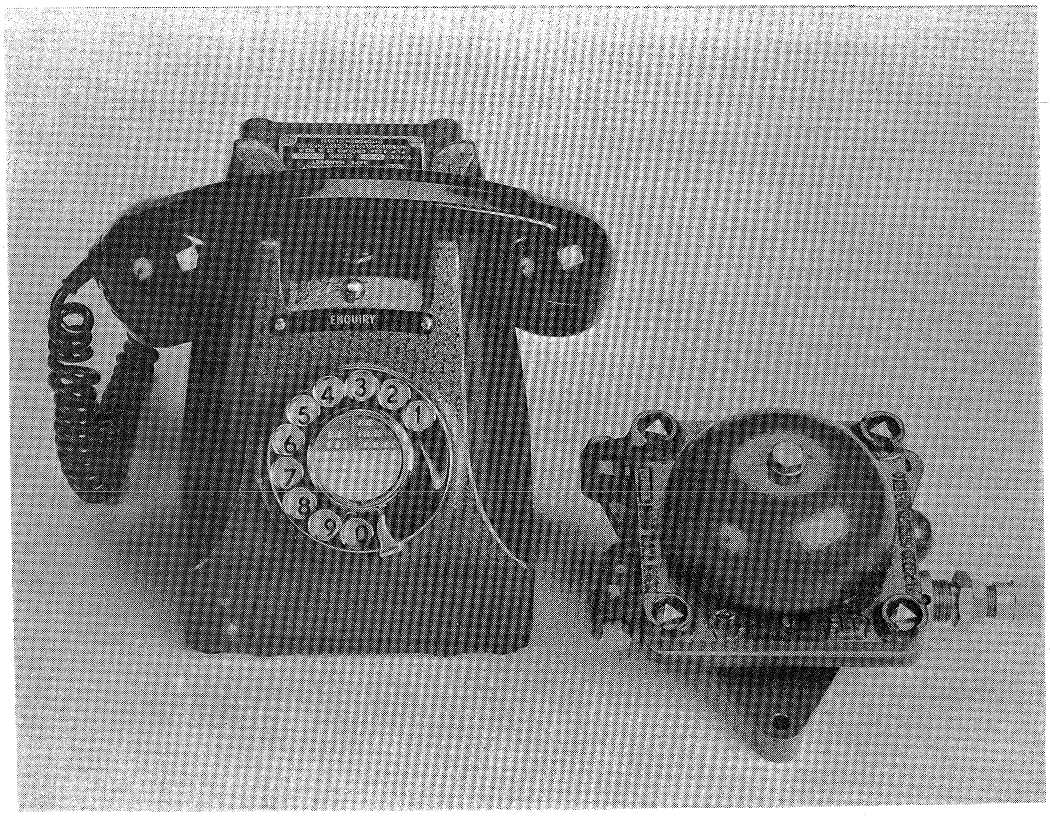
R47086

Fig. 35

Telephone No. 702

In a situation where there is an explosive gas mixture it is essential to guard against the risk of sparks from the telephone circuit, such as the dial springs and bell set, causing an explosion. The Telephone No. 702 (Fig. 36), has circuitry identical to the Telephone No. 746 except for the handset and wall mounted bell.

The handset and cord are made intrinsically safe by fitting transformers within the telephone case to isolate the transmitter and receiver from the rest of the circuit. Both the transmitter and receiver are in the form of rocking armature receivers to minimise the current flow in the handset. In order to restore the transmitter output to an acceptable level a two stage transistor amplifier is used to boost the signal. The bell is enclosed in a heavy metal case as is the telephone instrument. The metal is designed to withstand the force of any explosion occuring within the case and to prevent the ignition of the surrounding area.



R47087

Fig. 36

Keyphones

General

There are three main types of keyphone, one for use on Strowger exchanges, the other two for use on PABXs equipped with crossbar or electronic equipment. There is no immediate plan to introduce the very fast signalling speeds possible from the PABX type of keyphone into the normal public network, due to the large amount of Strowger equipment still in use. It should be mentioned that Strowger equipment can only operate at a slow speed, i.e. 10 pulses per second, whereas crossbar and electronic equipment can work at speeds many times faster. For this reason there is no gain to the customer, as far as switching time is concerned, by installing a telephone capable of fast signalling.

Self-Contained Strowger Pulsing Keyphone

This keyphone is based on the standard Telephone No. 746, with the dial replaced by a keypad and associated circuitry. Fig. 37 shows the keyphone and it can be seen how the keypad is arranged on the front of the case, with a blank space below to accommodate the telephone number.

R47088

Fig. 37

The customer can key the number into the telephone as fast as desired, but digits will be stored and retransmitted at 10 pulses per second as normal loop-disconnect signals. It could be possible to install equipment at the telephone exchange which converts signals from the customers' keyphone into 10 pulses per second, instead of each instrument being supplied with this circuitry. The disadvantages of this however are that exchange staff would be required to wire in the equipment each time a customer replaced an existing telephone with a keyphone. Also if the customer's instrument was faulty and could not be replaced immediately with another keyphone, exchange staff would be required to rewire the exchange equipment to allow a normal dial telephone to be fitted in its place. These, and certain other problems, can best be overcome by supplying the customer with a self contained unit which does not require special equipment at the exchange.

The digit store is in the form of an integrated circuit and can store up to 18 digits, each one being placed in the store in 1 millisecond. A second integrated circuit provides the timing waveforms for the loop-disconnect pulses. Pulsing out at 10 pulses per second commences when the first digit is stored and continues until the store is empty, with interdigital pauses of 800 milliseconds between each digit. A mercury-wetted reed relay transmits the pulses to line and the "off-normal" function is provided by a dry-reed relay. A small nickel-cadmium cell is used as a power source, which is recharged automatically from a small mains driven power unit or direct from the line when the telephone is not in use. A keyphone version of the Telephone No. 722, using the same principle of operation as previously described, is undergoing field trial. The major difference is in the power arrangements, where instead of a battery, the keypad draws its power from the line during the loop-disconnect pulsing.

PABX Type Keyphones

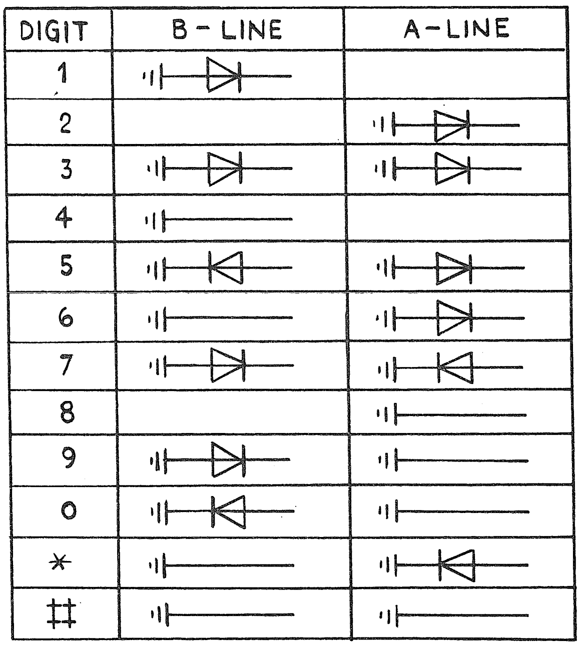
There are two types of keyphone in use on PABXs, one uses multi-frequency signalling, the other uses DC (Code C) signalling. Both types look identical, a picture of the instrument is shown in Fig. 38. The two additional keys are used for special facilities such as hold and transfer.

R47089

Fig. 38

Multi-frequency keyphone:- This uses a signalling system multi-frequency No. 4. When a key is depressed two tones are transmitted simultaneously, the combination being different for each of the twelve keys. The frequencies are produced by a single oscillator with two tuned circuits, each circuit able to produce four separate frequencies. The single transistor is biased to operate over the linear region of its characteristic and has 2 separate transformer windings in both the base and emitter leads. The turns ratio of these transformers is arranged such as to produce positive feedback, thus causing the circuit to oscillate. There is a magnetically coupled third winding associated with each transformer, and each of these third windings is arranged so that it can be tapped at four places by a fixed capacitor. This allows four separate resonant circuits to be produced from each winding, giving eight different frequencies of oscillation. The key contacts will determine which tappings are selected and hence which frequencies will be transmitted for each key. One winding produces tones in the upper frequency range (1200-1650 Hz) and the other produces tones in the lower frequency range (700-950 Hz). By combining one tone from each frequency range it is possible to get sixteen different combinations, but as only twelve keys are provided on the instrument the top frequency in the upper range is not used. To give the customer "confidence" that the telephone is functioning, the circuit is designed so that low level signals from the oscillator are received in the earpiece whilst keying out.

DC Signalling (Code C):- This uses the international DC (Code C) signalling system to transfer information to the registers in the PABX. As each button is depressed it presents certain d.c. conditions to the A and B wires of the line, as shown in Fig. 39. This telephone is polarized and as such the line must not be reversed otherwise incorrect conditions will be applied when a key is depressed. The exchange equipment has a signal detect unit which receives the DC (Code) C signals and transfers the information to the register. It consists of four relays to detect the four different line conditions. Two of the four relays are backed by a +ve battery and two by a -ve battery. Depending on the conditions sent from the telephone one or more of the relays will operate, the combinations of which determine the digit dialled.



R47090

Fig. 39

END