The Telecommunication Journal of Australia

Vol. 2, No. 3 — Registered at the General Post Office, Melbourne, for transmission by post as a periodical. — FEBRUARY, 1939

345

CONTENTS

THE POSTAL ELECTRICAL SOCIETY OF VICTORIA

The

Telecommunication Journal of Australia

Vol. 2, No. 3. *FEBRUARY, 1939*

BROADCASTING STATION VLR, LYNDHURST, VICTORIA

R. B. Mair, B.E.E., A.M.I.E. (Aust.)

Introduction.—VLR is one unit in the chain of broadcasting stations which forms the National radio network of the Commonwealth. It differs from other transmitters of this network in that it is the only one at the present time which operates with a carrier frequency greater than 1500 kilocycles/sec. which is the upper limit of the medium frequency band within which all other National Broadcasting transmitters operate.

The primary function of the station is to bring the National programmes within the reach of listeners living in the western and far northern districts of Queensland, north-west of New South Wales, and to the Northern Territory. Listeners in these areas are beyond the normal service range of existing National stations operating within the medium frequency broadcasting band (500-1500 kC). In addition, a high atmospheric noise level is a frequent experience, giving rise to very poor reception conditions in northern Queensland and the Northern Territory, especially during the summer months. To provide a signal on medium frequencies over this wide area of sufficient magnitude to override the high atmospheric noise level would be uneconomical even if there were sufficient suitable medium frequency channels available.

The most practicable and economical way of improving the existing service over such a large area is by the use of high carrier frequencies (short waves) because for a given field intensity they are far less susceptible to interference from atmospheric noise (static) than are the lower frequencies constituting the medium frequency band. It is true that high frequency transmissions are subject to a considerable amount of fading but the effect of this can be materially reduced by a correct choice of carrier frequency for daylight and night transmissions and for different periods of the year.

Although, as previously stated, VLR is designed to serve the northern areas of Australia, it is necessary to locate it in the southern part of the Commonwealth because of the well known skip distance effect peculiar to all high frequency transmission.

Recently the whole of the equipment at VLR was re-designed and it is with the design of the new equipment that this article is intended to deal. Before proceeding further, it may be of interest to review very briefly the development of this short wave service, a service which to-day forms a very important link in the National Broadcasting Service, and one upon which many listeners now depend for their radio entertainment.

History of the Station.—A station was first established on the present VLR site in 1928, and from that date until 1934 this equipment was used for experimental purposes by the Research Laboratories of the Postmaster-General's Department. The site really comprises one of the outdoor laboratories of the Department's research activities and is situated about 25 miles south-east of Melbourne—longitude 145 deg. 15 min. 14 secs. west, latitude 38 deg. 3 mins. 10 secs. south. The operating carrier frequency was 9580 kC and the carrier power approximately 500 watts. All of the equipment was of an experimental nature, but in spite of this fact, the modulation capability of the transmitter was 100 per cent. and the audio frequency characteristic reasonably flat over the range 30-10,000 cycles/sec. At this time the hours of transmission were limited to about two or three per day. An analysis of reports received over a period indicated that there would be a considerable benefit to listeners in northern Australia if regular broadcasts were commenced.

Accordingly in March, 1934, the station was placed into regular broadcasting service, taking one of the programmes of the Australian Broadcasting Commission and operating on a schedule which covered mainly the evening hours. At this period the call sign of the station was VK3LR. The radiating system consisted of a horizontal half wave doublet giving substantially non-directional transmission from the site, the power into the aerial being raised to 1000 watts and the carrier frequency still 9580 kC.

The favourable manner in which listeners responded to this service caused the Department to re-design the entire installation, the result being the new equipment which is described in brief below. This equipment was brought into regular service on the evening of October 1, 1938, and operates on a schedule of approximately 12 hours a day, including Sundays.

New Transmitting Equipment

The new transmitter was designed in the Research Laboratories of the Postmaster-General's Department and in quality of performance is equal to that of any other unit of the National Broadcasting network. Manufacture and assembly was carried out in the Laboratories and in the Melbourne Postal Workshops.

It is capable of being operated on any one of three carrier frequencies, namely, 6140 kilocycles, 9580 kilocycles and 11,880 kilocycles, the change from one frequency to another taking about six minutes. In normal operation a change of frequency is made every day at about 6 p.m., the change being to a lower frequency for the night time transmissions. The call sign of the station is VLR3 when operating on 11,880 kC, VLR when on 9580 kC and VLR2 when on 6140 kC.

sesses the big advantage of remaining in perfect neutralization over a wide frequency band—a condition which is very desirable in this case where the three operating frequencies are spread over the band 6-12 megacycles/sec.

As far as it was economically advisable, the transmitter was designed on the unit basis wherein each amplifier forms as far as possible a distinct unit with its own power supplies. This helps to provide a degree of isolation between stages by reducing to a minimum any possible feed back in filament circuits or other common power supplies. All the low power units comprising the equipment of No. 1 enclosure were mounted on standard relay racks and arranged so that in the event of a major fault occurring, the unit concerned could be removed quickly from the rack. The radio frequency circuits throughout the transmitter were coupled by means of low impedance transmission lines.

In a transmitter which is required to work over a large frequency range, in this case 6-12 megacycles/sec., parasitic oscillations are more likely to become apparent at some point in the tuning range, and particular care has to be taken to avoid as far as possible these unwanted oscillations. Parasitic oscillations manifest themselves in a variety of ways, by high anode

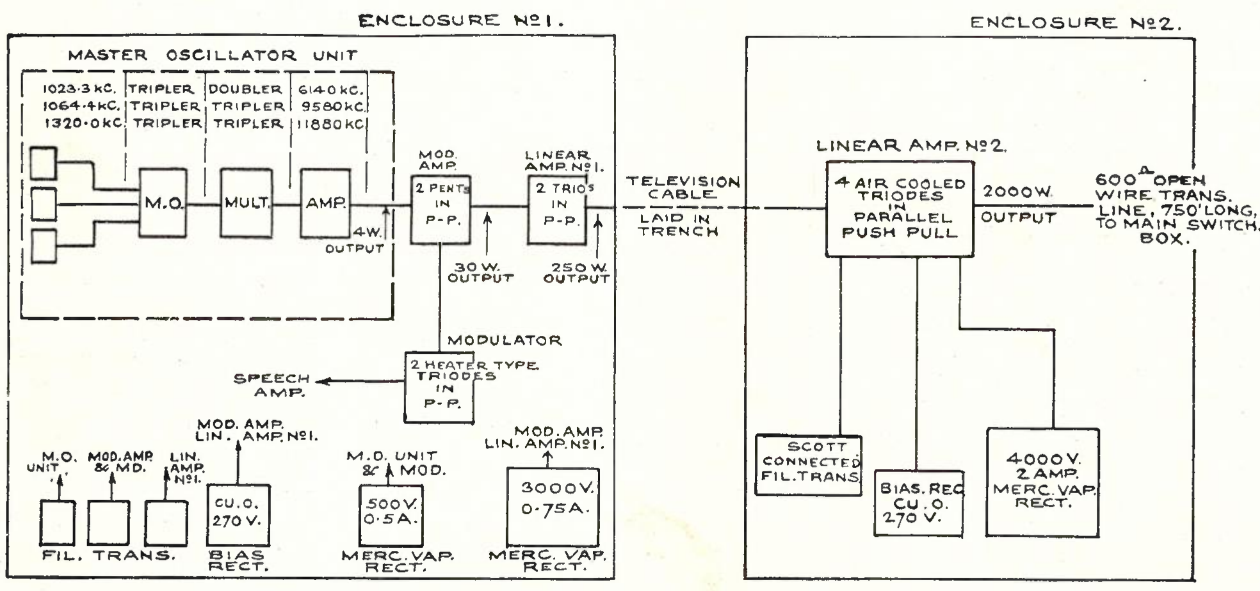


FIG. 1. VLR. LYNDHURST. BLOCK SCHEMATIC.

Figure 1 shows a block schematic of the transmitting equipment from which it will be seen that the whole of the transmitter with the exception of the master oscillator unit, is arranged for push-pull operation. The push-pull circuit offers distinct advantages over a single stage for transmitters working on high carrier frequencies in that perfect symmetry can be maintained and the radio frequency circuits balanced to earth. In addition, this type of circuit pos-

feed currents, abnormally high grid currents, circuit instability or even violent voltage transients; sometimes an audible note is heard when listening to a receiver. The ordinary anti-reaction arrangements do not stop these spurious oscillations and as they are considerably altered by slight differences of circuit layout, the exact design to prevent a particular parasite cannot be calculated beforehand but is largely a matter of experience.

In general there are two distinct kinds of parasitic oscillations to be guarded against in the design of a high frequency transmitter such as VLR, namely parasites of a very high frequency and those whose frequency is near that of the transmitter's fundamental frequency or frequencies. In the former case the inductance of connecting leads between valves and circuits together with the valve capacities may form a resonant circuit of very high frequency, thus giving rise to a parasitic oscillation which may develop considerable power. Parasitic oscillation near the fundamental may cause audible modulation and in some cases is due to a choke or choke condenser combination or even a lead with its self capacity to earth having a natural frequency too near the fundamental and producing self oscillation at a particular frequency which beats with the fundamental.

The design and layout of the equipment at VLR was such that when the transmitter was lined up it was possible to tune continuously the tuned circuit of each stage over the frequency limit of the equipment, that is 6-12 megacycles, without any trouble being experienced due to unwanted parasitic oscillations of any description.

Each stage was perfectly stable and as previously stated the complete transmitter could be changed from one operating frequency to another in approximately six minutes.

Referring again to Fig. 1, it will be seen that there are two main enclosures, the first of which contains all equipment for a completely modulated low power transmitter of approximately 250 watts output, and the second a linear amplifier with its associated power supply which raises the output of No. 1 enclosure to the level required to excite the radio frequency transmission line feeding the aerial systems, that is to a power output of 2 kilowatts.

For the control of the carrier frequencies three low temperature coefficient cold type crystals are used. The temperature coefficient of these crystals is approximately 0.75 cycle per million per degree centigrade over the range 10 deg. C. to 60 deg. C., and their frequencies 1023.3 kilocycles, 1064.4 kilocycles and 1320.0 kilocycles. The final carrier frequencies were therefore obtained by frequency multiplication. For this reason the master oscillator unit contains three pentode tubes, the first two acting as triplers in the case of the 9580 and 11,880 kC carriers and as tripler and doubler for 6140 kC, the third tube being an amplifier for all three cases to raise the output of the unit to approximately 4 watts. The appropriate crystal is selected by means of a low capacity rotary switch operated from the front panel of the master oscillator unit. Small variable condensers across each crystal enable the frequency to be brought right on to the assigned frequencies. Measurements which have been made regularly on the frequency of the station have shown that the frequency deviation is within ± 60 cycles in 11.88 megacycles, which is well within international regulations.

The output of the master oscillator unit excites the grids of two 100 watt radio frequency pentodes in push pull. These tubes possess the advantage of requiring only a small drive to obtain full output, and requiring no neutralization provided care is taken in the shielding of the grid and anode external circuits. Up to this stage of the transmitter no neutralization of tube inter-electrode capacities is necessary due to the use of pentodes and careful screening. The pentodes used in this stage have their suppressor grids brought out to the base of the tube and as such constitute an easy method for modulation of the transmitter. At this stage, therefore, that is at a radio frequency power level of approximately 30 watts, modulation takes place.

The method used is really a system of "efficiency modulation" in that the modulation of the carrier is accompanied by a change of radio frequency plate efficiency of the modulated stage rather than by modulation of plate input power. It is accomplished by injecting the audio frequency voltage on to the suppressor grids of the pentodes. Sufficient radio frequency excitation is applied to the control grids of the tubes for normal Class C operation and a negative bias to the suppressor grids of sufficient value to ensure that they remain negative during the whole of the audio frequency cycle. By correct design of the circuit constants, it is possible to obtain deep modulation with low distortion by this method. Actually the measured distortion from the modulated amplifier was approximately 1 per cent. for 85 to 90 per cent. modulation. Due to the fact that this stage is followed by two linear amplifiers, 85 per cent. modulation in this stage is more than sufficient to ensure 100 per cent. modulation at the final amplifier, the succeeding linear stages being so adjusted that at least a 15 per cent. modulation lift is obtained in them.

This method of modulation possesses the advantage that an extremely small audio frequency power is required to fully modulate the transmitter as the suppressor grids are not allowed to draw current. The modulator therefore becomes a very simple low powered audio amplifier capable of giving in this case an undistorted output of approximately 4 watts.

The radio frequency output of the modulated amplifier is approximately 30 watts and this excites the first linear amplifier stage through a low impedance transmission line. The linear amplifier uses triodes in a conventional cross neutralized push pull circuit and raises the carrier output of the preceding stage to 250 watts.

Fig. 2 shows the front panels of the equipment up to the first linear amplifier with the main control table in front, from which the control operator is able to do all the necessary control once the transmitter is on the air.

Considering now the equipment in No. 2 enclosure: This consists of the final linear amplifier with its associated power supplies. The enclosure is separated from No. 1 enclosure by approximately 5 ft. and the radio frequency energy from the output of the preceding amplifier is fed to the grids of the tubes constituting the final amplifier by means of a length of lead-covered television cable about 30 ft. long laid in the cable trench between the two enclosures—the characteristic impedance of this line is approximately 200 ohms. The final amplifier consists of four air-cooled tubes in a neutralized parallel push pull circuit and it delivers 2 kW of unmodulated carrier power to the radio frequency transmission line feeding the aerial systems. The D.C. input to this stage is approximately 6.25 kW, from which it is seen that 4.25 kW is dissipated in the form of heat. As the tubes are air-cooled it is necessary to provide forced draught—this is provided for by two fans in the bottom of the unit forcing air up past the tubes, and an exhaust fan in the ceiling immediately above the unit. The anode tuned circuit of this stage is designed for harmonic suppression, the output being capacity coupled to the radio frequency transmission line leaving the unit. The tuning of this unit is by means of a variable condenser, and in order to provide the optimum L to C ratio for the three operating frequencies—a condition which is essential in order that the amplifier may be worked at its maximum efficiency—the inductance is tapped at appropriate values and connected into the closed circuit by means of links. In the case of all preceding stages where it was not necessary to work the tubes under conditions of maximum efficiency, the tuned circuits were made the optimum value for the 9580 kC frequency and the three frequencies then tuned by the variable condenser without any alteration to the value of the inductance. By this means the transmitter was tuned by the condenser dials on the front panels for all stages except the final. In the final stage two operations were necessary, firstly to connect the appropriate inductance tap and then to resonate the circuit from the front panel. Fig. 3 shows a front view of the final amplifier and rectifier and Fig. 4 a back view of the amplifier.

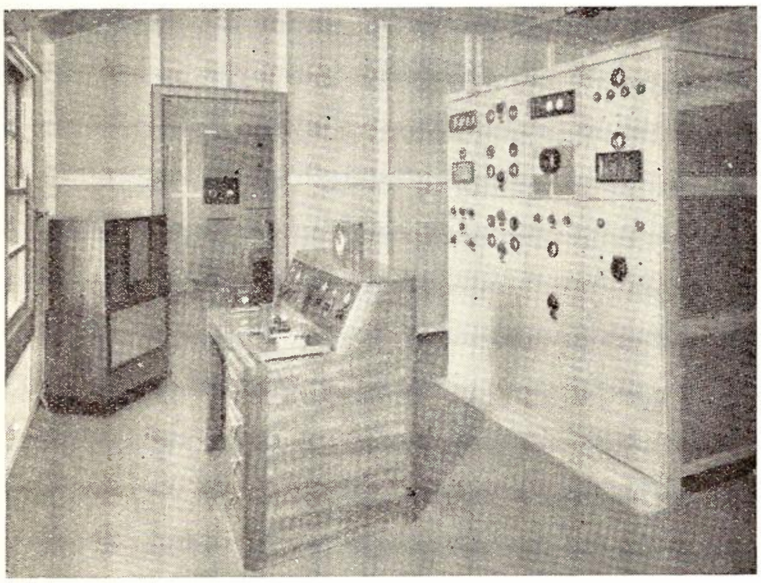


Fig. 2.—Low power units with control desk and monitoring loud speaker.

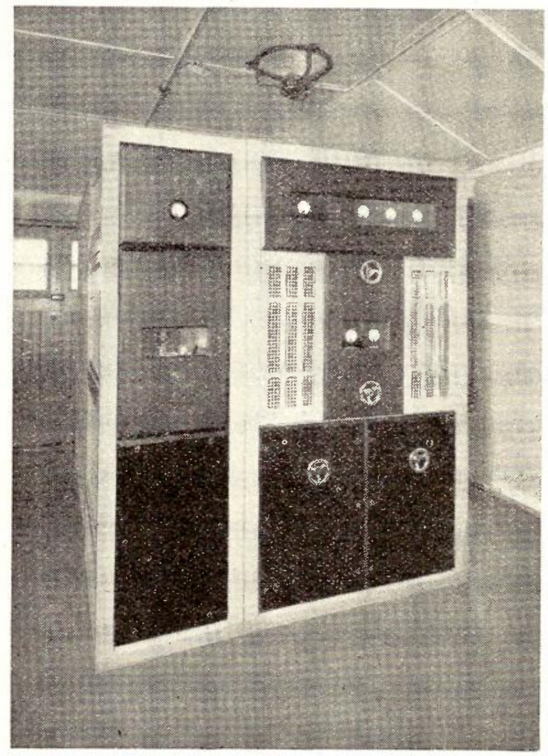


Fig. 3.—Front view of final amplifier and rectifier.

Power Supplies. — The transmitter operates from the 3-phase 50-cycle A.C. mains without the use of any rotating machinery.

The total load drawn from the mains when the equipment is delivering 2 kW to the radio frequency transmission line is approximately 11.8 kW, that is, the overall efficiency is about 17 per cent.

All filaments are heated from A.C. without the use of rectifying equipment. The filaments of the final amplifier are fed from a Scott connected transformer in order that each side of the push pull circuit has its filament heating supply with

90 deg. phase difference; this gives rise to a 5 decibel improvement in the carrier noise from this stage.

Anode supplies throughout are supplied by mercury vapour rectifiers as follows:—

1. Single phase full wave, 500 V., 0.5 A.;
2. Three phase half wave, 3000 V., 0.75 A.;
3. Three phase half wave, 4000 V., 2 A.

Each tube in the 3000 V. and 4000 V. rectifiers has incorporated with its anode circuit a flashback indicator to minimize time lost in locating faults of this nature. Bias voltages are supplied by two small copper oxide rectifiers, one for each enclosure.

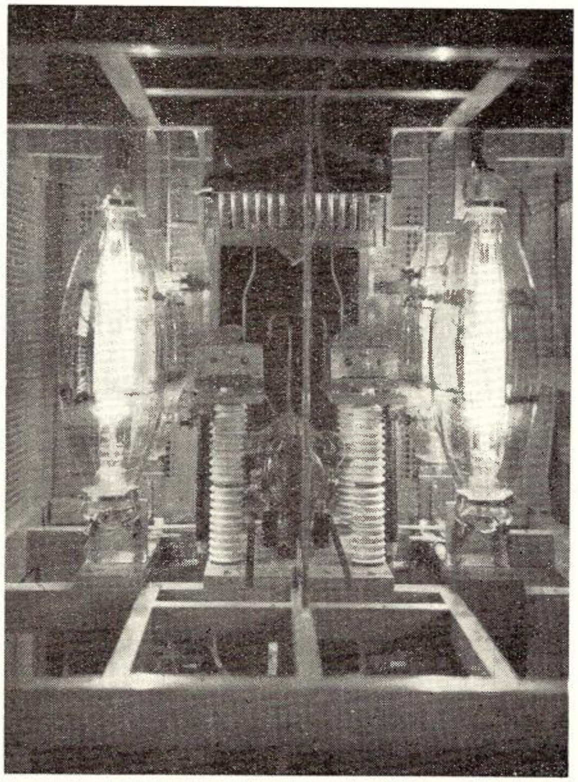


Fig. 4.—Rear view of final amplifier.

Control Equipment.—The transmitter is energized by means of three control buttons with the necessary interlocking relays and time delay relays to ensure that the equipment cannot be placed on the air except in the correct sequence of operations and with the necessary time delays between operations. The filament voltages are applied in two steps automatically by means of a time delay relay in which the time between low and full voltage has been adjusted to about 45 seconds.

Anode voltages are also applied in two steps by the use of a time delay relay, the delay being about the same order as in the case of the filament supply.

Overload relays in the 3-phase anode rectifiers guard against sudden overloads due to surges or a breakdown of any component in the anode circuit of the various stages. The doors of each enclosure are interlocked in such a manner that all voltages are automatically removed as soon as the door leading into the enclosure is opened. In the event of the failure of either bias rectifier, all anode voltages are automatically removed.

Measuring Equipment.—As far as possible the transmitter has been designed to facilitate the maintenance of the correct line up and the rapid localizing of the source of any trouble which may occur. For this reason, adequate meters have been incorporated in the tube circuits to indicate the operating conditions in each circuit.

In addition, the following facilities have been provided:—

(1) A cathode ray oscillograph is permanently mounted in a unit of No. 1 enclosure. The oscillograph is coupled by means of shielded low impedance transmission lines to the output circuit of the modulated amplifier, linear amplifier No. 1 and linear amplifier No. 2, the desired stage being connected to the oscillograph by means of a low capacity rotary switch operated from the front panel of the transmitter. By this means the envelope of the modulated carrier can be rapidly viewed in these three stages.

(2) The monitoring diode is also capable of being switched to the modulated amplifier as well as to both amplifying stages.

(3) The main control table (see Fig. 2) has, besides the necessary keys, master gain control and level indicator for controlling the programme entering the transmitter, means for rapidly checking by ear the quality of the programme entering and leaving the transmitter. In addition, the table also contains a General Radio modulation monitor which is coupled to the output of the final amplifier and gives a reading of the depth of modulation on positive and negative peaks, and detects the presence of any carrier shift due to modulation. This instrument also gives a visible signal to the operator when any pre-determined maximum peak modulation is exceeded.

(4) A General Radio Distortion and Noise Meter is also mounted on the racks of the speech input equipment and energized from the output of the final power amplifier. The overall distortion of the transmitter can therefore be quickly determined and if higher than normal the cathode ray oscillograph can be used to indicate the stage which is out of alignment.

(5) A beat frequency audio oscillator is also provided for general line-up purposes and for taking audio frequency characteristics.

Speech Input Room.—The speech input room contains a local programme table containing the moving coil microphone and gramophone turntables in duplicate together with the necessary switching keys and gain controls. In the event of a failure of the programme line or when testing or making announcements from the station, the control is switched from the main table to this local table.

Fig. 5 shows this table with the rack mounted A.C. operated speech input equipment. This latter consists of line amplifiers in duplicate, microphone amplifiers and monitoring amplifier with anode power supplies in duplicate. Although the carrier frequencies of the station are relatively high, no screening is necessary in the speech input room, and it is possible to open the microphone with all amplifiers on full gain without any noticeable effect due to radio frequency pick up. This is due to the design of the equipment and the fact that the building itself consists of sheet metal construction.

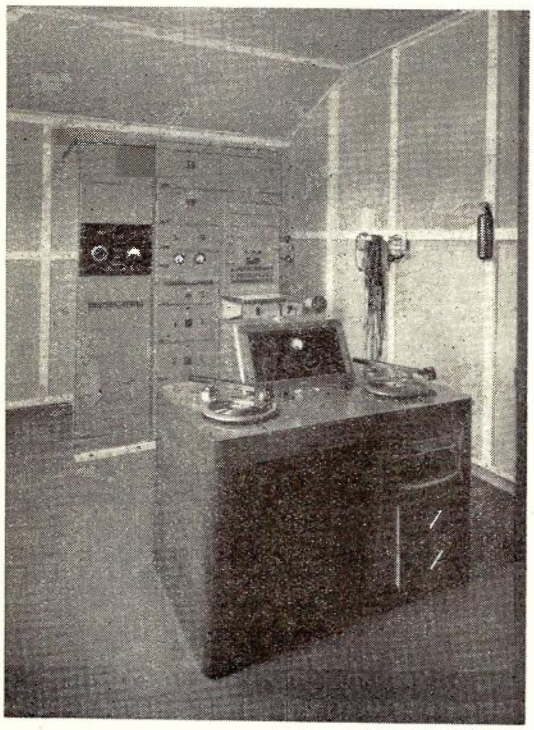


Fig. 5.—Speech Input equipment and local programme table.

Radiating Systems. — The radiating systems are situated remotely from the transmitter and fed by means of an open wire transmission line of 600 ohms characteristic impedance. Altogether there are three types of aerials to which the transmitter can be coupled:—

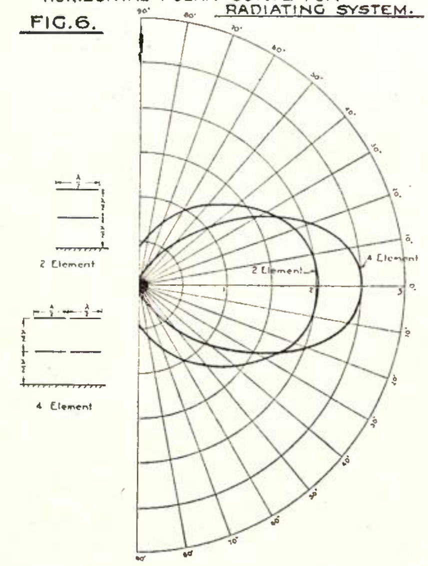
1. A vertical half wave omni-directional radiator for use on 9580 kC only;

2. A rhombic antenna directed on Great Britain and capable of being fed so as to enable transmission to take place over the long or short path. This aerial will accept a 2 : 1 frequency range and is therefore suitable for the three operating frequencies 6140 kC, 9580 kC and 11,880 kC.

3. The normal broadcasting aerials consisting of three tuned horizontal arrays for the three frequencies concerned.

These normal broadcasting aerials are of interest in that they provide a compromise between the omni-directional aerial system employed in normal broadcasting practice and the highly directive aerial systems used in point to point beam services. The area to be served by the transmitter consists of the sector between Brisbane and Darwin subtending at Melbourne an angle of about 63 degs., the distances from Melbourne of the places to be served lying between the limits of 500 and 2000 miles. It is obvious that an aerial for such a service must not be highly directional, the main requirement being adequate suppression of the wasteful radiation in the backward direction. The angle of maximum radiation in the vertical plane is an important factor and calculations indicated that an aerial having maximum radiation at an angle of 15 degs. to 20 degs. from the horizontal and having a fairly broad beam, would be satisfactory. The arrays for 9580 kC and 11,880 kC consist of two horizontal half-wave radiating elements located respectively one-half wave length and one wave length above earth and provided with two half-wave reflectors each one-quarter wave length behind its radiating element. Figs. 6 and 7 show the horizontal and vertical polar curves for such a system. The radiation is a maximum at an angle of 17 degs. with the horizontal and the horizontal polar curve is quite broad. The aerial for 6140 kC is of a simpler type, restriction being brought about by the cost of obtaining sufficient height for such a frequency. This array has therefore a single half-wave radiating element with reflector, each located about three-quarters of a

HORIZONTAL POLAR CURVE FOR RADIATING SYSTEM.
FIG.6.

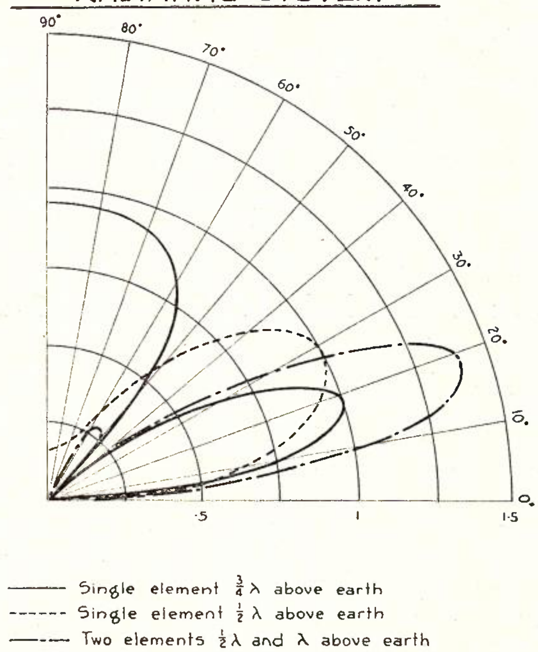


wave length above earth. The reflectors are parasitically excited and must therefore be slightly longer than the radiating elements in order that the reactance may be inductive and the phase relationship correct. Maximum radiation from the arrays is in the direction of Cairns but the power radiated in the direction of Brisbane and Darwin is still about 70 per cent. of that in the Cairns direction.

The gain of the 9580 kC and 11,880 kC arrays is approximately 6 decibels over the single horizontal half-wave element which was in use

FIG. 7.

VERTICAL POLAR CURVE FOR RADIATING SYSTEM



prior to the change-over to the new equipment on October 1, 1938, while the 6140kC array has a gain of 3 decibels over the same aerial. This, together with the fact that the power of the new transmitter is double that of the old, makes the total gain 9 decibels on 9580 kC and 11,880 kC, and 6 decibels on 6140 kC.

To increase the gain of the arrays above 6 db could only be realized by a corresponding narrowing of the horizontal polar diagram resulting in a satisfactory service being given over a smaller area, which is obviously undesirable.

Transmission Lines and Switching System.— The aerial systems are fed by means of 300 lb. per mile copper open wire lines of 600 ohms characteristic impedance, following standard telephone practice with the exception that special low capacity porcelain insulators are used throughout. The arrangements provided for switching the various aerials to the main transmission line are of some interest in that remote control switching is employed.

The contactors used for this purpose were designed from standard 230 V. 50-cycle, 2 pole, power contactors, the main modification being that the radio frequency contacts on either side of the line are spaced by a distance of approximately 10 ins. and mounted on long porcelain insulators. The general switching arrangements are shown in Fig. 8. From this it is seen that a transmission line 775 ft. long connects the transmitter to a main switching box containing three contactors. The function of this box is to connect the transmitter to the vertical aerial, rhombic ,or to a transmission line supplying the three broadcasting arrays. At the base of the 9580 kC array is an array switching box enabling connection to the desired array to be made. The switches are operated by means of 50-cycle power supplied through buried lead-covered cables and are controlled by two master selector switches on the front panels of No. 2 transmitter enclosure. The hand wheels can be seen at the bottom in Fig. 3.

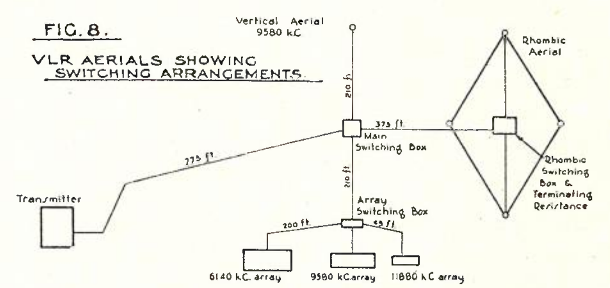
The contactors are provided with auxiliary contacts connected so that power cannot be applied to the final stage of the transmitter until one of the aerials has been connected to the transmission line.

The rhombic switching box carries four contactors arranged to switch a terminating resistance and the feeder line to opposite ends of the rhombic for transmission in either direction.

In any transmission line fed aerial system, care must be taken to eliminate standing waves from the line. These standing waves are manifest as a variation in current along the line, maxima occurring at intervals of half wave length and are introduced by incorrect impedance termination or by irregularities in the line itself, and lead to increased losses in the line.

FIG. 8.

VLR AERIALS SHOWING SWITCHING ARRANGEMENTS



See Test Report No 873

In this case it was found that after correctly terminating the line, standing waves were still present due to irregularities in the line at the switching boxes, probably due to the capacitance of the connections in the boxes.

These were corrected at the aerial box by connecting an inductance of the correct magnitude for each frequency across the aerial sides of the contactors. At the main box where three frequencies are required to pass through the one switch, the problem was solved by designing a network of condensers and coils to provide the impedance correction for each frequency. This network connected across the line in conjunction with the coils at the aerial box reduced the standing wave ratios to satisfactory values for all three operating frequencies.

Conclusion.—Tests which have been made on the transmitting equipment show that the audio frequency characteristic from line amplifier to transmitter output is within 2 decibels over the range 30-10,000 cycles/sec. The distortion at 95 per cent. and 2 kW output varies for the three operating frequencies between the limits of 3.5 per cent. and 5.5 per cent., the lower limit being realized on 9580 kC.

The transmitter was designed so that stabilized negative feedback could be easily applied. It was the intention however, to use the feedback as a means of obtaining quality of a very high order rather than to make the satisfactory operation of the equipment depend upon its use.

The transmitter is at present operating without any negative feedback and it is evident therefore from the distortion figures given above that high quality transmission has been realized without its use. It is intended however to instal the negative feedback at a later date and tests which have already been carried out have indicated that at least 15-20 decibels of feedback will be obtained without instability occurring due to phase shift in the transmitter.

In order to guard against a serious overmodulation of the equipment in the event of a failure in the feedback rectifier circuit, means have been provided for automatically reducing the audio level into the modulator circuit to the correct value for no feedback. It will be realized from the figures given that even with 15 decibels of feedback the distortion occurring in the transmitter will be reduced to an excedingly small value and very high quality transmission will be achieved.

AUTOMATIC TELEPHONE PLANTS

Dr.-Ing. F. Lubberger, Siemens and Halske A.G., Berlin, Germany

Automatic telephone systems are nowadays used for public exchanges in cities and villages, for P.A.B.X.'s, for private exchanges and for long distance operation. There are many differing systems in use and it is difficult to keep track of their features. The writer of these lines is, in a side line, professor at the Technische Hochschule, Berlin, and lectured for many years on Automatic Telephony. It was necessary to develop some kind of a review of all the systems. The writer's experience with the engineers in practice also indicated the advisability of treating automatic telephony in a general way so that all the properties of any system could be investigated, not only some outstanding feature.

The present article intends to show the generalization, but it does not go into the details of comparison of the various systems.

The features of all technical enterprises may be grouped into the technical and economic elements. Fig. 1 is a genealogy of the technical side of automatic telephone systems and Fig. 3 of the economic side. These two figures are supposed to contain all the elements that must be discussed before an opinion about a system can be formed. Fig. 1 refers to the "plants" with three main divisions: generalities, equipment and operation.

Generalities.—The **ownership** has a very marked influence upon the technique. The U.S.A. have about 10,000 independent telephone companies, Finland has 900. Hence a systematic and comprehensive "rural area automatic telephony" is practically impossible because the line plant for rural area systems closely interlinks the many small exchanges with payments in one of the exchanges for connections built up over a plurality of communities. A government may standardize a certain system, but the private companies may choose different systems for each village, and this will interfere with co-operation.

The **laws and rules** of the administrations greatly influence the techniques of a plant, e.g., in one country the secrecy of the conversation is a paramount "law" and the usual party lines are impossible, while in other countries the non-secret party lines serve a high percentage of the subscribers.

The **geography** brings flat and mountainous countries. In flat countries usually round communities are prevalent, with e.g., one exchange and many radial subscribers' lines. In a mountainous country, or in districts with a heavily cut up shore, the settlements are stretched out in long lines with an entirely different type of telephonic layout.

In sparsely settled countries the long distance service is economically very much more important than the local service, so that the equipment is preferential for the long distance service.

The influence of the **climate**—hot, cold, dry, moist, dusty—reaches down to the very details of the design; tropical or not tropical piece parts, safety against the influence of earthquakes, etc.

The past, present and future **history** comprises primarily the degree of saturation and the influences of economic depressions and booms. The planning engineers know the difficulties in deciding on the sizes of exchanges and cable routes. They want systems adaptable to all variations of the traffic and number of subscribers.

The **populations** differ in their demands for convenience and speed of the service. Some races do not use the telephone at all, with no prospect of them ever using it; other races want a telephone in every room.

Before deciding on a "system," these generalities should be studied thoroughly.

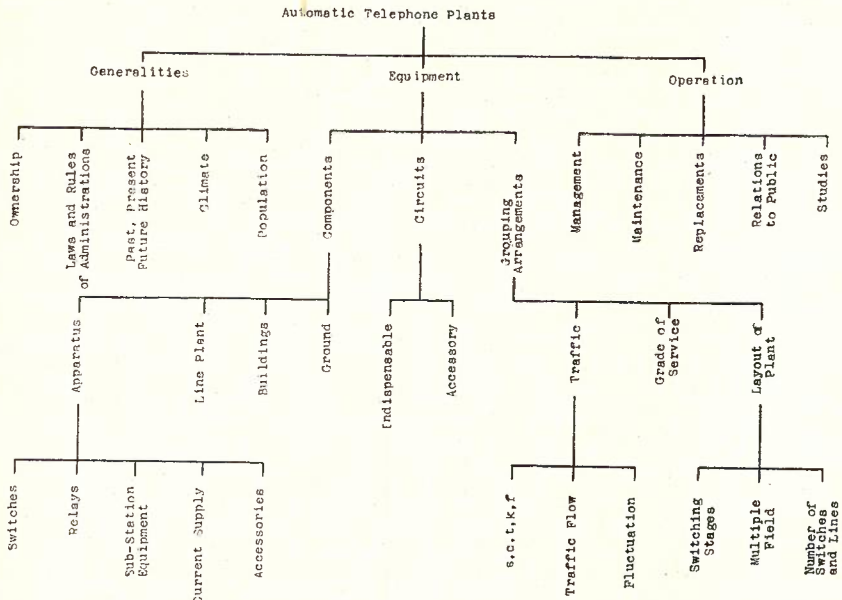


Fig. 1.—Technical Genealogy of Automatic Telephone Plants.

Equipment. — The physical components of a telephone system are the easiest to comprehend. They may be seen and may be studied by applying some tools and electrical measuring instruments.

Circuits

The "circuits" of automatic telephone systems may be classified as the "nerves" of the system. Usually they are judged to be "very complicated." But they may be subdivided into clearly separated items for detail study. To start with, we find "indispensable" and "accessory" circuits. The "indispensable" ones **must** be incorporated in a system and a description leaving out any one of them is incomplete.

There are ten indispensable circuits. They must be learned by heart:—

1. Dialling.
2. Steering.
3. Hunting.
4. Testing.
5. Switching through.
6. Busying.
7. Signalling.
8. Speaking circuit.
9. Power supply.
10. Releasing.

(1) **Dialling** is the act of setting the switches towards the desired direction. All present systems are controlled by some kind of impulses. Suggestions to use records to speak numbers to the subscribers have not been successful.

The impulses may be transmitted by d.c., a.c. inductive "peaks," voice frequencies, carrier waves or wireless waves. Impulses to set switches are nothing else but telegraph impulses.

From

To	A	B	C	D	E	Trunk Rec.	Trunk Exch.	Rural	Service
A									
B									
C									
D									
E									
Trunk Rec.									
Trunk Exch.									
Rural									
Service									

Fig. 2.—Square for traffic flow.

Wherever telegraphy is possible, dialling is also possible.

(2) **Steering** is the act of changing the behaviour of a switch, e.g., the steering tells a group selector to start the hunting after the end of an impulsing train, or tells a final selector to change from group to single line setting.

(3) **Hunting** is the act of motion of a switch when it selects a free line out of a plurality of equivalent lines.

(4) The **test** is the act of ascertaining whether or not a line touched by the wipers is engaged or not.

(5) **Switching through.**—During the hunt, the wipers pass over bank terminals of lines with conversations going on. If the talking wipers carried any potential, they would create disagreeable noises in the conversations. Therefore the talking wipers shall be "switched through" only after a free test.

(6) **Busying** is the act of making a line inaccessible to other offers after a free test.

(7) **Signalling:** (a) operating signals, (b) signals for the subscribers.

(a) The signalling of blown fuses, lack of battery or ringing current, stopping of driving motors (in machine driven systems) and other occurrences affecting the operation of the systems is indispensable. These signals must be transmitted from non-supervised exchanges to a main exchange which is permanently staffed.

(b) The subscribers must be advised about the results of their doings; by means of dialling, busy, n.u. and ringing tones. Only the dialling tone is indispensable, because a too early start of dialling would spoil the connection. The other signals are only psychologically advisable.

(8) The **speaking circuit** is the circuit that sells the telephone service. It is the most important circuit element. It is controlled by the science of electro-acoustics and is subjected to the rules of the C.C.I.F.

(9) **Power Supply.** — The original power is taken from public mains, if available and reliable. If not so, a prime mover is necessary. For very small places movable storage batteries (replaced from time to time by freshly charged ones) or a charging outfit on a motor-car may be used. If the battery of a small outlying exchange has a lower voltage than the one of the main exchange, a charge over the trunk lines may be used.

In all systems the switches receive direct current for operation. For the German systems 60 volts are used in large exchanges, American and English systems use 50 volts (formerly 48 volts).

The current consumption depends on the traffic and the size of the exchange. In a five figure exchange and with 10 calls per day per line, about 0.25 Ah is used per line per day, or .25 x 60 = 15 watt hours per day per line.

(10) **Release.**—For many years all systems had the feature that the calling or the called subscriber by replacing the receiver released some or all switches in order to be able to make a new call at once. In Germany some 12 years ago these circuits had to be changed to a release only by the calling party. In this case the called party, when it replaces the receiver before the calling party, is blocked. This change was the result of very bad experience with manually operated P.B.X.'s. The circuits of most of the many old, but still used, manual P.B.X.'s are liable to momentarily open the (called) loop when an incoming call is passed to the desired extension. The opening released the connection and the extension answered in vain.

It is a good idea for any student of automatic circuits to clearly separate his investigation into these 10 "indispensable" features.

The **accessory circuits** are used only when required, such as metering, P.B.X. hunting, trunk operation, etc. Take the index of a comprehensive book on automatic telephony, you may pick out a nearly infinite number of accessory features and their number increases permanently with the advance of the art.

Trunking Arrangements

Take a complete switch and add all the circuits for its operation — it is useless for telephone service. There must be a lot more switches and lines and subscribers, etc., and all these components must be trunked in a definite order before service can be given. The trunking arrangement is therefore the co-ordination of all component connecting parts to form a working plant.

The trunking is controlled by the traffic, grade of service and layout of the plant.

The **traffic** is the product of five items:

"s" number of lines, telephones, subscribers, names in the directory, sets of line relays in an exchange, working lines, spare lines and numbers. For planning, furthermore, the number of P.B.X.'s and P.A.B.X.'s and their "exchange lines" should be specified, also the number and type of party lines.

"c" number of "calls." There are conversations and engagements. Usually 20 per cent. to 30 per cent. of the total are engagements (busy reports, no answer, incomplete calls, erroneous calls). The load of the switches and lines is made up by the total traffic offered, not only the conversations. "c" must be specified separately for: local originated, local incoming from other groups, local outgoing to other groups, district offer, long-distance offer (in and out), service calls, and for P.B.X.'s and P.A.B.X.'s internal offer, public exchange traffic in and out (local, district, long distance).

"t" is the average holding time of the various calls "c." The load of the switches is made up by the holding time, not by the conversation time. The conversation time is important only for timed tariffs.

"k" concentration.—Usually the data for the traffic is given per year, month or day. The plant, however, must give satisfactory service in the "busy hour" per day. A telephonic year has about 315 to 320 days averaging the Sunday and holiday traffic in work day offers, a month has about 25 days. The busy hour is usually 10 per cent. to 13 per cent. of a days' load.

"f" factor of community.—In an area with a uniform tariff and several exchanges the traffic between the exchanges is not only proportional to the number of lines (or originated traffic) of the co-operating exchanges, but it depends also on the distance and the importance of the exchanges. An exchange at the periphery will call proportionately more to a main office down town than to another peripheral exchange. The down town main office will call proportionately less to the periphery than vice versa. English and German curves are known for the factors expressing the proportions and it seems that these curves are useful all over the world. For districts with varying tariffs corresponding curves are not possible.

The "traffic" expressed in Traffic Units (T.U.) is therefore the product of:—

s.c.t.k.f., when c is expressed in calls per day and t in hours.

To find the **traffic flow** throughout the whole plant a grouping diagram is first drawn up. It is advisable to draw a square with all "sources" in a horizontal and also in a vertical line, Fig. 2, e.g., five city exchanges, a trunk exchange, a rural centre exchange; services will show 9 x 9 = 81 different traffic rivers and rivulets using the most varied combinations of junction lines. Insert the results of each of the 81 rivers into the "riverbeds" of the grouping diagram. One particular "riverbed" may be loaded by, e.g., five different "rivers." The busy hours of these five different rivers certainly do not coincide. So the busy hour of the particular "riverbed" (traffic route) is smaller than the sum of the phase displaced individual rivers. The calculation of the actual busy hour load of a particular traffic route is possible by using the "traffc variation curves" and rules.

The **grade of service** is a figure to express some restrictions in the flow of the peaks of traffic over all stages of the plant.

The traffic is a very erratic phenomenon with high peaks of short duration. A plant equipped for the highest peak (usually some days before Christmas or Easter) would be hopelessly uneconomical. So some peaks are cut off. If a hunting step by step switch does not find a free outlet (overflow) the call is "lost." The calling subscriber must release and try again later. The "loss" is expressed as a percentage:—

$$100\frac{\text{lost calls}}{\text{effective calls}} \quad (\text{not by: } 100\frac{\text{lost calls}}{\text{offered calls}})$$

e.g., five lines carrying 2.2 TU = 132 traffic min. If t = 2 minutes, therefore c effective = 66, and if the loss is 5% = 3 trials. The offer is 69 trials.

In some systems (with registers) an offered call may wait for a junction to become free. There is no universally acknowledged definition for the waiting time," e.g., five lines carry 2.2 TU, t = 2 minutes, c = 66 calls go through without waiting, only approximately three trials would be lost (in a step by step system) or will have to wait. From some observations the average waiting time is found to be 20 seconds. The said hour of observation will show a total waiting time of 3 x 20 = 60 seconds. As far as information is usually given, it would be 60/69 = 1 second. This 1 second is misleading. The subscribers are interested only in calls that do not get through immediately; most of the calls, however, are neither lost nor do they wait.

To calculate the **number of switches**, two distinct sets of data are available. Germany uses a set of "loss" curves based upon measurements and extended by theories. Practically all other countries use certain probabilities. These data do not give "losses" but they do indicate a grade of service. Data for "waiting times" are beginning to be published in Germany. There are many theories on waiting times, but none of them tallies with the observations.

The "grade of service" for systems with losses is given as 0.1%, 1%, 5%, etc., losses. What percentage is to be taken is not discussed in this article. The percentages expressed by probabilities are also 0.1%, 1%, etc., but these figures do not mean "losses." No acknowledged information is as yet available for "grades of service" in systems with waiting times.

The **layout of the plants** consists of the sizes of the switches (100, 200, 300, 500 point switches) and the arrangements of the multiple fields (full availability and graded multiple fields) and the corresponding number of stages of switches in series. The teachings of the traffic curves belong to the most important items of knowledge for automatic telephone engineers.

Operation

The management is responsible for the technical and financial success of the plant. The plant must be maintained in good order until it is replaced by another equipment. The cost of maintenance and the time of replacements are principally economic questions. But the advance of the art sometimes justifies a replacement of parts of the plant still in good condition.

Economy

The economy of any technical plant is given by the yearly figures of the balance sheet and the loss and gain account of the commercial books. Fig. 3 applies the terms of automatic telephone plants to this general statement.

The liabilities in the balance sheet usually do not interest the engineer. He is usually not concerned with the means and ways of getting the money to build the plant. Most of the technical assets are self explanatory.

A word must be said about the **"intangibles."** From the moment of the decision to investigate the advisability to build a certain plant a great many expenses occur until the orders are placed which comprise the technical ("tangible") assets. The plant could not be built without the technical and financial planning. The technical planning results in a lot of blue-prints actually costing some shillings. But the preliminary work before the final drawings are made may have cost thousands of pounds. It is a good principle to "activate" (i.e., enter as "assets") all the costs for anything without which the plant could not be built. Private telephone companies pay considerable sums for one sheet of paper "franchise." Interest on borrowed money is the cost of money. All these items are not represented by iron, copper, bricks, etc. (tangible values), and the expenses for them cannot be booked out over "losses" (expenses) because the loss account of the year would be swelled to a heavy deficit. All these expenses are not made for the one year wherein they occurred, but for all the years to come. The intangible assets must be depreciated exactly the same way as the tangible values. Financial assets are — cost, various funds, undivided profits, etc.

The items of the "capital cost" refer generally to the sums of the technical assets. They are self-explanatory. The "operating costs" are the expenses for giving service. The "maintenance" need not be explained. The item "service" includes the operators (in manual and long-distance plants), operators for information, trouble, complaints. Furthermore, power, heat, light, cleaning, air conditioning, social items like rest-rooms, hospital, kitchen, baths, etc. The commercial items comprise the subscribers' directory, book-keeping, bank accounting. The "personal insurances" refer to old-age-sickness, disability, etc., insurances and other legal payments referring to the personnel. The "general costs" comprise the directorate or management, for governmental plants a proportion of the ministry of post, the head offices, the general laboratories and general technical offices, furthermore, legal expenses for law suits, etc.

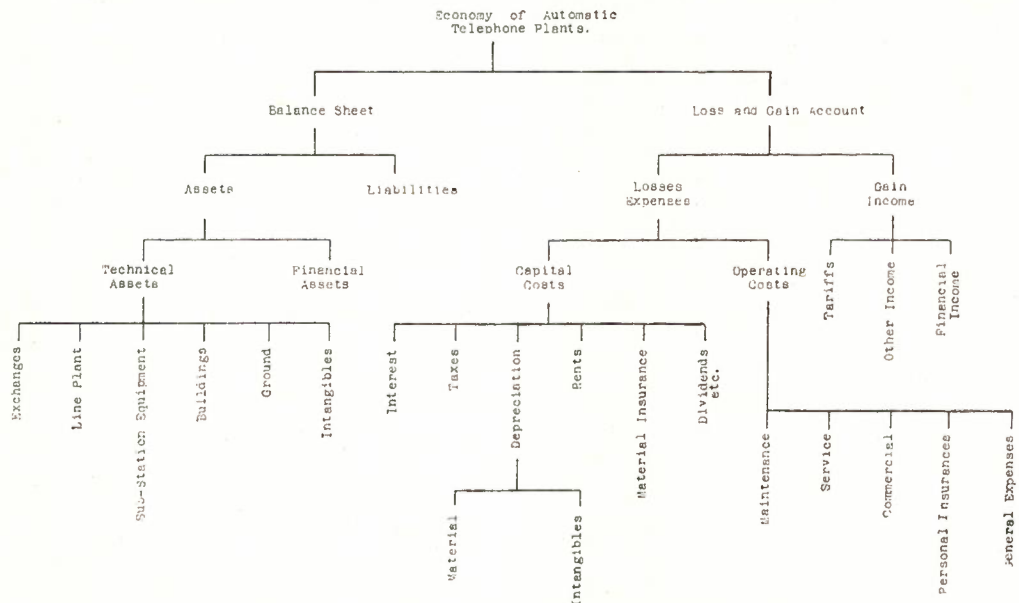


Fig. 3.—Economic Genealogy of Automatic Telephone Plants.

Summary

The technical and economical genealogies of automatic telephone systems show the complexity of the problem of how to choose a particular system. The danger may be seen if only one item, e.g., a particular type of switch, is taken as a base for important decisions.

The two genealogies may also be used in schools to show the students what they are up against.

Editor's Note.—Dr. Ing. F. Lubberger has kindly consented to write a number of articles on the fundamentals of Automatic Telephony. The above is the first of the series and further articles will appear in future issues. All members will appreciate the privilege of having this opportunity to read the views of such an international authority on this subject.

PRINCIPLES AND DEVELOPMENTS IN AUTOMATIC TELEPHONY

W. King

Early Developments.—In order to get a complete picture of the development of Automatic Switching let us go back to the time when the magneto system was standard. This consisted of local battery telephones with magneto signalling. While the number of subscribers connected to an exchange was comparatively small, this system appeared to meet the demand, but as the telephone became more popular and telephone users increased, particularly in the larger centres, it was found that the heavy maintenance costs on the substation equipment necessitated by the renewal of batteries and the comparatively high cost of the subscriber's telephone, were becoming serious problems to the telephone engineer. These problems eventually led to the development of the common battery system.

With the advent of this system, substation equipment was simplified by the omission of batteries and generators and the maintenance reduced to a very low figure, and although large batteries were required in the exchanges, the introduction of lamp signalling in lieu of the ring down indicators resulted in decreased maintenance costs of the exchange equipment also.

Therefore, the conversion of large exchange groups from magneto to C.B. working was done mainly for economic reasons. As the telephone density in the larger cities continued to increase at a very fast rate the operating costs of these large manual switchboards became rather alarming and some economic means of reducing them was sought. With this object in view the proposition of replacing switchboard operators, by utilizing machine switching, was seriously considered and this finally led to the development of the automatic exchange.

When it is considered that the early automatic exchanges consisted of bimotional switches only and it was necessary for each subscriber to be provided with a comparatively costly selecting switch, it is rather a wonder that the system

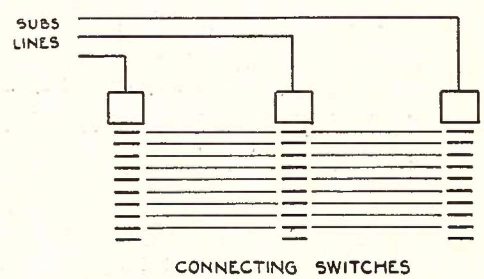


Fig. 1.—100 Line Exchange.

proved in economically at this time; however, it apparently did prove in and has continued to do so to such an extent that, to-day, very few large manual exchanges remain and these are being rapidly replaced by automatic equipment.

Simple Trunking Schemes.—Before describing the various stages of development of the Strowger Automatic System it may be of interest to indicate briefly how the trunking system is built up, commencing from the simple 100 line exchange. To simplify the diagrams bimotional switches only will be shown.

Figure 1 indicates the 100 line exchange. Each subscriber's line terminates on a selector having the whole 100 lines connected to its banks. By dialling two digits a subscriber can be connected to any other subscriber in the exchange.

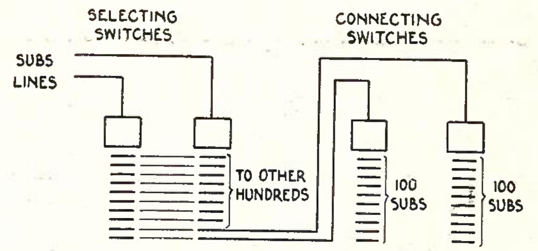


Fig. 2.—1,000 Line Exchange.

Figure 2 shows how a 1000 line exchange is built up by adding an additional rank of switches. The first switch in this case is a selecting switch having 10 outlets from each level to 10 connecting switches.

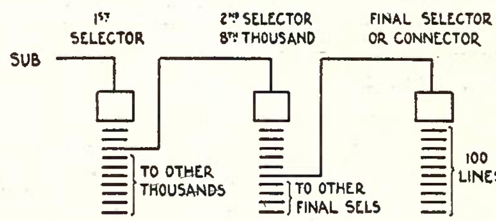


Fig. 3.—10,000 Line Exchange.

Similarly, Figure 3 indicates a simple trunking diagram for a 10,000 line exchange. In this case, the first selecting switch selects the thousands group required, the second selecting switch the hundreds group and the connecting switch or final selector the particular number required. As previously mentioned, in the early Strowger exchanges installed in America each subscriber was provided with a selector having access to 100 trunks. This was quite a good arrangement but a fairly costly one, and it was soon found that a considerable saving could be effected, by providing each subscriber with a cheaper switch, having a limited number of outlets to selecting switches. This led to the development of the well-known Keith or Plunger type line switch.

*Paper presented before the Postal Electrical Society of Victoria on 11th July, 1938.

Primary Line Switch. — As a plunger line switch could be manufactured for a fraction of the cost of a selector and a limited number of first selectors only were required, 10 per cent. being about the requirements in those days, it will be seen that by the introduction of the line switch the exchange equipment costs were considerably reduced. This system was standard for several years and it was this type of equipment which was installed in the first automatic exchanges in Australia about 26 years ago. Figure 4 shows a trunking diagram for this type of equipment.

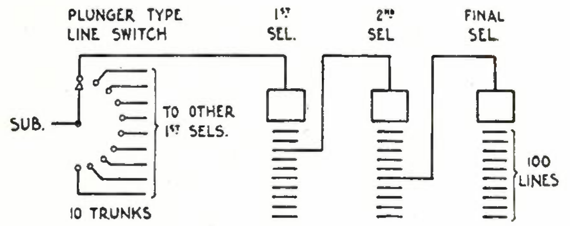


Fig. 4.—Exchange Using Plunger Type Line Switches.

The Plunger Type Secondary Line Switch.—In the switching system just considered, with 10 per cent. trunking from the primary line switches the choice of the 100 line switches in any unit is limited to the 10 outgoing trunks which are multiplied over the line switches and, consequently, to 10 selectors. Although 10 per cent. outgoing trunking calls for 10 trunks out of every 100 line switches, the probability against the simultaneous occurrence of peak loads in several units renders it possible that something less than 1000 selectors might meet the demand of 10 per cent. outgoing trunking over 100 line switch units.

It not only may occur, but almost certainly will occur, that the time when some units are exceptionally busy, will coincide with the time when others are comparatively slack. A proportion of the plant is likely, therefore, to be continuously idle. It is necessary therefore to give a wider field of choice to the line switches, such as would be secured, for example, if a hundred first selectors could be made accessible, to every line switch in 15 or 20 units. This can be brought about by interposing secondary line switches between the primary line switches and the first selectors. This is indicated in Figure 5.

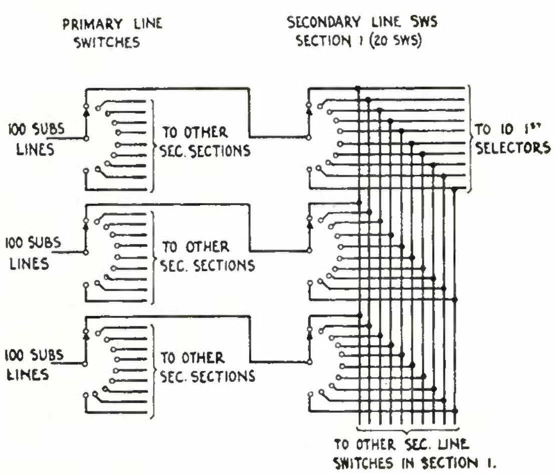


Fig. 5.—Secondary Line Switches.

The percentage of outgoing trunking from the primary units is not affected, but advantage is taken of the lack of uniformity, which characterizes telephone traffic, to reduce the number of selectors necessary to deal with a given volume of traffic, by a system of trunking, which gives wider distribution. The object of this is economic; fewer selectors, but additional line switches are required, the latter being far less expensive than the former.

Bimotional Switches.—The bimotional switches, i.e., selectors and final selectors, in these early installations, were of the well known uncovered type equipment with the various relays sprouting from the switch frames. Quite a large number of these switches are still in use in the Geelong Exchange.

A further advance in automatic equipment occurred a few years later when the old uncovered type bimotional switch was discarded and replaced by a covered type switch with the relays neatly arranged under a cover. The Brittania metal frames of the earlier switches also were discarded, and replaced by cast iron frames in the later switches.

Rotary Line Switch.—The next big step in development was the introduction of the rotary line switch. This switch was first introduced in Victoria at Carlton Exchange as a secondary line switch. Part of the trunking scheme for this exchange is indicated in Figure 6. The traffic carrying capacity per trunk increases as the size of the trunk group increases, therefore the introduction of 25 outlet rotary switches in lieu of 10 outlet switches resulted in a reduction of the number of 1st selectors required to carry a given amount of traffic, and as the cost of rotary switches does not greatly exceed that of plunger type switches, the introduction of rotary switches was an economic proposition.

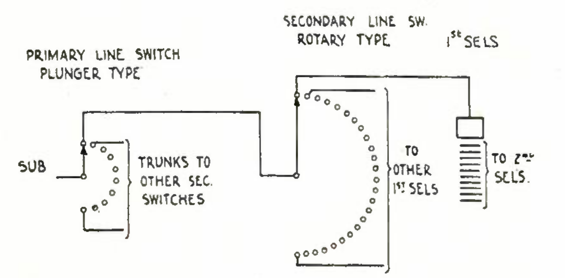


Fig. 6.—Plunger Primary and Rotary Secondary Switches.

The next logical step was the use of the 25 outlet rotary switch as a primary line switch.

Owing to the increased size of the trunk groups outgoing from these switches, secondary line switches were found to be unnecessary and the primary trunks were wired direct to first selectors. South Melbourne and Canterbury were the first exchanges in Victoria to use this equipment.

Junction Working and Branch Exchanges.—So far no mention has been made of the branch exchange and junction working, and it would perhaps be advisable to cover this phase of development before breaking any further new ground.

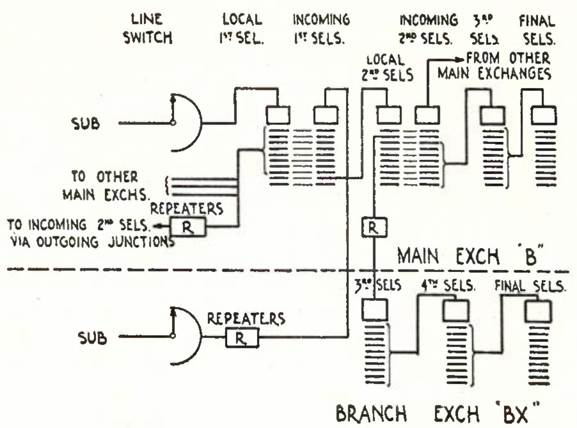


FIG. 7.
MAIN AND BRANCH EXCHANGES

Figure 7 indicates a trunking diagram for a main and branch exchange in a large network. The trunks from all but the local level of the 1st selectors in the main exchange, are connected to outgoing junctions via Repeaters. The function of the repeaters is to hold the switches in the local exchange, supply transmitter current to the calling party, and repeat the dialled impulses over a two-wire junction, which terminates on a second selector, in the distant exchange, in the case of main exchange to main exchange junctions. Branch exchange junctions from the main exchange leave the branch exchange level of the second selectors (the X level in the case illustrated) and pass via repeaters to 3rd selectors in the branch exchange. Incoming trunks from all other main exchanges terminate on incoming second selectors in the main exchange. Incoming trunks from the branch exchange, however, terminate on incoming first selectors. This is necessary in order that they may have access to the other main exchange levels.

With the arrangement shown, a call from a branch exchange subscriber to another branch exchange subscriber passes to the main exchange over an outgoing junction to a 1st selector in the main exchange, and back over a second junction to the 3rd selector in the branch exchange; thus two junctions between the main and branch exchanges, are held while a branch exchange local call is in progress.

In branch exchanges where the local calling rate is low, or alternatively, where the distance between the main and the branch exchange is small, the use of the two junctions on branch exchange local calls, does not justify the introduction of fairly costly plant to obviate their use, but on the other hand, if the local calling rate is comparatively high, or the distance between main and branch exchanges is considerable, alternative arrangements which keep the junction requirements down to the lowest possible figure are advisable.

Switching Selector Repeater.—A switch termed the Switching Selector Repeater was developed to meet this requirement. This switch, as its name implies, combines the functions of both a selector and a repeater in a single mechanism together with means of switching from one to the other. It serves as a repeater on outgoing calls, and as a selector on local calls. The Switching Selector Repeater is connected in the trunking scheme as indicated in Figure 8. It functions as follows:—When a receiver is lifted to originate a call in the branch exchange the calling party seizes a switching selector repeater. The associated outgoing secondary line switch seizes a junction to the main exchange where it terminates on a 1st selector. With the transmission of the first train of impulses both the selector and the switching selector repeater operate vertically, and the selector in the main exchange hunts for a vacant second selector. The switching selector repeater restores to normal but is still held engaged. The second train of impulses operates the second selector in the main exchange, and the switching selector repeater is again operated vertically. If the level reached with the second train of impulses is connected to local selectors, the switching selector repeater functions as a second selector, and the call is routed to the next rank of switches in the local exchange, while the junction to the main ex-

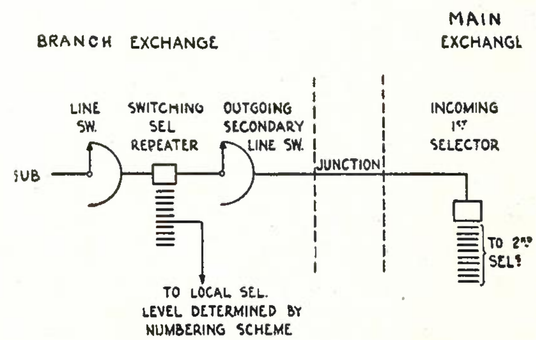


Fig. 8.—Switching Selector Repeater.

change and the switches there are released. The switching arrangements can be adjusted to meet the cases requiring switching on the first, secon or third digits if necessary. If the call is not destined for the local exchange the switching selector repeater functions as a repeater, the wipers remaining disconnected.

By the use of rotary switches as outgoing secondaries, or junction finders as they are sometimes called, the number of junctions required is less than the number of switching selector repeaters. Outgoing secondary line switches are also used for the distribution of any group of junctions trunked from selector levels. The number of junctions required can thus be reduced and made to approach more nearly to a simple group. It is a matter of economics whether or not the saving thus obtained in the junction lines will warrant the installation of the necessary switches. Outgoing secondaries are usually 25 point non-homing rotary line switches, and with the exception of those used in conjunction with switching selector repeaters are usually connected between the first selectors and repeaters.

Homing Type Rotary Line Switches.—Having briefly covered branch exchange developments, we will continue with the general development. The next step was the introduction of Homing Type Rotary Line Switches. Up to the present I have used the term Line Switch as the earlier switches were better known by that name. The designation was later changed to Preselector and later still to Uniselector, and this designation will be used in the remainder of this article.

The earlier type of rotary uniselector was non-homing, that is, the wipers remained on the trunks last used, and when again taken into use the switch rotated the wipers to the nearest vacant trunk. By introducing homing type

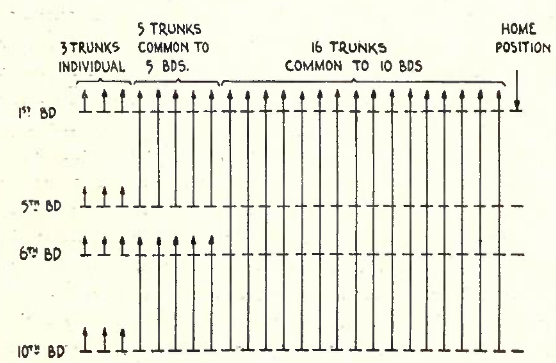


Fig. 9.—Grading.

uniselectors it is possible to apply grading to the trunks outgoing to first selectors. Figure 9 may help to explain this grading. It will be seen that from ten 100 line units, 56 trunks outgoing to first selectors are required to carry the originating traffic. These trunks are distributed as follows:—

(i.) Three trunks are allotted to each unit of 100 lines, and only subscribers in each particular hundred group have access to these trunks.

(ii.) The next five trunks on each unit are commoned to five 100 line units only.

(iii.) The remaining 16 trunks on each unit are common to the whole group of 1000 lines.

The object of this grading is to reduce the number of first selectors to a minimum. The bulk of the traffic from each 100 line unit is carried by the individual trunks and the common groups are used to carry the peak traffic, advantage again being taken against the probability of the peaks occurring in all ten units simultaneously. Without homing type uniselectors grading would not be possible, as the non-homing type switches would not be able to search over the individual trunks first. It is claimed that the number of local first selectors can be reduced by 10 per cent. to 15 per cent. by the introduction of grading.

Other Important Developments.—Within the last 10 years or so several important developments have taken place overseas, and although they have not as yet been introduced into this country, they are nevertheless of great interest. The most important of these are the Director and the Common Control Systems. A brief mention only will be made of these in passing.

The Director System was developed to cater for any very large networks such as London, where the number of exchanges is large; its main function is to enable calls to be routed over large common junction groups to many different exchanges by utilizing a translation scheme. The prefixes dialled are translated, to enable a call to reach any desired exchange in the network, and at the same time a standard number of digits for each call are maintained.

The Common Control System utilizes the standard step by step mechanisms, but a large proportion of the selecting switches are simplified, by reducing the number of relays to the minimum required to hold the switch only, during the duration of a call; a small number of switches of each grade being used to set up the call, after which they are released to set up further calls. This should result in a reduction in the cost of the equipment, unless the extra cost of the Common Control Switches outbalanced the savings.

A later development overseas also was the introduction of line finders into large exchanges in preference to using uniselectors.

The Line Finder System. — The line finder principle is not, of course, new to Australian practice as it has been used here for years in Rural Exchanges, but its introduction into metropolitan exchanges is a new development which we will now consider:—

Combined with the introduction of the line finder system in Australia, however, was the introduction also of a completely new bimotional switch mechanism known as the 2000 type equipment. The 2000 type equipment will be discussed later.

In the line finder system the subscribers' lines are divided into groups of 200 and each group is connected to the banks of a number of bimotional line finders. (See Figure 10.) These finders are tied to 1st selectors and the number of finders per group of 200 lines is determined by the average calling rate for the exchange

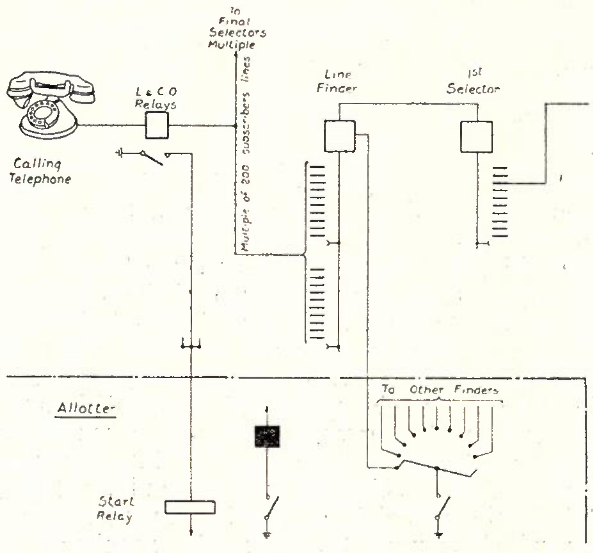


Fig. 10.—Line Finder System.

concerned. For instance, for the average outer suburban exchange 15 directly coupled finders per group of 200 subscribers should be sufficient to carry the outgoing traffic.

When a call is originated in a finder exchange the calling subscriber's line is marked on the banks of all finders in the group and a preselected finder searches for the calling line.

The mechanism of the finder is similar to any other bimotional switch, i.e., selector or final selector, but an additional vertical bank and wipers are provided. The finder is self-driven on both the vertical and rotary, an additional vertical interrupter being provided for the vertical drive. The particular level associated with the calling line is marked on the vertical bank and when the finder reaches this level, it stops the vertical stepping, and allows the switch to rotate on this level until the marked line is reached, when the switch stops and switches the calling line through to the 1st selector associated with the finder in use. Dial tone is transmitted to the calling subscriber who proceeds to dial the number required in the usual manner.

The finder system introduced recently into Brunswick Exchange differs slightly from that just described in the respect that partial secondary working is used. This is illustrated in Figure 11.

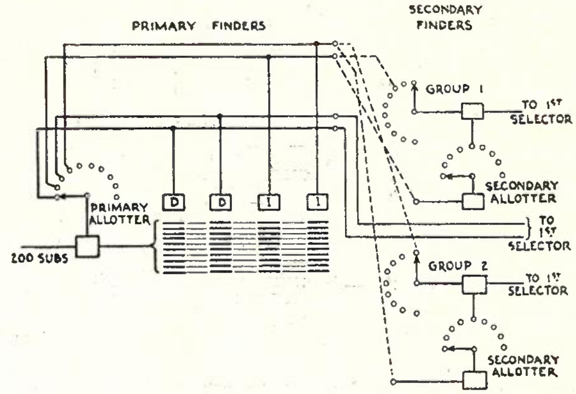


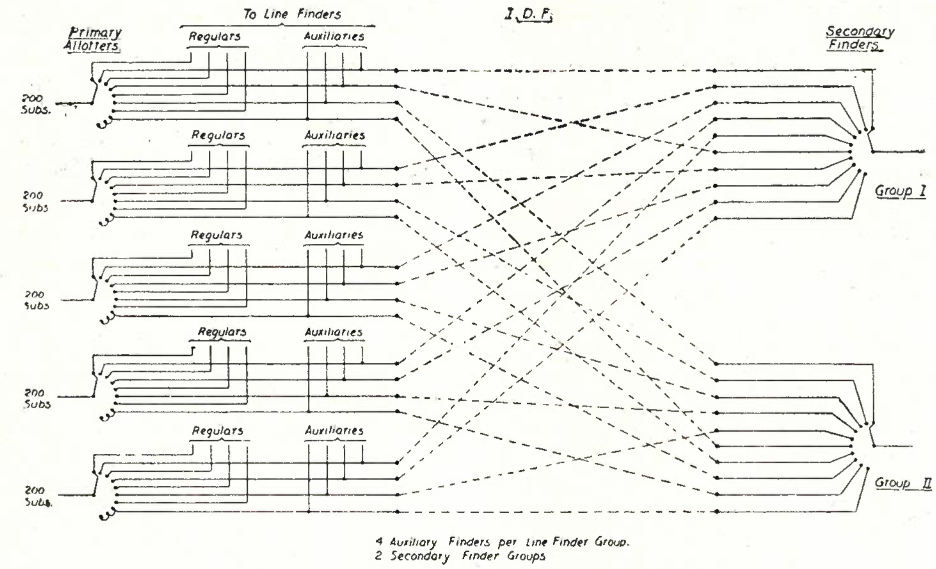
Fig. 11.—Partial Secondary Working.

It will be seen that certain of the finders in each group are directly connected to 1st selectors —or repeaters in the case of Brunswick, which is a branch exchange. The remaining finders in each group are indirectly connected to repeaters via secondary finders. About 50 per cent. of the finders at Brunswick are indirect.

The indirect finders are connected to the banks of secondary finders, each secondary finder being connected to a selector or repeater. The secondary finders which are 25 point rotary uniselectors are usually in small groups of 12 switches. The wipers of these switches are divided into two sets of four, so that as many as 50 indirect primary finders may be connected to their banks. The indirect finders from each group are staggered over the various secondary groups to avoid the possibility of congestion in a primary group should a secondary group become busy. This is illustrated in Figure 12. By the introduction of partial secondary working the number of 1st selectors or repeaters can be greatly reduced. The circuit arrangements are such that most of the traffic from each primary finder group is carried by the directly connected finders, as no indirect finder can be used until all the direct finders are busy.

The following considerations will help to explain the principle of partial secondary trunking:—

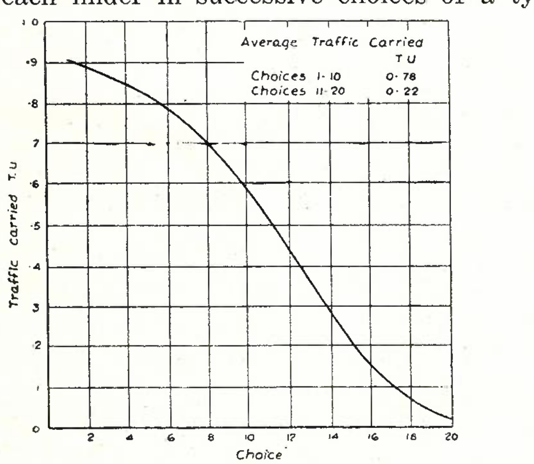
The minimum number of first selectors occurs when all subscribers' lines have access, directly or indirectly, to all 1st selectors, i.e., under the condition of full availability. While this condition can only be absolutely provided by a full secondary trunking system, full availability conditions can be practically attained and a very considerable saving in secondary apparatus ef-



Typical Cross Connections between Line Finders & Secondary Finder Banks – Partial Secondary Trunking Scheme

Fig. 12.

fected by means of partial secondary trunking. The graph in Figure 13 shows the traffic carried by each finder in successive choices of a typical group of 20 line finders. The average traffic carried by the first ten choices is 0.78 T.U., and is highly satisfactory. Consequently, in these cases, no useful purpose would be served by combining the traffic from these choices into larger groups by means of secondary apparatus. On the other hand, the average traffic carried by the second ten choices is only 0.22 T.U., and it is found to be of great advantage to concentrate the traffic from the latter choices into a common group of 1st selectors via secondary finders. This is the principle of partial secondary trunking, which ensures that the total number of 1st selectors is much less than would be the case if all the line finders were directly connected to 1st selectors.



Group of 20 line finders Full availability Traffic offered = 10 T.U. Grade of Service 1 in 500

Fig. 13.

[Editor's Note.—The lecturer then went on to describe the 2000 type switch, but as this has already been described in the Journal (Vol. 1, No. 4, Page 114) in detail, the subject matter is not reproduced here.]

A NEW MAGNETO HANDSET WALL TELEPHONE, 233 M.W.

T. T. Lowe

This article describes the Standard Magneto Handset Wall Telephone.

Magneto Telephones in Service.—At present, 270,000 Magneto Telephones are in service, and 55,000 are the Handset Type, introduced in 1932, 15,000 being Wall instruments and 40,000 the Table Type. The net increase per month in Magneto Handset Wall Telephones is about 450. Due to the replacement of magneto equipment by the automatic type, and the demand for handset instruments, magneto wall telephones are being returned to stores throughout the Commonwealth, at a rate of about 1000 per month, and of these about 600 per month are the British Ericsson wall type. Most of the telephones so returned would normally not be used as the main demand of new local battery installations has been for handset types. The design now to be described permits the reconstruction of these sets to modern, efficient, anti-sidetone handset types of neat appearance, and they are now the standard wall type magneto telephone.

Fig. 1.—Magneto Handset Wall Telephone, No. 233 M.W.

The Magneto Handset Wall Telephone—General. — The Magneto Handset Wall instrument which has been adopted as standard is indicated in Figure 1 and will be known as Telephone 233MW. The polished oak telephone case is 9 ins. wide x 15 ins. long x 6 ins. deep. The generator, magneto bell, switchhook spring set, anti-sidetone induction coil and 0.4 microfarad condenser, together with two or three dry cells as required are mounted in the wooden case. The generator handle is on the right-hand side of the telephone near the top and the switchhook and handset are on the left-hand side. The magneto bell gongs are mounted on the front panel near the top, and below them, a writing slope fitted with a paper clip is provided. The method of operating the instrument is indicated to the user, on an instruction card fitted under glass in a metal notice frame on the front panel between the bell gongs and the writing slope.

The telephone is a complete magneto local battery handset instrument of the anti-sidetone type and is the first local battery anti-sidetone set used here. Local battery telephones purchased previously have not included any special anti-sidetone features. The advantages, particularly for use in noisy situations, of anti-sidetone telephones, have been discussed in previous articles in the "Journal." (See Vol. 1, No. 6, and Vol. 2, No. 2.)

This telephone will be the Department's standard magneto wall type instrument. Some of the reasons for the change from the previous standard are:—

(a) The former standard instrument consisted of a magneto handset table telephone and its associated bell set, mounted on a black enamelled steel wall bracket with a generator fitted in a wooden case and a steel battery box. The components were generally mounted one below the other on a wooden backboard for the convenience of the subscriber, but still presented to the average telephone user, rather a formidable array. The instrument standardized is completely self-contained.

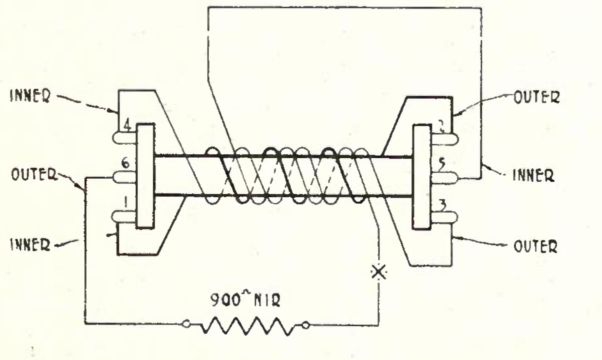
(b) The instrument adopted is an anti-sidetone telephone, and maximum sidetone suppression is obtained on long lines. Also, the transmission efficiency of the instrument (sending and receiving) is equal to the former standard telephone.

(c) If a standard magneto wall telephone is changed to the handset type, the latter instrument will fit in the same position on the wall as the former telephone, so that when the change is made, the wall is left unmarked and the same fixing plugs are used for both instruments.

Details of the Magneto Handset Wall Telephone.—The telephone is a recovered British Ericsson magneto wall instrument. If the woodwork of the telephone is damaged or in poor condition, the wooden case is repaired and the surface well polished. The magneto bell, British Ericsson hand generator, three contact switchhook spring set and line and battery terminals, after re-conditioning when necessary, are replaced in the case. The finish of all parts of the telephone is of very good quality, having high resistance to scratching and a tenacious surface.

The solid back transmitter and the bell receiver are replaced by a black moulded handset fitted with a black Swedish Ericsson instrument cord 3 ft. 6 ins. long. Little trouble is experienced in service on this type of instrument cord due to twisting, kinking or fraying.

The receiver hook for the bell receiver is replaced by a receiver hook "M" which is suitable for use with the handset.



✕ JOINED INSIDE THE COIL

Fig. 2.—A.S.T.I.C. No. 21A coil windings, Telephone 233 M.W.

As there is a tendency for the tip of the handset mouthpiece to touch the wall or backboard when the handset is replaced on the switchhook, the upper portions of the two prongs of the switchhook are bent slightly backward and the lower portion forward, thus removing any likelihood of damage to the handset being caused in this manner.

The sidetone type induction coil (Induction Coil No. 12, windings 1 ohm + 25 ohms) is replaced by a local battery A.S.T.I.C. (Induction Coil No. 21A.) This induction coil is of the open core type and has four windings, 1 ohm + 17 ohms + 33 ohms inductive and 900 ohms non-inductive. Figure 2 shows the connections and the windings. Instead of replacing the induction coil No. 12, it may be rewound to the anti-sidetone type. The operation of the anti-sidetone induction coil is explained later.

An 0.4 microfarad condenser, which is portion of the balance network associated with the anti-sidetone circuit, is fitted in the telephone.

The instrument is wired and connected in accordance with Drawing C.1434 (Figure 3), which shows also the connections between the telephone and the handset and the connections to the battery. If an extension bell is required, it is connected to terminals EB1 and EB2 and the strap is removed.

Specification 275 deals with the conversion of British Ericsson magneto wall telephones to the handset type referred to in this article, i.e., Telephone 233 MW.

Dry Cells.—Two dry cells are provided in the telephone except on subscribers' lines longer than 3.2 miles of 10 lb. cable, or 4.6 miles of 20 lb. cable, when three cells are fitted to improve the sending efficiency. (See Research Test Report, No. 572; the line limits for Telephone 566M are suitable for Telephone 233 MW.)

Alteration to Telephone 233 MW to Provide Metering Facilities.—It is the practice to fit a 2 mF. condenser in series with the magneto bell on Handset Telephones 566M when used at magneto exchanges in certain metropolitan areas, to provide for the metering of the call against the calling subscriber when the receiver is removed from the switchhook. This procedure may be followed also for Telephones 233MW, but, as is also necessary for other types of magneto telephones, care must be taken to ensure that the receiver is connected correctly with respect to the direction of the line current. If on incoming calls the receiving efficiency is low, the connections to the receiver should be reversed.

As it is preferable to prevent the passage of direct current through the receiver, an anti-sidetone circuit, which will overcome this difficulty, has been developed and the details will be available at an early date. This anti-sidetone local battery circuit will also be the standard for long distance C.B. and automatic telephones.

Circuit Description, Telephone 233MW—Drawing C.1434

(i.) **Incoming Calls.**—The incoming ringing circuit is from line 1 through the generator short

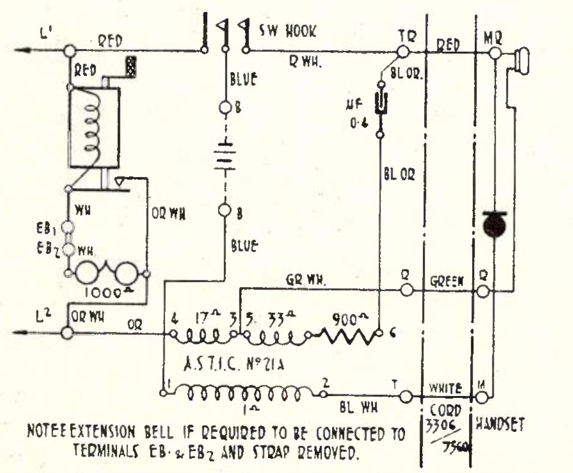


Fig. 3.—Circuit of Magneto Handset Telephone 233 M.W.

circuit to EB1 which is strapped to EB2 through the magneto bell to line 2.

(ii.) **Originating Calls:**

(a) **Outgoing Ringing Circuit.**—The outgoing ringing circuit is from line 1 through the generator and its make contact to line 2. The magneto bell is short circuited by the generator make contact. The short circuit is removed from the generator when the handle is turned as the driving spindle, the tip of which is not insulated, moves away from the main spring of the generator spring set.

(b) **Transmitter Feed Current Circuit.**—When the handset is removed from the switchhook, the transmitter local circuit is completed as follows: From the dry cell battery, through the 1 ohm winding of A.S.T.I.C. to telephone terminal T, through handset cord to handset terminal M, through the transmitter to handset terminal MR, through handset cord to telephone terminal TR, through switchhook contacts, back to battery.

(c) **Sending Circuit and Sidetone Suppression.**—Referring to Fig. 4, the operation when transmitting is best understood by considering that the turns and resistance of winding 4-3 are equal to those of 5-C, the impedance of the line

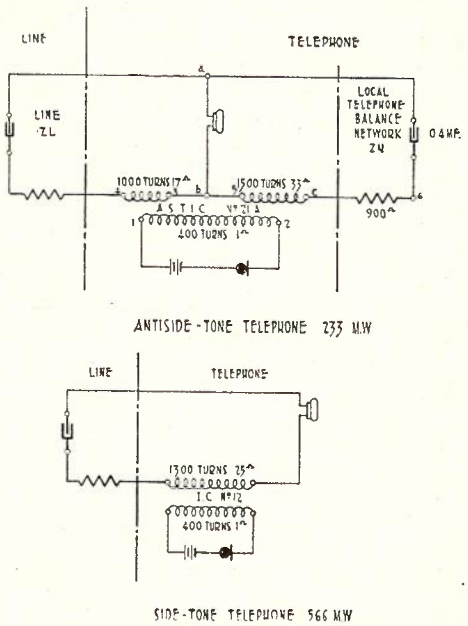


Fig. 4.—Antisidetone and sidetone local battery telephone circuits.

is equal to that of the balance network, and that the receiver is disconnected. Under these conditions, we have a simple transformer in which 1-2 is the primary 4-3 in series with 5-C is the secondary and the line in series with the network is the load on the secondary. The alternating current produced by the transmitter is transformed to the secondary and produces a P.D. between 4 and C. The potential at "b" will be at the midpoint of this P.D. As the point "A" is at the midpoint of the load on 4-C, its potential will also be at the midpoint of the P.D. across 4-C and therefore a and b have the same potential. It therefore makes no difference whether the receiver is connected or disconnected and when connected, no current will flow through it (that is no sidetone will be heard).

A.S.T.I.C. No. 21A has unequal turns on the line and network windings (4-3 1000 turns) (5-C 1500 turns). This has the effect of raising the receiving efficiency and lowering the sending efficiency compared with a coil having equal turns and it brings the efficiencies in line with those of the existing sidetone telephone No. 566MW. To obtain a sidetone balance with these unequal turns, it is necessary to use a balance network which has a higher impedance than would be used with equal turns.

In practice, some sidetone will be heard in all cases, and the amount will vary with different connections. The impedance of the balance network ensures maximum suppression on long lines and maximum advantage is obtained from the arrangement on connections over which the incoming speech level is low. It will be observed that under balanced conditions half of the power delivered to the 17 + 33 ohm windings from the transmitter is dissipated in the balance network impedance ZN, but this loss is compensated for by the fact that there is no loss in the local telephone receiver as is the case in the sidetone telephone. The sending efficiency of the antisidetone set equals that of the sidetone set.

(d) **Receiving Circuit.**—In the receiving condition, the voice currents pass from line 1 through the switchhook contacts, local telephone receiver, 17 ohm winding of A.S.T.I.C., back to line 2. Under balanced conditions no current flows through the network as the voltage across it is opposed by an equal and opposite voltage induced in the 33 ohm winding by the current flowing in the 17 ohm winding via the receiver. The receiving efficiency is equal to that of the sidetone telephone. It is interesting to observe that if the circuit to the balance network ZN is open, the sending efficiency and the receiving efficiency will not be appreciably altered but there will be no reduction in sidetone.

The development work in connection with the anti-sidetone magneto telephone circuit was carried out in our Research Laboratories.

INTERCOMMUNICATION TELEPHONES IN MAGNETO AREAS

J. L. Skerrett

Introduction.—Since the article on "Intercommunication Telephones, Types A5 and A10," which appeared in "Telecommunication Journal," Vol. 1, No. 5, was published, arrangements have been made to instal this type of equipment in magneto exchange areas. Installations have already been completed in the Sunshine and Werribee areas, and it is considered that a description of the alterations necessary at the respective exchanges would be of interest.

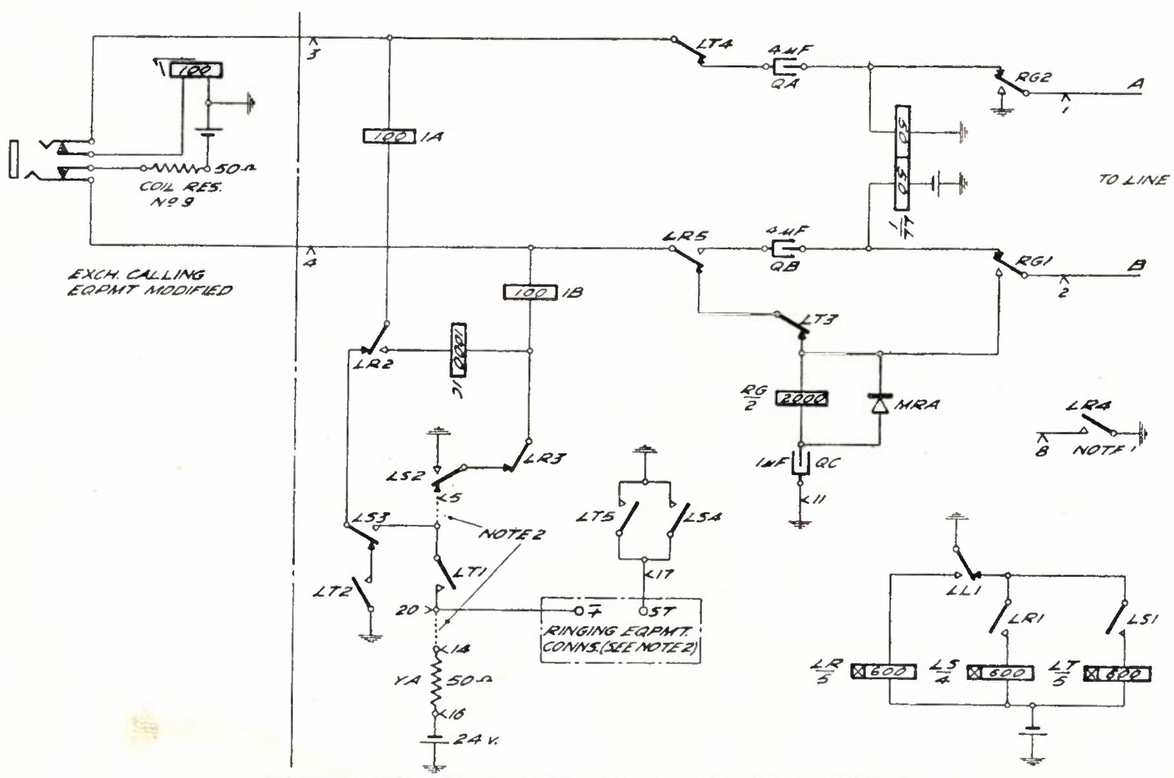
The equipment installed in the subscriber's premises is identical with that installed in common battery and automatic exchange areas and the service facilities offered to the subscriber do not differ from those previously described. Special apparatus is inserted in the exchange line at the magneto exchange which, in effect, converts it to a C.B. line, thus providing the necessary calling, clearing and battery feed facilities to function with the unaltered substation equipment.

Power Supply. — To provide the necessary power for speaking and signalling, 24 volt batteries are installed both at the exchange and substation premises. Dry cell batteries have been used in the existing installations but investigations into a more economical method of power supply are proceeding for future installations in areas where a suitable commercial power supply system is available.

Circuit Operation

The circuit shown in Fig. 1 indicates schematically the additional apparatus required at the exchange, the existing indicator circuit being modified and the relay set wired into the exchange line.

Outgoing Exchange Call.—When an exchange line is seized by a calling extension, the loop from the caller's telephone operates relay LL via contacts RG1 and RG2. LL1 extends an earth to operate relay LR. LR1 and LR3 do not have any function at this stage. LR2 places a 1200 ohm loop, consisting of retard coils 1A, 1C and 1B in series across the exchange line. This loop provides a circuit for battery to flow through and operate the calling indicator at the exchange. LR5 disconnects relay RG and establishes the speaking circuit. Battery and earth fed through the 50/50 ohm coils of relay LL provide the transmission bridge for the C.B. telephone at the calling extension.



Intercom. Telephone Systems, magneto exchange termination.

Release of Connection.—At the termination of a call, the calling extension replaces the handset and a ring off signal is provided by the application of ringing current to the exchange line for a period equal to the release lag of relay LS, the circuit operation being as follows:—

Relay LL releases when the extension loop is removed.

LL1 removes earth from relay LR and operates relay LS.

LS1 extends earth from LL1 to operate relay LT.

LS2 prepares to extend earth to the B line.

LT1 and LS3 prepare for the extension of ringing to the A line via LR2 and retard 1A.

LS4 and LT5 extend an earth to start the ringing equipment (if it is not operating continuously).

LT2 has no function at this stage.

LT3 disconnects relay RG from the B line against the release of LR5.

LT4 disconnects the A line.

Relay LR on releasing extends ringing current to the cord circuit via LT1, LS3, LR2, retard coil 1A, clearing indicator, retard coil 1B, LR3, to ground at LS2.

LR1 disconnects earth from relay LS which releases after its slow release period.

LS1 disconnects earth from relay LT which releases and the circuit restores to normal.

At many magneto exchanges special ringing equipment is not installed and an alternative method of providing a clearing signal is as follows:—

Relay LR on releasing extends earth to the B line via LS2, LR3 and retard coil 1B.

Battery is extended to the A line via retard coil 1A, LR2, LS3, LT1, and 50 ohm resistance spool YA to battery.

Relay LS on releasing removes earth from the B line at LS 2 and replaces it with battery via LT1.

LS3 disconnects the A line from battery and replaces it with earth from LT2.

A clearing signal is thus furnished to the clearing indicator in the cord circuit at the exchange by first applying battery and earth to the A and B lines respectively during the release period of relay LS and on release of LS the potential applied to the line is reversed for a period equal to the release lag of relay LT.

On release of relay LT the circuit is restored to normal.

Call Incoming from Exchange.—On the application of ringing current to the exchange line relay RG operates via the B line, LR5, LT3 and winding of relay RG to ground via the 1mF condenser.

Relay RG operates and ringing current from the exchange is extended via RG1 and RG2 to operate the exchange indicator at the main station. When the main station answers, the call proceeds as for an outgoing call.

Mounting of Equipment

The assembly of the relay equipment required at the exchange involved some preliminary consideration as orders for further installations in these areas are anticipated. It was finally decided to mount the equipment on automatic switch bases, the standard repeater base being suitable to accommodate all the apparatus. A four position repeater shelf was installed on the relay rack at Sunshine and on the lower portion of the M.D.F. at Werribee and the shelf wiring cabled out to tag blocks on the M.D.F., connections to exchange lines being made by means of jumpers.

The completed assembly is compact and neat in appearance and has several advantages over alternative mounting arrangements, including the following:—

Adjustment and fault attention is simplified.

A spare base can be held for emergency purposes to avoid service interruption.

Spare shelf positions allow future requirements to be readily met.

If the service is cancelled the relay base can be utilized readily elsewhere.

A P.B.X. Final Selector (2000 type) For Large P.B.X. and P.A.B.X. Services

F. J. Ryan, B.Sc.

The 2/10 P.B.X. final used in P.B.X. units in pre-2000 type exchanges is well known. A similar switch of the 2000 type is available. The 2/10 P.B.X. final provides for P.B.X. and P.A.B.X. services having up to 10 exchange lines connected. These exchange lines are both-way; that is, they are available for incoming and outgoing traffic.

With 2/10 P.B.X. services the first number of each P.B.X. group is listed in the directory. When the 2/10 P.B.X. final is dialled to this number it tests, and, if the line is engaged, the switch rotates and tests the various outlets in the P.B.X. group until a disengaged line is obtained. If all outlets are busy, the engaged signal is given when the last line in the group is tested.

To provide night service, that is, connection to a particular extension after the ordinary hours of business, any line within the group, except the first, may be allotted. When this number is dialled it is tested, and, if engaged, the busy signal is returned. In these circumstances the final does not rotate over the various outlets in the P.B.X. group.

In a city automatic exchange large P.B.X. and P.A.B.X. services having more than 10 exchange lines, must be provided for. It is also necessary to accommodate 10 line services so that additional lines can be given without involving the subscriber in a number change, and this must be done without providing a plant having a large amount of unused capacity.

One method of dealing with large services is to accommodate them in groups served by 2/100 P.B.X. finals. These finals perform the functions of 2/10 P.B.X. finals, but in addition to testing all outlets on one level they will release on the rotary, step vertically, and continue the search for a disengaged line on the next level, and so on until all the lines in the P.B.X. group have been tested. A pre-2000 switch of this type was tried out in the Commonwealth. It is a complicated switch and large P.B.X.'s served by these finals block out appreciable quantities of the numbers available in the final selector multiple. This is particularly so where reasonable reservations are made for future growth. Up to the present a 2/100 P.B.X. final of the 2000 type has not been tried out in the Commonwealth.

The simplest method of dealing with borderline cases, that is, those having 10 to 16 both-way lines, is to allot them a level in the 2/10 P.B.X. groups and cut in additional outlets as required on the first choices in each shelf or set of 10 banks. This method was adopted at City West, Victoria.

The 2/10 P.B.X. finals are of the 100 line type and 4 banks in sets of 10 are installed in each 100 line group. The final selector banks are multipled and cabled to the M.D.F. via the I.D.F. in accordance with standard practice for 2000 type equipment. There are also 10 auxiliary lines outside the numbering scheme cabled from each 100 line group to the I.D.F. and M.D.F. These auxiliary circuits are used when additional outlets are required.

The trunking diagrams for levels allotted to subscribers with 10, 12 and 16 both-way lines respectively are shown in Fig. 1. In the case of the subscribers M1161 and M1261, the lines form a graded group with an availability of 10. The lines in the numbering scheme and the auxiliary lines outside the numbering scheme are jumpered to uniselectors at the I.D.F., thus giving both-way working on all lines.

Night service can be given to subscriber M1061 on 9 lines and to M1161 and M1261 on 8 lines. Night service could be provided on the remaining lines in each group by cross connecting the lines concerned to spare contacts in the final selector multiple.

It will be seen, therefore, that subscribers with up to 16 lines can be accommodated in 2/10 P.B.X. groups, both-way service being given on all lines.

A list of typical services with 10 or more lines accommodated in 2/10 P.B.X. groups is given in Table I. To even the traffic loading these services are spread over the available final selector multiple.

TABLE I.

Subscriber	Exchange Lines: Incoming at P.B.X.	Outgoing at P.B.X.	Bothway	Total
(1)	(2)	(3)	(4)	(5)
M1241	—	1	10	11
M1321	—	2	10	12
M1551	—	10	10	20
M1581	—	6	12	18
M1761	10	8	—	18
M1901	—	1	11	12
M2011	—	8	12	20
M2341	—	—	10	10
M2381	—	3	12	15
M2551	—	5	11	16
M2701	—	7	12	19
M2831	—	2	12	14
M2851	—	—	10	10
M3201	—	6	12	18
M3921	—	1	11	12
M4141	—	—	10	10
M4161	—	2	10	12
M4281	—	2	11	13

Note.—The lines shown in columns (2) and (4) are accommodated on levels in the 2/10 P.B.X. final selector multiple.

A large service P.B.X. final is necessary to serve P.B.X.'s and P.A.B.X.'s with more than, say, 16 exchange lines, and the studies made indicated that the design should be based on the following principles:—

(1) Full availability was not necessary. Lines worked in graded groups with an availability of 10 would have an average traffic occupancy of 0.5 with a grade of service of P = 0.01. This agrees with standard practice in the design of trunk and junction groups of comparable size in exchanges.

(2) (a) Large P.A.B.X.'s would have their exchange lines arranged in two groups of one-way lines (incoming and outgoing);

(b) In general, large manual P.B.X.'s would have their exchange lines arranged in two groups of one-way lines, but both-way should be practicable if necessary.

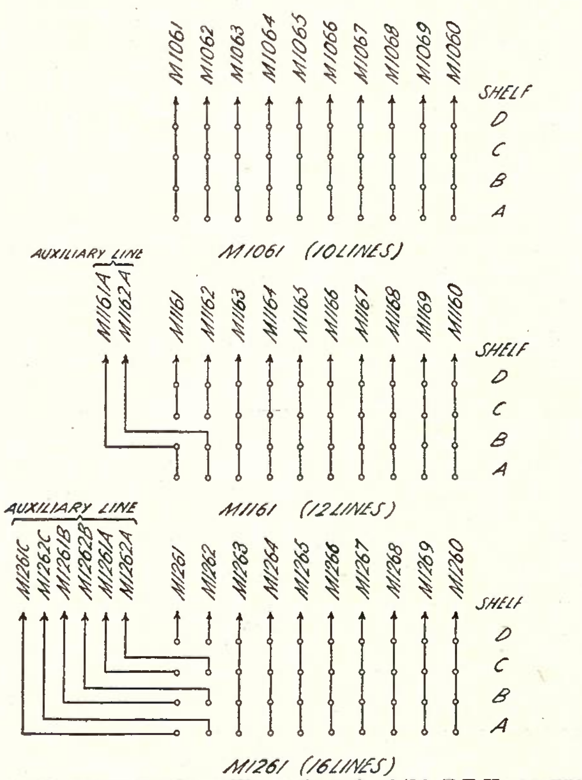


Fig. 1.—Connection of auxiliary lines in 2/10 P.B.X. groups.

(3) Each service should be restricted to one level and the finals grouped to serve up to 10 subscribers.

(4) Night service was necessary, but in general this facility would not be required on more than 50% of the total exchange lines—that is, incoming plus outgoing.

(5) The usual standard circuit elements should be included; transmission bridge, battery reversal to calling line, standard ringing, positive battery metering pulse, guard on private, last party release, and guard during release.

(6) Subscribers should not be allotted consecutive numbers.

(7) The switch should be as simple as practicable.

The circuit of a 2000 type switch supplied by the G.E.C., Coventry, to meet these requirements is shown in Fig. 2 and a brief circuit description is given hereunder.

When the subscribers' loop is extended from the preceding switch, relay A operates. A1 operates relay B through two metal rectifiers MRA connected in parallel and a 500 ohm resistance. B2 connects a guarding earth to the private. B5 maintains an earth on relay B after the switch has stepped off normal. B1 operates relay C. C1 prepares the vertical magnet circuit.

The subscriber proceeds to dial. The vertical impulses are given by A1 contact from earth B5, A1, C1, NR1, 5 ohm winding of relay C, and vertical magnet to battery. On the first step the vertical off normal springs N operate. N2 and N3 place a short-circuit on relay C. This makes it slow to release and enable it to hold while the vertical impulses are passing through its 5 ohm winding.

At each vertical impulse A1 short-circuits relay B. This makes B slow to release and it holds during dialling.

The metal rectifiers MRA oppose the inductive EMF from the vertical magnet and prevent the flow of a surge current through the 500 ohm resistance, which would slow down the release of the magnet during the make period.

At the end of dialling A remains operated and the circuit of the 5 ohm winding of relay C is opened at A1. After a pause, relay C releases. C4 closes the circuit of relay HS via G2, H5, N2 and B5 to earth.

Relay HS operates. HS2 makes relay HS independent of C4. HS1 completes the circuit for the rotary magnet which is now closed through B3, HS1, N1, G1, H4 and rotary magnet to battery. The switch, therefore, cuts in automatically like a group selector.

The rotary magnet drives the carriage to the first step and the rotary off normal springs NR operate. NR1 opens the vertical magnet circuit. NR2 removes a short-circuit from C, which re-operates.

As the carriage completes the first rotary step the rotary interrupter R1 closes the circuit of relay G, which operates. G1 opens the rotary magnet circuit. The rotary magnet releases and opens the circuit of G at R1. Meanwhile, the P wiper tests the private, and if a busy earth is found it is extended through the 900 ohm winding of relay H, 500 ohm winding of relay G, and B4 to earth. This makes relay G slow to release.

Relay G releases. The rotary magnet circuit is again completed and the switch steps as before and continues to do so until a free line is reached. Battery is then received from the private contact, and is extended to operate H and retain G in the operated position. H4 opens the rotary magnet circuit. H5 locks relay H. H3 short-circuits relay G, which releases. H6 prepares a circuit for relay J. Relay HS releases as its circuit is opened at H5 and G2, and HS3 and HS4 complete the circuit for relay J.

Relay J operates. J1 completes the circuit to the negative line for ringing current via 300 ohm winding of relay F and H1. Ringing return battery is supplied via 200 ohm resistance F6 and H2. J2 connects ringing tone to the 570 ohm winding of relay A and this tone is induced in the line via the line windings. J3 prepares the metering circuit.

Relay D operates around the subscribers' loop. D1 operates relay E which locks via E1. D3 and D4 reverse battery back to the calling subscriber. E2 applies positive metering battery to the release trunk, and E4 removes a direct earth. During the change over the switches behind are held in via rectifier MRB. E3 opens the circuit of relay J, which releases, J3 disconnects positive battery from the release trunk and replaces it with a direct earth.

If no free contact is available the switch drives to the 11th step and operates the eleventh step springs S. S1 applies a busy tone to the 570 ohm winding of relay A. S2 operates the overflow meter. S3 locks relay G. G1 opens the

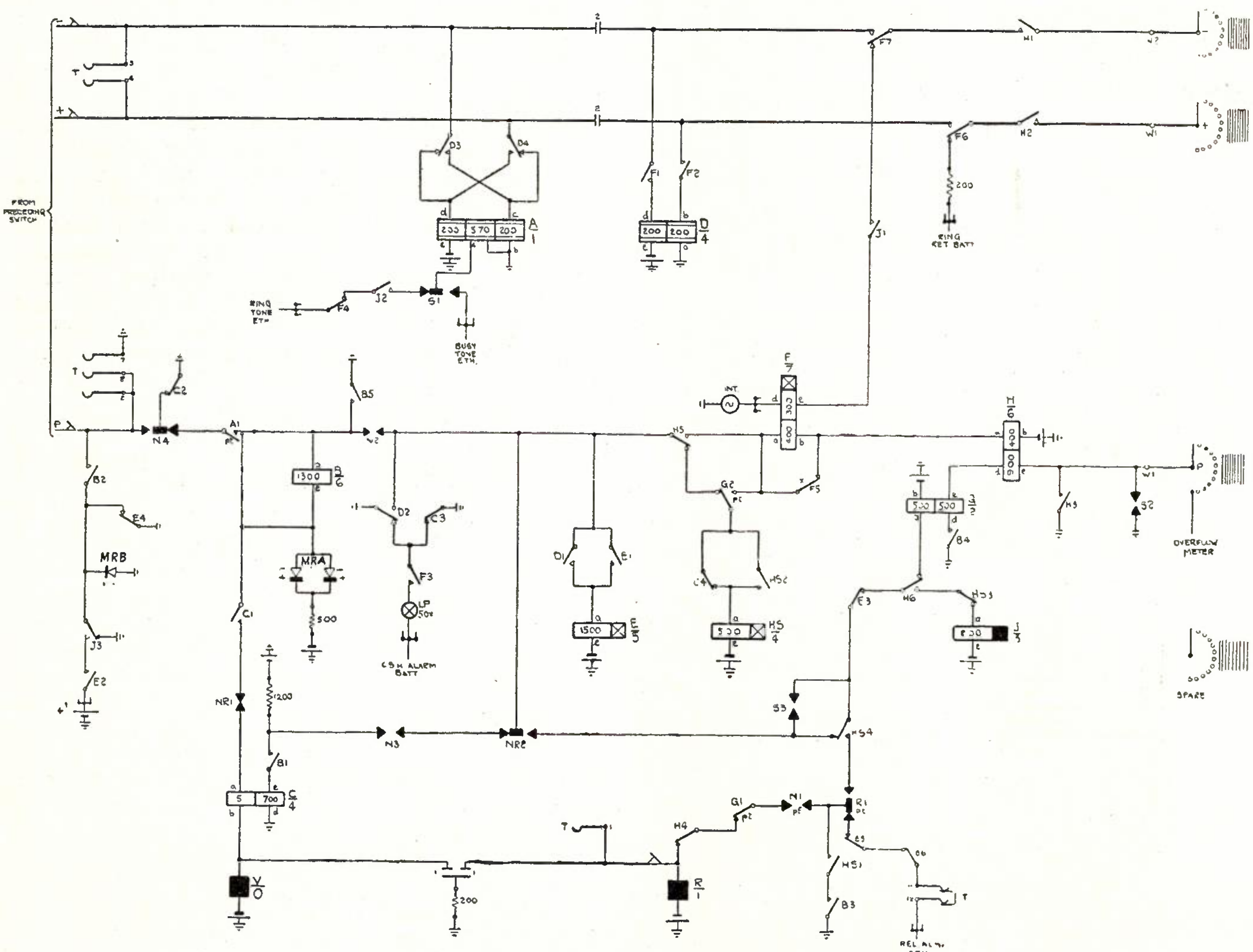


Fig. 2.—Circuit of P.B.X. final selector for large services.

When the called party answers, relay F operates and contacts F5 open. Relay F cuts through and holds on its 400 ohm winding. F4 disconnects ringing tone. F1 and F2 connect relay D to the positive and negative wires. F6 and F7 disconnect ringing current and cut the positive and negative wires through to the wipers.

rotary magnet circuit. G2 releases relay HS.

When the calling subscriber clears, relay A releases. A1 short-circuits relay B which releases. B2 removes the earth from the release trunk, permitting the switches behind to release. B1 opens the circuit of relay C. When relay C releases C2 places a guarding earth on the release trunk. C3 completes the circuit for the

C.S.H. lamp and alarm. Switches back of the final are, therefore, released, but the final is held and the release trunk guarded until the called subscriber releases. The C.S.H. lamp and alarm also operate via F3 and D2 if the called subscriber clears and the calling subscriber holds.

When the called subscriber clears relay D releases. D2 releases relays E, F, and H. H4 completes the circuit for the rotary magnet which drives the carriage to the twelfth step, where it falls and returns to the normal position. During release the switch is guarded via N4 and C2.

Ballast resistors are not provided on these finals as large services are gradually being converted to P.A.B.X. working, and in these cases there is a battery feed at the P.A.B.X.

A list of typical services served by a group of large service P.B.X. finals is given in Table II.

TABLE II.

Subscriber	Exchange Lines: Incoming at P.A.B.X.	Outgoing at P.A.B.X.	Bothway	Total
(1)	(2)	(3)	(4)	(5)
MY210	40	26	—	66
MY220	13	10	—	23
MY230	13	11	—	24
MY240	11	16	—	27
MY250	10	11	—	21
MY260	36	24	—	60

Notes.—(1) All services are typical P.A.B.X. subscribers. (2) The lines shown in column (2) are accommodated on levels in the MY2 group for large services.

Subscribers MY210 and MY220 are continuous service and special night service facilities are not required. In the other cases sufficient of the subscribers' outgoing lines are utilised to provide the night service required.

The letter prefix MY is used for large services. In accordance with the usual practice, MO (or MY) thirds are provided for special services, such as Complaints (MOO), Test Desk (MO9), Junction Test (MO8), Centralised Services (MO7) and Ring Back (MO1). Levels 2, 3, 4, 5 and 6 of these special thirds are available and will be allotted as required for groups of finals serving large P.B.X. services.

The subscribers listed in Table II. are served by finals which trunk from the second level of the MY thirds; that is, they form an MY2 group with the large service P.B.X. finals in the fourth rank.

Each level of this MY2 group of finals is allotted to one service, thus making the subscribers' numbers, MY21, MY22, MY23, etc. The final automatically cuts in on the level dialled, and there is no need for more than a 4-digit number such as MY21. However, a final "0" has been added and this digit is simply absorbed. If consecutive numbers such as MY21, MY22, etc., are published, some subscribers obtain the impression that a large and important business is renting only one exchange line. The final "0" is added to overcome this disability.

Large service P.B.X. finals (2000 type) have been in use in City West for over 12 months and are operating satisfactorily in service.

AUTOMATIC EXCHANGES: SEIZURE OF SWITCHES BEFORE AND DURING RELEASE

M. A. Mackey, B.Sc. Hons., and O. C. Ryan

This type of trouble is inherent in the early designs and though the existence of the danger period during which the switch is left unguarded was well known in the early stages of Automatic Telephony, it was not regarded seriously. However, now that the provision of the minimum number of switches to meet the traffic needs has become a science, the demands of the service are being more closely studied and inefficiencies such as unguarded intervals are being eliminated. With the latest designs it is practically impossible to seize a switch before or during release, and even should this happen, the switches are not prevented from restoring to normal. It will be obvious that the incidence of trouble due to seizing a switch in the unguarded interval depends on the intensity of the traffic and the available outlets.

In practice with the earlier switches, the trouble became evident in the following manner:—

(a) The discovery of switches with the shaft off normal and the wipers caught between bank levels; and

(b) The increasing number of calls which resulted in wrong numbers.

The first condition may have been due to faulty adjustment or shaft bounce, but in some instances it was possible to prove that these factors were not the cause of the fault. Similarly for the second condition the correct adjustment of the switch should be rapidly proved, but there was still the possibility that the wrong number was due to incorrect calling by the subscriber. With the greater use of observation positions the digits dialled could be checked, and while it was shown that many wrong numbers were due to the calling subscriber, a considerable number could only be explained by this catch on release trouble. It was further obvious that the difficulties were experienced with equipment other than the Siemens No. 16 type used in the Brisbane network, this equipment having a guard against seizure during the release period.

It will be appreciated that the Private wire in any switch train is referred to in various manufacturers' circuit drawings by various designations, for instance, "P," "C" and release trunk. Hereinafter for uniformity it will be referred to as the "P" wire. Taking an ordinary group selector with a circuit as shown in Drawing C. 711 (Fig. 1), as an example, it will be seen that this switch when in use is guarded from seizure by any other searching switch by means of an earth connected to the "P" wire by means of a make springset of the "B" relay. Then, referring to the release magnet circuit, this is not completed for release of the switch until "D," "A" and "B" relays are all in the unoperated condition again. "A" and "B" are both released after "D" operates to cut the switch through when a free outlet has been found, and then the guard on the "P" wire is by an earth from the switch ahead which also holds "D" operated. Before release can occur, the guarding earth must be removed from the "P" wire at some switch ahead. Thereafter the release magnet must operate and the switch then has to traverse in a rotary direction out of its bank and drop back to normal. At any stage in these subsequent operations the switch may be seized again as there is no guarding earth on the "P" wire. If seized, so that the "A" relay operates before the release magnet does, no release can occur. Again, if release has commenced, operation of either the vertical or rotary magnet can arrest the release at any stage. This can be tried out on a switch.

With the possibility of seizure before or during release being thus theoretically established, it is possible to study the actual releasing time required. Still concentrating on the group selector, we find that from the time the guarding earth is removed from the "P" wire until the switch returns to normal we have three operations:—

(a) The time of change-over of the "D" relay springs;

(b) The time of operation of the release magnet; and

(c) The time required by the switch to restore out of the bank, and then drop vertically to the normal position.

The times for the first two operations are respectively three milliseconds and 15 milliseconds approximately. The time for the third varies from a minimum when the switch is up one and in one to a maximum when the switch is up ten and in ten. These limits range from 44 to 142 milliseconds approximately. Thus, the sum total unguarded period of the switch ranges between a minimum of approximately 62 milliseconds and a maximum of approximately 160 milliseconds. If an "A" relay operates at any time prior to 18 milliseconds after the switch is unguarded, release will be prevented, or if at some subsequent stage within the unguarded period, it is possible for the release to be arrested.

It will be seen that from the original conception of the likelihood of such an inherent fault obtained from a study of fault returns it has been possible to clearly establish that the difficulty does exist in respect of group selectors and would undoubtedly account for a number of troubles which cannot be explained in any other manner. Its existence in respect of other switches, for instance, final selectors, selector repeaters, switching selector repeaters, can be similarly established from a study of the circuits.

Having thus derived the existence of this inherent weakness, it became necessary to study the best method of prevention, and it will be appreciated that the whole difficulty rest on two factors:—

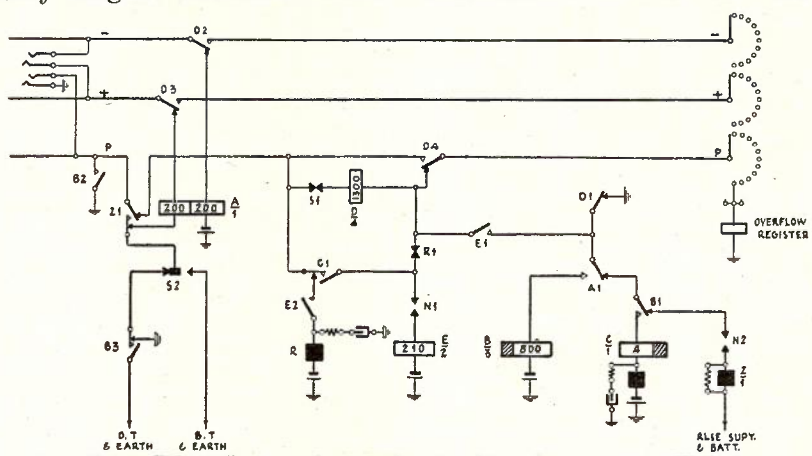
(a) The "P" wire is not earthed though the switch is off-normal; and

(b) The re-operation of the "A" relay can open the release magnet circuit, and also prepare the vertical and rotary magnet circuits to allow of the possibility of their operation. The cure, therefore, suggests itself, namely, that the release function of the switch shall replace a guarding earth on the "P" wire until such time as the switch is back to normal, and also that the "A" relay circuit shall be kept open for the same period.

Both these functions can be discharged by means of a springset associated with the release magnet to be operated by the armature of that magnet when it is attracted consequent on the energization of the coil. There is no difficulty in suitably attaching the necessary springset to the framework of the switch, and the necessary operating lever must be affixed to the release magnet armature.

Further consideration was necessary in regard to the type of springset to be used, as it is not sufficient merely to re-earth the "P" wire. Such an earth, for instance, in the case of a group selector, could cause re-operation of the "D" relay over the circuit from earth via contacts S1, relay D, contacts R1 and N1 both closed, to battery through relay "E," the N1 springs being closed until the switch is practically back to normal. Re-operation of "D" would in itself interfere with the release circuit.

Similarly with a number of other switches, circuit complication can be caused by the simple re-application of an earth to the release trunk, and to avoid this it is necessary that the springset re-applying the earth shall not only perform that function, but shall open simultaneously and where necessary the "P" wire circuit behind tha earth until the switch is back to normal. change-over springset is required for this phas of the functions, and when to this is added th necessity for opening the "A" relay circuit, i was found that a break-make-before-break springset was the most suitable. The break springs open the private wire behind the re-applied earth and the make-before-break springs disconnect earth from the "A" relay, and apply it to the "P" wire. The use of a make-before-break springset for this portion of the functions ensures that the circuit of relay "A" is closed again instantaneously with the removal of the guarding earth from the "P" wire.



Dwg. C711.—Group selector circuit with release guard (Z17).

With such a springset applied to a group selector we find that the switch is actually still unguarded for 18 milliseconds after the last conversation has completed, but this full period does not exist since an "A" relay requires approximately seven milliseconds to operate, and unless "A" does operate the release cannot be interfered with. The attachment of a springset as described in association with the release magnet of such a switch, therefore, means that the switch can no longer be taken when off normal except within 11 milliseconds of the preceding conversation having concluded. The liability of the trouble is thus eliminated except to a very small extent. In this connection reference can be made to the December, 1936, issue of this journal, where on page 138, in an article by W. A. Phillips on the B.P.O. Type 2000 line finder system, reference is made to the effective guarding during release of type 2000 group and final selectors. Therein it is indicated that such switches are unguarded for a period of 25 milliseconds, but even if re-seized in that period the release of the switch cannot be affected. The care taken in this respect for 2000 type switches proves the need for corresponding guarding means for earlier switches.

Further study was, however, necessary before the preventive means outlined could be considered suitable for general adoption. Consideration so far has been on the group selector. Each type of switch must, however, be considered individually to see if the cure is applicable. Taking these in order we find:—

(a) **Incoming Selectors (Dwg. C.711).**—There is no "P" wire to be guarded, but the same springset as developed for the group selector can be used, and made to open the "A" relay circuit; release of the switch can then be interfered with only if it be re-seized within 11 milliseconds of becoming unguarded. Fitting the full break, make-before-break springset leaves the switch interchangeable for use as a first or group selector.

(b) **Final Selectors (Dwgs. C.516 and C.517), Final Selectors B.G.E. (Dwg. C.655 or C.670) and Selector Repeaters (Dwg. C.525).**—In all of these, relays are associated with the "P" wire and consequently the preventive means developed for the group selector are applicable in exactly the same way, and reduce the danger period to the same figure.

(c) **Final Selectors Booster Metering (Dwgs. C.A.549 and C.712).**—In this type of final selector the "P" wire has no other relays associated with it, and so a simple re-applied earth causes no circuit complications. With the necessity for opening the circuit of relay "A" as well, a make-before-break release magnet springset is all that is necessary, and the break pair of springs of a break-make-before-break assembly can be left unused.

(d) **Switching Selector Repeaters.**—For switching selector repeaters three different release conditions occur:—

(i.) Release from a call to a distant or main exchange subscriber.

(ii.) Intermediate release when the switch is discriminating between a main exchange and a local call.

(iii.) Release after a local call.

(1) **Taking a switching selector repeater of A.E.Co.'s manufacture (H.41122A).**—It is already fitted with a make springset associated with the release magnet and actually for such a switch releasing after a call to a distant or main exchange subscriber, the release magnet operating locks itself, and, therefore, after approximately 18 milliseconds the release circuit cannot be interfered with. Unless the switch be re-seized within 11 milliseconds the release circuits cannot be interfered with as Relay "A" requires approximately 7 milliseconds to operate. The switch is not guarded from intrusion on a junction to the main exchange being taken and dialling affecting distant switches. An earth applied to the release trunk by the release magnet operation ensures that the switch and the junction are guarded after approximately 18 milliseconds.

Coming to intermediate release when a switch is discriminating between a main exchange call and a local call, the release magnet locks itself, but the "A" and "B" relays do not release, and, consequently, the switch is never unguarded. Any guarding feature applied to the release magnet operation must not open the circuit of relay "A," though an earth applied to the release trunk will not have any detrimental affect. If the "A" relay were opened the junction to the main exchange would be opened and the switch there released with a resultant false call should the next digit prove the call to be other than a local one. During release from a local call the earth disappearing from the release trunk leaves the switch unguarded and the release magnet locks itself to earth. An earth re-applied to the release trunk may cause re-operation of one relay, namely, the "H" relay which is completing the release magnet circuit, and any guard applied to re-earth the release trunk should, therefore, open the circuit of relay "H." Taking the three releasing conditions, it is necessary to re-apply earth to the release trunk, but we cannot open the circuit of relay "A" on account of the conditions prevailing during intermediate release when the switch is discriminating, but the circuit of relay "H" can be opened, and thus for this particular switch the existing make springset associated with the release magnet must be replaced by a change-over springset associated with the make set. The change-over set re-applies earth to the release trunk and opens the connection from that trunk to relay "H" while the make set as at present locks the release magnet to earth via contacts of "D" normal and "J" operated. With this preventive springset applied, the release circuit cannot be interfered with if re-seized after approximately 11 milliseconds, but a junction to the main exchange can be taken at any time inside 18 milliseconds.

(2) **Switching Selector Repeaters of S.T. & C. or B.G.E. Manufacture.**—These have different circuit arrangements to the A.E.C. switch dealt with in (1) above, and the release magnet is not equipped with the make springset referred to as already existing in the A.E.C. switch. As for that switch, and for the same reason any guarding arrangements must not open the "A" relay circuit, and the guarding earth applied to the release trunk by the operation of the release magnet must not be able to cause relay re-operation in the switch. A change-over springset applying earth to the release trunk and opening behind that earth the release trunk connection to any switch relay is the preventive means necessary. The switch and junction are then guarded after 18 milliseconds, and the

release circuit of the switch cannot be interfered with after 11 milliseconds.

The next consideration was how to apply a springset to the switch. Examination showed that switches manufactured by the Automatic Electric Co. (Chicago or Liverpool), and by Standard Telephones and Cables, were similar in that an extra bracket could be affixed to the switch by the screws holding the vertical off normal springset bracket and the release magnet springset attached to this new bracket. The operating lever could attach to the release magnet armature by means of the nut on the release magnet armature stroke adjusting screw. For British General Electric switches, the different type of frame necessitated a different bracket and operating lever, the latter riveting to the release magnet armature, and the former being secured by the protection post and the screw, $\frac{3}{4}$ in. to the right of that post.

Supply of Springsets

Having arrived at these conclusions, Schedule C.2017 was issued providing for the following five items:—

(i.) Springset consisting of a "break, make-before-break" spring contact unit associated with a metal bracket, suitably drilled, for association with the release magnet of a covered type group or final selector of A.T.E., A.E.C. and S.T. & C. manufacture. Switch wire should be included, also arm assembly to operate this spring set and suitable for attachment to release magnet armature.

(ii.) Springset Set consisting of a change-over contact unit and a make contact unit associated with a metal bracket suitably drilled for association with the release magnet of a switching selector repeater of A.T.E. and A.E.C. manufacture. Switch wire should be included; also arm assembly to operate this springset and suitable for attachment to release magnet armature.

(iii.) Springset consisting of a change-over contact unit associated with a metal bracket, suitably drilled, for association with the release magnet of a switching selector repeater of S.T. & Co. manufacture. Switch wire should be included; also arm assembly to operate this spring set and suitable for attachment to the release magnet armature.

(iv.) Springset consisting of a change-over contact unit associated with a metal bracket, suitably drilled, for association with the release magnet of a switching selector repeater of B.G.E. manufacture. Switch wire should be included; also arm assembly to operate this springset and suitable for attachment to the release magnet armature.

(v.) Springset consisting of a "break, make-before-break" spring contact unit associated with a metal bracket, suitably drilled, for association with the release magnet of bi-motional switches of B.G.E. manufacture. Switch wire should be included; also arm assembly to operate this spring set and suitable for attachment to the release magnet armature.

Orders under this schedule were placed in May, 1938, and supplies of these springsets are coming to hand. When these have been fitted, existing covered type switches will be guarded to the extent which has been described herein, and considerable improvement in fault occurrence should be achieved in respect of those faults which in the past it has not been possible to ascribe as being due to any definite cause.

No attempt has been made to develop preventive means for the old uncovered type switches, as these are being replaced steadily, and the number still in use does not represent any appreciable percentage of the total switches in use throughout the Commonwealth.

Application of Preventive Measures to Future Purchases of Switches.—So far consideration has been given to the most simple method, electrically and mechanically, of achieving the satisfactory guarding of switches, i.e., the problem was attacked from the viewpoint of working switches. It was next looked at from the viewpoint of switches being manufactured, and it was then seen that an even more satisfactory method of opening the "A" relay circuit in the case of selectors would be by means of an additional break springset on the vertical off-normal spring assembly, this set being designed to open the operating earth via contact B3 normal once the switch steps off normal. It is then impossible for "A" and "B" to release and re-operate again without the switch restoring to normal. A simple change-over release magnet springset can then be used to re-apply earth to the "P" wire and open the circuit of that wire behind the re-applied earth. This arrangement is not applicable to switches in which the original operating earth for relay "A" continues to be used during dialling.

While the investigations were proceeding, additional automatic switching equipment was purchased under Schedule C.1640, and arrangements were made for such switches to be guarded against the possibility of seizure during release. Depending on the stage to which investigations had progressed when manufacture of different deliveries was undertaken, different methods were used by the various contractors and switches guarded as follows have been delivered:—

(i.) **B.G.E. Company:—**

(a) **Group Selectors.** — A "break, make-before-break" release magnet spring assembly as previously described, but with the break springset used to disconnect the earth normally applied to relay "A" through contact B3 (normal) and the make-before-break used to re-apply earth to the "P" wire and open it behind the re-applied earth.

(b) **Group Selectors.**—An extra pair of vertical off-normal break springs with a change-over release magnet springset as previously described. This change in later deliveries was made as the result of a request from the Department.

(c) **Final Selectors (Regular and P.B.X.) and Selector Repeaters.**—A break set to open the "P" wire and a make-before-break set to disconnect the operating earth from relay "A" and apply it to the "P" wire to guard the switch against seizure.

(ii.) **Automatic Electric Telephones (Liverpool):—**

(a) **Group Selectors.**—The arrangements are as for (i.) (b) in connection with the B.G.E. Co.

(b) **Final Selectors Regular P.B.X. Positive Battery Metering.**—A make-before-break assembly, the earth normally used to operate the "A" relay being disconnected from "A" by the break springs and applied to the "P" wire when the springset operates. As the "P" wire in positive or booster battery metering finals is not associated with any relays it is not necessary to open it behind the re-applied earth.

(c) **Switching Selector Repeaters—Positive Battery Metering.**—In these switches as with the final selectors referred to in (b) above, the "P" wire is not associated with any relays, and consequently a simple release magnet make springset applying earth to the "P" wire, has been used.

(iii.) **Automatic Electric Co. (Chicago):—**

(a) **P.A.B.X. Final Selector Repeater H. 58569.**—A release magnet make-before-break springset re-applying earth to the "P" wire and disconnecting the circuit of that wire behind the re-applied earth.

(b) **P.A.B.X. Selector Repeater H.58570.**—A release magnet change-over springset re-applying earth to the "P" wire and disconnecting the circuit of that wire behind the re-applied earth.

(c) **First Selector—Metering H.58571 and Group Selector H.58572.**—An additional vertical off-normal break springset disconnecting from Relay "A" the operating earth normally applied via the contacts of "B" relay (normal) and a release magnet change-over springset re-applying earth to the "P" wire and disconnecting the circuit of that wire behind the re-applied earth.

(d) **Switching Selector Repeater Circuit H. 58,573.** — An additional make springset has been added to the release magnet spring assembly to re-apply earth to the "P" wire circuit when the release magnet operates.

(iv.) **Standard Telephones and Cables:—**

(a) **Group Selector (L.M.56, Group 15, Sheet 7).**—A limited number of these switches were supplied with a simple change-over springset associated with the release magnet, which springset re-applied earth to the "P" wire and opened the circuit of that wire behind the re-applied earth when the release magnet operates. In reply to a request from the Department the additional vertical off-normal break springset was added to later deliveries to open the "A" relay circuit, and supplies of these springs were forwarded to allow of the earlier deliveries being similarly amended.

(b) **Final Selector Regular (L.M.294, Group 1).**—A number of these switches were supplied with a simple change-over springset associated with the release magnet which springset re-applied earth to the "P" wire and disconnected earth from the circuit of relay "A." This arrangement is not satisfactory, and the Company in reply to a request from the Department subsequently supplied "break, make-before-break" springsets to replace the simple change-overs, and to achieve the same object and also to open the "P" wire circuit behind the re-applied earth.

(c) **Final Selector P.B.X. (Booster Metering L.M.295, Group 1).** — A number of these switches were supplied with a simple change-over springset as described in (b) above for regular final selectors. Subsequently make-before-break springsets were supplied to replace these. These replacement springsets fulfil the same purpose, but ensure that the circuit of relay "A" is re-completed as soon as the release guarding earth is removed from the "P" wire.

(d) **Switching Selector Repeaters (L.M.313, Group 1).**—A simple change-over springset re-applying earth to the "P" wire and opening behind the re-applied earth the circuit of that wire to any switch relay.

Alice Springs and the Overland Telegraph Line

R. C. M. Dale

The name "Alice Springs" is really a misnomer, because the deep pool of water after which the place is named is not a "spring" but a soak. The town, a panorama of which is given below, is in the centre of the continent on the Overland Telegraph Line between Adelaide and Darwin. The locality was given its name by a party engaged on the construction of the Overland Telegraph Line in 1871 when they sighted the big, deep waterhole in the bed of the dry creek or river now known as the River Todd. The Todd only flows after each rain, and at this place there is a large outcrop of granite rocks. The swirling of the quickly flowing water keeps this big hole washed out and leaves it full of water. Quite good soakage water can be obtained anywhere in the creek at about six feet down, and this soakage keeps the hole full of water, and because the hole does not dry out, it was probably thought by the party that there must be a spring at that place. There are, however, many springs in the MacDonnell ranges, but none at the particular spot after which the old Telegraph Station was named.

Alice Springs, looking south from Anzac Hill.

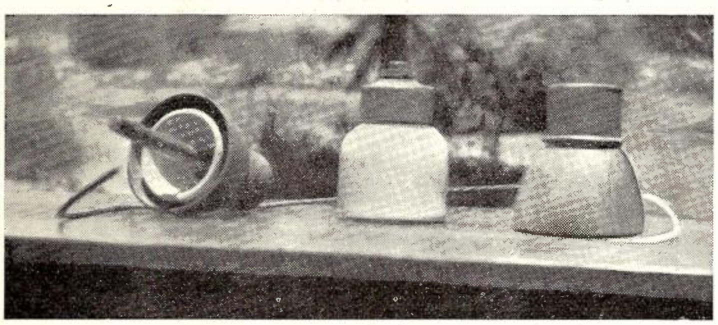
Although the continent was crossed for the first time by the explorer (McDouall Stuart) in 1862, less than ten years later a telegraph line had been completed practically along the route taken by him. In the late 1860's there was great rivalry between Queensland and South Australia as to who should have the honour of linking their telegraph system with the cable being laid from Singapore to Darwin. Each wanted the other Australian colonies to support the project from their particular point of view. When in June, 1870, no agreement had been arrived at and the Cable Company seemed to favour the land line being constructed from Darwin to Brisbane, the South Australian Government, evidently realizing that some drastic action was necessary if they were to have the line in their State, made an offer to the Cable Company to build a telegraph line from Adelaide to Darwin (1975 miles) and have it completed by the time the Company had completed their cable, this being estimated at eighteen months from the time of the offer. The offer, which meant that the telegraph line had to be constructed at the rate of 110 miles per month, was accepted, and heavy penalties for non-completion of the line in the time were provided for in the agreement. Actually it was not until about the middle of August that year that the construction was commenced. The route was divided into three sections—from Port Augusta to latitude 27 deg. S. (about 60 miles north of where Oodnadatta is now, a distance of 550 miles), from 27 deg. S. to 19 deg. 30 mins. S. (approximately where the present town of Tennant Creek is, about 570 miles), and thence to Darwin, approximately 650 miles. The first section was in more or less settled country and provided very little difficulty, the northern section had some difficulties but not very great, but the centre section was in practically unknown country and therefore was the most difficult. Each section was subdivided into many sub-sections, and a party allotted to construct each sub-section. A small exploring party went ahead of each main party and marked out the route to be taken. The equipment of each party included 15 horse wagons, 17 bullock drays, one bullock wagon, five express wagons, 165 horses and 200 bullocks. A depot was established at the Finke River (about 830 miles from Adelaide) for the provision of fresh meat for the men working on the adjoining sections, and 2000 sheep were sent there. It must be remembered that all the material, provisions, etc., had to be hauled from either Port Augusta or Darwin by horse, bullock vehicle, or camels, and some idea of the difficulties experienced can be realized by the fact that it took

Harvey's party, who constructed one of the central sub-sections, eight months to reach the beginning of their section.

It was far too big a job to be done in the time, and when the period had expired (December, 1871), there were still many gaps in the line. A delay had also occurred in the cable construction, and although not far off completion, the cable was not completed on the contracted date. A compromise was reached regarding the infliction of penalties, which were considerably reduced but not entirely abolished, and the South Australian Government redoubled its efforts, but it was not until 22nd August, 1872, that the last gap was closed and telegraphic communication established between Australia and England. The total cost of the line was £479,154.

The original line was a 7/14 stranded iron wire conductor, and although most of it was removed and replaced by a 400 lb. G.I. conductor many years ago, there are still some small sections of the original wire in use.

During October, 1938, it became necessary to remove a small piece of the original wire in connection with the establishment of a Telephone Office at Finke, and it was found that the old wire was in perfect condition and not showing any signs of deterioration. Several types of insulators appear to have been used. One type was of porcelain, about 4½ inches across at the bottom, but having a metal top, two inches in diameter, screwed on to the porcelain. A metal plate bolts on to the metal top, and two holes, through which a wire could be passed were



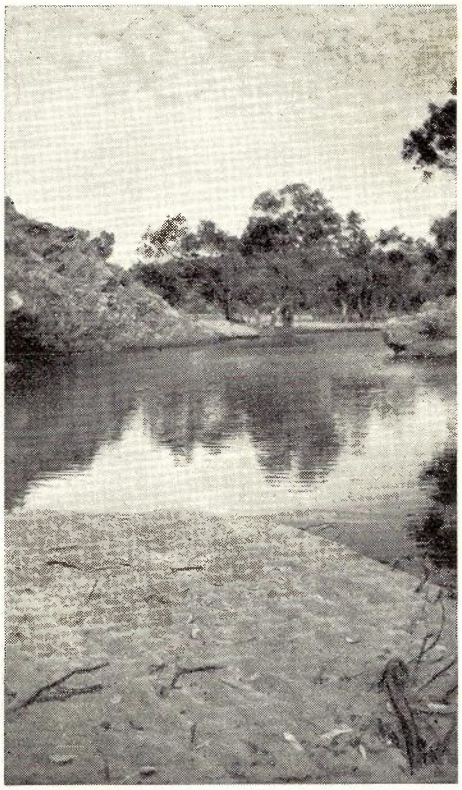
Old types of insulators used on the original Overland Telegraph Line and a piece of the original iron wire. The two outer insulators are the metal armoured type and the holes through which the wire was passed can be seen in the top of the centre insulator.

formed when the plate was screwed down. Apparently only one hole was used, but the tightening of the bolt held the wire firmly between the plate and the metal top of the insulator. There were thus no tie wires necessary with this type. Another type is similar to the present day trunk line insulators, a little smaller, but completely covered with a metal armour. The metal armour is shaped exactly like the insulator, and the wire was tied to this similarly as is done on present day porcelain insulators. The porcelain was set into the armour by a kind of cement, and a thread was provided in the porcelain for the spindle. A number of these insulators are still to be seen lying along the line, and although over 66 years old, do not show the slightest sign of rust or deterioration.

In many instances the line did not take a direct route between various points, but followed creeks and watercourses. The reason for this was that most of the poles were cut from the timbers growing along these watercourses, and also that it was necessary to follow them in order to obtain water. However, the white ants soon showed their presence, and although there are some of the original butts still to be seen besides the present iron poles, most of the wooden poles had very short lives, perhaps only of a few years' duration. In 1880, re-poling with Siemens and Oppenheimer poles was commenced in places, but it was not until 1898, when a 265 lb. copper conductor was added that the line was fully iron-poled. During the erection of the copper wire and the final iron poles, the line route was considerably straightened, now following a more direct route and not keeping to the watercourses. No more wires have been added since then, but the methods of telegraphy used have kept abreast of the times and enabled the growing volume of traffic to be handled satisfactorily.

Originally the messages were repeated by hand at several stations along the route, and in between these stations were many others at which linemen were located. These latter were placed at points where water could be obtained, and varied in distance from 95 to 180 miles apart. As the country became opened up and telegraph systems improved, it became possible to abolish many of these stations, and one by one they have passed out of the Department's control. Some are now police stations, some are cattle station homesteads, and others railway stations. To-day the only repeater stations apart from Port Augusta, in the circuits, are Alice Springs on the copper line, and Marree, Powell Creek and Alice Springs on the iron. Besides these the only other stations remaining in the Department's hands are Tennant Creek, Daly Waters and Katherine.

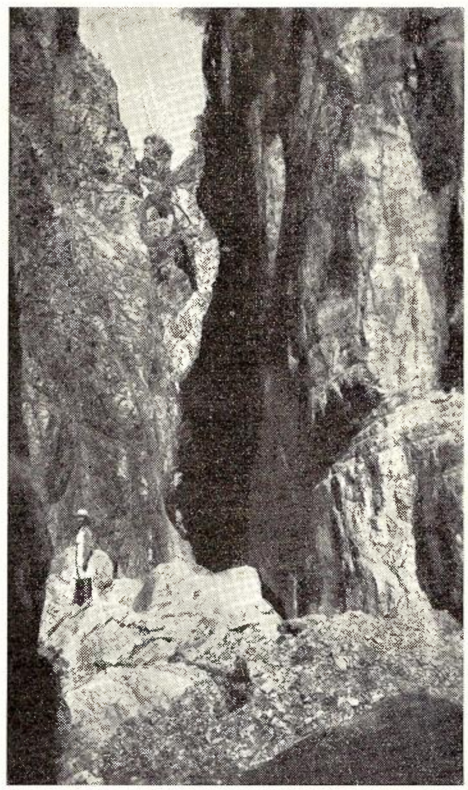
In time, hand repeating gave way to "pole changer" repeaters, and about 1926 relay repeaters were installed at the three repeater stations. Just recently the B.P.O. relays have been replaced (on the copper circuit) at this station by Creed 1927 type, and although Alice Springs is the only repeater between Darwin and Port Augusta (1775 miles) no difficulty was experienced in working Creed duplex at 100-120 words per minute. Creed working has now given way to the Teleprinter, and I understand that this is the longest physical in Australia on which Teleprinter working is done. In these areas during summer, an amount of foreign current is noticeable, sometimes as much as 6 m.A.s. Providing it remains steady, it can be overcome by adjustments to repeater and home station receiving relays, but occasionally the foreign current will vary from spacing to marking or vice versa within a few minutes, and continue doing this for hours, and then Teleprinter working becomes very difficult.



Jay Creek Water-hole, 28 miles from Alice Springs.

Nearby the pool which the first party had mistaken for springs, the Alice Springs Telegraph Station was built. For many years it was a lonely outpost, receiving its mail only once every six weeks or two months. At first it came by packs and camels from Port Augusta, later from Marree, still later from Oodnadatta, and in 1927 the railway line was completed to Stuart Town, two miles south of Alice Springs Telegraph Station. Although Stuart Town was surveyed in the late 1890's, it did not take shape until the completion of the railway. With the growth of the town it became necessary to establish an official office, and in 1932 the old telegraph station at Alice Springs was closed and a new post office opened in what was originally Stuart Town, but which now had its name changed to "Alice Springs." Business has continued to grow, and the office is now quite a busy Grade 2 office. Some idea of the town's growth can be gauged from the population, which increased from 398 in June, 1936, to 700 at June, 1938. There is also a quite large outback population served by the office. Many substantial buildings have been erected in the town and many more are in the course of erection, including a large business house, hospital, and other Government buildings. The streets are well made and properly kerbed, and thousands of ornamental trees have been planted along them. The town is dependent on the pastoral and mining industries, and these, especially the latter, are growing steadily. Many ores are found in the surrounding country, including wolfram, tin, mica, gold, silver-lead, and other base metals.

The climate is certainly hot, but it is a clear heat, and it is seldom that we do not have a cool night. In the winter many frosts are experienced, some so severe that I have seen limbs of quite big shrubs covered with ice because the frost had caused the bark to break and had frozen the sap where the bark had split. Citrus fruits, vines, vegetables and most flowers do remarkably well, but the stone fruits do not thrive, principally because of the frosts. The town nestles in between mountain ranges, and is becoming popular as a tourist resort. Most of the better scenic attractions are, however, some miles out, but they are well worth visiting,



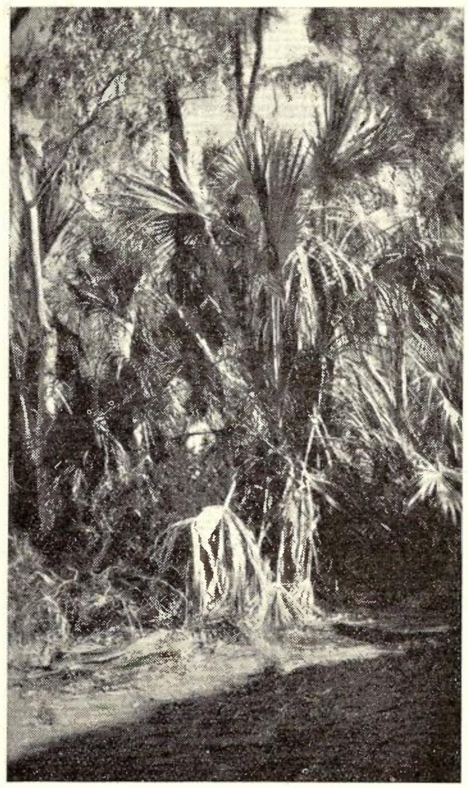
Looking down into Stanley Chasm.

and there are people who claim that our Stanley Chasm is quite equal to the famous Grand Canyon of Arizona.

Some lengthy mail services radiate from here —that to Tennant Creek being 341 miles, Birdum 657 miles, and Huckitta 502 miles. Motors are used on all these services, but in the wet season (November to April) packhorses are used on the Powell Creek-Birdum section of the Birdum route. On the Huckitta route there is only about 60 miles of cleared road, the remainder of the journey being over bush tracks, across wide creeks, and over some very rough hilly country. There is still one camel mail service operating in North Australia, being that which leaves Rumbalara once monthly and serves the stations north and north-west of there.

The Alice Springs' Line Foreman's district extends from Oodnadatta to Taylor's Crossing (about 26 miles north of Barrow Creek), a distance of 510 miles. The whole section is patrolled by him twice each year, usually just before and just after the wet season. The portion north of Alice Springs (205 miles) mostly follows fairly well defined tracks or bush roads, but on the southern section to Oodnadatta (305 miles) there are very little of even tracks, and he just follows the telegraph line, whether it be through sandhills, over gibber plains and clay flats or across creek and watercourse beds. Some of these plains a few days after a rain appear to be quite dried up and firm, but beneath a thin crust is a real quagmire. In October, 1938, the Line Foreman and his assistant were returning from the patrol to Oodnadatta and about 120 miles north of there, were passing over what appeared quite firm and dry ground, when all of a sudden the truck broke through the crust and straight away dropped until it was resting on the running boards. Immediately water began to ooze through, and in a few seconds was almost flowing from where the crust had been broken. It took them until midnight that night digging drains to carry the water away. The next day was spent in trying to build up a corduroy under the truck with timber cut from the sparse mulgas nearby. Although the weather was very hot (the shade temperature at Alice Springs being over 100), they had to wait until the water had drained away before they could move, and then their disappointment can be imagined when, after going only a few yards, down they sank again and were no better off than they had been 24 hours earlier. It meant doing the same thing over again, and it was not until two days later that they got out of this hole. Usually a good supply of provisions is carried, but as the patrol had finished and they were returning home and anticipated replenishing at Finke the evening they first got bogged, the supply carried was not large, and so, after the second day, although they still had plenty of good water, the only foodstuff remaining was tinned pineapple, and for two days they lived solely on this. On the evening of the third day they managed to get out of the second boghole, but on examining the surrounding country decided to wait at least another day before attempting to go any further. They were thoroughly tired out after cutting scrub, digging trenches to carry water away and attempting to get the truck out of bogs. On the evening of the fourth day they managed to reach Finke (30 miles away) but not before some more anxious moments had been spent in crossing other bad patches of country.

It is not often that we get a good downpour of rain, but we usually manage one good one each year. On 19th February, 1938, from two to five inches of rain fell from Alice Springs to Oodnadatta. Rivers ran bankers, and at one time the



View in Palm Valley, near Alice Springs. This particular variety of palm is not found anywhere else in the world.

Alberga was flowing 16 feet above the railway bridge and over half a mile wide. Communication with Adelaide was completely cut off for several days, and the train service was not restored until six weeks later. Miles of railway line was washed away and many sections of the telegraph line carried away in the floods. Where the telegraph lines cross the Alberga there were two 28 ft. iron beam poles, but after the water had subsided they were found in different places about a quarter of a mile downstream, one end of each just showing through the mud and the other end under between six and seven feet of mud and silt. Some food supplies were brought to Alice Springs by aeroplane, but by the time the train service had been restored, there were many items which were unprocurable in the town, despite that rationing had been resorted to.

When the waters had subsided sufficiently to allow movement, Mr. E. Colson, of Bloods Creek Telephone Office (the nearest resident to the Alberga River), offered to attempt repairs to the lines, and set out on camels to do the job. Progress was slow, as it is a fair day's ride to do 30 miles by camel, especially in wet country, and stoppages were frequent in order to clear debris away from the lines. In addition, many detours had to be made to get across creeks and rivers which were still flowing, and he estimated that to traverse the 100 miles of line from his place to Oodnadatta, he travelled 160 miles. At the Alberga crossing he and three natives worked most of one day in water up to their armpits, rigging up temporary supports for the line. These were tripods about 10 feet high, and were constructed from timber cut from the trees growing nearby. Insulators were tied on to them, and the lines in turn tied to the insulators. Altogether it took eight days to travel and repair the 105 miles of line between Bloods Creek and Oodnadatta.

On the south side of the Alberga no wire was left on the poles (which were washed out and bent all shapes) for a quarter of a mile, the wire evidently having been caught and carried away by debris which was washed down. Many miles of railway line and two bridges were washed away, and it took nearly five months to repair the permanent way. It is interesting to note that none of the railway bridges carried away have been replaced. Instead, the line is laid on a built-in rock foundation in the bed of the creek or river. Excavations are made to some depth in the river bed and stone or rock firmly packed therein and the line laid on top of the stone. This method was first tried out when the Finke bridge carried away about six years ago, and has proved to be quite effective for, at the most, the damage amounts only to a short length of railway line being twisted, instead of an irreparable costly bridge.

"On the South Patrol." Many miles of country, such as this, have to be traversed.

Still, with all nature's vagaries, there are many who do not wish to leave here. The town is complete with most of the modern comforts, including an excellent electric lighting and power service, we have three air mails each week, a remarkably well built office which keeps cooler in summer than some southern offices I have worked in, and last, but not least, a good-hearted public to commune with.

THE EARLY HISTORY OF THE TELEGRAPH ELECTRICAL SOCIETY, MELBOURNE

B. McMahon, D.P.A., A.M.I.E. (Aust.)

In the June, 1938, issue of the "Telecommunication Journal of Australia," Mr. E. J. Credlin, in writing of the inauguration of the Postal Electrical Society in 1908, referred to the formation of the first Electrical Society in Victoria in 1874. Through the courtesy of Mr. F. R. Bradley, Superintendent of Mails, Sydney, copies of the transactions of this Society have been made available.

The transactions were first published in a bound volume issued in 1875, from which it is learnt that the first Ordinary General Meeting was held on Wednesday, 12th August, 1874. On one of the introductory pages it is advertised that the Society was established "for the promotion of the knowledge of electricity, especially as connected with telegraphy." The Society arranged to meet for the transaction of business at the Melbourne Athenæum on the second and fourth Wednesdays of each month at 8 p.m.

The first Committee of Management comprised Mr. G. Smibert, Mr. D. Mickle, Mr. D. J. McGauran and Mr. H. W. Jenvey. The Honorary Secretary and Treasurer was Mr. L. S. Daniel. Throughout the first volume of transactions, Messrs. McGauran and Daniel were frequent contributors, and apparently their work and enthusiasm contributed greatly to the successful establishment of the Society. The subscription was £1 per annum for town members and 10/- per annum for corresponding (or country) members. In the early volume no mention is made of a President, and the transactions show that there was a different Chairman at each meeting, Mr. D. J. McGauran occupying the chair at the first meeting, followed by Mr. C. W. Miller, Mr. D. Mickle and Mr. George Smibert.

There were 48 members and 61 corresponding members, and at the inception of the Society membership was restricted "for the present" to officers of the Post and Telegraph Department. On September 9th, 1874, however, it was resolved "that any gentleman intimately connected with the practice of telegraphy in this or the neighbouring colonies shall be eligible for membership of this Society." Apparently no provision was made for female, or perhaps in the spirit of the age I should say lady members, for Rule No. 12 provided eligibility for membership for no others than "any gentleman intimately connected with the practice of telegraphy. . . ."

We can admire the broad outlook of the founders of this Society, who so soon after its inception made membership available to telegraph workers in the neighbouring colonies, a quarter of a century before Australia became a Federation. In 1875 the telegraphic art was more or less a mystery to the general public, if not to many members of the Department, and in this respect it is interesting to read that a short elementary lecture on electric telegraphy was given by Mr. L. S. Daniel as an introduction to the Exhibition of the Electric Telegraph at a public entertainment which was given by the members of the Society at the Melbourne Athenæum on Monday, 1st February, 1875. The entertainment, which was presided over by Mr. Turner, the then Deputy Postmaster-General of Victoria, "was very successful, and the Melbourne Press was unanimous in pronouncing it one of the most interesting lectures ever given in the city."

In recent times there has been much discussion on the use of proper functional designations for professional and technical occupations, and some of the words around which the discussion has turned are "Mechanic," "Electrician" and "Engineer." Those who now lean to the word "Electrician" are perhaps unconsciously following a precedent established as far back as 1874, when Mr. H. W. Jenvey, in his paper on "Electrical Resistance," wrote "and here I will introduce a fundamental law of electrical measurement named after an **Electrician** who put it into form. It is, 'That the quantity of electricity passing a given point in a circuit in a given time is equal to the electro-motive force, or original and natural power of the battery, divided by the resistance of the circuit.' This is called Ohms Law, and Mr. Culley, **the Electrician,** calls it 'the basis of all the mathematical laws of electric currents' —a very important definition."

That these Electricians of the past were no less human than the Mechanics, Linemen, Electricians and Engineers of to-day may be gathered from the observations of Mr. L. S. Daniel at the first Ordinary General Meeting of the Society. Mr. Daniel, in submitting that the object of members was to gain knowledge, which was power, put it that "If our value be increased, we may naturally expect a tangible recognition of this improvement." He is rather diffident in mentioning this aspect, and confesses that he "would never have thought of putting the matter in such plain language as he finds it in the Journal of the Telegraph Engineers' Society of London, where he came across the following passage in a lecture on the Advantages of Scientific Education, delivered by Mr. W. H. Preece, C.E." Mr. Preece, afterwards Sir William Preece, Chief Engineer of the British Post Office, said, "There is no doubt that a knowledge of the technical details of telegraphy will eventually lead to an increase of the emoluments of those who are now engaged in the Department."

The Society continued to prosper in its first year, and we find that, by July, 1875, the membership had increased to 49, with 78 corresponding members. Though Rule No. 12 making "any gentleman" eligible for membership apparently remained unaltered, we find in the Progress Report for the quarter ending the 30th April, 1875, that the Society had a number of lady members, donations towards the printing fund of the Society having been received from "the following members:—Miss F. A. Dobson, Telegraph Office, Dandenong, 10/-; Mrs. S. E. Kinahan, of Terang, 10/-; Miss E. Allison, of Sorrento, 5/-." The report states that, "These donations are the more gratifying that they have been quite unsolicited."

For the information of its members, the Society published in its transactions a reference to "telegraphing the St. Leger, 1874." Over the four days' race meeting the total number of messages transmitted "reached the astounding figure of 16,500." On the same page a reference is made to working speeds of morse instruments. From New York came two instances of fast transmission of ordinary messages, viz., 330 messages in 6 hours, 30 minutes, 50.7 per hour, and 136 messages in 2 hours, 68 per hour. It is then recorded that, on the occasion of the last Melbourne Cup race (1874) 216 messages were sent from the racecourse to Melbourne, on one of the wires, in 1 hour and 58 minutes, being at the rate of 109.8 per hour, while at the Cup of the previous year the rate was 124.5 per hour. It is explained that, on account of the frequent occurrence of the same names, abbreviations could be used to a great extent, and it is then added that, "As a matter of swift penmanship on the part of the receiving operator, these performances could not easily be surpassed." It is clear that our pioneer members did not intend to be outdone by any reports from America.

Even in the first year of its life the Society did not lack recognition overseas, for it is reported that Mr. H. W. Jenvey's paper on "The Adjustment of the Morse Instrument," which was read before the Society in October, 1874, was published in the London Telegraphic Journal of July 1st, 1875.

Reading on through the transactions, we are brought nearer to the present day by seeing a name at present well known in telegraph and telephone engineering circles in Victoria, for on the 22nd September, 1875, "Mr. H. Quarry described and illustrated Wheatstone's Alphabetical Instrument by taking to pieces and showing the construction and mechanism of its different parts." In the same issue we find the Society attempting to lighten the tedium associated with reading heavy technical matter by including a paragraph culled from the "Electrical News," which read: "The practice of hanging linen to dry on the telegraph wires has, according to the Pall Mall Gazette, lately become general in Armenia, and revealed the hitherto unknown fact that the peasantry of that country are in the habit, occasionally, of washing their clothes . . . ."

The march of time in the affairs of nations is brought vividly before us in reading the report of the International Telegraphic Conference which was held at St. Petersburg. We no longer hear this city so named, but surely all engaged in the business of telecommunication will derive some satisfaction from the thought that, for three-quarters of a century, representatives of all nations have gathered together for a common purpose and discussed amicably and with such wonderful results the problems which have arisen in telecommunication affairs throughout the world. Another matter of interest in the same issue is an extract from the "Queensland Times" of March, 1875. The editor of this paper often wondered how it was that a proper word had not been invented to express the name of a message sent by the submarine wire, without pedantry. He affirmed that the word "Cablegram" was simply execrable, both in sound and linguistic propriety. He then suggests, "Why not use the euphonius word 'Calogram,' which is from the Greek word 'Calos'—a cable? . . ." and to think that, in 1939, we are still using "Cablegram."

In the transactions for the year ending July 31st, 1875, is published an extract from the "Sydney Morning Herald" of January 11th regarding the submarine cable to connect the Colony of New South Wales with New Zealand. "The Herald" article reported that the first portion of the cable arrived in the steamship "Edinburgh," which was the first cable ship that had then visited this part of the world. On this account the arrival of the ship created great interest in Sydney. She carried a 240-mile length of the New Zealand cable, the remainder being on board the "Hibernia," which was expected in Sydney in another few weeks. It was reported also that the "Edinburgh" on the same trip brought from England a short cable "about 35 miles in length, which she laid near Adelaide, across what is known as the Back Passage, to connect the telegraph line between Western and South Australia." South Australian members might know what has become of this cable.

That the same friendly spirit which now characterises the association of technical officers of the telecommunication services was in existence to just the same extent in the early days of telegraph societies may be gleaned from a report of a gathering held on Tuesday evening, 7th March, 1875, at 9 p.m. About 60 officers of the Department assembled at Clement's Café (Does any member remember it?) to make a presentation of a silver tea and coffee service to Mr. D. J. McGauran. The report relates that, "It having transpired early in March that the New South Wales Government had secured the services of Mr. D. J. McGauran, Operator, of the Melbourne Office, and a member of the Committee of Management of this Society, it was immediately and unanimously resolved not to allow him to leave the Department in which he had for so many years been so deservedly popular, without some souvenir from his fellow-telegrahists." The Chairman was Mr. T. R. James, who referred to his amusement at receiving a letter from a country member complaining that "New South Wales was gobbling up all the plums." Mr. James added that "the sister Colony had now gobbled up our choicest plum. (Hear, hear.)"

A separate paragraph in the report relates that "Champagne and other refreshments being now introduced, the Chairman called upon the meeting to drink Mr. McGauran's health, which was done amid great applause." It is not known what effect the refreshments had on the gathering, but it is naively reported later that, "The official portion of the proceedings having now terminated, **the remainder of the evening was spent in a most pleasant manner.**" (The black type is ours.) The report concludes, "Some astonishment was subsequently excited at the Hobson's Bay Railway Terminus by the larger portion of the meeting accompanying Mr. McGauran to the St. Kilda 11 p.m. train, and saluting him as the train moved off, with hearty cheers." It may be a fair inference that the last train in those days departed at 11 p.m.

Those members who are particularly concerned with the telephone side of telecommunication will be interested in a report headed "Novel Telegraphy in Canada." It includes an extract from the "Brantford Expositor," which relates that a number of gentlemen interested in scientific matters recently assembled at the office of the Dominion Telegraph Company to witness some very wonderful experiments on an apparatus invented by Mr. A. Graham Bell, son of Professor A. M. Bell, of Tutelan Heights. "This gentleman claims to be able to transmit musical sounds over a telegraph wire." Members are aware of the rapid progress made in the years immediately following, and the photograph published in the June, 1938, issue of the welcome to Dr. Graham Bell at Melbourne Central Exchange on the 17th August, 1910, will now be of special interest.

From 1874 to 1876 the proceedings of the Telegraph Electrical Society were published as "transactions." In the next issue covering the period March to July inclusive, 1877, the title "Journal" is used, and as the only other copy of the proceedings which is available is for the January to December period of 1881, when the term "Journal" is still used, it may be assumed that the "transactions" permanently gave way to the "Journal of the Telegraph Electrical Society, Melbourne."

In the 1877 Journal further reference is made to Professor Graham Bell's telephone. "The most wonderful of these telephones is that invented by Professor Graham Bell. By means of his telephone the human voice (or any other sound) is carried by magnetic currents along a telegraphic wire and reproduced at the stations on the lines. . . . It has been seen by Sir William Thomson and pronounced by him to be 'the greatest by far of all the marvels of the Electric Telegraph,' and the Telegraphic Journal, London, states that so many proofs have been given of the authenticity of the invention that its reality can no longer be a matter for doubt."

That this confidence in the report was not shared by the editors of the Melbourne Journal may be gathered from the comment just a little later in the report. It reads: "What we are called upon to believe about this invention is of such a nature as to make a personal inspection of it almost essential, in order to destroy all doubt of its reality." After a reference to the method of working the report goes on: "This is hard enough to believe, but when we have to add to this that the vibrations are produced in the first instance by the human voice, and that the vibrations produced on the plate at the other end of the line **are made to reproduce the articulate sounds of the human voice,** surely it is no wonder that there are to be found persons of no small scientific attainments who, in the absence of ocular demonstration, have declared the so-called invention to be 'a physical impossibility.'" (Reference July, 1877.)

However, the editors were not without a broad outlook on general matters, and during 1875 an article was published on the "Typewriter." It said that, although this clever invention was not directly connected with electricity nor with telegraphy, the art of **fast writing** was so important a feature of the latter that it was considered the accompanying article (from "The Times" of April 25th) would not be out of place in the Journal. One of these instruments was reported to be in the possession of the New South Wales Telegraph Department, and the Committee of Management of the Victorian Society indicated that it would be glad to have a practical opinion of the estimation in which it was held there.

In "The Times" article the reporter states that, "The typewriter more nearly resembles in outward appearance a sewing machine than anything else. . . . The uses of this ingenious contrivance are so obvious and so numerous that we may content ourselves by observing that the only work to which it cannot be applied is that of bookkeeping or writing in books."

In the Journal for the period ending July, 1877, is published an account of the first steps in electric telegraphy in England, being an extract from the inaugural address by Mr. C. V. Walker, F.R.S., on the 12th January, 1876, on being elected President of the Society of Telegraph Engineers. Mr. Walker referred to the deep debt of gratitude owed to electric telegraphs by the Railways, but he remarked that the debt was not all on one side. He quoted remarks published as early as March, 1850, that "The electric telegraph is greatly indebted to the Railways, if not for its existence, at least for the friendly hand they have held out to it, and indeed for the protecting care with which they have guarded it. . . . This little line of telegraph (Great Western Railway) was then one of the sights of London. Well do I remember in 1845 paying my shilling to see it. It was made known by handbills to passers-by." Present members will be interested in the reprint of the handbill published on this page.

THE WONDER of the AGE!!

INSTANTANEOUS COMMUNICATION.

Under the special Patronage of Her Majesty & H.R.H. Prince Albert.

THE

GALVANIC AND ELECTRO-MAGNETIC

TELEGRAPHS

ON THE

GT. WESTERN RAILWAY

May be seen in constant operation, daily (Sundays excepted), from 9 till 8, at the

TELEGRAPH OFFICE, LONDON TERMINUS, PADDINGTON AND TELEGRAPH COTTAGE, SLOUGH STATION.

An Exhibition admitted by its numerous Visitors to be the most interesting and ATTRACTIVE of any in this great Metropolis. In the list of visitors are the illustrious names of several of the Crowned Heads of Europe, and nearly the whole of the Nobility of England.

"*This Exhibition, which has so much excited Public attention of late, is well worthy a visit from all who love to see the wonders of science.*"—MORNING POST.

The Electric Telegraph is unlimited in the nature and extent of its communications; by its extraordinary agency a person in London could converse with another at New York, or at any other place however distant, as easily and nearly as rapidly as if both parties were in the same room. Questions proposed by Visitors will be asked by means of this Apparatus and answers thereto will be instantaneously returned by a person 20 Miles off, who will also, at their request, ring a bell or fire a cannon, in an incredibly short space of time, after the signal for his doing so has been given.

The Electric Fluid travels at the rate of 280,000 Miles per Second.

By its powerful agency Murderers have been apprehended, (as in the late case of Tawell,)—Thieves detected; and lastly, which is of no little importance, the timely assistance of Medical aid has been procured in cases which otherwise would have proved fatal.

The great national importance of this wonderful invention is so well-known that any further allusion here to its merits would be superfluous.

N.B.—Despatches sent to and fro with the most confiding secrecy. Messengers in constant attendance, so that communications received by Telegraph would be forwarded, if required, to any part of London, Windsor, Eton, &c.

ADMISSION ONE SHILLING.

T. HOME, *Licensee*

Nurton, Printer, 48 Church St., Portman Market.

It is of interest to note the comparatively wide range of technical discussion and study covered in the early years of the Society, despite the limited membership and the restricted facilities. Following are titles of some of the lectures delivered between 1874 and 1877, following the inaugural lecture by Mr. L. S. Daniel on "The objects, use and working of the Telegraph Electrical Society":—

By Mr. Geo. Smibert:
- Electricity.
- Origin of the Voltaic Current.
- Magnetism and Electro-Magnetism.
- Arrangement of Circuits and Commutators in the Chief E.T.O., Melbourne.

By Mr. D. J. McGauran:
- Duplex Telegraphy (with demonstration).
- On the Transmission of two messages in the same direction at the same time on one wire.
- An auto-translator for closed circuits.

By Mr. H. W. Jenvey:
- Electrical Resistance.
- The Adjustment of Morse Instruments.

By Mr. H. Quarry:
- Wheatstone's Alphabetical Instrument.

By Mr. S. Deverell:
- Sea-water Battery.

By Mr. P. R. Challen:
- Statical Electricity and a brief discussion of the means of producing it.

Mr. L. S. Daniel, in addition to lecturing on "The Morse Instrument," read an extract entitled "Aldini's Bovine Battery" dealing with electricity in the bodies of human and other animals.

Mindful of the interests of its members, the Society in 1875 set out to provide a course of instruction, and there are printed four papers on "Galvanic Batteries" read by Mr. D. J. McGauran, "being part of the course of instruction which it has been determined to pursue." During the visit of the cable ship "Duke of Edinburgh" the opportunity was taken to invite the ship's Chief Electrician to read a paper on "Interference Between Lines."

The Journal for March to July, 1877, was devoted largely to "giving members some account of the instruments at present exciting much interest in Telegraphic circles, and which, from their power of conveying sound, are called telephones." In addition to reports of Bell's lectures and demonstrations in U.S.A., reference was made to Reiss' telephone and Gray's instrument. The trend towards telephony continued, for the 1881 Journal opened with "Modern Forms of the Telephone," by James Doyle, M.S.T.E., though the remainder of this issue dealt with telegraphy, and in September, 1881, we see the first reference to quadruplex in a "Note on the working of the Quadruplex between Sydney and Melbourne," by Mr. D. J. McGauran.

The last reference in the 1881 volume is a review of the Report of the Adelaide Observatory for 1879, presented to the Society by C. Todd, Esq., C.M.G. Mr. Todd, who was then P.M.G. and Superintendent of Telegraphs in South Australia, later became Sir Charles Todd, a name prominently associated with the building of the overland telegraph line between Adelaide and Darwin.

This 1881 volume is the last printed record we possess of the proceedings of the Telegraph Electrical Society between the time of its inception in 1874 and its revival as the Postal Electrical Society in 1908. The enthusiasm of its founders and early members has left us this record of their splendid work for the first eight years.

THE NEW TRUNK INSULATOR

R. M. Osborne, M.E.E., A.M.I.E.E.

With the extension of the practice of dialling over trunk lines, troubles have been experienced on account of the large variation in the insulation resistance of the aerial circuits used. Some dialling lines, in wet weather, have an insulation resistance of 10,000 ohms or even less, and become unworkable, and in 1936 it was decided that the standard trunk insulator should be re-designed in order to effect, if possible, an improvement in this state of affairs. It was recognized that, although there are several sources of loss in a telephone insulator, by far the most important one at voice and telegraph frequencies is surface leakage between wire and pin, and the object of the designers was, therefore, to reduce this effect.

With a clean insulator the surface leakage, even in wet weather, is small, but, as dirt accumulates, a semi-conducting path is formed on the surface if the atmosphere is moist, particularly if the dirt includes salt or carbon. The resistance of this path depends upon its length and cross-sectional area in the same way as the resistance of any conductor depends upon these variables, and it is therefore desirable to make the length of the path as great as possible whilst, at the same time, keeping its cross-section area as small as possible, i.e., by keeping the circumference of the insulator as small as possible.

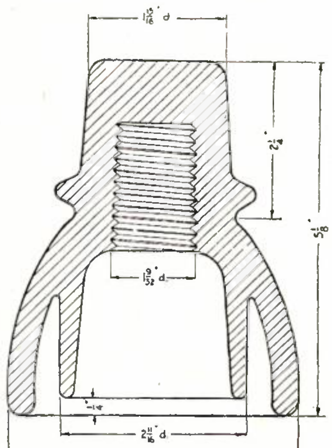


Fig. 1.

This result is partially achieved in many insulators by using two skirts. The trunk in-

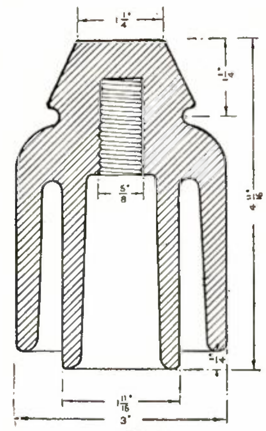


Fig. 2.

sulator which has been standard in Australia for many years is one design which incorporates this feature, and so is the B.P.O. trunk insulator. These two designs are shown in Figs. 1 and 2. Examination of them shows that the B.P.O. insulator provides a longer leakage path between wire and pin (32 cms. as compared with 23 cms.), and at the same time the average diameter of the leakage surface is considerably less (4.60 cms. as compared with 7.54 cms.). Thus, if each of the insulators has an equal thickness of similar deposit upon it, the surface resistance of the B.P.O. insulator will be nearly 2.3 times as great as that of the Australian trunk insulator. In addition, exposure tests conducted at the Research Laboratories indicated that the external surface of the Australian insulator which curves outwards is more likely to accumulate dirt than the straight vertical sides of the B.P.O. design.

It was therefore decided to use the B.P.O. insulator as the basis for design, but to attempt to make it suitable for use with wooden spindles which, in Australia, are more economical than steel spindles. The use of wooden spindles would necessitate increasing the diameter, for it would not be practicable to obtain a sufficiently strong wooden spindle to fit the thread of the B.P.O. design.

This increase of diameter would tend to reduce the surface leakage resistance and also would increase the weight of the insulator; it would therefore be undesirable. Instead of abandoning the wooden spindle the designers decided to depart from the B.P.O. practice and eliminate the second skirt. They argued that, although by doing so they would reduce the length of the leakage path, they would also reduce the average diameter of the insulator, and thus the two effects would partly cancel out. Furthermore, they believed that the outer surface, which is continually washed by rain, is the most important part, and that the elimination of the inner skirt would not be as serious as might be imagined. To obtain the maximum benefit, however, a wooden spindle of minimum practicable diameter was designed for use with the new insulator, the final design of which is shown in Fig. 3. It is hoped that, when tests have been completed, this insulator will become the Australian Standard Trunk Insulator.

The length of the surface leakage path of this insulator is slightly less than that of the old trunk insulator (18 cms. as compared with 23 cms.) but its average diameter is considerably less (5.08 cms. as compared with 7.54 cms.) and therefore its theoretical surface leakage resistance is greater than that of the old design. Furthermore, as stated above, a large proportion (57 per cent.) of its leakage path is exposed to the cleansing action of rain. With the old trunk insulator, this proportion is 37 per cent. and with the B.P.O. insulator it is 32 per cent. The designers hope that this feature of the new insulator will largely compensate for the higher theoretical leakage resistance of the B.P.O. insulator.

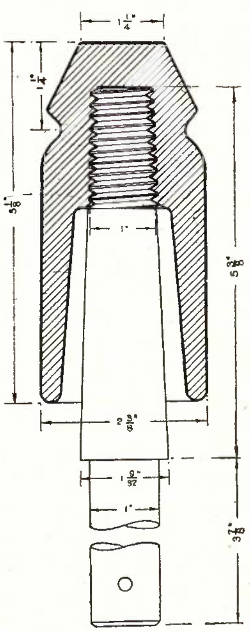


Fig. 3.

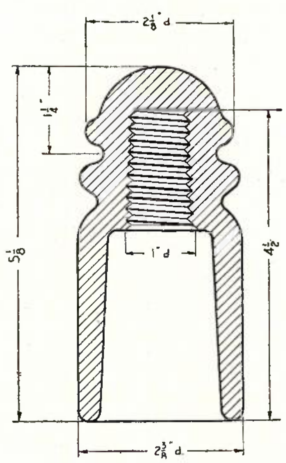


Fig. 4.

After the design had been completed, it was decided to conduct field tests by installing the insulators on the Melbourne-Geelong trunk route but, before this was done, the decision to scrap this route made other plans necessary, and it was decided to equip certain lines between Melbourne and Dromana which were known to have very low insulation resistance during periods of high humidity. It was intended to equip one circuit with the new insulators made of porcelain, and one circuit with B.P.O. porcelain insulators, and to compare the results obtained with the standard Australian porcelain insulators erected on the same poles. It was then thought advisable to make some of the new insulators in glass in order that the value of this material for the purpose could be examined. The Australian Glass Co. agreed to co-operate but pointed out that the new design, although suitable for porcelain, was not ideal for glass because of the cooling stresses likely to be set up in the body of the insulator. They submitted a design which gave the same leakage path but which, they considered, would be better for glass, and the Department purchased sufficient of these insulators to equip a circuit between Melbourne and Dromana. Fig. 4 shows a glass insulator of the design tested.

The installation of the insulators on the Melbourne-Dromana circuits was completed in March, 1938, and each of the circuits was connected to the Research Laboratories by an underground cable pair between the Glenhuntly cable head at the Melbourne end of the circuits, and the Laboratories, and a recording galvanometer was arranged to record the insulation resistance of each of the circuits. The method of connection did not affect the usefulness of the circuits for their normal traffic, and they were not, therefore, withdrawn from service. Before tests commenced, the insulators on these lines were cleaned by spraying them from the ground.

In July, 1938, the first analysis of the results was made. As was known, the insulation of the various lines varied considerably with the humidity, and in order to compare the results, it was therefore necessary to compare the readings at equal humidities, and for the purpose of these tests, the readings at high humidities are, of course, the most important because it is under these conditions that lowest insulations occur.

Some variations occurred in the day by day readings, but the lowest insulation resistances recorded at any time were as under:—

B.P.O. Standard	38,000 ohms.
Australian Single Skirt—	
Porcelain	34,000 ohms.
Glass	14,000 ohms.
Australian Double Skirt (old design)	5,000 ohms.

These readings are the overall readings between wires of the lines which are approximately 46 miles long; the lowest readings at other humidities were in about the same order. For example, at 80 per cent. they were:—

B.P.O. Standard	450,000
Australian Single Skirt—	
Porcelain	450,000
Glass	160,000
Australian Double Skirt (old design)	50,000

These results are very satisfactory and, so far, confirm the designers' belief in the single skirt design. It would be unwise to be unduly optimistic until further results have been obtained and the effect of weathering has been ascertained, but on the results so far, the Department has felt justified in purchasing large supplies of trunk insulators to the new design. This will, of course, introduce complications such as are always met when an old standard is replaced by a new, but it is felt that the advantages to be obtained are very real and far outweigh the objections.

The reason for the low value of the glass insulator is not very clear at present, but it is possibly due to the presence of cracked insulators on the line. During installation, some of these insulators cracked and a number actually broke. Whatever the reason, however, the results so far reflect some inferiority of the glass insulators installed for test, which may or may not become more pronounced as the tests proceed.

It is possible that an extra groove may be added to the design of Fig. 3, but unless future tests cause opinions to be modified considerably, it is probable that no drastic alterations to it will be made and that it will become the new Departmental Standard, and will be known as Insulator, Trunk, L.S. (Long Skirt) to distinguish it from the present Trunk Insulator. The new wooden spindle for use with it has already been designed, and designs for the necessary steel spindles are in course of preparation.

As a matter of interest it is recorded that a number of these new insulators were installed on junction lines from McLaren Vale Exchange in South Australia. These lines had previously been very unsatisfactory in damp and foggy weather, but since the installation of the new insulator have been satisfactory. It is hoped that the general introduction of the new insulator will have similar satisfactory results in many parts of the Commonwealth.

CABLE JOINTING. PART 5

G. O. Newton

Operations on Working Cables (Cont.)

JOINTING OPERATIONS

Types of Operation.—The majority of operations on working cables involving conductor jointing may be divided into the following main types:—

(i) Connection of non-working cables to working cables (See Fig. 16a, Part 3).

(ii) Transfer of working cables—

(a) from an existing working cable to a non-working cable (See Fig. 16b, Part 3);

(b) from one position to another on the same working cable;

(c) from one working cable to another working cable.

(iii) Replacement of a section of working cable between two points on the route with a cable of either the same or a different size.

(iv) Diversion of existing cables to new exchanges or to cross-connecting facilities.

Occasions will arise where the operations involve two or more types, but usually each type can be attended to separately. If circumstances are such that it is expedient to perform two operations of the same or different types simultaneously, generally the methods will be on similar lines to those normally adopted for the separate operations, but the simultaneous application will require special planning to ensure effective co-ordination between each set of operators.

Types (ii) and (iii) (and in some cases Type (iv) also) involve what is designated "cutover" jointing necessitating alterations at two points. Normally in Type (ii) the changes are effected at a joint in the cable and at the exchange M.D.F. or some intervening cross-connecting facility; the alterations at the latter point affect working circuits only. In Type (iii) the location of the alterations is usually at a joint in the cable in each case.

METHODS

General methods of dealing with each type will be indicated first, while methods of conductor jointing in such cases will be set out in a subsequent section.

Connection of a Non-Working Cable to a Working Cable.—Usually the non-working cable is a new one similar to the example in Fig. 16a, Part 3, but it may also be (wholly or in part) an existing cable from which all working lines have been transferred by a previous operation.

Excluding identification work, the operation is confined to one point and only necessitates one operator. The non-working cable is first tested from its terminal points to the point of connection to the existing cable, and pairs tagged (see Part 3). The numbers of these tags should be the same as or in corresponding order to the ultimate record cable pair numbers. In the particular case quoted, the simplest arrangement is to tag the pairs in the 38 pair cable, 1-38. The working cable is then opened and the required pairs identified (see Part 4 for methods) and tagged according to record cable pair numbers. (In the example these are pairs 363-400 and they should correspond to rotation pairs 63-100 in the outer layer of the 100 pair if it has been jointed correctly.) On completion of identification the pairs of the non-working cable are jointed in the order of the tag numbers as obtained from the check, to the identified pairs in the working cable in the order of their record cable pair numbers. When the pairs of the non-working cable are not properly terminated at the distant end they must be insulated before jointing to the existing cable, if working lines in the latter are likely to be made faulty.

Transfer of Working Lateral or Branch Cable. —In each of the three subdivisions of this type of operation spare pairs are dealt with in a similar manner to the non-working pairs in the previous type, but working pairs involve alterations to the jumpers at the exchange M.D.F. (or an intermediate cross-connecting facility) in conjunction with the changeover of the cable pairs. This involves the preparation of transfer sheets indicating the existing and new record cable pair numbers (also M.D.F. numbers where a separate numbering scheme is used for this) for each working line. To avoid delays and interruptions, these transfer sheets must be prepared accurately and care taken to amend them when any alterations to the occupancy of pairs occur after their preparation and before the commencement of the work. They should also be checked as far as possible, just prior to effecting any changes in cable pairs.

In some instances the main cable pairs, to which it is proposed to transfer the lines, already accommodate working lines connected to other branch or lateral cables and these must be moved to other pairs to clear the way for the former. These alterations should be set out on transfer sheets and attended to prior to commencing the main operation by altering the jumpers at the M.D.F. and the leads at the cable terminal. In other instances it may be preferable to alter the positions of working lines in the cable being transferred so as not to clash with working lines already occupying pairs at the new position. In this latter case the alteration of the leads to the open wire at the cable terminal may be attended to concurrently with the alteration of the lines at the joint and of their jumpers at the M.D.F. or the changes may be effected by altering the leads at the cable terminal and by a temporary transposition of pairs in a preliminary operation at the joint.

The first operation in each case is to identify and tag at the joint the pairs to be transferred in order of record cable pair numbers. Concurrently, non-working pairs may be cut away ready for conductor jointing in their new positions. The next operation is the identification and tagging (with record cable pair numbers) of the required pairs in the new position. In the case of a new non-working cable (Type ii (a), such as the example of Fig. 16b, Part 3), this identification and tagging is part of the check and test out of the new cable from the M.D.F. as explained in Part 3.

Having identified the pairs in both the old and new positions, the transfer from the old to new positions can proceed by cutting away one conductor or pair at a time from the old position and jointing it into its new position in accordance with the instructions for the alteration. Concurrently as each working cable pair is changed, the connection on the M.D.F. (or cross-connecting facility) must be altered.

The time taken to shift a jumper on an M.D.F. is usually much longer than the time occupied by the cable jointer in effecting the changes at the joints, and increases with the size of the M.D.F. To minimize any wastage of time on the part of the cable jointer in such cases the following courses are open:—

(i) Action can be taken to run new jumpers in the new positions prior to commencement of the cutover operations so that the actual changeover operation can be performed in the minimum time possible. In most cases the new jumpers can be connected permanently, but with the fuses out on the line side of the M.D.F. When the lines are being cutover all that is then necessary is to shift the fuses from the old to the new position. The removal of the old jumper can be attended to as opportunity occurs, but care should be taken to ensure that this is not overlooked.

(ii) Without waiting on the alteration of the jumpers the jointer can shift the cable pairs to their new positions, and concurrently in the case of working lines leave a temporary cross-connection or bridge between the old and new pairs so that each working line will appear on the M.D.F. in both the old and new positions. Where it is safe to do so, he can then wrap up the joint (or joints) carefully, and proceed with other work while the jumpers are being changed. Where any danger is involved in merely wrapping the joints, temporary lead sleeves will be necessary. When the jumpers have been altered he can return, cut away temporary connections between the old and new positions and permanently close the joints.

Method (i) is considered to be the most suitable for general adoption, but under some conditions method (ii) will have advantages. The former permits of a continuous operation at the joint and of the ready availability of the cable jointer if any faults or difficulties arise as jumpers are being altered. The latter has limitations in regard to the number of temporary cross-connections that can conveniently be made at a joint (or joints) in many cases and necessitates additional time on the temporary cross-connections and sleeves and travelling from and to the job. Further ineffective time may be occupied in returning and opening the temporary sleeves if troubles arise before the completion of the alterations to the jumpers. Faults and delays will occur in either case if transfer sheets are not carefully prepared in the first place and the necessary corrections made if there are any subsequent changes in the working lines concerned.

Replacement of a Section of Working Cable

(a) **Where the existing cable is in working order.**—The simplest case of this is one where the existing cable has been jointed in an orderly manner, has no intermediate lateral or branch connections and is being replaced over one or more sections by a cable of the same size, on account of the re-routing of the cable, due to such causes as alterations to road alignments, regrading of roads, etc., on the lines of the example in Fig. 20 (a).

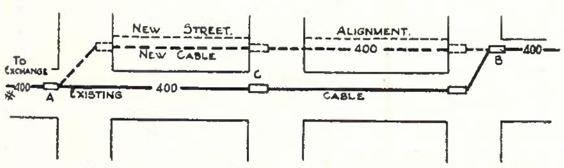


Fig. 20.—(a) Schematic diagram of typical case where the replacement of a length of cable is involved.

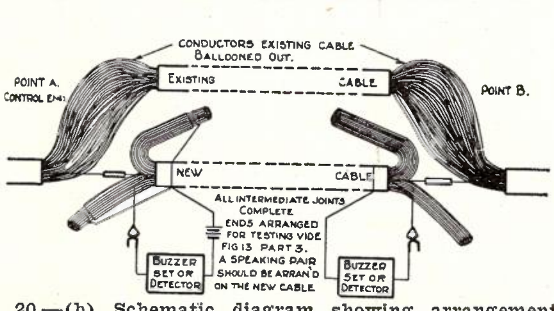


Fig. 20.—(b) Schematic diagram showing arrangement of cable ends at "A" and "B" for cutover to new cable.

Any intermediate joints are completed first and then each end of the new cable is set up in the required position for the joint and prepared for a test out (including the arrangement of a speaking circuit) on the lines indicated in Part 3. The joints of the existing cable are at the same time opened and the conductors ballooned out by working slack in the cable towards the joints so as to make the inner pairs accessible [see Fig. 20 (b)]. At each point the end of the existing cable which is to remain should be set up so that it will facilitate the making of a permanent joint with the new cable and, if necessary, the cable sheathing should be cut back to fit in with this. The cable sheathing on the side to be cut away may also be cut back to assist in obtaining slack in the conductors, but the possibility of having to fit temporary sleeves during the operation (or in some instances of having to re-use the cable) should be kept in mind when doing this.

When both operators have completed these arrangements the control operator (who, normally, should be located on the exchange side) connects his set to the A wire of the 1st pair (by rotation) of the new cable, and when this has been located at the other end and tested O.K., cuts the A wire of the first pair in the existing cable and transfers the lead of the testing set to it. When the other operator has located this conductor in the working cable he also cuts it and the two operators then check the test and joint the conductor through the new cable. When the A wire is cutover to the new cable the B wire of the first pair is dealt with in a similar manner and is followed by the conductors of the remaining pairs in their rotation order at the control end.

If the conductors at the intermediate joints in the existing cable have not been jointed in proper order, it may be advisable to partly identify the cable at each point from the exchange M.D.F. before proceeding as described, as progress in the initial stages of the cutover may be seriously retarded through the searching operator having to prick through a large proportion of the cable pairs when searching for the required conductor on each occasion (see Part 4, p. 104).

In those cases where it is not possible to obtain sufficient slack to balloon out the conductors at the cutover joint, in order to obtain access to the inner pairs (assuming identification with the exchange is not required) it is necessary to operate in the reverse order (i.e., to commence with the last pair of each cable) and cut over temporarily by leaving extra length in the conductors so that the centre and inner layers will be accessible when it is necessary to deal with these. If the number of spare pairs in the new and old cables are different, due allowance for this should be made at the point or points in the layers where they are located. After completion of the cutover in this manner it is necessary to rejoint the conductors in a permanent manner. Where identification at each joint is necessary, it will involve piecing out a proportion of the conductors of outer layers to obtain access to inner pairs and therefore they will also be accessible for the cutover jointing which follows, and this can proceed from the centre.

If there were a branch or lateral connection to the existing cable at point C, Fig. 20 (a) it would be necessary, prior to the main cutover and to the completion of the joint in the new cable at this point, to identify the pairs concerned by buzzing on the pairs in the old cable between points A and C or, if local conditions necessitate it, to identify them from the exchange M.D.F. at each point (A and C). The cutover of the pairs concerned may then be effected by a triple operation at points A, B and C, on lines similar to that for a cutover between A and B. Alternatively the lateral or branch can be cutover to the new cable at C and this joint completed whilst each pair concerned in the new cable is temporarily tee-ed on to the corresponding pair in the existing cable at point A. The operation between A and C would, of course, be carried out conductor for conductor as in the case of a cutover between A and B. When these pairs have been altered the cable can then be cutover between points A and B as already described.

If the existing main cable tapered down at point C to, say, a 300 pair the cutover would involve two operations—one of 300 pairs between A and B and one of 100 pairs between A and C. If the pairs of the existing cable are not in rotation, it will be necessary to identify the 100 pairs from C to A. In extreme cases identification from the exchange to A and C would be necessary in addition to the identification of sufficient pairs in the other 300 pairs at A and B to permit of a speedy operation between these points.

Sometimes requirements for development render it advisable to take advantage of the alterations to install a larger cable, e.g., an 800 pair cable might be drawn in between A and B in

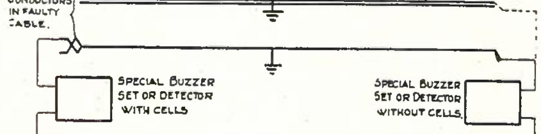


Fig. 21.—Showing arrangements for identifying conductors in an earthed (wet) cable.

lieu of a 400 pair. In this case the cutover between A and B can be done on the first 400 pairs of the 800 pair cable and the balance of the pairs left dead between these points until relief cable is provided on other sections.

(b) **Where the existing cable is faulty.**—This case arises where it has been decided to replace a faulty cable between two joints. The fault may consist of a minor loss of insulation on all or a few of the pairs, in which case it is often possible to cutover as if the cable were not defective, or the fault may be dead earth or nearly so, i.e., the paper insulation is wet throughout and the lines are completely unworkable. Usually in either case there is no intermediate joint so that apart from isolated instances of misplaced pairs due to faulty manufacture the difficulty arising from pairs not being in corresponding order at the two points of cutover should not occur.

Taking the case where the insulation loss is appreciable, it will be seen on reference to Fig. 21 that normal buzzing or other identification methods already referred to (except by using detectors) will not be effective since there is a cross from each conductor, which it is desired to identify, to the other conductors via the earth fault. It is, therefore, necessary to have a means of identification which

(a) will not signal when the connection is from one conductor at the control end through the earth fault to another conductor at the other end, or

(b) gives a different signal whenever the connection is not made to the same conductor at each of the cutover points.

In the former class are special types of buzzer sets which are available at most of the larger centres and in which the circuit arrangements are such that a buzz will only be obtained when the connection is made through the lower resistance of a through conductor and will not be given when a connection is made through the higher resistance via the earth when contact is made with a wrong conductor at the searching end. As a safeguard some of these sets incorporate both methods by the inclusion of a detector or milliammeter—the operation of which will be described. It is essential that these sets be operated on a low voltage and that they be tested from time to time to ensure that they will be in good order when required for cable repair operations. Difficulties are liable to arise with these sets when there is exchange or other battery on any of the lines (unless a detector or milliammeter which indicates their presence is included) and therefore it is essential that each conductor be checked between the two points after it is cut at both. Whenever a signal is obtained it is always advisable to test the sets by momentarily transferring the lead at one end to the mate or other adjoining wire to ensure that they are operating correctly and false signals are not being obtained.

Where these special buzzer sets are not readily available and there is no foreign or exchange battery on the pairs, as an expedient, a low resistance buzzer in a direct circuit will often be found satisfactory. This should be connected to a good wire at the control end via the minimum number of dry cells necessary for a signal on a through wire, and the other end of the good wire used for searching (see Fig. 22). If a high resistance buzzer is used, or too many cells, or any attempt is made to use it over a lengthy section it will not be found possible to obtain the required safe working margin between a connection over a through conductor and one via the earth fault to a second conductor.

The method which comes in the different signal class is to connect up two detectors or milliammeters (with cells at one end only) as in Fig. 21 and observe the deflection of the needle over a through conductor in the faulty cable and then over a connection via the earth fault. The deflection in the former case will be the larger and a similar deflection will be obtained whenever the connection is made to the same conductor at each end of the faulty section. A smaller

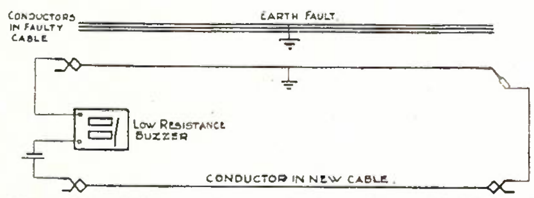


Fig. 22.—Alternative method of identifying individual conductors in earthed cable where special buzzer set or detectors are not available, satisfactory for short sections where no foreign or exchange battery present.

deflection similar to that obtained in the latter case will indicate a connection via different conductors at each end. This method which, as previously stated, is often incorporated in buzzer sets also indicates the presence of exchange or foreign battery by a variation from either of these deflections.

Under any of these methods difficulty will arise if the faulty cable has been injured mechanically and bare conductors brought into direct contact with each other or the sheathing, since there will be no extra resistance through wet insulation to earth to stop the signal (or reduce the deflection in the case of a detector) if contact is made with a different conductor at the distant end. In other cases the conductors may be cut and the wet paper insulation may form the only path at the fault for the signal current. If the actual point of mechanical damage is not readily accessible for the purpose of clearing any such direct contacts or open circuits, no great trouble should arise if such contacting conductors are cutover in rotation unless there is an intermediate joint, where the pairs have not been jointed in the correct order. If it is known that the pairs are not likely to be in the same rotation at each end a special effort should first be made to clear the contacts and, failing this, identification of the pairs from the exchange on one side and the cable terminals on the other will be necessary. Where such pairs are cutover in rotation and faults do arise due to odd misplaced pairs it will be necessary to identify the pairs concerned at one point after the completion of the cutover and rectify any wrong connections.

Where the replacement of the cable cannot be avoided and there is not any spare duct nor sufficient room in any duct to draw the new cable alongside an existing cable, it is necessary to cut the cable and withdraw it before the new cable can be drawn. In this case before cutting each pair of the old cable, it should be identified between the joints by special buzzers or detectors in rotation order and tagged at each end on the side which is to remain. If possible at the same time the new cable should be cut to the exact length required, buzzed through in rotation order and pairs tagged at each end, and the ends temporarily sealed with a rubber hood and bandages ready for drawing when the old cable is withdrawn. If this is done a quick jointing operation with speedy restoration of service will result, since it will then only be necessary for each operator to joint pairs number to number without the delay caused by simultaneous identification. If the old cable is not checked and tagged as it is cut away, identification from the exchange on one side and from the terminals on the other will be necessary. This is a slow operation (especially where pairs are not in rotation) and should be avoided if at all possible.

Whether the cable being replaced is faulty or not, one conductor only should be cutover at a time, and not the pair, to ensure that reversals are avoided, where cables are balanced or where the correct functioning of circuits is likely to be affected by such reversals. If any pairs should happen to be split it will also ensure that legs of different pairs as connected to the M.D.F. are not interchanged. If any difficulty arises in connection with the testing of odd pairs in either the existing or the new cable, the corresponding pair in each cable should be set aside and dealt with at the end of the operation. It is advisable to cross reference the pairs of each such group, which is set aside, by suitably marked tags.

Diversion of Cables to New Exchanges.—This is a special type of operation, the details of which may vary considerably with local conditions. Normally the operation is covered by special instructions and subject to special supervision.

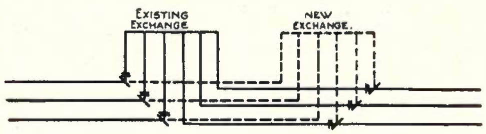
Such diversions necessitate arrangements in the cables concerned whereby all the lines which are to operate from the new exchange will be available at each M.D.F. (i.e., old and new) prior to the opening and can be readily cut clear of the old exchange after the opening. The most common arrangement [see Fig. 23 (a) and (b) (ii) and (iv)] is one where all the cable pairs concerned are tee-ed into the new exchange involving—

(i) Prior to the cutover to the new exchange
(a) the terminating on the new M.D.F. and the jointing and testing out of the

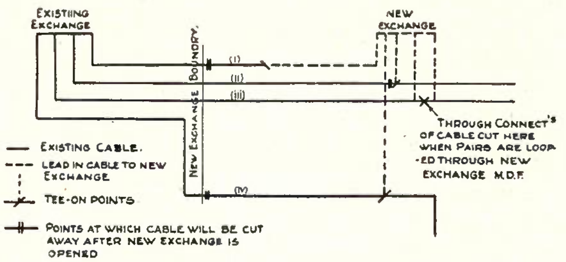
lead-in cables between the tee-on point or points on the existing cable tracks and the new M.D.F.;

(b) the identification at tee-on points of the cables to the existing exchange and teeing on the lead-in cables.

(ii) After the cutover to the new exchange the cutting away of the cable concerned on the side leading to the old exchange (a) at the tee-on points, or (b) at the new exchange boundary on the side adjacent to the old exchange, or (c) at some suitable intermediate point, depending on local conditions.



(a) New exchange located in proximity to existing exchange.



(b) New exchange located some distance from existing exchange involving cutover of portion of existing exchange area.

Fig. 23.—Schematic diagrams of typical cable arrangements for diversion to new exchange.

In Fig. 23 (a) the cutting away is done at the tee-on points. In Fig. 23 (b) (ii) and (iv) it may be done at any point between the tee-on and the exchange boundary according to local conditions.

The general methods of dealing with the various phases of the operation set out in (i) should be apparent from previous descriptions.

Other common cases likely to be met are those set out in the schematic diagrams, Fig. 23 (b) (i) and (iii). In the case of Fig. 23 (b) (i) the cable pairs are extended to the new exchange instead of being tee-ed in. The cutting away, subsequent to the cutover of the new exchange, would in most cases be at or near the exchange boundary.

In the case of Fig. 23 (b) (iii) the cable is looped through instead of being tee-ed into the new exchange prior to the cutover. This case arises where

(i) a considerable number of lines are connected to the cable on each side of the new exchange and on account of congestion in the cable it is desired to afford relief immediately the cutover to the new exchange takes place:

(ii) the section of cable between the old and new exchanges will be required for routing junctions and miscellaneous services after the cutover.

The jointing operations in this case can be completed prior to the cutover. They involve

(i) the terminating, jointing and testing out of sufficient pairs in one or more cables from the new M.D.F. to the connecting point (or points) to permit of the connection of the full number of pairs required on each side of the new exchange, and the identification of the existing cable at the connecting point (or points);

(ii) the cutting of the through connection in the existing cable at the connecting point (or points) and the routing of each pair from the far side of the new exchange over one cable pair to the new M.D.F. and out again over another cable pair (usually in another cable) to the existing exchange via the existing cable on this side. At the same time temporary jumpers are run on the new M.D.F. between the terminating points of the "in" and "out" pairs for each working line. All that is necessary after the cutover is the removal of these jumpers.

Operations involving diversion of existing cables to cross-connecting facilities such as pillar terminals are of a somewhat similar nature on a very much smaller scale, except that no alteration of exchange is involved. To a large extent such diversions are dealt with on similar lines to the case just described where lines are looped through the new exchange prior to the cutover. In this case, of course, the jumpers are permanent.

Conductor Jointing and Cutting Away

Preliminary Precautions.—Attention is drawn to the sections in Part 1 dealing with preliminary precautions and setting up of cables which apply to operations on both new and working cables.

Conductor Jointing: Permanent Joints.—Where the pairs to which the new connections are to be made terminate at the point of operation completion of the conductor joints is straightforward and is carried out on lines described in Part 2. In other cases the most suitable practice to be followed will vary to some extent with local conditions. Whatever course is followed the first essential is to ensure a well-made tightly bedded twist joint wherever it is to be permanent.

Where the conductors to which a new connection has to be made are already jointed through, and the existing paper sleeve is large enough to permit of its re-use when the additional conductor is jointed on, the paper sleeve is slipped back on the side opposite to that on which the additional conductor is to be laid and the wire joint is untwisted as far as the paper turns [see Fig. 24 (a)]. The conductor to be connected is then given $1\frac{1}{2}$ to 2 turns around the paper-covered twists in the same direction as the twists, the paper being left intact on this portion, and then the whole of the bare conductors are twisted together by gripping the ends and turning them with the thumb and forefinger in the case of light gauge wire and with pliers in the case of other gauges until a neat, well-bedded twist of the usual length is obtained. At the same time the paper-covered portion is held tightly with the other thumb and forefinger to prevent the twists running back too far. In either case the joint is given a final twist at the tip with the pliers and the end cut clean.

Where the existing paper sleeve is not large enough for re-use it is necessary to completely undo the joint, remove the old paper sleeve and slip on one of suitable size. In this case it will usually be found possible to obtain a little slack in the conductors which will permit of the paper-covered portion of the twists being re-made on a fresh section of the conductors, the conductor forming the new connection being twisted in concurrently. Surplus paper is then removed with the fingers and the bare wire twists are made as described in the previous case [see Fig. 24 (b)].

In some cases the cable connection has to be made at a point where there is no existing joint. Under these circumstances the through conductors must be cut and double jointed as shown in Fig. 24 (c). This arrangement will often be advisable also where the conductors have been previously jointed. It will also apply in those cases where pairs have been pieced out [see Fig. 24 (d)] to obtain access to inner pairs for identification purposes.

Where the cable to be jointed on compares with the through cable in size (e.g., diversions to new exchanges) or only small cables are involved and sufficient slack in the cable is available for the purpose the most satisfactory arrangement is to cut back the sheathing on one or both sides of the existing joint (taking care to re-bind the conductors adjacent to the sheathing), balloon out the conductors by working sufficient slack towards the joints and then re-joint them to the correct tension and at the same time joint in the new conductors by making the normal three-wire joint. Where slack is not available it will be necessary to piece and double joint the conductors.

Where the tee-on operation necessitates some temporary slackening of the conductors to permit of more ready access to pairs in other than the outer layer, care must be taken that correspond-

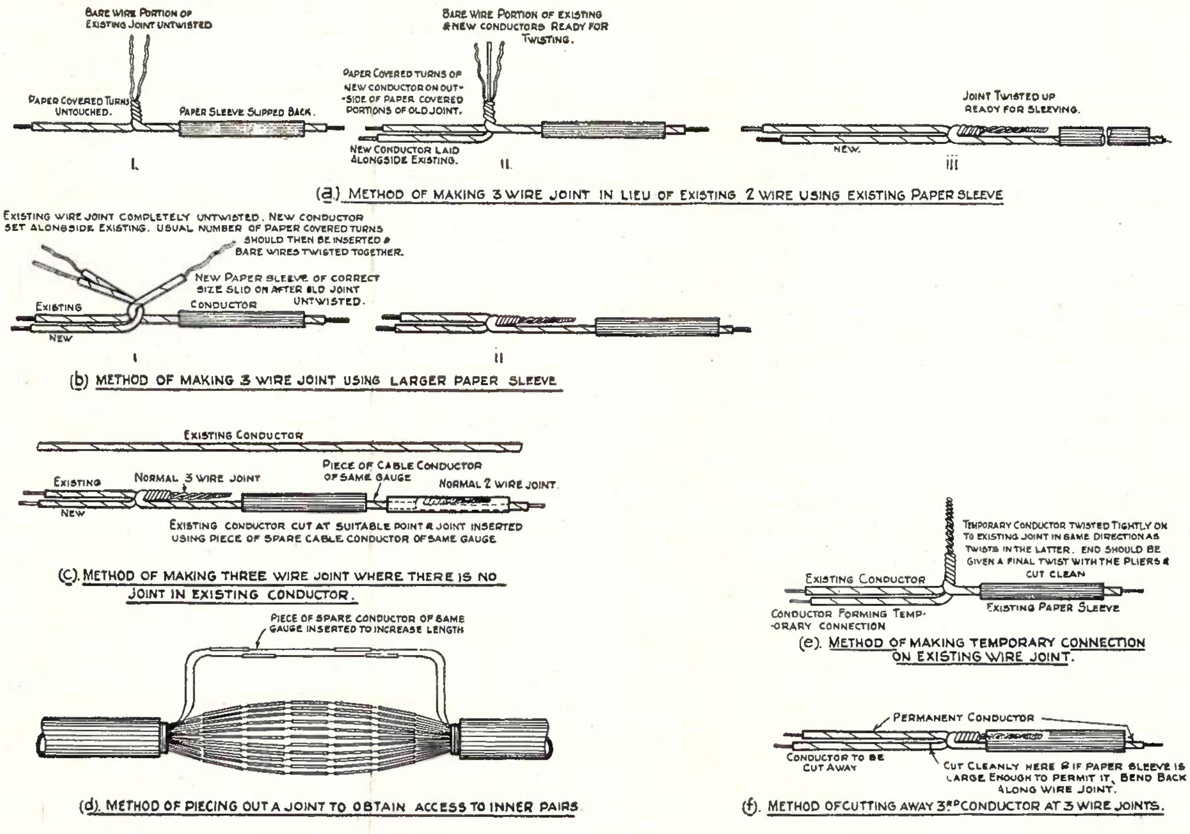


FIG. 24. METHOD OF ALTERING CONDUCTOR JOINTS ON EXISTING CABLE.

ing slack is left in the altered conductors so that they will not be too tight or too slack when the other conductors are set back to their original tension prior to the closing of the joint.

Where the tee-on is part of an intermediate stage in the operations (e.g., in the case of diversion of cables to a new exchange, etc.) it is necessary that the arrangement of the conductors to be included in the final connection be such that they will be disturbed as little as possible when the dead portions of the cables are cut away. The conductors which are to be cut away should as far as possible be arranged evenly among the permanent conductors so that when they are removed there will be little or no unevenness in the tension of the latter.

Conductor Jointing: Temporary Joints. — To avoid the possibility of loose contacts or other faults it is advisable to make temporary conductor joints in the same manner as permanent joints wherever it can be arranged, i.e., by adopting the standard twist arrangement. Depending on local conditions, ways and means of doing this will suggest themselves to jointers on most occasions. A typical case of a transfer of a lateral cable from one main cable to another involving a temporary cross-connection with standard twist joints while the jointer is waiting on the alteration of the jumpers at the M.D.F. is shown in Fig. 25, which is self-explanatory.

Where a cross-connection is to remain for only a very short period and is not likely to be subject to much disturbance, a suitable arrangement is to twist the cross-connecting conductor tightly on to the existing wire joint in the same direction as the twists in the latter (see Fig. 24 (e)). The ends of the wires should be given a final twist with the pliers and snipped clean.

Cutting Away Conductors at Tee-on and Other Points.—The cutting away of temporary cross-connections and of conductors at tee-on points should be done so that there will be no disturbance or danger of damage to the permanent conductors and their joints. This is done by sliding the paper sleeve off the joint away from the conductor to be cut until the paper-covered portion of the twists is showing. The conductor to be removed should be cut cleanly about a $\frac{1}{4}$ in. back from this point, vide Fig. 24 (f). The paper sleeve should then be slid back into position.

The cable pairs from which a branch or lateral cable is transferred may not proceed beyond the joint concerned. It will then be necessary to insulate them as the branch or lateral cable is cut away.

Where through connections are cut away, as in the case of cable cut at or near an exchange boundary after a cutover to a new exchange, the conductors should be cut on both sides of the old wire joints so that these are entirely eliminated and the pairs insulated on each side. Very often in cases of this nature the cable will be entirely "dead" on one side and will be recovered later. In this case there will be no need to insulate the conductors on this side.

Before any attempt is made to cut away a conductor at any point, the operator should be certain that the cable pairs are dead. It is particularly important to watch this point at locations where cross-connections of a permanent nature have been made between pairs or where pairs have been by-passed clear of the exchange for special purposes or where other conditions of an abnormal nature exist.

Precautions for the Avoidance of Interruption to Services.—The necessity for every effort to avoid interruption to services must be stressed again, especially where busy and important circuits are concerned. The adoption of the following rules when performing jointing work on working cables will help very considerably towards the attainment of the ideal:—

(i.) Carefully consider each step to be taken during the alterations and ensure that there is

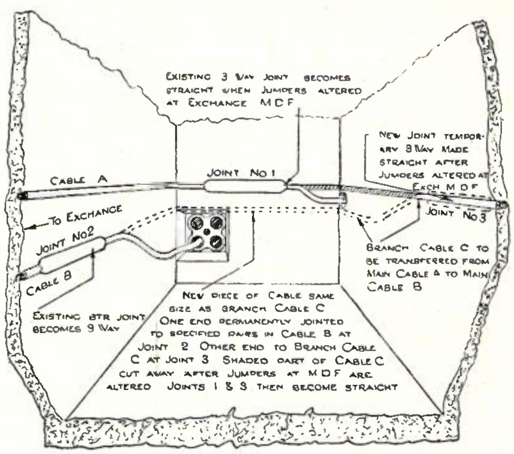


Fig 25. Showing a method of transferring a branch Cable C from a Main Cable A to another Main Cable B, using temporary tee-on method while waiting for alteration of Jumpers at Exchange M.D.F

proper co-ordination with other operators so that each working line will be kept as free from interruption as it is possible to arrange. Check details of transfer sheets before altering working pairs.

(ii.) Arrange with the exchange for a test out of each working line immediately after any alteration is made to guard against any prolonged interruption. Any lines reported faulty should be attended to immediately. With a view to avoiding the possibility of having to return and re-open a joint, an "All Clear" should be obtained from the exchange before finally closing a joint.

(iii.) When connecting spare pairs in new positions, make sure that they are clear of faults and not likely to cause interruption to any existing working line in the new position. Make sure recorded spare pairs which it is proposed to cut or alter are not working pairs which are incorrectly recorded.

(iv.) Before cutting the conductors of or otherwise interfering with working pairs, make sure that a conversation is not progressing, so that subscribers will not be cut off suddenly during a conversation.

(v.) Where the proper functioning of a circuit is likely to be affected by the reversal of the legs of the pair, alter each leg separately so as to avoid any possibility of confusion, i.e., start on the A leg and complete its alteration before touching the B leg or vice versa.

(vi.) Where conditions are not dry and loss of insulation in the opened cable is likely to take place, the precautions referred to in Part 1 should be followed. Where these cannot be followed or are not completely effective, the joint should be dried out from time to time by one of the methods suggested in Part 2, or if power is available, by applying an electric blower. Another method of drying a joint is to use a special drying agent such as silica gel.

(vii.) When a joint has to be left unplumbed overnight, it should be dried out and then if there is no danger of water reaching the joint it should be carefully wrapped first with dry clean cloth such as moleskin or muslin (previously boiled) and finally with waterproof material, making it as airtight and waterproof as circumstances will permit. The use of rubber bandages —well stretched when applied and allowing a good overlap, both on the turns and on the sheathing—is normally the most effective for any final wrapping. Where there is any danger of water reaching the joint, a temporary lead sleeve should be fitted. Even when leaving the jointing chamber for short periods during the day an opened joint should be protected by covering it with waterproof material or wrapping it up as just described.

(viii.) When cutting the conductors of working pairs or cross-connections thereto, only cut one wire at a time. It is also a good idea to cover the handles of cutting pliers with short pieces of rubber tubing or a binding of insulating tape. The former precaution will minimize the introduction of shorts and the latter of earths, on working lines.

(ix.) As far as possible keep exposed parts of the body clear of earths while handling conductors. All clothing should be kept as dry as possible. Where manholes are damp, the feet should be kept dry by standing on dry boards laid clear of any water or by wearing rubber boots.

Completion of Work.—On completion of any jointing operation in a tunnel, or manhole, or other jointing chamber, the joint should be carefully inspected before sealing as set out in Part 2. After the joint is closed the following points should be given careful attention:—

(i.) Make sure that the cables are set up neatly and are properly supported. It is advisable to support small cables, which have been jointed to larger ones, by a lead strap soldered to the larger cable at a point about three or four inches from the wipe.

(ii.) Inspect all cables in the jointing chamber for conditions likely to give rise to trouble, such as:—

(a) Inadequate or defective supports.

(b) Cable bearing on edges (such as mouth of ducts) or projections of any description.

(c) Broken or cracked cable sheathing or wipes.

(d) Drainage bonds, connections to zinc plates or interconnecting bonds between cables, which are required for electrolysis reasons, broken or disconnected or otherwise defective.

(iii.) Leave the jointing chamber clean and tidy.

Wherever possible all necessary repairs should be given immediate attention. Where the conditions require special attention or if in doubt regarding the action to be taken the matter should be reported to a supervisory officer before leaving the spot.

Conclusion.—Attention is again drawn to the introduction to Part 1 of these articles and the necessity for accuracy and care above other considerations throughout all jointing operations. The attainment of this object and the simultaneous development of reasonable speed will be greatly assisted by the cultivation of methodical habits and the execution of each job in a neat and workmanlike manner. The cultivation of methodical habits applies to the handling of tools as well as to the actual details of jointing operations. As far as possible, tools required for a particular operation should be arranged in boxes and bags so that they can be withdrawn with a minimum of effort and time. Before starting any particular operation, each necessary tool should be set out in the handiest arrangement and a fixed arrangement of tools for each type of operation will be found most helpful.

In conclusion, the writer desires to record his indebtedness to a number of officers of the Department who have from time to time assisted him by advice and constructive criticism.

EDITOR'S NOTE.—As a knowledge of the value and properties of solders will assist greatly towards an understanding of the methods and precautions to be adopted when plumbing and wiping lead-covered cables, Mr. Newton will describe these phases of the duties of a cable jointer in the concluding portion of a subsequent series of articles on Soft Solders, Soldering and Wiping. The first article of this series will appear in Vol. 2, No. 4.

THE RACK-MOUNTING OF TELEPRINTER AUXILIARY APPARATUS

B. Edwards

In previous issues of this Journal reference has been made to the recent tendency towards the mounting of telegraph apparatus upon racks of standard type and dimensions. The advantages of rack-mounting are well known in the telephone field, and have always been recognized by telegraph engineers. The earlier adoption of rack-mounting in telegraph offices has been retarded by the demands of telegraph operating technique and the non-uniformity in the apparatus and circuit types available for consideration.

Neither objection is present where teleprinter circuits are concerned; and so, full advantage can be taken of the principles underlying this form of mounting. So far as the installation pictured in the following photographs is concerned, the services to be provided by the apparatus on the racks are of two general types: (a) Local point-to-point services in which two or more operating terminals are joined together through the cable network of the same city, and (b) Long distance point-to-point services in which an operating terminal in one city is joined to a second in another city over a telegraph trunk channel. In the latter case the trunk

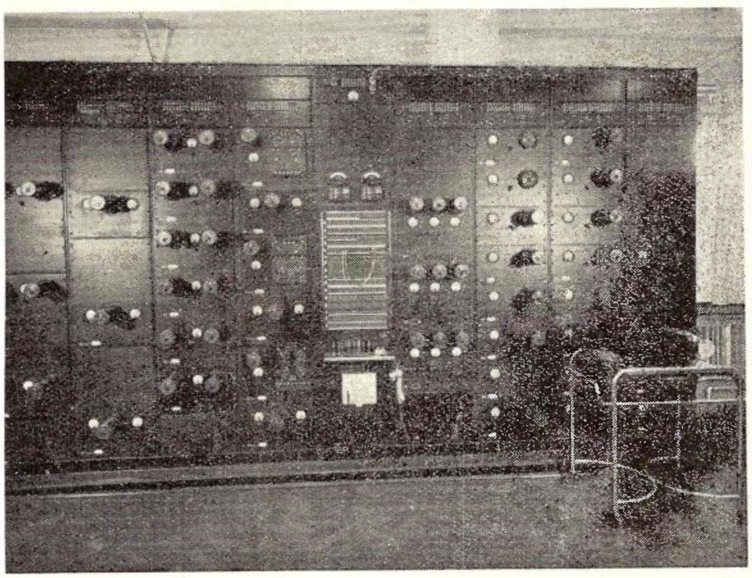


Fig. 1.—Front view of Teleprinter racks, C.T.O., Melbourne.

channel may be either a physical or a carrier channel, and so the line terminating apparatus provided must be of a type suitable for the channel which is to be used.

It will be convenient at this point to refer to Fig. 1, which is a full front view of the installation just completed in the Melbourne C.T.O. The racks were manufactured in the Postal Workshops in accordance with the designs covered by Drawing C.1190. The jack equipment, speaking and general testing gear is grouped on the central test bay. All of the lines and lessee's loops terminate here, as do the In and Out terminations of each separate relay set;

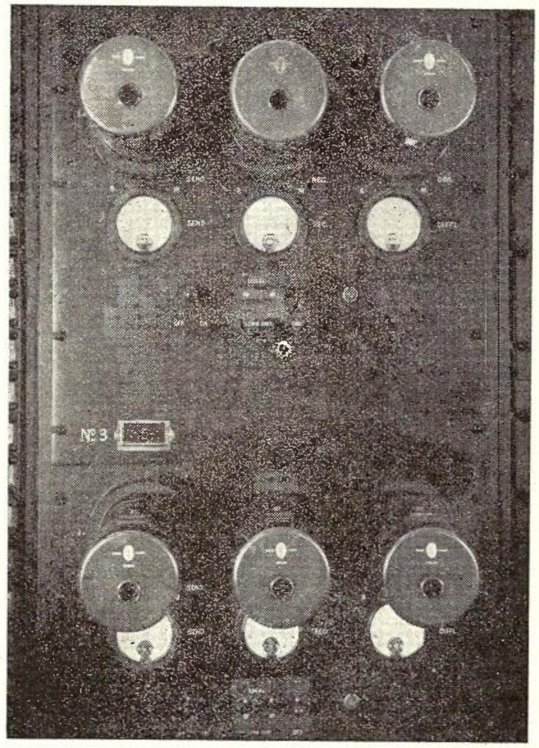


Fig. 2.—Observation and testing panels.

so that it is possible to patch any service to any relay set that would be suitable for the operation of that service. The test bay is fused for 40 volts, as local and alarm circuits are the only ones to be catered for at this point. On all other bays, 120 volts positive and negative are provided for the double current operation of the lines. In order that a standard voltage might be used on all loops, regardless of their length, together with uniform current values in the relay windings, resistances have been provided for adjusting the loops to a uniform resistance value. The limiting resistances are mounted at the rear of the test bay. Also at the rear of this bay, an I.D.F. is installed so that all of the inter-bay cross-connections may be made at a central location.

On the right of the test bay, as seen from the front, the observation and testing panels are mounted. A close-up of these panels is given in Fig. 2. Their purpose is to allow for the substitution of the usual working panel on either a local or long distance service. They may be used in conjunction with physical, carrier or U.G. cable channels when it is required to test with the teleprinter terminal stations; or for the observation of signals passing different points on any system without interruption to the normal service. An alarm lamp mounted on each panel gives warning should the switching keys be thrown for, say, a long distance test when the associated plugs are connecting the panel to a local point-to-point service.

Further to the right of the observation panels, three bays carry the local point-to-point relay equipments, one panel of which is illustrated in Fig. 3. The designation card which may be seen in the enlarged view specifies the name of the lessees and the numbers of the jack quads to which the lines and the normal working panel are connected. Since the system of numbering throughout the installation has been related, so far as possible, to the jack quad numbers, it is possible to trace the wiring, and so on, without the aid of diagrams. The horizontal mounting of the Creed relays will have been noted, and can be seen clearly in Fig. 3.

To the left of the test bay, alternate bays carry channel termination equipments and long distance auxiliary relay equipments. Two such

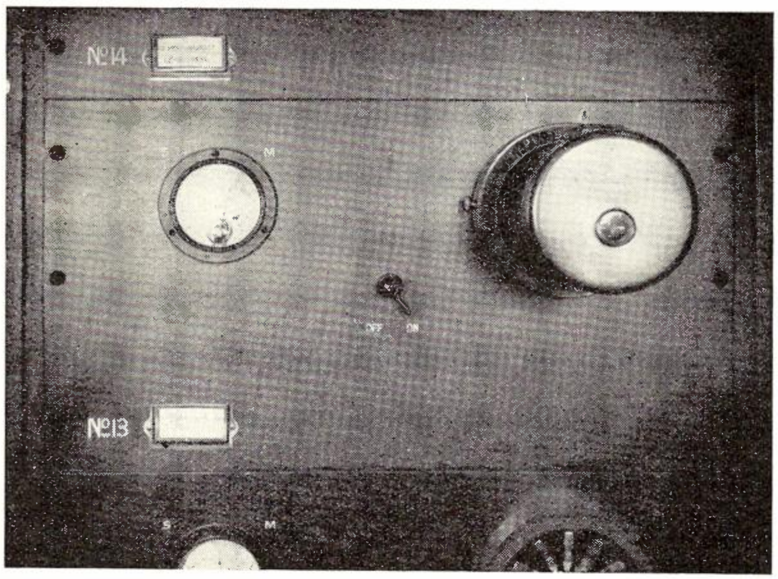


Fig. 3.—Panel mounted local point to point equipment.

bays are shown in Fig. 4, in which may be seen alternate panels of physical and carrier channel terminations on the right, and long distance auxiliary relay equipments on the left. Whether the channel terminations are mounted thus alternately or not depends on the services to be provided.

With final reference to Fig. 1, attention might be drawn to the portable teleprinter used for testing in conjunction with the test bay and the associated observation and testing panels. Three portable teleprinters have been provided with the installation being described (one for each of the testing panels); and connection points, together with the necessary power outlets, are available

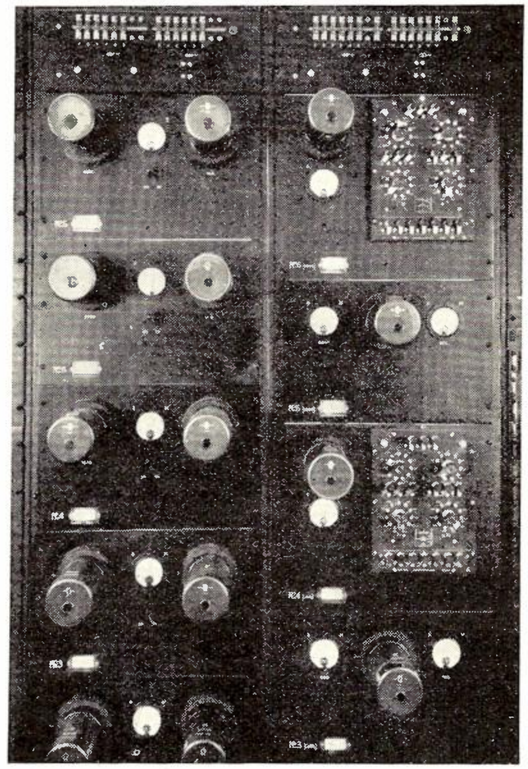


Fig. 4.—Long-distance auxiliary relay equipments and line terminal equipments.

for each, at regular intervals throughout the length of the racks.

Having thus briefly scanned the face of the teleprinter racks, something might be said of what lies behind the polished exterior. Fig. 7 is the schematic circuit of a local point-to-point panel. The single Creed polarized relay is connected so that the single current signals delivered into the U circle winding from the teleprinter transmitter at either terminal station are converted into double current signals at the tongue of the relay. Being connected to both of the receiving loops in parallel, the relay tongue transmits the signals to the distant teleprinter, which at this time is the receiving station proper, and also to the station from which the signals are being transmitted in order that that station might obtain a home-record. It will be noted that the circuit can be used only in one direction at a time; and the necessity for a home-record arises, inter alia, because of the manipulation of these machines by operators who are not trained to "blind" sending.

In designing these circuits on direct current principles, it was considered advisable to ensure the utmost simplicity of the apparatus at the lessee's premises; so that, apart from the teleprinters themselves, all of the apparatus involved in routine tests, and so on, would be confined to the C.T.O. For this reason, the type of signalling used on the sending loops was made single current, and though, as a result of this, limitations might be placed on the length of loop over which good working could be secured, the provision of line "battery" at the lessee's premises was obviated. Should difficulty arise because of excessive signal distortion being introduced by a long single current loop, effective measures could easily be taken in that particular case. (See "Telecommunication Journal," Vol. 1, No. 5, page 223.)

Previous reference to jack quads can be elucidated here. In Fig. 7, on each side of the relay equipment, the send and receive loops pass

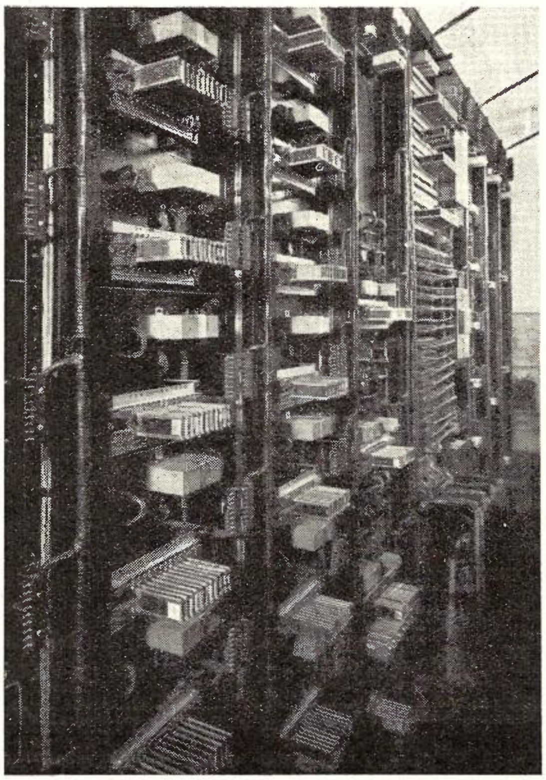


Fig. 5.—Rear view of racks from local point to point end.

through In and Out jacks which together form a group of four. As located in the jack field on the test bay, the jacks of any "quad" form the four corners of a square; therefore it is possible to designate them with a number placed in the centre of the square. The single wires from the jacks of a quad are run to four point tag strips, and each set of four tags is designated by the same number as is the corresponding jack quad. Further, by the use of the general terms, "In," "Out," "Send," "Receive," each of the jacks can be individualized.

In common with the long distance auxiliary relay circuit, the local point-to-point schematic shows (a) the adjusting resistances in the local loops; (b) the shunted condensers introduced into the send and receive loops for the purpose of signal shape correction; and (c) the milliammeter in the relay "split" for the checking of loop and bias winding currents. From the "obs" jack, connection may be taken for the observation of passing signals.

Of the two bays illustrated in Fig. 4, that on the right carries the telegraph trunk line terminating equipments. The circuits used in these terminations are well known, being the ordinary differential duplex for the physical channels, and direct sending and receiving loops to the carrier equipment for the carrier channels. The relay seen on the carrier terminal panel is in the receiving loop, it being a more flexible arrangement to have a receiving relay at the C.T.O. rather than to connect the auxiliary apparatus straight into the tongue of the 209 FA relay at the carrier receiving terminal.

In order to provide long distance teleprinter operation on the usual basis; i.e., operation in one direction only at a time, home-record at the sending end, and means of allowing the distant station to "break" the transmission; auxiliary equipment must be added to each line terminal equipment. Long distance auxiliary relay equipments of this kind are seen mounted on the left hand bay in Fig. 4, and the schematic circuit of these equipments is shown in Fig. 6.

From the latter figure it will be clear that the "local" teleprinter terminal is connected up on the same general scheme as that used for local point-to-point services. There are two auxiliary relays in place of the single relay of Fig. 7, and these are usually termed the sending relay and the home-record relay. In order that the signals sent into the line might be as distortion free as possible, the send side of the physical or carrier terminal has been kept free of all parallel circuits by the use of the separate sending relay. Further, should a voltage other than 120 be desirable on any particular channel, the necessary change can be made on the send relay contacts without upsetting the standard arrangement on the local side of the equipment.

Before referring to the contact arrangement which will have been noted on the home-record relay, something of the operating features of teleprinters might be recalled. When a teleprinter system is lined up for service, but no transmission is taking place, both of the teleprinter transmitter tongues are resting on their marking contacts. They are sending negative potential to line in order that the distant receiver might be held stationary in the rest position, and the particular signal element being transmitted at this time is known as the stop signal. At the end of every letter code transmitted, and for as long as the transmitter might remain idle between transmissions, this negative potential or stop signal is applied to the line.

Returning then to the home-record relay in Fig. 6, it will be seen that the spacing contact has positive potential connected directly to it, but that the marking contact receives its potential from the tongue of the line receiving relay. While the latter relay is held to the marking side under the influence of the stop signal from the far end, the marking contact of the home-record relay will have negative potential applied to it. Under this condition, the operation of the home-record relay under the influence of the local teleprinter transmitter will supply a home-record to the local teleprinter receiver. During this process, any movement of the line relay tongue to the spacing side will mutilate the home record being received on the local machine. It is thus within the power of the distant operator to "break" the transmission being sent, by operating his transmitter and thereby mutilating the home-record of the sending station.

The provision of the "breaking" facility in this way on long distant services makes necessary the inclusion of a device during testing which it is not necessary to include in local point-to-point circuits. When it is desired to test with the distant station, a testing equipment (shown in Fig. 2) is connected to the long distance terminal OUT jacks. Since this operation opens the receiving side between the line receiving relay and the home-record relay, the local teleprinter would, in the ordinary course of events, lose the negative potential essential to hold it in the rest position. But by arranging for the

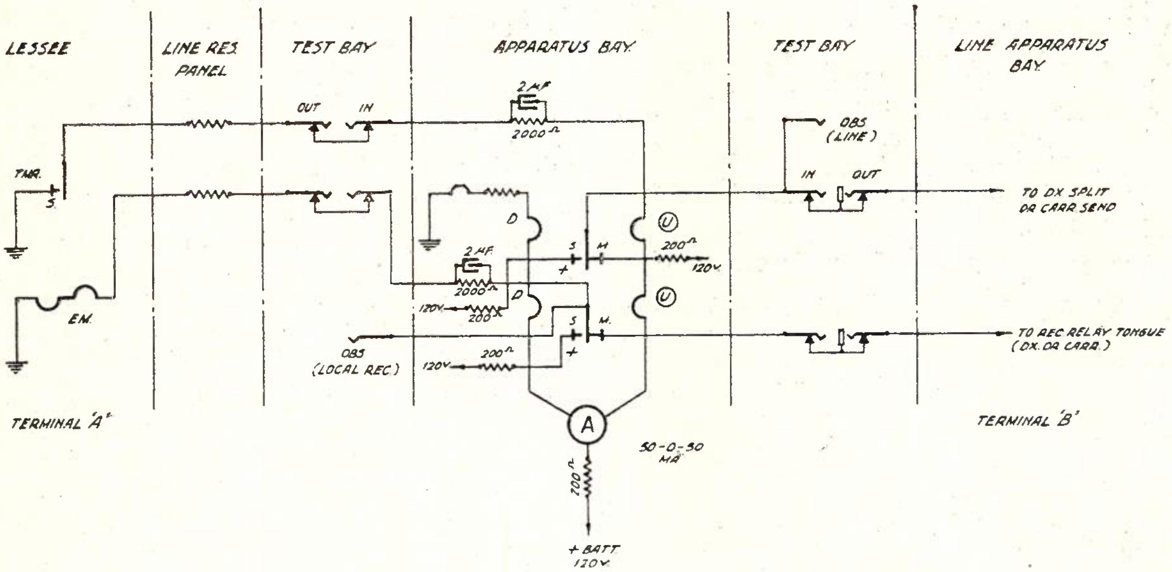


Fig. 6.—Long-distance auxiliary relay equipment, schematic circuit.

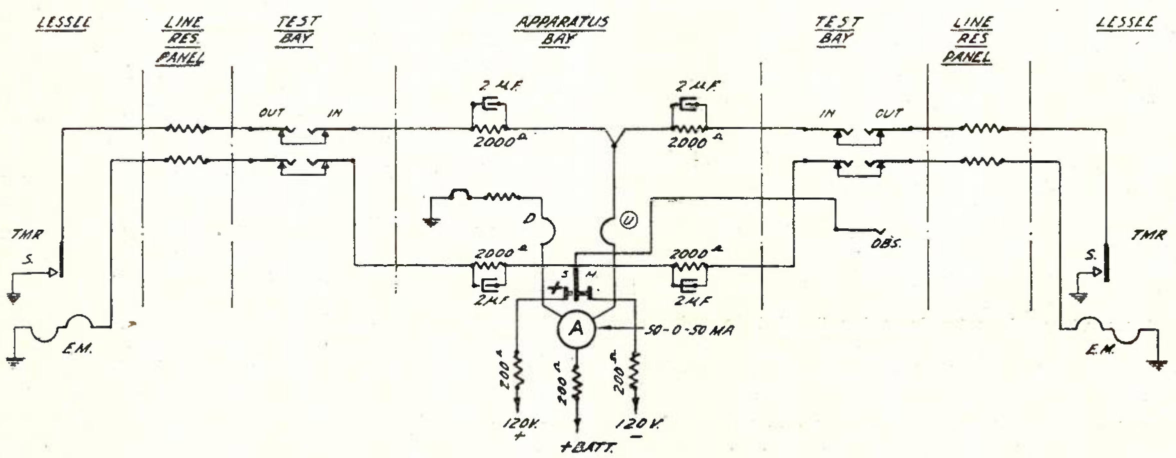


Fig. 7.—Local point to point equipment, schematic circuit.

sleeve connections of the test plugs to be connected together, the negative potential from the send relay tongue is joined to the marking contact of the home-record relay in place of that which has been cut off from the line relay. In this, or any other teleprinter circuit, a marking potential must be placed on the receiving loop whenever a working teleprinter is isolated from its operating relay.

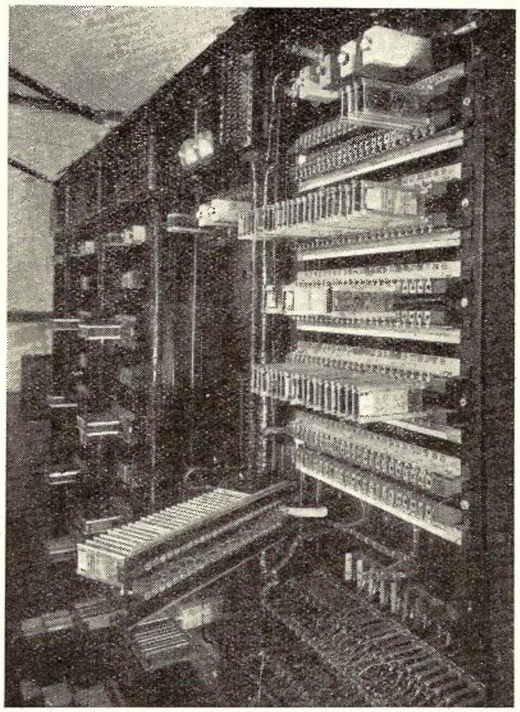


Fig. 8.—Rear view of test bay, showing gate mounting of mica resistance spools.

The circuit appertaining to the observation and testing panels depicted in Fig. 2, is merely a combination of the types shown in Figs. 6 and 7. It is possible, by means of keys, to connect the portable testing teleprinter as the "local" terminal of either a long distance or a local point-to-point equipment, while the other side of the equipment is brought out to plugs for connection into the jacks on the test bay as required. The third relay to be seen in Fig. 2 is the observation relay which is connected in the conventional way.

Having described at some length the two main circuit arrangements associated with these racks, readers might be referred to Drawing C.1190 and to "Telecommunication Journal," Vol. 2, No. 2, page 76, for further information.

Fig. 5 shows a rear view from the local point-to-point end of the racks. Of note here is the method of terminating the wiring from each panel on a tag strip which is mounted alongside a similar strip bearing the incoming wiring terminations. By cutting the bare wire bonds between these two strips, it is possible to remove a panel intact should any bench work be required. Each piece of apparatus on a panel is designated in accordance with the letter or figure designation given to that piece of apparatus in the wiring diagram for the panel. Mica spool type resistances have been used almost exclusively, and these have been mounted on a specially designed gate which allows of their quick and safe removal or substitution.

Details of the resistance mounting gates are given on sheets 4 and 16 of Drawing C.1190, and in Fig. 8 gates mounting 24 line limiting resistances are illustrated. One of the gates has been swung open the better to show the ferrules which screw on to the 3B.A. threads already existing on the shanks of standard spools. The ferrules hold the brass nuts of the spools in electrical contact with the terminals to which the wiring is connected. In order to remove a spool it is only necessary to loosen the ferrules with a screwdriver and to pull the spool forward. The ferrules are non-removable in the ordinary sense, and cannot short-circuit with one another at any time.

ANSWERS TO EXAMINATION PAPERS

The answers to examination papers are not claimed to be thoroughly exhaustive and complete, 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. 2107.—MECHANIC, GRADE 2 SECTION "C"—BROADCASTING

J D. CAMPBELL

Q. 1.—With the aid of circuit diagrams describe the two methods of modulating a high frequency carrier wave with audio frequencies, specified below—

(i.) Plate modulation;

(ii.) Grid modulation.

What are the advantages and disadvantages of each method?

A.—(i.) A schematic diagram of an arrangement for plate modulation is shown in Figure 1. Valve V1 is an audio amplifier. Valve V2 is a high frequency power amplifier which amplifies the high frequency carrier wave. The plate supply for both V1 and V2 is supplied from a common source through the modulation choke L1 which has a high impedance to audio frequencies. Since L1 tends to resist any change in the current taken from the H.T. Supply, it may be said to tend to keep constant, the sum of the currents taken by V1 and V2. When an audio frequency voltage is applied to the grid of V1, the plate current of V1 varies in accordance with this voltage. As the sum of the plate currents is constant, the plate current of V2 will vary also and so modulation of the high frequency carrier is effected.

QUESTION 1.

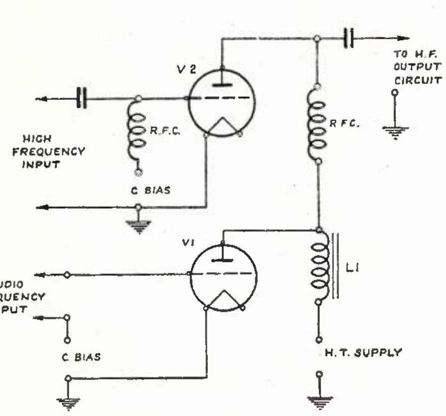


FIGURE 1

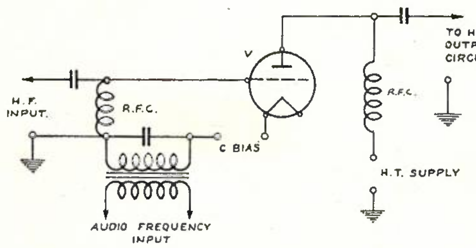


FIGURE 2

(ii.) The principle of grid modulation is indicated in Figure 2. The valve V is a high frequency power amplifier which amplifies the high frequency carrier. In series in the grid circuit of this amplifier, is connected the source of high frequency carrier, the secondary of an audio frequency transformer and the grid bias supply. The secondary is shunted by a small condenser in order to reduce its impedance at the carrier frequency. The audio frequency voltages are applied to the primary of the transformer and the voltage variations in the secondary vary the potential of the grid, thus modulating the carrier frequency output of the amplifier.

The advantage of plate modulation is that it is possible to obtain large modulation percentages with low distortion. The chief disadvantage is that to obtain the high percentages of modulation the audio amplifier must be large in comparison with the modulated amplifier and the system as a whole is inefficient.

Grid modulation possesses the advantage that a relatively small amount of audio power is needed to modulate the carrier, but the system possesses the disadvantage that it is not possible to obtain large modulation percentages without distortion.

Q. 2.—Show the schematic circuits of—

(i.) a self-oscillator;

(ii.) a crystal controlled oscillator,

as used in a radio transmitter and describe the operation of each.

What measures are adopted to ensure that the frequency of the crystal oscillator remains constant and why are these measures necessary?

A.—(i.) Figure 1 shows the circuit of a valve oscillator which consists, essentially, of an oscillatory circuit L1C and a valve amplifier V. The circuit is arranged so that part of the energy in the output circuit is returned to the grid circuit, where it is amplified and again returned by the plate filament circuit to the output circuit. The circuit will oscillate at a frequency determined by L1 and C, provided the voltage reacted back on to the grid is 180° out of phase with the anode voltage and provided that this voltage exceeds a certain value. In the diagram these conditions are provided for by the grid coupling coil L1 which is tightly coupled to the anode coil L. The H.T. supply is fed to the valve through the high frequency choke L2. Power is drawn from the circuit via the coupling condenser C1.

QUESTION 2.

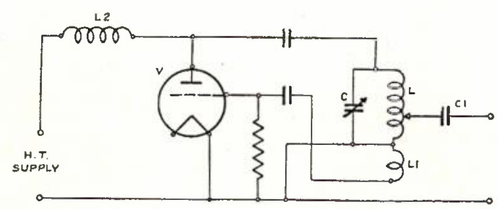


FIGURE 1.

(ii.) Figure 2 shows a schematic circuit of a crystal oscillator. The circuit is essentially that of a tuned grid tuned plate oscillator, the feedback being provided by the grid plate capacity of the valve V. The crystal is connected in the grid circuit of the valve and an oscillatory circuit LC in the plate circuit. If the LC circuit is tuned to a frequency which is slightly higher than the frequency of the crystal, the circuit will oscillate at a frequency which is determined mainly by the constants of the crystal. C1 is a small variable condenser which is used to alter the operating frequency by a small amount. Power may be drawn from the circuit by the coupling coil L1.

The measures which are adopted to ensure that the frequency of the crystal oscillator remains constant are as follows:—

(a) The crystal should be cut from the quartz block in such a manner as to have a minimum temperature coefficient;

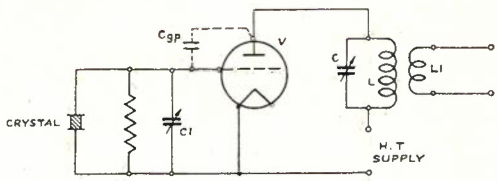


FIGURE 2.

(b) It should be placed in an oven which maintains the temperature substantially constant;

(c) The power supplies to the oscillator should be kept constant;

(d) The power drawn from the oscillator should be small and the amount kept constant;

(e) The crystal and holder should not be subjected to mechanical vibration.

These measures are necessary in order that the transmitter shall cause a minimum of interference with other transmitters which are transmitting on the same frequency or on neighbouring channels.

Q. 3.—In operating a triode valve as a class A amplifier, the grid is maintained at a potential which is negative with respect to the filament. Why is this necessary?

A.—It is necessary to maintain the grid at a negative potential with respect to the filament or cathode in a class A amplifier in order that the current in the plate circuit shall be directly proportional to the varying voltage applied to the grid circuit. Figure 1 shows a typical curve of the variation of plate current with

QUESTION 3

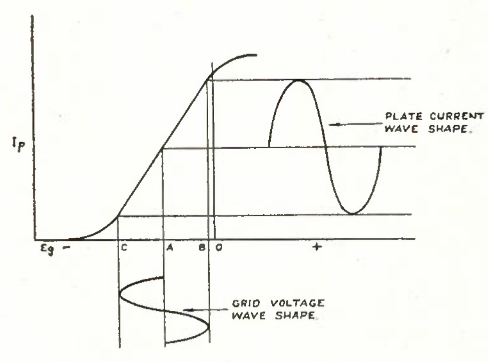


FIGURE 1.

grid voltage. It is seen from this curve that if the grid bias is fixed at point A and an alternating voltage is applied to the grid, the grid voltage swings more or less negative about the mean value at A and the plate current swings up and down about the mean plate current. Providing that the alternating grid voltage does not exceed values marked by points B and C, the plate current wave shape will be a replica of the grid voltage wave shape. If the bias be altered or the input voltage increased so that grid voltage swings past points B and C, the output from the amplifier will be distorted.

Q. 4.—Give a diagram of a two-stage resistance coupled audio frequency amplifier suitable for operation between circuits of 600 ohms impedance.

Show what additional components would be required to provide decoupling in the grid and plate circuits of the first stage and give the approximate values of these.

QUESTION 4

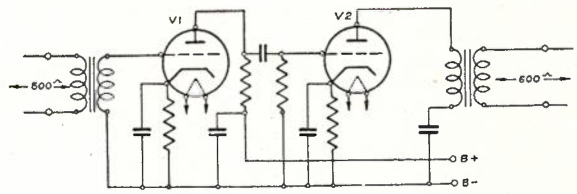


FIGURE 1.

A.—Figure 1 shows the schematic circuit of a resistance coupled amplifier suitable for operation between circuits of 600 ohms impedance. The amplifier employs indirectly heated valves V1 and V2 with cathode resistors for providing grid bias. The transformers T1 and T2 are of suitable design to provide input and output circuits of 600 ohms.

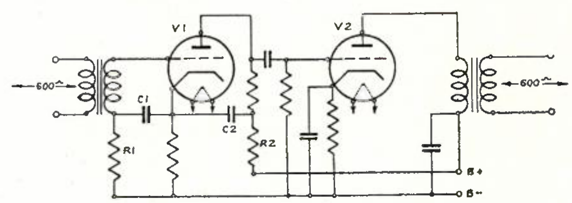


FIGURE 2.

Figure 2 shows the modified circuit to provide decoupling in the grid and plate circuits of the first stage.

The approximate values of the components are:—

R1 = 100,000 ohms.
R2 = 10,000 ohms.
C1 = 0.5μF.
C2 = 2μF.

Q. 5.—A control room is required to supply branches of the programme generated in its associated studio as follows:—

(i.) To the transmitting station;
(ii.) to the trunk test room;
(iii.) to the monitoring equipment.

By means of a block schematic, show what equipment would be required to provide these branch transmissions and give a brief description of the equipment, stating reasons for necessitating its provision.

A.—In the diagram A is the main control room speech amplifier, the purpose of which is to bring the programme up to a level suitable for sending to the line connecting the control room with the station. The gain of this amplifier is very high, of the order of 100 db, as the output of the microphones is very low. A gain control is provided variable in steps of approximately 2 db by which the control operator is able to modify the programme range and to keep the output level at the proper value. The output of the speech amplifier is connected to the line and the programme level is monitored by means of a volume indicator B connected across the line. Also connected at this point is a two-channel splitting amplifier C of low gain which provides a separate programme output to the trunk test desk and to the monitoring equipment. This amplifier acts as a buffer between these two circuits and the output to line, and prevents any variation or disturbance which may occur in the circuits from affecting the output to line. The volume indicator is calibrated in

QUESTION 5.

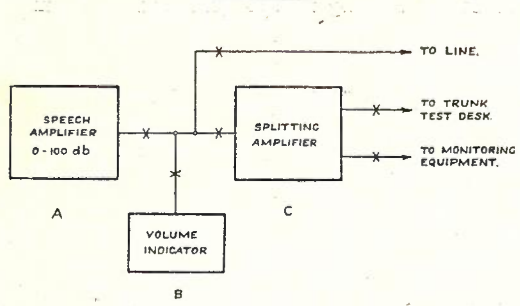


FIGURE 1.

decibels and is designed to follow the rapid variations in programme level. The input circuits to the indicator and the splitting amplifiers are of high impedance in order that they will not draw an appreciable amount of power from the main load. Jacks are provided at points marked X in the diagram to give monitoring facilities.

EXAMINATION NO. 2106—ENGINEER—TRANSMISSION

A. H. KAYE, B.Sc

Section 1.—General Theory and Measurements

Q. 1.—(a) What is the attenuation in decibels per mile at 5,000 radians of a cable circuit having the following characteristics per loop mile:—

Resistance	**88 ohms.**
Inductance	**0.001 henry.**
Leakance	**1×10^{-6} mho.**
Capacity	**0.065 microfarad.**

(b) If loading coils having an inductance of 0.088 henry are added at intervals of 1.136 miles, what is the attenuation per mile?

The candidate should use approximate formulæ.

A.—(a) In the case of cable circuits, as in the example, inductance and leakance are very small, and the approximate formula for attenuation constant becomes:—

$$\alpha = \sqrt{\omega CR/2}$$
$$= \sqrt{(5000 \times .065 \times 88 \times 10^{-6})/2}$$
$$= 0.1195 \text{ nepers per mile}$$
$$= 1.04 \text{ db per mile.}$$

(b) For loaded cables the leakance is small, and the approximate formula is:—

$$\alpha = R/2.\sqrt{C/L}$$

For coils of 88 millihenry inductance at a spacing of 1.136 miles—

$$L = 0.088/1.136$$
$$= 0.0775 \text{ henry per mile.}$$

Hence—

$$\alpha = 44\sqrt{.065 \times 10^{-6}/.0775}$$
$$= 44 \times 10^{-3} \times .916$$
$$= .04 \text{ nepers per mile}$$
$$= .35 \text{ db per mile.}$$

In the above—

α is the attenuation in nepers per mile.

ω radians equals $2\pi f$, f being frequency in cycles per second.

C = capacity in farads per loop mile.

R = resistance in ohms per loop mile.

L = inductance in henries per loop mile.

Q. 2.—(a) What are the important requirements to be met by a variable oscillator for use on transmission measurements up to 50,000 cycles per second?

(b) Describe an oscillator which meets these requirements, and give a schematic diagram of the circuit.

A.—(a) A variable oscillator for use on transmission measurements must in general provide the following requirements:—

(i) **Calibration.** The oscillator should be suitable for use down to at least 100 cycles per second, and should be calibrated at frequent intervals, such that interpolation on a linear basis between calibrated points gives accurate frequency settings.

(ii) **Accuracy.** The frequency setting should be accurate to within 1%, and this accuracy must be independent of variation of filament and anode power supplies within the working limits which may be taken as 10% of the normal voltages. The accuracy must likewise be independent of temperature variations likely to be experienced in practice, of tube replacements and of ageing of components. Weather conditions, i.e., temperature and humidity, should not affect the frequency.

(iii) **Output.** The output impedance of the oscillator should be approximately 600 ohms non-reactive.

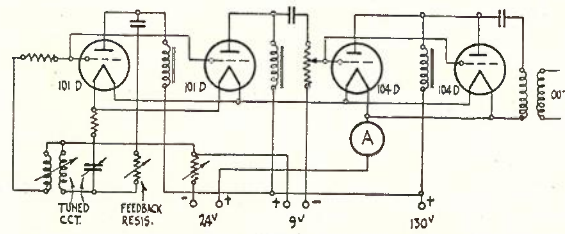


FIG. 1

An output power of not less than one watt will be required, and, up to this, power level must be substantially free from harmonics, i.e., the output wave shape is to be a pure sine wave. On a voltage basis the percentage of harmonics in the output should be not greater than 1%. The output power is to be continuously and smoothly variable, and for any output setting the level must not change with frequency.

(iv) **Shielding.** Shielding is to be such that the oscillator is not affected by the presence of external fields, and must not generate fields likely to interfere with other equipment.

(v) **Mechanical Requirements.** The oscillator must be of robust construction and the components and wiring readily accessible for ease of maintenance. This is particularly important in the case of an oscillator required for portable use, in which case there is the further requirement that it must be of light weight and suitably mounted for transport.

(b) The Type 8A oscillator manufactured by Standard Telephones & Cables is a portable instrument suitable for use on carrier and voice-frequency measurements. The apparatus is mounted on an angle iron framework to which is attached the panel carrying controls, meters, etc., the whole being mounted in a substantial wooden case.

Figure 1 gives the circuit of the oscillator, which is of a straightforward feedback type using one 101D tube. Following the oscillator tube is a second 101D which operates as an amplifier. Two 104D tubes in parallel are choke capacity coupled to this amplifier tube, thence through an output transformer to the test circuit.

Control of the frequency is arranged through one dial which selects the required inductance coil and three dials which select the tuning condenser. An air condenser which overlaps the steps of the last dial provides fine tuning. Coarse and fine potentiometers preceding the parallel 104D tubes give output control.

Battery supplies required are 24 Volts for filament heating, 130 Volts for anode supply and 9 Volts for grid bias. An ammeter and a rheostat are provided for adjustment of the filament current.

Q. 3.—(a) What are the essential differences between a "balance network" in a voice-frequency repeater and an "equivalent T network"?

(b) On an open wire line a voice-frequency repeater is installed at an intermediate station. State—

(i) What tests you would make to determine the line characteristics to be reproduced in the balance networks; do not describe the methods of making the tests.

(ii) Within what limits the balance networks should match the line characteristics.

(iii) The form of network you would use.

A.—(a) A balance network as used in a voice-frequency repeater is a 2-terminal network, and is required to have similar impedance characteristics over the range of frequencies being transmitted by the voice-frequency repeater, to the line with which it would be associated.

Fig. 1.

An equivalent T network is a 4-terminal network having series and shunt arms, and when correctly terminated it can be made to represent from the point of view of both impedance and propagation constant any finite length of line at one frequency.

(b) (i) With the far end terminated in an impedance of 600 ohms non-reactive, measure the impedance, i.e., the resistance and reactance, components of the line over the range of frequencies which is to be transmitted by the repeater. Usually this will involve measurements at intervals of 100 cycles per second from 200 to 2800 cycles per second, but where the line is not uniform sufficient additional intermediate measurements

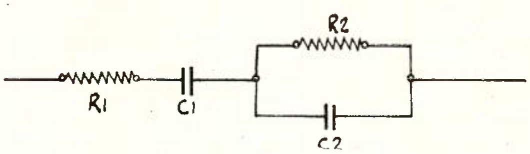


Fig. 2.

should be made so that irregularities in the impedance curve are definitely determined.

(ii) The balance networks should match the impedance characteristics of the line as closely as possible within the frequency limits of the repeater. If any irregularity exists along the line the network should be designed to follow the mean impedance-frequency curve. The difference between network and line impedances must not exceed 10% of the network impedance.

(iii) For a uniform open wire line a network of the general form shown in Figure 1 will probably be satisfactory, but usually the presence of cables leading into the exchange and exchange wiring complicates the problem, and in general the network shown in Figure 2 would be required.

Section 2.—Radio Transmission and Acoustics

Q. 4.—A type of antenna for a radio-telephone broadcasting station consists of a mast of a height slightly greater than half wave length. Discuss the advantages and disadvantages of such a radiating system as compared with an antenna of the quarter wave type.

A.—For use with a radio-telephone broadcasting transmitter in the 550-1500 kC per second band it is desirable that the radiating system be such as to provide as strong a horizontal ground wave as practicable with a minimum of high angle radiation.

The reason for this refers primarily to night transmission when the high angle (or sky) wave is returned to earth by the ionosphere and adds vectorially to the low angle (ground) wave. Due to minor fluctuations of the ionosphere, the phase of the received sky wave will vary, alternately adding to or subtracting from the ground wave causing "fading." This fading is obviously most serious when the magnitudes of the two waves are equal or approximately equal and the point at which this occurs places the limit on the "primary service area" of the transmitter. The attenuation of the ground wave is greater than that of the sky wave and hence it is desirable to limit the sky radiation at the transmitter in order to ensure that this wave is small compared with the ground wave for as great a distance from the transmitter as possible.

Some appreciable distance from the transmitter and beyond the abovementioned interference zone, the low angle radiation will meet the ionosphere and, being reflected, will provide the "secondary service area." The signal in this area is obviously dependent on the strength of the low angle radiation.

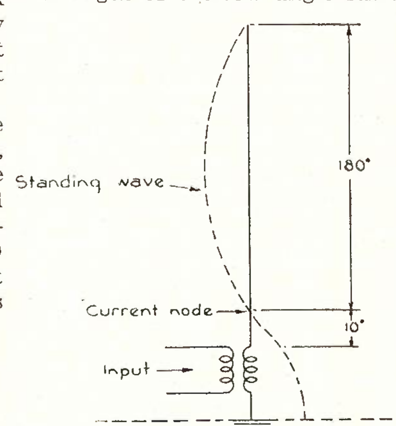


Fig. 1a.

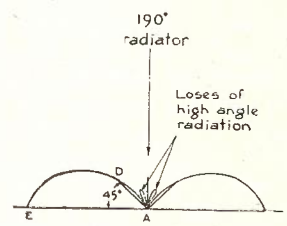


Fig. 1b.

During daylight hours the sky wave causes little trouble, but it is desirable that the ground wave be as strong as possible in order that it may extend over a wide area.

When correctly tuned, a standing current wave is formed on the antenna, and the field around the antenna will depend on the number and position of the nodes and loops (anti-nodes) so formed. Considering the antenna slightly greater in length than half wave length, the current distribution in mast and coupling unit is shown in Figure 1A, and results in a radiation pattern as indicated by the vertical polar diagram in Figure 1B.

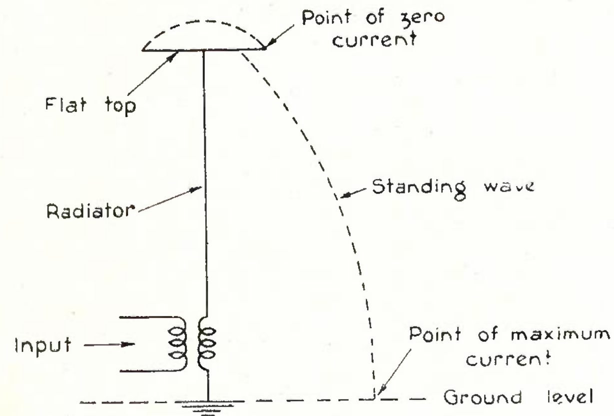


Fig. 2a.

The ratio of the length of the line A-D drawn at 45 degrees to the horizontal is the ratio of the energy radiated at an angle of 45 degrees to that radiated horizontally.

The two small lobes on Figure 1B should be noted as indicating high angle radiation; their magnitude is very small.

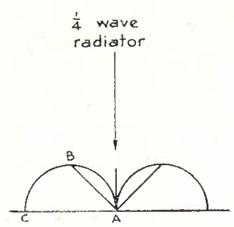


Fig. 2b.

Compare these figures with the case of the quarter wave aerial, which usually consists of a vertical wire somewhat less than a quarter wave supporting and connected to a horizontal flat top, and whose current distribution and vertical polar diagram are shown in Figures 2A and 2B.

The "half wave" antenna provides a more satisfactory vertical polar diagram, as the greater part of the radiated energy is concentrated at low angles.

From the above it follows that, from the point of view of service area, the half wave radiator has the following advantages over the quarter wave:—

(i) It is more efficient for the daylight transmission on account of the stronger ground wave.

(ii) It is more efficient for night transmission as the zone in which fading-distortion (interference) occurs is further out owing to the higher ratio between low angle and high angle radiation.

(iii) The "secondary service area"—night transmission—is more extensive because more energy is concentrated at low angles.

On the other hand, where service is required only over a limited area and the points mentioned above are of less importance the quarter wave antenna may be more suitable, since the great height of the half wave radiator has the following disadvantages:—

(i) It is very costly to install and maintenance costs are higher.

(ii) More attention must be given to protection from lightning.

(iii) There is greater danger to aviation, and an expensive system of warning lights must be provided.

(iv) A large area of land is required, whereas a quarter wave radiator may be erected in cities on the roof of a building.

Q. 5.—Give a circuit diagram of a rectifier suitable for providing 2 Amperes at 12,000 Volts for the anode power of an electron tube amplifier in a radio broadcasting transmitter. The primary power supply is 415/240 Volts 50 Cycles 3 phase.

A.—A circuit diagram of a suitable rectifier is shown hereunder. The following notes are added in explanation:—

(i) The filament transformers must be insulated to withstand 12,000 Volts between primary and secondary windings.

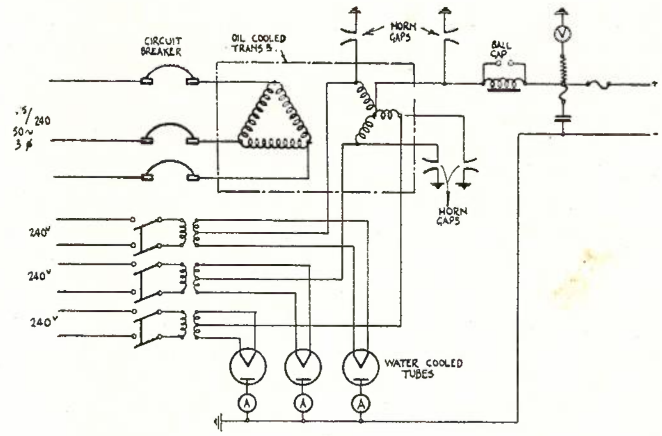


FIG. 1

(ii) The control system should provide automatically for a lapse of at least one minute between switching on of the filaments and application of anode volts.

(iii) The rectifying tubes, which are of the high vacuum water-cooled type, are operated with the anodes at earth potential to simplify the water-cooling arrangements.

(iv) The secondary windings of the anode transformer must deliver an R.M.S. voltage equal to 12,000 Volts multiplied by form factor plus drop in rectifying tube, i.e., approximately—

$12,000 \times 0.855 + 1000 = 11,260$ Volts.

(v) Each rectifier tube must be capable of supplying a peak current of 2 Amps.

(vi) The tubes must be capable of withstanding a peak inverse voltage of 25,000 Volts.

(vii) The smoothing filter must be designed for a minimum ripple frequency of 150 cycles.

Q. 6.—Describe the basic principles of design for a modern super-heterodyne receiver. Compare the relative merits of such a receiver with one of the tuned radio-frequency type.

A.—The basic principle of operation of a superheterodyne radio receiver is the changing of the frequency of any received carrier to an intermediate frequency which is fixed and independent of the carrier frequency. The main amplification of the signal takes place at this intermediate frequency.

The block schematic in Figure 1 shows the operation of the receiver.

The radio-frequency tuned circuit selects the required carrier, which is passed to the first detector where the signal is modulated by a local oscillator. In the absence of modulation on the received carrier, the output from this first detector will include sum and difference frequencies between carrier and locally produced oscillations. One of these (usually the difference) is selected by the intermediate frequency circuits. When the carrier is modulated the sidebands are similarly treated, resulting in the production of the intermediate frequency plus sidebands, which correspond

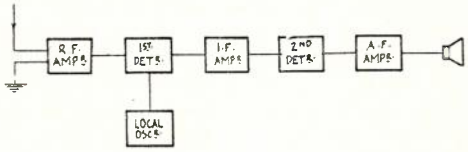


FIG. 1

exactly with the original. In tuning the receiver the frequency of the local oscillator is adjusted so that this difference frequency is that for which the intermediate frequency amplifier was designed.

From the first detector the signal, now at intermediate frequency, passes through the intermediate amplifier and then to the second detector. This carrier (I.F.) and the two sidebands thereof, on demodulation, result in the production of the voice-frequency at the output as well as other frequencies. After the detector the voice-frequencies are amplified in an audio-frequency amplifier which provides sufficient power for driving a loud speaker, the unwanted products of demodulation being prevented from entering this amplifier by radio-frequency chokes.

The Intermediate Frequency. In selecting the intermediate frequency the following points must be taken into account:—

(i) With any setting of the local oscillator frequency the correct intermediate frequency may be obtained from two incoming carriers, each differing from the local oscillator frequency by the required amount, but one being higher and the other lower. The higher the intermediate frequency the greater the separation between these two carriers, and the unwanted signal, called the image frequency, is more readily separated by the radio-frequency tuned circuits.

(ii) If the intermediate frequency is in the band on which the receiver is to be used there is a possibility of direct radio pick-up by the I.F. circuits due to poor screening or power supply filtering.

(iii) Better I.F. amplifier characteristics can be secured at low frequencies, but this necessitates a local oscillator working close to signal frequency, which may result in instability.

(iv) For receivers used on the broadcast band the intermediate frequency is usually between 100 kilocycles and 500 kilocycles, the present tendency being to use the higher frequencies; 465 kilocycles is in common use.

The Intermediate Frequency Amplifier. Since this amplifier operates at a constant frequency, fixed tuned circuits are used and can, therefore, be adjusted to give optimum performance. This results in stable operation and very high sensitivity. Since the percentage difference between the required frequency and an interfering frequency is higher after modulation in the first detector than the percentage difference between the original carriers, high selectivity can be obtained while still retaining a response curve, which is substantially flat over the required audio-frequency sideband. In many receivers this selectivity is variable.

Use of Radio-Frequency Amplifier. In modern superheterodyne receivers a tuned radio-frequency amplifier of one or more stages is generally used before the first detector. This has the following advantages:—

(i) The sensitivity of the set is increased.

(ii) Radiation from the local oscillator is prevented

(iii) Selectivity is increased, reducing the likelihood of cross-modulation, and of trouble due to image frequencies.

The advantages and disadvantages of the superheterodyne receiver as compared with the tuned radiofrequency receiver are as follow:—

(i) Sensitivity. The gain per stage of the superheterodyne is much greater than the tuned radiofrequency, and is approximately independent of signal frequency.

(ii) The selectivity of the super-heterodyne is better.

(iii) Sideband cutting may be reduced while still retaining selectivity in the case of the super-heterodyne, because of the "band-pass" characteristic of the I.F. amplifier.

(iv) The noise level is lower in the case of the tuned radio-frequency receiver.

(v) If the super-heterodyne is slightly detuned due to poor design or operation, very bad distortion results, whereas in the case of the radio-frequency this only means loss of sensitivity.

(vi) The design of the super-heterodyne is somewhat more complex, and hence is more expensive.

Q. 7.—(a) What do you understand by the terms—

(i) Reverberation time;

(ii) Optimum reverberation time?

(b) In what manner can the reverberation time of a room be modified?

(c) What are the desirable properties of a material to be used to reduce the reverberation time of a room?

A.—(a) (i) Due to reflection from the walls, ceiling, floor and objects in a room, sound will be transmitted from the source to an observer by a number of paths of differing lengths. This results in the observed sound persisting for some time after the source is cut off due to the greater time taken to travel over the longer indirect paths. The reverberation time is the time in seconds required from cutting off the source for the observed sound to die away by 60 db.

(ii) The optimum reverberation time is the reverberation time which experience has shown is most suitable for the purpose to which the room is to be put. This optimum time will vary according to the type of room, i.e., home living room, lecture hall, music hall, etc., and with the volume. For broadcasting purposes the optimum time varies from approximately .6 to 2 seconds according to size.

(b) Reverberation time can be modified by the use of absorbent materials for covering walls, floor, ceiling and furnishings, thus reducing reflection. An extensive use of materials having absorption results in a very short reverberation time or "dead" room, while materials having good sound reflecting properties give a long reverberation time or "live" room. Suitable proportions of absorbent and reflecting surface areas give intermediate values.

Absorbent materials which have been extensively used include carpets, curtains, rockwool, fibre board, etc., whilst plastered brick walls provide good reflecting surfaces.

(c) Materials for reduction of reverberation time should have the following properties:—

(i) The absorption coefficient, which is measured by comparison between the absorption of a material and absorption by an open window (equals 1) should not vary with different samples.

(ii) The absorption coefficient should be substantially independent of frequency.

(iii) The material should be suitable for building purposes or for attaching to the walls, i.e., available in the form of sheets or tiles, should be mechanically strong and of pleasing appearance.

(iv) To keep the area of wall to be treated and hence the cost to a minimum, the absorption coefficient should be as high as possible.

Section 3.—Long Line Equipment

Q. 8.—Describe the method in which 1,000 cycles per second current is used for signalling over carrier telephone channels. Give a diagram to illustrate your answer, and show how false operation of the signalling device from speech currents is prevented.

A.—The 1,000 cycle ringer as used for ringing over carrier channels consists basically of two branches bridged across the voice-frequency line, one of which responds to the 16 cycle ringing current from the switchboard and the other to 1,000 cycles. These two bridged circuits are of high impedance and, therefore, cause little loss in transmission.

A schematic circuit of the 1,000 cycle ringer is shown in Figure 1. On receipt of a 16 cycle ring from the switchboard an A.C. relay operates in series with the condenser, and in turn results in the operation of three further relays which—

(i) Opens the line between the 1,000 cycle and the 16 cycle bridging circuits, leaving the local line terminated in the 16 cycle branch of the ringer.

(ii) Disconnects the hybrid coil balance network, thus preventing this network from acting as a shunt on the outgoing ring.

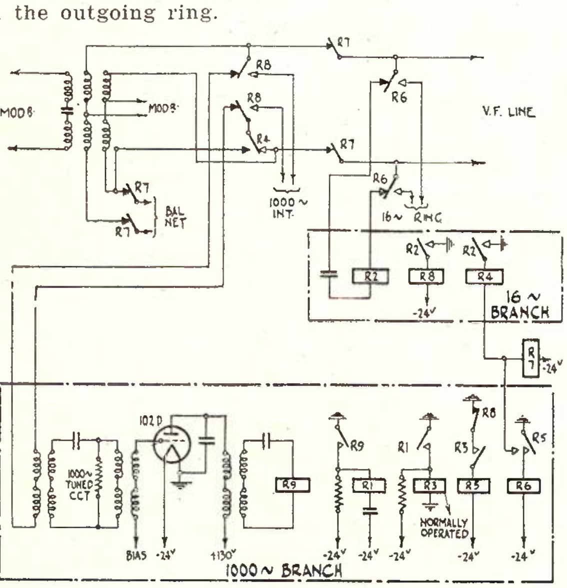


Fig. 1.

(iii) Alters the connection to the hybrid coil so that the transmission of the voice-frequency ring to the carrier system modulator is most efficient.

(iv) Cuts off the 1,000 cycle branch and connects 1,000 cycle tone, interrupted 16 times per second, to the line.

At the receiving end the interrupted 1,000 cycle tone is restored by the demodulator, and passes through a tuned circuit to a rectifying valve. The output from this valve is a direct current, pulsating 16 times per second, which is fed to a vibrating relay. Contacts of this relay alternately charge and discharge a bank of condensers in series with an alternating current relay which operates. In consequence, this results in the operation of two final relays which—

(i) Opens the line between the 1,000 cycle and the 16 cycle bridging circuits, leaving the incoming line terminated in the 1,000 cycle branching circuit.

(ii) Connects 16 cycle ring to the local line and opens the 16 cycle branch.

False operation of the ringer by speech currents is prevented by—

(i) Ordinary speech will contain no components to operate the 16 cycle side.

(ii) The incoming side will operate only on 1,000 cycles due to the use of the tuned circuit.

(iii) To avoid operation by momentary 1,000 cycle components in speech, the chain of relays discussed above introduces a time lag, which demands a sustained ring to complete the operations.

Q. 9.—(a) State the difficulties likely to be experienced in designing a two-stage transformer coupled amplifier to have substantially constant amplification over the frequency range from 50 to 7,500 cycles per second.

(b) Give a schematic diagram of such an amplifier, and state how the difficulties described in your answer to part (a) of this question have been met.

A.—(a) The difficulties likely to be experienced are:

(i) Instability, resulting in oscillation, due to coupling between the stages or between transformers.

(ii) Due to the capacity between turns of the transformers there is likely to be a loss of amplification towards the higher frequencies.

(iii) Due to the decrease in impedance of the primary side of the transformers at low frequencies there is likely to be a drop of amplification.

(b) Figure 1 shows a schematic circuit of a suitable type of amplifier.

In this amplifier the above difficulties have been overcome as follows:—

(i) The coupling is reduced by separating input and output transformers, by screening and by the use of decoupling resistors and condensers which prevent coupling in the anode power supply circuits.

(ii) The transformer windings are made up in sections and then laid side by side so that the inter-

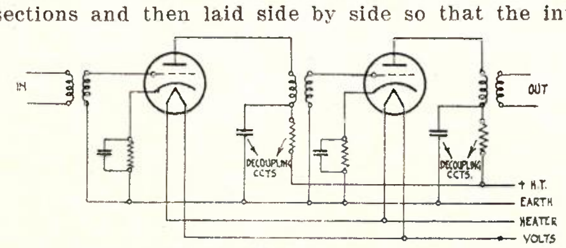


FIG. 1

turn or inter-layer capacity is a minimum. The transformer will be designed for a resonance at a frequency somewhat higher than 7,500 cycles.

(iii) By the use of an adequate amount of iron of high permeability in the transformer core, the impedance of the transformers is kept high with respect to the impedance of the sending circuit even at the lowest frequencies required.

Q. 10.—(a) What do you understand by the following terms:—

(i) A wave filter of the constant K type;

(ii) A wave filter of the derived type?

(b) Give a schematic drawing of a low pass filter of each type, together with a diagram of its attenuation-frequency characteristics.

(c) A low pass filter of a constant K type has shunt and series elements consisting of a condenser of 5 microfarads and two inductances each of 1 henry. What is the cut-off frequency?

A.—(a) (i) A constant K wave filter is a T network in which the components are so related that the product

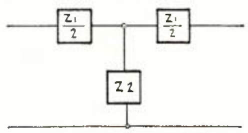


Fig. 1.

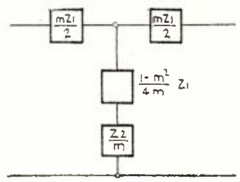


Fig. 2.

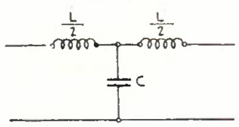


Fig. 3a.

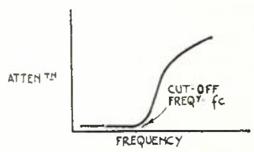


Fig. 3b.

of series and shunt impedances is constant, i.e., independent of frequency. The form of such a filter is shown in Figure 1, where $Z_1 \times Z_2 = K^2$.

It may be designed either as a low pass or high pass filter, transmitting with little attenuation the required range of frequencies. and then attenuating all frequencies above or below (according to type) design cut-off frequency, which depends on the ratio between the series and shunt impedances. The attenuation is finite in the attenuated range, and the cut-off is not very sharp.

(ii) In order to obtain greater attenuation beyond the cut-off frequency and sharp cut-off, impedance elements may be added to the series and/or shunt arms of the constant K filter to give infinite (theoretically) attenuation at some frequency in this range. These

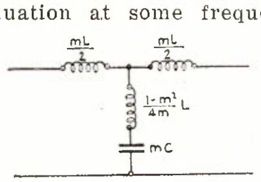


Fig. 4a.

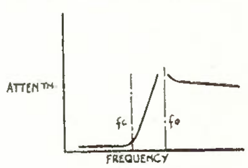


Fig. 4b.

added impedances must be so proportioned that the input impedance of the filter is constant and a pure resistance in the required pass range. This is the derived filter; the form of the first type known as the m derived type is shown in Figure 2, where m is less than 1.

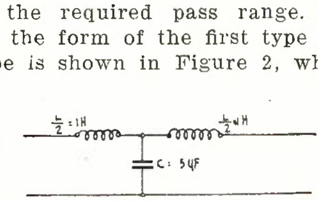


Fig. 5.

(b) The circuit of a constant K low pass filter and its attenuation-frequency characteristics are shown in Figures 3A and 3B.

The circuit of an m derived low pass filter and its attenuation-frequency characteristic are shown in Figures 4A and 4B, where $m = \sqrt{1 - \left(\frac{f_c}{f_o}\right)^2}$.

(c) Cut-off frequency $f_c = \dfrac{1}{\pi\sqrt{LC}}$

$= \dfrac{1}{\pi\sqrt{2 \times 5 \times 10^{-6}}}$

= 100 cycles per second.

EXAMINATION No. 2106.—ENGINEER—LINE CONSTRUCTION—CONTINUED

A. S. BUNDLE

Q. 7.—(a) Give the principal physical and electrical differences between—

(i) Twin cable.

(ii) Starquad cable.

(iii) Multiple twin cable.

(b) Describe in detail the make up of a 200 pair 10 lb. starquad cable, mentioning amongst other details the lengths of twist, numbers of quads in the various layers and the direction of lay of the layers.

(c) What are the main physical and electrical differences between local type and trunk type starquad cable and what are the reasons for the differences?

A.—(a) (i) In twin cables the two wires forming a pair are twisted together so that the capacity unbalance between the two wires and other conductors is reasonably low.

(ii) With starquad cables four wires are twisted around a central strand of cellulose yarn to form a quad. The four wires are numbered 1-3-2-4 taken in a clockwise direction. The diagonally opposite wires (1-2 and 3-4) are used as pairs.

Within the quad the capacity unbalance between the wires of one pair and either of the wires of the other pair is very low, as they are equi-distant within manufacturing limits.

As two pairs of wires are included in each quad and the four wires are twisted together, their capacity unbalance to other circuits is also low. This fact enables a phantom circuit to operate over the wires of a quad without undue crosstalk. This is an important feature in the case of trunk and trunk entrance cables.

With quad cable the area occupied by a given number of pairs is smaller than with either twin or multiple twin cables.

(iii) Multiple twin cables consist of a number of quads each of which is made up of two twisted pairs of wires twisted together.

Because they are twisted the wires forming a pair have a reasonably satisfactory capacity balance to other circuits.

Phantom circuits can also be operated over the quad because of the fact that the twisted pairs are themselves twisted together, thereby keeping their capacity unbalance to other circuits down to an acceptable level. This is the primary object of multiple-twin cables, but the cross-sectional area occupied by a given number of pairs is greater than in the other types of cable.

(b) In making up a 200 pair star cable, the quads (as described previously) are assembled in the following manner:—

Centre: Quads No. 1, 2 and 3 are twisted together.
1st Layer: Quads No. 4 to 11 are wrapped around

the centre group with a stranding lay in the reverse direction.

2nd Layer: Quads No. 12 to 25 are wrapped around the inner layer with a stranding lay in the reverse direction.

3rd Layer: Quads No. 26 to 45 are wrapped around the inner layer with a stranding lay in the reverse direction.

4th Layer: Quads No. 46 to 70 are wrapped around the inner layer with a stranding lay in the reverse direction.

5th Layer: Quads No. 71 to 101 are wrapped around the inner layer with a stranding lay in the reverse direction.

This actually makes 202 pairs. The two additional pairs being provided as spares.

The lengths and actual direction of lays both in the individual quads and the layers are not specified by the Department, which defines instead the electrical requirements. The lengths of lays will depend upon the particular manufacturer. Ordinarily the quads are twisted with lays at 5″ and 7″ and are so arranged that adjacent quads in a layer have a different length of lay. The quads in adjacent layers are twisted in opposite directions, the actual direction being the opposite of the stranding lay, which is itself reversed in consecutive layers.

The length of each stranding lay is dependent upon the diameter of the layer, and a general figure would be 18″ for the centre and first two layers and 24″ for the remaining three layers.

For identification purposes the four wires forming the quad are indicated by ink stripes across the wrapping paper. The colour of the ink markings on adjacent quads in a layer alternates. In addition, each quad is wrapped with coloured cotton. The colour scheme is as follows:—

Position of quad in layer	Ink for numbering wires in quad	Cotton wrapping	
		Centre and even layers	Odd layers
1 (termed "marker")	Red	White with orange strands	Black with orange strands
2, 4, 6, etc. (even numbers and intermediates)	Blue	White	Black
3, 5, 7, etc. (odd numbers and intermediates)	Red	White	Black
Last (termed "reference")	Blue	White with orange strands	Black with orange strands

(c) **Electrical Differences.**

Trunk type cable requires to be superior to local type in the following features:—

1. The Mean Mutual Capacity is lower and only a limited variation from the mean is allowed. This is to obtain generally improved transmission and to limit impedance irregularities. For different sized trunk cables the maximum allowable mean mutual capacity varies between 0.075 and 0.066 μf per mile, while for local type star quad cable the figures are 0.0825 and 0.075 μf per mile.

2. The insulation resistance is higher (15,000 megohms as against 5,000 megohms). This is also for the purpose of improving the transmission.

3. Capacity unbalance. The limit of mean unbalance is reduced from 200 $\mu\mu$f to 50 $\mu\mu$f and the maximum variation per length is reduced from 1,000 $\mu\mu$f to 200 $\mu\mu$f. The reason for this is reduction of crosstalk.

Physical Differences.

These are governed by the more severe limitations of the electrical characteristics in the case of trunk type cable.

The principal differences are:—

1. Care is taken to ensure that, as far as practicable, the same quantity of ink and the same thickness and quality of paper are used for wrapping the four wires in any one quad. This is done by cutting the four strips from one sheet of paper across which the ink marking lines have been printed. This has been found advisable to ensure that capacity unbalance conditions are kept within the specified limits.

2. The four wires of a quad are taken from the same reel.

3. To increase the spacing between conductors in trunk type cable, the paper used for wrapping the wires is made .001″ thicker.

4. A helical lapping of cellulose yarn is provided between the wire and the insulating paper. This arrangement provides a greater air space to allow for the requirements in regard to mutual capacity to be met.

5. The lengths of lays are more carefully controlled to assist in reducing capacity unbalance. Usually three or four different lengths of lay are used in the twisting of wires forming quads.

6. There is generally more supervision of the manufacturing process and a slower operation of stranding machines.

Q. 8.—(a) What are principal troubles to which lead-covered cables are subject? Explain briefly how each affects the cable.

(b) Which of the troubles mentioned in your answer to (a) would be most likely to affect cable—

(a) in earthenware pipe;
(b) in iron pipe;
(c) laid direct in the ground;
(d) on the wall of a building?

(c) How would you ascertain whether a cable failure, where corrosion was present, was due to electrolysis or to purely chemical action?

(d) Why are substances such as antimony and tin sometimes added in small proportions to the sheath of a cable to be used underground?

A.—(a) The principal troubles affecting lead-covered cables are:—

(i.) Mechanical Damage.
(ii.) Chemical Corrosion.
(iii.) Electrolysis.
(iv.) Intercrystalline Fracture.

Mechanical Damage.—The sheath may be penetrated or crushed from a wide variety of causes, e.g., picks, crowbars, rats, collision, vandals, road-rolling operations, passage of heavy vehicles, workmen treading on cables in manholes and tunnels, etc.

Penetration of the sheath by picks, crowbars, etc., may cause damage to the paper insulation and possibly sever the conductors.

Crushing may jam the conductors (and possibly the sheath) together. Both the sheath and the paper insulation may be destroyed.

Chemical Corrosion.—Due to the presence of a local concentration of acid or alkali salts in solution near the cable, the lead is attacked and reduced, usually to a metallic salt. This action continues until the sheathing is penetrated. Moisture then enters and reduces the insulation resistance.

Electrolysis is usually associated with the pick-up and discharge of stray currents. At each point the cable sheath becomes in effect an electrode immersed in an electrolyte and the corrosion is divided into two types depending upon the polarity of the sheath. At the point where the cable sheath is the anode, the corrosion is termed "anodic" and where the sheath becomes the cathode, the corrosion is called "cathodic."

Anodic corrosion is the commonest and most severe. The lead is attacked by the anions and is usually reduced to a metallic salt. This form of corrosion is characterized by isolated pitting of the sheath as distinct from cathodic corrosion or chemical corrosion, where the lead is attacked more uniformly.

Cathodic corrosion is much more rare. The cations are innocuous except in an alkaline solution where alkaline salts are formed. These in turn may attack the lead sheath.

Intercrystalline Fracture. — Vibration of the cable sheath causes the crystals to separate and the lead becomes "porous." This permits the ingress of moisture and consequent loss of insulation. It usually occurs in cables:—

(i.) In pipes attached to the walls of buildings, to bridges or to poles, that are subject to movement;

(ii.) In pipes under ground that is subject to vibration, e.g., near or under roadways.

Temperature variations cause increase in the grain size of the crystals and make the lead more susceptible to intercrystalline fracture when vibration occurs.

(b) **Cables laid in:—**	**Troubles most likely to occur:—**
(i.) Earthenware pipe.	Electrolysis.
(ii.) Iron pipe.	Chemical Corrosion.
(iii.) Direct in ground.	Chemical Corrosion. Mechanical Damage
(iv.) On the wall of a building.	Intercrystalline Fracture.

(c) **Distinguishing Between Electrolysis and Chemical Corrosion.**—As this is frequently necessary in proving claims for compensation, care is required in collecting evidence as to the possible factors causing the corrosion.

The steps to be taken are as follows:—

(1) **Stray Currents.**—Information regarding the relationship of the cable to sources of stray current is assembled under the following headings:—

(i.) History of cable, previous faults, etc.

(ii.) Location of traction systems, other electrical reticulations, etc.

(iii.) Detailed electrical tests. These consist of soil resistivity surveys and measurements (recorded over 24 hours) of the potential differences between the cable sheath and earth.

(2) **Soil Conditions and Corrosion Products.**—Detailed chemical analyses are taken of:—

(i.) The soil and/or duct matter surrounding the cable. These include tests for pH. value, resistivity, main soluble salts contained, and corrosion tests on lead samples.

(ii.) The corroded cable sheath and corrosion products. The presence of carbonates of lead, lead chloride or lead peroxide among the corrosion products, although not conclusive, forms useful evidence in determining the nature of the cause.

(3) **Composite Analysis.**—The results of (1) would be carefully examined in conjunction with the results of (2) in order to reach a final decision. Neither section in itself would form conclusive evidence, but the combination of the two usually enables a reliable decision to be made.

(d) **Alloys.**—The liability of lead to intercrystalline fracture increases with the grain size. By alloying lead with certain other metals, the grain size is reduced, and consequently the resistance of the lead to disintegration is appreciably increased. A number of metals may be used for the alloy, but those that have been found most satisfactory in practice are tin (3%) or antimony (1%). Combinations of these metals with one another or with cadmium have also been used with success.

It has been found that there is no appreciable difference between these alloys and pure lead in respect to their resistance to chemical corrosion.

Q. 9.—(a) What do you understand by the terms "Balanced Voltage" and "Residual Voltage" in connexion with a power circuit? In what ways can the effect on a telephone circuit of:—

(i.) Balanced voltages and currents.

(ii.) Residual voltages and currents.

in an adjacent power circuit be reduced?

(b) Give a sketch showing four of the simplest transposition arrangements sometimes referred to as "fundamental types" or "transposition patterns" over a section containing 31 transposition points.

What are "derived patterns" and how are they obtained from the fundamental types?

(c) What are the four types of phantom transpositions? Illustrate by a sketch. What is meant by the term "eighth point" in connection with an "E" transposition section and why is it important?

(d) The exposures of a group of telephone circuits on a pole route to a power circuit are severe and so irregular as to be difficult to co-ordinate with the ordinary transposition system. What arrangement of additional transpositions would you propose in the telephone circuits? Give your reasons.

A.—(a) **Definitions:—**

(1) **Balanced Voltages.**—Term applied to those electromotive forces in a power circuit which balance one another so that at any point along the line their vector sum is zero.

(2) **Residual Voltage.**—The vector sum of all the electromotive forces to earth in the wires of a power circuit.

Reducing the Inductive Effects in Telephone Circuits from Power Circuits:—

(1) **Effects of Balanced Voltages and Currents.**—These can be reduced by:—

(i.) Increasing the separation between the power and telephone lines. This is the primary consideration, and should, of course, be taken into account before the lines are erected.

(ii.) Providing equal exposure conditions for each wire of the power circuit to the telephone circuits by adequate "barrelling."

(iii.) By transposing the telephone circuits and co-ordinating these transpositions with those in the power circuit.

(iv.) By provision of balanced electrical conditions in the telephone circuits.

If a power circuit could be economically constructed so that the voltages (and currents) are balanced and each wire equidistant from the telephone circuit, there would be no inductive interference. In practice, this is not economically possible, and the practical approach is by transposing (or "barrelling") the power wires so that each changes position with each of the other wires for an equal proportion of the distance over which the parallel occurs. With this method there are two features which prevent the inductive effects from balancing out exactly, viz.:—

(a) Irregularities in the distance separating the power line and the telephone line, e.g., for the whole or portion of a section in which wire A occupies the position nearest the telephone route, the separation between the routes may be less than on the sections where wire B or wire C occupies this position.

(b) At any instant on an A.C. power circuit the electrical condition is different at every point along the line over each complete wavelength. (e.g., On a 50 cycle 66 Kv. circuit the voltage of the fundamental wave varies approximately 44 volts per mile.) Therefore at any particular instant, the voltage on power wire A over the section where A is closest to the telephone line is different from the voltage on wire B over that section where wire B is closest to the telephone line, and similarly with wire C.

To be effective, therefore, the transposition interval must be very short compared with the wave length. The most satisfactory method in practice of overcoming the inductive effects is to transpose both the power wires and the telephone wires, co-ordinating the two transposition schemes.

(2) **Effects of Residual Voltages and Currents.**— Steps (i.), (iii.) and (iv.) set out in (1) are necessary in this case. Transposing the power wires will not reduce the effect of the residual voltages and currents but, by equalizing the capacitance of the power wires to ground, may reduce the residuals themselves. To overcome the inductive effects it is necessary to transpose the telephone wires so that each has equal exposure to the power circuit as a whole. In this way the vector sum of the transverse electromotive forces induced in a telephone circuit is reduced to a negligible quantity, provided that the transpositions are sufficiently close to overcome the effect of irregularities and the wave length factor previously mentioned.

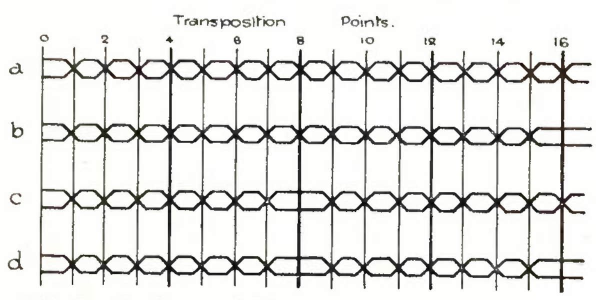


Fig. 1.—Fundamental Transposition Types—using 31 transposition points (half-section only shown).

(b) (1) Fundamental Types of transpositions are transposition patterns based upon a section with 32 transposition intervals. Commencing with a reference pair without a transposition in it, and using a maximum of 31 transposition points, a total of 32 fundamental types is possible.

Fig. 1 shows a half-section with four fundamental types of transposition patterns.

(2) Derived Patterns are transposition patterns additional to the 32 fundamental types. They are used when greater variety of patterns with short intervals between transpositions is required. They are developed in the following manner:—

(i.) "Single Extra."—By inserting a transposition in the middle of each 1/32 interval. These transpositions are additional to those occurring in the fundamental type and will result in the division of the section into 64 transposition intervals and a maximum of 63 transposition points.

(ii.) "Double Extra."—By inserting transpositions at the 1/4 and 3/4 points of each 1/32 interval in addition to the transpositions of the fundamental type. This will involve 128 transposition intervals and 127 transposition points for the section.

(c) Phantom Transpositions.—When it is required to transpose wires, over which phantom circuits are superimposed, four sets of conditions may be necessary, viz.:—

(i.) Transposition in the phantom pairs and each side circuit.

(ii.) Transpositions in the phantom pairs and side circuit A.

(iii.) Transposition in the phantom pairs and side circuit B.

(iv.) Transposition in the phantom pairs and neither side circuit.

Transpositions giving the four sets of conditions are standardized and given type numbers as shown in Fig. 2.

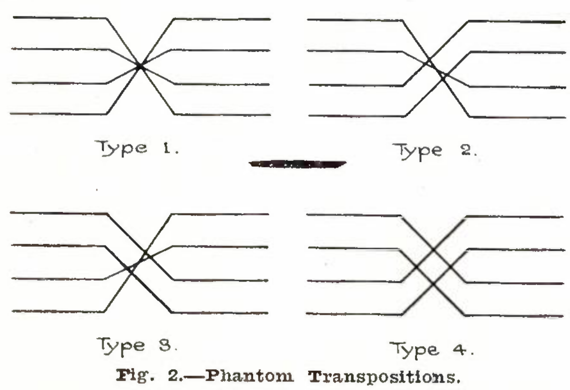


Fig. 2.—Phantom Transpositions.

"Eighth Points" are the seven points which divide an "E" section into eight equal lengths. They are significant because in each eighth of an E section the wires are transposed so as to give each wire of a circuit equal exposure to any source of inductive interference external to the route. Therefore the section must be so laid out that any minor discontinuities in a power circuit or other source of interference external to the route, occur at "eighth-points."

(c) Where:—

(i.) Irregularities in a severe interfering source are so frequent that it is difficult to arrange for them to coincide with the eighth points of the usual E section; or

(ii.) Because of the wave length factor (mentioned in part (a) of the answer to this question), it is necessary to make the transposition intervals shorter in comparison with the wave length than is the case with the ordinary transposition intervals;

(d) "Whole Line Transposition Units" would be introduced.

These are systems of additional transpositions cut into every circuit on a route at points midway between normal transposition points. By reducing the intervals over which each circuit is balanced against external interference, it is usually possible to locate the discontinuities in the power system opposite or close to the points of balance. In any case the extent of the unbalance is reduced, e.g., in the standard "E" section of the usual length of eight miles, the points of balance to external interference (i.e., the "eighth" points) are one mile apart. By the use of suitable W.L.U.'s the intervals between the points of balance are reduced to one-quarter mile or one-eighth mile.

By systematically cutting transpositions into all the wires over eighth sections, the balance against external exposure is improved and the crosstalk balance preserved. To achieve this, on V.F. phantom circuits (where the wires are transposed "on circuits") it is also necessary to make certain changes in the normal transpositions.

Whole Line Units are designed for eighth sections of the ordinary "exposed line" system. To preserve the balance it is necessary to cut in a complete unit over the full eighth section. The W.L.U. would be cut into only those 1/8th sections where the interference is severe.

Two types of W.L.U. are designed and are known as the 32-pole unit and the 64-pole unit. The 32-pole unit is designed for use in E sections with 31 normal transposition points. It introduces whole line transpositions at four points midway between the normal transposition points in the 1/8th section.

The 64-pole unit is designed for use in E sections with 64 normal transposition points, but may also be used on one with 32 normal transposition points. It may also in special cases be applied to L sections. This unit introduces whole line transpositions at the eight points midway between the normal transposition points in the 1/8th section.

These two types of units may be used on adjacent eighth sections of a 32 pole E section. The 32 pole unit is, of course, more economical than the 64 pole, and should be used if it will provide sufficient balance.

Fig. 3 shows the application of one 32 pole unit and one 64 pole unit to consecutive 1/8th sections to overcome severe exposure. The 64 pole unit is used so that the discontinuity near Pole 21 would be opposite a balance point.

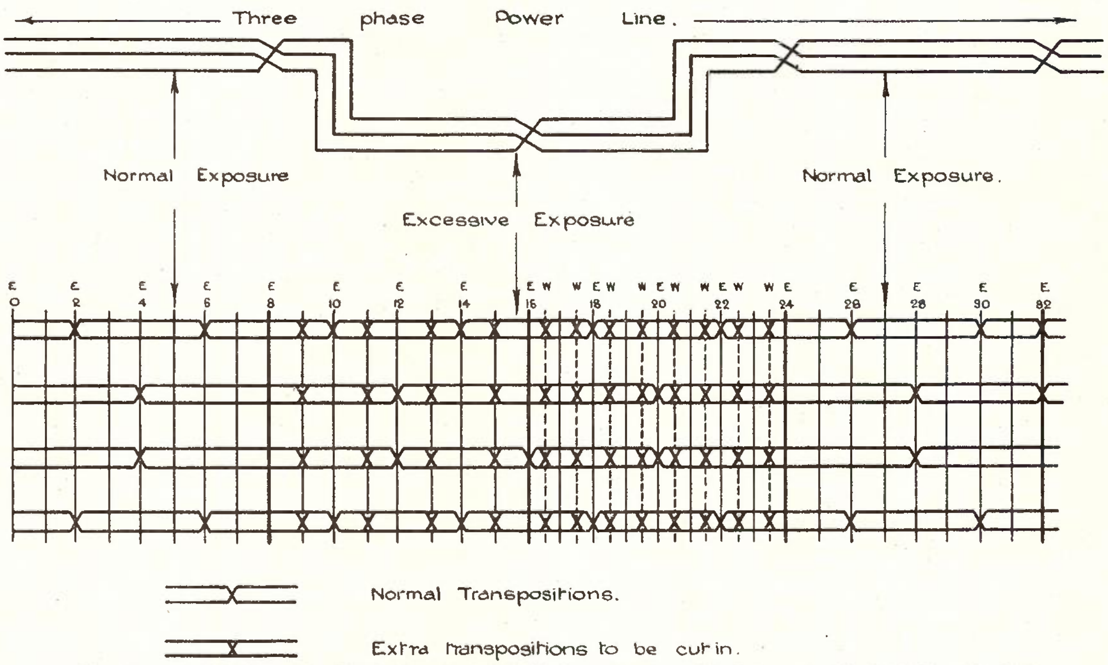


Fig. 3.—Application of whole line transposition units in 2nd, 3rd and 4th eighth sections. Existing circuits non-phantom with some fundamental types of transposition as in Fig. 1.

Q. 10.—There is an existing wooden pole route 50 miles long carrying the trunk lines between two towns. The pole route was erected 20 years ago and is in fair average condition, the pole renewals being up to date.

There are at present 24 physical and 12 phantom circuits between the two towns. The development during the next twenty years is expected to be at the uniform rate of three speaking channels per year.

It may be assumed that the existing poles will accommodate the twenty year requirements and that carrier circuits will not be used.

The following information is given:—

Value of the existing aerial construction	£40,000
Cost of dismantling the existing aerial construction	£2,000
Value of material recovered from aerial construction	£9,000
Cost of providing two physical circuits over the route complete with transpositions and terminal equipment, thus providing three speaking channels	£4,000
Cost of providing and installing ready for use ducts, cable, loading coils and terminal equipment required to give standard service—	

(i.) For 8 year development £70,000
(ii.) For 20 year development £100,000
(iii.) For 8th to 20th year development £45,000
Interest rate .... 5% per annum
Maintenance cost per annum for aerial wires, including pole renewals .... £1 5 0 per wire mile
Maintenance cost per annum for underground cable, including ducts loading and equipment .... ½% of providing cost
Sinking fund provision per annum for aerial wires .... 5% of providing cost
Sinking fund provision per annum for underground cable, including ducts loading and equipment .... 2% of providing cost
Present value of an annuity of £1 per annum from 1st to 20th year £12.46
Present value of an annuity of £1 per annum from 8th to 20th year £6.68
Present value of an annuity of £1 increasing by £1 per annum from the 1st to 20th year £111

With the foregoing information prepare an economic study showing the relative costs of:—

(a) Retaining the existing aerial construction and adding to it as required for the 20 year period.

(b) Demolishing the existing aerial construction and providing an underground cable capable of carrying the twenty year development.

(c) Demolishing the existing aerial construction and providing an underground cable capable of carrying the eight year development and then installing an additional cable to carry the development from the eighth to the twentieth year.

Note.—On 20/1/39 the Chief Engineer approved of Engineering Administrative Circular No. 8 dealing with "The Principles of Economic Comparison of Plant Proposals." The principles set out in this circular are somewhat different from those previously used. Although the supplementary data provided in the question was not designed for the new procedure it would be futile to furnish now an answer that is not in accord with present standard practice. On the contrary there is more benefit to be derived by utilizing the question and its answer as an example to illustrate the new method.

As we cannot state definitely what will happen to the plant at the end of 20 years, we shall (in accordance with E.A.C.8) assume that it will continue in use forever. To answer the question on this basis it is necessary to provide supplementary data to that supplied in the question, viz.:—

Present value of a perpetual annuity of £1 = £20.

Present value of a perpetual annuity of £1 increasing by £1 p.a. for 20 years = £261.7.

Present value of a perpetual annuity of £1, the first payment to be made 8 years hence = £14.21.

Present value of £1 spent in 8 years time = £0.711.

Present value of 20 annual payments of £1, first payment to be made now = £13.01.

A.— **Proposal A**

Proposal.—Retain existing aerial construction. Each year for 20 years add 200 miles of wire and equipment to provide three speaking channels at a cost of £4,000.

Existing Plant.—50 miles of pole route, 2,400 miles of wire.

Annual Charges on Existing Plant:—

Maintenance £1.25 per wire mile for 2,400 wire miles = ... £3000
Sinking Fund.—5% providing cost £40,000 (assuming that the sum quoted refers to the initial value) = ... £2000
Total = £5000

Annual Charges for Development:—

Maintenance £1.25 per wire mile for 200 wire miles increasing by £250 per annum for 20 years.
Sinking Fund.—5% of £4,000 = £200 p.a. increasing by £200 p.a. for 20 years.
Total.—£450 p.a. increasing by £450 p.a. for 20 years.

Capital Expenditure:—

Development.—£4,000 p.a. for 20 years. P.V. factor = 13.01 P.V. = ... £52,000

Annual Charges:—

Existing plant.—£5,000 p.a. P.V. factor (perpetuity) = 20.P.V. = ... £100,000
Development.—£450 p.a. increasing by £450 p.a. for 20 years. P.V. factor (perpetuity) = 261.7.P.V. = ... £117,800

Total P.V.'s of all charges = £269,800

Proposal B

Proposal.—Dismantle existing plant. Provide U.G. cable to carry 20 year development at cost of £100,000.

Residual Value Existing Plant = Value Recovered material less dismantling costs = £9,000 — £2,000 = £7,000.

Annual Charges on U.G. Cable:—

Maintenance.—½% providing cost £100,000 = £500
Sinking Fund.—2% providing cost £100,000 = £2,000

Total A.C.'s = £2,500

Capital Expenditure:—

Provision U.G. cable £100,000
Less Residual value existing plant £7,000

Nett capital expenditure £93,000

P.V. Capital Expenditure = £93,000

Annual Charges:—

Maintenance U.G. cable .... £500 p.a.
Sinking Fund U.G. cable .... £2,000 p.a.

Total A.C.'s = £2,500 p.a.

P.V. factor (perpetuity) = 20.
P.V. = £50,000.

Total P.V.'s of all charges = £143,000

Proposal C

Proposal.—Demolish Existing Plant. Provide U.G. cable, to take 8 year development at a cost of £70,000. Eight years hence provide additional cable, to take 20 year development at a cost of £45,000. Residual Value Existing Plant, £7,000.

Annual Charges:—

Initially:

Maintenance U.G. cable ½% of £70,000 = £350
Sinking Fund U.G. cable 2% of £70,000 = £1,400

Total £1,750

In eight years time:

Maintenance U.G. cable ½% of £45,000 =	£225
Sinking Fund 2 % of £45,000 = ...	£900
Total	£1,125

Capital Expenditure:—

Providing U.G. cable immediately, £70,000. P.V. factor 1.P.V. = ...	£70,000
Providing U.G. cable in 8 years, £45,000. P.V. factor .711.P.V. .... =	£32,000
Total	£102,000
Less residual value of aerial plant = ...	£7,000
Nett Total P.V. on Capital Expenditure =	£95,000

Annual Charges:—

Maintenance and Sinking fund on initial cable, £1,750. P.V. factor (perpetuity) = 20 = ...	£35,000
Maintenance and Sinking fund on subsequent cable £1,125. P.V. factor (perpetuity) = 14.2 = ...	£16,000
Total P.V.'s of Annual Charges =	£51,000
Total P.V.'s of All Charges =	£146,000

Summary.—A statement for comparison purposes of the three proposals for dealing with plant shows the costs brought to the basis of present values to be:—

Proposal A—£269,800.

Proposal B—£143,000.

Proposal C—£146,000.

Q. 11.—(a) What are the reasons for capacity balancing a trunk line cable?

(b) Describe a method of balancing a trunk line cable 10 miles long loaded at 6000 feet intervals.

(c) State what instruments you would use and give a schematic diagram of the connections.

A.—This question is similar to No. 6 of Examination No. 2050. Mr. Griffiths' answer to that question contains the information asked for and will be seen on pages 314-5 in the "Telecommunication Journal" of December, 1937.

Q. 12.—(a) What are the objects of making a telephone survey?

(b) Describe the method of making a telephone survey you would adopt.

(c) How would you record the information obtained in a telephone survey?

A.—(a) Objects.—The object of a Telephone Survey is to determine the present and future needs of a street, town or district for telephone and other Departmental facilities (broadcast lines, private lines, etc.) requiring connection by wires.

By means of such a study it is possible to:—

(1) Forecast with reasonable accuracy the number of telephones and lines required in a locality at any future period;

(2) Determine the number and most suitable locations for telephone exchanges;

(3) Decide upon the size and type of building required and possible extensions;

(4) Lay out a programme for providing lines on the most economical basis.

(b) Method of Making a Survey.—The principal phases of a telephone survey are:—

(1) A study of telephone development in the past with relation to the population and of probable development in the future, having regard to:—

(i.) Increase of population.

(ii.) Increasing proportion of telephones to population.

(2) Studies of probable local development.

(3) Field observations of the present and probable telephone lines in every street in the area.

(4) Recording the information on suitable street plans for purposes of reference by those concerned with the provision of outdoor plant.

(5) Summarizing the information for use when determining the location of exchanges and their sizes, junction requirements, etc.

(1) Development.—From statistics of telephone development and population growth, two curves should be prepared and produced. The curves should show:—

(i.) The proportion of telephones to population, in relation to time.

(ii.) Population in relation to time.

If these two curves are produced, it is possible to forecast with reasonable accuracy the number of telephones and lines required at any future date. This serves as a useful overall check upon the field observations. The curves should be used with care and allowance made for special factors which may influence the statistics, e.g., wartime or depression periods, peak periods, saturation point, or discoveries, extension of railway or other transport facilities, etc.

(2) Local Development.—Possible sources (e.g., local council, public bodies, etc.) must be explored to obtain information in regard to such aspects as: —

(i.) Trend of development of the locality.

(ii.) Projected buildings such as factories, flats, business blocks, etc.

(iii.) Reservation of land for special purposes, e.g., parks, rifle ranges, schools, etc.

(iv.) Determination of "brick areas."

(v.) Subdivision of land.

(vi.) Variation of transport facilities.

(vii.) Land values and rates, possible variations.

These enquiries should be made prior to the house count so that the officer making the count is armed with the information. The information should be kept up to date by constant reference to all items in the daily news and following them to their conclusion.

(3) Field Observations.—These consist of making a "house count" in every street of the area. The number of existing subscribers, probable subscribers, possibilities of vacant land, re-building, etc., should be recorded.

(4) Recording of the information is dealt with in part (c) of the answer.

(5) The detailed information shown on large scale maps must also be summarized to show:—

(i.) Total number of lines, present and future, in each exchange area.

(ii.) Total number of exchange lines, present and future, in each exchange area. This is determined on a proportionate basis from the "existing" figures.

(iii.) Total junctions, present and future, between exchanges. In supplying this information, consideration must be given to the traffic handling methods over junctions. This aspect must be taken up with the traffic engineer.

(c) The method of recording the information obtained on telephone surveys can be divided under the following headings:—

(1) Maps for use as office plan.

(2) Maps for use as field record.

(3) Symbols for use on field records.

(4) Method of showing information on office plan.

(1) and (2) **Maps.**—Two heliographic copies of an up-to-date map of the area, on a scale of five or six chains to the inch should be obtained. Each map must be ruled out so that the area is divided into blocks 15 to 16 chains square.

One of the maps will be retained as the office plan. The other will be cut into sections of convenient size for use in the field.

(3) **Symbols.**—Standard symbols to be used are as follows:—

(i.) Existing subscribers.—Each is designated by a letter indicating their types, viz.:—

Residence = R.
Business = B.
Outdoor Extension = E.
Public Phone (Cabinet) = P.
Fire Alarm = F.
Private Lines (Taxi, Ambulance, Broadcasting, etc.) = M.

(ii.) Possible subscribers are designated by a figure (1 to 5) and a symbol.

The figure indicates the possibility of a service being required. The figure used should indicate how many places out of five of a similar type would have services within 20 years.

The accompanying symbol (or absence thereof) indicates the nature of the place as follows:—

5 (no symbol) = residence of a type expected to have a service in 20 years.

4, 3, 2, 1 (no symbol) represent respectively houses of type 4, 3, 2 or 1 or which should require a phone in 20 years.

5X, 4X, 3X, 2X, 1X = vacant residential blocks, the figures indicating the possibilities.

5, 4, 3, 2, 1 (each in a circle) = businesses.

5X, 4X, 3X, 2X, 1X (each in a circle) = shop sites.

PX value 5 = anticipated public phone.

FX value 5 = anticipated fire alarm.

MX value 5 = anticipated private line.

When the count along a street is completed the 20-year figure is found by adding all the possibility figures, dividing the total by 5 and adding it to the number of existing lines. With this information and the knowledge of the street and locality fresh in mind, the 8-year figure should be estimated—preferably on the spot.

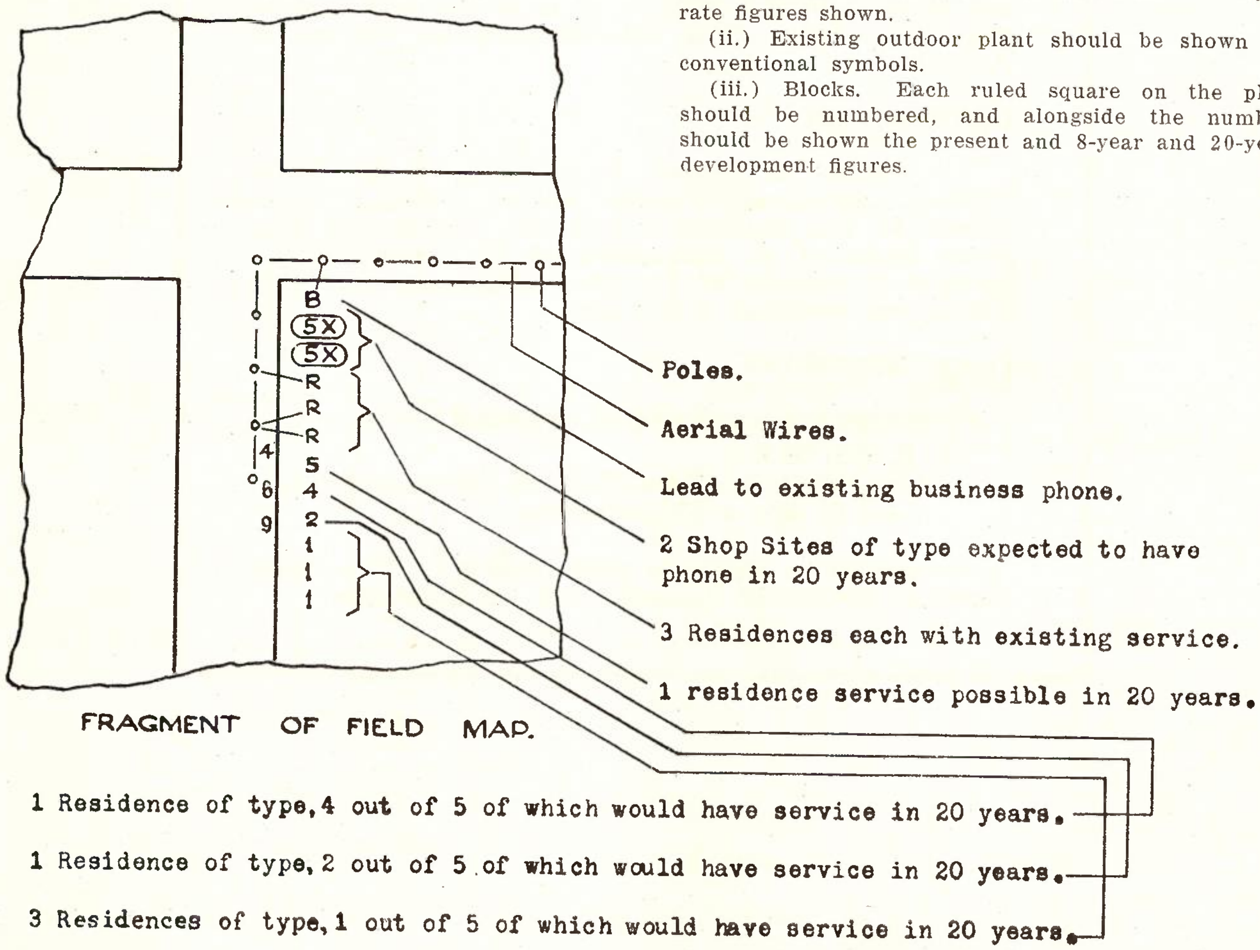
Fig. 1 is an example of the information shown on the field record.

(4) **Information on Office Plan.**—This should be of three types, and separate coloured inks used for each.

(i.) Development. Three sets of figures down each side of the street represent the present, 8-year and 20-year development. Such information should apply only to that section of a street falling within the square. If a street extends into more than one square, separate calculations must be made and separate figures shown.

(ii.) Existing outdoor plant should be shown by conventional symbols.

(iii.) Blocks. Each ruled square on the plan should be numbered, and alongside the number should be shown the present and 8-year and 20-year development figures.



FRAGMENT OF FIELD MAP.

POLICY :

THE object of the Postal Electrical Society of Victoria is to promote diffusion of knowledge in the communication services of the Post Office.

In advancing this object by the publication of this Journal the Board of Editors is not responsible for the statements made or the opinions expressed in any of the articles in this Journal, unless such statement is made specifically by the Board.

Editors are welcome to use not more than one-third of any article provided credit is given at the beginning or end, thus:—From "The Telecommunication Journal of Australia."

DISTRIBUTION :

This Journal is available to members of the Postal Electrical Society of Victoria without charge. Other officers of the Postmaster General's Department may obtain copies of all publications of the Society on the payment in advance of 4/- p.a. Single copies of this Journal are available at 2/- each.

COMMUNICATIONS :

All communications should be addressed to:—

A. R. GOURLEY,
Hon. Secretary, Postal Electrical Society of Victoria,
G.P.O. Box 4050, Melbourne.

All remittances should be made payable to "The Postal Electrical Society of Victoria," and not negotiable.

Ruskin Press Pty. Ltd.
123 Latrobe Street
Melbourne