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THE POSTAL ELECTRICAL SOCIETY OF VICTORIA

The
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Vol. 2, No. 2. OCTOBER, 1938

THE 300 TYPE HANDSET TABLE TELEPHONE

T. T. Lowe

Interesting additional facilities and improvements in design are included in the new 300 Type Magneto, C.B. and Automatic Handset Telephones which will be delivered during 1939.

Number of Handset Telephones in Service.—Recently there has been a marked increase in the demand for Handset Telephones. Fig. 1 indicates the increase in the number of handset and other telephones connected during the past three years and the anticipated development during the next 18 months.

The total number of telephones of all types in service in Australia is about 650,000, and of these, 270,000 are magneto, 320,000 automatic, and 60,000 common battery. The net annual increase in the number of telephones connected is now 36,000, and about 55,000 of the older type telephones in service are being changed annually to the handset type.

The total number of handset telephones installed is about 220,000, 55,000 being magneto, 132,000 automatic and 33,000 common battery. Handset telephones in service are increasing now at the rate of 72,000 per annum.

By September next year, 180,000 handset telephones of the 566 type and 120,000 of the 232 type, making a total of 300,000 instruments, should be in service throughout the Commonwealth. This is exclusive of the 300 type, deliveries of which should commence about the middle of 1939.

Types of Handset Telephones.—As the new telephone will be the third type of handset telephone to be used in the Commonwealth, it is necessary to explain the significance of each type and the numbering.

Type 566.—This is the B.P.O. type 162. It is the type already in use in the Commonwealth with anti-sidetone transformer included in the body, i.e., the upper portion of the instrument, and the induction coil, which is not of the anti-sidetone type included in the bell set.

Type 232.—This is the B.P.O. 232 type recently supplied which is similar to the 162 but with an anti-sidetone induction coil included in the body of the telephone instead of the anti-sidetone transformer.

Type 300.—This is the new B.P.O. 300 type which is described in this article. The distinguishing numbers which are allotted to these instruments are in the group from 300 to 399.

Handset Telephones Fitted with Anti-sidetone Induction Coils (ASTIC Type).—The 232 and the new 300 type C.B. and Automatic Telephones are the ASTIC type, i.e., fitted with anti-sidetone induction coils. Local battery telephones purchased up to the present are not fitted with anti-sidetone induction coils, but a suitable coil and circuit have been developed, and their use is now under consideration. In view of the importance of the anti-sidetone telephone in its effect upon transmission, it is of interest to discuss the factors which have led to the adoption of this type of instrument.

It is, of course, the ideal of good telephone practice to provide a high standard of transmission efficiency approaching as nearly as possible to direct face to face conversation.

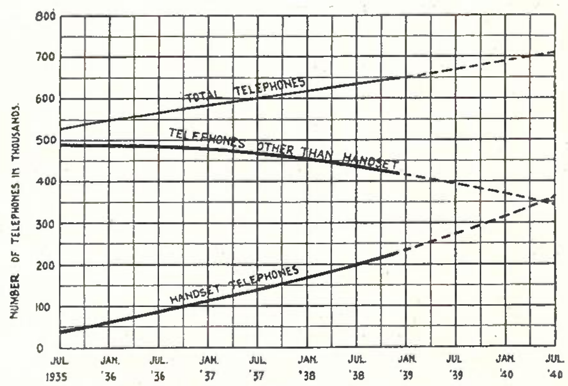


Fig. 1.—Number of Telephones in Service.

Sending efficiency should be as high as is required to keep the speech level well above the level of induced noise, but not so high as to cause appreciable crosstalk into other telephone circuits. The maximum desirable receiving level is determined by the limitations imposed by the ear in accepting without strain speech levels above a certain intensity. In a telephone conversation the environment and prevailing noise conditions for the speaker may be quite different to those at the listening end.

In a direct conversation, say across a table, both the speaker and the listener are subject to the same environment including the prevailing noise conditions. The speaker regulates the volume of his voice unconsciously by the ease with which he hears himself under the prevailing noise conditions, and by the ease with which he is hearing the other person and the other person is hearing him. The ease with which the speaker hears himself is the primary controlling factor.

These factors also regulate the volume of telephone speech, but their magnitude and relationship differ from those of ordinary face to face conversation, and vary with different telephone connections. The sidetone of a telephone is substantially higher than the sidetone of direct face to face conversation, and as the speaker is much more accustomed to direct conversation, the extra sidetone of the telephone deceives him by causing the impression that he is talking louder than he really is.

The three factors which affect conversation, whether direct or by telephone are volume, quality and noise.

The performance of telephones in service is affected by the following factors:—

(a) The characteristics of the exchange equipment, subscribers' lines, junction lines and trunk lines with which the telephones are associated.

(b) The amount of extraneous noise present at the transmitting and receiving stations.

(c) The effect of sidetone upon the volume of speech.

(d) The distance between the user's lips and the transmitter.

(e) The closeness of contact between the receiver and the user's ear.

The total noise as distinct from speech in the user's telephone ear is made up of the following:—

(a) Leakage of room noise between the receiver cap and the ear.

(b) Room noise picked up by the transmitter of the local telephone and returned as sidetone to the receiver.

(c) Room noise picked up by the transmitter of the distant telephone, and transmitted over the line to the receiver of the local telephone.

(d) Circuit noise.

An anti-sidetone telephone effectively reduces side-tone. This means that sounds, either noise or speech, acting upon the transmitter are reproduced in the receiver of the same telephone (i.e., the transmitting telephone) at a much lower level, without materially affecting either the sending or the receiving efficiency of the instrument.

In the anti-sidetone telephone the transmitter and receiver are coupled to the line through the anti-sidetone induction coil which in addition to three inductive windings is provided with a balancing network. The circuit which is made up of the following four elements: transmitter, receiver, line and network, when coupled by the transformer (anti-sidetone induction coil) is so arranged that the voltages produced by the transmitter tend to balance out and thus reduce sidetone in the receiver.

In theory the complete elimination of sidetone is possible, but in practice due to the unavoidably wide variations in line impedance, this cannot be entirely realized. Also variations in the loop resistance affect the transmitter current loss, and, therefore, vary the sending efficiency and sidetone volume.

The ASTIC is arranged to reduce sidetone to the maximum extent on average loop conditions.

Receiving efficiency is reduced by sidetone through reproduction in the ear of the listener of room noise picked up by his own transmitter. In the anti-sidetone telephone the level of room noise in the receiver is lower than the level of

Fig. 2.—Automatic Table Telephone No. 332 A.T.

received speech resulting in a gain in effective reception when compared with the sidetone instrument. It should be remembered that leakage between the receiver and the ear, if the receiver is not held tightly against the ear, causes a large reduction in volume and permits further room noise to be picked up by the listener's ear.

For either sidetone or anti-sidetone telephones, sidetone is louder than for ordinary face to face conversation, and the effect of sidetone as indicated previously is to make the user think he is speaking louder than he really is. In the anti-sidetone telephone the reduction of sidetone causes the input level to be increased by the speaker with a resultant gain in effective transmission when compared with the sidetone telephone.

A transmitter is really a form of amplifier, and when it is attached with a receiver to a common handle the two components are mechanically and acoustically coupled. A vibration in the receiver may be transmitted via the handle (mechanical coupling) or via the air path (acoustical coupling) to the transmitter which in turn conveys it via the telephone circuit back to the receiver, so renewing the process. Conditions may be set up in which sustained oscillation or howling between the transmitter and receiver will result. If a handset is placed face downwards on a table, an air column is created which is resonant at a frequency of about 2500 cycles per second. Acoustical coupling may, therefore, limit the transmission improvement which may be effected under a given set of conditions. The anti-sidetone telephone circuit provides a greater margin of safety against howling due to mechanical and acoustical coupling.

Fig. 3.—Magneto Table Telephone No. 333 M.T.

Handset Telephones. — The new 300 Type Handset Telephone which has been developed by Ericsson, England, is designed on the lines of the Swedish Ericsson model, and is a complete unit. The 566 and 232 type telephones each consist of two units, a moulded handset telephone and a moulded bell set. The two separate parts of the telephone can be installed in different locations or combined as one instrument. A magneto telephone requires in addition a separate hand generator mounted in a wooden or moulded case, and two or three dry cells in a battery box. The object of the two unit design was to enable the telephone to be used with the wooden type bell sets formerly associated with pedestal type table telephones in service, thus avoiding the purchase of moulded bell sets. Experience has shown that a combined instrument is now usually required.

It will be interesting to see which type of handset telephone the public will prefer:—

(a) The 566 or 232 type black telephone with a separate wooden cased or moulded bell set and a separate generator when necessary; or

(b) The 566 or 232 type black telephone and a moulded bell set combined as one unit, and a separate generator when required; or

(c) The 300 type black, ivory, jade green or chinese red combined instrument.

It is considered that there should be a demand for a 566 or 232 type telephone associated with a wooden bell set as a separate unit for a service where the bell set can be conveniently mounted out of sight, e.g., under the desk or table. Also the 566 or 232 shape may become more popular as a portable telephone than the 300 type due to the ease with which this telephone may be picked up and carried from room to room.

As the 300 Type Telephone will be the Department's standard instrument, some of the reasons for the change from the 566 and 232 types which are alike in general appearance are set out briefly:—

(a) As the 566 instrument consists of 10 separate moulded parts, and only 5 are included in the 300 type, the latter design should be more convenient and economical to manufacture as a combined telephone.

(b) In the 566 type the incidence of cradle breakages and plungers sticking is high. No cradle is included in the 300 type, and sticking of the brass plunger rods should not occur.

(c) The cradle switch and spring set in the 566 type are not of good design, and trouble has been experienced in service due to unsatisfactory spring contacts. In the 300 type the switch and spring set are of greatly improved design. The spring set is fitted with double silver contacts, and adequate spring contact follow is provided.

(d) For certain services it is desirable to replace the magneto bell in the telephone with a trembling bell. This is provided for in the 300 type, but a trembling bell cannot readily be fitted in the 566 telephone.

(e) It is desirable also on certain services for non-locking press button keys to be fitted in the telephones. In the 300 telephone this is provided for, but suitable press buttons for these facilities cannot be fitted readily on the 566 type.

(f) A generator must be provided on magneto services and on C.B. extension services when an extension switch is at the main. In the 300 type the generator is mounted in the moulded case of the instrument, but a separate generator must be provided for the 566 type.

The 300 Type Table Telephone.—The general appearance of the 300 type Automatic and Magneto Handset Table Telephones is indicated in the Photographs, Figs. 2 and 3. In a C.B. telephone the dial is replaced by a dial dummy. It will be seen that the same moulded body is provided on all telephones, the generator in the magneto being accommodated within the telephone body.

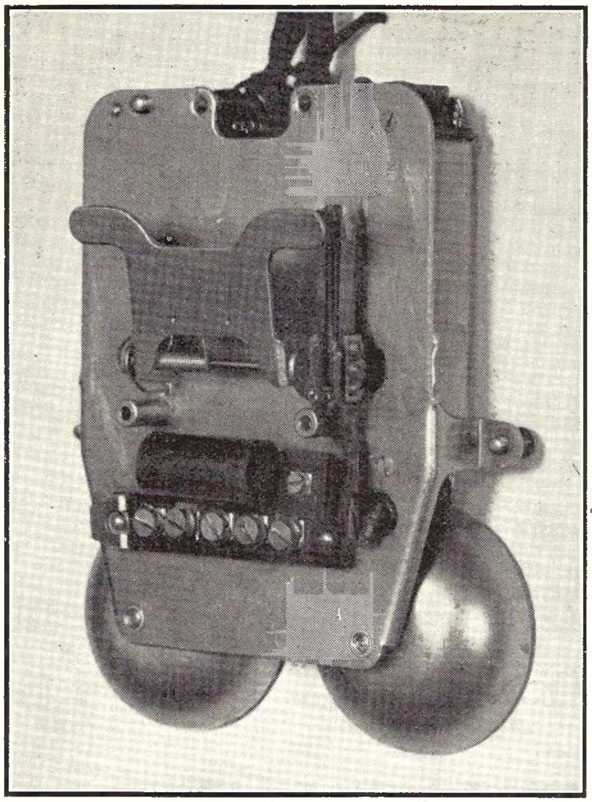


Fig. 4.—Upper Side of Metal Chassis for Automatic Telephone No. 332 A.T.

The 300 type telephones are designed on modern simple lines and are of pleasing proportions. The ordinary instrument supplied will be black conforming with present practice, but supplies are being obtained also coloured ivory, jade green and chinese red to meet special cases. All telephones are provided with the Swedish Ericsson type instrument cords which are coloured to match the instruments. Extensive experience in service has indicated that Swedish Ericsson instrument cords are comparatively free from kinking and twisting when in use.

The telephones are provided with new moulded Terminal Blocks No. 20 fitted with moulded covers. Normally the line cord and leading in cable are led in at opposite ends of the terminal block, but both or either may be led in through the bottom by breaking out thin moulded fins. Suitable recesses are provided in the blocks to enable the leading-in cable to be sealed when necessary. To minimize surface leakage raised portions of the moulding are provided between the terminals.

The 300 type Handset Telephones are table instruments and are not designed for wall use. The 566 or 232 type handset telephones fitted with wall brackets will be used as wall instruments.

C.B. and Automatic Handset Table Telephones (Nos. 332 C.B. and 332 A.T.).—The handset and the body of the instrument are supplied in highly polished moulded material, the body being moulded in one piece. All external metal fittings are finished in chromium plate having hard wearing surfaces which are easily cleaned. The metal base plate which carries four rubber feet is readily removed by unscrewing four captive screws, one in each corner, and provides access to the sheet metal chassis (Figs. 4 and 5) on which all the components other than the dial are mounted. The metal base plate is fitted with two metal runners for a directory tray, which will not be supplied. Instead of the directory tray the base plate of each telephone will be provided with a moulded dummy which can be

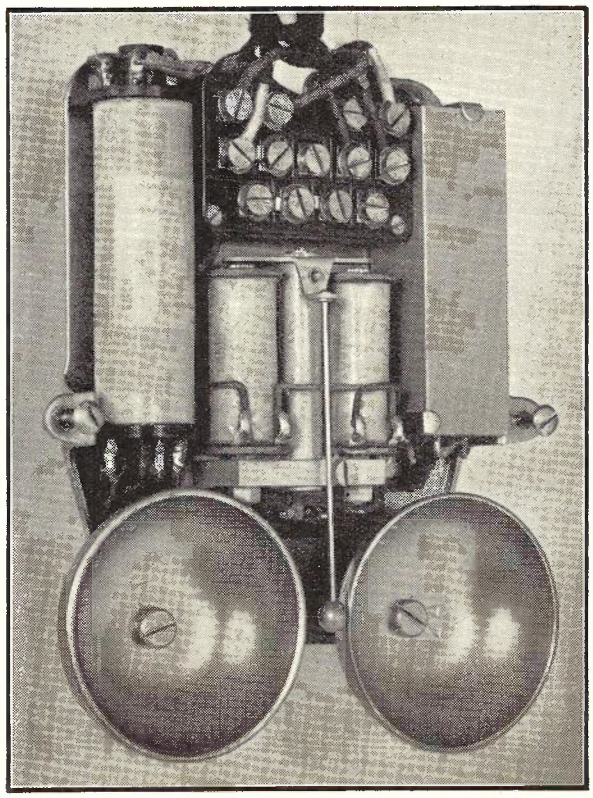


Fig. 5.—Underside of Metal Chassis for Automatic Telephone No. 332 A.T.

removed by unscrewing two screws from the underneath side of the base plate. A circuit diagram will be provided in the recessed portion of the upper surface of the metal base plate.

The bell gongs can be adjusted and the instrument cords changed without removing the chassis from the telephone.

The chassis, however, is readily removable when necessary by unscrewing three captive screws. The handset, the magneto bell and instrument cords are interchangeable with similar parts on Telephones 566 and 232. On the upper side of the pressed metal chassis (see Fig. 4) the cradle switch lever, the cradle switch spring set, the dial cord terminal block and the radio interference suppression unit when required are fitted. On the under side of the chassis (see Fig. 5) the magneto bell, the bell gongs, the anti-sidetone induction coil, the dual condenser and the instrument cord terminal block are mounted.

Magneto Bell (Fig. 5). — The magneto bell polarizing magnet is a cobalt steel rod having an armature pivoted at one end, whilst the other

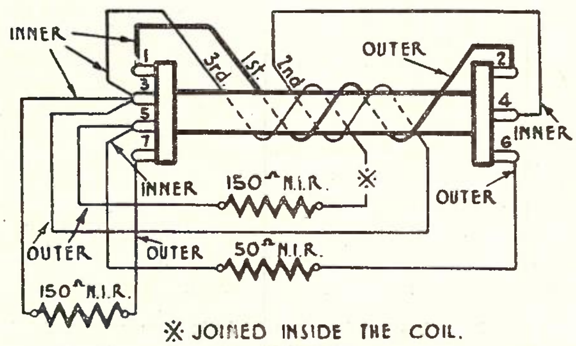


Fig. 6.
A.S.T.I.C. No. 22, Coil Windings, Telephone No. 332.

end fits into an iron yoke slotted to form an effective clamp for the magnet. If adjustment is necessary, the clamp is slackened off by loosening one screw only, and the magnet is then free to move in or out of the yoke. Each bell coil is wound to 500 ohms resistance and the coils may be readily connected, either in series or in parallel. On the telephones supplied they are connected in series, the resistance of the bell being 1000 ohms. The bell gongs (Nos. 2 and 2A)are manufactured from different thicknesses of metal which give to each gong a different tone when struck by the hammer, thus providing a distinctive and pleasing ring. The bell gongs are adjusted in the usual manner, the centre mounting hole being slightly eccentric to the outer rim of the gong; the gongs are turned to vary the spacing between the outer rim and the striker. The gongs are fixed by screws to short projections on the chassis, and to prevent them from working loose, spring steel locking washers are fitted between each gong and the chassis.

Anti-sidetone Induction Coil No. 22.—The ASTIC No. 22 (Fig. 5) is provided with an open type core and has six windings, three inductive and three non-inductive, wound on a moulded bobbin. Fig 6 shows the direction of windings and the connections. The operation of the anti-sidetone induction coil is referred to in detail later.

Dual Condenser (Fig. 5).—The two condensers (2MF and 0.1 MF) are accommodated in one metal case, the outer dimension of which is 1 in. x 1 in. x $3\frac{1}{4}$ in. The electrical characteristics of each condenser are similar to those of the ordinary larger size type. The reduction in size is made possible by improved manufacturing processes, and by the use of synthetic wax having a higher permittivity (specific inductive capacity) than paraffin wax. The 0.1 M.F. condenser is connected across the trans-

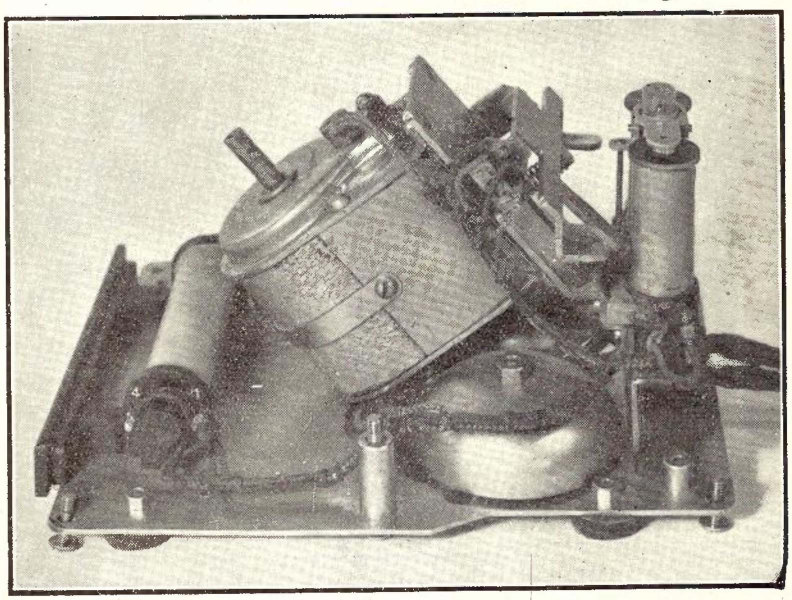


Fig. 7.—Metal Baseplate and Component Parts of Magneto Telephone No. 333 M.T.

mitter to prevent radio interference due to the pickup of radio programmes by the receiver as a result of rectification by the carbon granules of the transmitter.

Cord Connection Blocks (Figs. 4 and 5).—The two cord connection blocks are of moulded material. The terminals which are fitted with 4 B.A. screws and cupped washers are retained in position by a half turn on the soldering tag portion. The cord connection block for the handset and line cords has 13 terminals, some of which are commoned with metal strips used for altering the circuit arrangements for various "Plan Numbers Services" as will be described in a further article. The terminals marked 4, 5 and 6 are used for the handset cord, the line cord being connected to terminals 1, 2 and 9.

Cradle Switch Mechanism.—The cradle switch mechanism (see Fig. 4) consists of a spring controlled pivoted lever which carries the usual polished ebonite plunger tip and contact springs fitted with double silver contacts. The centre spacing insulator of the spring set is much shorter than that usually provided and the short inner springs are tensioned outward ensuring adequate contact follow.

The cradle switch lever is operated by two metal plunger rods which project through the cradle portion of the moulded body of the instrument. The plunger rods, which are operated when the handset is replaced in the cradle position, move freely in metal bushes fitted in the moulded case. With this arrangement the liability of trouble due to plunger sticking is reduced to a minimum. The spring set can be adjusted with the chassis removed from the telephone case, and when the chassis is replaced the adjustment will be maintained.

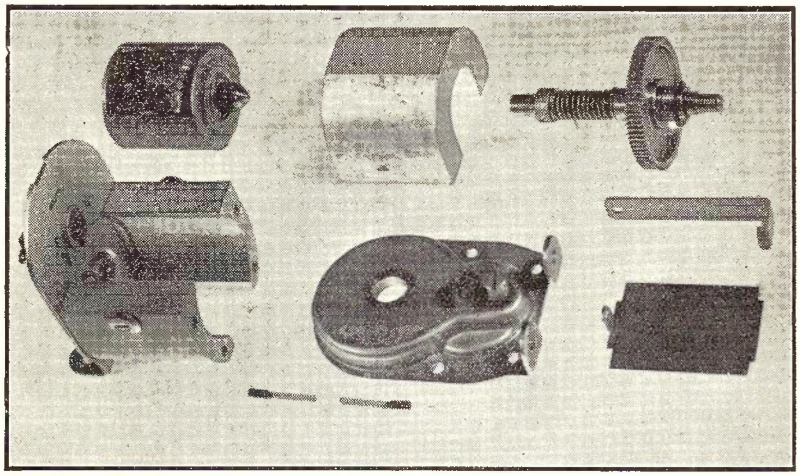


Fig. 8.—Alnico, Hand-Generator Disassembled.

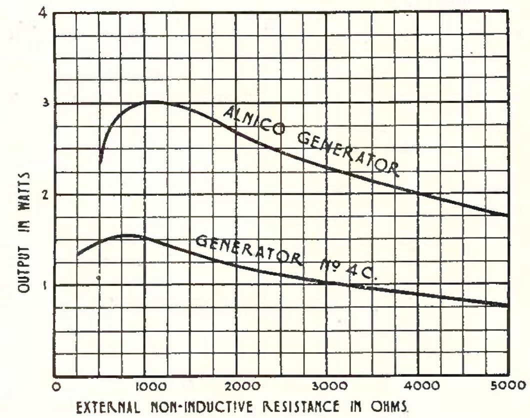


Fig. 9.—Load Characteristic Curves for Alnico and Type 4 C Hand-Generators.

Dial and Dial Dummy.—For C.B. operation the usual dial dummy is fitted in the dial aperture and terminals 4 and 5 of the moulded dial cord connection block (see Fig. 4) are strapped. For automatic working a Dial No. 10 provided with a stainless steel finger plate is fitted and connected by means of a five-way instrument cord to the dial cord connection block. At one end of the dial connection block a spring clip is fitted to keep the dial cord clear of the dial impulse springs.

Radio Interference Suppressor (Figs. 4 and 11).—A radio interference suppressor to absorb the high frequency components of the dialling impulses is connected when required to the appropriate terminals on the dial connection block. The unit consists of a capacity and inductance mounted on a moulded base. It is shown mounted immediately above the terminals in Fig. 4.

Handset Telephones.—The handset telephone is of the modern moulded type fitted with a three conductor cord 3 ft. 6 ins. long. The connections from the transmitter recess in the handset to the receiver recess are embedded in the moulded handle and consist of heavy gauge insulated copper wires soldered to screwed brass terminal inserts. The receiver is of the inset type having a cobalt-chrome steel polarizing magnet, the fixing screws forming the electrical connections. The moulded earpiece screws to the receiver case and clamps the diaphragm in position. The connections to the transmitter inset (B.P.O. No. 13 type) are made by the centre terminal spring, and a double contact flat spring. The mouthpiece is fixed by a clip operated by a special key to prevent interference to the inset.

Magneto Handset Table Telephone (No. 333MT)

In general appearance the new model Magneto Handset Table Telephone is the same as the C.B. and Automatic type except that a small hand generator is mounted in the dial space in the moulded body of the instrument. The general appearance of the instrument is shown in the photograph (Fig. 3). The telephone is a complete magneto unit except for a battery box. The first deliveries will be the sidetone type, but future supplies will probably be the anti-sidetone type.

Base Plate.—The sheet metal base plate (see Fig. 7) which carries all the electrical components of the telephone is provided on its under side with four rubber feet and two metal cover plates. One cover plate fits over a recess in which is mounted a moulded connection block for the instrument cords. The other cover plate fits over an aperture in the base plate provided to enable the generator cut-out springs to be readily adjusted. Instrument cords can be changed and the generator cut-out springs adjusted without removing the metal base plate from the telephone. To remove the metal base plate from the telephone the generator handle is first removed by unscrewing the centre holding screw in the generator driving axle. Then the four corner and two side captive screws are unscrewed, and the base plate carrying the components is readily removed.

Induction Coil (Sidetone Type).—The 1 ohm plus 19 ohm induction coil which is of the open core type fitted with a moulded bobbin is mounted on the upper side of the base plate near the front. The primary winding of the induction coil has 400 turns and the secondary 1300 turns. Future supplies will probably include an anti-sidetone induction coil.

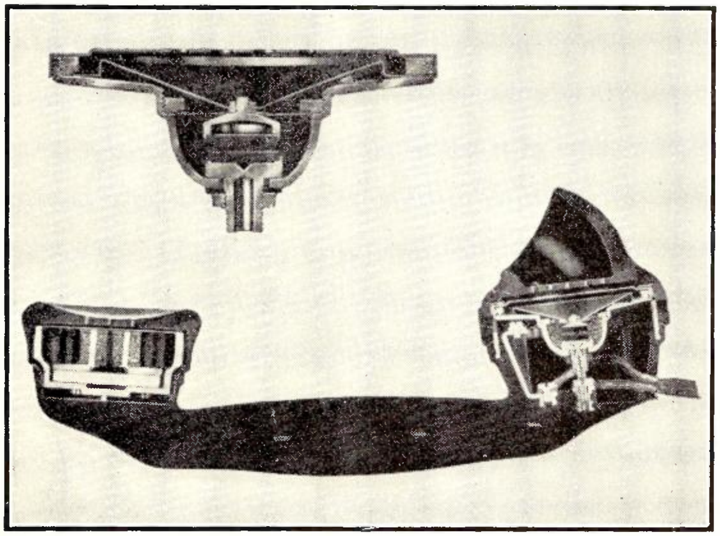


Fig. 10.—Handset for Magneto Telephone No. 333 M.T.—Transmitter Inset N 7750.

The Magneto Bell and Cradle Switch are similar to the C.B. type. The metal base plate at the rear is shaped to form a shelf which carries on its under side the moulded instrument cord connection block and on a metal projection fitted to its upper side the magneto bell assembly and the cradle switch. The bell gongs are mounted on the upper side of the base plate directly in front of the metal shelf.

Hand Generator.—The metal shelf projection also carries the small hand generator which is fitted with an "Alnico" permanent magnet. The generator is mounted with its driving axle at an angle of about 50 deg. to the metal base plate. When assembled in the telephone the generator driving axle to which the handle is fitted protrudes through the hole in the moulded dummy which is fitted in the dial aperture. The generator is screwed firmly to the metal projection and the metal base plate by five holding screws.

The recent introduction of a new magnetic alloy, aluminium-nickel-cobalt-steel, "Alnico," to replace tungsten steel formerly used in the manufacture of permanent magnets has resulted in the development of a telephone hand generator of an entirely new design. "Alnico" has the maximum flux density per unit of volume for any magnetic material yet discovered. The specific gravity of the alloy is low also, giving a reduction in weight which is distinctly advantageous.

The very high starting force necessary due to the high magnetic flux and small air gap between the armature and the permanent magnet pole pieces has been a difficulty in connection with the development of a telephone hand generator using an "Alnico" permanent magnet. The force necessary when operating the generator on short lines of low resistance at the commencement of turning the handle was sufficient to move the table telephone in which the generator was fitted unless it was held firmly in position. The high efficiency of the generator has been retained and the turning force reduced by backing off the armature pole pieces at the trailing tip in order to reduce the flux density in the air gap and mounting the armature between pivots and collecting the current by means of small carbon brushes bearing on slip rings fitted one at each end of the armature.

The generator is provided with a malleable cast iron two pole armature running on pivot bearings and wound with enamelled wire to 500 ohms resistance. The brass driving wheel has 78 teeth and the steel pinion wheel 18, giving a ratio of 1 to 4.33. The pinion wheel may be withdrawn by removing the locking nut securing the pivot bearing which is accessible by the removal of the armature cheek. All moving parts of the generator other than the cutout spring set and the handle are totally enclosed. The cast "Alnico" permanent magnet is used

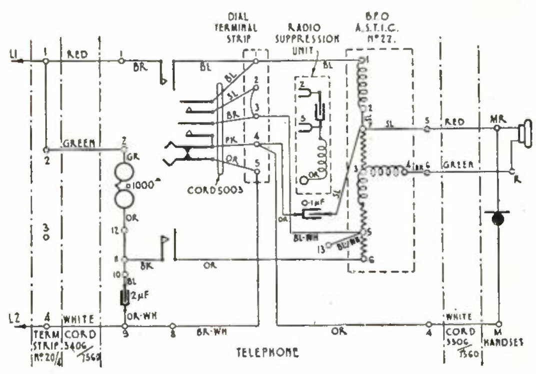


Fig. 11.—C.B. and Automatic Table Telephone No. 332 (C 1350).

For C.B. working omit dial and strap terminals 4 and 5 on dial cord terminal strip. Extension bell, if required, to be connected to terminals 1 and 2 of terminal strip No. 20/4 and strap removed. Radio suppression unit, if required, to be fitted to terminals 2 and 5 of dial cord terminal strip and "OR" wire of 5003 cord removed from terminal 5 and connected to the screw terminal of unit.

for the bridge piece only, high quality soft iron pole pieces being provided. The generator cut-out springs are fitted with double silver contacts. The weight of the generator is only 2 lbs. and its open circuit voltage at normal turning speeds is about 112 V. Fig. 8 shows the generator disassembled. Fig. 9 shows the load characteristic curve of the generator compared to the present standard Hand Generator No. 4C (formerly No. 3).

Handset.—The handset (see Fig. 10) is exactly similar to that provided on the C.B. type telephone with the exception that Ericssons' Transmitter Inset N.7750 is fitted instead of Transmitter Inset No. 13. Ericsson Inset N.7750 is interchangeable with No. 10 and No. 13 types, and is an efficient type for local battery use, being suitable also for common battery operation. It is similar to No. 13 type in that the oiled silk membrane provided on the No. 10 inset is omitted, the diaphragm being protected by a special lacquer. The inset has a resistance of approximately 50 ohms and is provided with a completely enclosed carbon granule chamber to prevent the ingress of moisture.

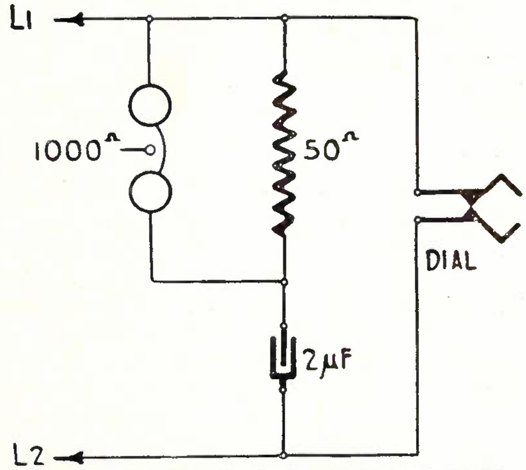


Fig. 12.—Dialling Circuit, Automatic Telephone No. 332.

C.B. Handset Table Telephone with Hand Generator (No. 336, C.B.T.)

A 300 type C.B. Handset Table Telephone with a hand generator fitted in the dial aperture in the body of the instrument will also be supplied. This instrument is for use as a C.B. extension telephone when an extension switch is at the main. In outward appearance the telephone is similar to the magneto type.

C.B. and Automatic Telephones—Circuit Description.—C.B. and Automatic Handset Table Telephones No. 332 A.T. and 332 C.B.T. will be wired to Drawing C.1350 (see Fig. 11).

The drawing shows the cord connections between the terminal strip and the telephone and between the telephone and the handset. When an extension bell is required, it is connected to terminals 1 and 2 of the terminal strip No. 20/4 and the strap removed. When the telephone is required for C.B. working, the dial and dial cord are omitted and terminals 4 and 5 of the dial cord terminal strip are strapped together. The 0.1 microfarad condenser is connected across the transmitter to reduce radio pick-up interference to a minimum. The radio interference suppression unit for dial impulses is connected, if required, to terminals 2 and 5 of the dial cord terminal strip and the orange wire of the dial cord removed from terminal 5 and connected to the screw terminal of the unit designated O.R.

The following is a brief description of the operation of the telephone (see Figs. 11, 12 and 13). Fig. 12 indicates the dialling circuit.

(i.) **Incoming Calls:**

The ringing circuit is from line 1 through the magneto bell and 2 microfarad condenser to line 2.

(ii.) **Originating Calls:**

(a) **Impulsing Circuit** (Figs. 11 and 12).—The impulsing circuit is from line 1 through the cradle switch, dial off normal springs, dial impulse springs to line 2. A shunt circuit is provided across the dial impulse springs to prevent high voltage surges and correct impulse distortion, from line 1 through the magneto bell and 50 ohm non-inductive winding 5-6 of the induction coil in parallel through the 2 microfarad condenser back to line 2.

(b) **Transmitter Feed Current Circuit.**—The transmitter is supplied with current from the exchange battery feeding bridge. The feed current circuit is from line 1 through the cradle switch, induction coil winding 1-2, transmitter, dial impulse springs to line 2. The transmitter may be regarded as an alternating current generator.

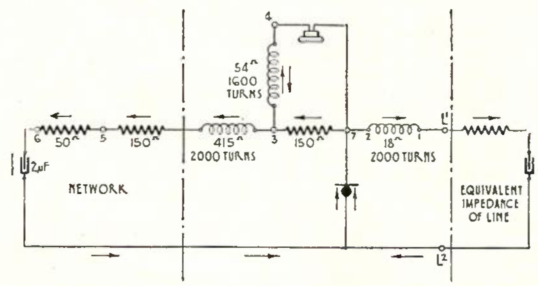


Fig. 13.—C.B. and Automatic Telephones No. 332. Schematic Circuit omitting Dial and Bell, showing Balanced Arrangement of Transmitter, Receiver, Line and Network.

(c) **Sending Circuit** (Figs. 11 and 13).—Considering the transmitter as an alternating current generator, the transmitter current divides, the major portion passing from the transmitter through the induction coil windings 7-3, 3-5, 5-6, the cradle switch springs, 2 microfarad condenser, dial impulse springs, back to the transmitter, the remainder flowing through winding 2-1 to line 1 and back through line 2 and the dial impulse springs to the transmitter.

As the current in winding 3-5 produces a greater magnetic flux in the core than winding

1-2, winding 3-5 acts as the primary of a step-up auto transformer in which windings 1-2 and 3-5 together form the secondary. The transmitter is, therefore, approximately matched to the impedance of the line with a

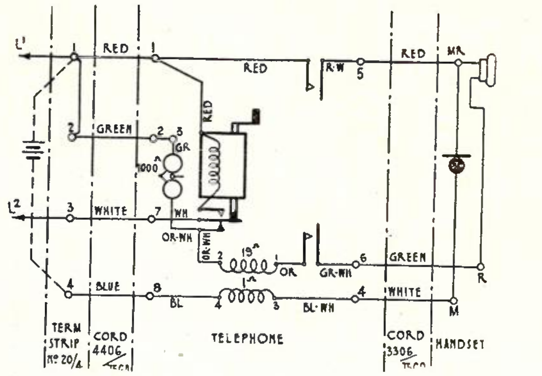


Fig. 14.—Magneto Table Telephone No. 333 (C 1351).
Extension bell, if required, to be connected to terminals 1 and 2 of terminal strip No. 20/4 and strap removed.

resulting increase in line current compared to a telephone without an induction coil. This increase in current is sometimes referred to as the booster effect.

(d) **Sidetone Control.**—The flux produced in the core of the induction coil by current from the transmitter is the resultant of the opposing effects of windings 2-1 and 3-5. This flux induces an E.M.F. in the winding 3-4 and would produce sidetone current in the receiver. One method of reducing this sidetone current would be to increase the ampere turns of 2-1 until they were approximately equal to those of 3-5. This, however, would destroy the auto transformer or booster effect. To retain this effect, and at the same time reduce the sidetone the non-inductive winding 7-3 is included in the local circuit of the receiver, and for ordinary line impedances, the potential across this winding opposes the E.M.F. induced in winding 3-4. Since the resultant flux from windings 2-1 and 3-5 depends upon the current in 2-1 which is controlled by the impedance of the line, the amount of sidetone is influenced by the line conditions. The circuit is designed to give minimum sidetone under average line impedances. Fig. 6 shows the connections of the ASTIC No. 22.

(e) **Receiving Circuit.**—In the receiving condition the major portion of the voice frequency passes from line 1 through the cradle switch springs, induction coil winding 1-2, transmitter, dial impulse springs, back to line 2. Due to the low impedance path offered by the transmitter compared to its parallel circuit formed by the induction coil windings 7-3, 3-5 and 5-6, cradle switch springs and two microfarad condenser, the flux due to the current through the induction coil winding 1-2 induces a potential in winding 3-4 which drives the current through a local circuit consisting of the receiver and the induction coil winding 7-3. The small current from the line passing through winding 3-5 tends to assist the current passing through winding 1-2.

Magneto Telephone — Circuit Description. — Magneto Handset Table Telephones No. 333 M.T. will be wired to Drawing C.1351 (see Fig. 14) which shows also the connections between the terminal strip No. 20/4 and the telephone, and between the telephone and the handset and the connections to the battery. If an extension bell is required, it is connected to terminals 1 and 2 of the terminal strip No. 20/4 and the strap removed.

The following is a brief description of the operation of the telephone (see Fig. 14):—

(a) **Incoming Calls.**—The incoming ringing circuit is from line 1 through the magneto bell and the break contacts of the generator to line 2.

(b) **Originating Calls.**—When the generator is operated, the generator cut-out spring set disconnects the magneto bell and connects the generator across the line. The outgoing ringing circuit is from line 1 through the generator, and its make contact to line 2. When the handset is removed from the cradle switch the transmitter local circuit is completed from battery through the 1 ohm winding of the induction coil, transmitter and cradle switch back to battery. The receiver circuit is completed also from line

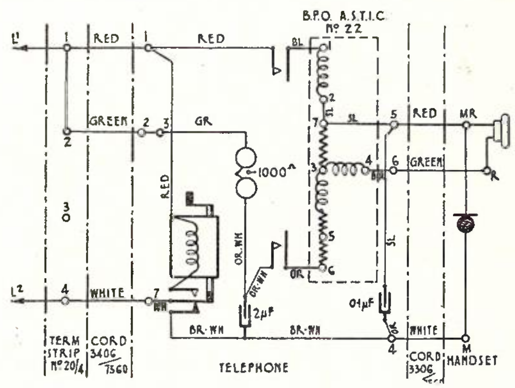


Fig. 15.—C.B. Table Telephone with Hand-Generator No. 336 (C 1352).
Extension bell, if required, to be connected to terminals 1 and 2 of terminal strip No. 20/4 and strap removed.

1 through the cradle switch, receiver, cradle switch, 19 ohm winding of induction coil, break contacts of generator to line 2.

C.B. Telephone with Generator—Circuit Description.—The operation of the C.B. Handset Telephone with hand generator, Drawing C.1352 (Fig. 15) will be readily understood from the descriptions of the C.B. and Magneto type telephones.

[EDITOR'S NOTE.—In the December, 1937, issue of the "Journal" the 232 type Handset Telephone was described. An article in a later issue will describe the 300 Type Telephone fitted with interlocking press button keys, trembling bell, etc., for use on various Plan Number Services.]

THE CITY WEST UNISELECTOR (G.E.C. TYPE C.3100)

H. G. Kuhn

In City West, Melbourne, subscribers' lines will terminate on uniselectors supplied by the G.E.C., Coventry. These uniselectors are five level homing switches of their C.3100 type.

The switches are assembled in units of 50, consisting of two shelves of 25 uniselectors with an intermediate mounting plate containing 50 sets of L and K relays of the B.P.O. 600 type. The general arrangement is shown in Figure 1. The switches have two spring mounting points to the frame, and the condensers are fitted below the switches. Six assemblies of 50 switches, that is a total of 300 uniselectors, mount on a standard rack 4 ft. 6 ins. wide and 10 ft. 6 ins. high.

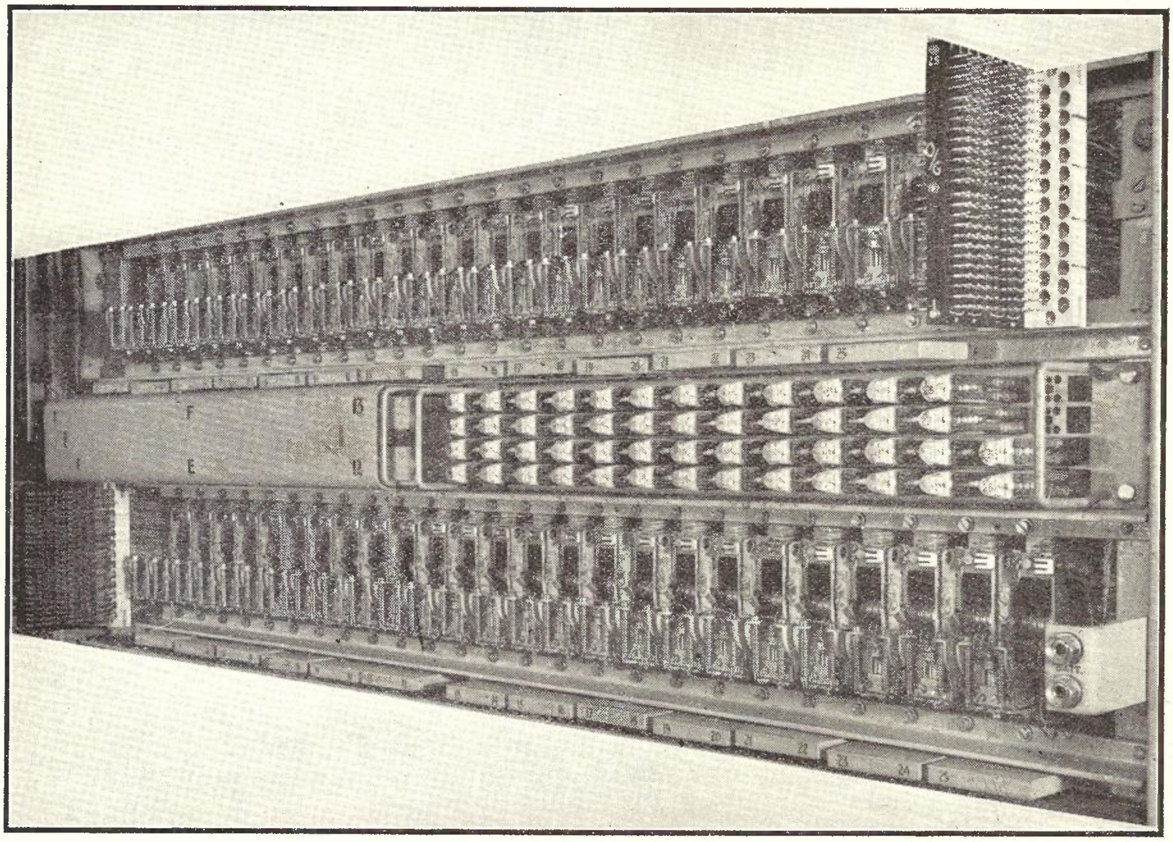


Fig. 1.

The incoming line wires, Negative, Positive, Private and Meter, terminate on an 8 x 25 terminal block shown at the lower left hand corner of Figure 1, the back 4 x 25 tags being terminals for the lower or A shelf, and the front 4 x 25 tags for the upper or B shelf. The outgoing lines from the bank contacts terminate on a second 8 x 25 terminal block, shown at the upper right hand corner of Figure 1. On this block, the Negative, Positive, Private and Meter wires from each shelf of 25 switches are arranged to facilitate the commoning of two shelves by bridging adjoining tags (see Figure 2).

The uniselectors are cabled from the local side of the I.D.F. to the incoming terminal blocks on the racks by means of 84 wire cables, each cable serving 20 circuits. A total of 15 cables is required per rack of 300 uniselectors and these cables are fed down the right-hand side of the rack when viewed from the rear. A typical cabling cross-section is shown in Figure 3.

On the left hand side of the rack viewed from the rear, the cables running from the outgoing terminal blocks to the T.D.F. (Trunk Distributing Frame) are accommodated. These are 102 wire cables and the number of cables per rack depends on the trunking. Tie cables for multipling shelf banks are also accommodated on the left-hand side, the number of such tie cables depending on the trunking scheme.

The simplest method of multipling is, of course, by bridging adjoining tags, as referred to previously and shown in Figure 2. This can be done very neatly, and quickly. When terminating, the wire is twisted around the rear tag and continued to the adjoining tag where it is again twisted. When both tags are soldered, a permanent bridge is established.

As the switches are of the homing type, the outgoing cables from the uniselector racks are taken to a T.D.F. where the outlets are graded,

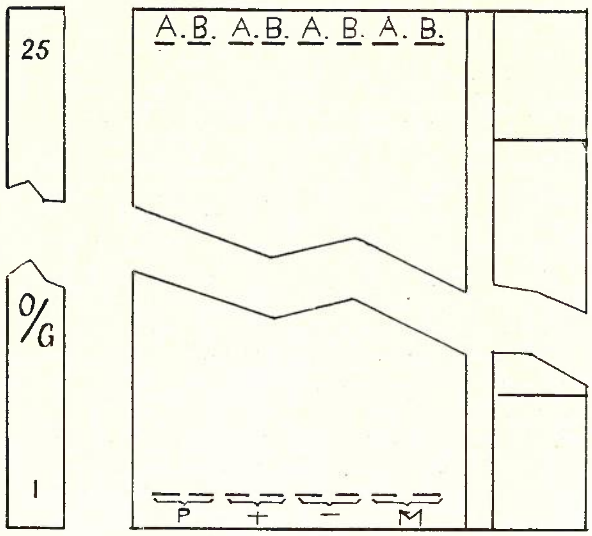


Fig. 2.

thus increasing the average traffic occupancy of the first selectors by approximately 20 per cent.

A type C.3100 uniselector is reproduced in Figure 4 and in general appearance it is similar to the B.P.O. standard uniselector. It has the same contact bank and feeder brush assembly, but it differs from the B.P.O. standard in the following respects:—

(i.) A single coil magnet is used instead of the standard double coil magnet.

(ii.) The magnet coil and armature assembly are fitted in the lower portion of the mechanism, thus facilitating inspection.

(iii.) The armature and pawl assembly has been re-designed and the pawl is now close to the restraining or detent spring. There is only one free tooth between the pawl and the restraining spring, so that even if the pawl does over-step, it cannot move the wiper assembly more than one tooth. A further advantage is that manufacturing errors in the cutting of the ratchet teeth do not appreciably affect the positioning of the wipers on the bank contacts. The maximum error is that due to one tooth and not to the cumulative error of 12 teeth as in the B.P.O. standard switch.

(iv.) The wiper tips are flared to prevent the wipers locking behind bank contacts in the event of "forward lash" developing during service.

(v.) The pawl backstop is of more substantial construction, thus reducing the liability of breakage.

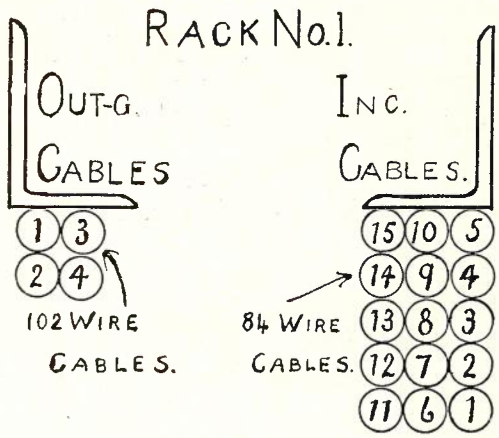
(vi.) The mechanism frame has been redesigned so as to secure a more compact switch. The type C.3100 switch mounts on $1\frac{3}{4}$ in. centres whereas the B.P.O. standard switch mounts on $2\frac{1}{8}$ in. centres.

The subscribers' line circuit is shown in Figure 5. It possesses the following advantages over many circuits already in use:—

(i.) The uniselector will step over open trunks.

(ii.) The switch is guarded during the homing period.

(iii.) When all trunks are busy the switch stops on the last contact and returns busy tone. This prevents excessive rotation. This feature also eliminates the necessity for chain



OUT-G. CABLES			INC. CABLES					
Cable No.	Rack	Shelf	Cable No.	Rack	Shelf	Cable No.	Rack	Shelf
1	1	B	1	1	A	9	1	G
2	1	D	2	1	A	10	1	G
3	1	H	3	1	A	11	1	I
4	1	J	4	1	C	12	1	I
			5	1	C	13	1	I
			6	1	E	14	1	K
			7	1	E	15	1	K
			8	1	E			

Fig. 3.

relays and avoids the complicated re-arranging of these relays when regrading is necessary.

When the subscriber lifts his receiver a circuit is completed from Earth, K3, line loop, K2, relay L, to negative battery. L operates and closes L1 and L2. L1 extends the homing magnet through to the P wiper. L2 puts an earth on private wire of final selector multiple, through home contact and the homing wiper H. This guards the line against intrusion at the final selector multiple. L2 also grounds the home contact of the private, thus completing a circuit through wiper P, L1, K1, interrupter contacts DM and driving magnet to negative battery.

DM operates and the switch steps from home contact to the first outlet. If this outlet is free there will be no earth on the private bank and K will operate from ground, L2, K relay, DM contacts, DM to negative battery (DM does not operate in series with K).

K2, K3 and K4 cut the negative, positive, and private wires through to the first selector ahead. This switch returns an earth on the private wire to busy the private bank contacts and to hold in K after L relay releases and L2 opens. L relay is made slow releasing because L2 must keep the private grounded until an earth is returned from the first selector. When L relay restores, the homing drive circuit is prepared by the back contact of L1 but this circuit is now held open at K1.

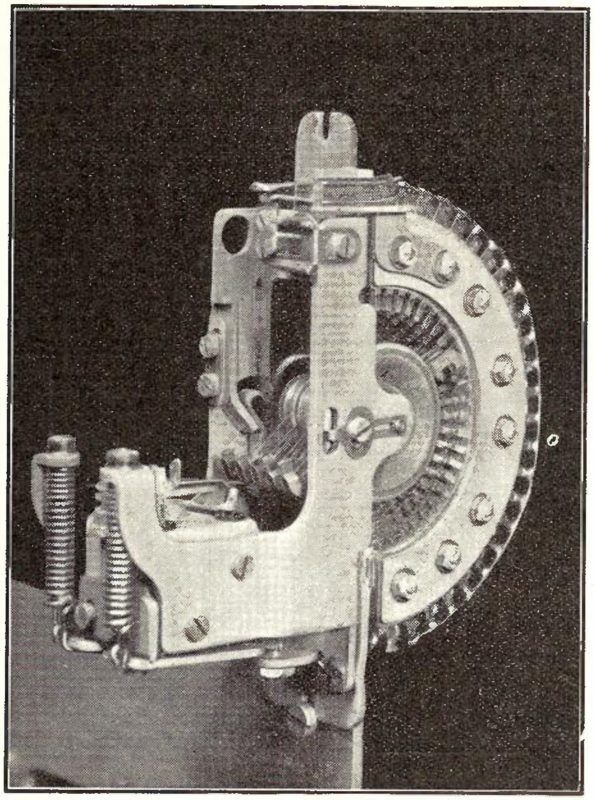


Fig. 4.

If the first outlet is busy, K relay is prevented from operating by an earth on the private bank contact which short circuits K relay and completes the driving circuit through the P wiper, L1, K1, interrupter springs, DM, to negative battery. This steps the switch until a free outlet is found. It will be noted that the P wiper is shown as a bridging wiper. This is necessary to maintain a short circuit on K until a free outlet is found.

When all outgoing trunks are engaged, the switch steps to the last contact where it will stop, because no earth will be found on the 25th private bank contact. K cuts through and a circuit is established from earth—25 ohms winding BT relay, positive wiper, K3, line, K2, negative wiper, relay L, to negative battery. Relay L remains operated and BT operates and connects Busy Tone to the 150 ohms winding. This tone is induced into the 25 ohms winding and extended to the subscriber.

When a switch is hunting for a disengaged trunk, it will stop on the first trunk which is clear of earth on the private. If an open exists in the outgoing trunk, or in the switch ahead, no earth is returned on private wire, and K releases, K1 closes the step on circuit from earth on homing bank, L1, K1, interrupter springs, DM to negative battery. The switch steps over the faulty trunk and at the same time L operates from the subscriber's loop, opens the step on circuit at L1, and re-establishes the normal hunting circuit. A disengaged outlet is located in the usual manner and K will operate again and cut the line circuit through to the first selector.

An important feature is that L1 must make before contact L2. This is necessary to ensure that the test circuit to the private bank contact is established before contact L2 closes the circuit of K.

Metering is effected either from repeaters or final selectors. A positive battery pulse is applied to the private wire through a 1/12A rectifier, meter bank contact and wiper M, K5, subscriber's meter, to earth. The meter operates and records the call. The 1/12A rectifiers are mounted on the first selector racks.

The P wiper is of the bridging type and as it sweeps over the bank contacts it may momentarily connect an earthed private to an adjacent private carrying positive metering battery. It is therefore necessary to instal 50 ohm protective resistances in the meter pulse circuits on repeaters and final selectors.

On the completion of a call the uniselector returns to its home position. Relay K is held by the earth on the private while the call is in progress. When the call is finished, this guarding and holding earth is removed from the private and K releases and completes the homing circuit at K1. The homing circuit is from earth on the divided homing bank, bridging H wiper, L1, K1, interrupter springs, DM to negative battery. The switch drives to the home contact at the rate of 70 steps per second. When the switch homes, earth is removed from the homing circuit and the private wire of the final selector multiple.

It may be of interest to describe briefly certain adjustments which are somewhat different from those employed on previous uniselectors. The coil and coil box are rigidly fixed to the mechanism frame, and the armature stroke must be obtained by moving the armature relative to the pole face. This is achieved by adjusting the knife edge and the back stop in the following manner. First the position of the armature back stop is adjusted to centre the wiper tip flats on No. 1 bank contacts. The armature is then operated. The knife edge must now be adjusted to give a gap of 65 mils between the armature and its back stop. This should result in a stroke of approximately 1-1/3rd ratchet teeth. Care must be taken when making this adjustment to see that the position of the knife edge is such that the pawl is kept central on the ratchet teeth and that the clearance between the armature and the sides of the coil box is equalized. The adjustment of the interrupter contacts is important for smooth running. The approved method is to place a 36 mil feeler gauge between the armature and its back stop and adjust the stationary interrupter spring to give a contact opening of 1 to 4 mils.

Apart from the above, the adjustments to this switch are generally similar to those required for the B.P.O. standard switch and with the exception of the adjustment for the index wheel pointer, they can all be performed without removing the mechanism from the bank.

The uniselector described above is being installed in City West for straight and P.B.X. lines. The initial installation consisting of 6000 uniselectors will be cut into service in November, 1938.

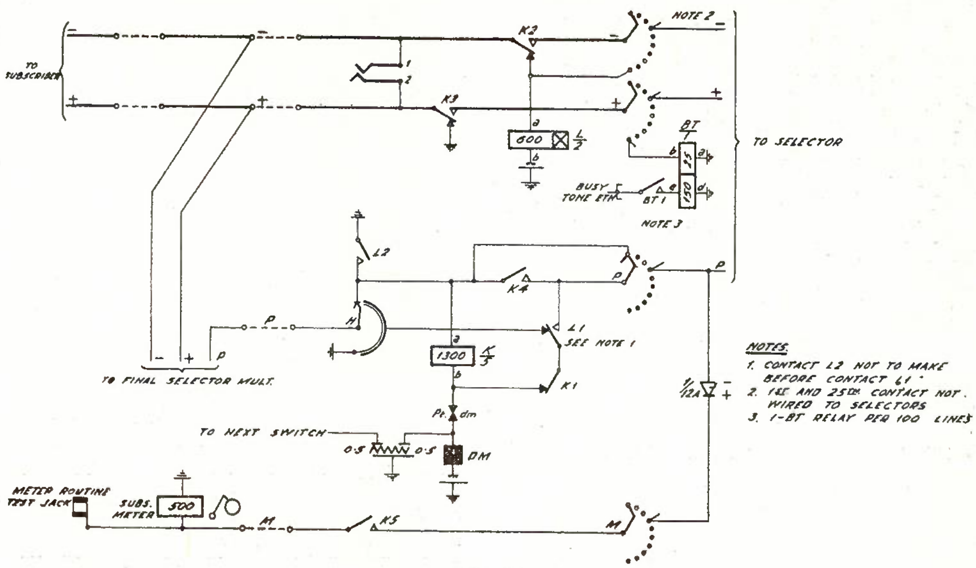


Fig. 5.

The Trustees of the Public Library of Victoria have requested a copy of Vol. 1 (Nos. 1-6). As stocks are exhausted, it would be appreciated if any subscriber who can oblige will communicate with Postal Electrical Society of Victoria, Box 4050, G.P.O., Melbourne.

FEATURES OF VICTORIAN R.A.X.'s

E. Bulte

General.—It is generally recognized that the telephone service plays a very important part in the development of the country, and is of particular value in Australia where the distances suggest isolation, and every encouragement for land settlement is necessary. The usual type of equipment at present in use in country districts is the manually operated magneto signalling type of installation, which, when the amount of business transacted is not large enough to justify an official office is installed in the premises of a local store, farm or private house. Because of the costs involved to provide continuous attendance for an exchange, a restricted service is given at most country switchboards, the hours depending on the office revenue. Hence the development of the R.A.X.

The R.A.X. is an automatic or semi-automatic exchange of less than 200 lines with the outlet to the rest of the distant telephone exchanges obtained through a manual exchange, which is known as the parent exchange. Typical trunk layouts are as below:—

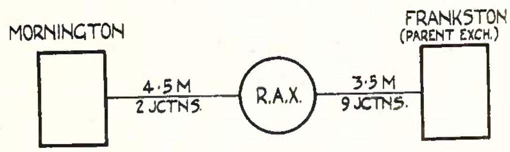


Fig. 1.—Mt. Eliza Trunking Arrangements.

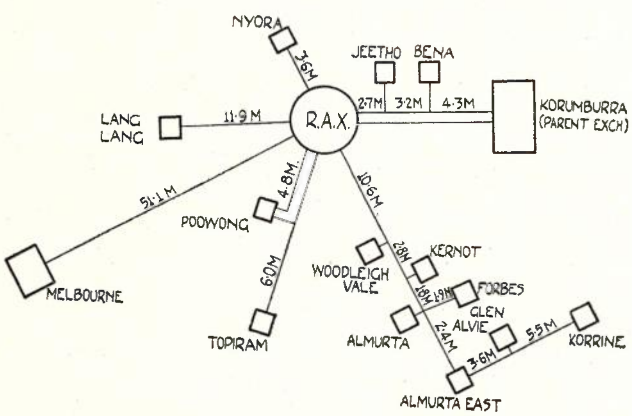


Fig. 2.—Loch Trunking Arrangement.

There are 18 R.A.X.'s installed at various parts of Victoria and proposals are in hand for many more installations.

Sites and Buildings

(a) **Sites.**—In some of the larger exchanges officially owned buildings and sites are available, but in the majority of towns for which R.A.X.'s have been considered no land is owned by the Department. The size of the block usually required is only 20 ft. x 20 ft., and in one case, permission was obtained to erect the necessary building in the corner of a school ground.

(b) **Buildings.**—For an ultimate capacity of 50 lines, a building of internal dimensions of 9 ft. x 9 ft. is sufficient for all the plant. A typical plan layout is given in Fig. 3, while Fig. 4 gives a layout for a 200 line, mechanical operator type as installed at Mt. Eliza.

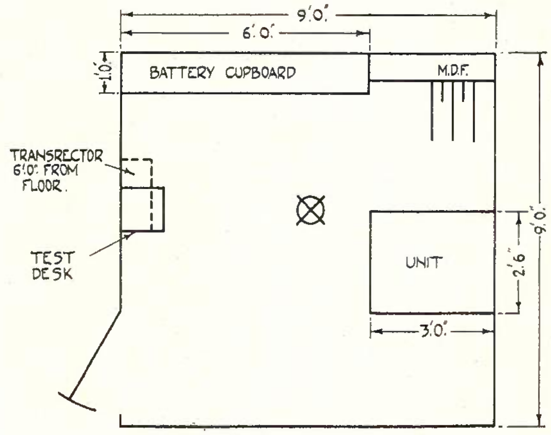


Fig. 3.—Macedon Plan Layout.

With regard to the type of material of which the buildings should be constructed, the erection cost, appearance, resistance to fire and the maintenance costs are all considered in the light of the particular site selected. Favour has at present swung to the fibrous cement and

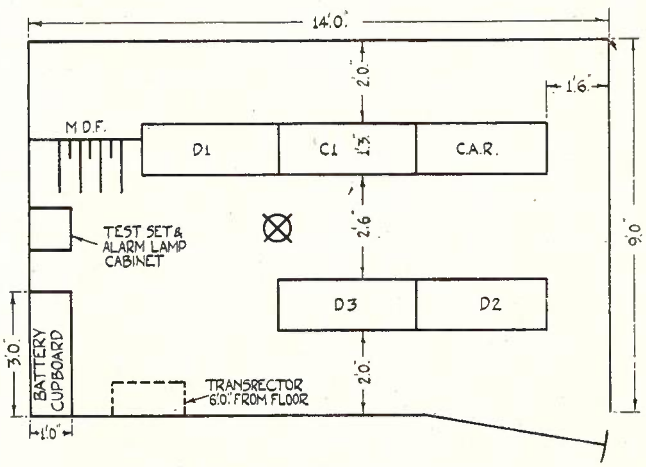


Fig. 4.—Mt. Eliza Plan Layout.

weathered iron types of building owing to the good appearance coupled with reasonable erection costs of these types. Fig. 5 shows the Kallista structure which is of weathered iron.

Power Supply.—This is one of the important problems that has to be faced in R.A.X. installations. The most convenient and economical arrangements are possible when local A.C. is available, where a single 30 A.H. battery charged

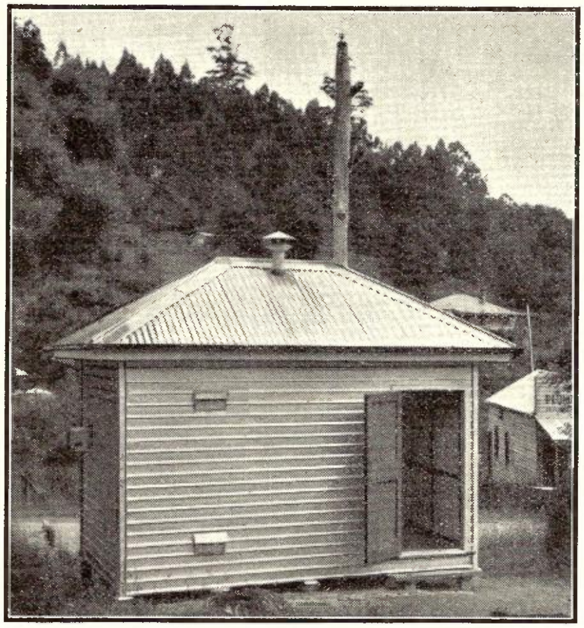


Fig. 5.—Kallista R.A.X. Building.

by a transrector is used (see Telecommunication Journal, Vol. 1, No. 1, page 20). The only alarm necessary in this case is an A.C. power failure alarm.

When the local supply is D.C., 2-70 A.H. batteries are necessary, with some form of control for changing over the batteries when the one on load gets below a predetermined voltage limit, and also for switching off the mains from the fully charged battery. An alarm system is also necessary to indicate that the change-overs are proceeding satisfactorily and that the exchange is not left with two flat batteries.

Where no supply of any type is available at the R.A.X., charging over the trunk line is employed in some cases. This can be done when the supply is either A.C. or D.C., a rectifier being necessary at the parent exchange in the former case to convert to D.C. and a resistance in the latter case to limit the current to the required value. The maximum voltage fed to the line is 150 volts, and the present standard is to charge cailho over the trunk line. A relay set at each end allows the charging to proceed when no demand is made on the trunk. With a call either way the relay sets automatically disconnect the charging circuit for the duration of the call, connection being re-established when the line is again clear of traffic. A typical manual and auxiliary circuit is given in Fig. 6 illustrating this feature.

The line circuit is normally terminated in the winding of the repeating coil with the condenser in the split. The ringing signal of an incoming call drops the indicator and on an outgoing call the insertion of the plug connects an earth through the dial key to the negative leg of the line to establish the call at the R.A.X. The dial is connected by the dial key and impulsing takes place over the single wire circuit. When the batteries are to be charged the "charge key" is thrown and if there is no plug in the jack a circuit is completed for relay A, the charge indicator circuit being opened at contact A2, the circuit of F closed at A4 and relay B connected to the positive leg of the line at contact A3. The switchboard is isolated from the line at contacts F1 and F2, and F3 shorts the indicator to prevent condenser surges falsely indicating a call. If the circuit at the R.A.X. is normal, battery is available to operate relay B which closes a holding circuit for its second winding over contact B2, and opens the circuit of relay A at B3. Contact A1 falling back closes the circuit of relay C and contacts C1 and C2 connect the two legs of the line in parallel to the power supply circuit over relay B. Contact C3 connects relay E but the circuit is immediately broken by D1 and as E is slow to operate it does not pull up. When the charge is on, relay D is held over the charging circuit and relays B, C, and F are energized with the charge indicator also up.

If now a call originates at the R.A.X. the circuit of relay D will be broken and at contact D1 it connects relay E to the charge start lead so that this relay energizes and locks over contact E2. Contact E1 opens the circuit of relay

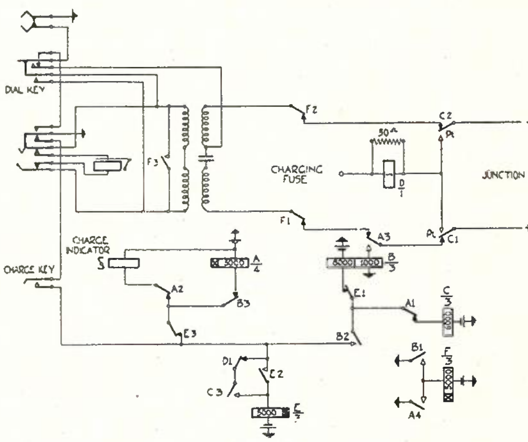


Fig. 6.

B and E3 opens the circuit of the charge indicator. C releases and after a delay relay F drops back and connects the line to the switchboard circuit so that the call can now proceed normally. When the telephonist answers, the removal of the earth at the jack releases relay E, so that when the jack is unplugged at the end of the call the power connecting sequence is automatically set in motion. The resistance of the line limits the charging rate and in some instances precludes the use of the system.

The scheme is prone to electrolysis trouble since the very low earth resistance of the cable system tends to concentrate current on the underground cables. There is also the maintenance of the relays to be taken into account and the difficulty of retaining satisfactory contacts with the frequent breaking of the charge circuit by incoming and outgoing calls.

Petrol electric sets have been used and consideration has been given to wind lighting plants and carrying the batteries to and from a central charging plant. Experience may prove that combinations of these schemes are desirable.

The types of charge control in use at present for the purpose of starting and stopping battery charges at the correct times are, firstly, the relay type, secondly the ampere hour type, and thirdly the contact voltmeter type fitted with a thermal delay.

In the relay system the charge circuit is controlled by a relay, the operation of which is adjusted by a resistance in series with the winding or a micrometer control for varying the spring tension. The adjustment is affected by changes in temperature, air conditions, etc., and as it might operate on surges, special precautions are necessary to avoid irregular operation due to mains voltage fluctuations and battery voltages lowering when the ringer starts.

With the ampere hour meter control, by means of a differential slipping cam arrangement, the needle of the instruments move more slowly when the battery is being charged than on discharge, and consequently an allowance is made for the loss in the charge-discharge cycle. The amount taken from the battery can be regulated by altering a cam which operates a contact of the battery change-over relay, and hence allowance can be made for old or new batteries. This system has proved satisfactory in service.

Contact voltmeter control with thermal delay to prevent operation due to surges are used in some of the later deliveries. These should prove even better than the ampere hour meters, as it is the voltage which is the correct limiting factor in the efficient operation of the R.A.X. equipment.

Types of Lines.—In country districts, owing to the low actual telephone density, lines are on the average much longer and extensive private construction exists. Some of these lines, while being reasonably satisfactory for local battery working, are not always suitable for automatic working. The types of subscribers' lines encountered are:—

(a) Metallic circuit exclusive service.
(b) Metallic circuit party lines.
(c) Single circuit exclusive service.
(d) Single circuit party lines.

The metallic circuit exclusive service offers no difficulties if in good order. Bad joints very often have to be cut out of the privately erected lines, clearing needs to be done in some cases, also straining between spans. It may not cause much annoyance or inconvenience on a local battery line if the wires swing together in rough weather, but it has to be remembered that if that line is made automatic, a train of switches is set in operation every time a momentary short circuit is put on the line, the ringer is started and much extra wear and tear on the switches and batteries result.

An interesting dialling circuit has been incorporated in one of the recent deliveries of equipment which provides for reliable dialling on lines of low insulation resistances.

As is seen from the circuit in Fig. 7, the desired effect is obtained by the addition to the

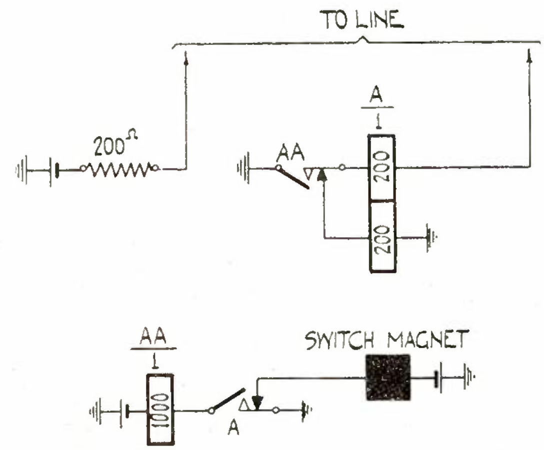


Fig. 7.—Impulsing Circuit for Low I.R. Lines.

normal impulsing circuit of Relay AA, which operates via a make contact of A relay, and in so doing opens the circuit of one winding of the latter. Thus the impulsing relay, although energized by its two windings, is only held by one and, therefore, releases more readily when the dial contacts open. This is a great aid on lines of low insulation where the tendency is for the switch magnet to receive "light" impulses, due to the impulsing relay holding up to the low insulation loop. Tests taken on equipment provided with the above circuit indicated that with a 350 ohm loop, reliable operation of exchange switches was obtained with 3500 ohms in shunt across the line.

The party lines fall into two groups, two or three parties and four to ten parties. In dealing with the two or three party line, metallic code ringing is used, an extra digit being dialled to discriminate for the party required. For calls between parties a reverting number is dialled which throws clear all the exchange apparatus, except a busying relay, and ringing is then done by hand generator. One of the main problems with party lines is to give discriminating meter-

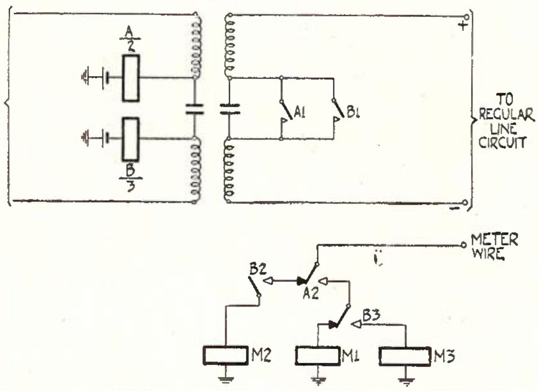


Fig. 8.—Party Line Metering—Schematic Circuit.

ing against the calling party and this is obtained by the separate parties calling on either "A" or the "B" side of the line to earth, the third party calling between earth and the both sides. Figure 9 shows a typical auxiliary circuit arrangement at the R.A.X. which illustrates the method of obtaining the discriminating metering for each party. In the full circuit other relays are included but Fig. 8 gives the principles employed. If party X is connected across the line with the dial in circuit from the positive line to earth and a condenser in the loop then on lifting the receiver only relay A would operate and accept the impulses which would be passed to the normal line circuit over contact A1. The metering impulse when received would operate meter M1. Party Y would be connected with a condenser in circuit across the loop with the dial from the negative line to earth and relay B would direct the metering impulse to meter M2. Then party Z has the dial circuit taken from earth to the mid point of the bell coils which are direct across the two lines, so that when the receiver is lifted both relays A and B operate and meter M3 receives the registering impulse.

For party lines with more than three parties the operation is substantially the same from the subscriber's point of view except that he prefixes all directory numbers by "O." Special dials are fitted on the party line phones which have an adjustable cam that can be set to operate on any particular impulse. In dialling the initial prefix "O" that particular impulse is "blanketed" out on one side of the line and a uniselector in the exchange auxiliary equipment is thereby

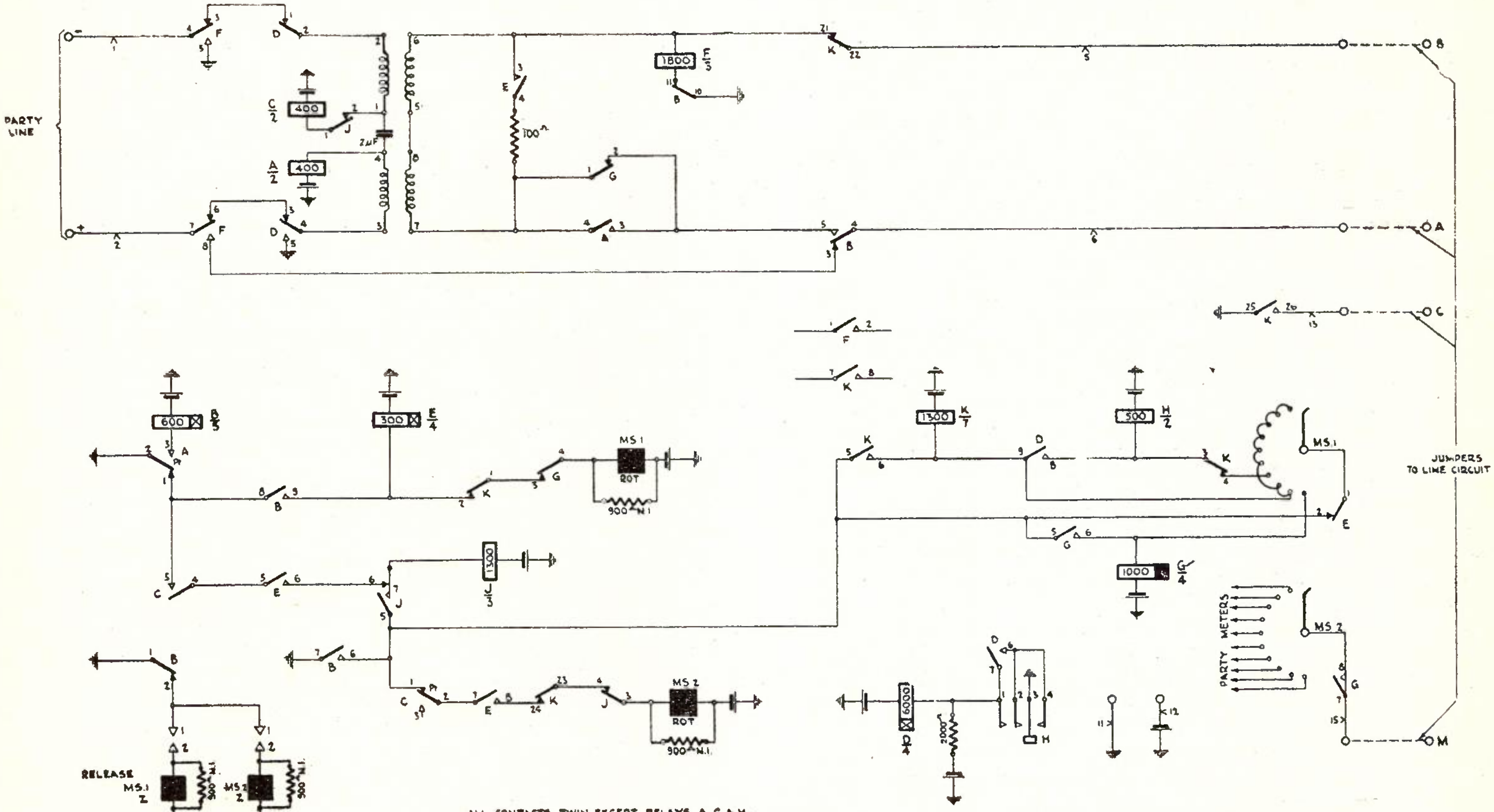


Fig. 9.—Party Line Auxiliary—2-10 Parties Incoming Call.

stopped opposite the particular meter lead required. The circuit is designed so that the subscriber does not get service unless the prefix is dialled. The circuit of the R.A.X. Auxiliary is given in Fig. 9, a brief description of the operation being as follows:—

(a) **Seizing the Line Circuit.** — Ground is closed over both sides of the line, from the calling party's telephone, closing A and C. A closes B, closing a loop circuit, through the transformer seizing the regular line equipment.

(b) **Recording the Calling Party's Number.**— When the preliminary "0" is dialled, relays A and C follow the impulses from the dial, and MS1 steps to the 10th position. On the "blanketed" impulse C remains operated while A releases, thus closing the circuit for J, which operates and locks, opens the MS2 rotary circuit and removes a multiple short circuit from the repeating springs of A. G operates when E restores, thus preparing the register circuit. The succeeding operations follow as in an ordinary call.

Outgoing Call.—Battery is closed over the negative side of the line from the mechanical operator closing F. Ringing current is thus sent over the positive side of the line through contacts of F returning to ground at F5.

Reverting Call.—A, C and B are closed as in (2), the party dials "7" stepping MS1 to the 7th contact. E operates during dialling. When E restores relay H operates. H closes D removing A and C from the line and closing ground to A. K is closed, opening H. H is a vibrating type relay holding D operated. K opens the loop and releases the mechanical operator, but holds the L and K relays in the line circuit to give the busy condition. The calling party now codes the ring of the desired party on their line with the hand generator.

Single circuit exclusive services present no difficulties, a typical circuit which is successfully used being illustrated in Fig. 10.

An originating call energizes relay A in an earth circuit which for the metallic section (if any) of the line has the two legs in parallel. The impulses are transmitted to the normal line circuit over contact A1. On an incoming call the ringing signal passes over the condensers in turn, the connections to the mid point of the transformers in the metallic portion of the line having no effect.

For single circuit party lines there is at present no circuit available to give discriminating metering and a common account for local calls must be rendered.

The same general principles as above apply to trunk lines, with the exception, of course, that no metering is required. A ring-off signal, however, is necessary when the R.A.X. subscriber hangs up and an auxiliary circuit at the R.A.X. is necessary to provide this facility. A typical circuit which provides for a double reversal ring off is given below in Fig. 11. In this circuit a

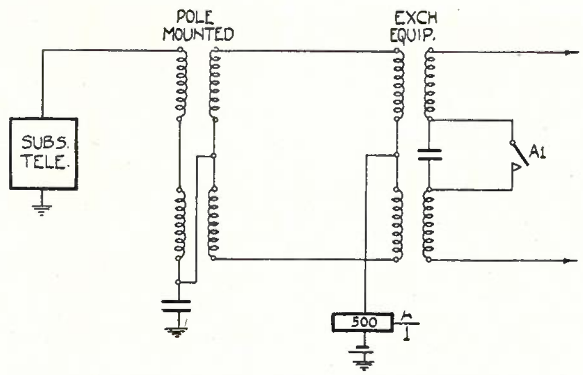


Fig. 10.—Single Lines—Circuit Arrangements.

ring off occurs when the R.A.X. subscriber is the originator or receiver of the call.

The circuit depends for its operation on the fact that relay JS operates whenever the trunk line circuit is used for calls in either direction, and when JS releases it reverses the line and the indicator will receive a kick. JR then releases and again reverses the line to give another pulse to the indicator.

Extension of Alarms.—When a fault condition occurs, an alarm relay is operated and if the trunk set aside for the extension of alarms is free, a call is made to the line. The operator on answering hears a tone combination which tells her what type of fault has occurred. The alarms transmitted are P.G. alarm, fuse blown, release failure, ring fail, mains supply failure and battery change over. The alarm systems

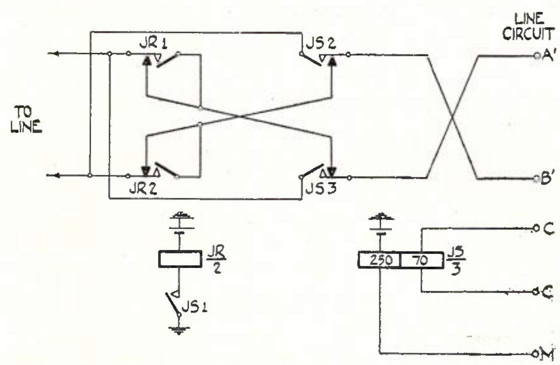


Fig. 11.—Magneto Junction Line—Auxiliary Circuit.

are so designed that urgent faults, such as fuse, ring fail or release failure, take preference over battery change over or P.G.'s. If more than one urgent fault is in at the same time, preference is given to the fuse alarm and ring fail alarms when checking back on the fault test number for the tone combination.

Test sets are provided at the R.A.X.'s for testing line conditions and routine testers are provided where necessary to routine the exchange equipment. Test selectors ar provided in the later types of R.A.X., the mechanic can dial any number from the parent exchange and perform tests which in many cases would obviate a visit, e.g., with a P.G. alarm coming in the mechanic can ascertain which line caused

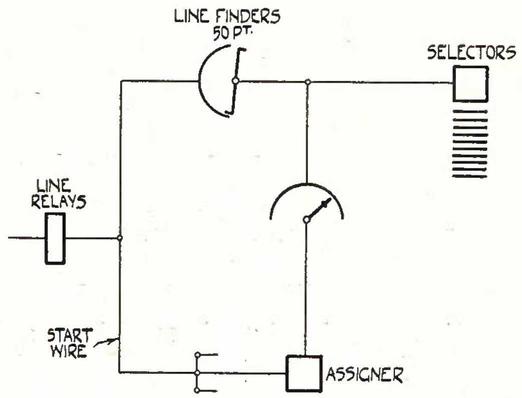


Fig. 12.—"Straight" Trunking Scheme (100 Lines).

it. In the 50 line type of exchange in which there are all uniselectors and no bimotional switches, the mechanic dials the lowest exchange number, and without releasing can dial successively to step the switch over the whole of the exchange lines.

Trunking Schemes

Figures 12, 13 and 14 are typical trunking diagrams of different systems in operation. That shown in Fig. 12 is applicable to a 100 line installation with two groups of 50 lines connected to 50 point uniselector line finders. In each group a common start wire gives a start signal to the assigner which is a relay set with a uniselector for selecting a free selector—line finder circuit. The finder rotates to pick out the calling line and having established the connection from the line to the selector the assigner is released. The dial tone is now received by the caller and the impulses set the selector to give the desired connection.

Fig. 13 shows the "mechanical operator" trunking system in which the assigner picks out one of two or three mechanical operators. The operator is connected by the "Connector Circuit Finder" to a Final Selector—Line Finder circuit. The bimotional finder steps vertically and then rotates to pick out the calling line. The assigner is then released but the mechanical operator is retained and sends out the dialling tone over the line finder connection. The impulses set the Final Selector and are also re-

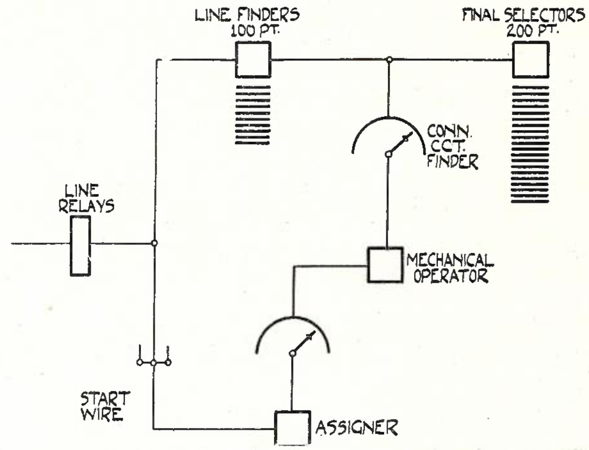


Fig. 13.—"Mechanical Operator" Type Scheme (200 Lines).

ceived by the mechanical operator on uniselectors for determining party line coding, manual board, public telephone requirements and the equipment associated with these facilities can be placed in the two or three operators instead of in each of the selectors. The ringing current and tones, and in due course the metering impulse are sent out from the operator. When the called subscriber answers and the metering is effected the connection is established over the simple circuit of line finder and final selector, and the mechanical operator is released to become available for setting up other calls.

Fig. 14 is a trunking scheme applied to 50 line exchanges and has many points similar to the system just described. Only uniselectors are

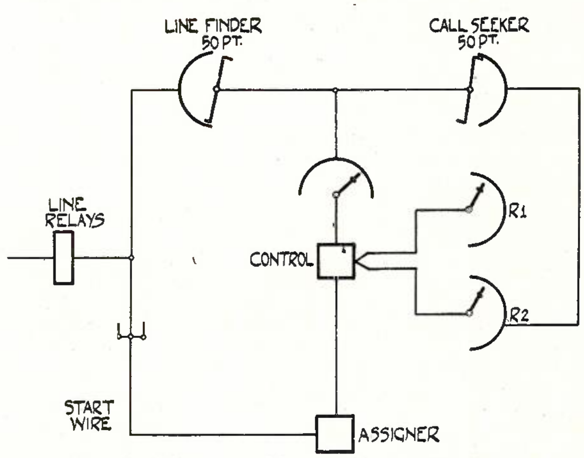


Fig. 14.—"Control" Type Scheme (50 Lines).

employed. The assigner selects a control which in turn finds a free line finder—Call seeker circuit. When the calling line is picked up by the finder, the assigner releases and dial tone is sent out from the control circuit which receives the dialled impulses to set switches R1 and R2. There is a bank multiple between the call seeker and the R2 switch and when the latter has been set by the dialling, the call seeker is operated as a finder to pick up the setting of R2 and connect with the wanted line. Ringing, tones and metering are set up by the control circuit and when the called subscriber answers the connection is established over the simple circuits of line finder and call seeker, all the other more complex circuits being made free for use by other callers.

Tandem Trunking.—At Somerville and Tyabb R.A.X.'s, which are in the unit fee radius of each other, calls between these exchanges are routed via the common parent exchange, Frankston, thereby using two junctions and increasing the transmission equivalent. Action is contemplated in this and similar cases to introduce interdiallling to provide direct access between the exchanges.

This does not involve multi fee metering, which will of course be necessary for full auto. working between exchanges more than the unit fee distance apart. These phases must form the subject of later articles on this very interesting subject.

RECENT DEVELOPMENTS IN TELEGRAPH EQUIPMENT

S. Marks

The main developments in Telegraph systems and equipment seem to be mostly in connection with new types of repeaters, teleprinter services, rack mounting, Voice Frequency systems, changes in equipment, and better testing facilities. A brief review of the position will be attempted, sufficient, it is hoped, to indicate the trend of the developments.

To provide manual Duplex facilities at country centres a very compact arrangement has been standardized and this was introduced first in New South Wales. A full description of the arrangements was given in the last issue of the Telecommunication Journal and readers are referred to that article should they desire further information. Suffice it to say that these compact installations not only occupy a minimum of space, but make full use of recent developments in Telephone practice and Power equipment.

There are many different types of morse repeaters in use in the various States, and the intention is to standardize on either modified types of Full Type or Half Type repeaters, depending, of course, on the circuit requirements. Figure 1 shows the circuit of this morse simplex "through" repeater utilizing 1000 ohms telephone relays with a make before break action on the relay springs. It has been found that the telephone relay retains its adjustments without alteration for long periods, and in this respect it is superior to the morse transmitter which it replaces.

The action can be traced as follows: The down station when opening the circuit preparatory to sending signals, causes the 150 ohm relay to release and open the circuit of the 1000 ohm M/B relay of the up station. (a) The latter opens the line on the up side of the repeater and (b) maintains the closed circuit condition of the 150 ohm relay of the up side of the repeater. The latter remains on closed circuit as it was before the "up" line was opened, and the local circuit maintains the closed circuit condition of the M/B relay on the down side, so that the original opening impulse from the down station cannot be returned in the down station direction.

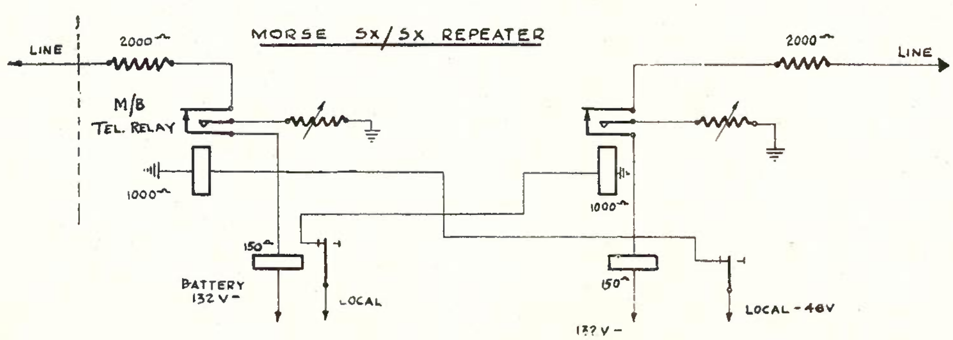


Fig. 1.

The morse/V.F. repeater is shown in skeleton form in Fig. 2 and the Duplex/V.F. repeater in Fig. 3. A higher speed machine system repeatered from the V.F. system to a physical line would use a repeater on the lines of the last figure, but equipped with signal shaping devices.

Teleprinters

The development in Teleprinter services is being steadily maintained and new problems are constantly being met in meeting the different service requirements of the lessees. The following are the main developments:—

The circuit shown in Fig. 4 which was developed to meet the requirements of a particular case provides simplex teleprinter transmission in either direction over a single composite line. The advantage to be derived from the use of this circuit lies in the fact that a good balance is not necessary and consequently the attention of a skilled operator is not imperative. Only one line is required.

On the other hand, with this circuit an undesirable feature is that the provision of signalling voltages and the installation of the relay set at the lessee's premises is necessary.

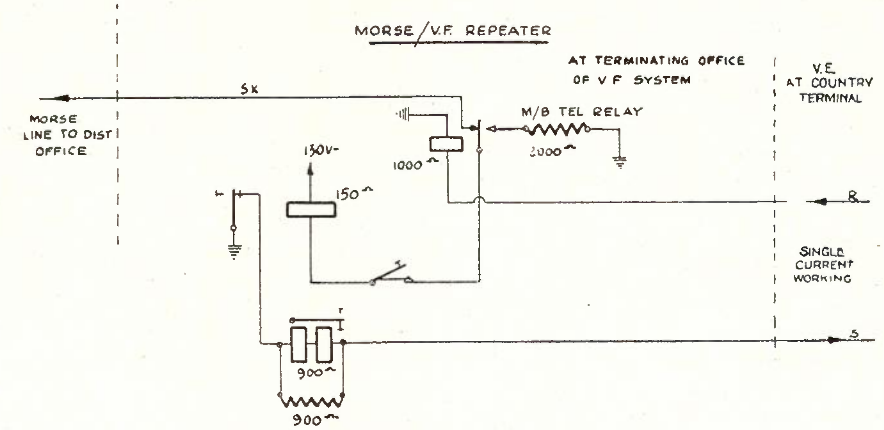


Fig. 2.

Figure 5 shows a teleprinter simplex circuit utilizing three wires to the subscriber's premises, retaining battery supplies at the C.T.O.

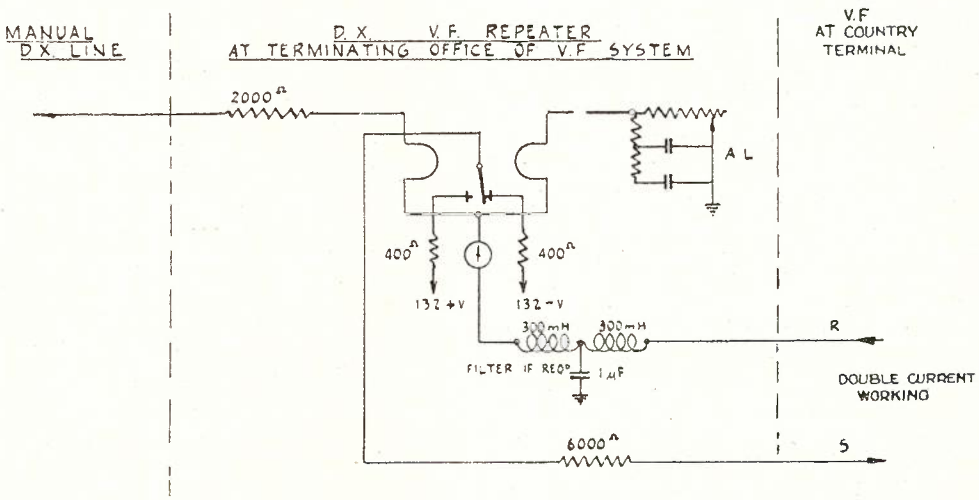


Fig. 3.

In this circuit use is made of the teleprinter send-receive switch to connect the receiving magnet to the receiving relay or teleprinter transmitting tongue respectively when receiving or transmitting signals over the line.

Fundamentally, the circuit consists of a simplified composite duplex set with a very simple form of balancing network. The use of this simplified balance is possible because the receiving teleprinter magnet is disconnected from the receiving relay when transmission is in progress, and as a consequence a faulty balance does not affect the home record reception. The advantage to be derived from the use of this circuit lies in the fact that a good balance is not necessary and consequently the attention of a skilled operator is not imperative. Only one line is required.

and obviating the necessity for exact balancing. By means of the send-receive switch the teleprinter receiver is connected to the tongue of the home record relay whilst transmitting and to the tongue of the duplexed receiving relay whilst the station is in the normal position for receiving.

Calling in and Switching Facilities.—At lessees' main offices where the number of terminating teleprinter loops exceeds the number of teleprinters installed, calling in and switching facilities are provided. Figure 6 shows the arrangements for an installation comprising one printergram service and one local point to point service. At the lessee's main office a key is provided which enables the operator to switch either loop through to the teleprinter. When a

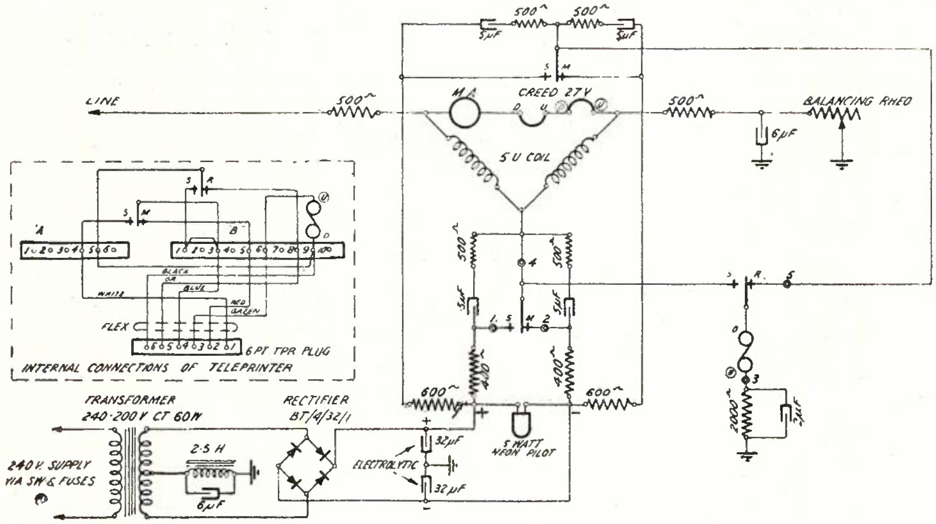


Fig. 4.—Modified Teleprinter Terminal.

loop is disconnected from the printer, its receive leg is connected through a drop indicator (a) and copper oxide rectifying unit (b) in series to earth. The rectifier is so arranged that it will pass current when spacing battery is applied and therefore when marking battery is applied—the normal at rest condition—the indicator remains unoperated.

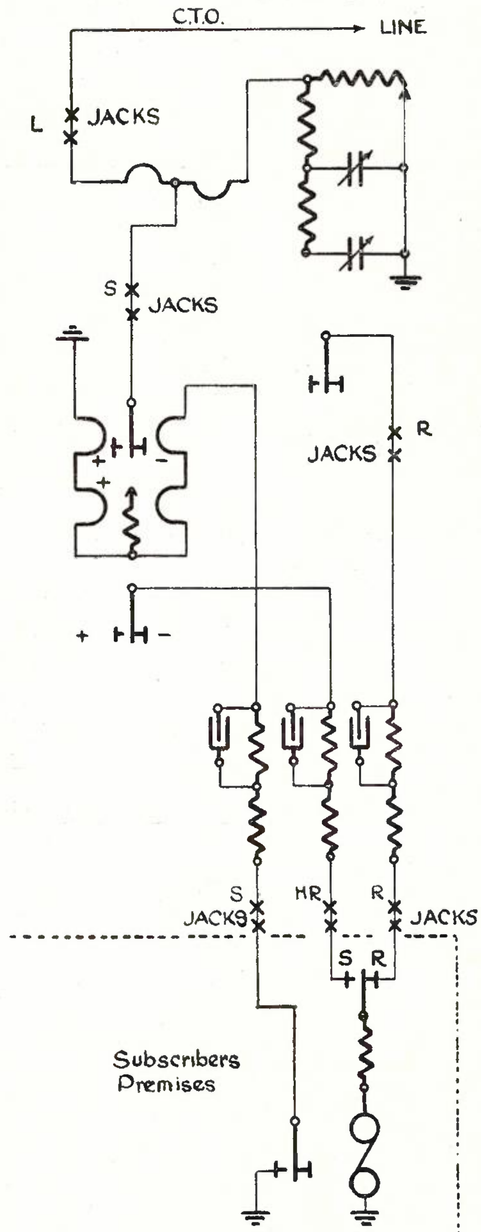
Immediately a key is depressed at the distant teleprinter, the relay at the C.T.O. is operated, spacing battery is applied and the indicator is operated closing a buzzer alarm circuit which indicates to the operator that attention is required. Switchboards of this nature have been supplied for several services and the rectifier element used in this manner has greatly simplified what would otherwise be a complicated calling circuit.

Test for Distant Termination.—As printergram installations must be regarded as urgent services, in the foregoing circuit a special test facility is provided at the C.T.O. for testing the termination at the lessee's main office when the "Who are you?" response is not received and to enable prompt action to be taken to dispose of the traffic otherwise should a faulty condition have developed. This facility is made necessary because:—

(a) The "Who are you?" response from the distant end is normally regarded as an indication that the transmission may proceed, and failure to receive this "Who are you?" response is taken as an indication that a fault condition exists.

(b) If the teleprinter at the lessee's premises is connected to the local point to point service, the operator at the C.T.O. will not receive a response to the "Who are you?" signal, although no fault condition exists.

The testing equipment consists of a shunted relay (C) in series with the receiving leg. When



TELEPRINTER LONG DISTANCE SIMPLEX WITH HOUSE RECORD.

Fig. 5.

its contacts are closed, the circuit of a lamp at the operating position is prepared and this circuit is completed by the operator operating a push button. By this means, the operator is able to determine the termination of the loop at the lessee's premises, a glow indicating that the teleprinter is connected to the loop. This addition has proved very effective and convenient in practice. The arrangement is shown in Fig. 6.

Isolation of Loops for "Who Are You?" Tests.—Where more than two terminals are connected to one service, as obtains in the Weather Bureau circuit, the "Who are you?" test is not effective unless steps are taken to isolate the distant teleprinter under test by disconnecting the other receiving loops. Where required, this facility is provided by means of relays operated over additional loops by the switching of a non-locking key. When a receiving leg is disconnected at the contacts of the relay a marking current is applied to hold the disconnected teleprinter in the at rest condition. Figure 7 shows the arrangements.

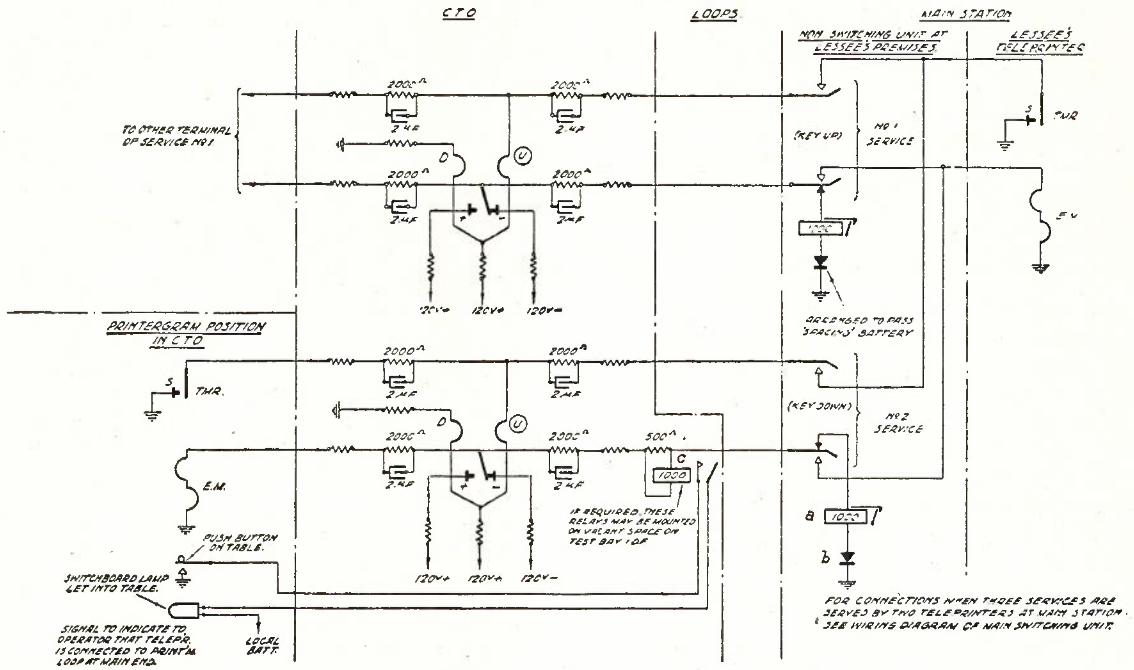


Fig. 6.

With regard to teleprinter machine developments, the following items are considered worthy of notice:—

Sprocket Feed Carriages.—Certain lessees of teleprinter services use printed forms on which the positioning of the printed matter is most important. Using carriages with ordinary rubber platens, it was practically impossible to maintain a perfect relationship between the forms in the teleprinters at the two ends of the service because of a slight variable slip between the paper and the platen which occurs when the vertical feed is taking place. To overcome this difficulty, Creed & Co., have designed a teleprinter carriage fitted with a sprocket feed platen. This platen consists of an aluminium shell with positioning pins at each end. The paper forms are prepared in a fan-fold and are perforated to coincide with the pins in the platen, the relationship between the perforations and the printed matter being specified. The installation of this type of carriage has overcome the difficulties associated with the feeding of the paper which were previously experienced.

Increase in Mass of Starter Weight.—With the teleprinters as originally supplied, considerable trouble was experienced due to the starter weight failing to operate the starter switch unit when it was released. A failure of this nature rendered the teleprinter inoperative and interrupted the service until rectified. Following on representations to Creed & Co. by the Department, the mass of the starter weight was considerably increased with the result that a switch operation failure is now almost impossible. It might be added that, due to the accelerated wear which this increase in weight occasions, the switch now sometimes fails to cut off, but under these conditions the motor is running continuously and although a fault condition exists, the service is not interrupted.

Stroboscope for Checking of Teleprinter Motor Speeds. — As neither accurate nor continuous speed checks can be made with the vibrating reed type of stroboscope supplied with the machines, a neon lamp type of stroboscope has been developed. By connecting the stroboscopic lamp to the 50 cycle, 230 volt A.C. supply, the motor speed can be readily adjusted to its correct value, i.e., 3000 r.p.m. by altering the governor spring tension until a white segment painted on the governor case appears to remain stationary. Where a 50 cycle A.C. supply is not available, the circuit shown in Fig. 8 may be used, in which case the neon lamp is controlled by the distant teleprinter transmission, and any difference between the motor speeds of the distant and home machines can be readily observed.

The extension of this method of speed observation to teletype and Murray systems is receiving attention.

Regenerative Repeaters.—In order to improve Teleprinter working over very long channels, some tests have been made with a Regenerative Repeater. The Regenerative Repeater must act in the nature of a receiver so far as the sending Teleprinter is concerned, and as a sender in relation to the receiving Teleprinter. The spacing of the segments on the repeater is therefore arranged on a basis intermediate between that of the Teleprinter transmitting cams and that of the Teleprinter receiving cams. On the 7C machines, which is our present standard, transmission corresponds to 7 equally spaced signal elements and reception to 6.5 signal elements. The segments on the regenerative repeater drum correspond to 6.8 signal elements. The tests showed that on any channel on which a repeater was necessary and distortion present, the insertion of a regenerative repeater in lieu of an ordinary repeater would increase the working margin. However, the speeds of the different machine cams at a transmission speed of 50 Bauds are:—

7C Teleprinter Transmitter	428.6 r.p.m. 140 millisecs. per rev.
Regenerative Repeater	441 r.p.m. 136 millisecs. per rev.
7C Teleprinter Receiver	461.5 r.p.m. 130 millisecs. per rev.

It will be seen that by the introduction of the Regenerative Repeater between the sender and receiver there is a theoretical reduction in speed between the two. Under practical conditions the operation of two Regenerative repeaters of the type tested, inserted in tandem in a circuit would render the speed adjustments extremely critical. An improvement might be obtained by using 7B Teleprinters where the transmission is equivalent to 7.5 signal elements with a cam speed of 400 r.p.m. Another method would be to use Creed automatic reperforators and tape transmitters at the repeating points.

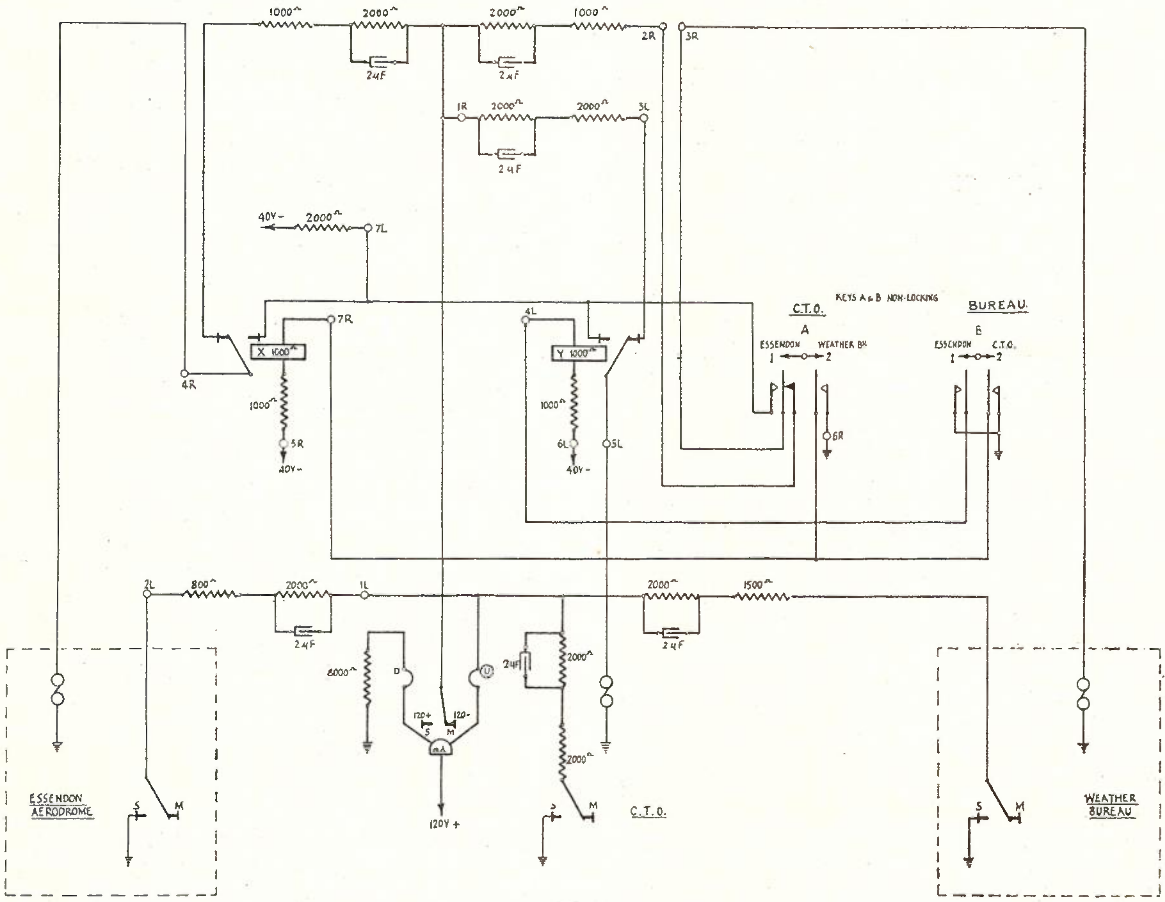
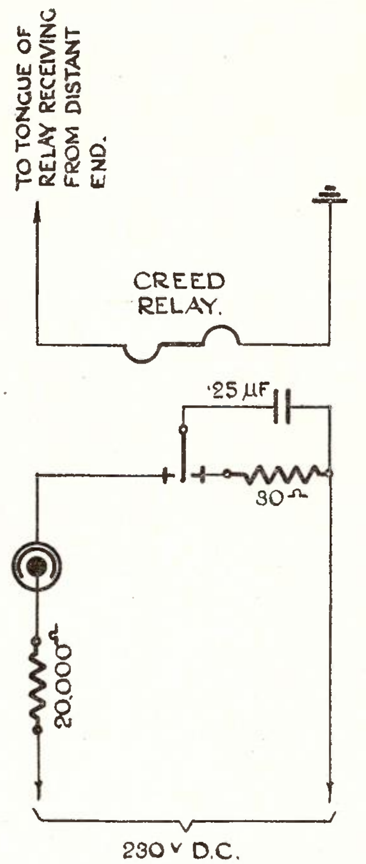


Fig. 7.

Telegraph Tape

It might be of interest to mention that during the hot months of recent years, difficulty has been experienced in some northern centres due to an absorption of moisture by the Murray transmitting tape during conditions of high relative humidity. The question of procuring a tape which will be suitable for use under these adverse conditions is receiving attention but, in the meantime, a considerable improvement has been effected by the provision of a heating element situated beneath the Murray Perforator tape chamber. The heating element consists of a small electric light globe mounted in such a fashion that the heated air, in rising, passes through the tape chamber with a resultant increase in temperature and decrease in relative humidity at this point.



TELEPRINTER STROBOSCOPE.
Fig. 8.

Cricket Broadcasts

Many were doubtless interested in the Cricket Broadcasts during the last visit of the Australian team to England and the telegraph arrangements which formed an essential part of the arrangement might be mentioned. Figures 9, 10 and 11 show the arrangements in the different C.T.O.'s for connecting carrier channels for morse working across the continent so that any one capital can be the transmitting centre and all other capitals receive the drop copy material. Each of the C.T.O.'s can send back to the transmitting centre R.Q. messages and all stations on the system can hear what is being sent. The transmitting point for the whole network was located in the Cable Company's office. The degree of success achieved by the entire organization responsible for the transfer of the cricket telegrams can be realized when it is stated that the average time of despatch of a cricket telegram from the scene of the match in England to the time of receipt simultaneously in broadcasting stations in the various capital cities was 1.9 minutes. The circuits used for terminal, intermediate station or transmitting station at each C.T.O. can readily be followed. From the C.T.O. the connections to broadcasting stations are by means of either morse circuits or telephone loops.

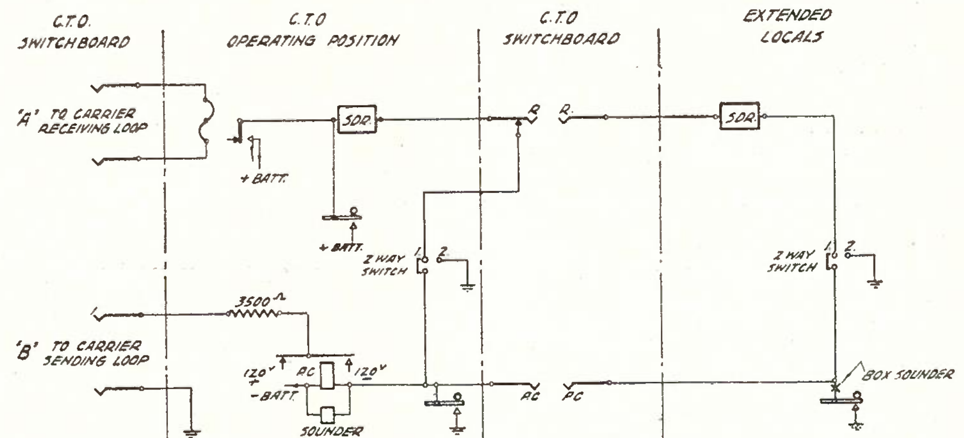


Fig. 9.
Drop Copy and R.Q. Telegraph Circuits over Carrier Channels (Terminal Stations).

NOTES: Circuit of arrangements at the terminal stations for the following conditions:—

1. When the station is the "receiving" terminal on the R.Q. line, and the "sending" terminal on the drop copy line, plug "A" to the R.Q. channel and "B" to the D.C. line, switch in position "1," except when it is desired to prevent the R.Q.'s going back over the D.C. line.
2. When the station is the "sending" terminal on the R.Q. line, and the "receiving" terminal on the D.C. line, plug "B" to the R.Q. line and "A" to the D.C. line, switch in position "2."

Voice Frequency Telegraphs—Terminations

The V.F. telegraph system has proved to be entirely satisfactory and additional systems are now being provided on several routes. The V.F. System was described by C. Anquetil in Paper No. 26, and we need here only consider the telegraph loops and terminations. Figure 12 shows morse simplex and manual duplex terminations for V.F. working, and Figure 13 shows the connections for Teleprinter operation. If a V.F. channel is extended beyond the V.F. system termination by means of a physical telegraph line, V.F./physical repeaters are necessary and some of these have already been mentioned.

Arrangements have been made to provide on future V.F. systems both double current and single current loop facilities which may be selected as desired, the change being simply effected at will by means of a switching key. Figure 14 shows the facilities and the loop circuit alterations effected. In order that the V.F. channels may be used to the fullest advantage as circumstances demand, it is necessary that it should be possible to switch any system

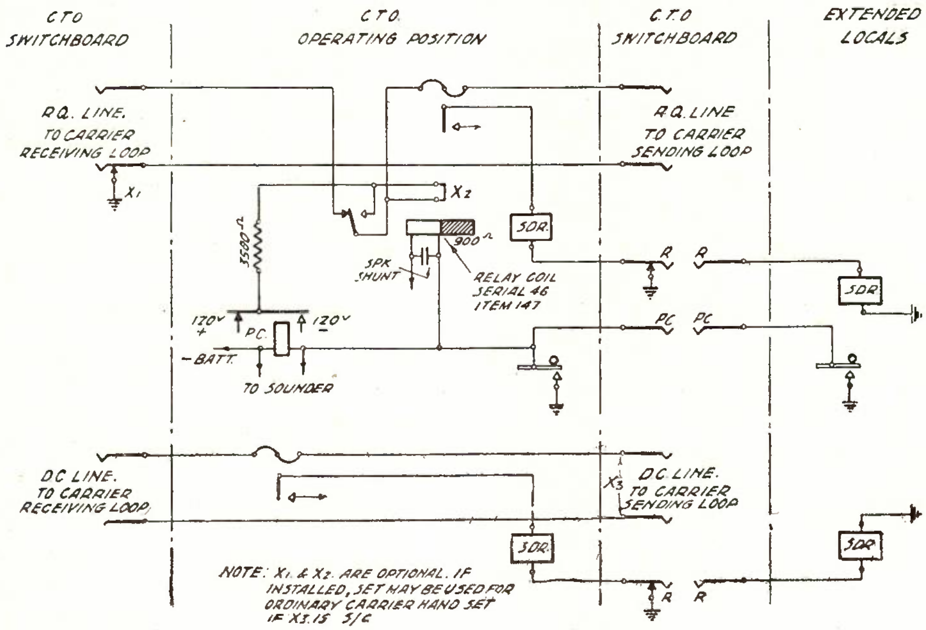


Fig. 10.
Drop Copy and R.Q. Telegraph Circuits over Carrier Channels—Intermediate Stations.

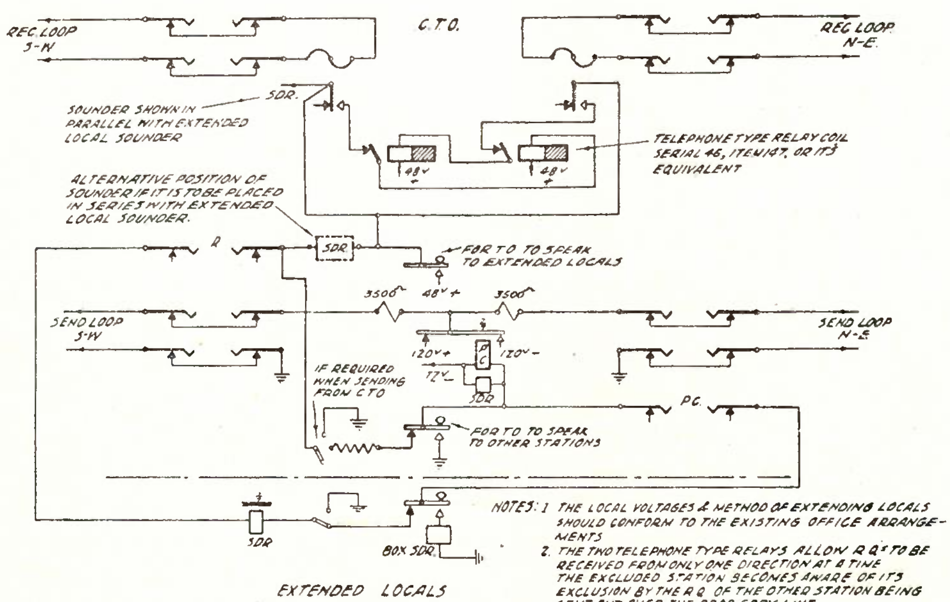


Fig. 11.
Hand Operated Drop Copy and R.Q. Telegraph Circuits over Carrier Channels. (Stations sending business and receiving R.Q.'s in two directions.)

within the speed capabilities of the channel into service as the incidence of the traffic and demands of the office may dictate. This means that any single current morse set, as well as

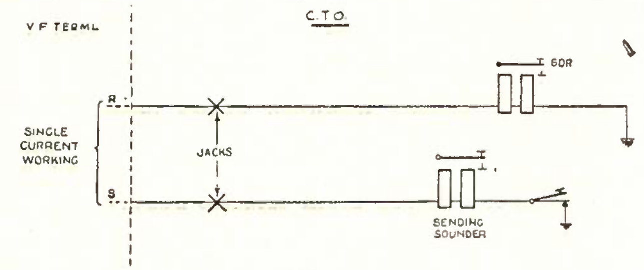


Fig. 12.

double current set, including teleprinter or other machine sets in the C.T.O., should be capable of working into a V.F. channel. The advantages of double current working for machine telegraphs on loops to carrier systems have been well proven and the V.F. systems follow the earlier telegraph carrier practice in this respect. Double current loop working enables high speed bias free signals to be passed between the telegraph machine and the carrier channel and equally balanced positive and negative impulses are vitally important on high speed systems. The earlier method of working carrier channels by means of single current loops and the relay electrically biassed by means of a local winding, was not entirely satisfactory as a bias was experienced owing firstly to varying conditions necessitating re-adjustments to the bias winding and secondly, under the best conditions the bias winding giving a bias to the tongue equal to the travel time of the single current sending tongue across its contact gaps.

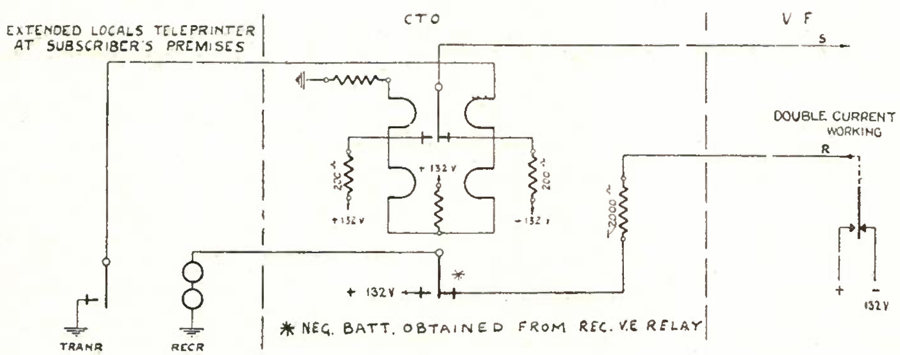


Fig. 13.—Teleprinter Long Distance Over V.F. System.

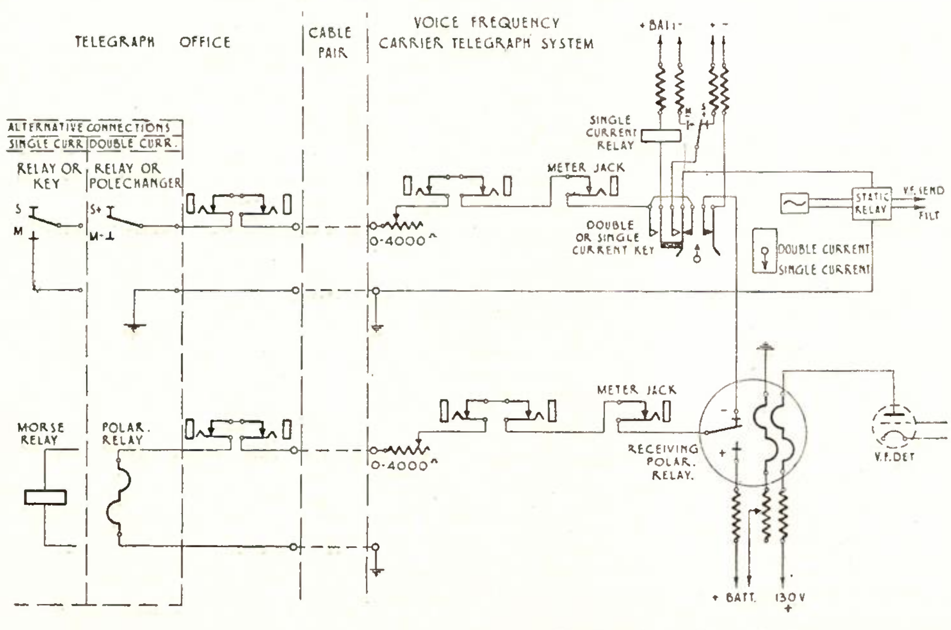


Fig. 14.—Telegraph Loop Arrangements—V.F. Carrier Telegraph System.

Indicator Lamp—Murray Perforator

Trials of an alteration in the mounting of Murray Perforator Indicator Lamps are at present in progress. The life of these lamps is relatively short and it is thought that their early failure is largely due to the vibration to which they are subjected during the operation and handling of the perforator. To eliminate this cause of failure, lamps have been mounted in the fixed perforator cover instead of in the perforator itself, as was the case previously. Although the tests are not yet complete, the results so far obtained indicate that a considerable lengthening of the life of the lamps may be expected.

No references have been made in this article to the new type of Conveyor Belts which are being developed, design of racks, and the jack and test circuits involved for teleprinter services, and other associated plant. These items are too large to cover in an article of this nature and it is better for them to be dealt with separately. I should like to acknowledge the assistance rendered by Messrs. F. E. Moore and S. T. Webster in compiling this article.

Broadcasting Station Maintenance

S. V. Hosken

From the mechanic's point of view, broadcasting provides an avenue of occupation which differs from that of telephony. Broadcasters require the full range of voltages including the low, medium, high and extra high, both rectified and alternating at low power frequencies, medium voice frequencies and the very high radio frequencies. Most of the equipment is at a dangerous potential. Safety devices are provided for the protection of personnel, in the form of interlocked enclosures and earthing switches to discharge high potential circuits.

With his various indicating meters and the programme monitor, the operator, like the doctor equipped with stethoscope, watches and listens for symptoms. He hopes for the best and expects the worst, and when the worst does happen it is usually a case in which he must act quickly in order to save plant or time. Most of the time which is available for maintenance duties is occupied on engines, rotating machinery, electron tubes, the water cooling system, contactors and the effects of dust. The dust imp creates a major problem, particularly at a station like 3 WV, which is situated in the Wimmera, where most of the country is ploughed, harrowed and fallowed every year. This dust is deposited in thick layers on the floors, in contactors and on the surface of high voltage equipment, including meters. Those meters which are in high potential circuits are effected by electrostatic precipitation to a much greater extent than others in low potential circuits. Cobwebs must also be removed from horn gaps and radio frequency circuits to prevent breakdown. A newly-spun cobweb is moist and conductive.

The effects of lightning are sometimes awe-inspiring. At one station a lightning discharge may cause an explosive report like a field gun, whereas at another station the noise may not be so prominent but the lightning may start an arc which develops into flames in a very short time. These arcs may quickly be quenched by opening the extra high tension circuit for a fraction of a second to cut off the power which sustains them.

Broadcasters of the national network of which there are 23, may conveniently be divided into two groups—metropolitan and regional. The metropolitan stations are situated near the capital cities of the Commonwealth to serve densely populated areas. The programme line between studio and broadcaster is comparatively short and free from interference hazards. During transmission practically the whole of the programme level control is in the hands of the studio control operator. Maximum reference level is determined by preliminary test between the studio and transmitter before each programme session begins. This test provides for appropriate levels to be sent simultaneously to the regional stations. The metropolitan transmitter is a master reference for the whole State. A telephone circuit provides direct communication between the studio and transmitter. The necessary power for transmitting equipment in this group is derived from electric supply mains.

Regional broadcasters are situated in the more densely populated country regions. The programme line is comparatively long and subject to variations in programme level and interference hazards such as electrical storms. Facilities are, therefore, provided at regional broadcasters for supplementary control of programme levels, and to provide local emergency programmes during interruptions or serious interference. A telegraph circuit is provided for direct communication between the metropolitan studio and regional operators. Where electric supply mains are not available such as at 2 CR, 3 WV, 4 QN and 6 WA, power for the regional equipment is derived from diesel engine-generator sets installed at the broadcaster.

The staff required at a broadcaster is determined by local conditions. Each staff consists of a Foreman or Senior Mechanic, and may include transmitter operators, control operators and diesel engine mechanics. The transmitter operators control the power and radio frequency equipment. The control operators are required to control the audio-frequency power levels at the end of a long programme line which may exceed 200 miles in length. The diesel engine mechanics maintain the engines, generators and power equipment.

It is necessary for transmitter operators to gain some knowledge of amplifiers, rectifiers, electron tubes, meters, etc., with their functions and operating conditions in a transmitter, in order to know by observing its various meters how the transmitter is behaving. Brief details of these items are given below:—

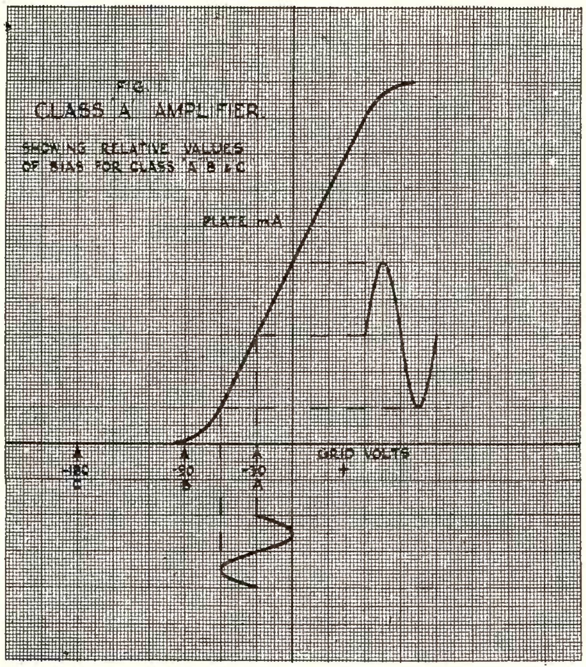
Amplifiers

A **Class "A" Amplifier** is one in which the output wave forms of the plate current are a true replica of the input grid volts. See Figure 1. In its static condition the grid is negatively biassed to the centre of its grid volts-plate current characteristic between zero grid bias and plate current cut-off. A steady plate current is indicated by the "DC" plate meter. In its dynamic condition the plate current alternates about its steady mean value and no changes are indicated by the "DC" plate meter: it remains at the steady current value.

Plate Efficiency, or efficiency of conversion

*Lecture delivered before the Postal Electrical Society of Victoria on 8th August, 1938.

from "DC" input power to audio "AC" output power is low, approximately 18 per cent. to 20 per cent. The greater part of the "DC" input power is lost in heating the plate of the tube; the plate circuit is non-resonant. Class "A" amplifiers are employed as high fidelity audio frequency voltage and power amplifiers and modulators. All audio amplifiers used by the Department operate under class "A" conditions. Their input grid circuits possess a constant high impedance due to running no grid current. They, therefore, offer a constant high impedance load to their preceding amplifiers.

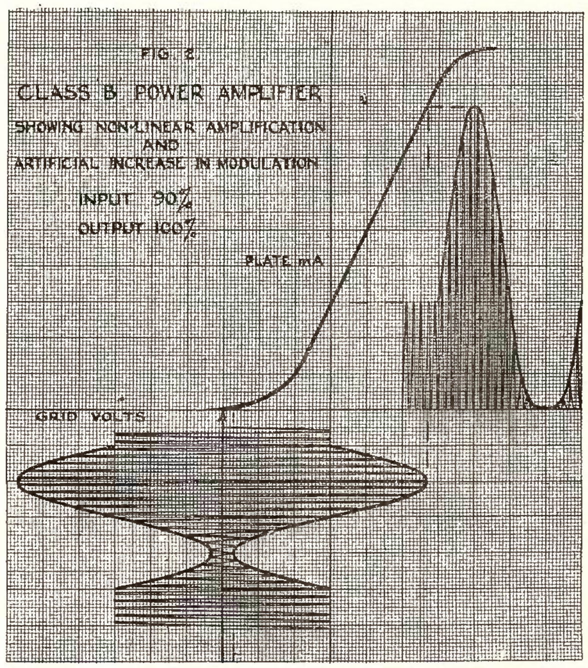


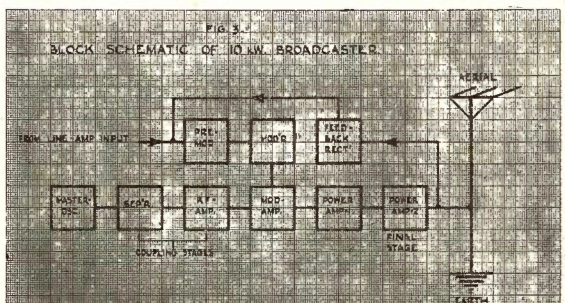
A **Class "B" R.F. Amplifier** is one in which the output power of the plate circuit is proportional to the square of its input grid volts. In its static condition the grid is negatively biassed near the cut-off point on its grid volts-plate current characteristic and practically no plate current is indicated by the "DC" plate meter (See Figure 2).

In its first dynamic conditions (carrier only), the positive excursions of input R.F. grid volts are of sufficient amplitude to drive the grid into the positive region and grid current flows. The "DC" plate meter indicates an average value of the plate current.

In its second dynamic condition (carrier plus modulation) the carrier input amplitude increases and decreases with the modulation envelope, causing the plate current to alternate about its average value at audio-frequency, and no changes are indicated by the "DC" plate meter. It remains steady during modulation.

The efficiency varies with operating conditions from rather low values up to 60 per cent. It should be noted that as efficiency is a variable quantity the highest can be attained only with maximum input or at the greatest modulation depth of 100 per cent. and with sine wave modulation. The wave forms of speech are complex and peaked, consequently the efficiencies attained in practice seldom exceed half that which is possible with sinusoidal modulation. A class "B" R.F. amplifier usually includes a tuned plate circuit which, by virtue of its pendulum action can supply both halves of a cycle after having received a comparatively short impulse from one tube. It is not essential, therefore, to employ more than one tube in order to complete the output cycle.



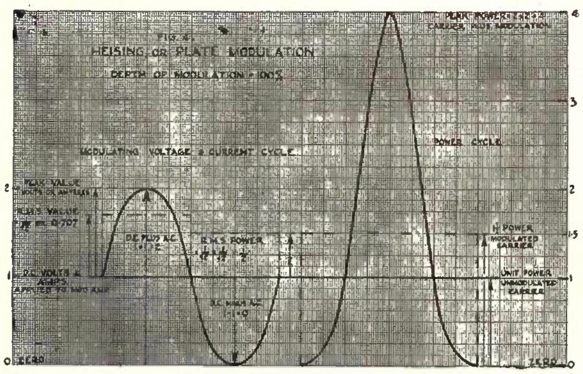


Two common uses of class "B" R.F. amplifiers shown in Figure 3 are:—

(a) As a separator connected to the output of a temperature governed crystal controlled master oscillator, in which position the amplitude of input R.F. grid volts is limited to a value which will not cause grid current. The grid circuit then offers a constant high impedance load to its preceding master oscillator. This limited operating condition is frequently referred to as class "AB."

(b) As an R.F. amplifier following the separator in order to sufficiently raise the carrier power level to fully excite a modulated amplifier. The separator and successive R.F. amplifiers are sometimes called coupling stages. Those class "B" R.F. amplifiers employed in cascade after a modulated amplifier to further raise the modulated carrier power to the rated aerial power are usually referred to as linear class "B" R.F. amplifiers, or briefly R.F. power amplifiers.

A **Class "C" R.F. Modulated Amplifier** is one in which the output power of the plate circuit is proportional to the square of the plate volts. In its static condition the grid is negatively biassed to approximately twice the value necessary for plate current cut-off (See bias points shown in Figure 1.) and no plate current is indicated by the "DC" plate meter. In its first dynamic condition (carrier only) the grid is driven hard into the positive region to cause plate current saturation. The "DC" plate meter indicates an average value of this plate current. The "DC" plate volts must not exceed the peaks of the "AC" audio output volts from the modulator in order to attain 100 per cent. modulation. Grid current flows by virtue of the grid becoming positive during part of each positive half



cycle. In its second dynamic condition (carrier plus modulation), the audio "AC" plate power from the modulator is dissipated in the resistive load of the modulated amplifier which is calculated from the "DC" plate volt amperes. Modulation is effected by the modulator's "AC" output power which is superimposed on the average "DC" plate power consumed by the modulated amplifier causing amplitude modulation of the output carrier power.

The modulation is an alternating component, and no changes are indicated by the "DC" plate meter, thus it remains steady during modulation. The grid current varies with the audio modulation envelope causing a variable load on preceding R.F. amplifier circuits. It is for this reason that the constant impedance separator is employed in order to separate this variable loading from affecting the master oscillator and thus prevent frequency scintillation during modulation. Grid swamping resistors also aid in swamping this variable load. Efficiency may attain 70 per cent. due to its resonant plate circuit and maximum excitation. The class "C" R.F. amplifier is rich in harmonic distortion due to the plate current being controlled during a part only of each positive half cycle of voltage on the grid, but the pendulum action of the tuned plate circuit maintains a nearly pure sinusoidal R.F. output. This method of modulation is called "Heising," or plate modulation. There are several modifications of the original Heising System. The class "C" R.F. modulated amplifier may be employed in a high level system as the final R.F. amplifier, where it requires comparatively large modulating powers or in a low level system as an intermediate amplifier where comparatively small modulators suffice.

In a fully modulated high level system the depth of modulation may be carried to the point of 100 per cent., but in a low level system the maximum depth at the modulated amplifier is limited by the equivalent non-linearity or curvature in subsequent power amplifier characteristics (See Figure 2). This non-linearity causes an artificial increase in modulation depth which may amount to 15 per cent. in which case the maximum permissible depth at the modulated amplifier would be 100 per cent. minus 15 per cent., or 85 per cent., any excess of which would cause over-modulation at the final amplifier.

The percentage increase in R.F. circulating current due to modulation is, therefore, less at the modulated amplifier than at the final amplifier. It is the peak value of the audio "AC" volts from the modulator which determines the actual depth of modulation (See Figure 4). During 100 per cent. modulation the modulator's "AC" peak volts will equal the "DC" plate volts on the modulated amplifier, the algebraic sums of the two will alternately amount to twice and zero during each audio cycle. When for an instant the sum of the voltages on the modulated amplifier is doubled, the current is also doubled, resulting in a quadrupled instantaneous peak carrier power output. Thus a 10 kW broadcaster may radiate instantaneous peak powers of 40 kW.

It will be remembered that the R.M.S. value of a sine wave is 0.707 of the maximum or peak, and as the peak voltage and peak current must each be multiplied by 0.707 to find their R.M.S. values, it follows that peak power would be multiplied by the square of 0.707 (which is 0.5). The R.M.S. power required from a modulator is, therefore, half the equivalent "DC" power consumed by the modulated amplifier to attain 100 per cent. modulation. This half power from the modulator is added to the unit carrier power, making a total of 1.5 times carrier power.

With this added power in the carrier, the aerial and circulating current R.F. ammeters would be expected to register an increase above unmodulated carrier values.

Power is proportional to I^2, but the meters are calibrated in I amperes, therefore, instead of indicating an increase by 1.5 times, they register the square root of 1.5 (which is 1.226) times carrier current during sustained sinusoidal 100 per cent. modulation.

With speech modulation, therefore, the instantaneous peak power may attain four times carrier power, but the average power may not attain 1.2 times. Which means that speech and sinusoidal modulations may equally attain a depth of 100 per cent., but the average increase in carrier power will not be so great with speech modulation. The aerial and circulating current R.F. ammeters are sluggish in operation, and will not register the equivalent current increases of speech modulation. Increases of only 1.05 times carrier current being usual in practice.

It will be observed that one criterion of good transmission is the active R.F. ammeter and the passive "DC" meter.

Inverse Feed Back

Some broadcasters employ the principle of inverse feed back, which by simply diverting into a rectifier a small amount of the output carrier power by means of an electrostatic potential divider improves the fidelity and reduces the carrier noise. This small power is then rectified to obtain the modulation component just as the detector does in a radio receiver, and this modulation component is then fed back in inverse phase or phase opposition into the input circuits of the premodulator at the audio input end of the transmitter.

All non-linear amplification and foreign modulation of the carrier such as "AC" ripple occurring between the input feed back point at the pre-modulator, and the output of the final amplifier are almost although not completely counter phased, resulting in a very high standard of transmission at medium cost. The counter phasing effect of the feed back is equal to a loss of 10 db in the depth of modulation which must be compensated for by a 10 db increment to the audio input level from the line amplifier to the pre-modulator.

Meters

The "DC" voltmeters and ammeters are usually of the D'Arsonval moving coil type and their scales are linear. The insulation employed in meters is not designed to withstand very high voltages to frame and the personnel, therefore, must be protected from any danger which may arise from contact with those meters.

Ammeters and milliammeters in high potential circuits are placed behind glass windows around which are earthed metal frames. Voltmeters across high potential circuits are connected to the earth end of their multipliers, and, in addition, a neon lamp is connected across the meter element. Then if the moving coil should become open-circuited and dangerous potentials develop at the meter, the neon is excited into operation to form an auxiliary path to earth, and remove those dangerous potentials from the meter.

The basic principle of R.F. ammeters usually depends in one form or another on the heating effect of a current in a conductor. The heat developed is proportional to I^2, but as the meters are calibrated in I amperes and not I^2, the scale is non-linear. Its calibrated divisions are close together at the zero end of the scale, and their distances apart increase toward the maximum deflection end. The maximum scale deflection of a thermo-couple type R.F. ammeter is limited to slightly more than three times its minimum readable deflection.

Electron Tubes and the Water Cooling System

Several types of electron tube are employed in a broadcaster. Their range extends from the small tubes of a few milliwatts output to the large water-cooled types rated at several kilowatts. High power tubes are costly items, exceeding £125 each and every care must be exercised to gain the maximum effective tube life, not only to prevent unnecessary costly wastage, but also to minimize those annoying interruptions to the transmitted programme caused by tube failures. Of the various characteristics possessed by an electron tube, two of them, maximum plate dissipation and maximum filament emission, are the immediate concerns of the operator.

In the first case, excessive dissipation will abnormally heat the plate, and soften the vacuum by releasing occluded gases from the metal electrodes. It has been possible to reharden the softened vacuum by operating the filament only at an effective emission temperature while the remaining electrodes are either open circuited or negatively biassed.

In the second case, the skill and attention of the operator can do much to minimize maintenance costs and annoyance. Each electron tube is designed to give a guaranteed life (which may be 1000 hours) for a given maximum emission at the maximum filament volts (as stated on each tube), but the plate volts, plate dissipation, and circuit functions determine the actual operating emission in terms of plate current. This operating emission is, in most cases, considerably below the maximum rating. It is, therefore, an unnecessary waste of tube life to operate such filaments at their maximum filament voltage.

The filament volts (and subsequent temperature and emission) should first be reduced to a point where the amplifier or rectifier output begins to fall. Then the filament volts, temperature and emission are again raised by that necessary increment which will ensure full output plus a small marginal factor to provide for variations which may occur. There must be no limitation of output power, nor slide back on peaks due to a deficiency in emission, otherwise distortion and poor regulation will occur.

When a tube has lost its effective emission it must be removed from service. On reducing the filament volts, however, the emission is reduced, and a point is reached where the space charge in the tube is also reduced. A higher velocity and kinetic energy is then imparted to the electron stream, causing an increase in plate dissipation and temperature. The plate volts, however, may remain constant.

One particular value of filament voltage is found to coincide with the highest dissipation, which may be sufficient to ruin the tube.

In the case of rectifiers, the input "AC" plate voltage will also rise above its normal value to the maximum or peak value. This increase in input plate volts imparts an added velocity to the electron stream.

In the case of grid current biassed oscillators a reduction in filament volts below a critical point also results in instability with the added danger that the oscillator may cease to function. Its "AC" output power would cease, and plate dissipation may become so excessive as to ruin the tube in a few seconds. It is essential that all amplifiers, rectifiers and oscillators are periodically examined to ensure optimum conditions and full output.

The evaporation of a filament is not equally divided over its entire length, and local acceleration may occur due to physical non-uniformity. Where it is possible, the filaments are observed during their initial heating (when first switched on each day), in order to detect hot spots. A hot spot is caused by a relatively higher resistance developing in a short section of the filament, and the filament does not heat uniformly. When a hot spot definitely appears, the effective tube life is at an end, for it may be only a matter of a few hours, or even minutes, before the filament will burn out. The affected tube should immediately be removed from service to prevent a possible interruption to the transmitted programme.

The water-cooled tubes, and their applied extra high tension are in direct contact with the cooling water which circulates by means of a motor driven pump. It necessarily follows that the specific resistance of the water must be maintained at a high value (not less than 10,000 ohms per cubic centimetre) in order to minimize current leakage, and its resultant electrochemical effect.

Free oxygen is liberated in the high potential end of the cooling system, and this oxygen causes a high rate of hose coupling corrosion near the water-cooled tubes. Zinc is eaten out of its brass alloy, leaving a spongy copper structure which collapses. The zinc, copper and dust particles contaminate the water; its specific resistance falls, and electrolysis is accelerated. The combined effects are cumulative. The zinc is precipitated as zinc oxide on to the earth potential hose couplings, resulting in a building-up process inside those couplings causing a constriction which, if permitted to continue, would eventually stop the flow of water. This precipitate must periodically be removed to clear the obstruction.

To reduce this corrosion of the high potential couplings, an iron cathode is submerged in the water reservoir. The liberated oxygen atoms freely combine with the iron and form iron-oxide on its surface. Large quantities of iron-oxide are thus rapidly formed in a thick layer which must be washed off daily, otherwise the chemical process would stop, the iron become ineffective, and the specific resistance of the water would rapidly fall. Some of the zinc-oxide and other foreign substances in the system are precipitated on the high potential plate of the tube, by electro-static precipitation. Cooling becomes less effective and the maximum plate dissipation of the tube is reduced.

The electron tubes are periodically taken out of their water jackets (weekly in most cases) and the precipitate removed by immersing the plates of the tubes in a solution of one part hydrochloric acid to six parts by volume of water. The precipitate disappears in a minute or so. When hard scale is formed, however, it may be necessary to remove this mechanically. Thermometers are installed with contacts which close and ring an alarm when the water temperature rises above a pre-determined safe value, usually 60 deg. C., due to some abnormal condition. Excessive water temperature may, in an emergency, be reduced by decreasing the extra high tension which subsequently reduces plate dissipation and output power.

The cooling fans are also reversible for hot weather conditions in order that they may drive the air through the radiators in the same direction as the prevailing wind. Stationary air is thereby reduced to a minimum.

Water flow contacts which become open circuited to cut off the power when the rate of flow falls below a pre-determined safe value are also installed.

Rectifiers

The output rectified voltage from copper-oxide rectifiers varies with seasonal temperature changes, being highest in summer and lowest in winter. Seasonal compensating adjustments are made to the applied "AC" voltage in order to maintain correct rectified output voltage. Owing to the many soft lead washers employed in rectifier units, the surface pressure acting on each rectifier element is reduced with time and the output voltage falls. This is corrected by tightening each unit.

Power Plant

The engines employed to drive electric generators are of the residual oil class diesel such as the Ruston-Hornsby type 6 VCR airless injector 6 cylinders vertical 180 h.p. 600 r.p.m. direct coupled to a 415 volt 50 cycle generator and a field exciter. These engines are started by air compressed to 300 lbs. per square inch.

Unlike the petrol engine, which takes into each cylinder a charge of combustible gas from a common carburetter, and thereby automatically power balances itself relative to the power in each cylinder, the multi cylinder diesel engine cannot balance itself. Each cylinder of the diesel engine possesses an independent fuel injector and spill valve to control the quantity of fuel injected. The fuel oil is first passed through a separator (like a cream separator) to remove its wax content. This fuel is then conducted from a nest of spill valves through a separate pipe to each cylinder.

In order to power balance the loading on all cylinders, a Pyrometer thermo-couple is fitted into each of the six cylinder exhaust pipes. Load is then switched on to the engine, and each spill valve is adjusted until all cylinder exhaust temperatures are equalized, thus ensuring that all cylinders are doing equal work. A well balanced engine is comparatively free from hunting, and consequent generator voltage fluctuation. The engines are completely overhauled after each successive 3000 hours running. The lubricating oil is continuously filtered, first by means of an electrically heated streamline filter at a temperature of 160 deg. F. The streamline is blown down with compressed air twice daily to remove accumulated carbon formations, and secondly by means of a simpler type of filter called an Auto-Klean. The Auto-Klean is adjusted to oppose an oil pressure of approximately 24 lbs. per square inch, and this adjustment determines the pressure of the forced feed lubrication through a by-pass to the engine bearings. The Auto-Klean and engine bearings form a parallel circuit.

It is claimed by one oil re-refining company that the process of engine lubrication does not affect the lubricating qualities of the oil itself, but that the real deterioration is due to other foreign substances such as carbon and engine metal becoming mixed with the oil. The oil itself does not break down. Also, that used oil re-refined is a far better lubricant than new oil owing to the re-refined oil being comparatively free from carbon forming contents. Moreover, that an engine is the best refiner of oil.

The exhaust valve stems are periodically hand fed with a mixture of equal parts of oil and kerosene to prevent gumming and seizing. The added kerosene does not affect the lubricating qualities of the oil. It will be remembered that the two-stroke engine is supplied with a petrol oil mixture for both power and lubrication. The best time to begin valve stem lubrication is immediately after starting the engine, after which they are thoroughly flushed.

Starting the Transmitter

The transmitter is switched on by pushing a sequence of buttons which control electrically interlocked contactor circuits, and by rotating a hand wheel which regulates the extra high tension. Nothing now remains but to remove the cob-webs from the horn gaps, start the engine, pumps, fans, and air compressor, flush the valve stems, and push those transmitter start buttons, and then regulate the extra high tension while simultaneously watching to see that all circuits are functioning normally.

Having proved the transmitter is normal, the control room equipment is next switched on. A short test transmission is made, and at zero hour circuits are closed and transmission of the national programme has begun.

From the moment the transmitter is switched on the operator observes the equipment and listens to the programme monitor, and every hour approximately 60 meter readings are recorded in the log, until Close Down.

THE J-12 OPEN-WIRE CARRIER SYSTEM

C. J. Griffiths, M.E.E., A.M.I.E.E., A.M.I.E.. Aust.

Introduction.—The purpose of this article is to give readers some preliminary details of the new 12-channel open-wire carrier system which is shortly to be installed between Sydney and Melbourne.

Route Conditions.—The existing open-wire route carries from 6 to 10 3-channel carrier telephone systems (frequency range 5-30.2 kc./sec.), 5 of which operate between Sydney and Melbourne, a Sydney-Melbourne Type B Telegraph carrier system (frequency range 3-10 kc./sec.), a Sydney-Melbourne Programme carrier (34-42.5 kc./sec.), and a Melbourne-Corowa physical programme circuit. Each of these systems requires a carrier-transposed pair involving the following main alterations to the existing voice-frequency pairs:—

(a) Re-spacing of wires to 9 in., 18 in., 9 in., instead of 14 in., 14 in., 14 in.

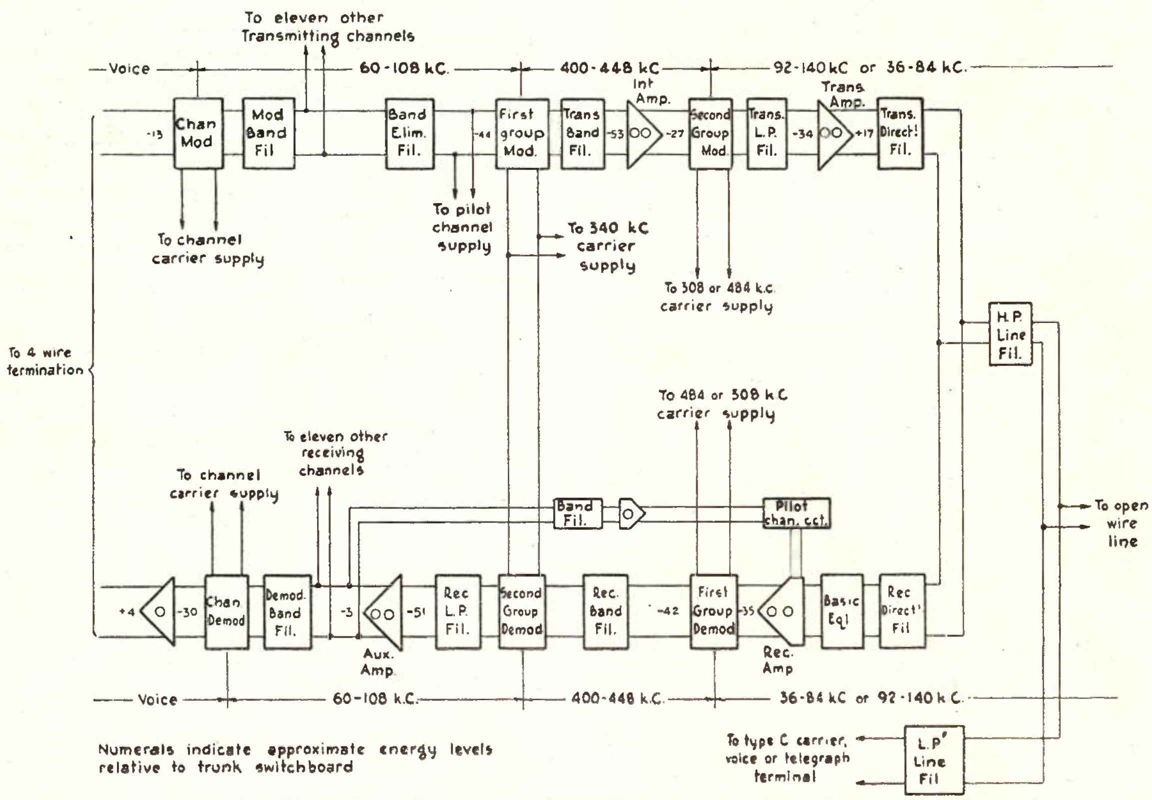
(b) Twenty-eight in. vertical spacing between arms.

(c) A considerable increase in the number of transpositions.

(d) A reduction in transposition pole irregularities.

To provide for these requirements on an existing route transposed many years ago for voice frequency crosstalk conditions only, necessarily involves considerable expenditure and the possibility of interruption to working circuits. Depending on the route conditions, cost of (a) and (c) approximate £15 per pair mile of wires re-transposed.

It is evident, therefore, that the re-transposing costs enter largely into the economics of carrier system provision, and that the newly developed 12-channel open-wire systems to which reference (1) (2) has been made in the technical press during the last two years, offered very definite advantages from the point of view of open wire requirements per channel for the initial system applied to a route. For such an initial system the two important line characteristics are attenuation and impedance, for which little alteration to the existing route conditions is required. Consideration of the application of more than one system to a route will necessarily involve appreciably more stringent line conditions to provide the required cross talk characteristics up to 140 kc./sec. The costs per pair re-transposed to 12-channel requirements will certainly be higher than the £15 per pair mile quoted for 3-channel systems, but with the experience obtained with one system and the associated line measure-



Type "J" Carrier Telephone System. Block Schematic at Terminal Station.

ments it will not be difficult to determine the line and overall economics of 12-channel systems. Some idea of the stringency of line requirements for operation to 140 kc/sec. is provided by the recently completed Transcontinental line between Oklahama City and Whitewater, California, in U.S.A., a distance of 1200 miles. Transposition poles are erected to within ± 5 feet of their correct position and are spaced every 260 feet (every second pole). Wires of a pair are spaced at 6 ins. and the centres of adjacent pairs are spaced 30 ins. apart. Sags of wires forming a pair are adjusted to within ± 0.7 ins. of each other and arms are spaced 36 ins. vertically.

The development of such a system has been carried out primarily by the Bell Laboratories in U.S.A., and after keeping closely in touch with this development, the Department arranged for the purchase of one system in July last for installation between Sydney and Melbourne. The conditions of purchase provide for the system to be installed on the existing open-wire route with minimum alterations to the poling and transposition arrangements.

Description of the J-12 System.—The main features of the J-12 system, a block schematic of which is shown in the accompanying sketch, are as follows:—

From the voice-frequency termination speech passes on the transmitting side to the channel modulators and associated modulator band filters where the 12 channels are modulated with carrier frequencies spaced at 4 kc./sec. from 64 to 108 kc./sec. The resulting band of frequencies 60-108 kc./sec. then passes through two group modulators, associated amplifiers and filters to line. On the receiving side the demodulation follows the same general principles as the modulation process. The reason for the double modulation arises from the standardization by the A.T. & T.Co. of the channel frequencies 64, 68, 72—108 kc./sec. for the carrier on cable, open-wire carrier and coaxial cable systems. The channel equipment and associated carrier supply bays are similar in each case, and the necessary transfer of the 12 channels from the frequency band 60-108 kc./sec. to 12-60 kc./sec. in the case of the cable on carrier system (Go and Return occupy the same band on separate pairs in separate cables) to 36-84 kc./sec. and 92-140 kc./sec. for the two directions required by the open-wire system, and to any of a number of bands up to 1000 kc./sec. or more for the coaxial system, is obtained by suitable group modulators. Apart from the standardization obtained, such an arrangement has two important advantages. Firstly, crystal type channel filters giving a very sharp cut-off for the 4000 cycle/sec. channel bands can be economically built for operation at frequencies above 50 kc./sec. Secondly, this range of frequencies (60-108 kc./sec.) is high enough that all harmonics fall beyond its upper limits. Thus the second harmonic of 60 kc./sec. is 120 kc./sec. which is well above 108 kc./sec.

The carrier frequencies for the twelve channels are obtained from a common source of supply consisting of a vacuum tube oscillator controlled by a tuning fork adjusted to 4 kc./sec. The oscillator output is amplified and led through a coil-type harmonic producer giving all the desired harmonics of 4 kc./sec. at about equal intensity. Duplicate and automatically switched-in carrier supply is provided in all cases to guard against break-down; automatic gain control throughout the system is provided by means of a pilot channel at 84.1 kc./sec. This is an essential requirement as the open wire attenuation at high frequencies may vary up to 50 per cent. between wet and dry weather conditions. The automatic gain control maintains the level within ± 1 db. of the initial setting.

Layout of System on Sydney-Melbourne Route.—The normal repeater spacing for the J-12 system is 65-75 miles, but this is dependent in particular cases upon firstly, the conditions normally influencing line attenuation, namely weight of conductor, type of insulator and weather conditions, particularly frost and sleet, and secondly, upon the positioning of existing carrier repeater stations and the suitability of intermediate offices for repeater purposes. In the case of the Sydney-Melbourne route, the repeater stations together with intermediate spacings will be as follows:—

Melbourne
62.14 miles
Seymour
43.96 miles
Violet Town
41.82 miles
Wangaratta
46.32 miles
Albury
79.96 miles
Wagga
57.75 miles
Cootamundra
72.28 miles
Yass
60.62 miles
Goulburn
58.17 miles
Mittagong
69.94 miles
Sydney

Prior to the adoption of these repeater spacings, a careful examination was made with the co-operation of the Meteorological Bureau of frost and snow conditions over the whole route for a period of 27 years. Briefly, this examination showed that neither sleet nor frost formation on the wires would be a serious factor.

Having determined the repeater stations, the next step was the layout of the loop from the main line into the repeater and terminal station. For short loops up to 100 yards in length, special loaded disc insulated cable will be run from a terminal pole on the main route to the carrier bay. For loops over 100 yards, open-wire construction to a terminal pole adjacent to the repeater station with a short disc insulated entrance cable will be used. Because of the high frequencies involved and the difference in level on the incoming and outgoing sides of the repeater station, special transposing of the open wire loop circuits will be necessary.

The disc insulated cable is of novel construction, and consists of four wires .0508 in. in diameter in a star quad formation which is maintained by hard rubber discs 0.640 in. in diameter and spaced at 1 in. intervals along the cable. Screening of 1 in. x 0.005 in. copper tapes and two wraps of 9/16 in. x 0.003 in. steel tapes is provided. Over this is placed the lead sheath 0.083 in. thick, making an overall diameter of 0.89 in. The weight of the cable is 1.2 lbs. per foot.

Line Characteristics.—In order to check the line characteristics of the carrier transposed lines which are available on the route, tests for impedance, attenuation and cross talk over the range to 150 kc./sec. are at present proceeding. These are the first tests up to such a frequency on open-wire lines which have been made in Australia, and as available literature gives little information in this direction, many interesting problems have been met and overcome. However, the work carried out in this direction will be the subject of a separate paper at a later date. It is sufficient to mention at this stage that there is little doubt that the circuits with satisfactory impedance and attenuation characteristics for the first J-12 system will be available with little alteration to the existing conditions. For a typical repeater section Melbourne-Seymour (62 miles) the attenuation at 140 kc./sec. on a 200 lb. H.D.C. line is 0.32 db. per mile for a D.C. leakance of 0.366 meg-ohms per mile and 0.29 db per mile for a D.C. leakance of 9.0 megohms per mile. The impedance varies by $\pm$ 60 ohms from a mean curve of 600 ohms over the frequency range 36-140 kc./sec. In the initial design the maximum estimated wet weather loss for the longest repeater section on the route, 79.96 miles between Wagga and Albury, was 30.5 db. for a 200 lb. H.D.C. line including cable. Apart from impedance and attenuation conditions, an important problem is that of noise, arising not only from telegraph circuits, carrier systems and other circuits on the route, but also from atmospheric conditions and radio sources. Particular care has been paid in the design to the suppression of such sources of interference by the provision of suitable noise-filters, retard coils, "ceiling" and "cellar" filters.

(1) "Recent Trends in Toll Transmission in the United States," by E. H. Colpitts. The Bell System Technical Journal, April, 1937, pp. 119-143.

(2) "High Frequency Carrier Systems," Telegraph and Telephone Age, 1/11/37.

THE MELBOURNE-GEELONG TRUNK CABLE

A. S. McGregor

An underground cable is now being laid to carry all the telephone and telegraph traffic between Melbourne and Geelong, including channels to serve the Western District of Victoria and also Tasmania. This trunk cable will be, when put into service, the longest underground cable of any sort in Australia.

The reason for the installation of underground cable in this instance is one of practical economics. The existing aerial route, which was erected in 1912, has outlived its useful life. Necessary standardization and reconstruction would be very costly and the development is such that whatever expenditure might be incurred on the route at the present time, an additional route would be necessary to meet traffic demands in approximately eight years' time.

A comparison of the present value of annual charges showed that underground cable has substantial economic advantages; the estimated annual charges involved by the retention and extension of the aerial route to meet the development for 15 years being £12,960; whilst the corresponding and comparable annual charge on the underground cable would be £7,200 for the first eight years, and £8,000 subsequently as additional loading and terminal equipment is added. Apart from the economic advantages indicated, the cable will afford improvement in transmission and will reduce fault liability.

It will be seen from the road cross section shown in the locality plan (Figure 1) that a satisfactory position existed for the location of the cable on the travelling stock route along the side of the highway where it is not likely to be interfered with through future road widenings, etc.

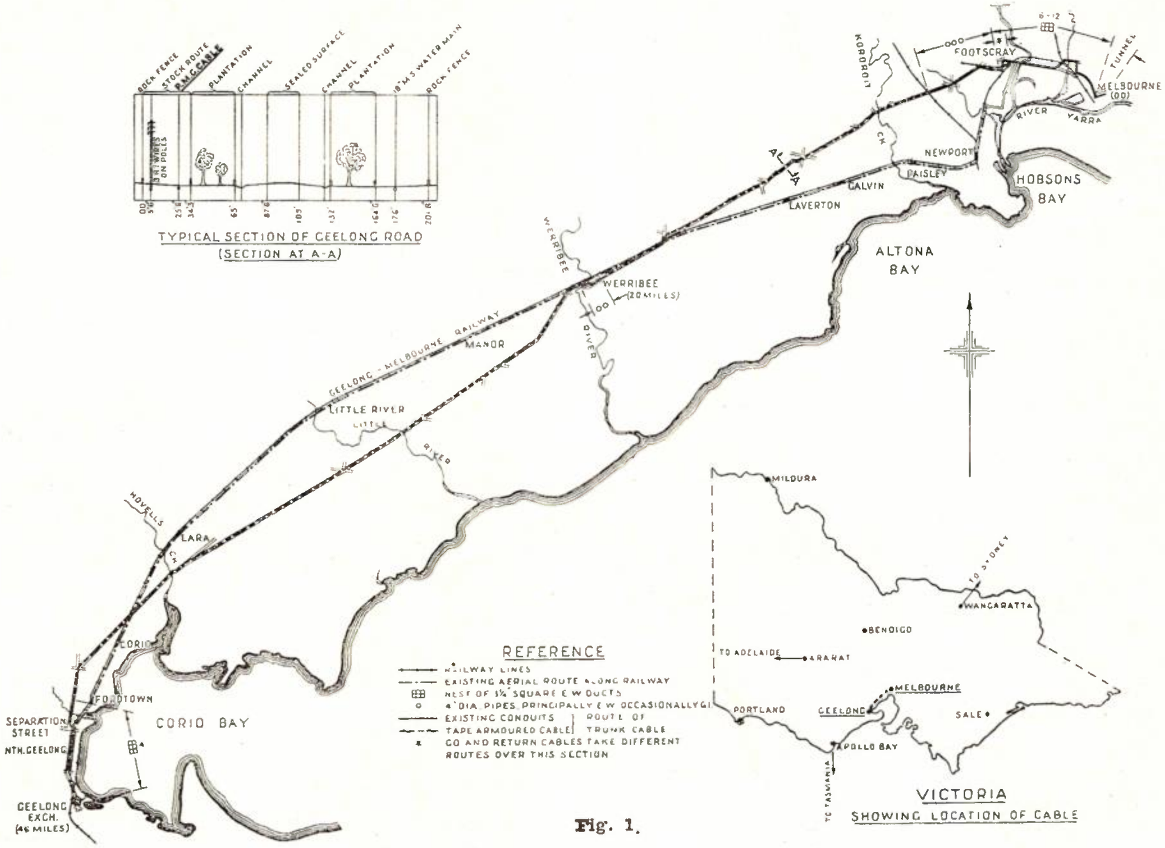


Fig. 1.

Melbourne-Geelong Underground Trunk Cable

With exception of the unarmoured sections leading into Melbourne and Geelong and a short section through the township of Werribee where in each case subscribers' development necessitated multi-duct runs, tape armoured cable has been adopted.

Apart from the novelty of the cable itself, the methods of installation are of considerable interest, having been developed specially to meet local conditions.

Underground trunk cables are gradually displacing heavy aerial lines in thickly populated areas of Europe and America, but the cost of

*On 12/9/38 at a meeting of the Postal Electrical Society of Victoria, Mr. A. S. McGregor presented a motion picture showing features of the manufacture and laying of the Melbourne-Geelong trunk cable.

such installations has been such that, though economical and offering many advantages in countries where urban areas are virtually linked together—the suburbs of one city often actually merging into the suburbs of the next—it has been hitherto difficult to justify similar construction under Australian conditions where the large cities and commercial centres are so widely separated. Because of the greater reliability afforded with underground cable plant, as compared with aerial plant, Australian engineers have, for many years, been keenly watching development abroad with a view to reducing underground cable installation costs to a point more comparable with aerial plant.

The "cable" in this instance consists actually of two heavy steel-taped armoured cables, one, comprising 3/40 lb. twinned screened pairs + 63/20 lb. quads (129 pairs) designated the "GO" cable, and the other, comprising 2/40 lb. twinned unscreened pairs + 48/20 lb. quads (98 pairs), designated the "RETURN" cable.

In order to simplify and lessen the cost of the cable and equipment and at the same time to secure the highest possible degree of electrical stability, the four wire system of transmission has been used. In simple language this system provides for all speech from Melbourne to Geelong to be transmitted over conductors in the cable designated as the "GO" cable and for all return speech from Geelong to Melbourne to be transmitted over conductors in the other cable designated the "RETURN" cable.

This arrangement ensures that high level transmission and low level receptions do not occur on adjacent pairs of conductors in the same cable, thus eliminating "near end" crosstalk and accordingly widening the scope for possible amplification.

Working amplification is therefore limited only by the speech-noise ratio at the receiving end.

A special group of pairs in the "GO" cable has been reserved for two-wire working to serve intermediate stations. With exception of the 40 lb. conductors having special characteristics designed for programme and high frequency carrier services, both cables consist of 20 lb. conductors in star quad formation. The cable being manufactured to "Local" or minor trunk specification.

It was found to be more economical to provide the full complement of physical circuits at the outset rather than to resort to phantom working, which would have entailed more expensive cable and considerably increased testing and jointing work.

The cable installation involved, therefore, the laying of these two steel-tape-armoured, bitumen-coated, lead-sheathed, paper-insulated, and air-spaced cables having conductors weighing generally 20 lbs. per mile, the combined weight of the two cables equalling approximately 26 tons per mile.

The cable route length and the total amount of each cable used comprised:—

	Armoured Miles	Unarmoured Miles
GO—3 pr./40 lb. + 126 pr./20 lb. RETURN—2 pr./40 lb. + 96 pr./20 lb.	35.5	5.5

It is interesting to note that 60 per cent. of this cable, involving both "GO" and "RETURN" sections and armoured as well as unarmoured lengths, was manufactured in Australia at the Port Kembla factory of Metal Manufactures Ltd.

Although tenders were invited for the installation of the cables, none was received and therefore it became necessary for the Department to undertake the work.

A preliminary detailed survey involving trial pot-holes put down at half mile intervals and exhaustive enquiries from such authorities as had carried out works in the vicinity indicated that a firm estimate of the amount of rock to be removed could not be obtained from a surface inspection, rock occurring in more or less mass formation at irregular intervals and depths.

Hitherto one of the principal factors in underground cable installation costs has been the excavation and restoration of the trench which, if done by manual labour, obviously would render such a project as the Melbourne-Geelong cable economically unattractive.

Several possible alternative methods of installation were therefore considered, the most obvious of which was to excavate the trench by a trenching machine equipped for side delivery, lay the cables side by side in the trench and back-fill by hand.

This method was advanced by the manufacturers as the orthodox process, but on the route in question, with rock occurring in unknown quantities at varying depths and intervals, it became obvious that the cable laying would be entirely dependent upon the excavation process; long lengths of trench would have been necessarily kept open along the stock route over lengthy periods dependent upon the rate of progress of the rock removal.

To avoid this difficulty it was decided that the cables would be laid by means of a mole plough, but to ensure that the ground would be free from obstructions in order to permit the laying to proceed without interruption a trench 30 ins. deep and 20 ins. wide was cut and the soil back-filled and lightly rolled in one operation by means of the machine illustrated in Fig. 2, which was developed for this job.

The excavation of a trench 2 ft. 6 ins. deep, 20 ins. wide, and 35 miles long, is in itself no mean task, and on this job the amount of rock excavated (4,800 cub. yds.) represents a fair quarrying effort.

The rock was treated in the orthodox manner by use of pneumatic drills and blasting, the surface having been first removed and the rocks

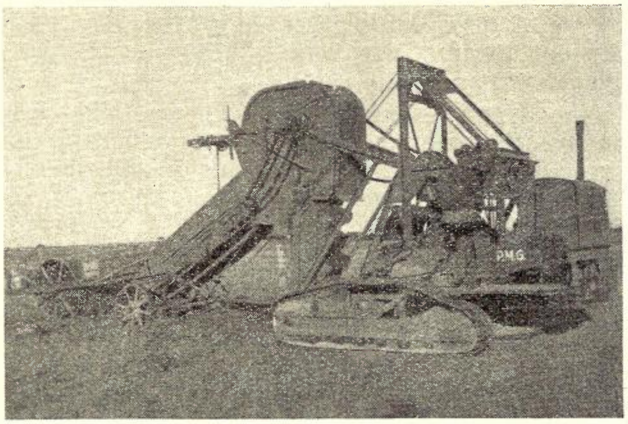


Fig. 2.—Excavating Machine.

exposed by the excavating machines. It might interest readers to know that the blasting entailed the use of 16,330 charges of gelignite.

Two Barber-Greene excavating machines were used to cut the trench. Each machine was staffed with one driver and an assistant. These two men between them did the necessary pegging out, lining, boning, etc., and each machine cut in the manner indicated from 200 to 1,000 lineal yards of trench per day according to the nature of the country encountered.

The width and depth of trench was decided upon, bearing in mind the possibility that at some future date it might be necessary to lay additional cables in the same trench, in which case further blasting operations alongside of the existing cables would obviously be impracticable.

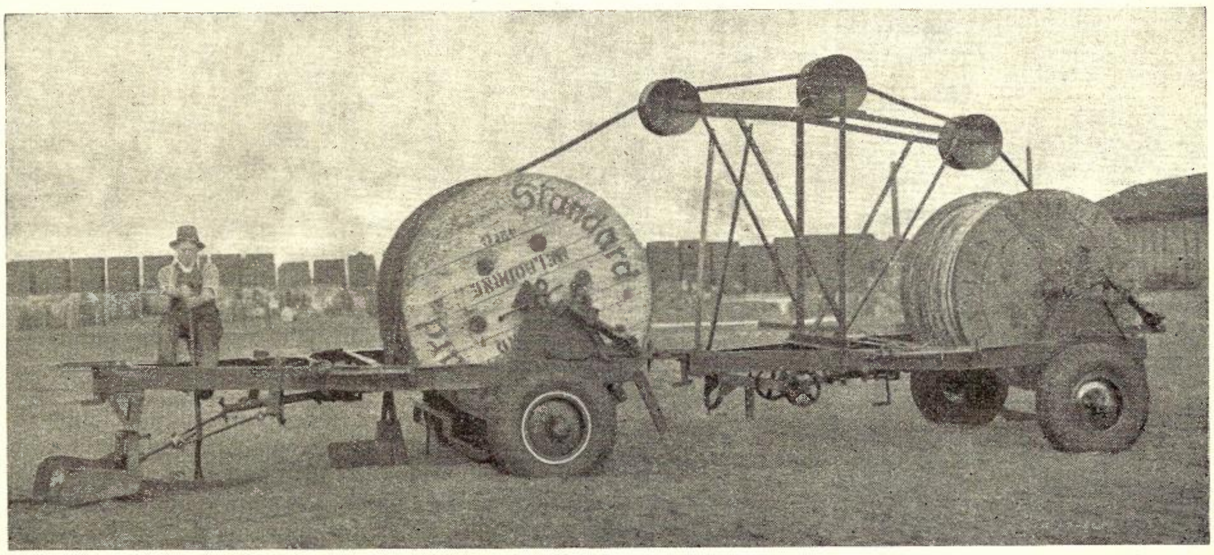


Fig. 3.—Mole Plough with Cable Reel Trailers.

Into the trench thus provided the two cables, which had been manufactured in approximately 500 yard lengths, were laid simultaneously by means of a modification of a deep sub-soil plough.

The plough outfit illustrated in Figure 3 consisted of four parts—the hauling tractor; the plough; and two cable drums carrying trailers arranged in tandem from which the cable was paid out.

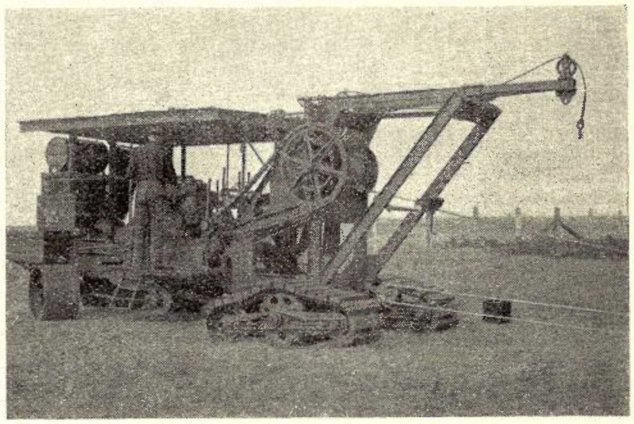


Fig. 4.—Crawler Tractor for Hauling Plough.

The plough and trailers were towed by means of a 15-ton crawler tractor, equipped with a robust winch and winding drum, as illustrated in Figure 4.

The tractor was generally used as a stationary unit, the plough and trailers being hauled up to the anchored tractor by a steel rope using double or treble purchase according to circumstances. This arrangement conserved the engine power of the tractor unit.

The plough consisted essentially of a vertical ploughshare to the back of which was fitted two tubes arranged in a quadrant bend through which the cable passed out of the bottom ends horizontally into the ground.

The plough was mounted on steel skids designed to slide over the ground and was placed partly under, and attached loosely to, the first cable drum trailer.

The trailers, of the two-wheel type, had the drums mounted in such a way that the cables passed in an easy bend over and into the tubes on the plough. The trailers were in tandem and articulated with a pivot coupling between them. A metal framework, with rollers, fitted between the trailers carried the cable from the rear trailer over the top of the leading drum and down into the forward tube of the plough. Manual assistance to rotate the drums was found to be unnecessary.

In operation the tractor took up a position about 100 yards ahead of the combined plough trailer unit and hauled the latter up to itself. The tractor then moved forward and the operation was repeated, etc. Each drum carried approximately 500 yards of cable and new trailers and drums came on at intervals of 500 yards, the empty drums being hauled to the nearest drum depot for re-loading.

Instead of laying the cable drums out along the roadside, the hitherto usual procedure, it was practicable by means of the arrangement adopted, using reel trailers, to store the cable in suitable temporary depots at convenient intervals of three to four miles along the route.

The combined cable laying equipment was staffed with three men, comprising the driver and two assistants, one of whom attended to the winding rope, whilst one man steered the plough. In order to facilitate the work, a crew of five men, with a heavy 4-ton lorry, was continuously employed removing lagging from drums at the depot, loading drums on to trailers and bringing the loaded trailers up to the cable laying party.

It was necessary to ensure that the drums were mounted on the trailers with the running end of the "GO" cable continuously in the same direction, and similarly the running end of the "RETURN" cable in the opposite direction. This was arranged with the manufacturers who provided identification marks on the drums therefor.

It is important to note that the cable was not drawn into the trench at all. The arrangement described ensured that both cables were paid off the rotating drums through specially shaped tubes in the plough blade and in such a manner that the minimum amount of flexing and stress resulted.

The cables have been laid one over the other in a single slit in the ground, this method saving considerable tractive effort. The minimum of cover provided above the top cable throughout is 21 inches. This cover was determined by the depth at which the ploughing operations were carried out.

Because of the urgent need to complete the cable in time to afford relief over the heavy summer season's traffic, the excavation and laying work in this instance was carried out during the most unfavourable season of the year when the natural roadside was saturated with heavy winter rains.

The track where the cable was laid, was, during the course of the work, generally impassable to ordinary motor vehicles and, in fact, it would have been impracticable to have controlled such heavy drums of cable over an open trench. The handling of the heavy equipment involved, under such adverse conditions, necessitated many novel departures from orthodox methods, details of which are beyond the scope of this paper.

The lineal length of cable laid per day, with a gang of nine men, was from 200 yards (400 yards of cable) to 3,000 yards (6,000 yards of cable), which was the maximum single day's output.

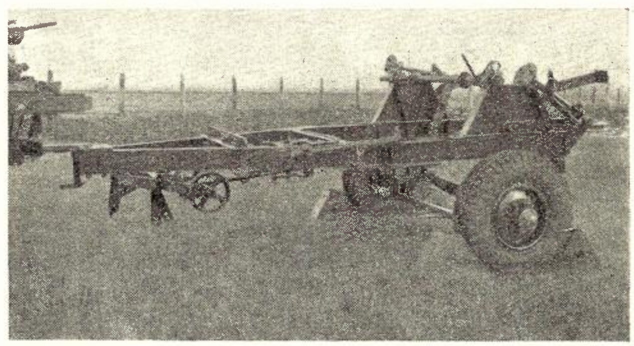


Fig. 5.—Cable Reel Trailer.

The cable reel trailers, illustrated in Figure 5, although specially developed for this work, have, nevertheless, general application. These trailers are jack controlled in such a manner as to permit two men to load 5-ton drums without risk. When mounted, the drum is centred on a spindle, in such a way that it permits safe road transport and when the reel trailer is placed over a manhole the cable can be drawn directly into the duct without further manual attention.

With unarmoured cable a suitable bent guide tube equipped with a funnel mouth at the top can be inserted directly into the duct and the cable drawn through this tube can then be effectively greased by keeping the funnel at the top end filled with grease of suitable viscosity.

By means of this arrangement two men can conveniently and safely handle and raise, ready for laying, heavy cable drums which have, in the past necessitated the attendance of eight or nine men, the operation even then proving at all times comparatively hazardous.

As a matter of fact, in order to conserve duct space both the "GO" and "RETURN" cables, unarmoured sections, were on this job drawn simultaneously into a single duct, the cables being prevented from twisting by the introduction of ballrace swivels.

Apart from the simplicity of the cable installation methods illustrated in the foregoing, these cable reel trailers afford revolutionary and economical measures which will, no doubt, appeal to many interested cable laying authorities.

The cable has been designed to provide the following traffic channels for the periods indicated:—

Melbourne to Geelong, and beyond:—

Existing	77
At date of cutover	88
1945	107
1957	182

Apart from the special circuits (40 lbs. conductors), for the present all channels will be derived by physical circuits without resort to carrier systems.

In the "GO" cable the pairs have been allotted as follows:—

Centre Core: Three screened broadcast pairs.

First Layer: Thirty pairs loaded in 30 coil pots to Werribee but unloaded and spare beyond. This provides for the two-wire circuits Melbourne and Footscray to Laverton and Werribee.

Second and Third Layers: These will be regarded as one group. Seventy pairs will be loaded with 70 coil pots for four-wire through circuits, with selected pairs allotted for some two-wire intermediate services. Twenty-six pairs will be left unloaded.

In the "RETURN" cable the pairs have been allotted as follows:—

First and Second Layers: Seventy pairs will be loaded with 70 coil pots for four-wire through circuits, with selected pairs allotted for some two-wire intermediate services.

Outer Layer: Twenty-six pairs will be left unloaded.

Outer Layer: Two unscreened broadcast pairs.

NOTE.—In the City West-Footscray section the above loading on the "GO" cable will be included in 290 coil pots combining trunk and junction loading.

The voice frequency circuits are loaded with 88m.H. coils throughout, the spacing being 8,924 feet on the armoured cable and somewhat more on the two end sections because of the slightly lower mutual capacity of the existing cables which have been utilized at the Melbourne and Geelong ends.

The three screened pairs in the "GO" cable are loaded with 16 m.H. coils at 2,975 feet spacing and one 40 lb. pair in the "RETURN" cable is similarly loaded.

Along the armoured cable sections where the principal 88 m.H. loading points occur, namely, at approximately 9,000 feet spacing, standard manholes, numbering in all 20, are provided to accommodate the large loading pots. At the intervening points, numbering in all 39, the 16 m.H. loading coils for the programme circuits are included under the lead sheath in the joint, thus making a sleeve about 4½ inches in diameter.

At these latter points and wherever unloaded joints occur, numbering in all 62, asbestos cement joint boxes (No. 5 type) are provided; the cables being there looped in the orthodox manner permitting the jointing operation to be performed above the ground level.

In general, the cable has only been tested for side to side capacity unbalances within each quad. For check purposes and for future guidance, "side to side" and "phantom to side" unbalance tests have been made at certain points. No trouble is expected from "side to earth" unbalances. From test results to date, it is anticipated that when the jointing has been completed, the "side to side" unbalances per loading section will be less than 50 micro-microfarads, giving a crosstalk value of approximately 93 d.b

The terminal amplifying equipment which will be installed at Melbourne and Geelong will consist of single stage pentode type high gain repeaters of the feed back type. The repeaters will be mounted 40 per bay, two bays being required at both Melbourne and Geelong initially.

From tests made to date, it is satisfactory to know that the transmission requirements will come fully up to expectations. It is also satisfactory to note that the work, which is being completed to scheduled time, will, from cost figures to date, be performed within the estimate.

The work is now sufficiently near completion to anticipate safely the completed cost figures. Exclusive of the cost of material, namely, cable, loading coils and terminal equipment, the anticipated final costs per yard of single cable laid is 2/9.

These figures cover all work performed in connection with the installation, testing, jointing and balancing, and include such items as the construction of manholes, and the operation of the special mechanical appliances, etc.

Now that the actual amount of rock excavation is known, it is possible to compute the cost of the work on a State average basis. On this basis, the computed saving through mechanization is £13,000. The saving in transport alone, because of the reduced manipulative staff required, has exceeded £700.

Whilst improvements in the technique adopted will no doubt follow as a result of the experience gained, the methods used on this job appear, nevertheless, to have provided a very satisfactory solution to a major problem.

"The Electrical Engineer" and "Merchandiser" have kindly supplied the halftone blocks used in this article.

CABLE JOINTING. PART 4

G. O. Newton

OPERATIONS ON WORKING CABLES

Introduction

General.—The operations which have been described previously are all of a comparatively simple type and an ability to perform them correctly and expeditiously can usually be acquired within a relatively short period. Proficiency in performing operations on working cables under all conditions is not acquired so readily.

In the smaller country magneto exchange areas the cable pairs are mostly occupied by exchange lines of a simple type and with low calling rates and there is little multipling of pairs of lateral or branch cables. Under these conditions operations are normally straightforward and are simplified by the fact that it is generally possible to take liberties with the circuits which, under other conditions, would seriously interfere with the service and give rise to complaints, but as the complexity of the exchange system, the size of the network, the calling rate on the exchange lines, the proportion and variety of circuits other than exchange lines and the extent of the multipling in the cables increase, the work becomes more involved. Even under the latter conditions no great difficulty will arise once a little experience is acquired if the cables have been jointed in accordance with the principles already set out, but where there is little or no ordered arrangement of pairs in the cables the accurate and reasonably expeditious performance of the operations will in most instances require initiative, close attention to detail and ability such as can only be acquired with experience.

Interruption and Interference to Services.—The most important rule in regard to operations on working cables is that every care must be taken to avoid, as far as possible, any annoyance to subscribers or interruptions to services, and where this is unavoidable, to so arrange the work that the minimum of inconvenience is caused. Where urgent calls are likely to be made (e.g., services to Fire Brigades, Police, Hospitals, Doctors, etc.) or where circuits have high calling rates with no alternative means of communication or are of a special importance or nature (e.g., broadcasting lines, power leads, alarms, etc.) it is advisable to seek the co-operation of the parties concerned, and if necessary to carry out the work at a special time to meet their convenience. It is particularly important to avoid interruptions when operating on junction cables owing to the generally busy nature of such circuits. Ineffective calls are very annoying to subscribers and with a view to avoiding any such cause for complaint it is advisable to arrange with the exchanges concerned to "busy out" any junction circuits likely to be interfered with before commencing work and/or if possible to confine operations to periods of low traffic density. Usually the junction circuits can be "busied out" in groups of convenient size and restored as soon as work on the group is complete and before another group is "busied out."

Whilst it is necessary to avoid to the greatest possible extent faults of any kind on any class of service to be found in cables, the need for particular care with exchange services in C.B. Manual and Automatic Exchange areas and with many types of miscellaneous services needs stressing. In a C.B. Manual Exchange area the earthing of the ring or "B" leg or the short-circuiting of the two legs (either by a direct short or double earth) of an exchange line lights the line lamp on the switchboard and unnecessarily causes the operator to plug into the line jack to answer what is the normal signal of a calling subscriber, whilst in an automatic exchange such faults engage switches unnecessarily, and if the non-standard condition is sustained a fault will be reported and unnecessary expense and effort in testing and tracing the trouble will be incurred.

On many miscellaneous services there are particular types of faults which must be avoided specially (e.g., short circuiting of the cable pair must be avoided on some types of alarm circuits whilst on others an open circuit will bring in the alarm. See also reference to Reversals in Part 2). It is desirable that everyone employed on cable work should become familiar with the different types of such services within the areas in which they operate and with their circuit arrangements so that the requisite care can be taken when operations involve such circuits.

Cable Records.—Inaccurate and inadequate records are not only a prolific cause of interruptions to services during operations on working cables, but they are responsible for serious delays to the completion of the operations. In addition to accurate details of the services occupying the various pairs and of their terminal points, complete and accurate information in regard to the record numbers of the pairs appearing in each branch and lateral cable is essential. Where pairs are commoned (multipled) the records should clearly indicate which services occupying such pairs will be affected by any proposed operation. Any conditions which are not straight-forward, such as cables containing two or more different classes of cable pairs (i.e., main, secondary and link), some of the pairs not jointed through to the Exchange M.D.F. and/or a cable head, etc., should be adequately recorded.

Instances sometimes occur where miscellaneous services (e.g., extensions, fire alarms and private lines), are by-passed clear of the exchange by a cross-connection of pairs either within a joint or from one cable to another at a point some distance from the exchange. Whilst considerations such as compliance with transmission requirements and economy of cable conductors may necessitate these arrangements, they add very considerably to the complexity of the cable records and if not correctly and adequately recorded, considerable confusion may be caused on future jointing operations. Therefore, such instances should be carefully recorded, and where disconnections of such services take place and the cross connection is not likely to be required again in the near future, it is most desirable that the cable pairs be altered back to their normal condition as soon as possible. Where a considerable number of such services are by-passed clear of the exchange it is preferable to arrange for the cross-connection on some cable terminating arrangement such as a pillar terminal than within a joint or by direct connection between joints. This does not, however, overcome the necessity for accurate and careful records.

Another instance which is sometimes encountered and which may give rise to considerable confusion is the case where two sections of a cable of one size are joined by two cables with a greater total pair capacity, e.g., two sections of 100 pair cable may be joined together by a section consisting of a 75 pair and a 50 pair cable. In some cases it will be found that 25 pairs in one cable or the other, or a number of pairs in each cable are not jointed at either end, whilst in others, 25 pairs of each are commoned at the exchange end and at the subscribers' end they are either commoned again or the 25 pairs in one cable (or a portion of them in each cable) are insulated. The records in such cases should not only indicate the numbers of the main cable pairs appearing in each cable but should also indicate the destinations, whether in cable terminal boxes or joints. In cases where some of the pairs are not connected at any point to main cable pairs, the rotation numbers of the "dead" pairs and their terminating points should be recorded. Information in regard to the relation between rotation and record cable pair numbers and in regard to joints where cable pairs are tagged is extremely valuable and should be recorded wherever possible.

Where the accuracy of the records cannot be relied upon or the available information is inadequate, it will usually be advisable to check the existing or obtain the additional records before commencing operations rather than incur delay to the completion of the operations or complaints brought about by undue interruptions to services.

Whilst on the subject of accurate records, it must not be forgotten that to a large extent this is in the hands of the cable jointers. It is not only essential that all work be performed accurately, but that the records furnished on completion of each work are complete and accurate. Any errors or omissions found in the records of plant on which work is being performed or in adjacent plant should be brought under notice. The little extra time incurred in ensuring accurate records will save the additional expense many times over when future operations are in hand, whether they involve cable alterations, connection of new lines, or attention to faults.

Identification of Pairs in Working Cables

General.—In addition to permitting the operation being carried out in a simple, speedy and correct manner, the requirements of an ideal method of identifying pairs in working cables are:—

(i.) Subscribers and renters of cable pairs for special purposes should have uninterrupted use of their services.

(ii.) They should not be annoyed by being called on their lines unnecessarily or by the operation of signalling arrangements due to the actions of the workmen (e.g., tinkling of bells, actuation of alarm signals, etc.) or by any other form of interference to their services.

(iii.) No noise should be introduced into the circuits either directly or by induction.

The large variety of conditions and circuits which may be encountered, together with considerations of time and cost, have so far defeated the development of a method which complies with these ideal requirements, and since the methods in general use necessitate some interference to the services in most instances, it is essential that every care be taken to ensure that the extent of this interference is the minimum possible in the circumstances. Even with this departure from the ideal, it is not possible to follow any single straightforward method which can be readily applied under all conditions, and therefore what are considered to be suitable methods under particular conditions will be outlined. In some instances it may not be advisable even to follow the one method throughout an operation and in such cases the use of two or more methods will be necessary to complete the work in the shortest time. In each case the matter will be discussed more in the light of the conditions to be found in the larger cities than in the light of the simpler conditions which prevail in small networks. As freedom from interruption and accuracy on the subsequent jointing operation depends largely on the accuracy of the identification of cable pairs, it is essential that every care towards this end be taken.

Conditions Under Which Identification May Have To Be Performed.—The conditions within a cable which are likely to be met when proceeding to identify pairs in working cables can be divided broadly into two classes:—

(i.) Where the cables have been jointed in rotation so that rotation and record cable pair numbers correspond or where the diversions from an ordered arrangement are only of a minor nature.

(ii.) Where the cables have been jointed without proper regard to order; the extreme case being one where none of the pairs is in any recognizable order and there is a large proportion of split pairs.

In each of these classes it may be necessary to identify either a portion of the pairs in the cable or the whole of them. Included with the latter would be the case where it is necessary to identify a large proportion of the pairs in a cable having little or no ordered arrangement of pairs.

Methods.—As the majority of identification work is done with the exchange, this will be described first. In this case the pairs should be identified from the M.D.F., since cable records are referenced to this point, and it ensures accuracy.

Identification of working pairs in manual exchange areas is often assisted by raising the exchange operator with a portable telephone or "buttinski," and obtaining the number of each line. Such identification should, however, be subsequently checked with the M.D.F., especially in C.B. exchange areas where it is possible to raise the exchange on a particular number when one lead of the telephone is connected to the tip or "A" leg of another line or to an earthed conductor. As extensive use of this method of identification adds very considerably to the load of operators at busy exchanges, it should not be used unnecessarily and, where necessary, its use should be confined as far as possible to slack periods. There may be instances also where identification of the cable pair will be facilitated by raising the subscriber on a portable telephone and ascertaining his number. In this case also the practice should only be adopted when essential on account of the possible inconvenience or annoyance to the subscriber and when used, the identification should be checked with the exchange M.D.F.

The first operation prior to commencing the identification work is to arrange a speaking circuit between the two points concerned. Where

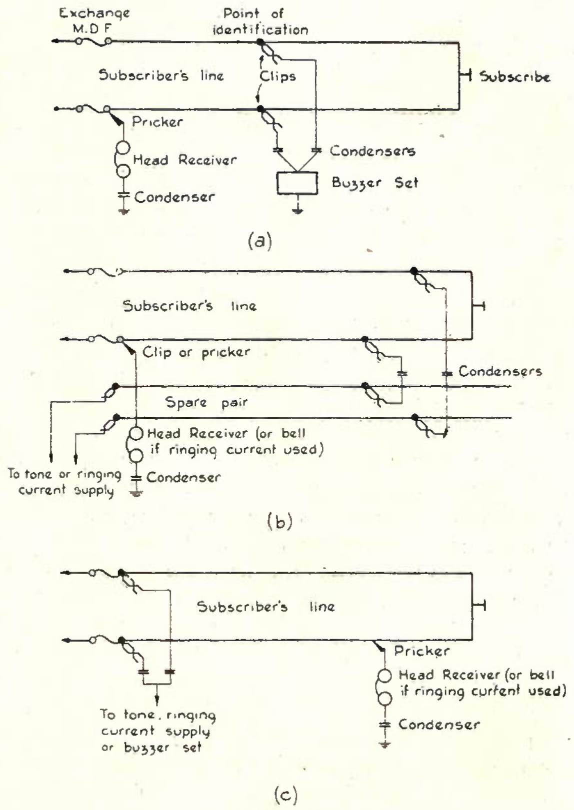


Fig. 18.

Showing Methods of Identifying Pairs in Working Cables from the Exchange M.D.F.

Methods (a) and (b) are the most suitable where all the pairs of a cable, or the individual pairs of a group of pairs which are readily identifiable as a group, require identification.
Method (c) is applicable to instances where it is desired to identify isolated pairs or a group of pairs which cannot be identified readily as a group.

cable pairs are in rotation, usually this can be pre-arranged by assigning a particular pair (by its number) for the purpose, but where any trouble is experienced with this, or where pairs are not in rotation, it is necessary to identify a suitable spare by one of the methods to be described later. In the latter case, unless some other suitable means of communication is available, preliminary communication from the joint to the exchange is obtained by means of a portable telephone (or buttinski in automatic or C.B. manual exchange areas) on an exchange line which is free for the moment. First of all, the subscriber of any line so used should be consulted and advised that he may be unable to use his line for a short period, after which it is advisable to cut off the telephone side so that the party concerned will not be annoyed by any ringing, buzzing, or if an automatic exchange line, by any tinkling of his bell due to dialling. The circuit should be restored at the earliest possible moment. As in the case of checking and testing on non-working cable, breast transmitters and headphones are the most suitable for use on the speaking circuit. (Probably some

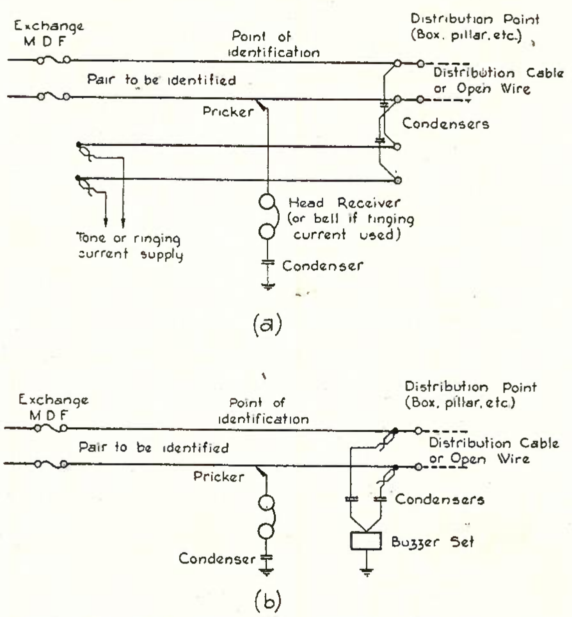


Fig. 19.
Showing Methods of Identifying Pairs in Working Cable from Cable Distribution Points.
The methods indicated apply more particularly to instances where it is desired to identify isolated pairs in a cable or the individual pairs of a group which cannot be identified as a group.
In those cases where the required group of pairs can be identified readily as a group the point of application of the signalling current and the searching point are the reverse to that shown.

form of loud speaking telephone would be more satisfactory for use at the cable joint, but as far as is known at present, a suitable inexpensive type is not available.)

In some instances, as indicated in a later section, and when dealing with spare pairs, use can be made of a direct current signalling arrangement similar to those suggested for checking and testing pairs in completed non-working cable (see Part 3), but under all the conditions likely to be met, the use of some type of alternating current, such as exchange ringing current or tones, or of buzzer sets (continuous signal type) is the only one which will permit of any uniformity. This is applied at either the joint or the cable termination and at the opposite end to which it is applied the pairs are identified by use of a head receiver (or a magneto bell when ringing current is used) and pricker (see Figures 18 and 19).

The head receiver (or bell) with the pricker, which is used for locating the required pairs, should always have a condenser in series as shown in Figs. 18 and 19, when used in C.B. Manual or Automatic areas so as to avoid the introduction of earths on to legs of working circuits whilst pricking for the required pair. Condensers should also be used in the signal supply circuit when operating in such exchange areas with the object of minimizing interference due to earths and shorts on working lines, but their use is not essential in the case of spare pairs or in other cases where the exchange side of the circuit is cut off during the process of identification. In the case of spare pairs the connection can be made by a single direct lead to the conductors of one or more pairs in parallel. As there is no disadvantage in the arrangement, however, it seems preferable to use condensers in all cases.

The signal current is applied simultaneously to both legs as shown in the Figs. 18 and 19, since it facilitates the search and identification of pairs. Where it is desired to distinguish between the A and B wires, it may be done as a separate operation after the pair is identified, if the signal current is disconnected from one wire only, for a short period before it is finally disconnected from the pair. In the case of working pairs, this identification of the separate legs will also involve opening one leg to prevent the signal current returning over the second leg through the connection with the first leg, at the telephone.

When using the method shown in Fig. 18C., in C.B. Manual or Automatic exchange areas, it will usually be advisable to temporarily open working lines by removing the fuses during the process, owing to the shunting of the signal tones by earths in the exchange line circuit. In these cases care should be taken to restore the fuses as soon as possible.

When using the methods indicated in the other diagrams of Fig. 18 on working pairs in C.B. Manual or Automatic exchange areas, difficulty may be experienced with the identification of one leg, owing to the signal current being shunted by the earth which is normally applied to the A leg at the exchange when the line is not in use. Usually it will be possible in such cases to identify the B leg readily after which the A leg can be opened and checked. Where there is any doubt in regard to identification of the B leg, this should be opened and checked also.

Normally when operating on working pairs, the use of ringing current or a low frequency buzz is not desirable unless arrangements can be made to cut off the instrument side temporarily, since it will cause ringing or tinkling of the subscriber's bell if there is any unbalance or earth on the line, or an accidental earth is caused. This will also happen whenever the searching pricker touches one leg or other of the pair.

Whatever type of alternating current is used, care should be taken to ensure that the inductive effect is not too pronounced. In no case should the volume of the tone induced in adjoining pairs be such that it is likely to interfere with conversation. Where there are indications that the inductive effect is too great, action should be taken to minimize it by reducing the volume or by changing over to some other type of alternating current. By using a sensitive type of head receiver, the current can be applied to the line at lower levels, and thus minimize the inductive effect without reducing its efficiency for identification purposes.

Under some conditions to be discussed later, some inductive effect is desirable, but where too great, it not only renders circuits on other pairs in the cable unworkable, but it may lead to errors in identification, especially on long cables, owing to the difficulty of distinguishing between the direct buzz or tone and that induced in adjoining pairs.

Where it can be made available, suitable signal current is a 1000 cycle tone. If this is applied at a suitable level and identified by using a sensitive receiver, inductive interference is not pronounced. By using a high wound head receiver, cable pairs carrying tones of this and similar frequencies can be located very readily in the cable by holding some bare portion of the receiver lead or of the pricker in one hand and feeling for the pair among the conductors with the other. The tone will be heard in the receiver due to the capacity effect between the cable conductor and the hand through the paper insulation, so long as the distance over which it is applied, and therefore the loss in volume, are not too great. This effect is valuable where there is little or no ordered arrangement of pairs, since a group of conductors containing the pair or pairs sought can be identified readily and the actual pair subsequently located by a process of continuous halving of the group which is found to contain the required pair.

Where it is desired to ascertain whether a pair accommodates an exchange line, or whether an exchange line is engaged, use is usually made of a telephone or handset, but in C.B. or Automatic exchange areas this can be ascertained by connecting the positive terminal of a detector (50 V. scale) to earth and tapping the negative terminal on each leg of the pair in turn. If it is a disengaged subscriber's line, a reading of the same order as the exchange voltage will be obtained on the B leg, and no reading at all on the A leg. If the line is engaged, a reduced voltage reading, varying according to the position of the test point on the circuit, will be obtained on the B leg, and a reading of a lower order will be obtained on the A leg. In the case of a power lead, a voltage reading similar to the exchange voltage will be obtained normally on both legs. As an alternative to the detector, use can be made of a test lamp fitted with a switchboard lamp of appropriate voltage rating. In this case, a power lead gives a bright glow, the B leg of a disengaged line a bright glow to a slightly less degree, and the A leg of a disengaged line no glow at all, while the B leg of an engaged line will give a glow varying in intensity according to the position of the test point on the circuit, and the A leg will give a very dull glow which often may be hardly perceptible.

Where it is not possible to obtain any slack in a cable, it may often be necessary to piece-out a proportion of the pairs prior to commencing identification, so as to make them all readily accessible to the testing leads.

If during the process of identification, any difficulty is encountered with particular pairs due to faults or other abnormal conditions, usually it will be preferable to set these aside and deal with them at the end of the operation. In those cases where there are any circuits which become faulty if the legs of the pair are reversed, care must be taken to identify each leg correctly.

Identification Where It Is Known That Pairs Are in Correct or Nearly Correct Rotation.—The case where it is definitely known that the cable pairs are in rotation is simple and straightforward. In the case of a partial identification, the pairs are first located by counting around the correct layer or layers (see Figure 4 and Tables 1 and 3, Part 1), and having located the pairs in this manner, checking them with the M.D.F. pair for pair or leg for leg, where it is necessary, to avoid reversals. Where total identification is necessary, the checking of the pairs with the M.D.F. in rotation order (either forward or reverse directions may be followed) is proceeded with immediately. This would also apply in those cases where pairs are already tagged, unless operations subsequent to the tagging have made them incorrect. In the latter case the tags may still be helpful if the identification of two or three pairs shows that the tag numbers give some indication of the relative positions of the pairs required.

The method of checking with the M.D.F. in such cases need only be some simple arrangement using direct current, similar to that suggested for checking and testing completed non-working cable provided that before operating on an occupied pair, any earths normally applied to the circuit (e.g., at the exchange in C.B. Manual and Automatic exchange areas) are temporarily removed by opening the lines at the M.D.F. and, if necessary, at the joint. The interruption under these conditions is only very minor, and where it may cause inconvenience and annoyance or affect the operation of special and important services, it is usually possible to arrange the co-operation of the parties concerned. If there are any minor departures from a correctly ordered arrangement of pairs (e.g., transposed pairs or quads), it will result in a little extra time being taken, but in no case should it be serious. Use can also be made of a buzzer or tone in accordance with the arrangements shown in Figures 18 (a) and (b). This is more in line with suitable methods in other instances and for this reason it will usually be the preferable method.

In this case, the signal current is sent to the exchange M.D.F. and the searching carried out there, whether a few or the whole of the pairs are to be identified. This enables the Jointer to deal with the pairs in the order which suits him best, and if there are any minor displacements of pairs, the searching can be done more readily at the M.D.F. than at the cable joint. If, however, any difficulty arises in cases where only a portion of the pairs are being identified, due to isolated displaced pairs not being readily located at the joint, it will be found expedient to complete the identification by changing over to the method shown in Figure 18 (c).

Partial Identification of a Cable Where the Arrangement of the Pairs in the Cable Is Not Known.—On most occasions the Jointer will not be certain that the pairs will be found in rotation order, or he will know from past experience that this will not be so. In the former case, the best method is to arrange for ringing or buzzing current or a tone to be sent out from the exchange (see Figure 18 (c)) on all spare pairs (or on a portion of them at a time) in parallel, and to identify them as a group (or in groups) after which the single pairs can be identified very readily. The search for these pairs should, as a general rule, commence at the correct rotation positions of the pairs, as normally, the chances of finding them at or near this point should be greatest. If the positions in the layers in which the spares (or first group of spares) are found, indicate that the pairs are in ordered arrangement, the remaining pairs can be identified readily on lines similar to those set out in the preceding section.

Where the number of pairs which it is required to identify is not great it will usually be most expedient to continue to use the method shown in Figure 18 (c), but in other cases it may be advisable to change over to either of the other methods of Figure 18. There is no need to change the method, however, where the former proves to be satisfactory. Whilst the method indicated for obtaining evidence of the ordered arrangement of the pairs is usually the most satisfactory, it can often be obtained by checking the relative positions of working and spare pairs by means of a telephone, detector or test lamp as indicated under "Methods."

If the location of the identified spares indicates that there is little or no ordered arrangement of the pairs or this is already known, it will be necessary to continue to use the method shown in Figure 18 (c). The spare pairs can be identified first in groups and then singly as described, and in cases where subscribers do not offer objections to their lines being interrupted to the greater extent required, working lines can be dealt with in a similar manner if it facilitates the work. Normally, however, working lines should be dealt with singly, so as to minimize the interruption period of any one line. The prior identification of the spares will be of assistance in locating the positions of working pairs in the cable, since the number of pairs over which the search has to be conducted will be reduced. Where the period of interruption during the operation of identification is likely to be extensive, it is advisable to consult the subscribers, especially in the case of very busy and "urgent" lines, so as to minimize possible inconvenience.

Usually the partial identification of a cable, when there is little or no ordered arrangement of the pairs, is a slow and tedious process. It is in such cases that the presence of some inductive effect and the ability to feel for the V.F. tone with the fingers is advantageous, since it gives a clue to the location of the required pair. In manual exchange areas the process may be expedited by obtaining the numbers of the services on working pairs from the operators, but as previously stated, this should not be done unnecessarily.

Whilst these methods will be the most suitable in most instances of partial identification, cases will arise where it will be more economical to identify the whole of the cable in the manner to be described in the next section. The decision of this point will depend on:—

(i.) The proportion of required pairs to total pairs in the cable;

(ii.) The degree of disorder (if any) of the pairs;

(iii.) The extent to which pairs are split;

(iv.) The proportion of working pairs in the cable;

(v.) The size of the cable.

In making a decision as to whether it will be cheaper to identify the whole of the cable, operators must be guided by these factors and by past experience as it is difficult to indicate any definite rules which may be followed.

Total Identification of a Cable.—Whether there is any ordered arrangement of the pairs in a cable or not, either of the methods shown in Figures 18(a) and 18(b) is suitable when total identification is necessary, and in this case, it is preferable that pairs be dealt with in their rotation order at the point of identification. Where the order of the pairs is correct, the work may also be carried out by the method indicated in Figure 18(c), but where the ordered arrangement is not complete, the performance of the searching at the M.D.F. permits of faster work than is possible if the searching is done in the cable. Where the work is being performed on cables containing only subscribers' lines with low calling rates and none of the services is of special importance and the period of interruption is not too extensive, or where pairs can be identified readily as spares, they may be dealt with in groups initially and afterwards singly, as was suggested for spare pairs in the preceding section. This often facilitates the work in cases where there is little or no ordered arrangement of pairs.

Identification from Cable Distribution Points (Boxes, Pillars, etc.).—Very often identification of the cable pairs from the cable terminal points at the subscriber's end of the cable is required, and in such cases the methods outlined in Figs. 19(a) and (b) can be used. If ringing current is used, working pairs should be opened temporarily at the cable head. In any case the possible inconvenience to subscribers during the operation should be considered and they should be consulted where necessary. Similar arrangements are suitable where identification of secondary cables beyond the cable head is necessary. In those cases, where pairs are in rotation order or are tagged, or the required group of pairs can be identified as a group in some other way (e.g., when identifying at the point of connection of the lateral cable to the main or branch cable), the tone or buzzer set can be applied at the point of identification and the searching done at the cable distribution point.

Identification Between Two Joints in the Cable.—Where it is necessary to transfer a cable at two points simultaneously as in the case where cables are being diverted to a new conduit route as a result of road alterations, etc., normally it is not necessary to identify with the exchange M.D.F. or cable distribution points so long as the corresponding pairs at each point can be readily identified. This would be done in a manner similar to that shown in Figure 19(a) or (b) except that the tone or buzzer set would be applied at a joint instead of at the cable distribution point. Where, however, there is no correspondence whatever in the position of the pairs in the layers at each point, the work may be accelerated in some instances by first identifying a substantial proportion of the cable pairs at each point with the exchange. It is not necessary to deal with the whole of the pairs in this manner since a point will be reached in each case where the work can be done faster by reverting to the previous method. Where pairs have been identified from the exchange, it is very desirable to check them between the two points of cut-over before the change-over takes place to avoid incorrect jointing due to possible errors in the identification of one or both points.

Addendum to Part 3

With regard to Fig. 13, it should be understood that, if signal buzzers (or trembler bells) are used at both control and searching points, satisfactory operation can be obtained only by placing them in local circuits which are controlled by relays operated by the testing current passing through the cable conductor under test. As a general rule it will be found that, if the buzzers are connected directly to the conductor, the interaction of their interrupter contacts makes their operation unreliable.

If, however, a low wound (60 ohm or less) earthed head receiver is used for searching at one end, it is practicable and satisfactory to use a buzzer (or bell) connected directly to the line at the other end to provide the signal tone.

ANSWERS TO EXAMINATION PAPERS

The answers to examination papers are not claimed to be thoroughly exhaustive and correct. They are, however, accurate so far as they go and as such might be given by any student capable of securing high marks

EXAMINATION NO. 2123.—SENIOR MECHANIC: TELEPHONE INSTALLATION AND MAINTENANCE

O. C. RYAN

Section A

Q. 1.—Define: (a) Retentivity,
(b) Decibel.

Describe: (a) Graded access as applied to trunking in automatic exchanges,
(b) Solenoid,
and in each case explain an example of its application or use.

A.—(a) Retentivity is the term used to indicate the power of a body for retaining magnetism. Soft iron does not retain magnetism to any extent, hence it has a low retentivity. Hard steel retains magnetism almost indefinitely and has a high retentivity. The retentivity of a magnet depends mainly upon the material, but the shape of the magnet and its temperature have a minor influence.

(b) The "decibel" is equal to one-tenth of a "bel" which is the unit of comparison between the power levels in two or more electric circuits or in different sections of the same circuit. The number of bels corresponding to any power ratio is equal to the common logarithm of that ratio, and the number of decibels is equal to ten times the number of bels.

If the power level in one circuit is P_1 and the power level in another circuit is P_2, the number of decibels corresponding to the ratio of these power levels equals

$$10 \log_{10} \frac{P_1}{P_2}.$$

(a) **Graded Access:**

Grading is a method of connecting level multiples together so that a group of switches is given access to individual outgoing links or trunks on the early choices but on the later choices shares access to trunks with other groups. A switch having access to the trunks in such a group would be said to have graded access. As an example, consider a group of 20 selector switches which require 11 trunks on one of the levels. There are 10 contacts on each level of each switch, and to arrange access for 11 trunks the multiple wiring for the first contact on the particular level concerned would be disconnected between the tenth and eleventh switches and trunks Nos. 1 and 2 connected to each section respectively, whilst trunks 3 to 11 inclusive would be multiplied over contacts 2 to 10 respectively of all 20 switches. Switches 1 to 10 would, therefore, have access to trunk No. 1, switches Nos. 11 to 20, access to trunk No. 2 and all switches would have access to trunks Nos. 3 to 11 inclusive. Trunks 1 and 2 are termed "individual" trunks and 3 to 11 "common" trunks or a common group.

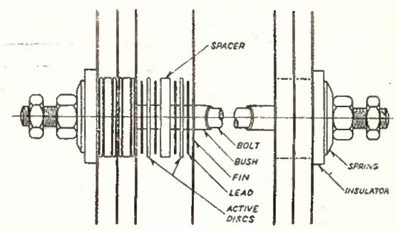
(b) **Solenoid:**

A solenoid consists of a coil of insulated wire wound on a hollow cylindrical bobbin so that the turns of wire are closely adjacent and of one or more layers deep. The length of the coil should not be small compared with its diameter. When current is passing through the coil it has a magnetic field resembling generally that of bar magnet, the intensity of the field on the inside of the solenoid being greatest midway between the ends of the coil. With the introduction of a soft iron core or plunger the solenoid becomes far more powerful. The effect of the iron is, due to its greater permeability, to multiply the number of magnetic lines as well as to concentrate them at definite points. The soft iron core or plunger tends to move into the position in which it best completes the magnetic circuit generally. The pull increases as the end of the plunger penetrates into the coil, being a maximum when the end of the plunger has reached the end of the tube. In practice the solenoid usually consists of a heavy coil of insulated wire wound on a brass tube. A short fixed core of iron is inserted at one end and an iron jacket or external frame provides a good return path for the magnetic flux.

On a plunger type uniselector unit a solenoid associated with the master switch circuit is employed to pull the line switch shaft and associated equipment from trunk 1 to trunk 10 in connection with the allotment of disengaged outgoing trunks.

Q. 2.—Describe, with the aid of diagrams, the construction of any type of Copper Oxide Rectifier. Explain one application of the rectifier you describe.

A.—Construction: Referring to Fig. 1, the rectifying element consists of a disc of pure copper, which has been oxidized on one side by special heat treatment. The resistance in the direction of the oxide to copper, i.e., from the oxide face inwards, is low but in the opposite direction it is very high. To ensure a low



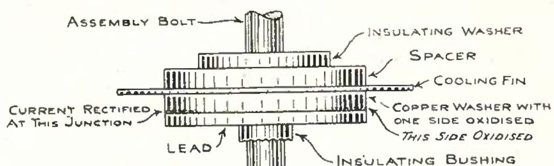


Fig. 1.

resistance and continuous contact of the free surface of the copper oxide, finely powdered carbon is rubbed into the surface of the oxide before being assembled. The rectifier discs are assembled on a screwed shaft from which they are insulated by a sleeve of insulating material. Lead washers, to the contact surfaces of which a thin coating of tin has been applied to render them non-reactive, are inserted on either side of the discs. Lead is used because it can be made to fit the surfaces more closely than any other metal. Radiating fins of sheet iron are used to dissipate heat and at the same time, to serve as conductors or connections. Spacing washers, copper plated, to increase their electrical conductivity, are inserted between successive radiating fins. This improves the ventilation of the unit, as it tends to prevent air pockets forming between more closely assembled fins. The discs and auxiliary components are then tightly clamped together by means of a nut and spring washer pressing on to a moulded insulating washer.

Each disc is able to withstand about 5 volts impressed and the assembly of these rectifiers is carried out in such a manner that the number of discs is sufficient to withstand the A.C. voltage necessary to produce the required D.C. voltage, and the number of parallel groups is such as to carry the required D.C. current; each completed unit can be designed for half wave or full wave rectification.

Difficulty is frequently experienced in maintaining satisfactory adjustments on relays to respond effectively to alternating current, generally ringing current. If an ordinary relay has a rectifier connected across its winding, then it will operate efficiently with ringing current. During the half cycle of the ringing current when the A line is positive, the rectifier offers a very high resistance and most of the current flows through the relay winding. When the B line is positive the rectifier acts as a shunt to the relay which receives comparatively little current. During the negative half cycles the relay winding and the rectifier form a local circuit for the currents set up by the collapsing field of the relay, this causes the relay to be slow to release. The values of relay windings may be arranged to eliminate chatter.

Q. 3.—Describe with the aid of diagrams, the construction and operation of a three phase induction motor and a suitable starting device for use with it.

A.—If a metallic cylinder, free to rotate about its axis, is placed in a magnetic field which rotates about

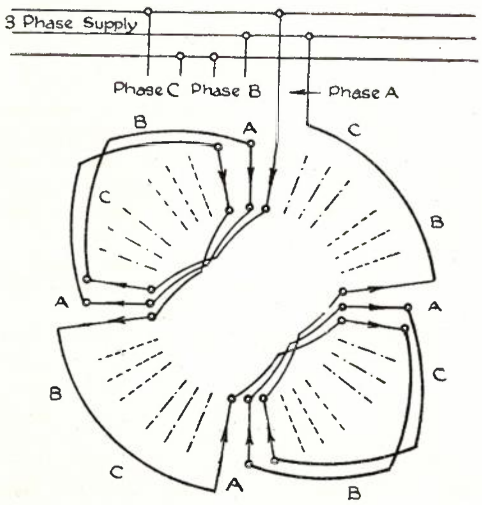


Fig. 1.

the same axis, current will be induced in the cylinder and produce a magnetic field which will react with the rotating field and provide a torque on the cylinder which will tend to make it follow the rotating field. This is the principle of the ordinary squirrel cage induction motor, which is the one commonly used. The ro ating portion is called the rotor, and the field windings which produce the rotating magnetic field are wound on the stator, which is part of the frame of the machine for, although the magnetic field rotates, the windings which carry the currents producing this field are stationary, the effect being obtained by the varying phase relations between the currents in the windings.

In the 3-phase motor each phase winding is placed on the stator in such a position in relation to the others that the resultant magnetic flux, produced by

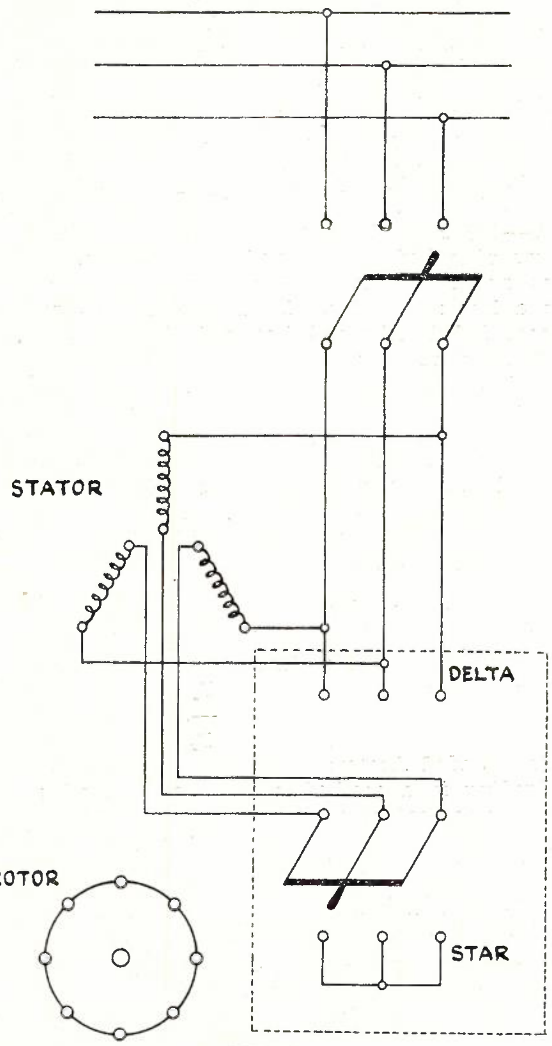


Fig. 2.

the alternating currents flowing through them, remains constant in magnitude but changes its direction at every instant, rotating through an angle of 360 electrical degrees during each cycle of the alternations.

Thus, although the stator and the stator windings do not move, an effect is produced as if a magnet is rotating about the rotor and, for the reason described, a torque which tends to cause the rotor to revolve is set up. The rotor tends to travel at the same speed as the rotating field, but it cannot do so because, if it did, there would be no relative motion and, therefore, no interaction and no torque. In practice, therefore, the rotor travels at a slightly slower speed. The difference between the rotor speed and the speed of the rotating field expressed as a percentage of the latter is called the slip.

In an actual motor the rotor consists of a set of laminated steel or iron stampings mounted on a shaft in a similar manner to a d.c. armature. The winding consists of copper bars which are laid parallel to the shaft in slots on the circumference of the rotor. The ends of the bars are connected together by copper rings. There is no commutator or other winding on the rotor. The stator, which is usually integral with the frame of the machine, surrounds the rotor and has a series of slots on the inside into which the stator windings are placed. The phases are wound separately, and they are connected to the line in star or delta when the motor is running.

The relative positions of the three phase windings in a 4-pole machine to produce the desired rotating field are shown in Fig. 1.

If a squirrel cage motor is connected directly to the line for starting, it will draw a very large current, which, with all except the smallest motors, is likely to disturb the system or to be dangerous. It is therefore necessary to start these motors on reduced voltage. This effect can be achieved in several ways, but a very simple method is the star-delta switch starter. Essentially it consists of a triple pole double throw switch, which is connected as shown in Fig. 2; in the starting position it connects the three stator windings in star to the line, and thus each winding has 0.58 of phase voltage across it; when the motor attains full speed, the switch is put into the running position in which the stator windings are connected in delta, and thus have the full phase voltage impressed across them. The motor will then develop full torque. The circuit shown is schematic; in practice it is usual for a no voltage release to be associated with the starter so that, if the pressure goes off the line, the starter will release to the open circuit (intermediate) position.

Q. 4.—A battery of 100 volts and internal resistance 1 ohm is connected to an external resistance of 10 ohms. What would be the change in the voltage across this resistance if a second resistance of 10 ohms is connected in parallel?

What power would be drawn from the battery in the second case?

A.—The current in the first case will be:

$$I = 100/(10 + 1) = 100/11 \text{ amps.}$$

The P.D. across the resistance $= R.I = 10 \times 100/11 = 1000/11$ Volts.

On connecting the second 10 ohm resistance in parallel, the combined external resistance is reduced to $10/2 = 5$ ohms, and the current is increased to:

$$100/(5 + 1) = 100/6 \text{ amps.}$$

The new P.D. will be $5(100/6) = 500/6$ volts. The change of voltage is therefore:

$$1000/11 - 500/6 = 1000\ (1/11 - 1/12) = 1000/132 = 7.58 \text{ volts.}$$

The power expended in the external resistance is I^2R watts and is $= (100/6)^2 \times 5 = 50{,}000/36 = 1.39$ kilowatts.

The power absorbed by the internal resistance of the battery $= (100/6)^2 \times 1 = 0.28$ kilowatts.

Q. 5.—Why is a patching board provided at a large trunk exchange?

Draw a block schematic diagram showing the patching connections on a pair of trunk wires to which a composite set is connected and which terminates on the trunk switchboard.

A.—The patching board is used to provide:

(a) A convenient and quick means of testing either "in" or "out" on a trunk or other line connected thereto. Among the principal tests effected from the board are:

Capacity tests for location of open circuits on lines.

Loop resistance tests for lines in contact.

Varley loop and Murray loop location tests for earthed and/or crossed circuits.

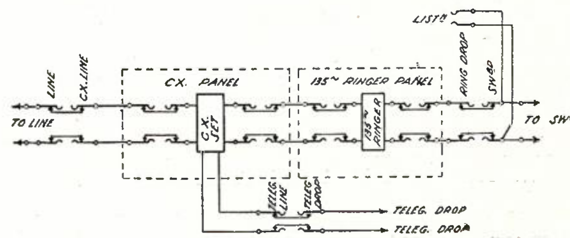
Insulation resistance of lines and apparatus.

(b) A means of substituting faulty lines or sections of lines with other working lines to ensure a minimum of delay in case of faulty conditions arising on the more important trunk lines.

(c) Facilities for observing lines on which intermittent faults have been reported.

(d) An arrangement whereby plugging into break jacks, located on the board, through which all lines and apparatus are wired, defective apparatus can be immediately cut out of service and temporarily replaced by stand-by equipment. The line is therefore maintained in service and the defective equipment can be adjusted or repaired at a more convenient time.

(e) A means for clearing apparatus from the circuit to enable the trunk line to be used for broadcasting purposes. When two or more panels are provided, transfer circuits are used between them to avoid the use of long cords.



Section B

Q. 1.—A subscriber connected to an automatic exchange is to be provided wtih a P.B.X. group of two lines, and there are prospects of the size of the group increasing.

Explain: (a) How you would provide for night switching on the two lines.

(b) What connections must be made to the private and auxiliary contacts of the final selector banks if the P.B.X. group is extended to five lines.

A.—(a) In normal practice no provision is made for night switching the first of a group of subscribers' lines connected to P.B.X. final selectors having night switching facilities, due to the hunting conditions set up when this number is selected.

The circuit provides for connecting battery through a 100 ohm resistance to auxiliary private bank contact, P1, for the first line, contact P2 being open, bridging P1 and P2 for intermediate lines, while the P1 and P2 of the last line of the group remain open.

One method of providing night switching facilities on the first line of a group is to allot a spare number which should be advertised for use as a night line only. The negative, positive and private (P2) of this number should be connected with similar terminals of the first line of the group at the uniselector terminal assembly. Thus the line is available from either number and if one number is in use the other will test busy.

As the number immediately following, the two in use would normally be held for expansion of the service, this number would be satisfactory for night switching purposes. If the directory number of the group is 1234 search would take place over 1234-5 and night switching facilities would be given on 1235-6.

(b) If the P.B.X. group be extended to 5 lines the third number, now being used for night switching purposes, would be disconnected from the first line of the group and P1 and P2 contacts of the second, third and fourth lines respectively would be connected together, thus making them intermediate lines. The P1 and P2 contacts of the fifth line would remain open. This alteration would be effected at the uniselector terminal assembly.

Q. 2.—Modern automatic equipment provides for the supply of speaking current to the subscriber's transmitters through a low resistance, high impedance relay and a ballast resistance lamp. Describe the improvements in the service resulting from the use of this arrangement.

A.—One method of improving the sending efficiency of subscriber's transmitters which are included in high resistance line loops to automatic exchanges, is to make provision for increased current through the transmitter. This is achieved by reducing the resistance of the battery feed relay from 200/200 to 50/50 ohms. While this method will result in increased current through the subscriber's transmitter, two additional factors must be taken into account. They are:—

(a) Voice frequency losses via the low impedance 50/50 ohm relay.

(b) Excessive current through the transmitters of subscribers connected to the exchange by low resistance line loops and having 50/50 feed relays.

Voice frequency losses through the 50/50 ohm relay are avoided by providing nickel iron sleeves over the core of the relay. This results in high impedance to currents of voice frequency but does not affect the D.C. characteristics of the relay.

To prevent excessive current through the transmitter connected to a subscriber's line having low resistance loops the ballast resistance lamp is introduced. This device has the characteristic of offering a low resistance to small currents but with an increase of current the resistance rises. The effect of this is that the lamp does not introduce much extra resistance for lines of high loop resistance, but on short lines the ballast resistance rises to a sufficient degree to prevent excessive currents through the transmitter. A compensating resistance is therefore provided which tends to regulate the direct current flow in the circuit.

The ballast resistance lamp consists of two tungsten or iron filaments of approximately equal resistance in hydrogen gas and enclosed in a glass envelope. The filaments are terminated in suitable pins in the base for external contact with the circuit. The resistance of the lamps associated with 50/50 ohm relays for use as transmission bridges varies from 130 ohms for currents of approximately 85 milliamps to 350 ohms of currents of about 100 milliamps.

The use of 50/50 ohm relays and ballast resistance lamps instead of the 200-200 ohm relays as transmission bridges on automatic exchanges result in improved sending efficiency of subscriber's transmitters connected with lines of high loop resistance. With this arrangement, therefore, the permissible loop resistance of subscribers' lines may be increased.

Q. 3.—Draw simple schematic diagrams showing how a test desk voltmeter is connected when testing a dial for: (a) impulse weight (impulse ratio); and (b) speed.

Do not show key connections.

Explain the circuit operation in each case.

A.—(a) The schematic diagram, Fig. 1, shows a test desk voltmeter connected in circuit for an impulse ratio test with a subscriber's line connected to the test circuit. The circuit operation is as follows:

The resistance R and variable resistance X is such that a full scale reading of 75 scale divisions (7.5 volts on low scale) is registered on the voltmeter. The

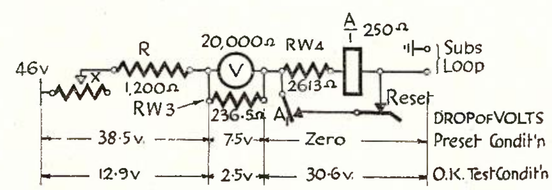


Fig. 1.

resistance X should be used to compensate for any variation in subscribers' loop resistance or battery voltage. In the figure the subscriber's loop is shown as of zero resistance. In testing a loop of 100 ohms resistance X should be adjusted accordingly. The operation of the re-set key, by removing the short circuit on R.W. 4 and relay A inserts a resistance

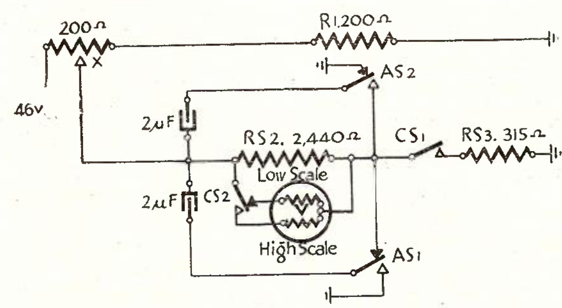


Fig. 2.

(2863 ohms) such that the voltmeter deflection is reduced to 25 scale divisions which represents a $33\frac{1}{3}$ per cent. make ratio. The series relay A forms part of this additional resistance and now operates, A1 maintaining the reset condition after the release of the reset key.

Upon the receipt of a train of impulses the first break releases A which has been held operated over the subscriber's loop, A1 restoring the short circuit to A and R.W.4. The voltmeter pointer thereupon tends to take up a position showing 75 scale divisions during make periods and zero during break periods, the resultant scale readings representing the percentage of the total dialling time for which the impulse springs are closed, i.e., the make ratio.

(b) Impulse speed: The connections for the test desk voltmeter for testing dial speeds are indicated in Fig. 2. The circuit operation is as follows:—

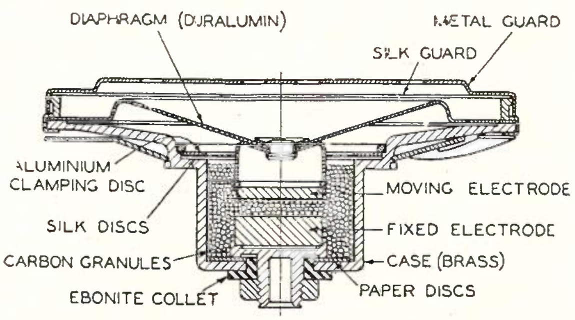
The test depends on the average value of the current flowing in the voltmeter circuit during the impulsing period. Two similar and equal capacities, in this instance 2 m.f. condensers, are alternatively charged from a common source of potential, 46 vol s, and then discharged through the voltmeter and its shunt via contacts A.S.1 and A.S.2. Relay A.S. is controlled by the dial under test. Both capacities are discharged every impulse, one during the make and one during the break portions of the impulse, the voltmeter receiving two discharges for every impulse dialled. At the standard dial speed of 10 I.P.S. there will be 20 condenser discharges per second, which gives a deflection of 40 scale divisions equal to 4 volts on the voltmeter scale. Higher dial speeds will cause the twenty condenser discharges to occur in a shorter period of time than one second, and as the quantity remains the same, the rate of flow will be increased, thus giving a higher scale deflection. Conversely lower dial speeds will give lower scale deflections.

Variations in the ratio and speed do not affect the accuracy of the test within required limits as the time occupied by the condenser discharge is brief compared with the contact time of the dial springs.

The voltmeter is pre-set by means of an adjust key which completes circuit for Relay C.S., not shown in figure, to show a normal reading, 46 volts from the test supply via the high scale of the voltmeter in series with a suitable resistance. The pre-set condition is maintained until the receipt of the first break of the impulse train which removes the conditions allowing the voltmeter to be influenced by the condenser discharge only.

Q. 4.—Describe, with the aid of diagrams, the construction of an inset for a handset telephone transmitter. What are the advantages of this type of transmitter as compared with the solid back transmitter?

A.—A typical immersed electrode type of transmitter inset consists of a brass container which carries the current for the moving electrode. Electrical contact is made by means of springs fixed to the moulded inset container and contacting with the metal case. To the



centre of the diaphragm which is attached to the front face of the case, a small aluminium cylinder which carries the front electrode, is fitted. This electrode is free to move in and out of a series of accurately fitting silk washers, the outer perimeters of which are clamped in position in the case to prevent leakage of the granules. The back or fixed electrode is fastened to, but insulated from, the case. The circuit to this electrode is completed via a pin and socket connection, the pins being fitted in the handset moulding and the socket is drilled in the back electrode mounting. Both electrodes protrude well into the chamber and are immersed in carbon granules, sufficient granules being used to enable the electrodes to remain immersed in the granules in whatever position the inset may be placed. A perforated metal guard covers the diaphragm and is arranged so that the holes are not in line with those cast in the mouth piece. This is to protect the diaphragm and oiled silk from mechanical damage. A piece of oiled silk is placed between the guard and the diaphragm to prevent moisture attacking the latter. The metal guard is spun on to the brass case in order to prevent interference and to ensure a damp-proof joint. A small hole is provided in the back of the capsule. This hole offers a high impedance to acoustic pressure changes but allows slowly varying differences of pressure, caused by temperature changes, to slowly equalize. Thus atmospheric changes and heating and cooling effects, due to the speaker's breath, do not cause diaphragm displacement.

The advantages of an inset transmitter, as compared with a solid back transmitter are:—

That it responds to a greater range of frequencies, has a more uniform output over the frequency range and can be used in any position. The solid back transmitter, due to its design, with a bell-shaped mouthpiece and a flat circular diaphragm supported at the edge and loaded at the centre, has a very uneven frequency response curve with marked peaks at 1000 and 1500 cycles per second. The shape of the chamber is such that the granules are liable to pack unless the transmitter is kept at the correct angle.

In the inset transmitter the mouthpiece and diaphragm have been re-designed. The granule chamber is, in effect, a piston moving in a cylinder filled with granules. These changes have flattened and increased the range of the frequence response curve and the almost complete immersion of the electrodes in the granules allows the transmitter to function satisfactorily in any position.

Q. 5.—(a) What supervisory alarms are provided in an Automatic Exchange?

(b) Which alarms are classified as urgent?

(c) Describe one method you know which is used to provide the necessary delayed action on some alarms; and

(d) To which alarms does (c) refer?

A.—(a) The supervisory alarms provided in a typical automatic exchange in which uniselectors are installed are:—

(1) Fuse operation.
(2) Ringing current failure.
(3) Circuit breaker overload and no voltage.
(4) Condenser breakdown—uniselectors.
(5) High-Low exchange voltage.
(6) Uniselector supervised ground.
(7) Selector (1st only) Permanent loop 6 minute alarm.
(8) Selector release.
(9) Selector supervisory.
(10) Final selector release.
(11) Final selector supervisory.

(b) Alarms 1 to 5 above are classified as urgent.

(c) Slow acting Set—Dashpot: On operating a supervisory relay feeding battery to a shelf of selector release magnets, the 1300 ohm relay associated with the slow acting set is operated via earth at supervisory relay contacts. The 1300 ohm relay closes circuit for the dashpot solenoid, which if the release circuit is not opened at the switch springs before the completion of the plunger stroke, operates springs which feed battery via its associated 15 ohm relay, 15 ohm trunk board pilot relay, shelf release lamp to earth at the shelf relay contacts. The shelf release lamp lights and other relays operate which completes the alarm system.

(d) Uniselector supervised ground.
Selector release.
Final selector release.

EXAMINATION 2106.—ENGINEER—TELEPHONE EQUIPMENT

(Continued from June issue, p. 56.)

D. F. BURNARD, B.E.

Q.7.—The figure is the circuit diagram prepared for issue with a subscriber's telephone and associated amplifier.

Could you certify the diagram as correct, or what alterations would you require, and in each case why?

A.—The alterations required to complete this diagram before it can be certified as being correct are:—

(1) Line 1 should be designated L.1. This is necessary for identification purposes.

pair of springs on the switch hook close the filament current circuit when the switch hook contacts are closed.

The output of the valve is fed through the primary of the voltage step down output transformer to the receiver.

(4) The amplifier valve should be designated "Valve No. 74."

The characteristics of this particular triode valve are suited to the requirements of this circuit.

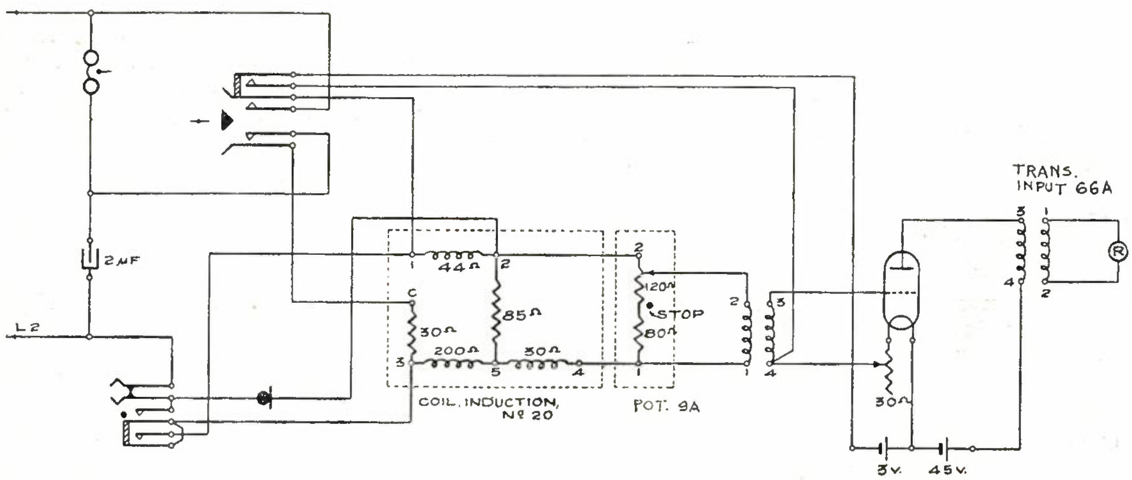
(5) The Switch Hook should be designated "Switch Hook."

The symbol used is unstandard and an additional pair of con.acts are added.

(6) The induction coil might be further designated as "Coil Induction, B.P.O. A.S.T.I.C. No. 20." This is a refinement in terminology.

(7) The drawing should be given the title "Automatic Handset Telephone, with Amplifier."

This assists in the interpretation of the circuit and makes reference possible.



(2) The transformer designated "Trans. Input 66A" should be designated "Output Trans. 66A."

The reason for this alteration is that this transformer is on the output side of the amplifier, and should be called the output transformer. As the number 66A refers to the transformer and not to the fact that it is used on the output side, the phrasing of the designation should be re-arranged as suggested.

(3) The input transformer should be designated "Input Trans. 66A."

The reason for this addition, together with the change in (2) above is seen from a brief description of the act:on of this amplifier.

The circuit is that for an automatic handset telephone, No. 232, except that an amplifier is put between the receiver and the terminals 2 and 4 of the induction coil, and a pair of springs are added to the Switch Hook contacts. The current, which in the straightout handset passed through the receiver, now passes through a potentionmeter in parallel with the primary of a voltage s ep up input transformer. The adjustment of the potentiometer varies 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 additional

Q. 8.—(a) What is the purpose and nature of "dialling tone" and how is it generated?

(b) Show, by schematic circuit diagram, how dial tone is derived and supplied to its objective in a branch automatic exchange having line finders and ordinary repeaters or relay sets.

(c) Explain how dial tone is derived in a main exchange equipped with rotary type preselectors.

A.—(a) The main purpose of dialling tone is to ind:cate to the calling subscriber that the first impulse accepting switch is available and dialling may be commenced. Secondary results obtained with dialling tone are:—

(1) In last party release systems, if the calling party hangs up during conversation, the called subscriber will hear dialling tone from the 1st Selector indicating that the calling subscriber has cleared.

(2) Distinguishes a subscriber's line from a junction line for a lineman.

(3) Informs a P.B.X. extension that he has been connected to an Exchange line without the operator informing him.

The generation of dial tone is associated with the ringing machines.

The latest type of tone generator is based on the principle of the inductor type of alternator. The special features of this machine are:—

(a) There are no brushes or commutators;

(b) Both the exciting (field) winding and the output (armature) winding are on the stator;

(c) The only rotating part is an iron shaft on which are four toothed iron discs (one for each tone output) each rotating within its own particular field system; and

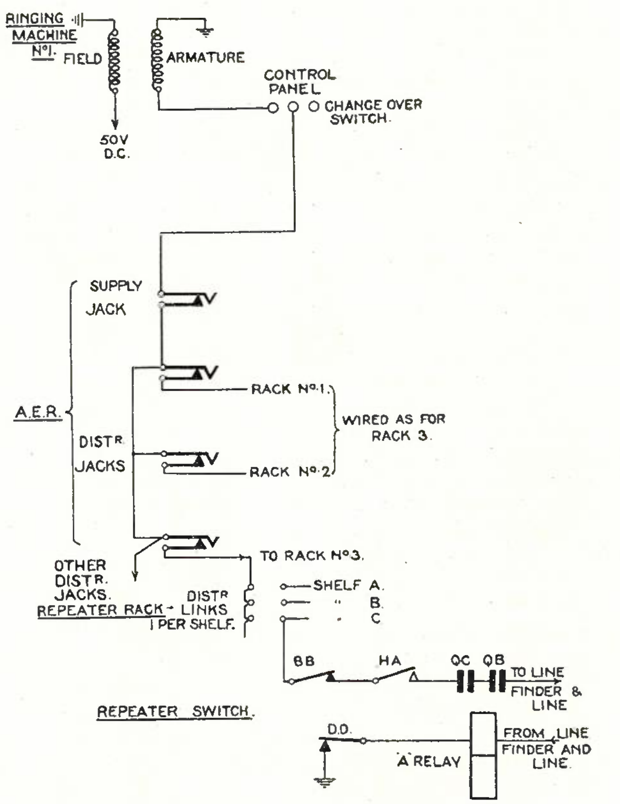
(d) The dial tone is fed direct to the ringer panel from the output winding. A dial tone transformer is not required.

50 volts D.C. is fed through the field winding to earth. The iron shaft is rotated at 1000 r.p.m. by the ringing machine induction motor. The iron disc rotates within the field winding which is designed so that the lines of force pass through the iron disc diametrically and through the output winding. Two teeth are cut in the circumference of the disc in position diametrically opposite. The field strength of the field winding varies with the length of the iron or air path. As the two teeth come in line with the lines of force, the field strength is changed and, at each change, an e.m.f. is induced in the output winding. This change occurs twice in each revolution of the disc and a 33⅓ cycle a.c. is produced in the output winding. This is the dial tone.

Dialling tone on the subscriber's line is an induced alternating current with a fundamental frequency of 33-1/3 cycles per second. In earlier types of switches, the tone was connected through one winding of the impulsing A relay direct to line but, in the 2000 type equipment, it is induced in the A relay line windings from a third winding. Harmonics are associated with the fundamental in the subscriber's line.

(c) On the first selector trunk boards are mounted transformers, one for each shelf of 20 switches. The primaries of these transformers are in parallel and permanently connected to the dial tone output from the control panel of the ringing machines. One side of the secondary of the transformer is earthed, and the other side is taken through the normally open contact of the supervisory relay (one relay per shelf of 20 switches) to the shelf common.

The connection to each switch from this common is taken via the normally closed S contacts, and the normally open B relay contact to the A relay 3rd winding or line windings.



(b) Schematic of Path of Dial Tone in a Branch Exchange using Line Finders and Repeaters.

Q. 9.—In a large automatic exchange a battery of 4,000 ampere-hours capacity is to be installed. The size of plates to be used is 14 in. x 14 in. and the capacity of a single positive plate is 150 ampere-hours.

(a) Give a free-hand sketch plan of a single cell sufficiently clear to show approximately the significant dimensions, assuming measurements not already given.

(b) How many positive and how many negative plates are required altogether for the two exchange batteries using end cells? Show your working.

(c) Give a free-hand sketch plan of the battery room required, and the layout of the two batteries therein.

(d) Give a sketch showing the elevation of two adjacent cells.

A.—(a)

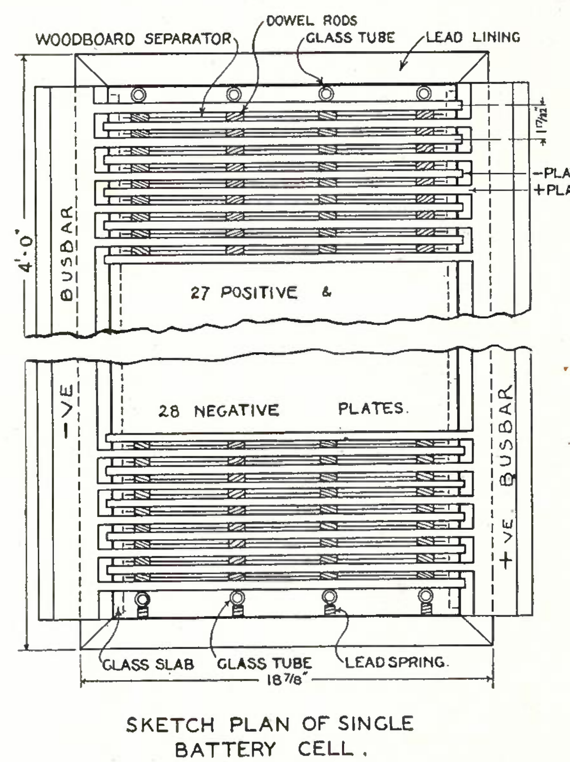


Fig. 1.

(b) Positive plates required per cell = 4000/150 = 27 (nearest plate).

Negative plates required per cell = 28.

For an automatic exchange, two batteries each of 23 main cells plus three end cells are required.

Total plates = positive 27 x 26 = 702.
negative 28 x 26 = 728.

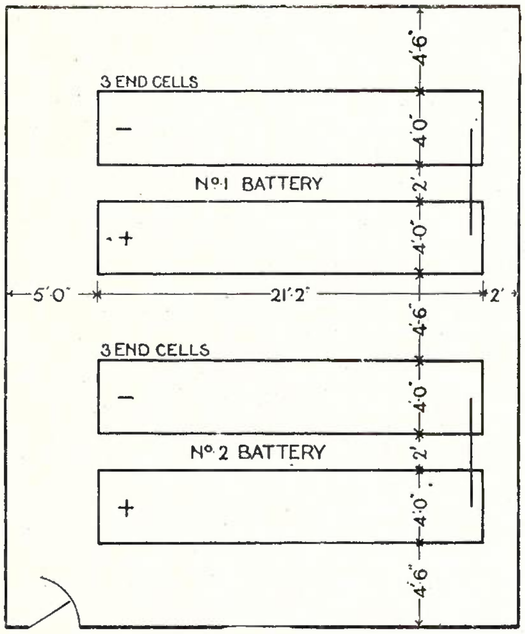


Fig. 2.
Plan of Battery Room Layout.

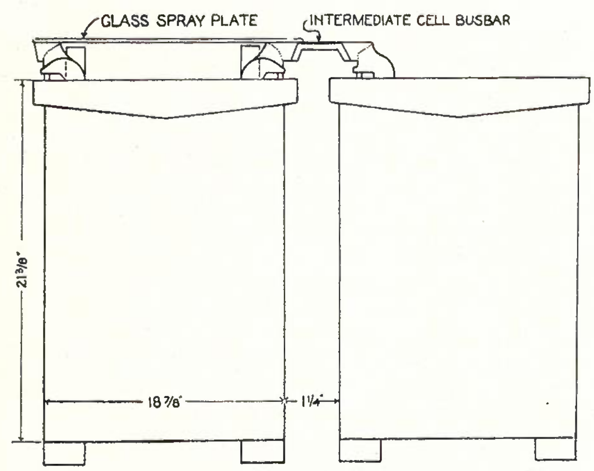


Fig. 3.
Elevation of Adjacent Cells in a Battery.

Q. 10.—(a) What are the standard tones and what is the standard ring for our automatic exchanges?

(b) In a network having a mixture of harmonic ringers and power ringing machines, what action is necessary to standardize the tones and the ring?

(c) Give a block schematic diagram showing how the tones and ring are supplied to the switches in a metropolitan exchange.

(d) If 1000 cycle ringers are installed, could you arrange for a manual trunk switchboard, installed in the same building as the automatic exchange, to use the automatic exchange ringing power? Discuss this point.

A.—(a) The standard tones for our automatic exchanges are:—

(1) Dial Tone, 33⅓ cycles/sec. continuous.

(2) Busy Tone, 400 cycles/sec., .75 sec. on, .75 sec. off.

(3) N.U. Tone, 400 cycles/sec. continuous.

(4) Ringing Tone, 133⅓ cycles/sec., superimposed on 33⅓ cycles/sec. interrupted at .4 sec. on, .2 sec. off, .4 sec. on, 2.0 sec. off.

The standard ring is 33⅓ cycles/sec., interrupted at .4 sec on, .2 sec. off, .4 sec. on, 2.0 sec. off.

(b) It can be assumed that the power ringers give the standard tones and ring, so that any alteration or addition must be done in the exchanges using harmonic ringers. For the most satisfactory arrangement, the harmonic ringers should be completely replaced by power ringers.

Exchanges using harmonic ringers are generally older, hence the selectors in use may or may not have facilities for the connection of all the tones to subscriber's lines. In the worst case, there will be provision for busy tone, for ringing tone and ringing current itself, but none for dial tone. It will be necessary, therefore, to add dial tone on 1st Selectors, which will involve the addition of an extra "B" relay contact and internal wiring to an additional jack. However, the harmonic ringer cannot be economically modified to give all the tones nor the standard interruptions of the existing tones. Further, the frequency of the tones supplied by the harmonic ringers for the various services is not uniform.

In practice, considerable latitude can be allowed in the frequency of the tones, so that if the interruptions can be standardized, satisfactory supervision can be given to the subscribers at a low cost. The harmonic ringer supplies ringing current, ringing tone and busy tone. The frequency of the ringing current may be 16⅔ or 33⅓ c.p.s. The frequency of the Busy Tone is approximately 400 c.p.s. It is found that the subscriber can discriminate if a low frequency tone is supplied for ringing and dial tone and a high frequency tone is given for busy and N.U. tones. Hence, if the ringing tone is used for dial tone and if the busy tone uninterrupted is used for N.U. tone, and a special means for giving the correct interruption is furnished, standard conditions are approximated at a low cost.

For a satisafctory interrupter, a small induction motor with correct reduction gear and interrupting cams is suggested. An alternative is a preselector stepped automatically by the harmonic ringer.

Summarized, the items to order in the worst case are:—

(1) One pair m.b.b. contacts on the B relay to change from earth to dial tone per first selector.

(2) One male jack and 1 female jack per 1st selector.

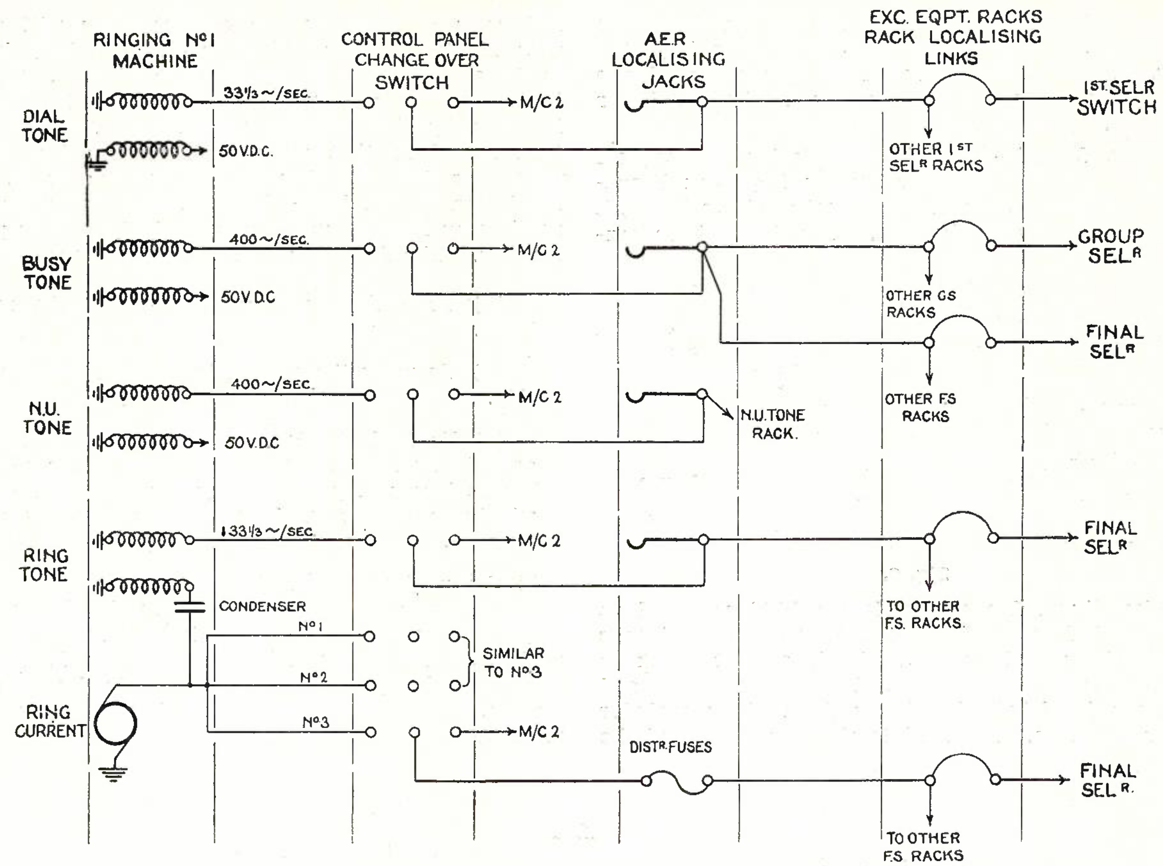
(3) Ringer complete; or

(4) Motor, reduction gear and interrupters.

(c) See sketch, page 113.

(d) The standard ringing machine installed in automatic exchanges gives an A.C. of 33⅓ cycles/sec. and the maximum frequency in the tone generator is 400 cycles/sec.

The standard ringing equipment for manual trunk exchanges supplies a ringing current of 16⅔ cycles/sec. In the carrier systems, a 1000 cycles/sec. current is



Block Schematic of Standard Methods of Distributing Tones and Ring in Auto.-Exchanges.

used. The 16⅔ cycles feed into a tuned circuit which will not respond to 33⅓ cycles unless especially altered. This alteration is possible, though generally not desirable.

As regards the use of the 400 cycle tone, this could not be utilized in the carrier equipment.

Hence, without wiring alterations, a standard automatic exchange ringing machine could not be utilized for ringing out from a manual trunk board.

EXAMINATION 2106.—ENGINEER—TELEGRAPH EQUIPMENT

V. St. G. MAGNUSSEN

Q. 1.—Describe the mechanical and electrical functioning of:—

(a) A Murray Multiplex Perfora'or; and

(b) A Murray Multiplex Transmitter.

Illustrate your answer with simple diagrams.

A.—(a) A Murray Multiplex Perforator is employed to perforate the tape and is fitted with a keyboard consisting of three rows of keys. Figure 1 shows sufficient of the mechanical set up to enable a description to be given. The various parts are side referenced and referred to hereunder:—Each key (K) rests on its corresponding key lever (KL) and immediately under these are placed the five code bars (CB). The code bars correspond to the five elements of the code and run horizontally from right to left of the keyboard. The code bars have teeth cut on their top edge in such positions that when a key is depressed those code bars which represent spacing elements in the selected letter combination move to the right. At the end of each code bar is a bell crank (BC) pivoted in such a way that when it is operated it allows the interposing rod (IR) to drop into the operated position. There are five interposing rods, one for each bell crank. The interposing rods are normally interposed between the punch hammer (PH) and the message hole punches (MP). In the selection of a punch combination for any key depressed, the spacing signals are selected by the withdrawal of the interposing rods from the front of the punches, so

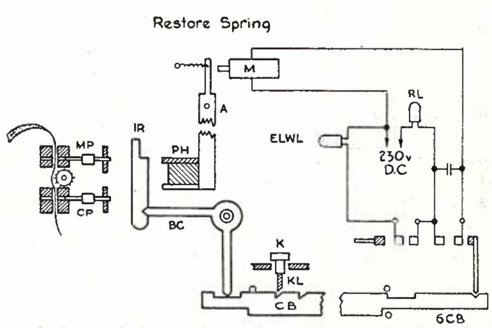


Fig. 1.

that holes are not punched in the tape corresponding to the positions of the withdrawn rods. A feed hole is punched every time the armature (A) is operated. In order to punch the holes at each depression of the keys, a 6th bar (6 C.B.) runs parallel with the code bars and whenever a key is depressed, the 6th bar is moved and closes the circuit through the power magnet (M). The circuit arrangements are indicated in Fig. 1. On the restore of the armature of the power magnet the paper is fed ready for the next letter perforation.

(b) Fig. 2 indicates the mechanical and electrical sequence of operations of a Murray Multiplex Transmitter. The function of the transmitter is to transmit the code impulses to the line. The transmitter consists primarily of five contact levers (CL) mounted on a shaft and free to oscillate between contact blocks (CB) marking and spacing. Each contact block is fitted with five contact screws. The contact levers and screws are insulated electrically from the remainder of the mechanism. Attached to the lower arms of the contact levers are two springs S_1 and S_2. S_2 is stronger than S_1 and when both are free to act together S_2 will force C.L. against M with a pressure of about 1.5 ozs. The oscillations of the contact levers are controlled by five needle levers (NL). If there is a message hole in the tape corresponding to the position of any of the five needles, the needle will pass through the tape and as a consequence the contact lever will contact with M block. This will transmit a marking impulse to the corresponding segment on the plateau. The tape is fed by one centre line hole for each impulse that is given by the cadence magnet (CM). The tape is thus moved so that consecutive letter codes are presented to the selecting needles ready for the next revolution of the plateau brushes. The cadence magnet receives an impulse once every revolution of the plateau brushes. The functions of this magnet are:—

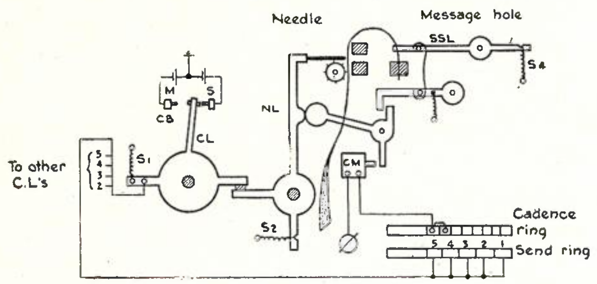


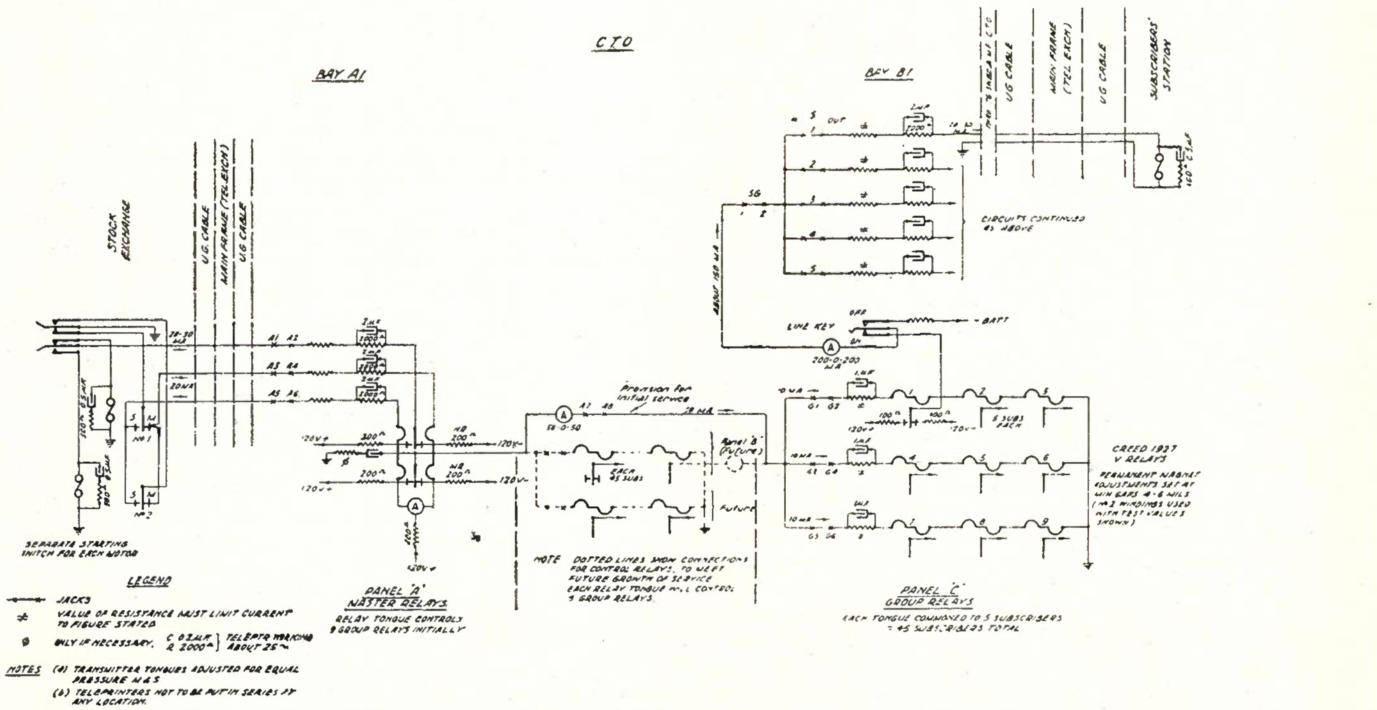
Fig. 2.

(a) To withdraw the needles from the message holes.

(b) To move the contact levers over to the spacing side.

(c) To feed the tape on by one centre line hole and then on the release of the magnet to allow the needle levers to press against the tape so that those which encounter a hole in the tape may pass through.

If the perforation of the tape ceases or slows up, SSL, an automatic start stop lever, is slowly pulled downwards until the armature is held in the operated position. The feed of the transmitter is thus cut off until the perforation again leads by a certain margin. The contact levers during the idle period must be resting on the spacing side.



Q. 2.—Fig. 1.

Q. 2.—Draw a schematic diagram showing how you would provide for fourteen (14) Teleprinter subscribers (receiving only) to be operated from the one subscriber equipped with a Transmitting Teleprinter. All control apparatus is to be installed at the C.T.O. Discuss the general arrangements you would make for ensuring a satisfactory service.

A.—The installation would be identical with a stock ticker system and a schematic of this circuit is shown in Fig. 1.

To ensure satisfactory service and operation of the system, the following procedure should be adopted:—

(a) Test panels should be installed at the C.T.O. for observation and test purposes, and the officer in control of this facility should be well trained for his duties.

(b) A telephone should be installed at the test panel to enable the officer that is stationed there to speak to a mechanic at any distant teleprinter.

(c) A test teleprinter should be installed for use with the test and observation panel.

(d) Routine tests should be carried out between the test and observation panel and the C.T.O. and between all teleprinters connected thereto.

(e) It may be desirable to arrange for drop copies to be taken at the C.T.O. in order that the mechanic would be able to provide any subscribers with business transacted during the time the machine is out of order.

Generally the organization and control of the system should be such that all faults are cleared with a minimum of delay and spare teleprinters and other apparatus should be readily available for replacement purposes. Apart from the organization and control aspects, as set out in (a) to (e) above, it is desirable that traffic requirements as indicated hereunder be provided for to ensure satisfactory service:—

(f) The printing of "home record" copies at the transmitting station.

(g) Means whereby the typing speed cannot exceed the transmission speed of the keyboard.

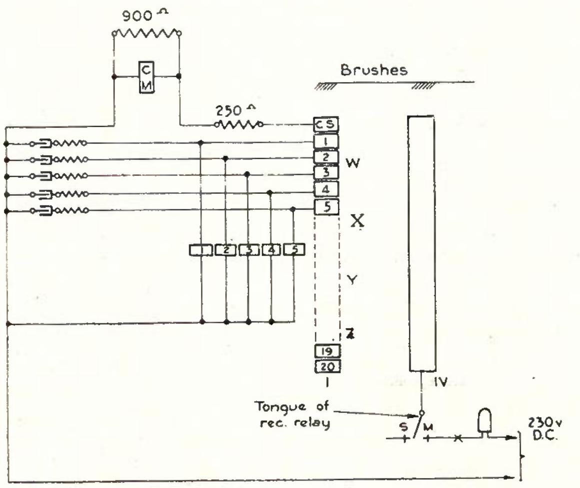
(h) A circuit arrangement which will switch the driving motors on during transmission periods only.

(j) Efficient signalling arrangements to ensure that there are no lost calls, and so that attendants may be called to the machines at any time.

Q. 3.—Draw a schematic sketch of the connections between the plateau and the Morkrum Printer on any one channel of a multiplex installation.

Explain the electrical and mechanical functions employed to produce the required printed character.

A.—



The above circuit represents schematically the connections between the plateau and the Morkrum Printer of a Murray Mux installation. The outer or first ring on the plateau is designated I, and is divided into segments, and the inner or IV ring is continuous and connected to the tongue of the receive relay.

Electrical Functions:—

(a) When marking current is received by the relay, a potential is applied by the receiving relay tongue to one of the segments on the outer ring, via the solid ring and the revolving brushes. (It is assumed that both stations are in synchronism). The return circuit to the relay tongue is completed through the printer magnet individual to the segment.

(b) If "Y" is being transmitted on "W" channel then potentials would be applied to the printer magnets corresponding to segments 1, 3 and 5, and the magnets would, of course, operate. The cadence magnet would then in sequence operate and the printing process commence.

Mechanical Functions:—

(a) When a printer magnet operates, it causes a plunger to strike a latch. This latch releases a lever which bears against the corresponding code bar and operates them when they have been freed by the locking bail after the printing of the previous letter. The code bars are slotted on the underside in accordance with the requirements of the 5 unit code, so that when any combination up to 5 are operated, the desired push bar (36 in all) rises into position. Each code bar is slotted at intervals and the code bars are arranged at right angles. The bars are locked when in the operated or unoperated position. The locking is done by a locking lever operated by a cam on the main shaft.

(b) So soon as any one printing magnet is operated, a cutout lever bail operates a cutout lever which withdraws from the path of the cadence magnet armature.

(c) The above describes the setting up process.

Printing, Sequence of operations:—

(a) When the cadence magnet energizes, it withdraws a projection from the driven clutch and allows the main shaft to revolve.

(b) The main shaft during its revolution performs the following functions:—

(i.) Locks the code bars in their operated or unoperated positions.

(ii.) Operates the selector levers through the action of a cam and reset bail and restores them all to their unoperated positions. (The machine is then ready to receive another signal combination.)

(iii.) By cam action the depressing bail is raised and this allows the push bars to rise under the action of their springs and the one which rises into the path of the striker bail is operated. The type and type bars are connected through links to the push bar. The corresponding type bar operates in a similar manner to that of a typewriter.

(iv.) Unlock code bars and depressing bail clears push bars from code bars.

Q. 4.—Explain the functioning with the aid of a sketch of a through simplex morse repeater. Discuss briefly the advantage and disadvantage from a transmission viewpoint of providing the repeater in lieu of increasing the line voltage at the terminal stations.

A.—For circuit see page 76, Fig. 1. This circuit indicates the usual circuit arrangement for a thorough simplex morse repeater. It is commonly referred to as a Toye repeater. Tracing the circuit of the up line, it will be seen that if the terminal station key is closed, the line at the repeater is connected to earthed battery through morse relay B_1 via the make before break contacts of morse transmitter A. If the key at the up terminal station is opened, however, B_1 de-energizes and opens the local circuit of the transmitter A_1. A_1 restores to the unoperated position and open circuits the down line. Relay B on the up side is kept in the operated position by earth feed through R_1 and the make before break springs of A_1. The sequence of operation is similar when the key at down station is operated. The current through R and R_1 should be the same as the line current. Although it must never be less, it may be greater by about 30 per cent.

The effect of placing a repeater in the centre of an ideal line would be to increase the speed capabilities of the circuit to four times the original speed. Experiments have shown that the working speed of a telegraph circuit is inversely proportional to the product of its total resistance and capacity, provided the inductance and leakance of the circuit is negligible. Under such circumstances, the speed of working S on a telegraph line can be expressed by the formula: $S = A/CR$. Where C is the total capacity in microfarads, and R the total resistance in ohms, and A a constant for the particular type of line and receiving apparatus.

Making use of the above formula, therefore, it may be shown that if the line is halved, the capacity and resistance for each section would be halved, and the formula for the half section would be: $S = A/(C/2 \times R/2) = 4A/CR$. As A is a constant it will be seen that the theoretical speed of the circuit is quadrupled by placing a repeater at the mid point.

As the speed of a simplex line is usually governed by the speed of manual operators, however, the inclusion of a repeater would mean that (a), greater margin would be obtained; and (b) it would be possible to work over a greater length of line. On the other hand, the inclusion of a repeater would introduce a slight mechanical lag, but this should be negligible, if proper adjustment is maintained. A further disadvantage is that apparatus and batteries have to be installed at an intermediate point.

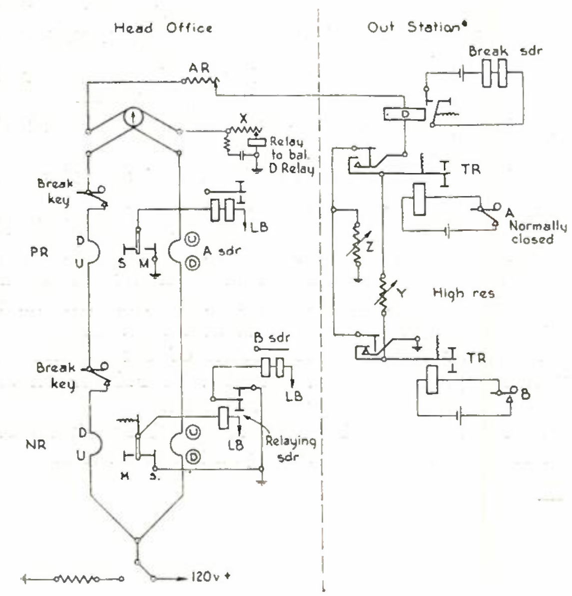
Increasing the line voltage would result in faster operation of the receiving relay, but in less proportion to that obtained by the use of repeaters. The disadvantages, however, may be serious if the voltages applied are excessive; the possibilities of inductive interference with telephone circuits and wireless receivers are increased, and leakance is greater. In addition, entry cable breakdowns may occur with high voltages and larger batteries need be maintained. Increased battery power may result in the breaking down of the I.R. of the line when bad weather conditions are experienced. With increased leakance the working margin becomes less. The use of a repeater on a line ensures the best circuit under any weather conditions that may be encountered. Furthermore, if a poor line is joined to one having good characteristics, the use of a repeater at the junction enables the best to be got out of the combination.

Q. 5.—It is desired to provide two manually operated channels from a centre to meet emergencies. The traffic is practically all inward to the C.T.O. and there is only one connecting morse circuit. Explain with the aid of a sketch how you would meet requirements.

A.—The facility could be provided by the use of a diplex circuit. Diplex working is an adaption of the Quadruplex System; depends for its operation on the differing characteristic of the polarized and neutral relays, and provides two simultaneous channels in the same direction. Facilities are provided for breaking in the opposite direction but not without interrupting the transmission.

Referring to the circuit, it will be noticed that when Key A is operated it substitutes low resistance Z for high resistance Y or grounds the line depending on the position of B. Key B grounds or opens the line, depending on the position of A. Key A should be normally closed so that the head station can speak to the out station.

The circuit is arranged so that the preponderance of current in the line windings gives marking and the preponderance of current in the artificial line windings gives spacing so far as the polarized relay is concerned. The neutralized relay will respond to a preponderance of current in either winding when this preponderance



becomes greater than a certain value. AR is used to increase the line resistance so that 120V battery may be used and the line resistance may be adjusted to 1000 ohms, 2000 ohms or 3000 ohms with normal current values.

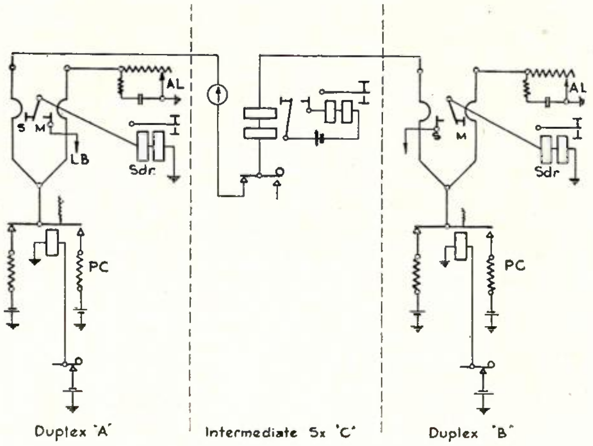
The following are the four operating conditions showing current values in relation to A and B key positions, with 20 mA through the AL winding:—

Key Positions		Line Current	Operating Current	Rec. Relays	
A	B			PR	NR
Closed	Closed	40 ma	20 ma M	M	M
Closed	Open	25 ma	5 ma M	M	S
Open	Open	15 ma	5 ma S	S	S
Open	Closed	0 ma	20 ma S	S	M

Q. 6.—(a) Explain how you would provide for the connection of a morse intermediate station on a manually operated duplex station.

(b) Show by means of a sketch how you would extend a manually operated duplex channel to a distant manual simplex station.

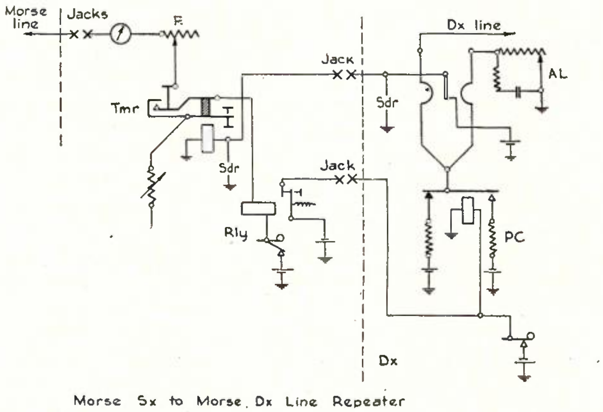
A.—(a) The required facility could be provided by a circuit arrangement in accordance with Fig. 1. To permit of simplex working when necessary, the main battery connections on the polechanger at A must be



Intermediate Morse Station on a Duplex Line

Fig. 1.

reversed and the relay contacts at B must likewise be reversed. If the facility is only required infrequently, reversing switches could be installed at each terminal station so that by throwing the switches the circuit may be readily converted to normal duplex working. If necessary, a short circuiting switch could also be installed at C, the intermediate station. It will be noted by reference to Fig. 1 that the normal line circuit is through the back contacts of the key at C. When the key is operated the line is open circuit.



Morse Sx to Morse. Dx Line Repeater

Fig. 2.

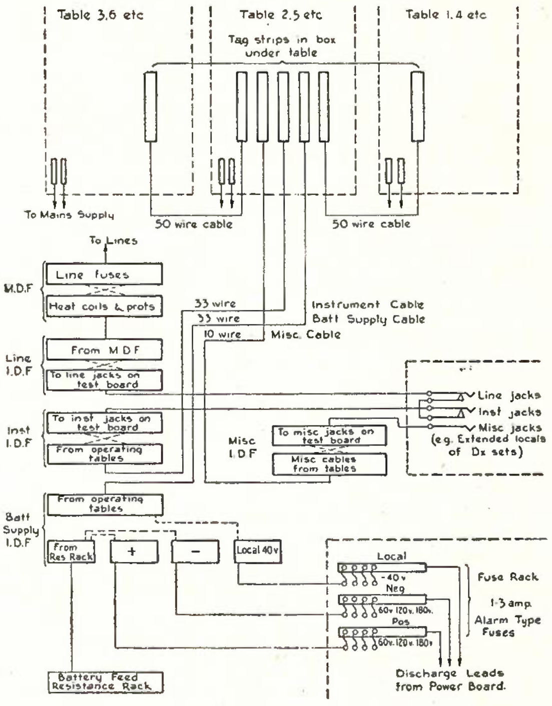
(b) Fig. 2 shows a circuit arrangement that is used extensively to extend a manually operated duplex channel to a morse simplex station. With the circuit shown, no alteration is made to the regular duplex circuit. The sounder and polechanger connections of the duplex set are connected to half toye repeater. When this circuit arrangement is employed, the simplex line can be disconnected from the duplex line at any time and worked separately.

At C.T.O.'s and large country offices, the half-toye repeater is treated as a separate unit and then terminated on jacks at the test board so that it can be joined to any duplex and simplex lines. The jack connections are shown in Fig. 2. It is necessary to include a variable resistance R on the simplex side of the repeater so that the line current may be adjusted.

Q. 7.—Show in block schematic form the distribution of channels, main and local battery supply, and commercial power supply in a Chief Telegraph Office. The size and type of wire or cable, also the capacity of the fuses you would use should be indicated. Describe briefly the method of wiring you would adopt.

A.—The sketch shows in block schematic the scheme underlying the wiring of a large telegraph office. The incoming lines (or superimposed channels) and the line terminals of the telegraph instruments are terminated on jacks on the test board for testing and patching purposes. In order that any instrument or incoming line may be connected to any jack on the test board, Line and Instrument I.D.F.'s are interposed on each side of the test board. The same method should be employed on connections to the miscellaneous jacks of the switchboard.

The distribution of line and local voltages to the instruments should pass through a Battery Supply I.D.F. which is interposed between the fuse rack and



the tables. Battery can then be supplied from any fuse to any table in the room. At this point resistances have to be introduced into those leads which are to supply the line voltages to transmitters, etc. This is effected by jumpering from the battery supply I.D.F. to the Resistance rack. The provision of I.D.F.'s for Line, Instrument and Battery ensures maximum flexibility of cabling, and also provides a convenient testing point.

Under normal circumstances, the most economical arrangement is to wire the tables in groups of three, a main cable being run to the centre table in each case. A short cable from the centre table is then run to the table on each side. A small distributing frame is fitted to the centre table for jumpering purposes. All wiring, excepting that carrying the outside power supply, should be 10 lb. silk and cotton, and enamelled insulated. Where cable is run in ducts it should be lead covered. For outside power supply, V.I.R. leads of a size and quality, that is in accordance with the S.A.A. rules, should be used. The representative sizes of cables and fuses are indicated on the block schematic.

Q. 8.—(a) Explain how the inductive effects of the windings of a relay can be reduced. Imagine a case and indicate the values you would use.

(b) Show the approximate current arrival curve at the earthed end of a long telegraph line if the other end of a line is suddenly connected to earth through a battery of "x" volts. Give reasons for your answer.

A.—(a) The inductive effects of the windings of a relay can be reduced by the use of a resistance and condenser of suitable values. The condenser is placed in parallel with the resistance and the arrangement (usually referred to as a shunted condenser) is connected in series with the relay winding. The effect of inductance is to delay the rise of current in a tele-

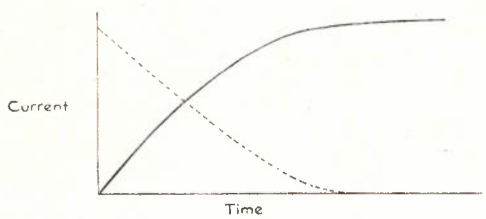


Fig. 1.

graph line, but to obtain maximum speed it is necessary to have a sharp rise in the initial stage of the signal, followed by a gradual reduction in amplitude as the signal proceeds. This sharp rise starts the receiving apparatus in motion quickly.

Fig. 1 represents graphically the current time relationship for an inductive receiver to the terminals of which a steady e.m.f. has been applied. The inverse of the current time curve is represented on the graph by a dotted line. If the currents represented by the two curves were to be applied simultaneously to a receiver then the current would always be expressed by the application of Ohms Law and the circuit would behave as a simple resistance only (i.e., non-reactive). The dotted curve represents the time rate of change of the current i and if v is the voltage producing the final current i and to this is added a voltage v represented at any moment by ϕ di/dt where ϕ is a constant, then the apparent non-reactive condition is approached. The resistance and condenser of the shunted condenser arrangement affords the means of furnishing v.

For the shunted condenser, to make an inductive circuit non-reactive, the inductance L must $= K R^2$, but as a telegraph circuit does not have an invariable inductance, the most suitable adjustment is usually obtained by observing the passing signals. Fig. 2 represents graphically the current time relationship for an inductive receiver fitted with a shunted condenser. The full line curve represents the total current through the apparatus, and the dotted curve is the current time curve with the shunted condenser omitted and the voltage adjusted to give equal final current values.

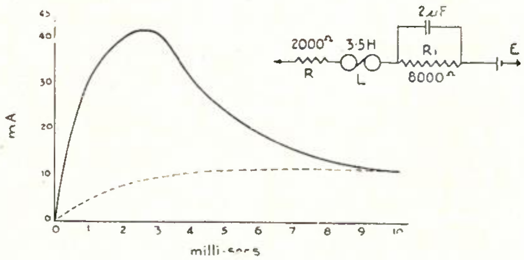


Fig. 2.

Assuming a case:—It is required to place a shunted condenser in series with a telegraph instrument of 8 henrys. If the condenser value is taken at 2 mF the resistance value would be:—

$K R^2 = L$ Where K = capacity in farads.
$2R^2/1{,}000{,}000 = 8$,, R = resistance.
$R^2 = 8{,}000{,}000/2$,, L = inductance in Henrys.
$R = 2{,}000$.

(b) The curve shown in the Fig. 3 indicates the approximate characteristics of the growth of current at the receiving end of the circuit from the moment that the voltage X is applied at the sending end, until the time when the current reaches a maximum steady value. This curve is commonly known as the "Arrival Curve." From the instant of time "O" when the earthed battery voltage "X" is applied, an interval

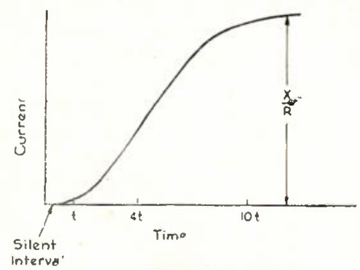


Fig. 3.

elapses during which no measurable current is received, this interval "t" is known as the "silent interval," and extends for an interval of time "t" seconds, which is approximately proportional to the product C × R where C and R are respectively the total capacity to earth in farads and resistance in ohms of the line. After this interval of no current, the received current (I_R) will commence to increase, at first rapidly and then more slowly, gradually approaching a maximum steady current value. The interval of time from O until the current is 50 per cent. of its maximum value will be 4 t seconds and that after an interval of 10 t seconds the current flowing will be nearly equal to the maximum steady state value.

The shape of the "arrival curve" is logarithmic in form and can be expressed as a mathematical law in terms of I_R, X, R C and time t.

In considering the growth of current in a normal line, the effects of line inductance and leakance can be neglected as these have a relatively small effect as compared with line resistance and capacity to earth.

At the instant before applying the voltage "X" at the sending end, the line is at earth potential; hence immediately voltage "X" is applied, a surge of current is propagated from the sending end and is continuously absorbed throughout the length of the line in building up electrostatic and electromagnetic fields. This will delay the reception of current at the receiving end and the received current will grow to a maximum as the line becomes fully charged. The delay and growth of received current will thus depend upon the line capacity and resistance.

Q. 9.—State the main points of difference between a compression ignition engine and one of the internal combustion type.

What are the main requirements for an engine used as a prime mover for a telegraph emergency supply?

A.—A compression ignition engine is an internal combustion engine in which the fuel is ignited by the high temperature which is developed when the charge in the cylinder is compressed. In order to accomplish this, a temperature of about 600 deg. C. is necessary and, consequently, the compression pressure must be high. The compression pressure required for this temperature is roughly 500 lbs. per square inch, which corresponds to a compression ratio of about 13 to 1—

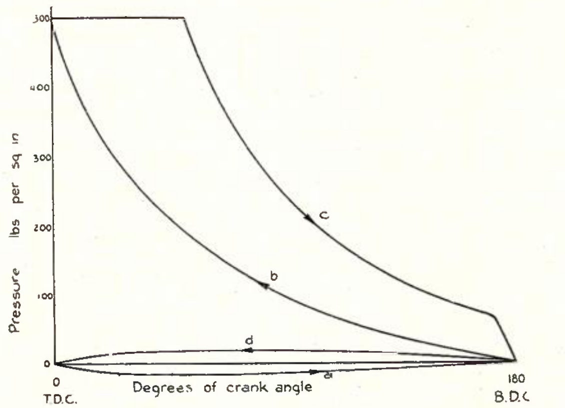


Fig. 1.

frequently higher compression ratios are used. In order that ignition may not occur prematurely, air alone is compressed during the compression stroke and the fuel is added when compression is complete, or almost so. The fuel is injected through a spray nozzle or valve under pressure—about 800 lbs. per square inch—and immediately ignites and burns during admission. The fuel is admitted in this manner during the first part of the outward or power stroke of the piston. The pressure does not rise much, if at all, during combustion because the piston is moving outwards and the rise in temperature is compensated by the increase in volume; also the fuel is burnt comparatively slowly as it enters the cylinder. The curve, Fig. 1, is a typical indicator diagram of a 4-stroke compression ignition engine and illustrates the manner in which the pressure varies during one cycle of operations.

Compression ignition engines are in general known as Diesel engines and various types of fuel such as coal gas or oil may be used with this system. Generally, however, the most satisfactory fuel is oil consisting of the heavier fractions of petroleum. With this fuel an injector nozzle is used to spray the fuel into the combustion chamber in a finely divided state.

The spark-ignition engine is quite different to the compression-ignition engine. In this the mixture of fuel and air is compressed together and ignited by means of an electric spark just before the completion of the compression stroke. A spark gap called a spark plug is provided in the combustion chamber for this purpose. When the spark occurs, the mixture burns rapidly and, unlike the C.I. engine, the pressure rises rapidly to a high peak value and quickly falls away again. This is illustrated in Fig. 2, which is a typical indicator diagram for a spark ignition engine of the petrol burning type.

There are two general types of spark ignition engine—one using coal gas or other combustible gas, and the other a spirit such as petrol. In the gas engine the gas is admitted in o the cylinder through a valve which opens and closes with the air inlet valve. In the petrol engine, the fuel is drawn into the cylinder in a vapourized or atomized state with the air. This is done by means of a device called a carburettor, through which the air must pass on its way to the cylinder. Petrol engines usually operate at higher speeds than C.I. engines.

Spark ignition engines in general have lower compression ratios than C.I. engines, because of the fact that the fuel and air is compressed as a mixture which would ignite prematurely if high compression

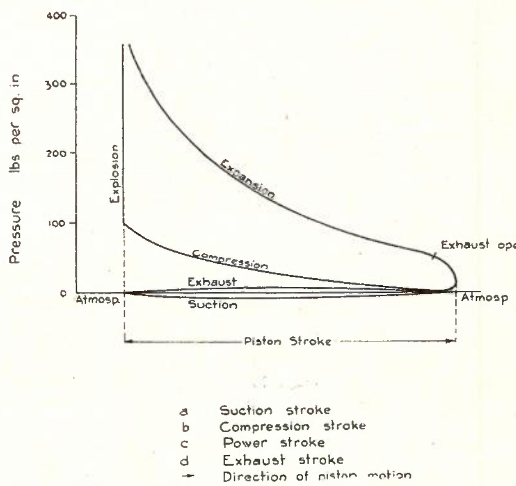


Fig. 2.

ratios were used. The compression ratio of spark ignition engines is generally between 4 to 1 and 8 to 1. These lower compression ratios are one reason for the higher efficiency of the C.I. engine, for the efficiency is theoretically independent of pressure and temperature and is affected only by the ratio of compression. This is expressed by the formula:—

Thermal Efficiency $= 1 - [(\gamma - 1)/R\gamma]$

where R $=$ Compression Ratio and where $\gamma =$ Ratio of the specific heats.

The efficiency of a compression ignition engine with a compression ratio of 16 to 1 would be greater than that of a spark ignition engine at 7 to 1.

An engine used as a prime mover for a telegraph emergency supply must be of sufficient horsepower rating to supply all normal requirements, and should be of a type that can be placed into operation with a minimum of delay. It must also be of a type that is simple in operation and easily maintained.

With the requirements of the previous paragraph met, the secondary considerations would be:—

(a) Must be economical and efficient in operation; and

(b) Availability of fuel supplies.

Considering all factors, the petrol engine would best suit the requirements, as it satisfies all demands and the capital cost would be low when compared with other prime movers of the same rating.

Q. 10.—Discuss the relative advantages and disadvantages of obtaining the required main and local current supply for a C.T.O., having 100 channels of varying length connected thereto, from:—

(a) Rectifiers.

(b) Generators.

(c) Secondary Cells.

Show by sketches the general arrangement you would suggest with each of the three sources of power supply.

A.—Generally, the power supply provided at a C.T.O. must be such that dependence entirely on an outside source is avoided, and even the normal supply that is made available should be supplemented by an emergency supply. Dealing in turn with the three schemes enumerated, the following are considered to be the advantages or disadvantages:—

(a) The use of rectifiers to supply the working voltages at a C.T.O. possesses the advantage of having no moving parts and, therefore, maintenance costs are low. Rectifiers are reliable and breakdowns from this source of supply would be rare. They have the disadvantage, however, of being dependent on the local power supply, and should this fail, some form of emergency supply would have to be provided. A rectifier unit may be panel mounted and can, therefore, be included with the fuse and switching power panels. This would mean economy in space as special accommodation is not necessary. One of the disadvantages of rectifiers is that the regulation is poor. (The voltage varies with load.)

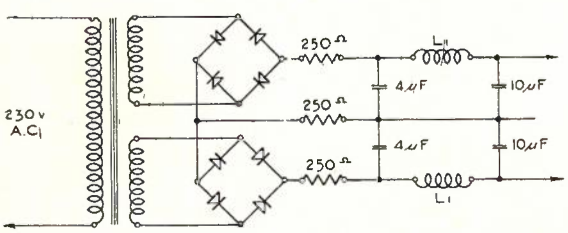


Fig. 1.

(b) Generators may also be used, but as they have to be driven from the local supply, they possess no advantage over rectifiers in regard to power failure. Furthermore, there is a possibility of mechanical and other troubles developing in the moving parts of the generator. Although the output of a generator is smoother than that of a rectifier, it is necessary to use filters. A special room is necessary to house the generators. With generators, one of the difficulties is to get the positive and negative voltages even when working double current.

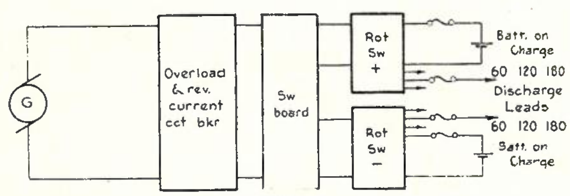


Fig. 2.

(c) Secondary Cells possess the advantage of having a smooth output and ease of tapping without waste of power, but have the disadvantage of requiring recharging when such is necessary. The outstanding advantage is that they are not directly dependent on the power supply. Provided a cyclical charging arrangement is installed and the idle battery is always kept fully charged, the load may be carried for a considerable time if power failure occurs. A reserve supply, as can be obtained by secondary cells, is a big advantage. Maintenance costs are higher when batteries are used and it is necessary to make special building provision to accommodate the cells.

Circuit Arrangements.—Figure 1 shows a typical circuit for use when rectifiers are used to obtain the power supply. Filters are necessary to smooth out the ripple. If a generator is used in lieu of the rectifier, a filtering network would still be required, although with the generator the output would be smoother.

The power circuit arrangement is much more complicated when secondary cells are used. Rotary switches must be connected in the charge and discharge circuits so that any section of the batteries commencing its discharge in position 1 is successively switched to positions 2 and 3, after which they are connected to the charging busbars for recharge. Fig. 2 shows in schematic form a typical layout of a circuit used in conjunction with secondary batteries at a C.T.O.

EXAMINATION NO. 2106.—ENGINEER—LINE CONSTRUCTION

A. S. BUNDLE

Q. 1.—It is proposed to erect a new pole route along a level country road where no clearing will be required. The line will be 9 miles long and will contain 8 light angles for which 7/14 stay wire will suffice. No head stays are required. There are 10 road crossings on the route. The poles, which cannot be placed close to the fence line are to carry two arms immediately and four arms ultimately. The arms will be spaced 14 inches apart. Three 200 lb. copper and two 100 lb. copper metallic circuit trunk lines are to be erected now and two phantom circuits are to be provided. Additional circuits will be required at the end of two years.

There are no wires joining or leaving the route and there are no power parallels. At present the route will carry voice frequency circuits only. The soil is clay with no rock. Prepare:—

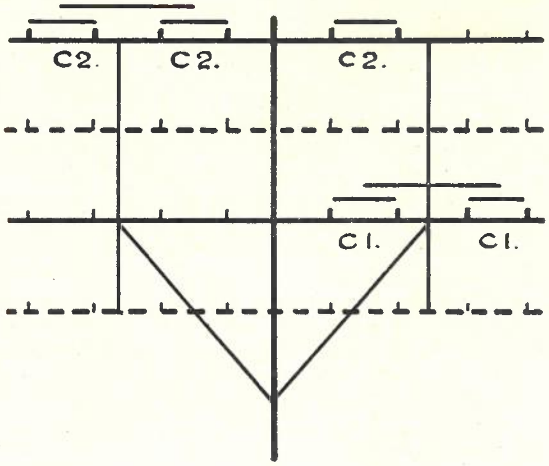
(a) A pole diagram shewing positions of wires and indicating the circuits to be phantom transposed.

(b) A straight line diagram shewing transposition sections and indicating the number of transposition poles.

(c) A detailed list of the material required for the whole job.

(d) A description of the method of carrying out the work, giving all the operations in their correct sequence.

A.—(a) Pole Diagram. Assuming that the ultimate circuits will be approximately equal numbers of 200 lbs. and 100 lbs. H.D.C. wires, the pole diagram will be:—



(If the additional circuits required within approximately five years will more than fill one arm, it will be as well to fit the 1st, 3rd and 4th arms initially and place the braces in their ultimate position. This would obviate the boring of one hole and transfer of braces later.)

(b) The total weight per mile of the wires to be carried ultimately will exceed 2,400 lbs. and therefore the spans must be between 57 and 55 yds. The 9-mile length could be divided into:—

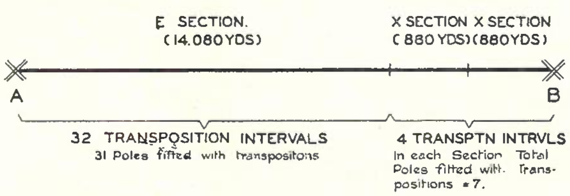
(i.) One 6-mile E section of 192 spans and one L section of 96 spans; or

(ii.) One 8-mile E section of 256 spans and two X sections of 16 spans each.

In each case the average span length will be 55 yards.

As there will not be more than 4 arms ultimately, the total transposition poles will be (31 + 15) = 46 in case (i.) and (31 + 7) = 38 in case (ii.). The latter would be adopted because it is not only cheaper, but it will also allow for 128 transposition poles in the E section and corresponding transposition spacing in the X section if (as may be inferred from the wording of the question) carrier systems are likely to be superimposed during the life of the poles.

The line diagram would therefore be:—



(c) The height of the basic pole will be made up as follows:—

Space occupied by arms (3 x 14 ins.)	= 3ft. 6in.
Maximum sag of wires below bottom arm	= 1ft.
Clearance above ground	= 12ft.
Depth in ground	= 4ft.
Total	= 20ft. 6in.
	Say 21 ft.

At road crossings the minimum clearance is 18′ above the crown of the road, requiring 28 ft. poles on either side. Twenty-four foot grading poles should be erected between them and the basic poles. Assume no vehicle entrances to property.

Also assume that steel beam or rail poles can be obtained and will prove economically justified.

Material:—

Steel Beams, 6in. x 5in. x 28ft	20
Steel Beams, 6in. x 5in. x 21ft. (terminal poles)	2
Steel Rails, 60 lbs. x 24ft.	20
Steel Rails, 60 lbs. x 21ft.	247
Arms, wood, 108in./8 terminal	8
Arms, wood, 108in./8S.S. (Assume 2 transposition poles at angles)	92
Arms, wood, 108in./8 W.S.	482
Hardwood distance pieces, 4in. x 3in. x 1in.	534
Gain blocks (for braces)	289
Combiners, angle, No. 4	578
Braces, 41in.	578
Bolts, ⅜in. x 4in.	1148
Bolts, ⅜in. x 6in.	16
Bolts, ⅝in. x 6½in.	534
Bolts, ⅝in. x 7in.	40
Bolts, ⅝in. x 10in.	8
Bolts, ⅝in. x 4½in.	289
Boiler plate, 9in. x 9in. x ¼in. (base plates)	289
Plates, foot, steel, 18in. x 9in. x ¼in. .... (Surface plates not required at angle poles or those with windstays fitted.)	550
U-bolts for foot plates	550
Stay rods, 8ft. x 1in. (terminal poles)	2
Stay rods, 6ft. x ⅝in. .... (Assume 4 transverse and 4 longitudinal stays per mile, the latter calculated to counteract one-third of the maximum total tension of the line wires.)	82
Stay plates, 18in. x 18in.	2
Stay plates, 12in. x 12in.	82
Wire, S.S., galvanized, 7/10 .... lbs.	32
Wire, S.S. galvanized, 7/12 .... lbs.	183
Wire, S.S., galvanized, 7/14 .... lbs.	135
Eyebolts, bent, ⅝in. x 3in.	4
Stay guards (secondhand crossarms)	84
Hook bolts, 4in. x ⅝in.	168
Bands, transposition, straight ⅝in. .... (38 phantom transpositions.)	152
Bands, transposition, bent ⅝in. .... (44 physical transpositions.)	88
Spindles, T1. J	20
Spindles, TK. ⅝in.	700
Spindles, TK. wood	2410
Insulators, Terminal	20
Insulators, TK. P	3110
Wire, H.D.C., 100 lb. .... lbs.	3700
Wire, H.D.C., 200 lb. .... lbs.	11,000
Wire, soft copper binding, 50 lb. .... lbs.	100
Busbars, assorted	152
Sleeves, metal jointing, 200 C.	270
Sleeves, metal jointing, 100 C.	180
Tapes, copper, 100/200	3110
Sundries (R.I.L.A.C. cable 1 pr. and 1 wire, clips, compound, paint, etc.)	

(d) Operations involved in carrying out the work:—

Make preliminary inspection.

Consider economics of steel poles versus wood.

Prepare estimates and obtain necessary approvals.

Survey route and mark location of each quarter-mile point.

Mark out pole positions, checking with quarter-mile points to ensure transposition poles are evenly spaced.

Measure angles with prismatic compass.

Prepare field book.

Order material and, when to hand, arrange staff.

Issue instructions to Foreman.

Gang fits poles, sets stay rods and then digs pole holes.

Arrange for pole-lifting truck for few days—gang fills in and rams soil after pole is set up by truck, and also attaches stays.

Mark transposition poles.

Gang runs out wires. It is advisable to allow wires to hang on arms for a while.

Fit transposition bands, spindles, insulators and combiners.

Gang regulates, terminates and ties in line wires.

Gang inserts transpositions and connects wires to offices via cable heads.

Circuits tested for I.R., C.R., balance and V.F. cross alk, then handed to traffic and Superintending Engineer advised.

Any surplus material returned to stock and Work Authority closed.

Pole diagrams, circuit diagrams, etc., forwarded to Draftsman for record.

Usually the conditions are not as straightforward as this, and it is necessary to inspect, survey and mark out route and prepare field book before the firm estimate and proposal are set out.

Note: Instead of two X sections, one R section to follow the E section would now be the correct arrangement. As the R section is comparatively recent and does not appear in current Instructions, it was not used in the answer.

Q. 2.—A main trunk route consisting of wooden poles with four eightway crossarms fully occupied with 200 lb. and 100 lb. copper wires is to be inspected every three months. Over one section of 20 miles long a railway with a road meeting the railway at about two-mile intervals the inspections are to be carried out from a line station si uated in the middle of the section. The staff at the station consists of a Line Foreman, Grade 1, and a Lineman, Grade 1, with temporary assistance engaged as required from time to time. The train service is not suitable for use in connection with the inspections. Describe the arrangements you would make for the work under the following headings:

(a) General layout of the inspection month by month, including distance to be covered, poles to be climbed, details of the examination to be made, corrective work to be done and reports to be furnished. The object is to ensure that the whole of the section is adequately inspected every three months.

(b) What men would you employ on the work and what conveyance would you provide?

(c) State what you consider should be the movements of the men and the conveyance on a normal day in order to obtain the best results.

(d) What action would you take to follow up the work to ensure that the inspections were regularly made, that they were thoroughly performed, and that all matters arising out of them received attention?

A.—(a) On a route of this size and importance, the four inspections would be set out as follows:—

(1) A quick general inspection made by the Foreman to check the condition of the route. Urgent matters to be attended to and the others noted in a field book to be carried out at second or fourth inspection.

(2) A more detailed inspection when all angle and transposition poles would be climbed and all work on them checked and brought up to standard. The majority of the matters noted for attention at the former inspection should be attended to. When this inspection is completed, the only matters requiring attention would be those not observed from the ground on poles which were not climbed and other matters requiring the attention of a larger party. In many instances it may be possible during this inspection to renew poles which were condemned at the previous annual pole inspection.

(3) A similar inspection to (1).

(4) A detailed inspection to be carried out in conjunction with the annual pole inspection. During this inspection every pole on the route must be climbed and all details inspected and attended to, if necessary.

These inspections would be timed so that, as far as practicable, no more than three months pass between the time that each pole and wire is observed by a competent inspecting officer.

Inspections (1) and (3) could be made at fair speed; a reasonable average for this route would be five to six miles per day. Every stay should be examined and tightened, if necessary.

One of the four inspections (preferably No. 2) should be made in conjunction with the pole renewals.

When poles are climbed during inspections (2) and (4), every tie or termination must be examined, every nut on bolt or spindle tightened, each insulator tightened on its spindle. Wooden spindles and transpositions must be carefully examined, as well as all other fittings or attachments, to ensure that the construction is sound and fit to provide a satisfactory service for at least twelve months. As previously mentioned, the only matters requiring at ention after such an inspection would be those which would need a larger party.

Upon completion of each inspection, the inspecting officer would furnish a report setting out the following information:—

Section inspected.

Date of inspection.

Number of poles climbed.

Work performed.

Work to be carried out at next inspection.

Work requiring the attention of a larger party.

During inspection (4) the information regarding work to be done should be entered in the field book for the route. If much work is noted during inspections (1), (2) and (3) for later attention, the information should be entered in a special notebook.

(b) As far as possible the Foreman should carry out the actual inspection, and if necessary, he could have ass'stance in the form of men and/or a suitable vehicle, to carry out the maintenance work, or to enable him to make the inspection in less time. If a capable and experienced Lineman is available and the Line Foreman cannot perform all the inspec ions himself, he may arrange with the Divisional Engineer for the Lineman to do portion of the inspection. In such cases, the Foreman should check sections of the route inspected by his Lineman to ensure that he is carrying out the inspection satisfactorily. He should also arrange that during the next inspection he himself inspects those portions done by his Lineman during the previous inspection.

For inspections (2) and (4) the Foreman could be accompanied by a Lineman who could be used to full advantage ramming poles, tightening nuts on bolts and spindles and re-tying or re-terminating line wires as well as assisting in many matters which would be impossible or difficult for one man. This arrangement would considerably reduce the time taken by the Line Foreman for these inspections, and allow him more time to attend to other matters in his district.

When poles are to be renewed, if they are numerous, it may be advisable to use a party of four or more men so that the poles can be lifted during the progress of the inspection. If the condemned poles are few, then only those men who could be used to full extent would accompany the Foreman on the inspection, and he would arrange to obtain other assistance occasionally to lift poles safely.

The conveyance would depend to some extent upon the amount of work to be performed and would probably be some form of motor vehicle in order to provide quick transport between the head station and the points where each day's inspection begins or ends. It would need to be big enough to carry sufficient men, material, tools and equipment for each day's work.

(c) The movements of men and conveyance to obtain the best results would depend upon the form of inspection to be made, material required, etc.

For inspections (1) and (3) where a capable Lineman is available to assist the Foreman on a quick general inspection, the best arrangement would be as follows:—

(i.) Assuming that a motor truck is available and each man can drive, A would commence to walk from the head station while B would drive the truck to the first point where the road is handy to the route.

(ii.) B would leave the truck and commence to walk ahead.

(iii.) When A reached the truck he would drive to the next convenient point where the road is handy to the route.

(iv.) A would leave the truck and commence to walk ahead.

(v.) When B reached the truck he would drive it to the next convenient point, and so on.

This is the ideal arrangement as it involves no lost time with the truck, but it is unsuitable where much material or the assistance of the second man is required. In such cases or when more extensive work is to be done, an effort could be made either to drive the truck along the route, or failing this, to take it (if possible) to more points along the route by circuitous tracks, and the two men would then carry the material to the poles where it would be required.

(d) To ensure that the route is regularly and thoroughly inspected, the following steps would be advisable:—

(1) Each year advise the Foreman what inspections are to be made and the dates they should commence. The communication containing this advice would also instruct the Foreman to arrange transport and inform his Engineer what men and transport he desired to assist on the inspection.

(2) A copy of this advice would be forwarded to the Line Inspector, and another would be held by a clerk in the office, whose duty it would be to check that the inspection was commenced on time and that a report was duly received when the inspection was completed.

(3) Each month the clerk would report to the Divisional Engineer the progress of inspections on all routes in the district. The reports from the Inspecting Officer would be perused by the Divisional Engineer and then passed to the responsible Engineer for any necessary attention.

(4) The Line Inspector would be expected to make check inspections of the routes to ensure that the work was being done properly, and the construction on the route was in accordance with the Departmental standards.

(5) In addition, the Divisional Engineer and the Engineer responsible for the district, would arrange to make check inspections to ascertain the condition of the route, and consider whether the maintenance inspections as laid down were adequate (consistent with economy) to maintain the route in good condition.

(6) This latter point would also be checked with the trunk line fault maps which indicate the number, nature and location of all faults located along the route.

(7) The check inspections would be arranged to follow, if possible, closely upon the Foreman's (or Lineman's) inspection to obtain a reliable check upon this man's work and ensure that he is fully aware of what is required of him and of the standard constructional methods.

Q. 3.—(a):

(i.) State the breaking stress, electrical resistance per mile and the approximate attenuation per mile at 1000 cycles of:—

400 lb. per mile galvanized iron wire.

200 lb. per mile hard drawn copper wire.

40 lb. per mile cadmium copper wire.

(ii.) For what purpose would you use each of the types of wire referred to in (a) (i.) of this question.

(b):

(i.) Name two materials used for insulators on telephone lines and state the important characteristics of each as an insulator.

(ii.) How is the insulation resistance of an insulator affected by its dimensions.

(c) State briefly the qualities desirable in timber for use as poles. Name, in what you consider is their order of merit, four classes of timber suitable for poles.

(d) Mention one type of iron pole with which you are familiar. Give any information you can with respect to its dimensions, weight and strength. In the case of a steel beam of H section 8in. x 6in. used as a pole, is it desirable to erect it with the 8in. dimension in any particular relation to the line of the wires. If so, what is the desirable relation and what is the reason for adopting it.

A.—(a):—

(i.) Line Wires:—

	Breaking Stress	Resistance per mile	Attenuation @ 1000 cycles
400 lbs. G.I.	1200 lbs.	13.32 ohms.	0.25 db.
200 lbs. H.D.C.	640 lbs.	4.4206 ,,	0.064 ,,
40 lbs. C.C.	200 lbs.	26.0 ,,	0.232 ,,

(ii.) Provided that in each case the attenuation would be in accordance with the transmission standards, the uses for each class of wire would be as follows:—

400 lbs. G.I.:—On short country public lines, short trunk lines and hand operated telegraph circuits where strength and/or economy would be important and there is no likelihood that a carrier system would be superimposed.

200 lbs. H.D.C.:—On general trunk lines, particularly where there is a possibility that carrier systems will be superimposed over the wires during the life of the route, this class of wire provides the best compromise between economy, mechanical strength and good transmission.

40 lbs. Cadmium Copper:—On subscribers' lines where its mechanical strength is sufficient.

(b):—

(i.) The two commonest materials used for insulators are glass and porcelain. Their more important characteristics are as follows:—

Glass.—High insulating properties.

Soft and workable when heated, but when cool it sets hard with a glazed surface.

Practically impervious to the action of the weather.

Because it is transparent, the surfaces inside the skirt and petticoat are well lighted and this discourages spiders from building webs there.

Internal stresses frequently occur as the glass cools, particularly in the thicker sections, and these sometimes result in fractures.

Specific Gravity, 2.5 to 4.5.

Dielectric Constant, 5.5 to 10.

Resistivity, 10^{13} to 10^{18} ohm-cm.

Porcelain.—Has high insulation properties.

When baked it sets hard, and a well-glazed surface can be provided at low cost.

Practically impervious to the action of the weather.

Specific Gravity, 2.3 to 2.5.

Dielectric Constant, 4.4 to 6.8.

Resistivity (unglazed), 10^{14} to 10^{15} ohm-cm.

Both of these materials are hard and brittle.

(ii.) Most of the leakage at an insulator does not occur through the body of the insulator but over the surface. The insulation resistance therefore depends upon the length of the path along the surface between the conductor and the supporting spindle, as well as the width of the path. The resistance increases with the length and decreases as the width increases. Hence the narrower the insulator and the longer its skirt and petticoat, the greater will be the resistance provided. For practical purposes there are certain limitations to these dimensions. For instance, the width depends upon the thickness of spindle and of insulating material necessary for strength, while the length of the skirt is governed by such matters as clearance from the arm, economic height of spindle, space between arms, etc.

(c) The desirable qualities in timber for use as poles are:—

(1) Long life, which is dependent upon its resistance to rot, termites and climatic conditions.

(2) Strength.

(3) Lightness consistent with strength and good lasting properties.

(4) Straightness with reasonable taper.

(5) In modern timber practice ability to absorb suitable preservatives is also considered a desirable quality.

Assuming that each timber will be used in the locality in which it is grown, four timbers suitable for poles, in order of merit, are:—

(1) Ironbark.

(2) Cypress Pine.

(3) Tallow-wood.

(4) Box.

On the western portion of the continent, Wandoo and Jarrah, in that order of merit, are the only suitable timbers available.

(d) Under the heading of "Iron pole" would be the 60 lb. single-headed rail.

Weight.—60 lbs. per yd.

Dimension.—Width of flange = 4-5/16in.
Height of rail = 4-5/16in.

Strength. — Maximum Bending Moment (Elastic Limit) = 280,000 inch lbs.

It is desirable to erect an 8in. x 6in. H section girder with the 8in. dimension across the line of the wires. This would mean that the major axis (along the web) would be across the line of the wires, which is desirable as the beam is more resistant to bending in this direction. The weakest axis (i.e., along the flanges) is in the same direction as the wires which may be relied upon to give a measure of support.

Q. 4.—A country trunk pole route will be required to carry as its ultimate load eight 200 lb. copper wires on the top arm and eight 100 lb. copper wires on an arm 14 in. below the top arm. At a point along the route the wires make an angle of 135 deg. and the angle pole at this point is to be stayed with one stay only. Assume the tension at the lowest temperature in each 200 lb. copper wire to be 260 lb. and in each 100 lb. copper wire to be 132 lb. when there is no wind. The maximum force due to wind pressure on the wires may be taken as totalling 320 lb. on the top arm and 244 lb. on the second arm with the ultimate number of wires in position. This additional force may be assumed to act along a line bisecting the angle made by the wires. Wind pressure on the pole may be neglected.

(a) Find the total resultant pull on the pole when carrying its ultimate load.

(b) State precisely the direction of the resultant pull in relation to the line of the wires and the distance below the top arm at which it will act.

(c) If the pole is stayed with a stay attached at the resultant point and making an angle of 45 deg. with the pole, what is the pull in the stay wire?

(d) What would be the pull in the stay wire if it were attached 2 feet below the resultant point, assuming the resultant point to be 24 feet above the line at which the pole is held in the ground?

A.—(a) The total maximum tension of the wires that will ultimately be erected on the route is:

$$8 \times 260 + 8 \times 132 \text{ lbs.} = 3136 \text{ lbs.}$$

The tension on either side of the pole will be equal and the resultant will, therefore, be along a line bisecting the internal angle formed by the wires.

Resolving the forces along this line we find:

$R = 2\ T \cos \theta/2$
$= 2 \times 3136 \times 0.3827$
$= 2399.3$ lbs.—
say, 2,400 lbs.

(R = resultant force, T = tension of wires, θ = angle between wires)

During maximum wind conditions this will be increased by $320 + 244$ lbs. to 2,964 lbs.

(b) Direction of Resultant.

As mentioned in (a), the direction of the resultant will be along the line dividing the internal angle formed by the wires. This may be proved by the application of the parallelogram of forces.

In Fig. 1, let A represent the angle pole and AB

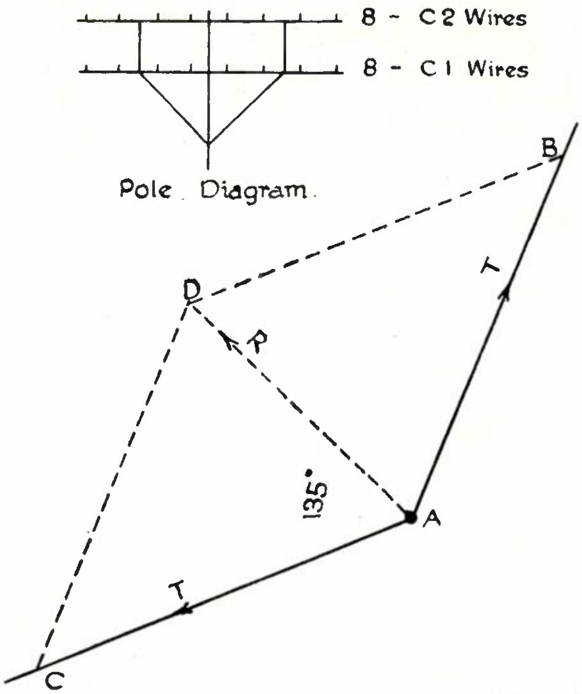


Fig. 1.

and AC the forces (T) due to the tension of the line wires.

Complete the parallelogram of forces A, B, C, D. The resultant (R) will be represented by AD.

The tension (T) of the line wires on each side of the angle pole "A" is equal and

$\therefore$ AB = AC.

By construction BD = AC, and CD = AB.

$\therefore$ BD = AC = CD = AB.

In the two triangles ABD and ACD, AD is common

$\therefore$ they are equal in all respects.

and the $\angle$BAD = $\angle$CAD.

Assuming that the ground is level and the poles at, and adjacent to the angle are of equal height, then the resultant will act in a horizontal plane.

Location of Resultant Point:—The resultant pull on the pole due to the pull of the wires on the top arm is

$2\ T \cos \theta/2 = 2 \times 8 \times 260 \times .3827$ lbs.
$= 1592$ lbs.

On the bottom arm

$2\ T \cos \theta/2 = 2 \times 8 \times 132 \times 0.3827$ lbs.
$= 808$ lbs.

When the wind pressure is acting in the direction that would assist the pull due to the tension of the wires, the total force at the arms would be

Top arm (P1) = $1592 + 320$ lbs. = 1912 lbs.
Bottom arm (P2) = $808 + 244$ lbs. = 1052 lbs.

These forces will act on the pole via the bolt which will be at the centre of the arm.

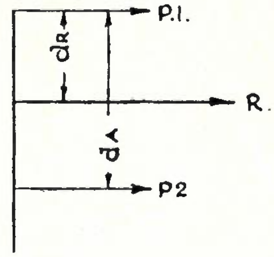


Fig. 2.

The resultant (R) (see Fig. 2) will be equal in magnitude to the sum of these forces, i.e., $1912 + 1052 = 2964$ lbs.

Consider the moments about the top arm—

$R \times d_R = P2 \times d_a$
$d_R = P2 \times d_a/R$
$= 1052 \times 14/2964$ inches

i.e., distance of resultant point from the top arm = 4.97 inches.

(c) The pull (S) on the stay wire must be such that when resolved along the line of the resultant force due to the wires, it will be equal (but opposite) to that force.

i.e., $S \times \cos 45° =$ Resultant force due to line wires.
$\therefore S = 2964/0.7071$ lbs.
$= 4192$ lbs.

(d) Find the force (X) at the point of attachment by the Principle of Moments.

$X \times 22 = R \times 24.$
$X = 2964 \times 24/22$ lbs.
$= 3233.45$ lbs.

and from Fig. 3 the stress on the stay wire will $\therefore$ be $3233/0.7071 = 4572$ lbs.

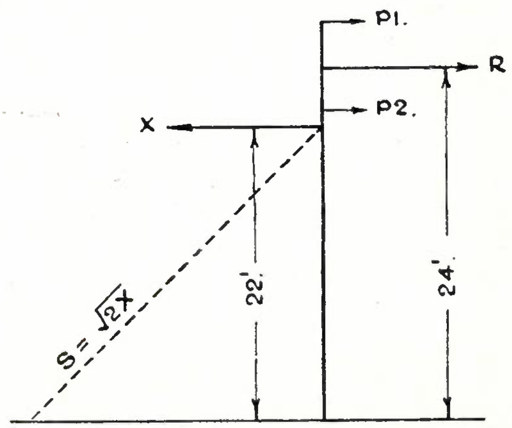


Fig. 3.

Q. 5.—It is desired to lay a 4-in. pipe to take a 200-pair subscribers' cable along a footpath for a distance of 880 yards. The pipes are NOT of the self-aligning type; you may assume them to be either earthenware 2 feet long or concrete 6 feet long. At four points along the route 1-in. iron pipes each 50 yards in length are to lead along streets at right angles to the main run. Ten suitable jointing chambers, including those at the points where the laterals will lead off, are to be provided along the main route and, in addition, two are required on each lateral run:—

(a) Prepare a complete statement of the material required for the whole work, mentioning the type and size of jointing chamber you propose at each point.

(b) Prepare a sketch of the work showing position of jointing chambers, depth of excavation at various points, including road crossings, distance of pipes from fence alignment and the points at which pipes enter the jointing chamber.

(c) Describe the method of carrying out the work, giving all operations in their correct sequence. State the number of men to be employed on each operation.

A.—(a) Material:—

Pipes, E.W. 4 in.	1310
,, G.I. 1 in.	600 ft.
Pits, Asbestos Jointing No. 2	6
,, ,, ,, No. 4	2
Manhole covers and frames (small double cover 4 ft. x 2 ft. 6 in.)	10
Cement	80 paper bags
Sand	16 cubic yards
Gravel or screenings	9 cubic yards
Bearers cable	38
Bushes, pipe, 1 in.	16
G.I. wire (secondhand if available)	1100 yds.

If the manholes or pits are to be drained, traps, grates and drain pipes will also be required. In some circumstances back flaps may also be necessary to prevent undesirable wa er flowing through the drain pipes into the manholes.

If the manholes are not drained, a 9-in. sump and grate will be necessary for each.

Other possible items required are steps, vent pipes, earthplates, explosives, manhole ring bolts.

Jointing Chambers:—Along the main run, small manholes have been provided on the assumption that during the life of the conduits one or more comparatively large cables will be drawn in. Assuming the excavation depths provided for on the sketch, 4 ft. x 2 ft. 6 in. double covers are most suitable because only a comparatively shallow manhole is necessary and a man can work comfortably half in and half out of the manhole. Increasing the depth of manholes increases both the necessity for and the cost of draining.

Because 1-in. G.I. pipe is to be laid along the lateral runs, it may be assumed that either 35-pair or 50-pair cable is to be drawn in. Therefore No. 2 and No. 4 asbestos jointing pits have been provided for, the latter being required to allow for sufficient cover at street crossings. The sizes of cable mentioned cannot be satisfactorily bent to fit in the smaller pits.

(b) See sketch above.

(c) Order of operation of work.

(1) Inspection of route, enquiries re underground construction of other bodies, survey, preparation of plan and estimate.

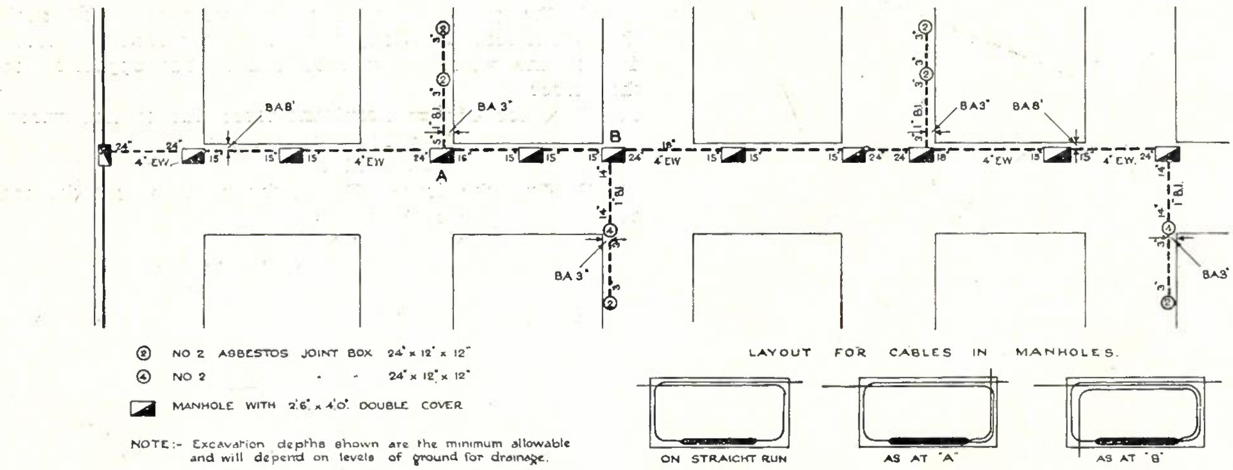
(2) Submission and financial approval of proposal.

(3) Requisition of material and service of usual notices on local authority.

(4) Issue of instructions to Foreman through Line Inspector.

(5) Marking out and excavation of trench for pipe and holes for pits, doing one complete section at a time to ensure absence of obstructions and straight (or nearly straight) run for pipe. When a direct run is obtained, bone and level up bottom of trench ready for pipe laying (not necessary for iron pipe). Iron pipe can usually be laid as the excavation proceeds, but of course must be laid as straight as is reasonably possible. Pipes should be pushed under roadway if practicable.

(6) If draining is necessary, it may be advisable to excavate deeper and lay a drain pipe between some manholes, draining the lowest manhole to the regular storm-water drain or other suitable outlet.



Sketch of Conduit Layout.

(7) Lay E.W. pipes, line up, then hold pipes in posi ion by placing some loose soil around them, compo joints and, after setting, fill in trench and ram. End pipes should be left till pits placed in position. Dispose of surplus soil.

(8) While the pipe and pit laying is proceeding, the rest of the gang would be excavating the next section of the trench.

(9) Temporarily set up the pits, mark position for pipe holes, remove the pits to surface and cut the holes. Replace the pit in the excavation and connect up the pipes, with bushes fitted. See that the surface of the pit is flush with the permanent surface of footpath. Pits should be set in sand where the ground is hard or rocky. Fill in around the pits and ends of pipe trench.

(10) Reinstate concrete paving, turf, stone sets, etc., where necessary and tidy up.

(11) Arrange with the local authority for any other reinstatement.

(12) On completion account for all material, submit plan and completion report.

(13) A gang of seven to eight men and Foreman are suitable for this work. Laying pipes and pits requires two men (except small pits, which only

require one man). Most reinstatement requires two men. The rest of the gang would be employed on excavation, filling in, etc., as required. When the manholes are to be built, one man with the assistance of another as required would be enough in this instance since they are not large.

Q. 6.—Several lengths of a new 400-pair 10-lb. star quad cable have been drawn in and are to be jointed together. The length at the exchange end has been jointed to a silk and cotton cable and terminated on the main frame.

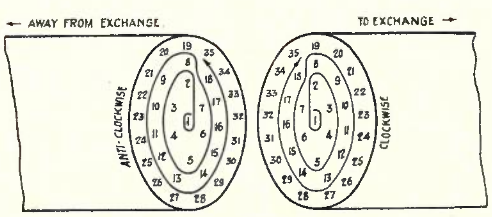
(a) Describe in detail the process of jointing the remaining lengths, giving each operation in its correct sequence.

(b) What identification would you consider desirable? Describe the method. In cases in which complete identification is not being used, how would the jointer select the pairs to be joined together?

(c) Assuming that a jointer and his mate are engaged continuously, how long would you expect one complete joint to take?

A.—(a) The jointing of the silk and cotton cables should first be checked and the pairs numbered by identifying from the M.D.F. to the end of the P.I.L.C. These will be the record cable pair numbers and the identification tags should be left on the pairs in accordance with E.I.5, part 2, paragraphs 172-4. If the terminations to the M.D.F. and the joint between silk and cotton cable have been done properly, the identification should appear strictly in rotation around the layers of the cable commencing from the centre.

The joint at the end of the first length of P.I.L.C. will be the first test point and will be left until later. (The distance between test points would depend upon local conditions. With good conditions and competent jointers, approximately six lengths would be a satisfactory separation between test points. In the example in question test points would probably be at the end of the first length of paper cable and at the end of the run of the new 400-pair cable.) The joints between the first and second test points should now be completed. In making these joints the cable quads should be taken in strict rotation around the layers, commencing from the centre and counting in one direction on the exchange side and in the opposite direction in the subscribers' side thus:



SHOWING RULE FOR NUMBERING P.I.L.C. CABLE PAIRS

When the quads are being jointed, care should be taken that the "a" wire is jointed to the "a" wire and "b" to "b," etc. The joints in the wire should be made by twisting the conductors two full, but loose, turns with the paper on, followed by three-quarters of an inch of twists in the bare wire with the twists made tight at the tip but loose at the paper-covered end. Care should be taken to keep the joint dry and when the jointing is completed the joint should be dried out, tied and wrapped and the lead sleeve put on.

Attention should now be given to the joint at the first test point. The pairs should be connected in strict rotation on the side away from the exchange to pairs on the exchange side in order of the M.D.F. tag numbers. Before this joint is closed the cable should be tested between the exchange and the second test point. This will check the jointing to the second test point and also allow for the faulty pairs to be tested. If any faulty pairs are located and they cannot be readily rectified, spare pairs can be substituted over the section between test points.

Jointing should proceed in a similar manner to the end of the cable. (Two alternative methods of procedure which would also be satisfactory are:—

(i) The cable should be divided into sections, each section jointed, the pairs at each intermediate joint being connected in strict rotation and the section then tested. The final joints would then be completed by jointing those pairs with tags of similar numbers which were attached during the testing.

(ii) After testing the silk to cotton joint and tagging the pairs the jointing can be continued, working from the exchange, by taking pairs in rotation except at test points, where a check should be made with the M.D.F. Rotation pairs should be brought into line with the record cable pairs by jointing the pairs in rotation to pairs in order of M.D.F. tag numbers on the exchange side of the joint.)

When the jointing of a new cable is completed and before cutting in to any working cables, the new cable should be completely tested out for:—

(i) Insulation.
(ii) Continuity of conductors.
(iii) Earths, shorts and crosses.
(iv) Faulty jointing splits, transposed pairs, etc.

Insulation tests are made with a Megger, the "a" leg being tested against "b," "c" and "d" legs earthed, then "b" leg is tested against the others earthed, etc.

The identification tests will be dealt with in section "(b)" of the answer to this question, and these combined with the insulation test provide for reasonably complete electrical testing of the cable. The only test not made would be for a cross between similar legs of different quads. When the testing is completed and all joints have been sleeved and plumbed, each joint requires pressure testing to ensure that it is properly sealed.

(b) The desirable identifications to be made are:—

(i.) M.D.F. to end of first length of paper cable (first test point) to establish the record cable pairs and check the silk to paper jointing.

(ii.) M.D.F. to each test point to check the jointing of intermediate lengths and the joint at the previous test point.

These identifications should be quickly made, provided that the pairs have been jointed in rotation as set out in part (a) of the answer, and that there are no defects in the manufacture of the cable. It should be possible to identify the pairs merely by counting in rotation.

All pairs should be identified to each test point.

The method of identifying would be as follows:—

(i.) Unless some special condition prevents it the pairs should be identified in the order of their fuse tag numbers on the M.D.F.

(ii.) An earthed signal current should be connected via a suitable signal device to both legs of the pair to be identified.

(iii.) The jointer at the testing point searches for the correct pair with an earthed detector. The actual apparatus used at each end may be of various types. Probably the most satisfactory arrangement for this particular type of identification would be to have a buzzer and a few dry cells at the exchange end. The searching apparatus may be another buzzer or a head receiver. The voltage of the battery would need to be sufficient to operate the two buzzers (or one buzzer and one head receiver) in series with the cable pair. (Other signal appliances which may be used with appropriate signal currents are polarized bells and No. 2 or 4 detectors.) Identification equipment which gives an audible signal when the pair is found is the most satisfactory, as the searcher is not compelled to look at a meter every time he connects to a wire.

(iv.) Using the apparatus favoured in (iii.), no tone passes through the cable (unless the pair is earthed) until the searcher connects to the particular pair which is being identified. Then, however, both buzzers operate so that the men at each end are advised that the pair has been found.

(v.) The searcher should touch the wire on each leg of the pair separately to ensure that both wires are continuous and the pair not split.

(vi.) In order to ensure that the signal is due to the searcher locating the pair, and not because of some other connection to earth, the searcher would touch his lead to the pair giving three short and distinct beats. A reply with two short beats would be sent.

(vii.) Each man would then know that the pair had been identified satisfactorily and would proceed with the identification of the next pair after designating the former pair at the testing point.

Assuming that the jointing work has been done correctly and there are no defects in the manufacture of the cable, it should be possible to identify the pairs by counting in rotation. Usually this is done by counting in a clockwise direction from the centre and facing toward the exchange.

(c) Under normal conditions such a joint should not require more than 24 manhours.

(To be continued.)

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