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The

Telecommunication Journal of Australia

Vol. 6, No. 6 February, 1948

NEW TUNNEL FOR TELEPHONE CABLES -- PITT AND DALLEY STREETS, SYDNEY

J. Fletcher and J. G. Brooks

Existing Tunnels: In the Sydney Metropolitan Area there are approximately 9 miles of tunnels belonging to the Postmaster-General's Department. The tunnels accommodate subscribers' telephone cables, junction cables between telephone exchanges, the city ends of telegraph and trunk cables, and pneumatic tubes.

The tunnels constructed hitherto have usually been 3 ft. 6 ins. wide and 5 ft. 6 ins. to 6 ft. in height, and of brick sides with an arched roof. The floor is of concrete and, on some sections, the brick walls have been cement-rendered. The tunnels were constructed in pre-Federation days, and are a tribute to the foresight of the State Administrators of that time.

The Dalley tunnel will be the first street tunnel of any length to be constructed for telephone cable accommodation in the Sydney area since the original tunnels were provided. Fig. 1 shows the new Dalley tunnel in relation to the existing tunnels in the northern portion of the city.

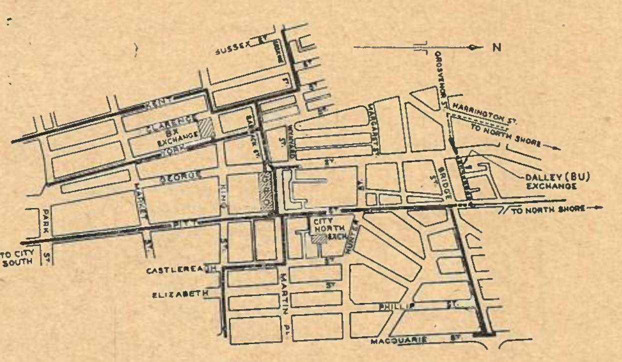


Fig. 1.—New Dalley Tunnel (shown thick dotted line) in relation to existing tunnel (shown thick full line).

Need for New Tunnel: An Exchange is to be established at the corner of Dalley and Underwood Streets, to relieve the City North Exchange, and the line plant diversion requires:—

(a) A number of large-sized subscribers' cables feeding from the new (Dalley) exchange.

(b) Large junction cables to other city exchanges. (In addition to the traffic between City Exchanges being heavy, the number of extensions, private lines, signal lines, etc., required, is high.)

(c) Large junction cables between the new (Dalley) exchange and the North Shore.

As a heavy underground cable route was needed from Grosvenor Street across George Street and along Dalley and Pitt Streets to link up with the existing tunnel at the corner of Pitt and Bridge Streets, a length of approximately 800 ft., the position of the underground plant of other Authorities in the locality was ascertained. (See Fig. 2.)

It will be noticed that there is a considerable number of underground services along Pitt Street. Extensive shifting of such services would be needed to permit an "open cut" for the laying of conduits, which would need to be placed at depths much greater than usual.

Running across Dalley Street is the course of the Tank Stream (a water supply to the early settlers of Sydney), which has since been reclaimed and built over. However, tidal waters still move in this course and, during high tides, water appears in the lift wells of buildings adjacent to the old Tank Stream. Laying a heavy line of conduits across the Tank Stream would be an expensive undertaking, and the narrowness of the footpaths in Dalley Street would add further difficulties to the provision of a multi-duct run.

On investigation, it was found that, giving due weight to

(i) the difficulties mentioned in the foregoing,

(ii) the great risk of disturbance to the foundations of buildings if an "open cut" were made, and

(iii) the interference with pedestrian traffic in busy streets inherent in the carrying-out of cable jointing work in manholes,

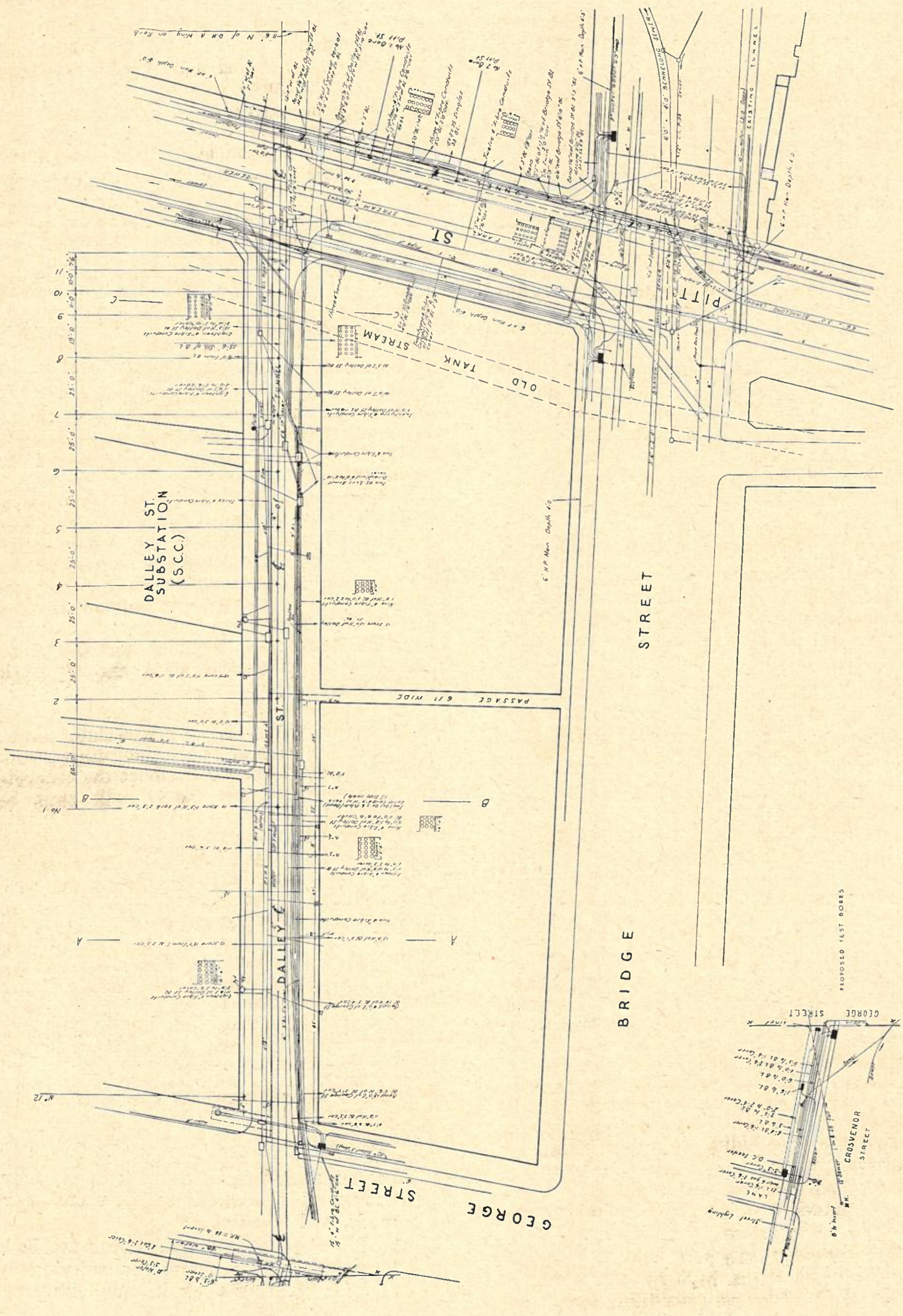


Fig. 2.—Location of underground plant of other authorities along route of new tunnel.

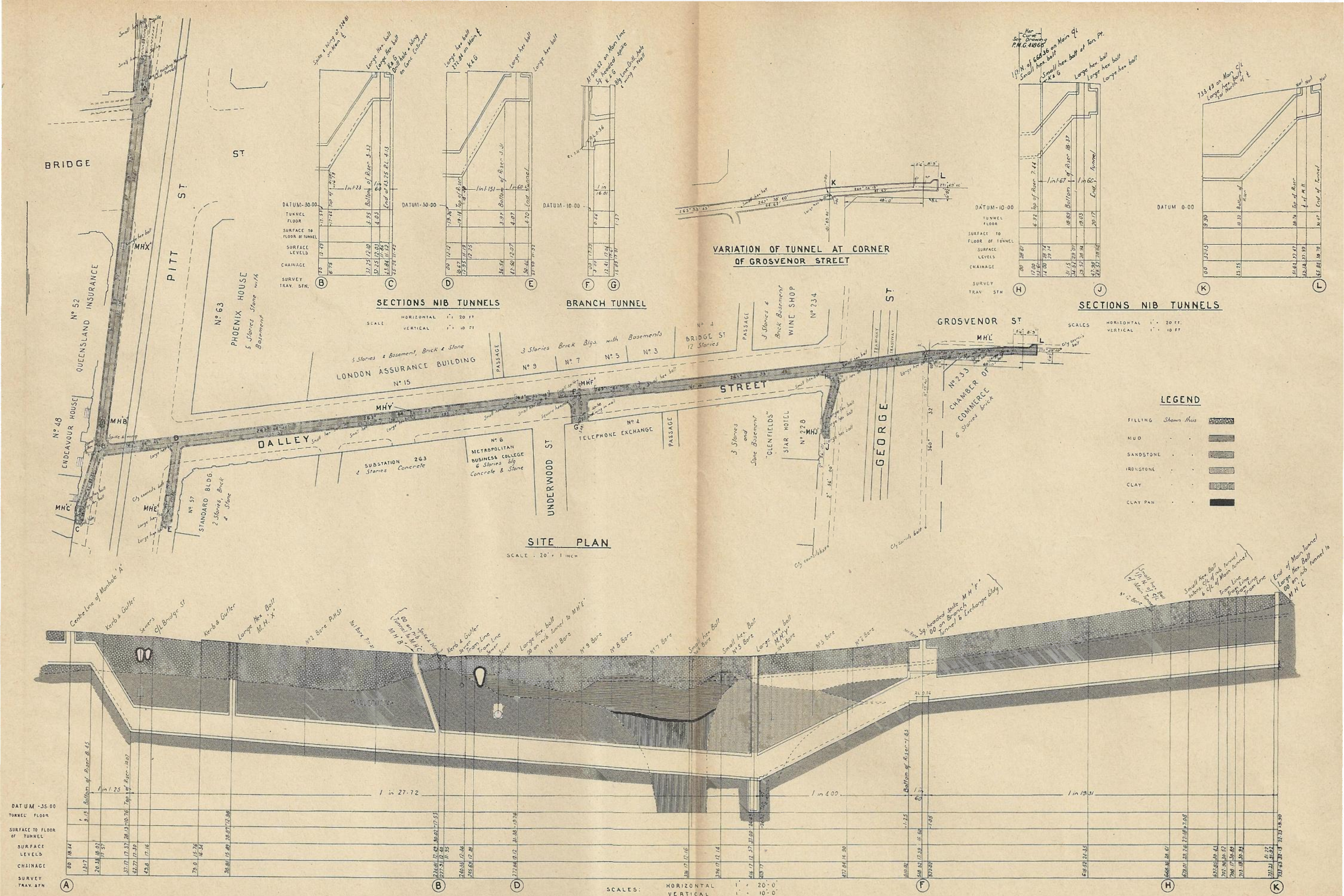


Fig. 5.—Layout of Tunnel.

(Note: The scales do not apply to the plan as reproduced in this figure, but they have been retained to show the relationship between vertical and horizontal distances.)

the estimated costs of a tunnel compared favourably with the estimated costs of a multi-duct route.

Nature of Strata Underlying the Route of the New Tunnel: The new tunnel is necessarily to be located at a depth clear of surface obstructions, but a more important factor to be considered in deciding the cover of the new tunnel is the character of the strata. On this matter, experience gained 30 years ago in driving a tunnel under Bridge Street from George Street was drawn upon, data acquired during the excavations for buildings erected within more recent years was examined, and test bores were put down in Pitt and Dalley Streets.

The rock formations were found to be nearly level stratified beds of sandstone and thin beds of clay. Fig. 3 shows a typical section.

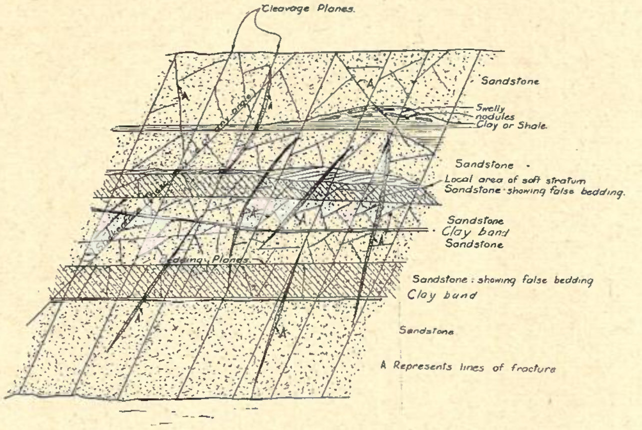


Fig. 3.—A typical section of strata.

There is a cleavage in a NNW direction dipping about 70° towards the east.

The bed of the Tank Stream consists of a deposit of white clay to a depth of about 60 ft. This white clay deposit was probably formed when water, passing through the sandstone, carried away some of the clay strata and cementing materials in solution. The fine silicates of alumina would be deposited in the bed of the Tank Stream and the carbonates, etc., carried further, probably into the Harbour. The broken character of the rocks, as distinct from the bedding planes and cleavage joints, has apparently been caused by such dissolution of the clay beds and the cementing materials in the sandstone. The passage of water through the rocks was probably greatly increased when the channel of the Tank Stream was formed, thus providing a quicker means of escape for the water.

The general nature of the strata along the route of the new tunnel, and the depth at which the new tunnel is to be located, are shown in Fig. 5.

General Features of the New Tunnel: The new tunnel is to be 6 ft. 6 ins. high by 6 ft. wide. A tunnel with a flat roof was considered more suitable for cable racking than the existing arched roof type of tunnel. Fig. 6 shows the wall thicknesses, etc., of the tunnel near Dalley exchange, and Fig. 7 at the Tank Stream.

High water pressures up to nearly 2000 lbs. per square foot have been designed for, and strength against, a possible earth movement towards the north, i.e., the Harbour, has been provided.

Surface plant (i.e., conduits) is to be linked with the new tunnel by means of manholes and nib tunnels at the following points:—

(a) Pitt Street, east side, opposite Dalley Street;
(b) Pitt Street, west side, near Dalley Street;
(c) George Street, north of Dalley Street;
(d) Grosvenor Street, near George Street.

It was intended to provide a manhole and nib tunnel to link up with the surface plant in George Street, south of Dalley Street, but numerous obstructions preclude the construction of a manhole at reasonable cost.

All buildings adjacent to the route of the new tunnel have been photographed externally, and every room of the buildings has been photographed internally. In the event of a claim for disturbance of foundations of buildings, the position before tunnel construction commenced, may thus be readily ascertained.

The new tunnel will provide for the cable racking and cables indicated in the isometric sketch. (Fig. 8.)

It may be of interest to mention that the mild steel channel uprights of the cable racking are to be fixed into the walls of the tunnel during construction, and will be used to support the concrete forms. Removal of the forms will thus be simplified.

Conduit for electric light wiring is also to be fixed in the ceiling of the tunnel during construction, and electric light fittings and plug points are to be provided at suitable intervals.

A drainage pump is to be installed at the lowest point of the tunnel to remove any water which may, through unforeseen circumstances, find its way in. The pumping plant is designed for automatic operation, control to be by float switch. A capacity of 2000 gallons per hour, against a total head, from all causes, of 55 ft., is to be provided.

Construction Requirements: The specification for the job provides:—

(a) When driving in rock, the length of the advance cuts must not exceed 6 ft. After each cut has been taken out, soft, scaly or defective bedding planes, cleavages, fissures and jointings are to be cleaned out to a depth of not less than 4 in., and adequately caulked with compo. of one part of early setting cement and one part of sand by volume.

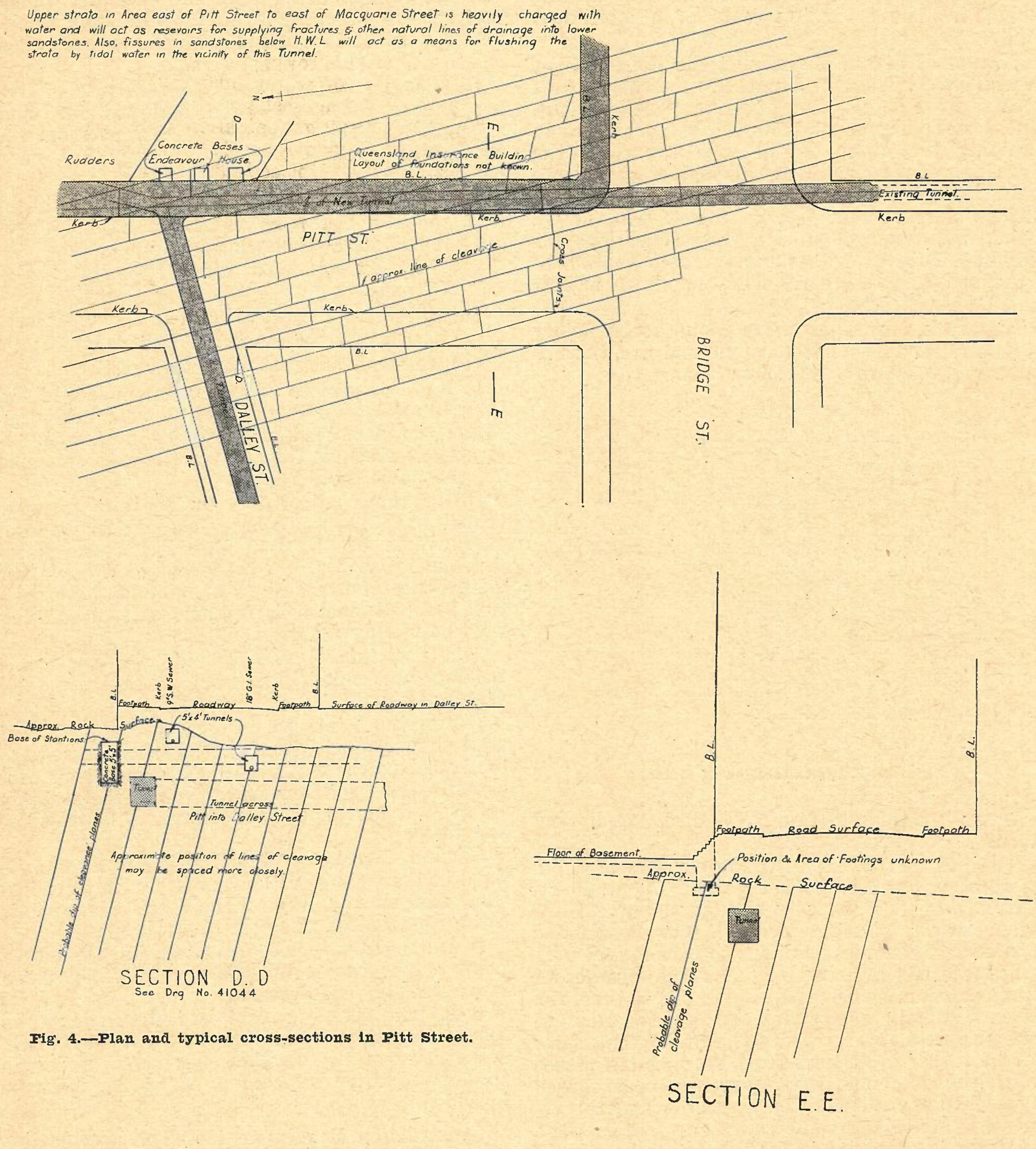


Fig. 4.—Plan and typical cross-sections in Pitt Street.

(b) No explosives shall be used in a certain defined area, and at any place in the tunnel or nib tunnels, where a side of such tunnel is 2 ft. or less from the building line, and no explosive shall be used for 4 ft. each side of the line of demarcation between the sandstone and clay formations at each side of the Tank Stream. Otherwise, explosives may be used when the whole periphery of the tunnel has been cut to a depth 6″ greater than the depth of the deepest shot hole.

(c) The whole of the concrete work and concrete is to conform to the requirements of the Standard Association of Australia Code No. CA.2-1937. The maximum size of particles of coarse aggregate is to be $\frac{3}{4}$″. Concrete is to be composed of one part of

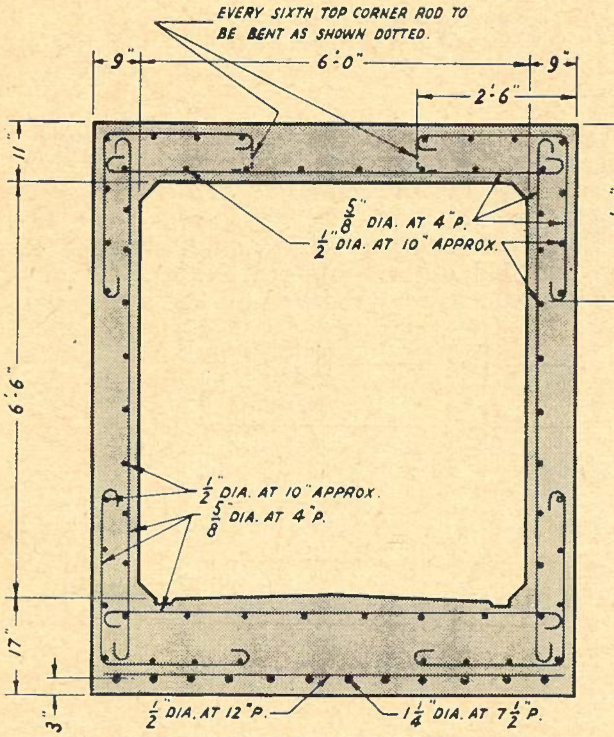


Fig. 6.—Cross-section of Tunnel near Dalley Exchange.

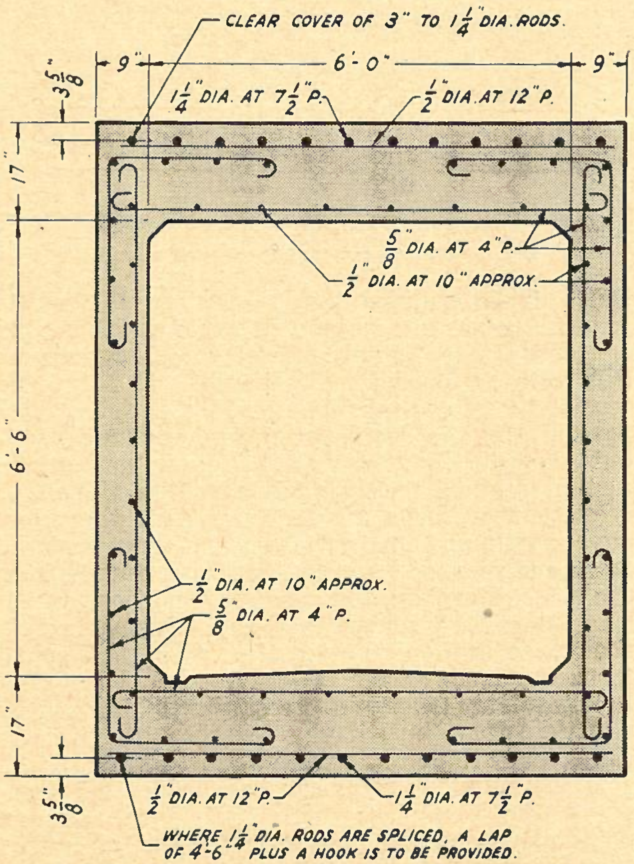


Fig. 7.—Cross-section of Tunnel at Tank Stream.

cement, two parts of fine aggregate and three parts of coarse aggregate by volume.

(d) Construction joints are to be made only where approved and, at each joint, the leakage of water into the tunnel is to be provided against by the insertion of a 6 in. strip of 22 gauge galvanised iron, placed in position and securely fastened before any concrete is placed either side of the joint.

(e) Walls and roof slabs of the tunnel are to be left as from the forms. The whole of the inside surface of the walls and roof of the tunnel is to be sprayed with two coats of hard drying and dustless water paint.

General: A construction shaft has been sunk at the deepest point on the route, and driving of the new tunnel has advanced a short distance.

The method of starting from the deepest point facilitates drainage and improves the conditions at the working faces.

It is of interest to note that during the sinking of the shaft a few clay beds were passed through. The clay appeared quite stable and, for various reasons, cleaning and caulking was not done for a few days. During the few days the incoming soakage water dissolved the clay stratum for a distance up to 21 ft. back from the shaft face, and, to fill the cavity, nearly 4 tons of cement grouting were required.

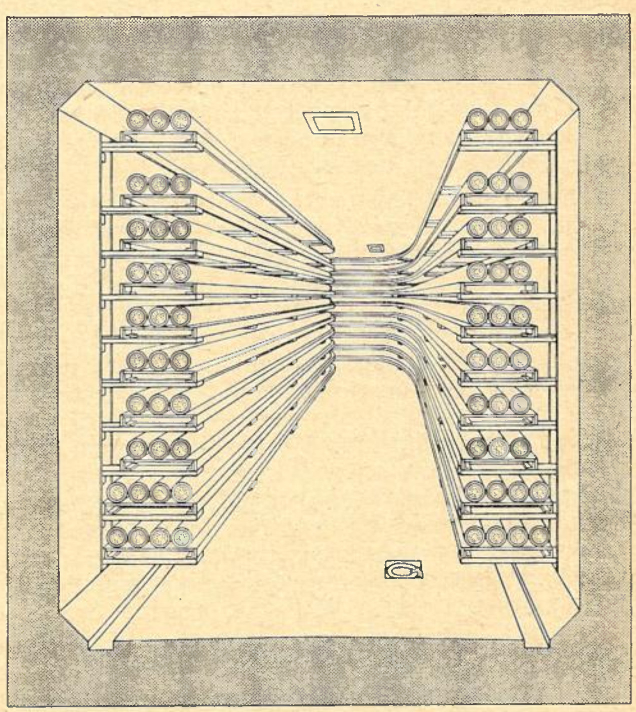


Fig. 8.—Layout of Cable Racking.

NATIONAL QUIZ CONTESTS, TECHNICAL ARRANGEMENTS

F. O. Viol

During 1946 and 1947 the Australian Post Office, at the request of the Director of Advertising, Department of the Treasury, provided the technical services necessary for three quiz contests which were conducted as part of Commonwealth Security Loan drives. The first two were limited to Australia, covering all States, while the third was an International contest involving teams from Australia, New Zealand, South Africa, England, Canada and U.S.A. The contests, generally, were broadcast on a nation-wide basis which required that all commercial and national stations on the air at the various times be supplied with the programme for broadcasting.

In the first two contests, teams were selected to represent each State and, on the nights of the interstate broadcasts, which totalled five in all, the arrangement was such that the Quiz Master located, say, at Melbourne, could question each team in turn and, by the process of elimination, decide the winning team. Each State team, except West Australia, was situated in its own capital city. In the case of West Australia, the team was brought to Adelaide, because of the limited number of programme channels available between Adelaide and Perth.

To provide the greatest flexibility, it was necessary to arrange circuits so that the Quiz Master could, at the commencement of the broadcast, speak to each team in turn and, as the contest progressed, drop out teams as required. To ensure correct timing for switching purposes, "word cues" were used, the Quiz Master stating the cue and the required State replying to indicate that the switch-over was correct. This briefly outlines the general method used, but the various aspects which were considered before the final scheme was adopted, will now be discussed.

General Considerations: As it was necessary for the Quiz Master to ask questions and receive replies from the teams concerned, a four-wire circuit, which could be switched or extended from, say, Melbourne to the other cities, was required. To facilitate the task of the judges who were present to assist the Quiz Master, and to permit people who were inexperienced in broadcasting to be at ease, microphones and loudspeakers were used at all points. In most cases the contests were arranged to allow an audience to be present, so that public address equipment also was necessary. Finally, to enable the contest to be broadcast, means were provided to obtain from the four-wire circuit, a distributing network which supplied all participating stations with the programme.

The Four-Wire Circuit: When a loudspeaker and microphone are associated with a four-wire circuit, one generally thinks of the "singing" likely to be encountered around the loop, and Fig. 1A shows such a circuit, consisting of a loudspeaker and a microphone with associated amplifiers. There are four factors which determine the singing point. First, the gain around the loop, which is the total gain of the amplifiers used, less the line and other equipment losses. Secondly, the acoustic power produced by the loudspeaker,

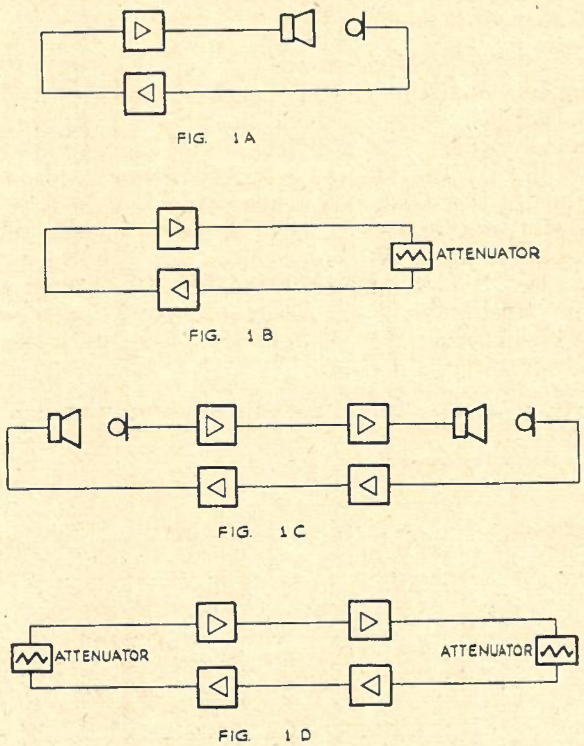


Fig. 1.—Development of the 4-wire circuit.

which is determined by its efficiency. As the acoustic power has to be of a value which will be of satisfactory listening level to all concerned, this can be considered constant. Thirdly, the sensitivity of the microphone. This is determined not only by the design of the microphone itself, but also its directivity. This is important, as certain microphones, particularly the ribbon or velocity type, have a directivity such that they have maximum sensitivity to sound sources at the front and rear, and are insensitive to sounds from the sides. Fourthly, the acoustic conditions which exist about the loudspeaker and microphone. If the reverberation is excessive, then the sound from the loudspeaker is sustained and reflected to the microphone, and the singing point will be unsatisfactory, but, if the reverberation time is short, then the circuit will be more stable.

If the amplifier gains can be considered as constant, the variables which control the singing point can be shown in the equivalent circuit of Fig. 1B, in which the attenuator represents these variables. In practice, this may be regarded as the actual case, because the output of the microphone amplifier must be of a standard level for transmission to line, and the loudspeaker amplifier must be at a level such as to give a satisfactory output from the loudspeaker. If, at the distant end, a loudspeaker and microphone with associated amplifiers are connected in a loop, as shown in Fig. 1C, the equivalent circuit, Fig. 1D, is obtained, such that the singing point, assuming the variables to be equal and the level at the input to similar amplifiers to be equal, is now reduced by the value of the second attenuator.

The arrangement shown in Fig. 1C was the basis of the final circuit used, and was entirely satisfactory, even though it was used under varying acoustic conditions. The microphones, generally of the ribbon type, were used side on to the loudspeaker, and were often within a few feet of it; nevertheless, the four-wire circuit was quite stable, and did not exhibit any tendency to sing, nor did it unduly introduce the effect of people speaking in large, reverberant halls, an effect which is often obtained with circuits near singing point.

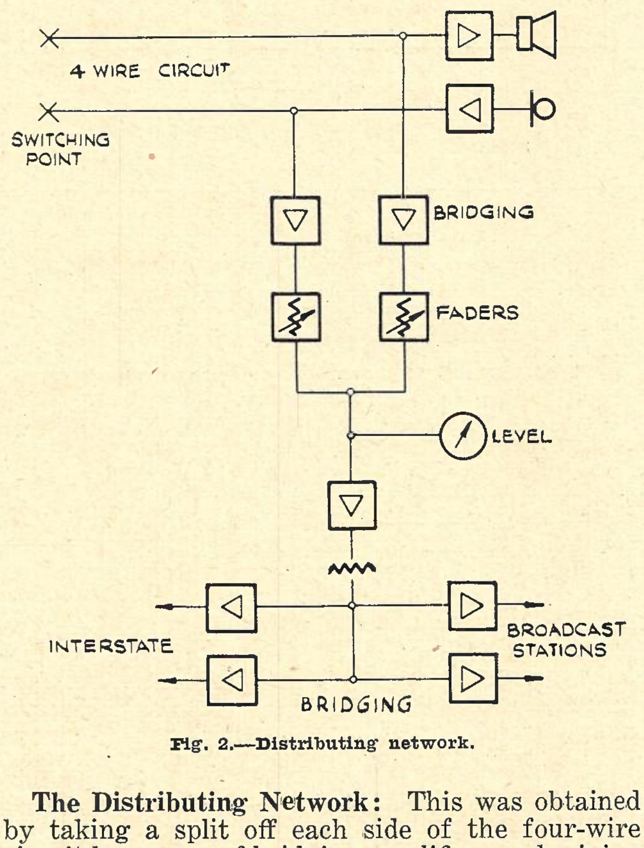


Fig. 2.—Distributing network.

The Distributing Network: This was obtained by taking a split off each side of the four-wire circuit by means of bridging amplifiers and mixing the output to obtain a satisfactory balance of levels. As the four-wire circuit was switched or extended from one city only, the splits were arranged at that city and the distributing network was then extended to all other cities, so that broadcast stations throughout Australia could be supplied with the programme. From Fig. 2, which shows the general arrangement, it will be seen that as many outlets as required can be obtained to meet local and distant requirements.

Public Address Systems: As many of the contesting teams were located in halls and auditoriums, to permit the general public to view proceedings and give local support to the State teams, arrangements were made to provide public address equipment. Generally, the arrangement was as shown in Fig 3. with the switching so arranged that, during periods in which the team was not being questioned, the contestant's loudspeaker was connected to the distributing network and, at the same time, the microphones were switched off to prevent singing, should the four-wire circuit be closed accidentally.

In one or two cases the public address systems caused instability, and difficulty was experienced in preventing the four-wire circuit from singing. An examination of Fig. 3 will show that there is a loop circuit from the microphone at A to the distributing network, then to the loudspeaker and back to the microphone. Unlike the four-wire circuit, in this case there is only one degree of attenuation. Hence, in a large, reverberant hall with a small audience, the chance of acoustic feedback is appreciable. Not only is this effect heard by the hall audience, but all broadcast listeners also hear this undesirable condition. The only remedy is to place the public address loudspeakers to the best advantage and use the minimum acoustic power consistent with a satisfactory level of sound for the audience.

The Interstate Network: As an example of the channels and switching involved in an interstate network, Fig. 4 shows the arrangements used when the Quiz Master was in Sydney. In this case, the four-wire circuit was switched north or south, as required, while in Melbourne it was used locally, extended to Hobart or connected to Adelaide, where both the teams from South Australia and West Australia were located. Generally, the switching followed in the numerical order used for the call signs of broadcast stations, i.e., Sydney, Melbourne, Brisbane, Adelaide, Perth and Hobart, but, as the teams were eliminated one by one, this sequence was lost, and the winning team (Victoria) finally emerged.

Some difficulty was experienced in providing suitable interstate channels, for, on one hand, there were not enough high quality circuits available, and, on the other, normal interstate programmes were being relayed to within a few seconds of the commencement of the Quiz broadcasts. The distributing network was, as far as possible, used to carry the normal programmes until the last moment, while J.12 circuits were used for a part of the four-wire circuit, as shown. This only impaired the quality, so far as the contestants and officials were concerned. In the case of Hobart, the normal broadcast transmission from one of the two National stations at Melbourne was used, the receiving point being at Station 7 N.T., Kelso, Tasmania.

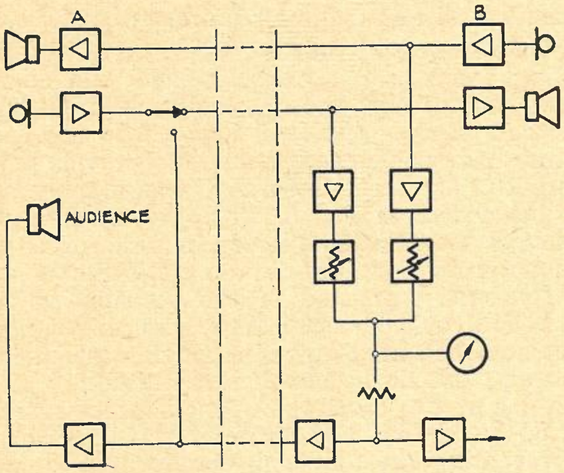


Fig. 3.—Public address system with 4-wire circuit.

It may be of interest here to detail some of the work and procedure involved in preparing the interstate channels for these broadcasts. The arrangements required that the four-wire circuits be in their correct direction and lined-up from programme room to programme room by 7.15 p.m. for the 8 p.m. broadcast. This required that some channels be available at 6.45 p.m., as 30 minutes is allowed for the reversal and lining up of interstate channels, terminal to terminal. The lining-up includes level adjustments, and tests for frequency response, noise and distortion. From 7.15 p.m., the four-wire circuits were lined up in each direction for correct level, progressively from Sydney to each city studio switchroom, and, finally, speaking tests were conducted from the Sydney broadcast point to all others. To complete the tests, the Quiz Master then spoke to each city in turn, as a check of the procedure to be used during the broadcasts.

From 7.15 p.m., it was necessary also to arrange for the distribution of the programme to commercial stations. As the majority of these are in country areas, many intrastate channels were involved and, in each case, it was necessary to feed programme and receive a satisfactory report on quality and level before 8 p.m.

Local Networks: So far, the four-wire circuit has been shown in a simple form but, in practice, it was necessary to provide additional facilities to it and to the distributing network. As shown in Fig. 5, three microphones were used, and a studio for the playing of records was included as a part of the network. In all cases, the switching of the four-wire circuit was done at the studio switchroom, and the distributing network was obtained from standard studio control booth equipment. As the broadcast point, generally, was not at the studios, this arrangement may appear unwieldy with the divided control, but it has the advantage that standard equipment is used and, further, operation on a functional basis does not depart from standard practice.

A brief outline will be given of the method of conducting a contest. The 8 p.m. time signal, followed by gongs, and then the opening theme music with publicity matter, was broadcast from one of the Melbourne studios, after which the network was switched to the auditorium, where the Quiz Master was introduced. The Quiz Master, in turn, called on New South Wales, by saying, "Are you ready, New South Wales?" and he received the reply, "Yes, New South Wales is ready, and the team, etc.," after which the questions were asked. At the conclusion of the questioning, the next State was called, and so on. In each case, the State to be questioned was mentioned in the opening words, followed by a pause, so that the staff responsible for the switching would be aware of the State required, and would have time to perform the switching operations necessary. The use of these word cues proved very successful, and no mistakes were made.

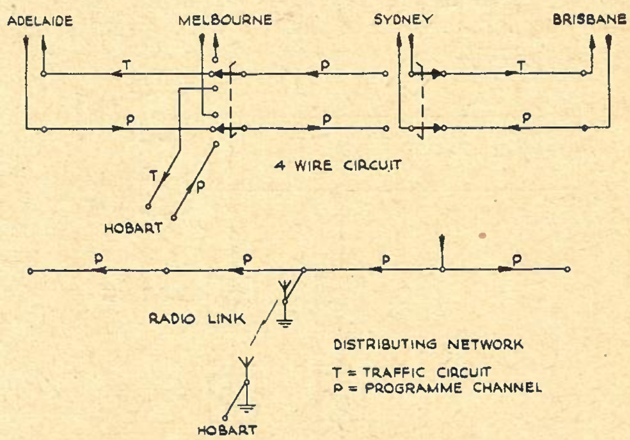


Fig. 4.—Interstate channel arrangement with control at Sydney.

In Fig. 5, which was the arrangement used at Melbourne for the occasions when the Quiz Master was in that city, the schematic circuit is shown of the studio switchroom, studio and auditorium connections. The only equipment not a normal part of the system is the special switching unit which was assembled to meet the needs of these broadcasts. At studio 320, standard facilities were used to supply the programme to the distributing network. These include the microphone, gramophone, splits from the four-wire circuit and, on this occasion, channels from Canberra for a broadcast by the Prime Minister, in connection with the Security Loan. The time signal circuit is not shown, but is a part of the standard equipment. The distributing network was extended to the programme room via a number of tie lines for interstate use, and for distribution to commercial stations.

At the auditorium, the four-wire circuit was equipped with three microphones and a loudspeaker, and was connected directly to the switch-

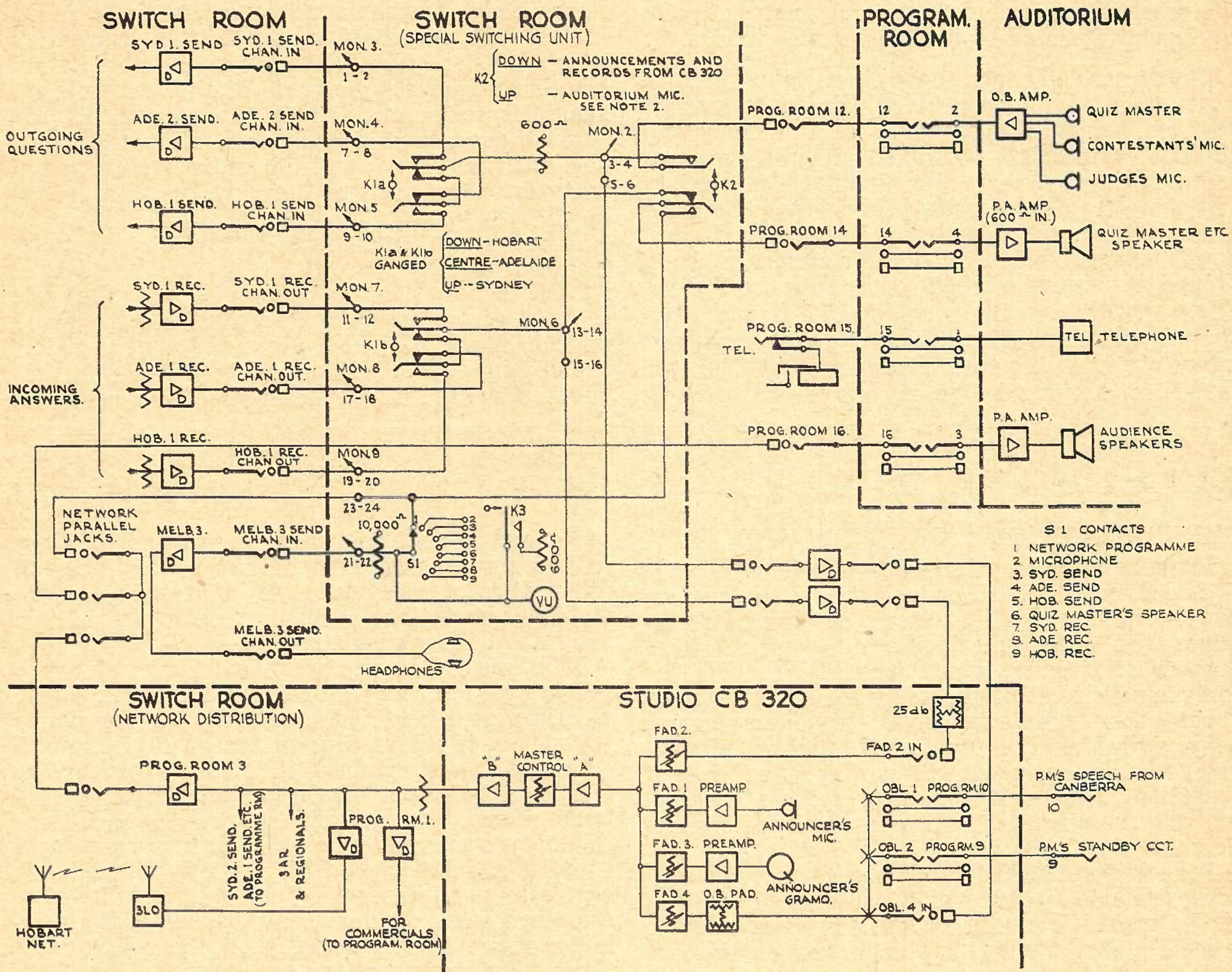


Fig. 5.—Interstate Quiz Contest, Melbourne Studios, Schematic Layout.

NOTES:

1. Fader 2 closed immediately interstate contestants finished answering. Kept closed while Melbourne was questioned.
2. Key 2 was operated "Down" for opening and subsequent announcements and records from CB.320, also P.M.'s speech. During questions and answers from States this key was operated "Up."
3. "D" amplifier is a bridging channel amplifier.

room. As shown, a public address system was provided for the audience.

The four-wire circuit was switched by key K1 and connected to each State in turn. At the Sydney switchroom a key was provided, so that the four-wire circuit could be extended to Brisbane, as required. Key K2 was used to feed the studio output to the Quiz Master's loudspeaker to obtain the cue for the commencement of the actual contest.

No attempt has been made to give details of the overall networks, nor to include all of the amplifiers actually used. The reason for this will be apparent when it is considered that the amplifiers used on interstate circuits alone, but not including those used for programme splitting, exceeded 70. Fig. 5 gives details of the special arrangements used at Melbourne, and is typical of the circuit used at Sydney, but, at other cities, four-wire switching was not necessary as, in all contests, the distributing network originated in either Melbourne or Sydney.

International Network: In general, the technical arrangements for the International Quiz followed those already described for the Interstate Quiz Contests, but the switching was not as complex, as only two teams were involved at any one time. The four-wire circuits were readily obtained, as radio-telephone channels are operated on a four-wire basis. In the case of the distributing network, this was derived at Sydney, to meet Australian requirements. The overseas connections, in terms of channel miles, assumed large proportions; for instance, Ottawa was routed via San Francisco to Sydney, and Capetown via Johannesburg and London to Sydney, but distance did not introduce any major difficulty. On the longer circuits, however, it was necessary to use headphones, instead of loudspeakers, to prevent the possibility of echo effects and singing, due to equipment peculiar to radiotelephone circuits.

Conclusion: Details have been given of an unusual broadcast network which, in magnitude and complexity, surpassed all of the many "all station" broadcasts arranged during the war years. Naturally, there were moments of anxiety and some frayed tempers, particularly when, for some unforeseen reason, an interstate channel developed trouble on reversal, or a circuit suddenly dropped level in the middle of a four-wire line-up. There was the evening when, at 7.15. due to widespread thunderstorms, four of the important interstate channels were faulty and, at 8.02, the four-wire circuit to Hobart was finally cleared. Fortunately, Tasmania was the last to be called in the first round of the contest, a connection which was required just four minutes later! Mention might also be made of the midnight rehearsals; rehearsals held at that hour because studios, equipment and channels were not available until that time; and the many humorous and witty answers given to the quiz questions asked in all seriousness.

In conclusion, credit must be given to the many technical officers concerned with the broadcasts. At all times they co-operated with the sole thought of providing service, mastered the many difficult situations which arose and, at the end of the evening, had the satisfaction of knowing that another successful broadcast had been achieved.

TELEPHONE RELAYS — PART 1

R. J. Kolbe

GENERAL DESIGN PRINCIPLES AND DATA

Introduction: In principle, a telephone relay is a device in which the magnitude of a current flowing in a controlling circuit or circuits determines the operation of several contacts in a number of circuits, which may also include the controlling circuit of the relay itself. In its most general form the design of a telephone relay can be regarded as the problem to find an electromagnetic device, that will perform the desired operation. The variables comprise: contact-load, controlling currents, and operate and release-times.

For every combination of these factors it would be possible to find the most suitable dimensions of the magnetic circuit and so the most suitable type of relay. Obviously, this is not practicable, and dimensions of parts forming the magnetic circuit must be standardised.

This immediately involves the choice of features which determine the suitability of the relay type in the following respects:—

(1) Volume and shape of winding space available for control.
(2) Type and maximum number of contact units that can be provided.
(3) Limits of operating times that can be achieved.

Acceptance of a given relay type as a standard imposes certain limitations on circuit design. The minimum number of relays required to provide a desired service function will increase if the type and number of contact units that can be utilised, and the winding space available for control, are restricted. This applies in particular to circuits which have to perform complicated sequences of switching operations in progressive stages of action dependent on, and varying in accordance with, conditions imposed by other circuits which are encountered.

On the other hand, there are a great number of functions which can be performed by simple relays with small contact loading and limited winding space and which, for intrinsic reasons inherent in the service demands, cannot be combined in order that a relay capable of fulfilling more stringent conditions could be used in lieu of two or more of these simple relays.

This has led to the adoption of two standard relay types: a "major" relay for more exacting working conditions, and a "minor" relay for simple tasks. It is interesting to note that this dual-standard is not confined to B.P.O. practice, but has its counterpart in continental telephone systems where Siemens and Halske (S & H), as leading pre-war manufacturers in that area, have adopted a relay type with a spring-hinged flat armature as a major relay, and a small knife-edge armature relay of more conventional design as a minor relay. Figs. 1 and 2 show these two relay types which represent the counterpart of the 3000 type and 600 type B.P.O. relays, and are used for similar functions.

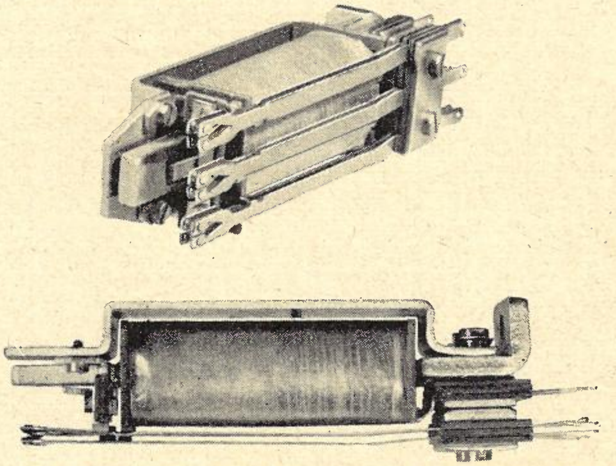


Fig. 1.—"Major" relay manufactured by Siemens & Halske A.G. (70-type).

It is proposed to consider the fundamental features of relay design in detail. Mathematical treatment is kept to a minimum, sufficient to prove statements made in the text.

Winding Space: As stated previously, the dimensions of the parts forming the magnetic circuit determine not only the maximum magnetic flux that can be usefully employed for the operation of the relay, but govern also the amount of space available for relay windings.

The volume of the winding space available cannot directly be used for comparison of different relay types as its physical dimensions and particularly the ratio of cross-sectional winding area to volume has influence on how often the required number of ampere-turns can be provided; in other words, how many independent windings, each sufficient to ensure operation, can be accommodated.

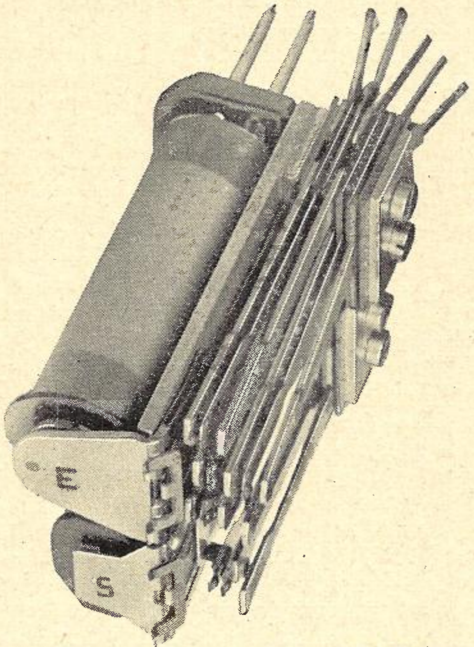


Fig. 2.—"Minor" relay manufactured by Siemens & Halske A.G.

This is caused by the fact that for a given gauge of wire and type of insulation, the cross-sectional area of the winding space determines how many turns can be accommodated, whereas the resistance of the coil is proportional to the volume of the winding space. The optimum relation occurs for a winding space giving maximum turns for a given resistance or minimum resistance for a certain number of turns. Actually, the absolute optimum is not attainable, as it demands a winding space with an inner diameter of nil, which is fictitious.

For the coil design, the inner diameter is predetermined by the cross-sectional area required to carry an adequate magnetic flux, but to a certain extent, it is left to the designer to choose between a winding space of short length and large outer diameter and one of greater length and smaller outer diameter. The latter presents the better conditions. This fact, which is well known to designers, will become quite apparent when the relations existing between resistance and turns have been examined in detail further on in this article.

However, before this is done, it might be useful to show that for any chosen type of winding space the range of resistance for fully wound coils of different gauges of wire is extremely large, as this will help to demonstrate the importance of studying the relationship between turns and resistance.

In the equations, the following symbols will be used:—

A = Winding area (cross-section).
a = Cross-Sectional area of wire.
σ = Space factor.
t = Number of turns.
d = Diameter of wire.
R = Resistance of windings.
l = Average length of turn.
ρ = Specific resistance of copper.

$$\sigma_n = a_n t_n / A$$
$$A = a_1 t_1/\sigma_1 = a_2 t_2/\sigma_2 = \dots = a_n t_n/\sigma_n$$
$$a_n = (d_n)^2 \pi/4$$
$$t_1/t_2 = \sigma_1 (d_2)^2/\sigma_2 (d_1)^2 \quad \dots\dots \quad (1)$$
$$R_n = 4\, l_n \rho\, t_n/\pi\, (d_n)^2$$

For fully wound coils $l_1 = l_2 = \dots = l_n$

$$\therefore R_1/R_2 = (d_2)^2 t_1/(d_1)^2 t_2 = \sigma_2 (t_1)^2/\sigma_1 (t_2)^2$$
$$= \sigma_1 (d_2)^4/\sigma_2 (d_1)^4 \quad \dots\dots \quad (2)$$

The space factors for wires with the same type of insulation do not vary much with the diameter, so that σ_2/σ_1 is approximately unity.

Thus disregarding the space factors, equation (1) shows that the turns ratio is inversely proportional to the square of the ratio of wire diameters, which is a well-known fact.

Equation (2) indicates that for fully wound coils the ratio of D.C. resistances is inversely proportional to the fourth power of the ratio of wire diameters used. This must be so because the resistance of wires of the same length is already inversely proportional to the square of the diameters and the number of turns, or the total length of wire on a fully wound coil is again inversely proportional to the square of the diameters.

The space factor represents the proportion of the actual sum of cross-sectional copper areas of all turns to the total amount of winding cross-sectional area taken up. The space factor, therefore, varies with the thickness of wire insulation.

With fine gauge wire, it is found impracticable to produce layer wound coils economically and, while every effort is made to achieve an even winding process, the resultant coils differ from the theoretically correct layer wound coil. The variation becomes apparent when the space factor for these coils is determined empirically and compared with tables published for layer wound coils. For standard type relays, tables are published, which show the resistance and turns for full coils of various types of winding wire, and take these differences into account. For the general case of non-standard coils, the table at the end of this paper contains the necessary data.

Up to now, only fully wound coils were considered but, as the big majority of relays, and particularly those forming part of modern circuits, have more than one winding, it is necessary to study the relations for partial windings.

For standard relays, it is general practice to give fullness percentage tables which show the change of resistance-per cent. with turns-per cent., and vice versa. These tables are specific for certain types of relays as the relations alter with the dimensions of the copper-winding space. For the B.P.O. 600 Type relay the appropriate table was given in an article in Volume 3, No. 2, page 72. The tables for the 3,000 type relay are available in the Departmental Specifications for this relay. As the proportions of winding volume and cross-sectional winding area are similar for these two types, the relations given in the corresponding tables are almost identical. Later on in this paper the extent of variation and its cause will be stated.

While these fullness percentage data are readily available for standard relays, and thus enable the accurate calculation of partial windings, it is difficult to design partial windings for coils at variance with the standard as, in the general case, the tables are not applicable.

In the following, it is proposed to show that the ratio of turns-per cent. to resistance-per cent. follows a relatively simple general law, and that for any type of coil the relation can be found either by calculation or by a simple graphical construction if the physical dimensions of the winding space are known.

Symbols used in addition to those indicated previously are shown hereunder:—

L = Length of coil.
D_a = Outer diameter of fully wound coil.
D_i = Inner diameter.
H = Height (Depth) of winding space.
$H = (D_a - D_i)/2$.
x = Height (Depth) of partial winding.
V_f = Volume of winding space (Fully wound coil).
V_x = Volume of winding space taken up by partial winding.

The cross-sectional area taken up by a winding of height x is:

$$A_x = Lx = a\,t/\sigma$$

or

$$t = K_1 A_x$$

when $K_1 = \sigma/a$ = constant for a given wire diameter and type of insulation

$R = l\,t/\rho a = K_2 l t$ when $K_2 = 1/\rho a$ = constant for a given wire diameter and conducting metal.

The average length (l) of a turn on a coil which is partially wound to the height x is the length of the turn at the average diameter (D_m) of the partially wound coil.

$$l = \pi D_m \text{ and with } D_m = \tfrac{1}{2}[D_i + (D_i + 2x)] = D_i + x$$

$$l = \pi(D_i + x)$$

so that:

$$\begin{aligned} R = K_2\, l\, t &= K_2 \pi (D_i + x) . K_1 A_x \\ &= K_1 K_2 \pi L x (x + D_i) \\ &= K_3 V_x \quad \ldots\ldots\ldots\ldots \quad (4) \end{aligned}$$

where $K_3 = K_1 K_2$ = constant for wire type
and $V_x = \pi L x (x + D_i)$ = Volume of winding space taken up by the partial winding to the height x.

Formulae (3) and (4) indicate that for a given gauge of wire and type of insulation the resistance of the winding is proportional to the volume taken up by it; whereas the turns of the winding are proportional to the cross-sectional area covered. The relation between resistance-per cent. and turns-per cent., therefore, can be expressed by the relation between volume-per cent. and area-per cent. (cross-section taken up by a winding).

The volume taken up by a partial winding which fills the coil to a height x is calculated:

$$V_x = L(D_x)^2\pi/4 - L(D_i)^2\pi/4$$

and with $D_x = D_i + 2x$

$$V_x = \pi L_x (D_i + x) \quad \ldots\ldots\ldots\ldots \quad (5)$$

The volume of the fully wound coil is then

$$V_f = \pi LH (D_i + H) \quad \ldots\ldots\ldots\ldots \quad (6)$$

so that resistance-per cent. of a winding expressed in terms of physical dimensions becomes:

$$\begin{aligned} R\% &= 100\, V_x/V_f \\ &= 100 \times (D_i + x)/H(D_i + H) \quad \ldots\ldots \quad (7) \end{aligned}$$

In order to find the expression for turns-per cent. in terms of dimensions equation (3) is used:

$$T_x = K_1 A_x = K_1 L x$$
$$T_f = K_1 A_f = K_1 L H$$

Then:

$$T\% = 100\, T_x/T_f = 100x/H \quad \ldots\ldots\ldots\ldots \quad (8)$$

and $x = HT\%/100$

Introducing this into equation (7) gives:

$$R\% = \frac{100 \times (D_i + x)}{H(D_i + H)} = T\% \, \frac{D_i + HT\%/100}{D_i + H}$$

$$= T\% \, \frac{100 + T\%\, H/D_i}{100(1 + H/D_i)} \quad \ldots\ldots\ldots\ldots \quad (9)$$

and:

$$\frac{T\%}{100} = \sqrt{\left(\frac{D_i}{2H}\right)^2 + \frac{R\%}{100}\left(1 + \frac{D_i}{H}\right)} - \frac{D_i}{2H}$$

$$= \sqrt{\left(\frac{r_i}{H}\right)^2 + \frac{R\%}{100}\left(1 + \frac{2r_i}{H}\right)} - \frac{r_i}{H} \quad \ldots \quad (10)$$

when $D_i = 2r_i$ and r_i = radius of core.

Equations 9 and 10 give the relations between resistance-per cent. and turns-per cent. in terms of coil dimensions.

In designing a coil with several windings it is necessary to find the relation between resistance-per cent. and turns-per cent. repeatedly, and the above formulae will soon be found unwieldy and cumbersome. As mentioned previously, it is possible to find this relation by means of a graphical construction. An application of methods of analytic geometry to above formulae is therefore indicated.

First, the extreme case of $D_i/H = 0$ shall be considered. This signifies a fictitious coil without core, so that $D_i = 0$, or a coil where $H >> D_i$ so that D_i/H converges to zero. Equation (9) then becomes:

$(T_o\%)^2 = 100\, R_o\%$ when $T_o\%$ and $R_o\%$ are turns and resistance per cent. for this case. As $x^2 = 2Py$ is the formula for the parabola of parameter P, above equation is represented by a parabola with a parameter,

$$P = 50$$

if the values of T% and R% for the full coil (100%) are represented by graphical values of 100. (See Fig. 3.)

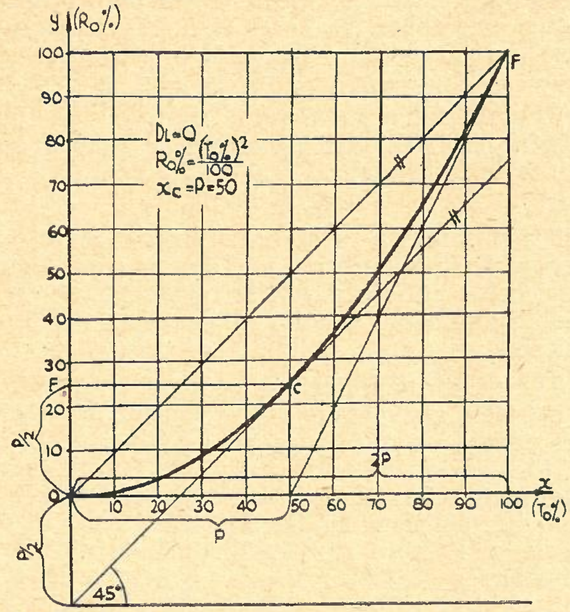


Fig. 3.—Relation between resistance-percent (R%) and turns-percent (T%) for fictitious coil without core (D_i = 0).

The relation between resistance-per cent. and turns-per cent., as shown graphically by the parabola for this fundamental case of $D_i/H = 0$, if given in the conventional tabulated form, would be as follows:—

Fullness Per Cent.	Equivalent Per Cent.	
	Resistance	Turns
1	.01	10.0
5	.25	22.4
10	1.0	31.6
15	2.25	38.7
20	4.0	44.7
25	6.25	50.0
30	9.0	54.8
35	12.2	59.2
40	16.0	63.3
45	20.2	67.1
50	25.0	70.8
55	30.2	74.2
60	36.0	77.5
65	42.2	80.7
70	49.0	83.7
75	56.1	86.7
80	64.0	89.4
85	72.3	92.3
90	81.0	94.9
95	90.6	97.5
100	100.0	100.0

To find the graphical solution for equation (9) in the general case of $D_i/H > 0$, it can be said that as far as D.C. relations are concerned, a winding starting at an inner diameter D_i and with layers of thickness H (outer diameter: $D_i + 2H$) may be regarded as part of a fictitious winding starting from the mathematical centre and wound to a diameter $D_i + 2H$, in which fictitious winding all layers up to the diameter D_i have been shorted out. Obviously, the fundamental relationship between resistance-per cent. and turns-per cent., which exists for the complete coil, and has been found to be represented by a parabola, has not completely changed by the short circuiting of all turns up to Diameter D_i. What actually happens is, that by arbitrary choice the values of resistance-per cent. and turns-per cent. at D_i are taken as 0%, and those at the outer diameter $D_i + 2H$ just as arbitrarily as 100%. It is to be expected, therefore, that the relationship between resistance-per cent. and turns-per cent. will be given by a part of a parabola and that the scale of the graphical representation has to be chosen suitably to coincide with the conditions given by the choice of the points 0% and 100%.

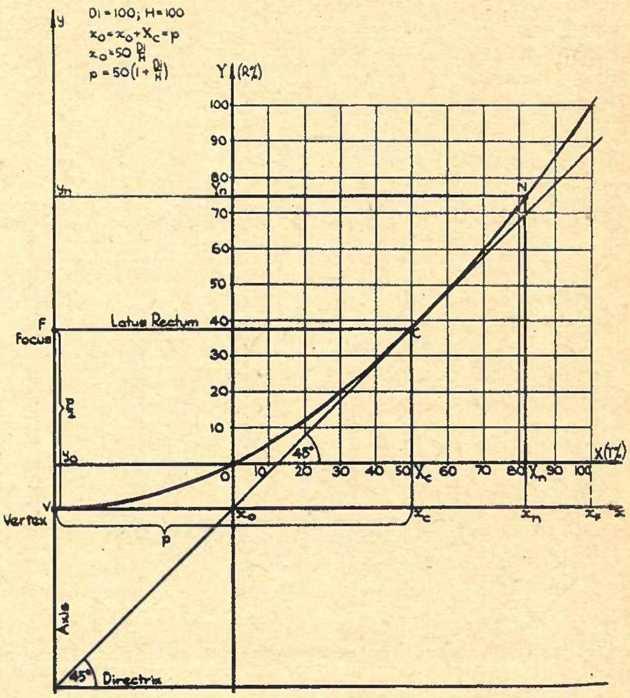


Fig. 4.—Relation between resistance-percent (R%) and turns-percent (T%) for a coil with a ratio of D_i/H = 1.

The equivalent procedure in analytical geometry can be put as follows, with Fig. 4 illustrating the equations:—

The fundamental parabola is given as:

$$x^2 = 2py;$$

we choose arbitrarily two new co-ordinates X and Y and make:

$$x = x_o + X$$
$$y = y_o + Y$$

so that:

$$(x_o + X)^2 = 2p\,(y_o + Y)$$

where x_0 and y_0 are the abcissa and the ordinate of point P_0 which was chosen as origin for the new system of co-ordinates. As this point is on the parabola, its equation is applicable:

$$x_0^2 = 2py_0 \text{ or } y_0 = x_0^2/2p$$

so that $(x_0 + X)^2 = 2p\,[(x_0^2/2p) + Y]$

and $Y = X\,(X + 2x_0)/2p$ .... (11)

Formula (11) gives the equation for the parabola in terms of the new co-ordinates X and Y, the arbitrary choice of which is represented by the values of x_0 and p. By making this choice as follows:

$$x_0 = 50\,D_i/H = 100\,D_i/2H \quad \text{.... ....} \quad (12)$$

$$\text{and } p = x_0 + 50 = 100\,(D_i + H)/2H \quad \text{.... ....} \quad (13)$$

equation (11) becomes:

$$Y = X\,\frac{100 + XH/D_i}{100\,(1 + H/D_i)} \quad \text{.... ....} \quad (9a)$$

A comparison with equation (9) shows that then $Y = R\%$ and $X = T\%$.

This proves that for every value of D_i/H which characterises the shape of the winding space, the relation between resistance — per cent. and turns — per cent. is given by a certain part of a parabola.

In Fig. 4, the parabola drawn represents a ratio $D_i/H = 1$, and the part of the curve between abscissae x_o and x_f can be used to find the relationship between T% and R% for this type of coil, with the help of a grid provided to facilitate the taking of readings.

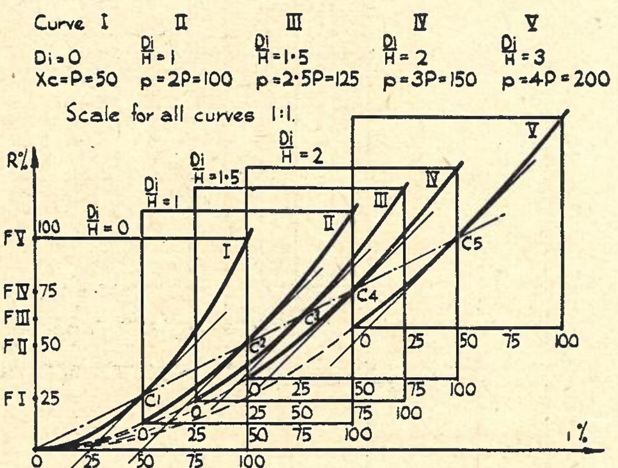


Fig. 5a.—Parabolae representing relation between R% and T% for various ratios of D_i/H shown with coinciding vertecae.

The size of the parabola (parameter p) and the position of x_o change with the value of D_i/H, as the equations show. In Figures 5a and 5b, the parabolae for different ratios of D_i/H have been plotted, and the parts of the curves representing the relation between resistance-per cent. and turns-per cent. indicated. It will be shown later that the values of parameter p and abscissa x_o both have a physical significance.

It is one of the characteristics of the parabolic function that by a suitable change of scale, and the choice of system of co-ordinates, all possible parabolae can be made to coincide. This is so because by changing the scale, all the parameters can be made identical.

For the fictitious case of $D_i/H = 0$ the parameter was found to be $P = 50$. In the general case the parameter was found to be:—

$$p = x_0 + 50 = 50\,(1 + D_i/H) = P\,(1 + D_i/H)$$

so that if, for a given ratio of D_i/H, the fundamental parabola with parameter P is to be used, the scale to be applied is:—

$$1/(1 + D_i/H)$$

All that remains to be determined now is, what part of the fundamental parabola is applicable for any chosen ratio of D_i/H to represent the corresponding values of resistance-per cent. and turns-per cent.

The most characteristic point of the curve for the given application is that point (C) where the change of resistance-per cent. becomes equal to the change of turns-per cent. It will now be shown that for all possible values of D_i/H, including the fictitious $D_i/H = 0$, this occurs at 50% turns, that is to say, in the middle of the coil winding.

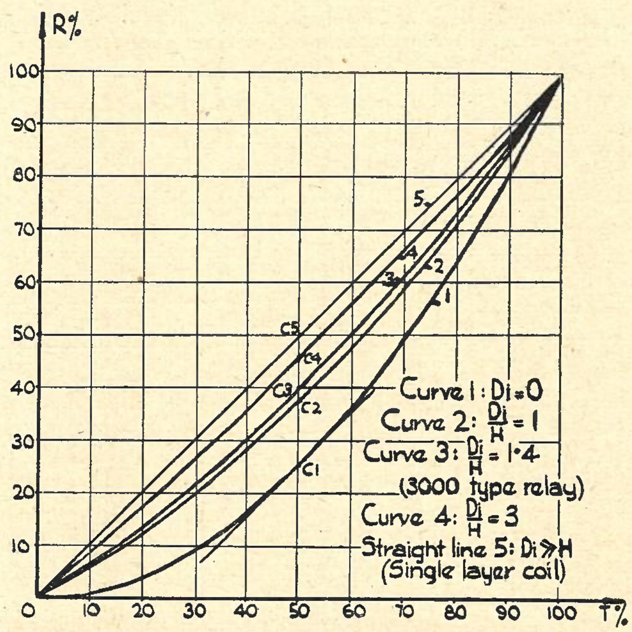


Fig. 5b.—Parabola parts representing relation between R% and T% for various ratios of D_i/H shown on one grid.

For the fundamental parabola representing the fictitious case of $D_i/H = 0$ the equation was found to be:

$$y = x^2/2P$$

In order to find the value for the tangent it is necessary to differentiate above equation:

$$\tan\alpha = dy/dx = 2x/2P = x/P$$

for point C: $(\tan\alpha)_c = 1$

$x_c/P = 1$

or $x_c = P = 50$ as shown previously

and as $x_o = 50\,D_i/H = 0$

and $x_f = 100$ .... the full coil being represented by this value.

$$x_c = (x_o + x_f)/2$$

so that the ratio of change for resistance-per cent. with turns-per cent. becomes unity at the centre of the coil (50% turns), as claimed above.

In the general case of D_i/H greater than 0 the equation was given as

$$Y = X \frac{100 + XH/D_i}{100(1 + H/D_i)}$$

$$= X \frac{X + 2x_o}{2p} = (X^2 + 2Xx_o)/2p$$

when $x_o = 50\ D_i/H$
and $p = 50\ (1 + D_i/H)$

To find the tangent the equation is differentiated:
$\tan \alpha = dY/dX = (2X + 2x_o)/2p = (X + x_o)/p$
for point C: $(\tan \alpha)_c = 1$
$x_c + x_o = p$
and as the parameter was found to be
$p = x_o + 50$
$X_c = p - x_o = 50.$

The point C at which the rate of change of resistance-per cent. and turns-per cent. becomes unity also occurs at 50% Turns, i.e., at the centre of the coil, and is characterised on the curve by its tangent forming an angle of 45° with the co-ordinates.

It might be useful to consider the significance of the results obtained so far. It has been shown that the relationship between resistance-per cent. and turns-per cent. for any type of winding-space is represented by part of a parabola. On this parabola the point C, which represents 50% turns, and therefore the average radius of the winding space ($D_m/2$) is characterised by a tangent forming an angle of 45° with the co-ordinates. This only occurs for that point on the parabola which is also on the latus rectum, i.e., the line through the focus at right angles to the axis. The distance of this point from the axis is equal to the parameter of the parabola. It follows that the parameter of the parabola represents the average radius of the winding space ($D_m/2$).

That this is so can also be shown by an analysis of the equations. These were based on the convention of nought turns-per cent. at the inner diameter D_i and 100 turns-per cent. at the outer diameter ($D_i + 2H$), the turns-per cent. being given by the ratio X/H (see equation 8). At nought turns-per cent. X = 0, and at 100 turns-per cent. X = H = 100, so that the height of the winding space is represented by the value 100 in the equations and graphs.

To solve equation (11) the value for x_o and p were chosen arbitrarily. (See equations 12 and 13.)

$x_o = 50\ D_i/H$
and $p = x_o + 50 = 50\ (D_i + H)/H$

which can also be written as:

$$2x_o/D_i = x_o/r_i = 100/H \quad (14)$$

$$\text{and } 2p/D_m = p/r_m = 100/H \quad (15)$$

when $r_i = D_i/2$
$D_m = (D_i + D_a)/2 = D_i + H$
$r_m = D_m/2$

Equations 14 and 15 indicate that the abscissa of the origin of the new co-ordinates (x_o) represents the inner radius of the coil (r_i) and the parameter (p) the average radius of the winding space (r_m) at the chosen scale for H.

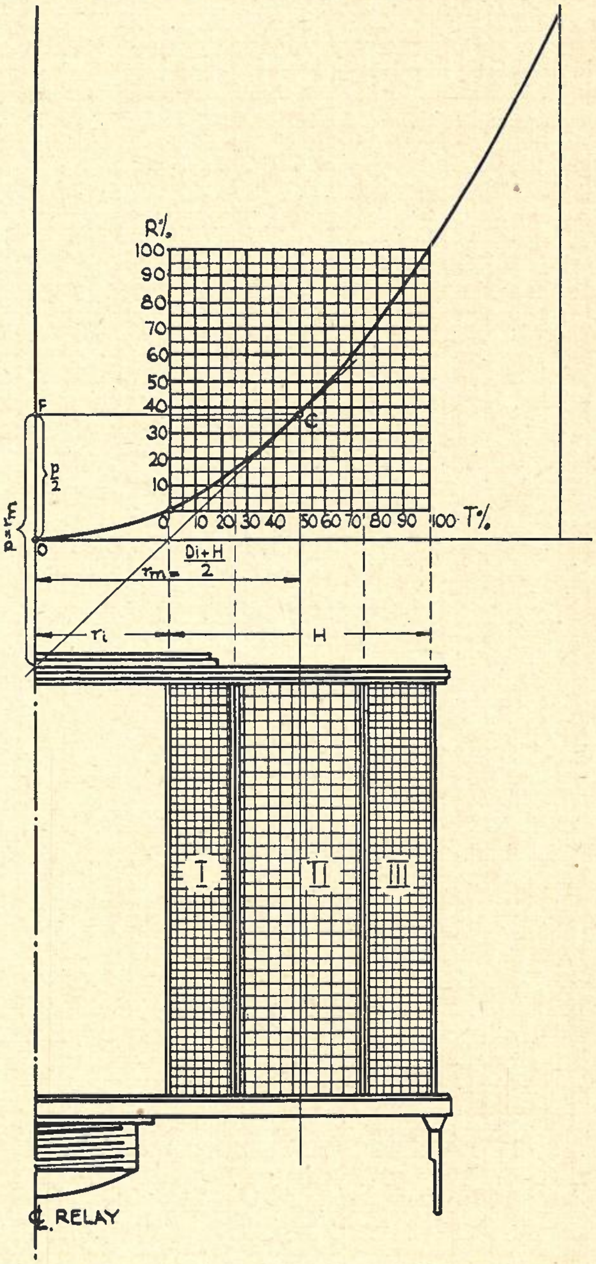


Fig. 6.—Physical significance of elements determining parabola and applicable part to represent relation of R% and T%.

Figure 6 illustrates these relations and shows that the fullness-per cent. figures for any type of coil are given by the parabola representing the fictitious coil without a core, which has the same average radius of winding space as the coil under consideration and that those parts of the curve, which fall into the actually available winding space, are to be used to find the relation between resistance-per cent. and turns-per cent.

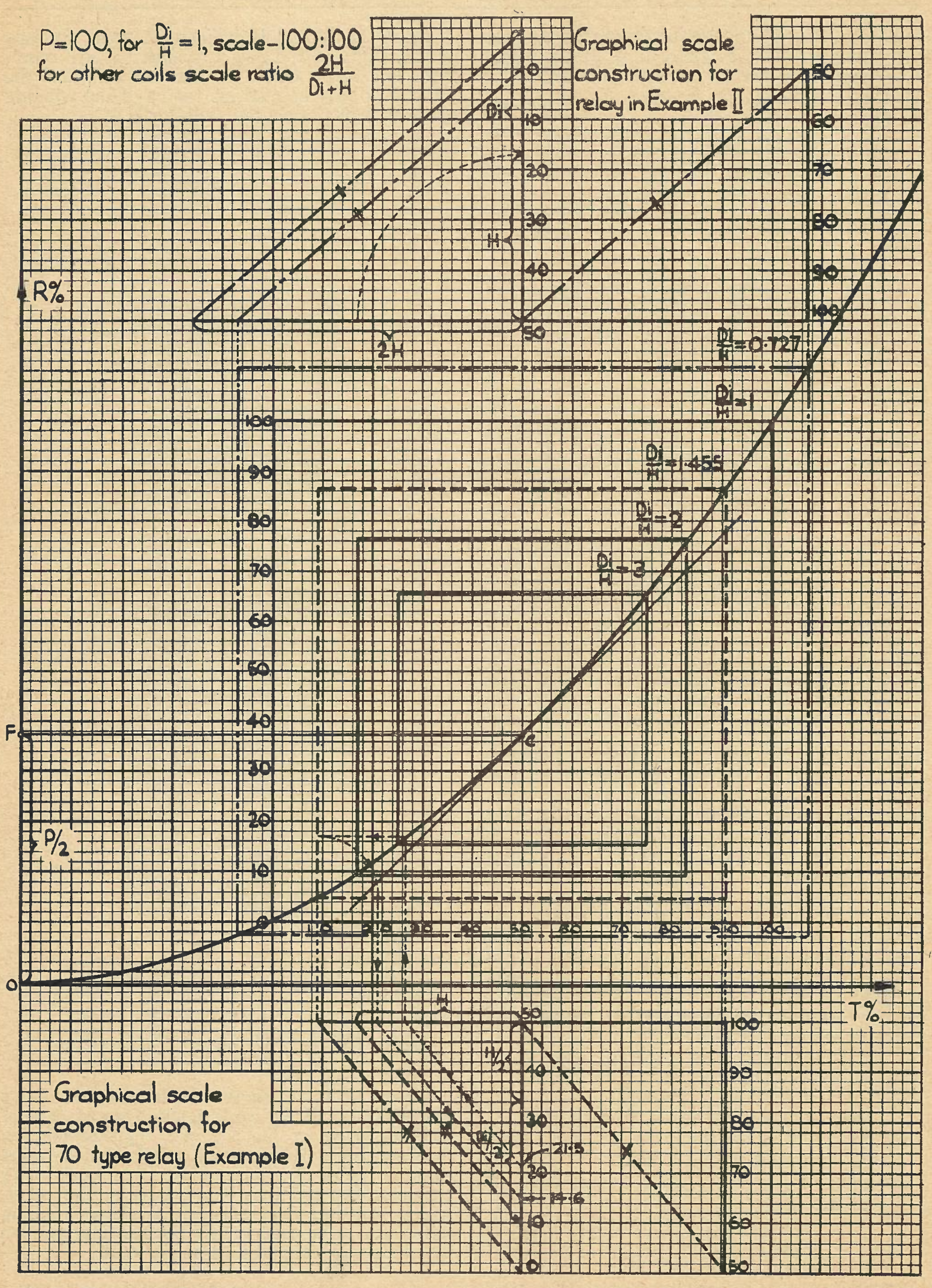


Fig. 7.—Fundamental Parabola representing relationship of resistance-percent (R%) and turns-percent (T%) for all ratios of D_i/H with help of scale-construction. The geometrical scale construction and application are shown for two examples.

As stated previously, it is possible to make all parabolas coincide by an appropriate choice of scale for the parameter, provided focus and axis are made to coincide. The scale to be applied was found to be:—

$$1/(1 + D_i/H)$$

To find the abscissa of the point corresponding to the start of the winding at the diameter D_i it is only necessary to subtract from the abscissa of C the scale weighted value of 50% turns, which is:

$$50/(1 + D_i/H)$$

if the fundamental parabola with parameter $P = 50$ is used.

In the same manner the abscissa of the point denoting the fully wound coil is found by adding this value to x_c. Correctness of this procedure can easily be checked mathematically, as the value for abscissa of starting point must be identical with the previously found value for x_o (abscissa of origin).

All readings taken from the graph then also have to be weighted with the scale $1/(1 + D_i/H) = H/(D_i + H)$.

When plotting the fundamental parabola on a millimeter graph-paper it will be found convenient to choose $P = 100$ or a multiple of it. If $P = 100$, the grid of the paper is directly applicable for coils with ratios of $D_i/H = 1$. This has been done in Fig. 7. For coils with various ratios of D_i/H, the scale applicable is then given by $2H/(H + D_i)$, and a simple geometrical construction can be used as indicated.

The influence of the ratio D_i/H on the relation between resistance-per cent. and turns-per cent. can be seen clearly from the graph on which different values for this ratio have been shown. With $D_i/H = 0$, the curve becomes the full parabola from 0 to $x_f = 2P$. The other extreme is given when $D_i >> H$, which is the case for a single layer coil. The scale weighting factor, $1/(1 + D_i/H)$, converges to nought and the ratio of change of resistance-per cent. with turns-per cent. becomes represented by the tangent at point C as constant and unity.

It will be interesting to check the graphical method for compliance with the tables published for the standard relays Type 600 and Type 3000.

For 3000 Type relay:

$H = 0.2675''$ $\quad D_i/H = 1.4$
$D_i = 0.375''$ $\quad p = 120 = x_c$
$x_o = 70,\ x_f = 170$

This particular parabola can now be constructed and the readings taken directly from the graph. Alternatively, the fundamental parabola can be used and the readings taken with scale 1:2.4.

For 600 Type relay:

$H = 0.1975''$ $\quad D_i/H = 1.36,\ p = 118 = x_c$
$D_i = 0.265''$ $\quad x_o = 68,\ x_f = 168.$

The scale to be used on the fundamental parabola is 1:2.36.

It is obvious that the parabolae for these two types will be very similar. This is due to the fact that the ratios D_i/H are nearly equal. For the 600 type relay D_i/H is slightly smaller, so that the ratio R%/T% for this type changes slightly more than with the 3000 type. However, the difference is so small that no serious error occurs if both relays are calculated with the same table. Provided that the graphs are drawn on a sufficiently large scale the readings will provide the same accuracy as the tables, with the added advantage of giving readings for fractional percentages.

Before concluding the remarks on the relationship of resistance and turns it is pointed out that the preceding calculations and formulae dealt with percentage ratios and not with actual values.

The length of the winding space did not appear in the formulae characterising the shape of the winding space because its influence cancels out, as it applies in the same way to the partially wound coil and to the fully wound coil. This means that the relation between resistance-per cent. and turns-per cent. does not change if the length of the winding space is altered. This is a well-known fact which is always made use of in caluclating windings for relays, where part of the length of the winding space is taken up by slugs extending through the full height of the coil.

As stated previously, the number of turns of any given type of wire that can be accommodated in the coil is proportional to the cross sectional area of the winding space, and the resistance of the winding is proportional to its volume. For every type of wire the number of turns per unit-area and the resistance per unit-volume are characteristic. To find the resistance of a fully wound coil it is necessary only to multiply the volume with the resistance per unit volume, while the full turns are found by multiplying the cross sectional area with the turns per unit-area.

Tables published by wire manufacturers usually do not comprise data for resistance per unit-volume. Furthermore, such tables as contained in some handbooks are only applicable to layer wound coils, and comparison with tables published for windings of standard relays shows that these data cannot be used as a basis for calculations of relay windings, as the divergence becomes very marked for fine gauge wires. In the appendix to to this article appears a table showing the necessary data. The figures given take into account the effect of "bunch" winding as it occurs on relay coils and the minimum space factor applicable for varying thickness of insulation within the tolerances allowed by the specification for winding wire.

In order to illustrate the graphical method for calculation of windings for a relay type for which no special design tables are available, examples of the procedure will now be given.

Example I. It is assumed that a relay is required, with two windings of 250 ohms each, and that the two windings should have equal resistance and turns. The coil is to be designed for maximum number of turns that can be accommodated under these conditions.

The physical dimensions of the winding space are:

$L = 1.97$ in.
$H = 0.26$ in.
$D_i = 0.378$ in.

$V = 1.018$ in.^{3}
$A = 0.512$ in.^{2}
$D_i/H = 1.455$

$p = 50(1 + D_i/H) = 122.3$
$x_0 = 50\ D_i/H = 72.3$
$x_f = 172.3$

If the parabola with above parameter is drawn, then the ordinates corresponding to abscissae between x_0 and x_f represent R% in relation to T%, and readings can be taken directly with the help of a grid.

This method would be chosen if several winding calculations for this relay type were to be made. If the calculation is only for isolated cases it will be found more convenient to use the general graph as shown in Fig. 7, and to find the desired relations between R% and T% with the help of the scale-weighting factor. As this parabola is drawn with P = 100, the scale to be applied in our case is 100/122.3 = 0.818. The geometrical construction of the scale is also shown on Fig. 7.

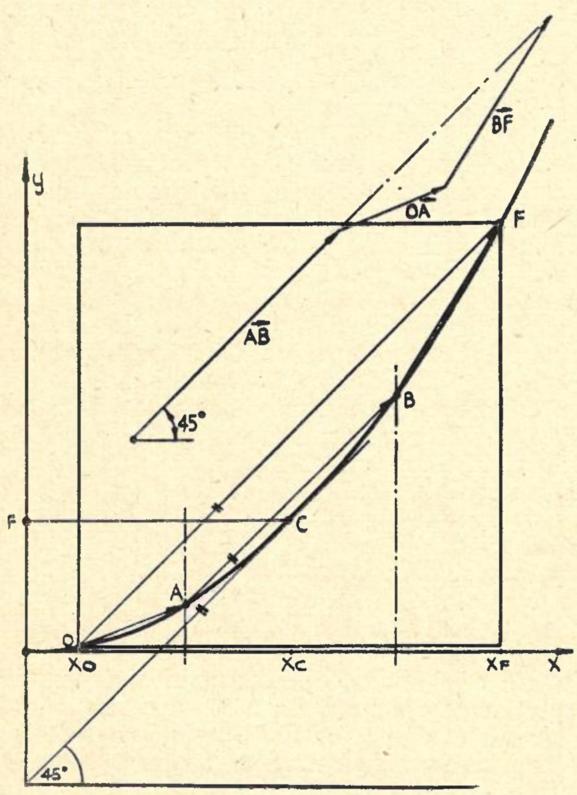


Fig. 8.—Graphical determination of data for "Sandwich-Windings."

Before the actual calculation is begun it might be of interest to consider the problem of designing windings with equal resistance and turns. The solution is provided by sandwich windings, a well-known feature of coil design. It can easily be demonstrated now, why these provide the desired characteristics. Fig. 8 shows again the relationship between turns and resistance represented by the part of the parabola between abscissae x_0 and x_f. The ratio of resistance to turns for the full coil is given by tan $\alpha = 1$. Now 1/2 of the full coil will constitute the centre part of the sandwich winding, and it is to be found what part of the winding space is to be chosen for this centre, so that the two remaining parts provide two windings which, when connected in series, have the same turns and resistance as the centre part. To meet that condition the centre winding and the sum of inner and outer winding must have the same ratio of resistance to turns as the full coil, or geometrically the straight line connecting start and finish point for the centre winding must have tan $\alpha = 1$ and these two points must be diagonally opposite points on a square of 50% turns abscissal length. By mathematical investigation of the parabolic function, or simply by applying the theorem that parallels to the tangent at point C (chords) are bisected by a diameter, i.e., a line through point C parallel to the axis (see Fig. 8), it will become apparent that this condition is met only if the centre winding starts at 25% turns and extends to 75% turns. The two remaining winding spaces together must then have the same average ratio of resistance to turns as the full coil of which they form part. In geometrical terms this is shown by vectorial addition as indicated.

The calculation proper can now be proceeded with. As a first step the suitable wire gauge is to be determined. The finished coil will have layers of insulation between windings at 2 places and 6% of the theoretical winding space must be allowed for this wastage. 500(100/94) = 532 ohms is the resistance of the 100% full coil wound with the desired wire without space wastage.

With $V = 1.02$ in.^{3}; $R_v = 532/1.02 = 520$ ohm/in.^{3}

The table in the appendix shows the most suitable standard gauge wire to be B & S 35 (5.6 mils copper diameter) with:—

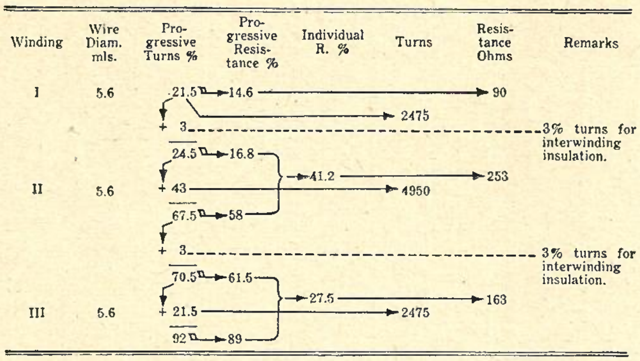
$R_V = 604$ ohms/in.^{3}
and $T_A = 22450$ turns/in.^{2}

so that our coil wound to 100% fullness would have:

$R_{100} = R_v \times V = 604 \times 1.02 = 616$ ohms.
and $T_{100} = T_A \times A = 22450 \times 0.512 = 11500$ turns.

As the total resistance of all windings should be 500 ohms thus, R% = (500/616) 100% = 81.2%, the corresponding turns % are found from the graph as T% = 86.1%.

The calculation of winding data for the innermost winding is based on 1/4 of these turns, i.e., 21.5%. Results of the calculation are given in table form below, with arrows indicating the progressive stages. Figures that have been taken from the graph are marked by feathered arrows.



Process Schematic No. 1.

This gives all the necessary data for winding the coil:—

Winding I: 5.6 mils	2475 Turns	90 Ohms
Winding III: 5.6 mils	2475 Turns	163 Ohms
Coil A = Wdg. I + Wdg. III	4950 Turns	253 Ohms
Coil B = Winding II: 5.6 mils	4950 Turns	253 Ohms

Total Fullness of Turns = 92%.

As the normal tolerance for resistance is 5%, the nominal resistance value for above coils can be taken as 250 ohms.

The relay dimensions chosen for Example I are those of the 70-type relay, manufactured by Messrs. Siemens & Halske (see Fig. 1). It might be of interest to compare the above result with the actual winding data as used by the manufacturer. The wire gauge of the original winding is 0.014 mm (5.5 mils) copper diameter.

Winding I	0.014 mm	2350 Turns	90 Ohms
Winding III	0.014 mm	2350 Turns	160 Ohms
Coil A: Wdg. I + Wdg. III		4700 Turns	250 Ohms
Coil B: Winding II	0.014 mm	4700 Turns	250 Ohms

Total Fullness of Turns = 87.5%.

It can be seen that by using the slightly larger B & S gauge wire the coil of same resistance can be wound with 5% more turns, which is an advantage, as the problem asked for maximum number of turns.

To demonstrate the actual influence that the shape of the winding space has on the windings that can be provided, a further example might be useful. For this, a relay-coil that has 1/2 of the length and double the height of the coil in Example 1 has been chosen, so that the same cross-sectional area is provided, but the ratio of D_i/H is halved. The winding shall have to meet the same conditions as previously.

Example II.

$L = 0.985$ in. $\qquad V = 1.445$ in.^{3}
$H = 0.520$ in. $\qquad A = 0.512$ in.^{2}
$D_i = 0.378$ in. $\qquad D_i/H = 0.727$

Scale to be used for taking readings on Fig. 7 = 1.17/1 or geometric construction as indicated.

It will be noted that the winding volume has increased by 43%. As in Example 1, an allowance of 6% for interwinding insulation is made:

$$(100/94).\ 500 = 532 \text{ Ohms.}$$

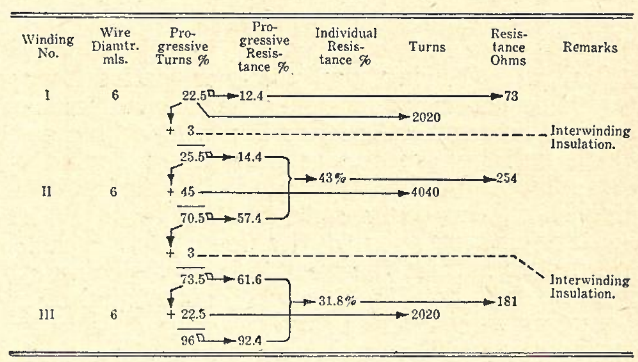
Therefore: $R_v = 532/1.445 = 368$ Ohms/in.^{3}; is desired for winding wire.

The most suitable wire gauge, chosen from the table, is:

$$\begin{aligned} \text{SWG } 38 &= 6 \text{ mils copper diameter} \\ \text{with } R_v &= 408 \text{ Ohms/in.}^3 \\ \text{and } T_a &= 17350 \text{ Turns/in.}^2 \\ \text{then } R_{100} &= 408 \times 1.445 = 590 \text{ Ohms} \\ T_{100} &= 17350 \times 0.512 \\ &= 8880 \text{ Turns} \end{aligned}$$

$$R\% = (500/590)\ 100\% = 84.8\% \text{ and corresponding } T\% = 90\%.$$

The calculation is started with 90%/4 = 22.5% turns.



Process Schematic No. 2.

The coil-winding data are, therefore:

Winding I:		
6 mils copper diameter	2020 Turns,	73 Ohms
Winding III:		
6 mils copper diameter	2020 Turns,	151 Ohms
Coil A: Wdg. I + Wdg. III	4040 Turns,	254 Ohms
Coil B: Winding II:		
6 mils copper diameter	4040 Turns,	254 Ohms

This result shows that, notwithstanding the fact that the same cross-sectional area of winding space was provided and the winding volume increased by 43%, about 20% less turns could be accommodated under the given conditions. The statement made earlier in this paper, that the ratio of winding volume to cross-sectional winding area is of great importance, is thus illustrated.

The problems associated with the determination of ampere-turns required for windings and the influence of various other factors that have to be considered in relay design will be dealt with in Part II.

(To be continued.)

APPENDIX
Table of Winding Data for Enamel Wire

Copper Diam. mils.	S.W.G.	Turns per in.^{2}	Ohms per in.^{3}	Copper Diam. mils.	S.W.G.	Turns per in.^{2}	Ohms per in.^{3}
3.2	44	58.800	4.930	10.8	32	6.120	44.6
3.6	43	48.900	3.190	11.2	—	5.780	39.2
4.0	42	41.800	2.230	11.6	31	5.350	33.8
4.4	41	35.000	1.540	12.4	30	4.740	26.2
4.8	40	29.200	1.078	13.6	29	3.780	17.3
5.2	39	24.620	770	14.8	28	3.270	12.7
5.6	—	22.450	604	15.6	—	2.960	10.4
6.0	38	17.350	408	16.4	27	2.730	8.62
6.4	—	15.500	321	18	26	2.270	6.0
6.8	37	14.400	268	20	25	1.875	3.93
7.2	—	13.030	209.5	22	24	1.580	2.77
7.6	36	11.800	171.5	24	23	1.350	2.0
8.0	—	10.700	141.5	26	—	1.170	1.46
8.4	35	9.820	117	28	22	1.000	1.08
8.8	—	9.130	100	30	—	883	0.845
9.2	34	8.400	84.6	32	21	783	0.615
10.0	33	7.030	58.3	36	20	622	0.385

CAMPING FACILITIES FOR LARGE LINE PARTIES

R. J. Mathew

General: During the post-war period many large line construction works will be undertaken by the Postmaster-General's Department, some of which will involve the setting up of camps to house large numbers of men. One large work which has been commenced in New South Wales is the laying of about 100 miles of trunk cable, and camp facilities for over 50 men are being set up at various points along the route. The first of these camps, at Blaxland, on the Blue Mountains, has now been in use for approximately a year, and, as some of the facilities and amenities provided are a considerable advance on pre-war standards, it is proposed briefly to describe them.

The camp, which is set up on a leased area of land, consists of sleeping quarters (18 huts), a large hut given over to kitchen, messing and recreational activities, a large engineering store and small fuel store, ablution and sanitary huts. Services and amenities provided include electric light and power, continuous hot and cold water to kitchen and ablution rooms, refrigeration, all-wave radio receiver, easy chairs, and internal heating in recreation room.

The general layout of the camp is shown in Fig. 1. Points of general interest are the isolated positions of the fuel storage hut and latrines, the quadrangle, which enables motor vehicles to be parked between the two groups of sleeping huts, and the position of the hot water system, between the ablution hut and the kitchen. Fig. 2 is a view of the camp looking in the direction of the arrow, Fig. 1.

Sleeping Huts: The sleeping huts are a pre-fabricated type known commercially as the "Davis" hut. They are timber framed, and have 7′ masonite covered walls and wooden floors, having an area of 16′ x 12′. The huts have gable roofs and double doors at one end, and ventilation is provided by means of flap type openings. They are built in 4′ sections, there being eight roof sheets, fourteen wall sheets, four half gable ends and twelve floor pieces, each 4′ x 4′. A hut accommodates four men, each of whom is supplied with a chain wire folding bed and separate locker or loughboy accommodation. Each hut is provided with a chair and is fitted with an electric light. Supervisory officers, such as Line Foremen, are accommodated two per hut and provided with a table and chairs, and the kitchen staff is housed together so as to avoid disturbing others when rising early. It is thought that, when the life of a camp is not likely to exceed 6 months, tents, suitably floored, would be more economical and preferable to masonite huts for sleeping quarters.

Kitchen, Messing and Recreation Hut: The hut used is of "Cyclone" manufacture, and the overall dimensions are 80′ x 20′. It is divided into three compartments, viz., a kitchen 20′ x 20′, a mess room 30′ x 20′ and a recreational room 30′ x 20′. The layout of the hut is shown in Fig. 3. The frame is of tubular steel in a fan truss construction, and is covered with corrugated galvanised iron. The partitions are of masonite on a tubular steel frame, and the wooden floor is formed with 4′ x 4′ sections, as used in the sleeping huts. Five windows are provided on each side of the hut. The kitchen equipment includes a hand-operated bread and bacon slicer, a large twin-oven fuel range, a double-ended sink and drainage board with hot and cold running water, and two kerosene-operated 5 cubic ft. capacity domestic refrigerators. In addition, a gauze-covered fly-proof room for preparing meat, etc., is provided. The refrigerators are in use temporarily, and will be replaced, when possible, by a

15 cubic ft. commercial refrigerator of the same type.

In the mess room, camp tables, each accommodating six men, are in use, and baize table-cloths and wooden chairs are provided. The ceiling of this room is of hessian stretched over the steel frame to avoid condensation from the iron roof, and to provide some measure of heat insulation. No wall lining is provided.

In the recreation room, which is provided with a battery operated radio set and centrally situated slow combustion stove, small tables and porch type wooden frame chairs, with canvas seats and backs, are provided to enable the men to read, write, play cards, etc., in comfort at night time. Magazines and other reading matter and recreational material are supplied by the Postal Institute. This room is fitted with a draped hessian ceiling, similar to the mess room (care being taken to guard against contact with the slow combustion stove), and the walls are lined with masonite-covered, light timber frames, clamped to the tubular steel frame. The whole building can be dismantled and re-erected in 4 man-weeks, with no loss of material except concrete stove beds, etc.

Stores: The main storeroom has an angle iron frame, covered with corrugated iron, and is 60′ x 20′. It is unlined and divided into two compartments, one being used as a tool store. In the other compartment, a specially partitioned and locked portion is used for small stores such as motor vehicle and tractor maintenance parts, etc. Both compartments are fitted with bins and shelving, in the same way as a standard Engineers' Store, and a counter and office furniture are provided for the storeman. The fuel store is of all steel construction, the dimensions being 10′ x 8′ with 7′ walls. It has a gable roof and earth floor. In the construction of this shed corrugated iron walls and roof are spot-welded to the tubular frame and the door and wire-guarded windows are integral with the walls. The whole store is in six pieces and can be dismantled and reassembled within 8 man-hours.

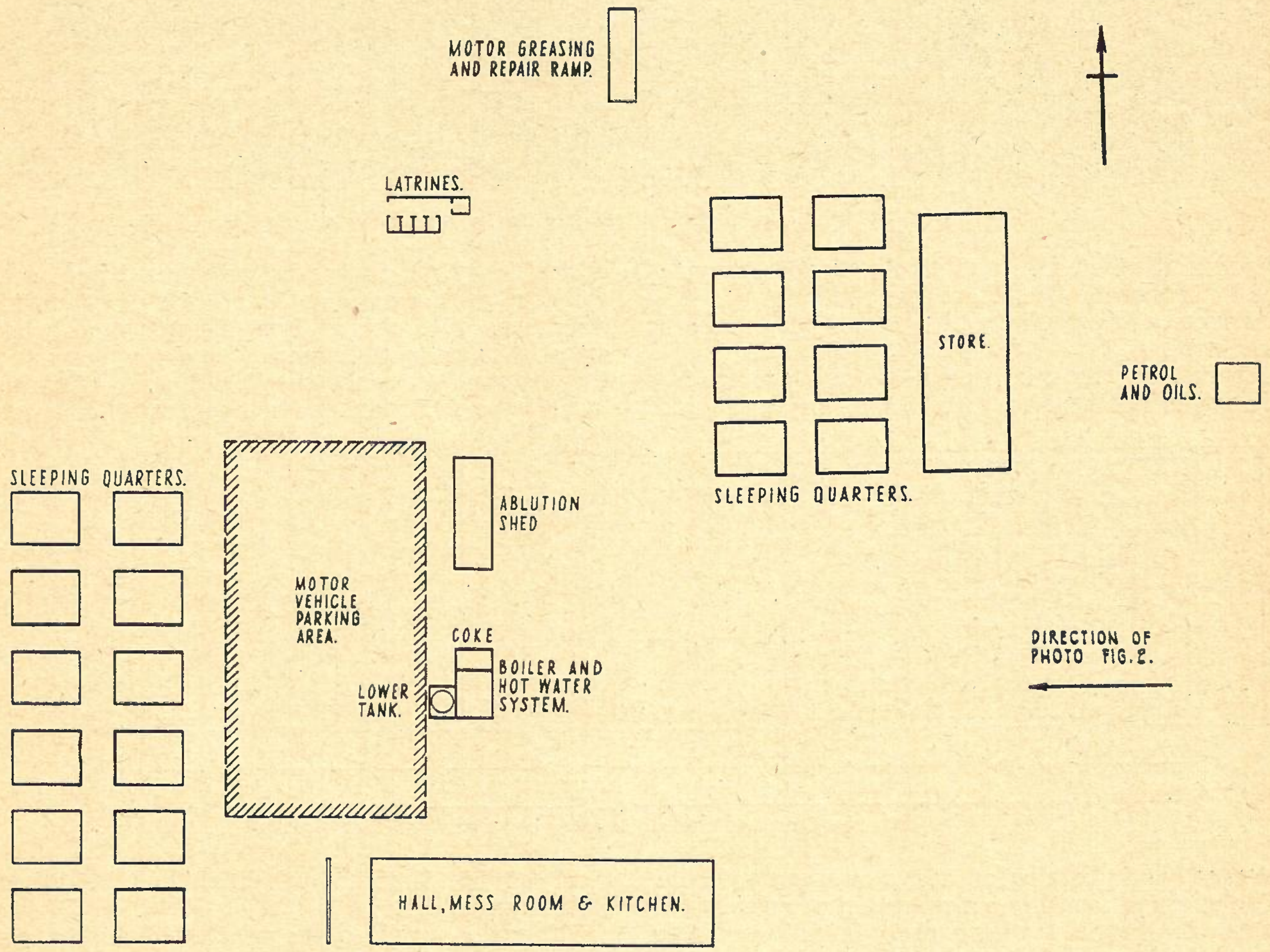


Fig. 1.

Miscellaneous Sheds: The ablution shed consists of two compartments, one being fitted with six hot and cold showers and the other as a washing and dressing room. In the latter room hot and cold running water is available over waste troughs made of half 44 gallon drums, cut longitudinally, fitted with a waste pipe and mounted on iron

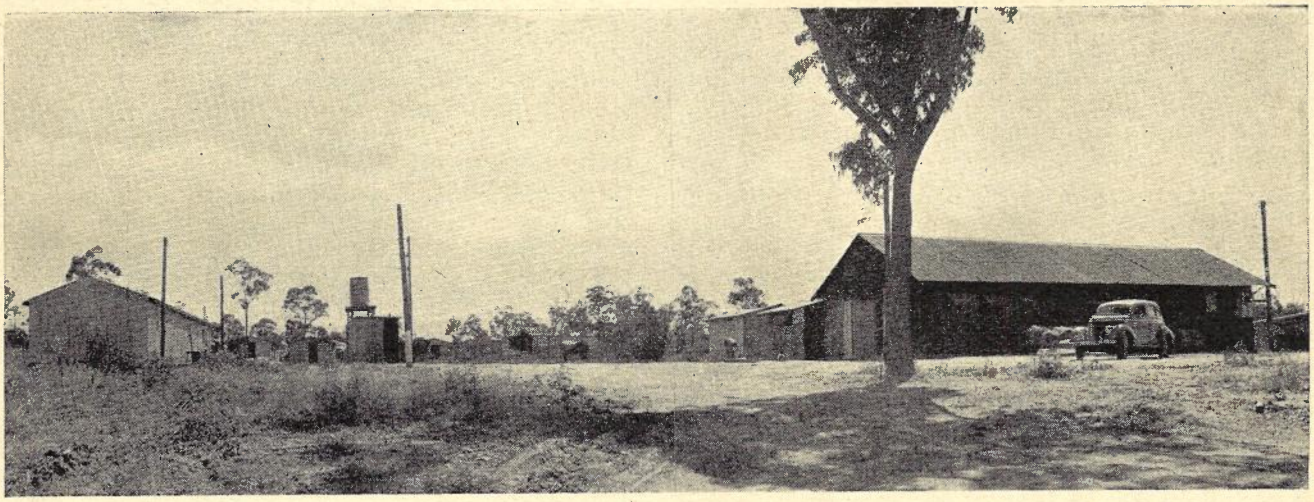


Fig. 2.—View of camp looking in the direction of the arrow, Fig. 1.

frames. Clothes pegs and stools are also provided and a concrete floor has been laid down. The latrines are standard E.C. cubicles, suitably screened.

Services: The coke fuel hot water system is a closed circuit type, gravity fed from an elevated cistern, and distributed via a storage cylinder. The average monthly consumption of coke is two tons. In districts where coke is not available, wood fuel could be used, and special pumping arrangements would be necessary where no water reticulation system is available, to ensure a continuous supply of water to the cistern.

All the huts are provided with electric light and yard lights are also installed. The average monthly consumption of electricity is 500 K.W. A parking area is provided in which each vehicle is allotted space. A ramp, to facilitate the greasing of motor vehicles, is also available.

Camp Staff: The camp is controlled by a Line Foreman, Grade 2, whose duties are also to arrange continuity of supply of stores and equipment for the whole construction project and to organise transport as required. He arranges the supply of foodstuff, acts as Messing Officer and generally attends to the welfare of the men. He is assisted by a cook who prepares three meals daily, a cook's assistant who performs normal cookhouse fatigues, and a general hand whose duty is to clean the camp grounds and assist in the preparation of lunches. The camp staff also includes a storeman and a lineman who devotes most of his time to vehicular and equipment maintenance.

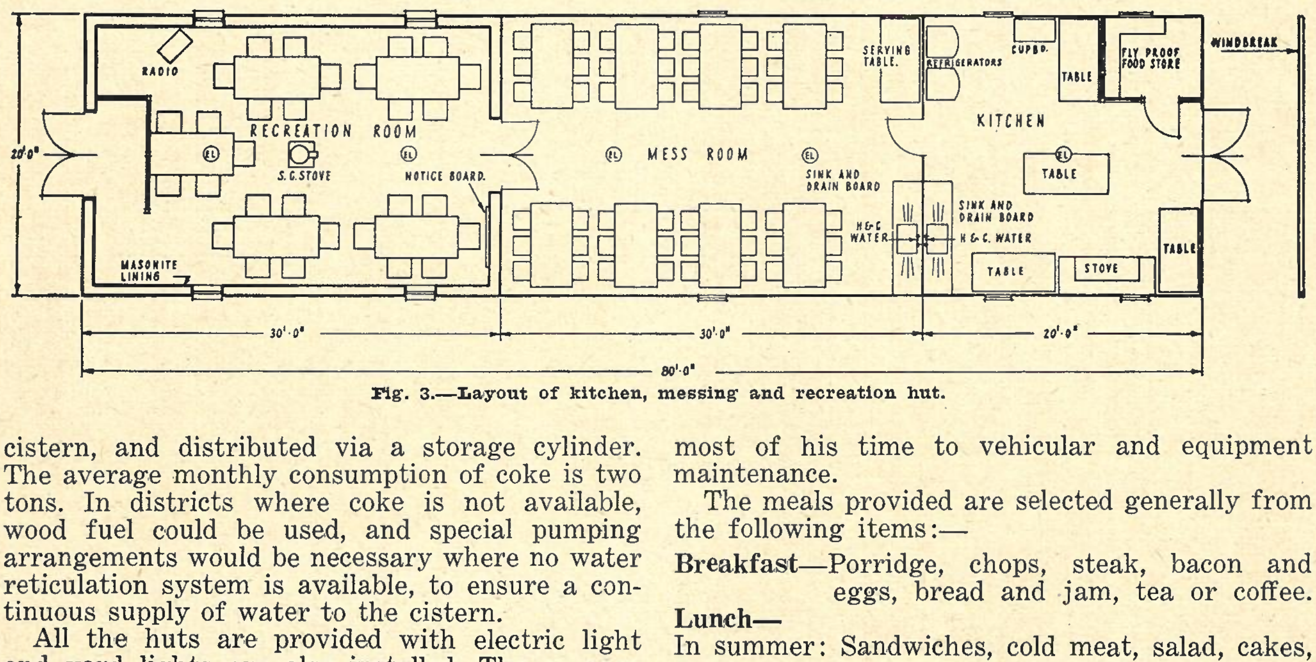


Fig. 3.—Layout of kitchen, messing and recreation hut.

The meals provided are selected generally from the following items:—

Breakfast—Porridge, chops, steak, bacon and eggs, bread and jam, tea or coffee.

Lunch—

In summer: Sandwiches, cold meat, salad, cakes, tea.

In winter: Stew or hot dishes carried to the scene of work in hot-boxes, bread and jam, cakes, tea.

Dinner — Soup, hot joint and vegetables, sweets, cakes, tea.

With the recreational facilities available, camp life at night, and at week-ends for those who do not return to their homes, is quite cheerful. A Camp Welfare Committee, elected by the men, organises cricket matches and other entertainment.

POWER PLANT IN TELEPHONE EXCHANGES

E. J. Bulte, B.Sc.

In the operation of power plant for telephone exchanges, the following main items are used:—

(a) Batteries.
(b) Motor generators.
(c) Rectifiers.
(d) Prime moving plant.

In the following, it is proposed to give a brief description of each of these items, before discussing some of the features of their operation, together with the problems which arise in such operation.

(a) Batteries

As is well known, the Australian Post Office uses only the lead acid type. Some overseas administrations use the Nickel Iron alkaline cell, which has a terminal voltage of approximately 1.5 volts, but these are in the minority. It is understood the B.P.O. uses this type of cell in some of its medium size exchanges for counter E.M.F. purposes.

As far as Australian practice is concerned, the types of cell used may be classified generally as being of three main types, as follow:—

1. **The Enclosed Type** of cell, which has pasted plates and woodboard separators. (One exception is the 10 Ah glass container cell which has a special "mass" type of pasted plate and has no separators, but depends on the distance apart of the 2 plates for avoidance of contact.) The present standard enclosed type cell used is in the form of the well-known motor vehicle type. Both 6 volt and 12 volt types are used, the majority being of the 6 volt type. The maximum capacity of this type of cell used is in the vicinity of 100 Ah (at the 10-hour rate). The chief advantages are cheapness, ready availability and the small amount of space taken up. In the latter regard a typical battery cabinet is in common use for a 48 volt 100 Ah battery, its measurements being 3′ wide, 4′ high and 1′ deep. This type of cell finds its greatest use in R.A.X's, P.A.B.X's and the smaller automatic and manual exchanges. A recent review of the records of life of this type of cell disclosed that an average life of approximately 3 years was being obtained throughout the Commonwealth. From investigations made, it appears that this average is low, due to the general shortages of first-class material as a result of wartime conditions.

At the moment, experiments are being made with a modified type of this cell, commonly known as a "radio battery." These batteries use the same containers as the motor vehicle type, but have a $\frac{1}{8}''$ thick plate in lieu of $^{3}/_{32}''$. Thus a container which would be used for a 6 volt 15 plate motor vehicle battery would contain 13 plates as a radio battery. It is claimed that a longer life will be obtained with this battery than is experienced with the motor vehicle type on telephone exchange work. Results to date are favourable. The price is approximately the same. Special connecting lugs provided with holes or screwed type terminals for easier interconnection of batteries are contemplated.

2. **The Glass Box Open Type** of cell is the second general type of cell used. This uses Plante type positive plates and box type negative plates. Glass tube separators are used for the smaller and woodboard separators for the larger cells. Due to the present difficult housing position, timber mills have been preoccupied largely with obtaining suitable housing timber, and difficulties are being experienced in obtaining woodboard separators, as they require logs of special quality. Because of this it has been necessary to obtain some batteries using $\frac{3}{8}''$ square unslotted wooden dowels as separators. These dowels are spaced approximately 6″ apart along the length of the accumulator plate. Capacities of this type of cell range from 72 Ah up to 432 Ah. They are used in small to medium sized exchanges. (See Fig. 1 for photograph of typical installation.)

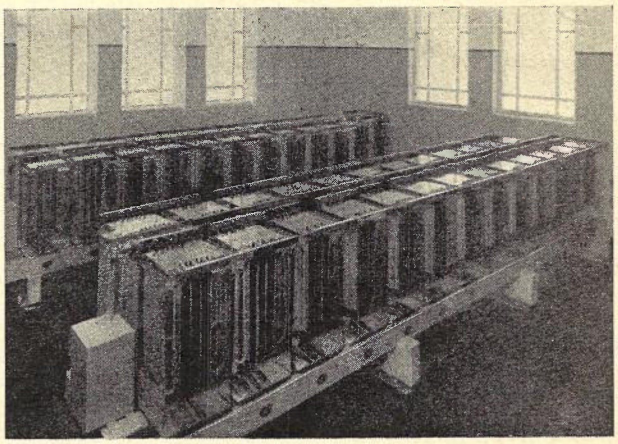


Fig. 1.—Glass box open type cell.

3. **The Wooden Box Type** of cell is the third general type of cell used. This type uses Plante positives and box type negatives, together with woodboard separators. These cells are used at the larger exchanges, the capacities ranging from 600 Ah up to 4500 Ah. Fig. 2 shows a view taken during installation of a 4500 Ah battery of this type.

It is of interest to note that the life of plates used in Types 2 and 3 cells has been recorded for the past 15 years. Below is the average life, in years, according to such records:—

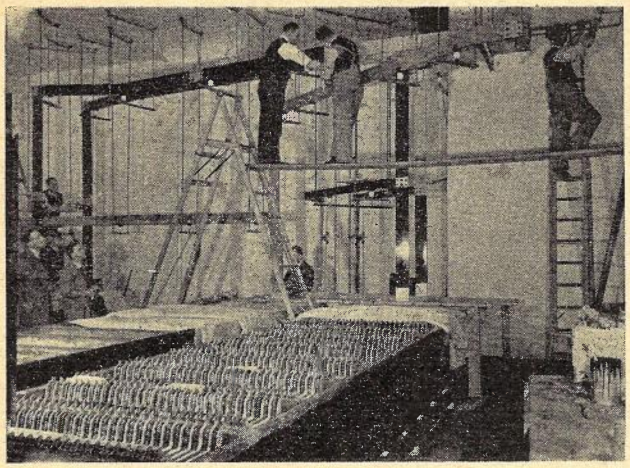


Fig. 2.—Wooden box type cell.

N.S.W.	8.3
Vic.	8.3
Qld.	6.0
S.A.	8.3
W.A.	7.4
Tas.	8.1

These averages are from the date placed in service until listed for replacement, so that the actual life would be about 9 months greater than the above figures show. As a result of the increase in the amount of "full float" service, it is probable that the life obtained from batteries in service now and in the future will be greater than the figures shown above. In this regard the batteries shown in Fig. 2 have now been in service on a "full float" basis for more than 10 years. Examination discloses that they are in excellent condition and there is only about ½" of sediment in the bottom of the boxes. The daily load at the exchange is in the vicinity of 20,000 Ah.

(b) **Motor Generators**

The motor generators used are of the direct coupled type, a flexible pulley type coupling being used. Three-phase A.C. distribution mains are available almost universally at exchanges, and the motors used are of the induction type. Starters are usually of the star delta type, with suitable overload and mains failure protective release devices. Bi-metallic strips and solenoid operated contactors are in general use for the respective protective functions. For the larger type of motor generator, wound rotors are sometimes used. In such circumstances the rotor connections are taken out via slip rings, and resistances are inserted in series in order to limit the current taken from the A.C. mains during starting. Some single-phase A.C. and also D.C. motors are still in use at some of the older exchanges. The single-phase motors use phase-splitting condensers or inductances for starting purposes. With D.C. motors the conventional type of starter which inserts resistance in series with the armature is used.

The generators to which the motors are coupled are of the shunt wound type, usually provided with interpoles for commutation correction purposes (see Fig. 3 for photograph of typical installation). As these machines are generally floated across the exchange busbars, the noise content of the output must be low enough to prevent noise being transmitted into the exchange speaking circuits. The specification covering the generators provides for a maximum of 2 millivolts on a psophometric basis across the exchange battery. The latter has been determined, from a series of measurements, to have an average impedance of approximately 0.1 ohms. In practice, therefore, noise measurements on the motor generator sets are taken using a non-inductive resistance of 0.1 ohms as a basis. The extraneous electrical noises of the generators are reduced, partly by machine design and partly by the provision of suitable inductances and condensers. In the latter regard the electrolytic condenser, with its small size for high capacity, has aided materially the solution of the "smoothing" problem.

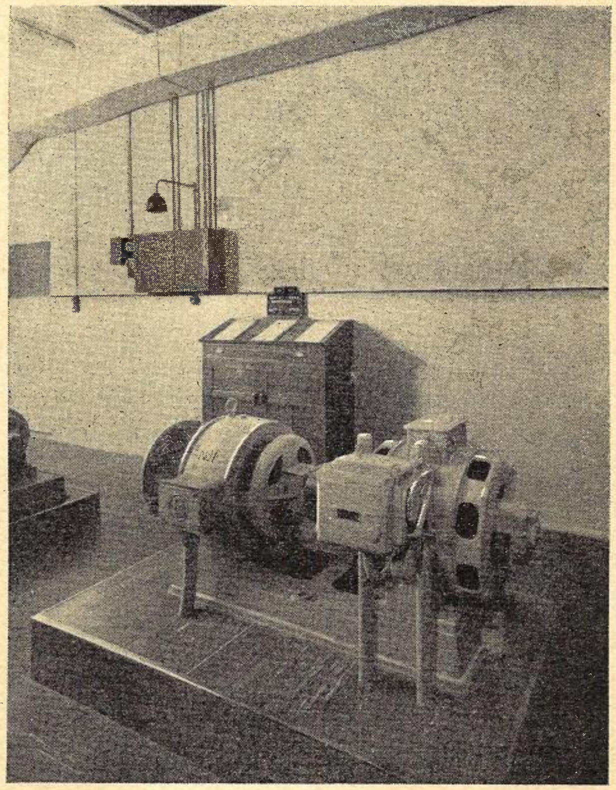


Fig. 3.—Typical motor generator installation.

Existing sizes of machines vary in output from 30 to 1000 amps. As will be realised, the existing sets have been obtained from a variety of sources over the past 30 years, there being no less than 21 different sizes of machine, as far as output is concerned, in service at the present time. In recent years the tendency towards the limitation in number of sizes purchased has been very marked. In this regard, in the last 8 years the only sizes obtained were 100, 200, 500 and 1000 amps., respectively. Present indications are that rectifiers will replace the 100 amp. size. It is also possible that an upper limit of 500 or 750 amps. may be established, higher outputs at the larger exchanges being met by the parallel operation of machines. This system has advantages in the event of machine breakdowns, and is somewhat more flexible from an operating point of view.

The machines are equipped with manual regulators. In addition, automatic voltage regulators are provided, these being designed to hold the voltage of the floating generator constant to within ± 1% of the nominal, even if the load should vary from zero current to 25% in excess of the rated current output of the machine. When more than one machine is running, one only is set for automatic voltage regulation to take the load variations, while the other machines which may be running are set at a fixed value, and "trail" the load. Three general commercial types of automatic voltage regulator are in use. These three each have a temperature compensated voltage control coil or solenoid connected across the discharge busbars. The armature of this control coil actuates a device which varies the resistance in series with the shunt field coils of the generator. The three types mentioned differ considerably in their constructional details. The other way in which they differ is in the manner of varying the series resistance in the generator field circuit. One type uses piles of carbon discs and depends on a variation in pressure between the ends of these piles. The second type uses stacks of carbon slabs pivoted about their centre of gravity, and depends for its operation on the amount of tilt of these stacks altering the current path through various numbers of slabs in series.

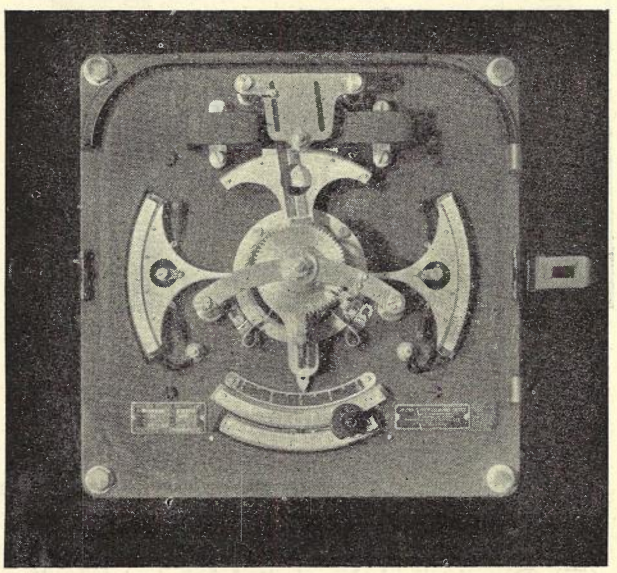


Fig. 4.—Automatic voltage regulator, wire resistance type.

The third type uses wire wound resistances connected to metallic contact blocks insulated from each other and laid in a crescent formation. The moving system associated with the armature of the control coil makes contact with the various contact blocks as the control coil responds to variations in voltage on the exchange busbars. Fig. 4 shows a front view of a double segment version of the latter type. Experience has shown that this type of regulator gives superior performance, although reasonable service is also obtained from the two first-mentioned types, which are, generally speaking, cheaper products.

In addition to the three commercial types mentioned above, there are in service some locally developed regulators. These use a contact voltmeter as the control. In one type, the resistance variation is obtained by driving a rheostat arrangement with a small D.C. motor, which may revolve in either direction, depending on whether the upper or lower contact of the contact voltmeter has been operated. In another type, a uniselector having two driving magnets with associated armature and pawl assemblies, making it possible for it to drive in either direction, is used. Wire wound resistances are connected across the bank contacts of this switch, which rotates in either direction, depending upon whether the upper or lower contact of the contact voltmeter has been operated. Operational reports on these types of regulator are favourable.

(c) **Rectifiers**

Three types are in general use, viz., the Tungar tube, copper oxide disc and selenium disc types. In addition, a few mercury arc tube types have been in service, but are practically all withdrawn now. The Tungar tube type has not been purchased for some time, but many are still in use in P.A.B.X's and the smaller exchanges. Their chief advantage is cheapness and the small amount of space taken up. As against this, the tubes are a consumable unit and are guaranteed only for 1000 hours of burning. The selenium type of disc has latterly replaced the copper oxide type for power rectifiers, because of several factors, namely:—

(1) Better temperature coefficient.
(2) Better power factor.
(3) Efficiency is about 5 to 10% greater.
(4) Working voltage in the reverse direction is approximately 14 volts per disc, as against 5 volts for the copper oxide type, therefore fewer discs are required for the same output, and less space is required per kilowatt output. In this regard, recent research indicates the possibility of even higher voltages per disc being possible, due to improved manufacturing technique, including the use of an aluminium in lieu of iron base. The research has proceeded to the stage where voltages of 28 volts per disc are in successful operation.

Most rectifiers used, in addition to having manual regulation facilities, are provided with an automatic voltage regulation device. This control is obtained by using:—

(i) marginal relays,
(ii) a contact voltmeter,
or (iii) saturable choke devices, the Transrector and Westat being typical examples of this method.

In addition to these methods, which are at present used in this country, consideration has also been given to the use of moving coil voltage regulators in conjunction with rectifiers having outputs of 30 amps. and upwards. It is understood overseas experience with this method has been favourable.

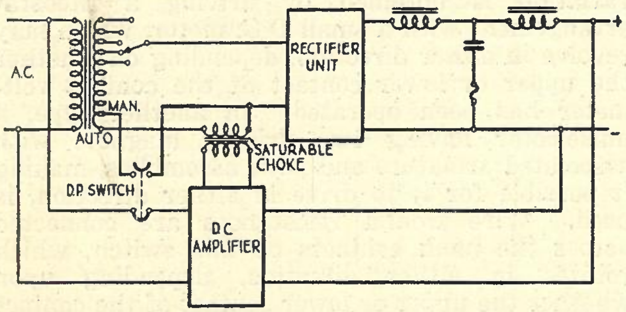


Fig. 5.—Saturable choke type, automatic control rectifier.

The present tendency in Australia is to favour the use of some form of saturable choke device, due to the advantage this method possesses in having no moving parts, as well as producing an output voltage characteristic which is controllable within fine limits. Fig. 5 shows a general schematic diagram of a type which has been developed recently. In this type, variations in output voltage of the rectifier are amplified in a D.C. valve amplifier, the tubes of which draw their plate current through the saturating winding of the control choke. The system is not affected appreciably by possible mains frequency variations, which is a drawback with the Westat type of control. With this type of control, the output voltage may be held constant to within approximately $\pm$ 2% for output values of from 20% to full load, even if the mains voltage may vary $\pm$ 5%. The output voltage is made to fall fairly sharply after full load on floating rectifiers, to prevent the rectifier from overloading itself, should the exchange load exceed the full load current rating of the rectifier for part of the operating time. Under such conditions the battery would take the load in excess of the full load rectifier rating. At the low output end of the voltage vs. current curve, the voltage is made to rise somewhat, in order than any current taken from the battery in the peak of the busy hours may be replaced during slack periods.

Up to date the largest 50 volt unit in use is of 50 amps. output. However, a few 100 amp. units will be in service very shortly, and orders are current for many more of the larger size. Units of 20 amps. and upwards are constructed to line up with the exchange power panels. The first 100 amp. units will be fan-cooled, with thermostatic protection against possible failure of the fan-cooling unit. Such a unit takes up 3' in a power panel suite. The later 100 amp. units will be convection cooled units taking up 4' under similar conditions. Oil cooling has also been considered, and may yet be incorporated in units of larger size which may be developed later. It is of interest to note that some overseas administrations have also used rectifiers for telephone exchange use, sometimes paralleling constant voltage and constant current types as variations in load demand. Fig. 6 shows a view of an overseas power switchboard suite, which includes 2 rectifiers, a constant current type having a rated output of approximately 220 amps., and a constant voltage type of approximately 150 amps. It will be noted from this photograph that the panels are grey in colour. An interesting point in this regard is that local experiments have been made in the finish of power switchboards in this colour in an effort to take advantage of the better light reflective value of grey, as compared with black. A further point of interest in this respect is that similar experiments have been made, with good results, in finishing exchange motor generator sets in light cream, for the same reason. The improvement is very marked in power rooms with little natural light.

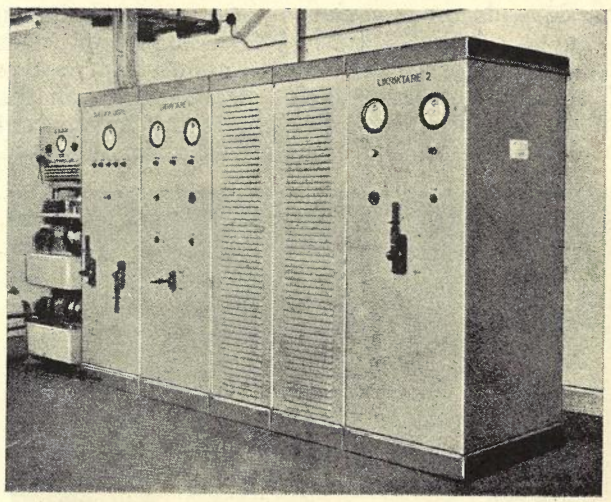


Fig. 6.—Power switchboard suite, including two large disc rectifiers.

(d) Prime Movers

The various types in use are:—

(i) Engines, belt-driving motor generator sets.

(ii) Direct coupled engine generators.

(iii) Direct coupled or belt-driven engine alternators.

Fixed and portable plant has been used with petrol or diesel engines. Fig. 7 gives a typical example of (i). Fig. 8 shows a fixed installation of a 110 KVA. diesel alternator set of the

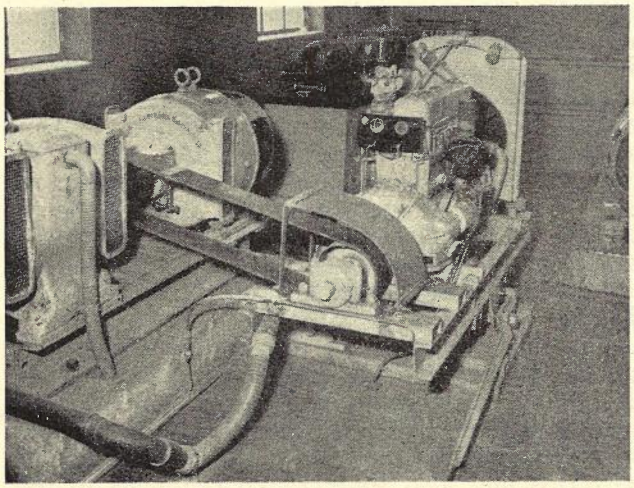


Fig. 7.—Petrol engine belt driving a motor generator set.

direct coupled type, whilst Fig. 9 shows a 30 KVA. direct coupled diesel alternator set mounted on a trailer suitable for portable duty at any exchange.

Prior to World War II, very little of this type of plant was used at all in Australia. Experience up to that time had indicated that mains supply failures were so infrequent and of such short duration that they could be covered by the exchange batteries. With the advent of war and the consequent possibility of dislocation of the public supplies due to bombing, sabotage, fires, etc., special consideration was given to this question. As a result, many engines, mostly of the motor car type, were installed in exchanges in such a manner that standard motor generator sets (which are specially designed for such a contingency) could be belt-driven thereby, if required. In addition, some direct coupled engine alternators and generators, both fixed and portable, were obtained. Fortunately, the units were

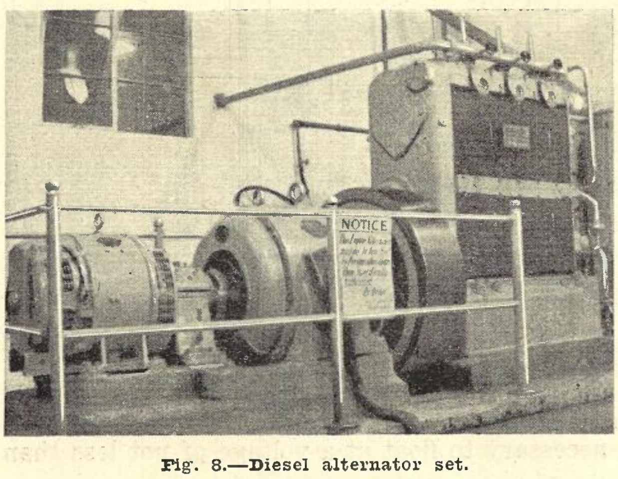


Fig. 8.—Diesel alternator set.

not required to be used during the war period. In the aftermath of the war there have been possibilities of power supply interruptions due to industrial disturbances. In addition to this, because the increase in generating plant during the war period has not kept pace with the load increase due to the growth of industrial activities, etc., electric supply cut-offs and threats of cut-offs, particularly during the winter months, have been experienced in some cities. A further factor is that the increase in the demand for coal generally has made the position of such public power supplies, which depend on this fuel, less reliable than formerly. As a result, more prime moving plant has been obtained during the post-war period. In view of past experience, coupled with the fact that it may be four to five years yet before the public supply authorities are in a position to meet all demands, no fixed policy has yet been determined with regard to the amount or type of plant for various locations. It appears that when the general margins of generating plant of the generating stations are restored to their

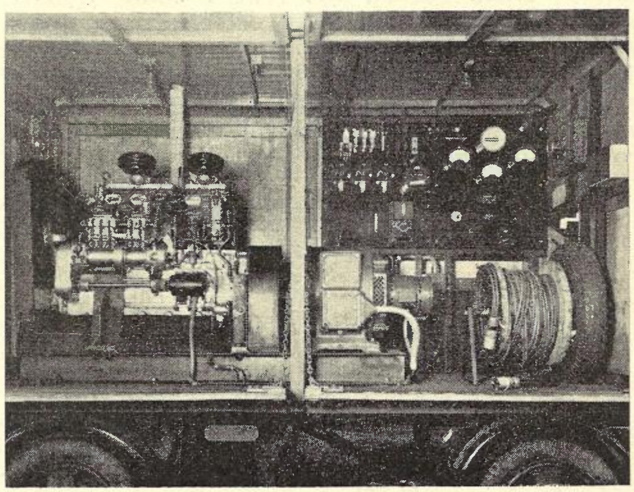


Fig. 9.—Direct coupled diesel alternator set mounted on a trailer.

pre-war level, the need for extensive use of emergency prime movers at exchanges will decrease greatly. It is probable, however, that at main exchanges, particularly, many portable plants and built-in alternators will need to be retained for many years. In this regard, due to the fact that the largest battery purchased by this department is of 4,500 Ah capacity, the busiest city exchanges need some standby plant in order that they may have a 24 hours' (10 busy hours) reserve supply, the latter being the general standard reserve as far as battery capacity is concerned.

Due to the fact that an alternator delivering standard 3-phase supply is capable of being used to run all types of generators, rectifiers, etc., which, in some exchanges, may be of different voltages due to the presence of carrier apparatus, this method of prime mover is favoured at the main city exchanges as well as country centres. For suburban exchanges, where only 50 volt supply is required and emergency lighting from the batteries is catered for, the provision of an engine generator has attractions, as this may be used in the case of a failure of the regular motor generator sets, as well as possible mains failures.

It is of interest to record that a review of the number and duration of power failures or cut-offs in the past 12 months was recently carried out, involving the Metropolitan areas of all States. This review disclosed that, by far, the largest number of stoppages of power occurred in Sydney, where power rationing during the winter months was somewhat less severe than in some other capitals. The average duration per stoppage was 77 minutes, and the longest 10 hours 10 minutes. The number of stoppages per exchange in the metropolitan area was 10 per annum. The average time per exchange per annum on this basis equals about 13 hours, which is approximately .15% of the total operating time. These figures are far in excess of any previously recorded. Other capital cities varied, the lowest being Hobart, which is served largely by hydro-electric systems, where no failures were recorded. In Perth, during the same period, there was a restricted power period of 9 days, due to industrial trouble, which affected some exchanges in the metropolitan network.

circuit. As is well known, the Department uses the divided battery float system, in which the load is floated across one of the two batteries, the latter being used alternately a week at a time. Upon being taken off the float, a battery is given a freshening charge at a low rate to ensure that any losses which may have been experienced during the floating period are made up. Usually, topping-up water is added prior to this charge, which also serves to mix up the electrolyte, thus obviating stratification troubles. At smaller exchanges, P.A.B.X's and R.A.X's, a single battery only is used. In such cases, the voltage characteristic of the floating rectifier is such that a small overcharge is given to the battery during light load periods, thus keeping it in good condition.

For many years the standard batteries for smaller to medium size exchanges have contained 24 cells. A few years ago this practice was extended to all exchanges, although, at the moment, there are quite a number of 23/25 and 25 cell batteries and also some 24/26 cell ones in use, City West Exchange, Melbourne, being an example of the latter. In some of the older exchanges, particularly those using American manufactured pre-2000 type equipment, counter E.M.F. cells are in situ. The 24 cell batteries and end or counter E.M.F. cell batteries are floated at various voltages at different locations, ranging from 2.1 to 2.15

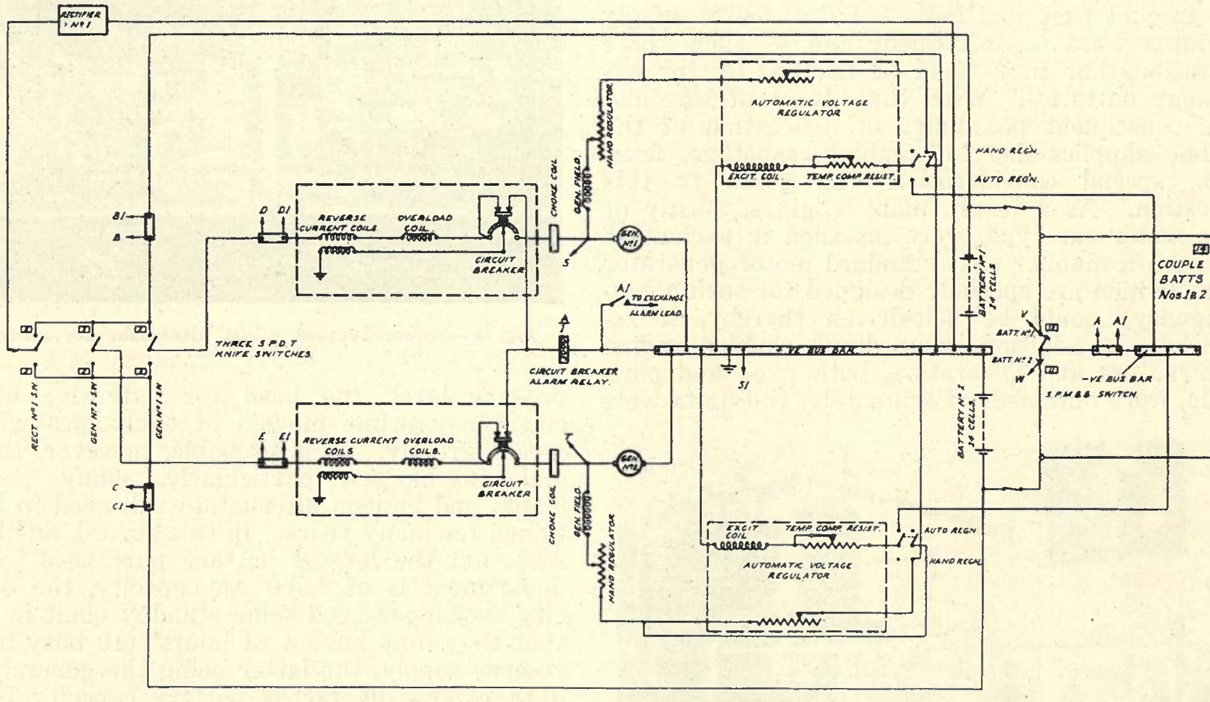


Fig. 10.—Exchange power supply system, schematic layout.

Methods of Operation

The method of connecting up the various items of power plant is, of course, to switch them at the exchange power switchboard. Fig. 10 shows the present standard

volts per cell. The 25 cell batteries are floated at figures of about 2.06 to 2.08 volts per cell.

In order to prevent self-discharge in a continuously floating cell, most authorities state that it is necessary to float at a voltage of not less than

2.15 (although experience of floating at 2.1 volts per cell for a week discloses that no fall in gravity can be detected in that time, at least). This cannot be done at automatic exchanges and still keep within the standard design limits of the equipment, namely, 46-52 volts, with more than 24 cells per battery. By providing 24 cell batteries, however, there may, under some conditions, be less capacity available at a voltage above 46 volts in the event of a mains supply failure than would be the case with, say, 25 or 26 cell batteries. If it is attempted to meet this position by providing end cell arrangements, floating on 24 cells and switching in an extra 1 or 2 cells during periods of power failure, the power circuit is thereby complicated and made more costly. A compromise is therefore necessary to meet this position. The tendency at the moment is to use the straight 24 cell batteries, and the main factors in favour of this are as follow:—

(a) It standardises the power circuit for all sizes of exchanges except, possibly, large city exchanges, where the busy hour discharge exceeds 1000 amps.

(b) Less energy is consumed by the apparatus, due to the fact that a lower floating voltage is possible than would be necessary with 25 cell batteries.

(c) Provided the batteries can be paralleled in an emergency, tests have demonstrated that there is practically no loss in the capacity available in an emergency. In this regard, although the standard battery changeover switch is suitable for use in paralleling the batteries if used within its nominal rating, a separate battery coupling switch is now being provided on the discharge panel at exchanges.

(d) It is possible to increase the state of charge of such a battery and still keep under the upper operating limit, namely, 52 volts, of the equipment.

General

As has been stated previously, a firm plan has not yet been formulated with regard to the provision of emergency prime moving plant. Up to date, at such exchanges where this plant has been installed, the tendency has been to provide a capacity such that the plant would carry the estimated 10-year exchange load (not necessarily the peak load), taking into account that the batteries could meet peak demands. In this regard the exchange load is reckoned to consist of that taken by the exchange and carrier equipment (if the latter exists), together with that required by the emergency lighting system normally run off the battery.

As far as the amount of charging plant per exchange is concerned, the general policy for the smaller exchanges, P.A.B.X's and R.A.X's which have only one battery, is to provide a single rectifier capable of meeting the peak load at approximately the 5 to 10 year period, and changing to a larger size if and when required. For an exchange with a busy hour drain at the 5 year period of 50 to 100 amps., two rectifiers, one 30 and the other 100 amps., are provided. For exchanges with a busy hour drain of 100 to 200 amps., a 100 amp. rectifier and a 200 amp. motor generator should be satisfactory. As the load builds up above 200-250 amps., the position can be met by the addition of a second 200 amp. motor generator. For the larger city exchanges, one generator is provided to take the night load, which usually lies between 100 and 200 amps. The daytime load may be met by paralleling generators of 500 to 1000 amps. output, depending on the magnitude of the load. As mentioned earlier, there are some advantages in using several machines of a smaller output as against one or two to take the whole load in such cases. The above rules are used as a general basis of charging plant provision. Local circumstances of supply, staffing, etc., may render variations more satisfactory, in some instances. The general aim is, of course, to have a reasonable amount of safeguard available in case a machine or rectifier becomes faulty in service, also to have a reserve unit available for routine charging of the second battery, where such is provided.

With regard to the size of batteries provided at various exchanges, the general basis is to provide plates for 10 busy hours at the 10-year period, and tanks for 10 busy hours at the 20-year period. This is based on an average plate life of 10 years, and an average box life of at least twice the life of a set of plates. Where the initial size of an exchange is small compared to its 20-year size, 432 Ah glass box cell batteries, which have bolted inter-cell connections, are often provided, as these can be shifted easily to another suitable location as the exchange grows in size. Also, where the sizes of exchanges do not vary very much from one another, some rationalisation with regard to the number of different sizes of batteries installed is practised. Due to the difficulties in estimating the probable growth in particular exchanges, consideration has been given to the parallel use of batteries using a standard size cell, the number of parallel batteries being increased as the size of the exchange grows. In this regard a standard branch exchange battery room of 27′ x 15′ would take 5 or 6 432 Ah cell batteries, on a single tier basis. It is of interest to note in this connection a proposal to instal two "A" batteries, each of 75,000 Ah capacity, to supply the London Repeater Station. The proposal is to use 15 sets of a single type of 5000 Ah traction type cell connected in parallel for each battery.

In estimating the size of the exchange load for new exchanges, an empirical formula is used frequently, particularly for branch exchanges. This is based on the fact that the following average figures of busy hour amps. per 1000 lines apply:—

It is found in general that the 24-hour load is

Busy Hr. Amps / 1000 lines :-

Type of Exchange	N.S.W.	Vic.	Qld.	S.A.	W.A.	Tas.
Branch metropolitan	40	35	35	30	25	20
Main metropolitan	50	40	40	35	35	—
Main city	100	100	90	70	50	35
Country	30	25	30	—	—	—

about 10 times the busy hour. The busy hour drain, particularly for main exchanges, may depart considerably from the above average figures, and in such cases calculations are made, the figures (in amperes per traffic unit) used for 2000 type equipment using uniselectors being as follow:—

Uniselectors	.04
D.S.R.'s—to other exchanges	.52
D.S.R.'s—to local exchanges	.04
Group selectors	.07
Final selectors	.45
Relay set repeaters	.24
Cut-off relay called line	.04

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MR. J. A. KLINE, B.Sc., A.M.I.E.E.

It is with considerable regret that the Postal Electrical Society records the resignation in November, 1947, of Mr. J. A. Kline, as a member of the Board of Editors. We desire to take this opportunity of placing on record his outstanding contribution to the Telecommunication Journal as Editor from its inception in 1935, and to wish him every success in his new sphere as Assistant Director (Training) in the Department of Labour and National Service. In recognition of Mr. Kline's work as Editor of the Telecommunication Journal, the committee unanimously elected him as a Life Member of the Postal Electrical Society of Victoria.

IDENTIFICATION OF CABLE CONDUCTORS (CONTINUED)

A. S. Bundle and W. C. Kemp

TREND OF DEVELOPMENT IN AUSTRALIA

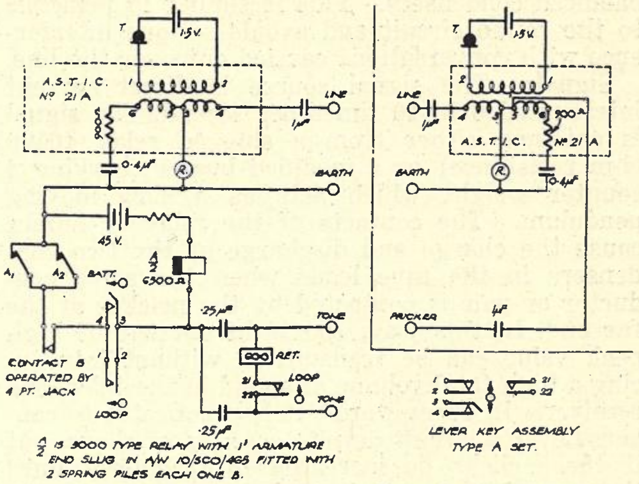
Work carried out in recent years has been based on the development of five cable identification units. Further work remains to be done on these sets, but it is felt that a description of the design and operating principles at this stage would be of interest to readers. Table 1 indicates the function of each set.

Case: Each set is to be assembled within a carrying case which will be provided with a hand grip and shoulder strap. A suitable recess will be provided for the associated cordage and head and breast sets. This provision will ensure full protection for all components during handling and transport.

The case has been designed so that the lid cannot be closed properly until the 4 point plug associated with the head set has been withdrawn. This feature is designed to conserve the batteries by preventing wasteful exhaustion. Where necessary, auxiliary springs have been fitted to the 4 point jacks so that batteries in other than speaking circuits may not be run down due to keys being operated inadvertently or by mishap.

Cordage: Owing to the severe usage, the cords should be of heavy tinsel. The terminations should be made by loops and screws, and not soldered.

Connections and Bonds: Observation of the following details is important to ensure efficient working. All connections to the sets should be clean and firm, as the introduction of resistance at the various points of contact may cause puzzling variations in performance of the sets. This is possible where a cable sleeve has been removed. Any gaps in the cable sheaths left by the removal of sleeves should be bridged over by a bond. This step will avoid breaking the electrical continuity



Type A (Sending) schematic circuit. Type B (Receiving) schematic circuit.

Fig. 15.—Cable identification units, Types A and B, for use on rotation jointed cables.

Table 1

Type	Circuit	Use and facilities provided	Used with
A	Fig. 15	Sending unit. (a) Speaking. (b) Tone. (c) Looping to obtain balanced battery feed in lieu of battery and earth.	(a) Type B (Searching) for use on new or rotation jointed cables. (b) Type C with capacity hand search feature for use on cables not jointed in rotation.
B	Fig. 15	Searching unit. (a) Speaking. (b) Pricker search.	(a) Type A (Sending) on rotation jointed cables.
C	Fig. 18	Searching unit. (a) Speaking. (b) Capacity hand search. (c) Pricker search.	(a) Type A (Sending) on rotation jointed cables.
D	Fig. 20	Control unit. (a) Speaking. (b) Page buzzer. (c) Foreign battery test. (d) Earth test.	(a) Type E (Searching) for use on wet cables.
E	Fig. 20	Searching unit. (a) Speaking. (b) Pricker search.	(a) Type D (Control) for use on wet cables.

of the sheath, and interruption to any circuits, such as electrolysis drainage schemes of which the lead sheath may form part. Without bonding, if a wrong assumption should be made as to which is the exchange side of the open joint, a high resistance earth in the identification set earth lead circuit may result.

Type A (Sending Set)

(Refer Fig. 15): This set employs the principle of sending out an audible signal over a circuit earthed on one side, the other side being connected to both legs of the line under test through balanced condensers. This is similar in principle to the cailho circuit and avoids serious interference with conversations carried out over the line.

Signal: The signal source is direct current interrupted 6 to 10 times per second. The signal is obtained either from a slugged relay (6500 ohm resistance) or a modified buzzer carrying a counter weight which acts as a slow moving pendulum. The contacts of the relay or buzzer cause the charge and discharge of the two condensers in the tone leads when the same conductor or pair is contacted by the pricker at the far end. In this way, spurts of current of high peak value can be transmitted without introducing a high total volume of sound in the telephone receivers. In other words, it is practicable to converse over a circuit despite a series of clicks, but if these clicks be increased in frequency until there are 50 or more to each one previously, the volume of noise becomes so great that conversation becomes impossible. This feature is necessary because the capacity unbalance between the two legs of lines working through subscribers' cables is frequently sufficient to permit some of the transmitted tone to be heard over the subscribers' circuit.

The signal can be sent over one, or, preferably, two wires of the required pair. On circuits such as are used in modern automatic exchanges, one side of each line is earthed (positive battery) through a very low resistance. The other side is connected to earthed negative battery through a relay. This results in a very loud signal being heard on the battery side but on the earthed side the signal may be too weak. This effect is most marked when close to the exchange.

Loop Key: The condition mentioned is due to the unbalance between the wires with respect to earth. The Loop key when operated causes the exchange apparatus to function and, by connecting the pair through to a first selector, connects either positive or negative battery to one leg of the line through a resistance (a relay coil). This tends to equalise the volume of the signal on each leg of the line and enables positive identification of each wire. Fig. 16 shows the circuit conditions.

Battery Key: This key starts the buzzer or relay operating by switching in the 1.5 or 45 volt battery. The Loop and Batt. keys are combined in a single 3 position lever key. Consequently, extra contacts are required on the Loop side to maintain the battery connection to the signal relay or buzzer.

Retard: A 600 ohm retard to loop the line is used so that should the Loop key be operated on a busy line the impedance of the retard will prevent interference with conversation.

Batteries: Standard 1.5 volt dry cells are used where an EMF of 1.5 or 3 volts is required. Light duty 45 volt batteries are suitable for operating the 6500 ohm relay. The estimated battery life with a 4-5 mA current drain is estimated to be about 600 hours but intermittent use is expected to increase this life.

Relay: The relay is a standard 3000 type in accordance with B.P.O. part number 10/SCO/465, wound with 30,000 turns of wire 2.8 mils dia. It is fitted with a 1" copper slug and a residual screw armature to enable an adjustment to pro-

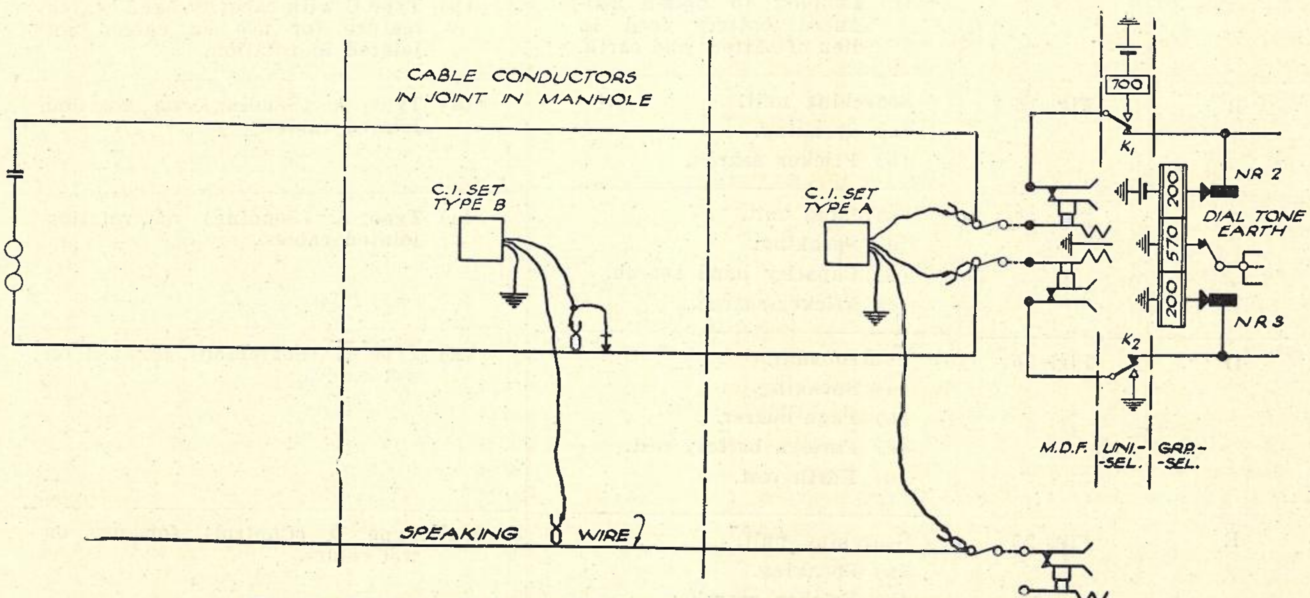


Fig. 16.—Type A and B sets. Schematic circuit showing exchange apparatus operated by loop key in the Type A set.

vide a slow, steady pulse. Two break springsets of standard 14 mil springs are used. This avoids uneven pressure on the armature as they are mounted in two spring piles; also, the provision of two double contact springs is expected to extend the period of satisfactory contact operation indefinitely. Pendulum buzzers, when used, were of 5 ohms resistance and required a 1.5 volt battery. Advantages of using a relay instead of a pendulum-weighted buzzer are as follow:—

(a) The relay components are standard parts which can be replaced from stock items if necessary.

(b) The relay functions reliably in any position. The buzzer is gravity controlled and the types obtainable vary in pattern from time to time, and must be modified to fit the counter weight.

(c) The 45 volt battery weighs about ½ lb. less than a 1.5 volt No. 6 cell.

(d) Power consumption can be reduced from 300 to 180 milliwatts by using a relay instead of the buzzer.

(e) Costs per milliwatt hour of estimated battery life favour the 45 volt battery.

Tests indicate that the relay will continue to function satisfactorily when the battery voltage has been reduced from 45 to 22.5 volts. As the battery voltage falls to a lower value, the relay indicates this condition by changing its steady pulsing to a chatter. Operating thus, the relay may still serve for a time during which a replacement battery can be obtained, without putting the set out of action.

Working Lines: When identifying a working line, it may be assumed that a short-circuit will not exist between the conductors of the pair, and both tone clips on the A set should be applied. This speeds up the process, and reduces possible interference.

Dead or Non-Working Lines: On dead or non-working pairs, however, only one tone clip should be used, and connected to each leg in turn. After the B end operator picks up tone in the second leg he should check back that there is no tone on the first leg. The presence of tone on the first as well as the second legs will indicate that the pair is probably short-circuited.

New Cables: The type A and B sets have been tried on two loaded junction cables between metropolitan exchanges. The cables were terminated on tag blocks but were not connected to circuits carrying battery and earth. It was found that the identifying signal could be heard at a high level throughout most of the cable, apparently due to the capacitive effect and the fact that no conductors were earthed. While it was possible to determine the pair on which the signal was being sent, it is considered that for these cases a relay and buzzer unit similar to the arrangement in the type D and E sets would be preferable. The relay, however, would require suitable modification in order to work on a lower current value over the higher circuit resistances involved. An alternative would be the use of a similar arrangement to that shown in Fig. 8, with the 4 ohm relays modified as suggested.

Type B (Searching Set)

This set is made up of standard components, and the remarks covering similar apparatus in the Type A set apply, with the exception of the pricker. The pricker, which is shown in Fig. 17, is constructed similarly to a fountain pen, having a protective cap for the needle points, which can be fitted on the other

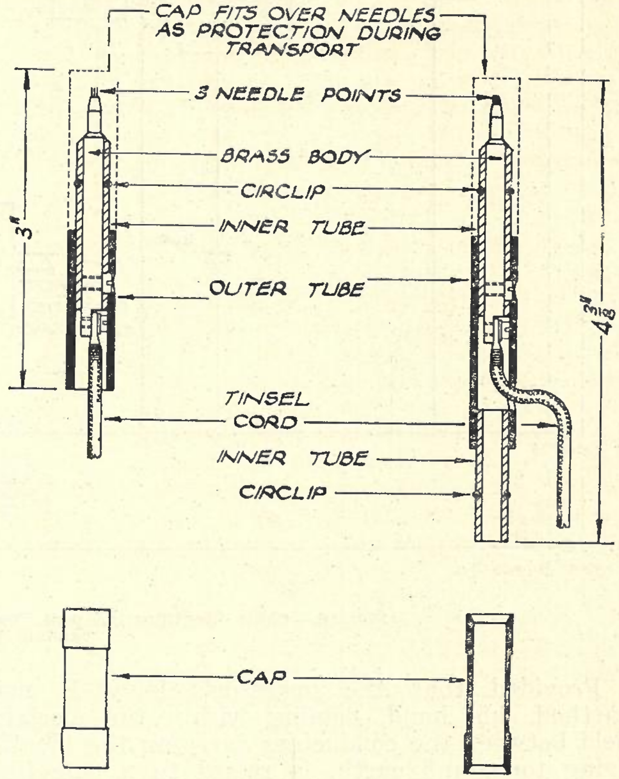


Fig. 17.—Identification prickers for use by cable jointers.

end when the instrument is in use. There should be a battery clip as well as a pricker on the pricker lead, to provide for cases where this lead is required to be connected to a cable conductor for some time. When one of the tone leads of the Type A set and the pricker of the Type B set contacts the same wire, both operators hear the signal, if the speaking and earth connections are set up as designated in Fig. 15.

Type C (Capacity Hand Search Set)

Figs. 18 and 19. This hand-capacity method is a development from early trials with a probe. It was found that with the arrangement then in view the fingers proved equally or rather more efficient than the probe. The current is received by capacitive coupling through the fingers by a tinsel cord connected from a metal wrist-band to the input of an amplifier, the cathode of which is earthed. This set is illustrated in principle in Fig. 18, and provides full communication facilities.

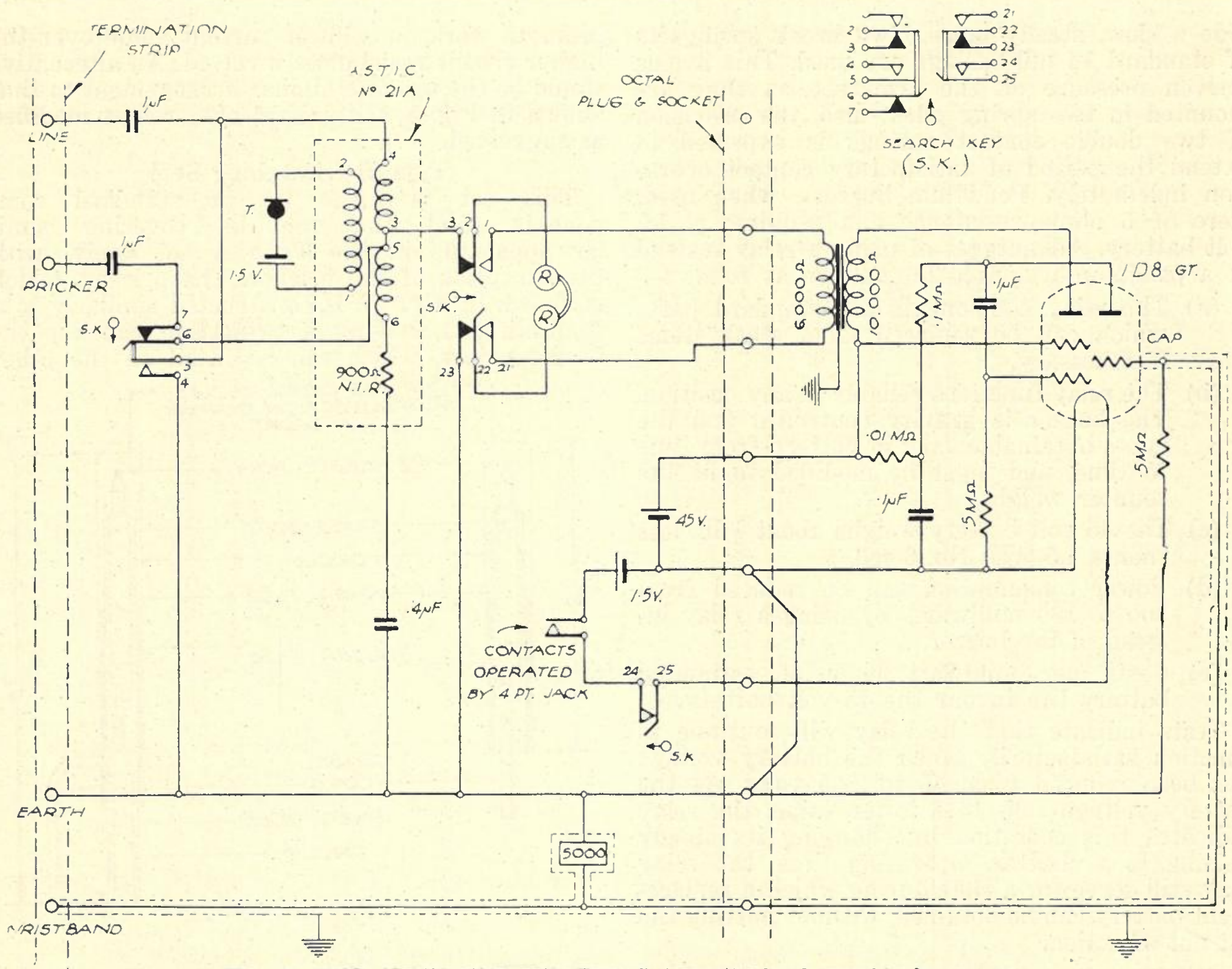


Fig. 18.—Cable identification unit, Type C (capacity hand search), for use on random jointed cable.

Provided that the operator's body is not earthed, his hand, coming within the electric field between the conductors carrying the identifying tone, and earth, is raised to a potential above earth, and this potential is applied via the wrist-band lead to the amplifier input. Long cables such as junction cables have higher capacity between the cable conductors and earth. Reception of the signal by hand is a little more difficult in such a case and the operator must stand upon a stool which, while acting as an insulator, will support him in a position at least 3 inches from the manhole floor and walls. The more usual case of the subscriber's cable is much simpler, and if the operator stands on dry boards, a rubber mat, or wears gum boots or goloshes in the manhole, reception of the signal by hand search, as shown in Fig. 19, is simple.

Searching is done by separating the pairs of the cable into approximately equal bunches, in order to determine quickly in which bunch the pair is located. Having ascertained this, the particular bunch is again split into smaller bunches, and so on, until the final pair is separated out or, at least, chosen as being one of a few pairs.

Search Key: The pick-up by capacitive coupling does not always provide completely positive identification, but is of great assistance. It enables a pair to be selected as one of a group of three or four pairs in a very short space of time. Usually, the actual pair can be picked up in this way with a little practice in the use of the set. However, checking facilities are provided by switching over to the pricker circuit by restoring the search key. This converts the Type C set to a Type B for purposes of identification. The pricker cap is fastened to the wrist-band. The cap thus acts as a sheath whilst the hand search proceeds, and the pricker is convenient when required for the final identification.

Amplifier: The amplifier uses a single valve which gives a two-stage amplification of approximately 30 db., and is operated from a 1.5 volt filament battery and 45 volt high tension battery. The current consumption is such as to give a life of approximately 320 working hours for each battery change; this is equal to 8 working weeks of continuous operation. Of course, the set will not be worked continuously for such a lengthy period. The amplifier is of unit type, contained in a small metal case and is capable of being interchanged quickly in cases of failure. Spare amplifiers can be provided and the faulty ones sent to a central repair section for attention.

Retard: The 5000 ohm retard prevents interference from outside sources such as the 50 c/s commercial lighting supply. Frequently, a wandering lead with an electric light globe is used in the manhole for illumination, and may be in close proximity when the amplifier is in use.

With the earth leads suitably terminated, speech between the operators is possible. Owing to the fault conditions, this procedure for identifying wires is not as simple as the methods previously described. When identifying through a fault, it must be kept in mind that any wire under test may be connected to either the exchange negative ("foreign"), or positive (earth)

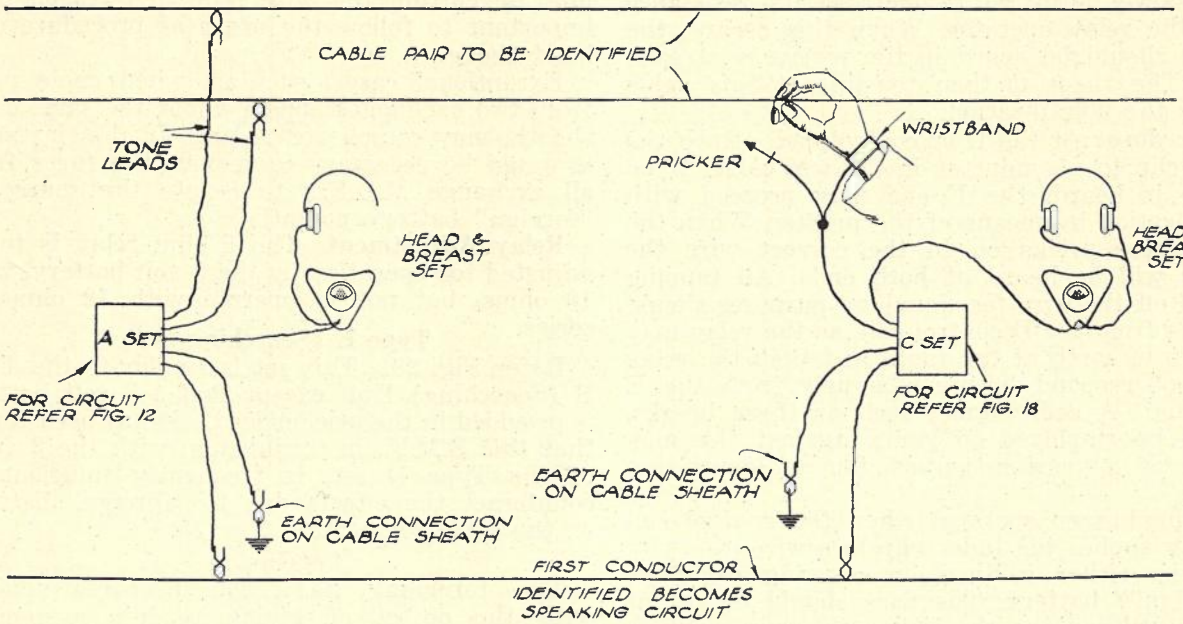


Fig. 19.—Using Types A and C sets in conjunction. Method of applying capacitive hand search feature.

The set is used in conjunction with the Type A set and provides for communication between operators at all times, as well as the two identification facilities.

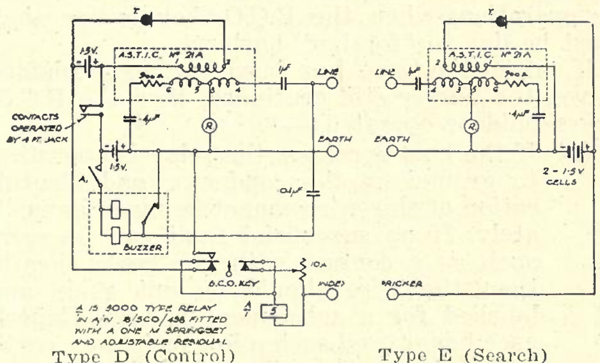
Type D (Control Set)

Refer Fig. 20. To be used in conjunction with a Type E set, the Type D has been designed to provide the intercommunication features obtained with the other combinations of sets, and also the Page buzzer feature. It is for use when identifying wires in a faulty cable, into which moisture has penetrated, with a consequent reduction of the insulation resistance between the conductors. The use of this combination is only suitable over a short distance of about 250 yards maximum. It cannot be used to identify pairs in a wet cable from the exchange M.D.F. where the fault lies beyond this radius. The following applies when a new piece of cable has been drawn in between the two manholes on either side of the fault. The pairs in the faulty cable are then identified, wire by wire, preparatory to being cut over into this replacement cable.

The D set is connected and placed in the manhole on the exchange side of the fault, and is known as the control unit. The preliminary operation consists of connecting the Line terminals of the D and E sets to each end of the same conductor in the replacement cable, or an alternative insulated conductor between the manholes.

battery, through some resistance, the value of which may vary considerably, according to the nature of the fault. Again, if the cable is only partially wet, the "foreign" battery conditions may alter from wire to wire.

Preliminary Adjustments: The previous remarks on connections and bonding apply, as high resistance contacts must be avoided at all times to ensure reliable performance of the marginal



Type D (Control) schematic circuit. Type E (Search) schematic circuit.

Fig. 20.—Cable identification units, Types D and E, for use on wet cables.

relay. Before proceeding, a test of the relay operation can be made. With the rheostat on open circuit, contacting the Index clip to the cable sheath should cause the buzzer to be heard in the receivers of each set.

Rheostat Adjustment: The value of the rheostat may now be set for the particular length (and resistance) of the conductors which are to be identified. This is done by connecting the Index clip to a good conductor (of the same resistance, i.e., weight per mile, as the faulty conductors) at the D end. The E operator earths the far end of this conductor to the cable sheath. The rheostat is turned to the short-circuit position and then slowly adjusted to increase its resistance until the relay operates. When this occurs, the buzzer should be heard in the receivers at each set. The rheostat then remains at this value during the identification.

Procedure: At the D or control end, attach the Index clip to a conductor in the wet cable. If no buzzer is heard, the E end may proceed with identification by means of the pricker. When the E operator pricks on to the correct wire the buzzer will be heard at both ends. All tapping on and off the wire for signalling purposes should be done from the D control end, as the relay may hold up to earth at the fault, and then the relay may not respond to break signals from the E operator. A code signal, such as three breaks, should be employed to guard against the mistaking of a passing contact for an identifying signal.

If the buzzer operates when the control end initially applies the Index clip to a wire, the wire must be either earthed or carrying exchange ("foreign") battery. The wire should be cut at the control end and the Index clip again applied. If the buzzer does not operate, the E end can proceed to prick for the wire, as the relay must have been operating to the exchange battery which has now been cut off. Wholesale cutting of the conductors should be avoided, as this confuses the arrangement of the joint and complicates the work unnecessarily in the later stages.

Premature operation of the relay: The B.C.O. key provides a means of cutting off the local battery supply at the D control end. Only the earthed 5 ohm relay remains in circuit so that its operation, when the B.C.O. key is operated, must be due to "foreign" battery.

If, after the wire has been cut, as explained above, the buzzer still continues, then the B.C.O. key should be operated:—

(a) If the buzzer ceases, the relay is operating to ground on the conductor and identification of this wire cannot be made immediately. If no superficial fault can be seen, such as a contact with the cable sheath, then the wire should be put aside and labelled for a subsequent re-test. Experience has proved such a low resistance earth is possibly not due to the fault, but may clear itself as the wires in the joint are re-arranged.

(b) If the buzzer continues, "foreign" battery must be feeding into the relay via other wet pairs from which the M.D.F. fuses have not been removed. The exchange technician should be asked to remove these fuses from the faulty pairs involved. When this has been done, identification can proceed.

When the cable contains both wet and dry pairs, identification over the dry pairs can be carried out in the same manner as for wet pairs. In some instances, premature operation of the relay may occur, and it will then be necessary to remove the battery potential, normally on the line, by cutting the wire. For this reason it is important to follow the order of procedure outlined above.

Exceptional cases, such as when cable pairs from two exchanges appear under the same cable sheath, may complicate testing. In this instance, it would be necessary to remove the fuses from all exchange M.D.F.'s to isolate the source of "foreign" battery potential.

Relay Adjustment: The 5 ohm relay is to be adjusted for operation by the 3 volt battery, with 10 ohms, but not to operate with 12 ohms in series.

Type E (Searching Set)

Refer Fig. 20. This set is similar to the Type B (Searching) Unit except that a 3 volt battery is provided in the pricker lead. It has been found that this E.M.F., in conjunction with the 3 volts of the Type D set, is frequently sufficient to counteract the effects due to "foreign" battery on the cable conductors.

Conclusion

The foregoing has been prepared mainly with the object of giving readers a general survey of the problem of cable identification and a description of various methods which have been developed by different administrations. Further work remains to be done in this field, both in equipment and methods, apart from changes necessary to meet new conditions of cable construction and installation, and exchange circuits.

In conclusion, it is desired to acknowledge the assistance rendered by Mr. J. A. Forster, Supervising Technician, Carlton Exchange, in the development and testing of the cable identification units described.

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INSTALLATION OF A MODERN CARRIER STATION

R. G. Ferguson and G. N. Smith, B.Sc.

In the limited space available for an article on this subject, it is not practicable to deal with all aspects of carrier installations, so the subject has been restricted to points which have more recently arisen and which should, therefore, be of interest.

The preparation of this article was first considered when it became necessary to revise completely the layout of transmission equipment in Queensland due to the installation of twelve-channel open-wire carrier systems. A standard scheme has been evolved which will be flexible enough to meet the requirements of any country installation and provide for the installation of twelve-channel systems later, with the minimum of alteration to cabling and bay positions which will then exist. Of course, the ideal conditions are seldom met, where a preconceived scheme will fit into every building space provided for transmission equipment, but, with slight rearrangements, practically any floor space can be successfully laid out. The article describes the average country installation, but the layout of equipment at large terminal centres has not been covered, as each such installation must receive individual study, although a segregation of cables and filters on the A and B sides of the station is still followed.

The main features in a carrier station can be divided, broadly, into three sections, viz.:—

(a) Power plant.
(b) Termination of outside equipment and testing equipment.
(c) Installation of apparatus racks, including distribution of power.

Each of these sections will be discussed in turn.

POWER PLANT

Power plant can be subdivided as follows:—

(i) Stations on important routes where local power supply is A.C.
(ii) Stations on important routes, where local supply is D.C.
(iii) Stations not on important routes where local power supply is A.C.
(iv) Stations in remote localities, where no local power supply is available.

(i) Station with A.C. supply, and on important route: On an important route where the local power supply is A.C., a power plant installed for use with the 24 volt filament batteries is either equipped with power rectifiers, where the charging current is less than 80 amps., or with motor generators where the charging rate is over 80 amps. Experience has led to the float routine being adopted in the charging of filament batteries so that the usual installation, comprising two 600 Ah batteries, would have a 35 volt 80 amp. rectifier for charging purposes and a 24 volt 25-80 amp. rectifier with automatic voltage control for floating purposes. If motor generators are provided, one would be of sufficient output to recharge one set of batteries in eight hours, and the other should have an output capacity large enough to float the battery at the maximum discharge rate for the office concerned. The float machine would be fitted with automatic voltage control and provided with the necessary noise filter to bring the busbar noise within the C.C.I.F. noise limits, which are 0.5 mV. for 24 volt batteries and 5.0 mV. for 132 volt batteries, measured, in each case, across the discharge busbars through a weighting network referred to 800 c/s.

A satisfactory voltage control for generators is the carbon pile type used in the field circuit and controlled by the voltage of the discharge busbars. With correct initial adjustment of the regulator, and a variation of the power board to provide protection under conditions of mains failure, the performance is accurate.

Deliveries have recently been received from Brown Boveri of regulators which should be equally satisfactory. A potential coil controls an armature which wipes over contacts connected to resistances forming the field control on the generator. This type of regulator has two disadvantages, however, the price and the space required for mounting.

Diverter pole generators are stated to provide constant potential control, and their performance is being closely watched. This control is obtained by an ingenious arrangement of auxiliary poles and magnetic bridges, by which the magnetic flux is diverted from the armature during periods of low output from the machine, thus controlling the output voltage within close limits over almost the entire range of the machine. Up to date, the machine installed in Queensland has not fulfilled all the claims made. The efficiency of this type of machine is rather low, being about 60% on full rated load.

Where the charging rate is not excessive, rectifiers are preferred to motor generators at new stations, for the following reasons:—

(1) No separate power room is required.
(2) They are suitable for a float routine, as they are easier to run unattended.
(3) The maintenance difficulties are less than with motor generators.
(4) They are more readily available.

The "Westat" constant potential rectifier has been designed to maintain an output voltage between limits of $\pm$ 4 per cent. for changes in load, from no load to full load, and mains variations of $\pm$ 6 per cent.; or within limits of $\pm$ 1 per cent. at constant load for mains variations of $\pm$ 10 per cent. The efficiency of this type of rectifier is satisfactory, being about 70%. Whilst "Westat" rectifiers should provide a satisfactory solution to the float requirements, experience has shown it is difficult to adjust these rectifiers in service, especially in country installations where the supply frequency may not be controlled accurately.

Recent deliveries of selenium rectifiers controlled by thermionic tubes show promise of easier adjustment, but, so far, no field trials have been made in Queensland.

A further method of voltage regulation which operates successfully overseas is the regulating transformer. This is connected in the A.C. mains and has one winding tuned to resonance with the supply frequency. With a suitable adjustment of magnetic characteristics, it is claimed that the effect of mains voltage variations is negligible. Any variation in frequency, however, appreciably reduces the efficiency. So far, supplies of these transformers have been limited in Australia.

Where the floating routine is established, the two 600 Ah capacity filament batteries are floated in parallel, unless this does not give 24 hours' reserve for the estimated ultimate load, in which case the battery is treated as a special case and a larger battery is installed. Two batteries, each of half the calculated capacity and paralleled on a float routine, are preferred to one battery of a larger capacity. The batteries are paralleled by the operation of the switches on a standard power board and sufficient flexibility is obtained to deal with any faulty battery condition due to short circuits, etc. As can be appreciated, replating, where only one battery is installed, is impracticable, whereas under the parallel scheme the battery to be replated is simply isolated, while the other one remains on float. The full capacity of both batteries is always available. Recent tests on batteries which had been floated for 15 months on a constant voltage basis confirmed this opinion.

The batteries are always loop installed, i.e., 6 cells of the 24 volt battery are installed in a row and the remaining 6 cells in another row, the 6th and 7th cells being at one end and connected together, and cells numbers 1 and 12 being at the other end. The cells are installed in this manner to reduce self-induction and so reduce the noise potential across the busbars. Furthermore, by the reduction of coupling between the two batteries, noise due to charging is reduced should it be necessary to operate on a charge-discharge routine. On important routes the basis of the installation is the provision of 24 hours' reserve power in the batteries for the ultimate load of the station, for both 24 volt and 132 volt supplies.

It is considered that all stations on important routes should also be provided with a prime mover as a standby plant. Experience has demonstrated the need for this plant, because of the possibility of interruptions due to fire, flood, coal and transport strikes, etc., and during the critical times of war.

The practice in the past has been to instal two or three anode batteries in stations of this type, depending on whether voice frequency telegraph terminals were installed or not, but, due to experience gained over the last seven years, trials are being made now to instal one anode battery only where a positive potential is required and two batteries where positive and negative potentials are necessary. Each of these batteries will be floated continuously with an automatic voltage controlled rectifier irrespective of the battery capacity; a second or third rectifier being installed for replacement purposes.

Many types of enclosed cells have been tried without satisfaction, and their use has been discontinued, except for isolated stations on Cape York Peninsula, where transport is the governing factor. A convenient open-type cell for anode batteries is that having a capacity of 72 Ah, as it can be mounted on a two-tiered stand 10' 3" long, and is the same overall length as the 24 volt 600 Ah battery.

A satisfactory standby plant is a self-starting

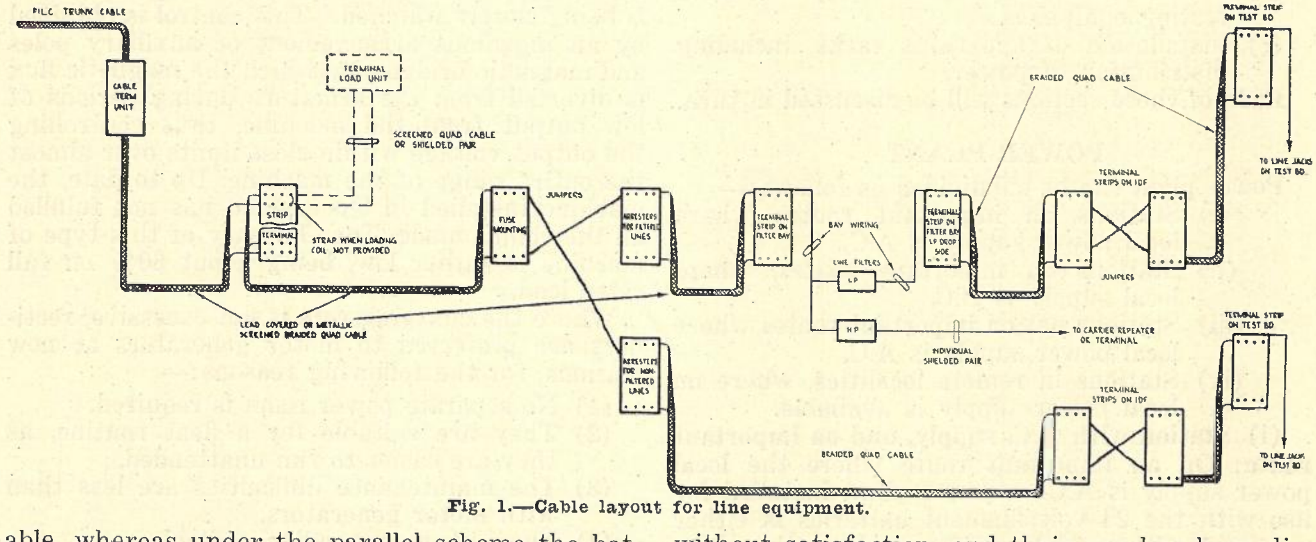

Fig. 1.—Cable layout for line equipment.

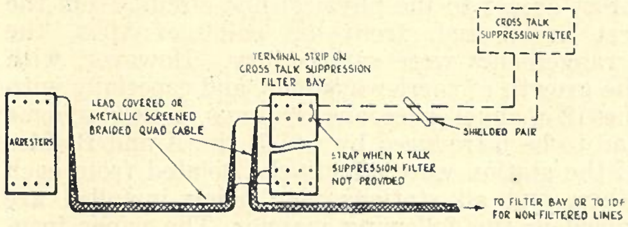

Fig. 1A.—Side of office provided with crosstalk suppression filters.

prime mover coupled to an alternator which would replace the mains in the event of failure. Plant of this type has been difficult to obtain and, during the war, smaller stations were equipped with petrol engines coupled to 30 volt 40 amp., or 140 volt 6 amp. generators. The available engine alternators were reserved for larger stations.

The prime mover can be either a diesel or petrol engine, but from experience a petrol engine is preferred, especially in a locality where the service of a skilled diesel mechanic is not available. The maintenance of a petrol engine usually

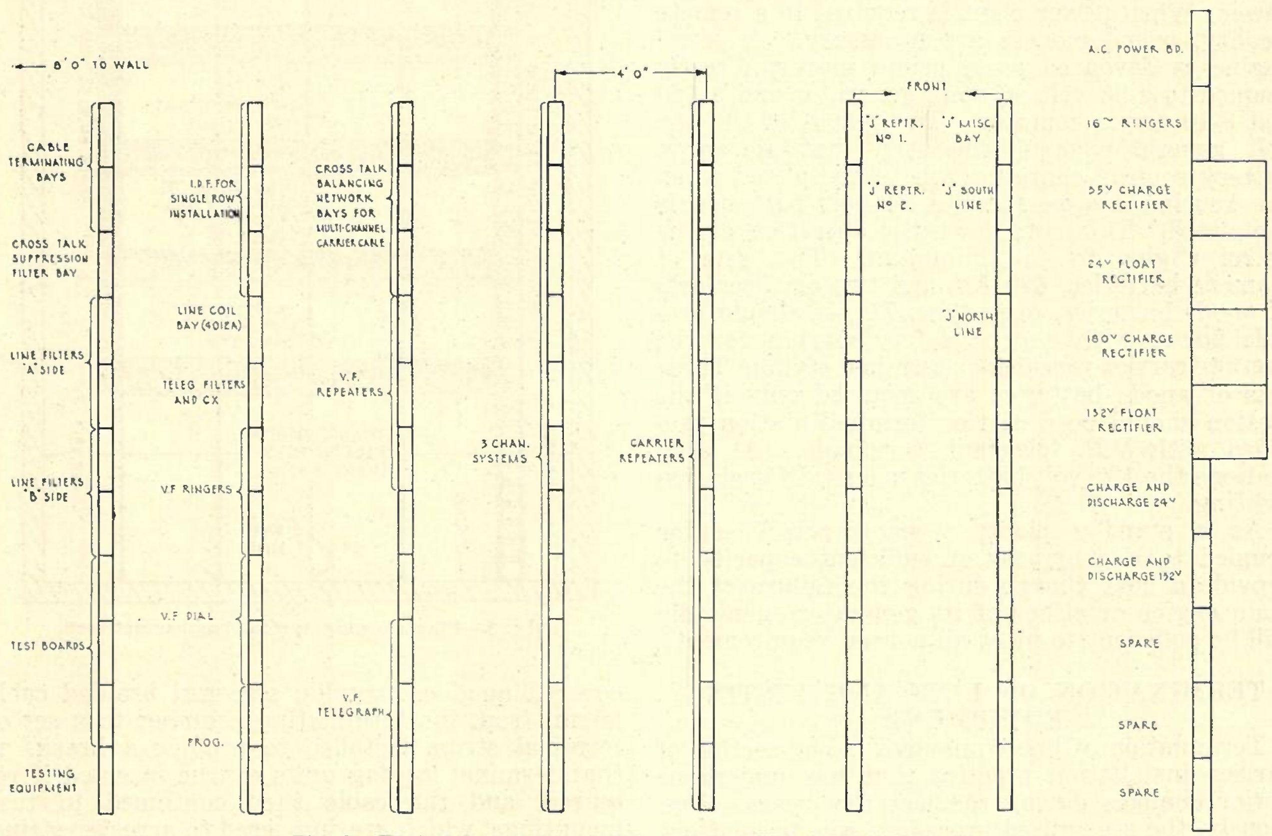

Fig. 2.—Typical layout for station equipped with power rectifiers.

presents little difficulty, but a diesel engine requires skilled attention for even routine maintenance, such as the checking of bearings, the maintaining of clearance between piston and cylinder head, and the maintenance of injectors, etc.

Whatever the type of prime mover, it is an advantage to have a machine provided with radiator cooling, in preference to tank cooling, to simplify the installation. For this same reason a direct coupled engine generator set is preferred to separate units belt driven.

(ii) Station with D.C. supply on an important route: Whilst stations of this type are decreasing rapidly in number, the problem still sometimes arises. Battery capacities are provided on the same basis as in (i), but charging of the filament batteries is done with motor generator sets. Satisfactory floating conditions have been established by equipping duplicate motor generators with carbon pile regulators and using these alternatively for floating. Generally, under these conditions, two anode batteries are provided and operated in a charge-discharge routine.

The charging current for these batteries can be provided directly from the mains and controlled by a 10 amp. variable resistance unit. When charging from the mains, it will be necessary to remove the earth from the battery during charge and replace it when the battery is placed on discharge. This can be arranged by coupled auxiliary switching on the power board. The removal of the battery earth is generally required by the local authority providing power, but, even if permission is granted for the earth to remain, trouble with electrolysis will surely result, unless provision is made to provide a neutralising current when the anode batteries are on charge. This was accomplished, in the following manner, in cases where only one anode battery was provided and a 3-wire supply was available. Provision was made to charge the filament batteries from the negative mains at the same rate of charge as the anode battery on the positive mains. This has given satisfactory results and obviated the necessity of providing a second anode battery at the station concerned. When the anode batteries are not on charge, the filament batteries are charged, as usual, from a motor generator.

(iii) Station with A.C. on unimportant route: At stations not on important routes, where A.C. power supply is available, the practice is to operate these stations direct from rectifiers. The usual practice is to have regulated rectifier cubicles which provide 24 and 132 volts D.C. for the equipment, so that no alteration is necessary to standard carrier equipment. It is not the practice to provide emergency equipment at stations that come under this classification.

(iv) Station in remote locality without local power: When power plant is required in a remote locality, prime movers are necessary. A petrol engine is favoured as a prime mover, directly coupled to a 35 volt 80 amp. generator and a 180 volt 3-10 amp. generator. The output of the 180 volt generator should be such that all anode battery routine charging will be completed when the routine charge for the 24 volt batteries is completed. This cuts down the operation of the petrol engine to the minimum. Two sets of filament batteries, 600 Ah, and two or three sets of anode batteries, open type, 72 Ah, should provide power with a good safety margin for the average carrier repeater or terminal station. Three sets of anode batteries are required only if the station should be a carrier terminal station provided with V.F. telegraph terminals. At such stations the 132 volt batteries are used for station lighting.

As a standby plant, a small petrol engine coupled to a generator of sufficient capacity to provide a float charge during the failure of the main engine or either of its generators generally will be sufficient to meet all normal requirements.

TERMINATION OF LINE AND TESTING EQUIPMENT

Termination of line equipment is one section of carrier installation practice that has undergone major changes during the last few years. Previously, the recognised procedure was to allot one or more bays on the M.D.F. for trunk line working and terminate thereto a S. & C. cable tail which had been joined to the trunk paper insulated cable. An S. & C. cable was installed between the M.D.F. and the toll test board line jacks. The various line equipment, such as line filters, composite sets, etc., was installed inside the line equipment jacks. With this scheme, the testing officer had direct access to the physical line circuit from the test board and, from his point of view, the arrangements were satisfactory. However, with the growth of carrier systems, and especially with the 12-channel open-wire systems, a new scheme had to be introduced by which the A and B sides of the station were effectively isolated from each other, and all stations now being installed are cabled in the following manner. The paper insulated trunk cable is terminated directly in a cable terminating chamber, mounted on a standard 10′ 6″ bay, a separate bay being used for the cable on the A and B sides of the station. Lead-

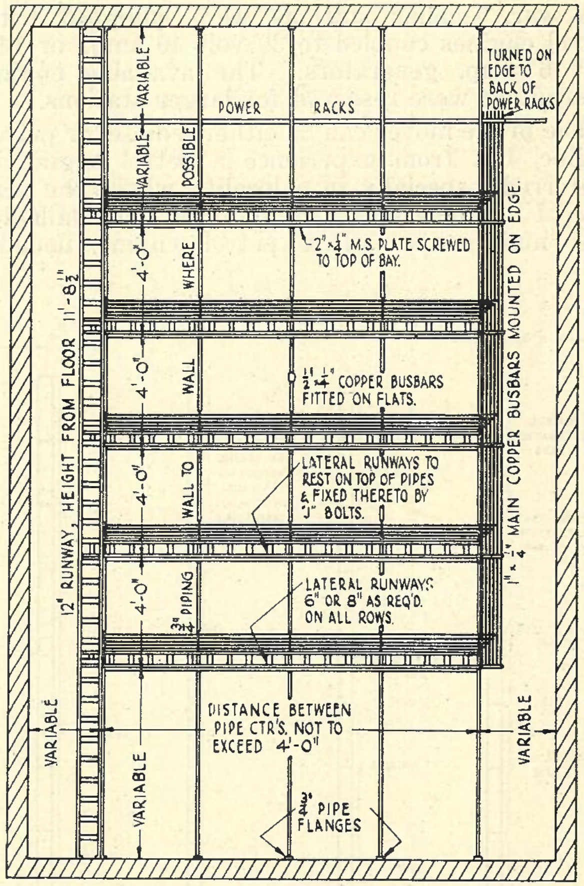

Fig. 3.—Plan showing typical bus-bar network.

covered quad or metallic screened braided cable is run from the terminating chamber to a set of terminal strips installed to provide a break, so that terminal loading units can be inserted if required, and the cable then continued to fuse mountings, which are jumpered to arrester strips.

These arresters are standard arrester strips, with the springs for the heat coils and test shoes removed, leaving only the springs for the protector blocks. In many installations the length of the entrance cable makes the provision of arresters unnecessary, but, if they were omitted, a terminal block would have to be installed for jumpering, instead of the arrester. Arrester strips are, therefore, installed as standard equipment, irrespective of the length of the entrance cable. One strip of these arresters is cabled in lead-covered quad, or metallic screened braided cable, to a terminal strip on the filter bay, and the low pass side from the filter bay is cabled to the I.D.F. in ordinary braided quad S. & C. cable. The high pass side from the filter bay is run in individual screened braided covered pairs to the associated carrier terminal or carrier repeater. The other two strips of arresters are cabled in braided quad cable to the I.D.F., and carry "non-filtered" lines.

To provide for the installation of crosstalk suppression filters, which are necessary when the second 12-channel system on any route is installed, a crosstalk suppression filter bay is provided on the left of the cable terminating bay for that side of the office which has the least number of physical lines, as crosstalk filters are only required on one side of an office. Cables are run from the terminating bay as described, except when they are required. This cable layout is shown in Figs. 1 and 1A. The physical line can be tested from the test board through the L.P. filter or, if necessary, by using test trunks to the filter bay, and so direct to line clear of filters.

APPARATUS RACKS

Layout: The layout of equipment bays is controlled by the cable runs required, the association with other bays and the need for accessibility of certain bays to the testing officers. A typical layout is shown in Fig. 2. This shows the test boards, line filter groups, crosstalk filters and line cable terminating bays in the same row. This is to provide the shortest distance possible between the cable terminal bays and the line filters. Carrier frequency bearer circuits can then be taken off the high pass drops of the line filters close to the cable terminal bays and, in screened braided wire, proceed to their associated carrier repeaters or terminals. The test boards are associated with

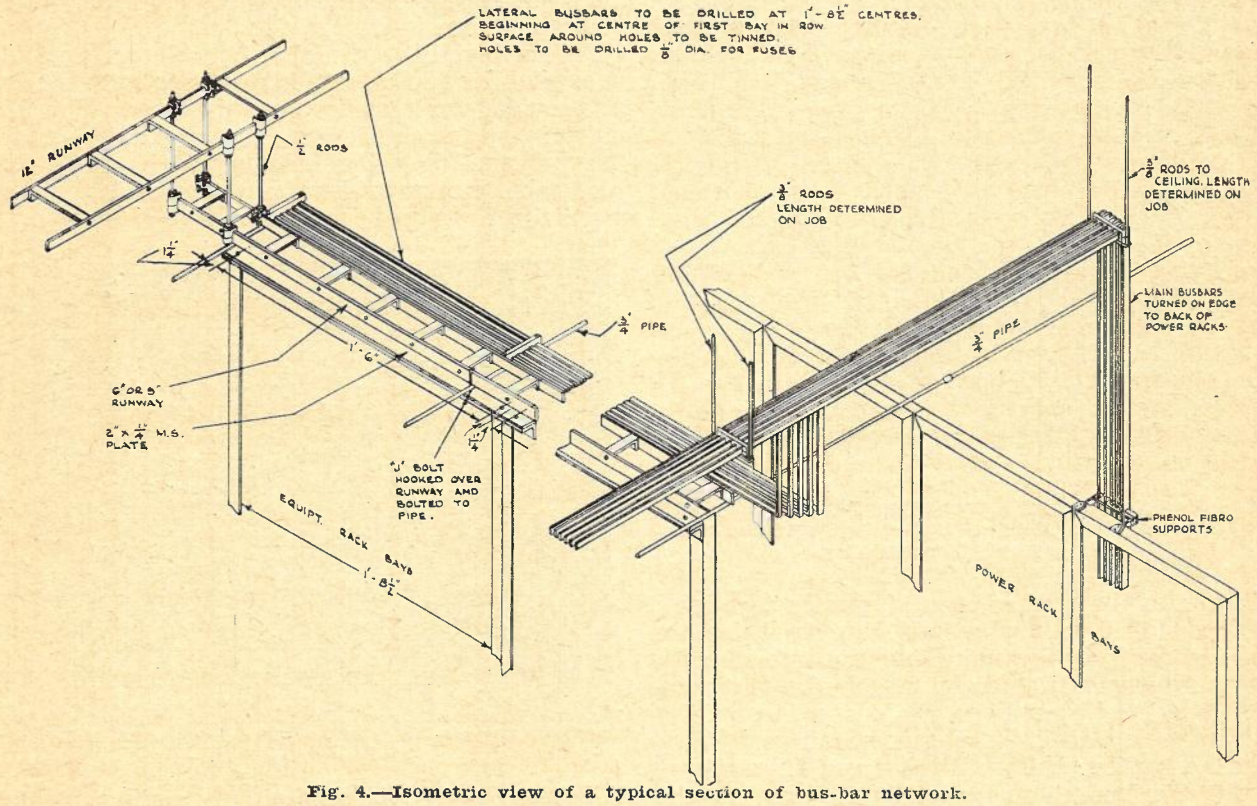

Fig. 4.—Isometric view of a typical section of bus-bar network.

that all cables from the arresters terminate on terminal strips on the crosstalk suppression filter bay, and are wired to enable a break to be made in the pairs to insert the necessary crosstalk filters when required.

This scheme segregates the trunk cable and filter bays on each side of the office, routes the high pass circuits clear of the test board, and provides for terminal loading, where necessary, and the provision for crosstalk suppression filters the line filter bays because the only jack on a filtered circuit giving access to the physical line is installed on the jack field of the line filter bay. The second row of equipment contains the I.D.F. and, in close proximity to it, are the line coils and equipment, such as V.F. dialling, V.F. ringers, V.F. repeaters, etc. These all terminate on the I.D.F. In small country installations, row bays are not required as supplementary units to the I.D.F., but each row is fitted with two or more terminal strips which are cabled to the I.D.F. and provide for miscellaneous circuits, such as test trunks, alarms, etc., and, in the case of rows of carrier terminals, the derived lines are also included in these row cables.

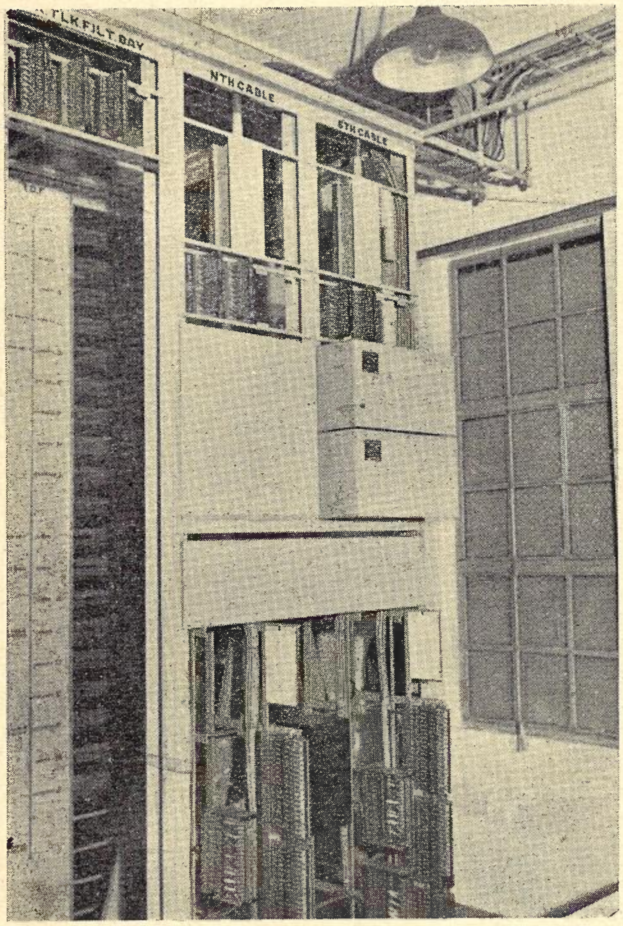

Fig. 5.—Non "J" pairs cable terminating bays, showing cable terminating chambers, terminal load units, protective equipment and crosstalk filter bay.

Owing to the many types of carrier terminals installed, the 2 to 4 wire switching facilities are provided on the bays mounting the hybrid coils. Switching any channel from 2 to 4 wire is accomplished by key operation. This key is provided with a locking device in the operated position.

In the 2 wire position the derived line appears on the "derived channel test board," and in the 4 wire position the channel appears on the "4 wire test board" which also terminates the send and receive jacks of the V.F. telegraph terminals. In small installations these two boards can be combined.

When the installation demands the provision of Spiral 4 disc insulated cables (S.P.4) for the "J" equipment, special precautions are taken in running these cables. The S.P.4 cables from either side of the office are insulated on the runway and are not allowed to run closer than 9 inches on any

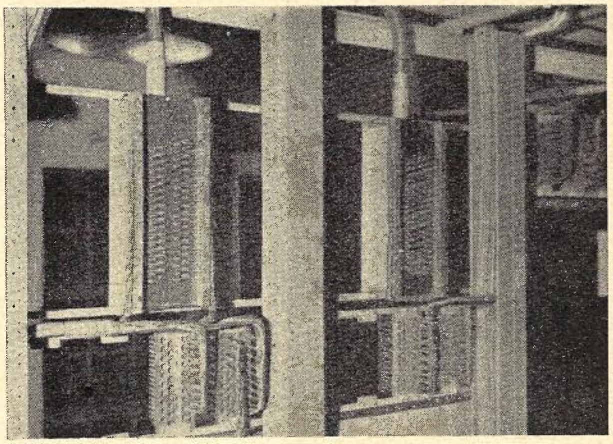

Fig. 6.—Non "J" pairs cable terminating chambers.

parallel run, the route being as direct as possible. These cables terminate on the "J" line filter bay. Where filter huts are provided, the S.P.4 cable does not appear in the apparatus room, but terminates in these huts.

When installing a multi-channel carrier cable, a special far end crosstalk balancing network bay is provided for terminating this cable. This bay is generally installed in close proximity to the normal non-"J" cable terminating bays, so that the cable run provided for these cables can be used for the multi-channel carrier cable.

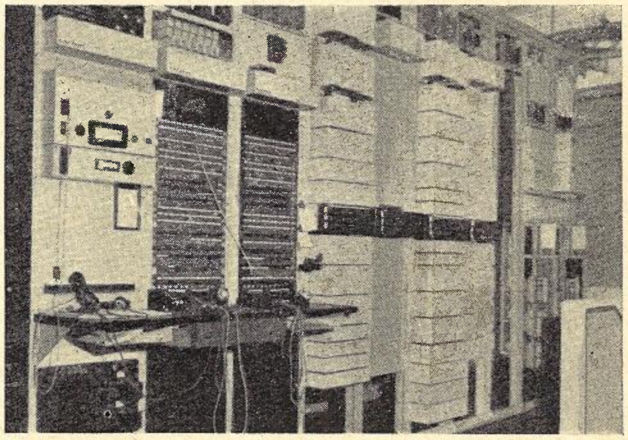

Fig. 7.—Equipment row showing cable terminating bays, crosstalk suppression filter bay, line filter bays, test boards and testing equipment.

Power Supply Distribution: All equipment bays have been provided with individual circuit fuse panels and, where these were not provided by the maker, they have been fitted, and power is distributed to the bays by a busbar network. A typical busbar and overhead structure layout is shown in Figs. 3 and 4. The power take-off to all bays is through an individual "slydlok" fuse. This fuse is mounted directly on the respective busbar and protects that particular bay only. Before painting, all busbars are drilled to take the ultimate number of "slydlok" fuses, and the contact area is tinned before installation. When an additional fuse is required on a busbar, the enamel covering the tinned area is scraped off and the "slydlok" fuse mounted in position. Busbars are painted a distinguishing colour with a good quality enamel and, although this does not provide an insulating coat, it nevertheless provides sufficient increase in contact resistance to make the blowing of a main fuse a remote possibility, due to an accidental momentary contact with the busbars. The busbars are also mounted in such a position that the possibility of an accidental contact is unlikely. Isolating the busbar network into groups is not favoured, as a

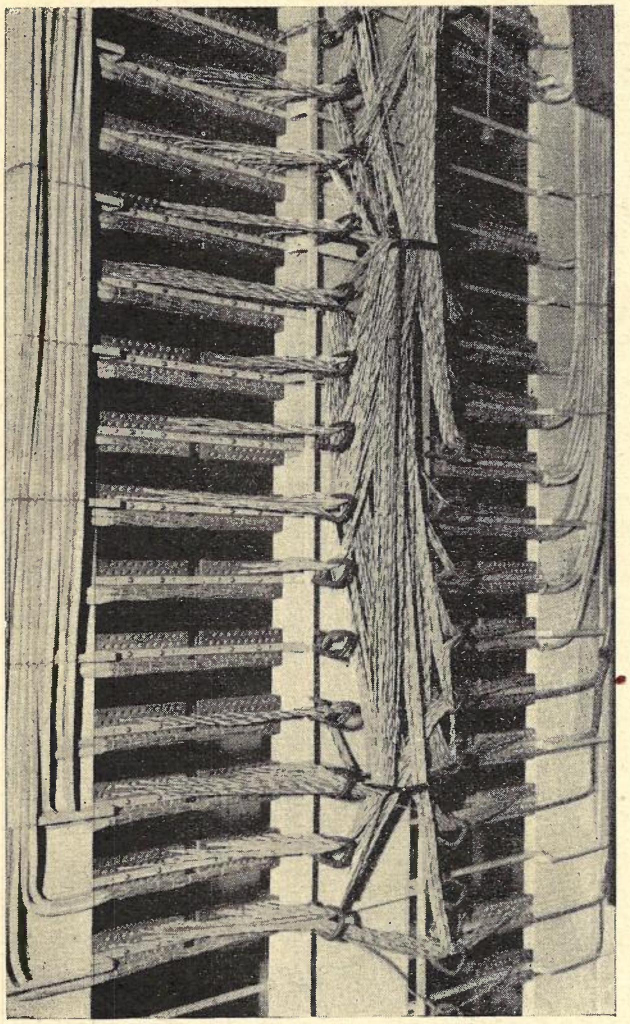

Fig. 8.—Rear view of single row I.D.F.

visual examination would immediately disclose a short circuit should this occur on any portion of the busbar network, and, as the take-off to all bays is protected, there is no advantage in isolating sections. The overhead structure, as can be seen from Figs. 3 and 4, is light, but gives perfect stability to all bays. Plinths are not installed except in exceptional cases where the floor surface demands their provision. Except in a complete installation where the ultimate bays are provided, the unoccupied plinths become an obstruction. Figs. 5 to 10 show a number of typical installations.

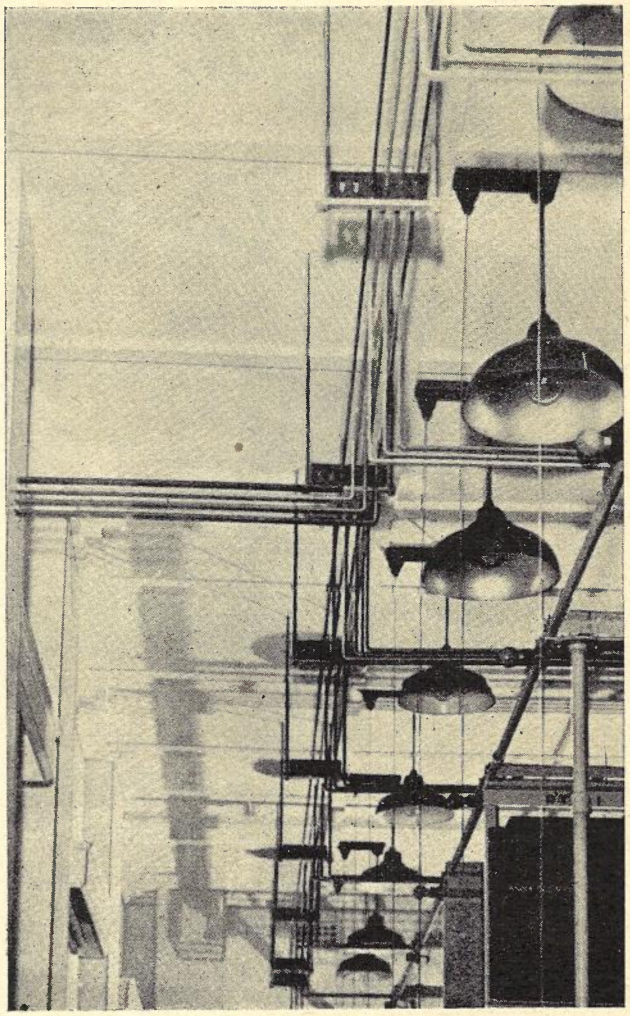

Fig. 9.—General view of power bus-bar distribution.

Earth System: The provision of a good earth system is of major importance. At new buildings, the contractor should provide earths for the M.D.F. and a separate electric supply earth. This provision, however, only partly meets the requirements for carrier purposes. One of the earth systems required is for protection purposes and should, therefore, be as near as possible to the cable terminating bay. A resistance of 5 ohms for this earth, if measured in accordance with instructions for the megger earth tester, would be satisfactory, but may not always be obtainable.

The second earth system required is for connection to the power board and should, therefore, be installed for easy access thereto. Special efforts to reduce the resistance of this earth would be well worth while, but it would be difficult to improve on a resistance of 5 ohms in most parts of

Queensland. A resistance of 2 ohms is the objective, but is generally unobtainable.

The provision of an earth for the electric supply will not normally be a function of the installation staff. Such an earth should be at least 30 feet away from the power board earth and, under no circumstances, should any fittings associated with the town lighting or power supply be connected to either of the earth systems described above.

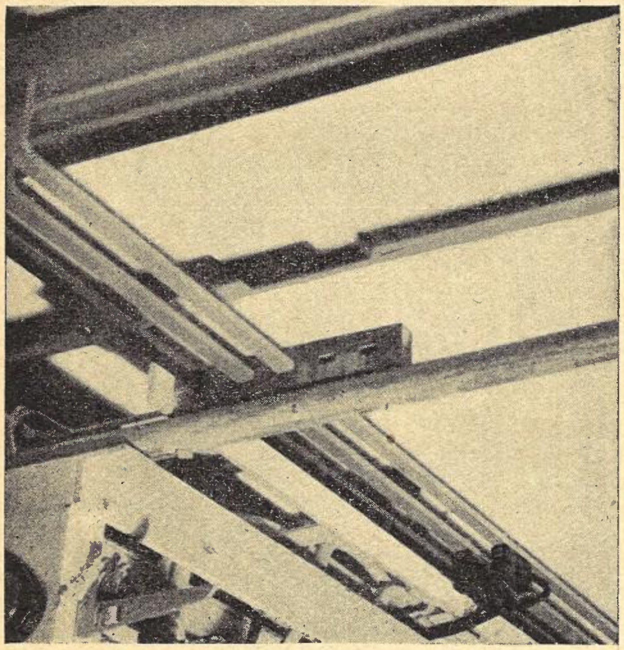

Fig. 10.—View showing take-off from power bus-bars.

Designations and Painting: Designating apparatus in the past by signwriting has been unsatisfactory and, in order to provide a good finish for transmission equipment which has been well installed, workmanlike and uniform designations are provided by making use of card frames and cards. Wherever practicable, the card frames are fixed to covers and panels, and the cards designated by using "Wrico" or similar stencils.

For years past, it has been recognised that few men have the ability to do good installation work and good lettering. Consideration has been given to numerous methods of overcoming this difficulty, and it is thought that the method prescribed will most generally meet the case.

It is appreciated that some hand-painted designations will still be necessary, but these will be reduced to a minimum. It is expected that with ingenuity, most cases can be met by using card frames or metal designation strip holders.

Light Battleship Grey (British Standard Specification No. 31) has proved a satisfactory standard colour, as it tones well with aluminium finished equipment supplied by some contractors. It has the advantage over aluminium that it is easy to touch up if a surface is scratched in transit, and shows little or no variation in finish.

TWO - PARTY LINE SUBSCRIBERS' AUTOMATIC SERVICE WITH SECRECY AND SELECTIVE RINGING AND METERING

J. Silvester, A.M.I.E. (Aust.)

In order to provide telephone service to applicants in localities where there is a shortage of cable pairs, a facility has been designed whereby two subscribers may be given exchange service via one cable pair. The service will be restricted to subscribers in flats or buildings in close proximity to ensure that the line plant involved is reduced to a minimum.

The most desirable feature of a service of this nature is the preservation of secrecy and, to accomplish this, arrangements are made for the automatic disconnection of one party whilst the other is using the line. The circuit arrangement which has been designed to permit the use of standard automatic telephone instruments, is shown in Fig. 1, and it will be noted that the switching medium is a special relay set mounted at the subscriber's premises. When the two parties are in separate buildings, the relay set will be installed at the "A" party's premises. At the exchange a further relay set is used for the selection of the appropriate line switching equipment.

Individual numbers and line switches will be allotted for each party, to provide for exclusive services when cable pairs become available. No provision is made for the two parties on the one line to call each other.

Circuit Operation

Outgoing Calls: Subscriber removes the handset and listens for dial tone, which will not be heard if the other party is using the telephone.

In the case of party "A" originating the call, relay LA operates from earth at A1. LA1 operates L relay of line switch via YA 500 ohms. The line switch circuit returns earth over P wire, operating relay LC. LC disconnects relays LA and LB and connects line through to line switch circuit. The increased current on the line then operates relay A. A2 disconnects party "B." A1 extends subscriber's loop to exchange first selector or equivalent switch. LC2 in the exchange relay set busies the final selector outlet of the number associated with party "B."

When reversal is received over line, the rectifiers MRA prevent relay A from flicking out and opening the line. Calls from party "B" operate in a similar manner to the above, except that relays B, LB and LD operate. The meter associated with the number allotted operates in each case.

Incoming Calls: In the case of party "A," the bell is operated over the negative leg of the line to earth at A1. When the subscriber answers, relay "A" operates to the ringing current and closes the loop back to the final selector; the ring return battery then holds relay "A" until the loop is extended to the D relay of the final selector. Party "B" is disconnected at A2. Similarly, when party "B" is called, relay "B" operates and disconnects party "A."

General: Although standard telephones are used, it is necessary to bias the bells to eliminate the possibility of tinkling of the idle party's bell, which otherwise may occur under certain conditions of dialling. The changeover make-before-break spring assemblies A1 and B1 ensure that, in the event of the relevant relay momentarily operating during an incoming ring, the bell of the other party will not tingle.

Consideration was given to the provision of some positive indication to the calling subscriber (apart from the absence of dial tone) that the other party is using the telephone, as distinct from a fault condition, but it was felt that, in relation to the importance of conserving equipment and raw materials, as well as the need for simplicity, the inclusion of the feature was unnecessary.

The particular arrangement of the relay set at the exchange has been chosen with the object of simplifying the ultimate changeover to exclusive services when cable pairs again become available to the parties concerned.

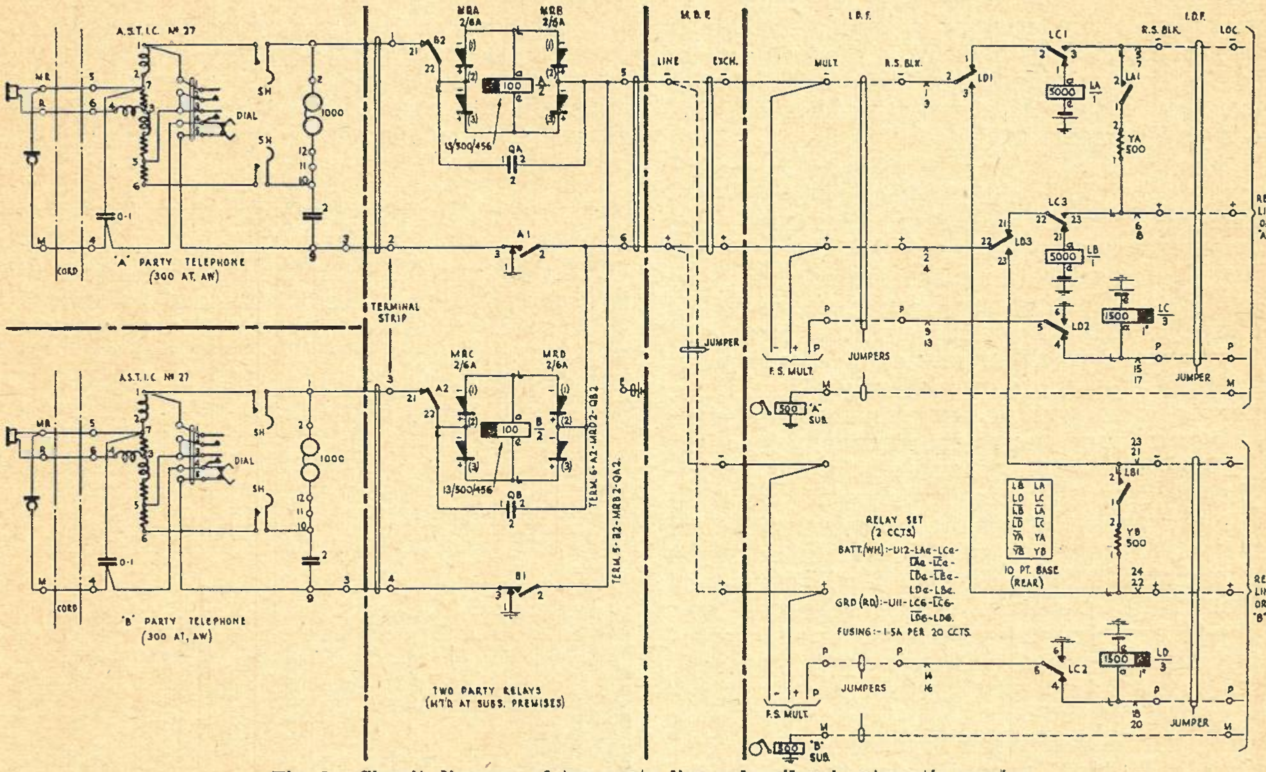

Fig. 1.—Circuit diagram of two-party line subscribers' automatic service.

TRANSPORT AND HANDLING OF PORTABLE TYPE EXCHANGES

D. J. Mahoney and S. J. Davie

Introduction: Portable exchanges have been developed in N.S.W. to overcome difficulties being met with in both the metropolitan network and country areas. In the metropolitan network the establishment of approved new exchanges is being seriously hindered by a lack of buildings or delay in completing them. With the tremendous demand which prevails for building materials for homes, this situation is easily understood, but difficult to overcome.

So that some relief may be afforded exchange areas partly or wholly closed because of difficulties in establishing new exchanges, or because there is no room in existing exchange buildings for additional equipment, the unusual course has been followed of fabricating small, standardised buildings capable of being transported by road, and setting these down either on new exchange sites or on leased sites more conveniently placed for a temporary exchange than the permanent exchange site. The exchange equipment is usually installed before transportation, and such exchanges, which can then be brought into operation with very little line work, are intended to remain until the permanent exchange is established. In no sense are they intended to defer the establishment of the permanent exchange. When released, they may be transported and used at other sites without any dismantling of exchange equipment, and, in this way, are to be preferred to temporary exchanges in fixed buildings. An important loss is involved when the latter exchanges are dismantled, and this tends to defer the establishment of a permanent exchange. It is anticipated that equipment installed in portable buildings will have a full economic life and give service successively in a number of locations.

In addition to the advantages of the portable exchange already described, there is another important advantage when the installation is required in a country district. Usually, it is difficult to obtain staff for country installation work, especially when the installation is an R.A.X. in a small and somewhat remote town without suitable living accommodation and social amenities. With the portable building, the major part of the installation work may be carried out in the metropolitan area.

A description will be given of the transportation of a 500 line portable exchange within the metropolitan area, from the Departmental Workshops at Sydenham, to a site at Caringbah, near Cronulla and also—as this is of relevant interest—the removal of a 200 line R.A.X. in a fixed type R.A.X. building (not intended to be portable), from Blacktown to Kurrajong. The R.A.X. had been installed at Blacktown, in the outer metropolitan area west of Parramatta, in 1934, and was transported to Kurrajong, some 26 miles away, over difficult roads, without any dismantling of equipment. In the case of both removals, the equipment, wiring, etc., did not appear to suffer any ill effect, and, when in position, cable and power were connected and the exchanges placed in service within six weeks and two weeks respectively. A longer period was required in the case of the Caringbah exchange because the installation work was not complete prior to removal.

Transport of Portable Exchange from Sydenham to Caringbah.

Description of Trailer: The trailer used for the purpose is shown in Fig. 1, and consists basically of two steel girders, secured together and pivoted on a turn-table on the rear of the tractor. The rear end of each of the girders is welded to a round steel shaft, approximately 5″ in diameter, and threaded at the end. Pivoted on each of these shafts is a set of 4 wheels, held in position by a large nut and locking pin. This arrangement allows each wheel to follow the contour of the road, and thus take its share of the load at all times.

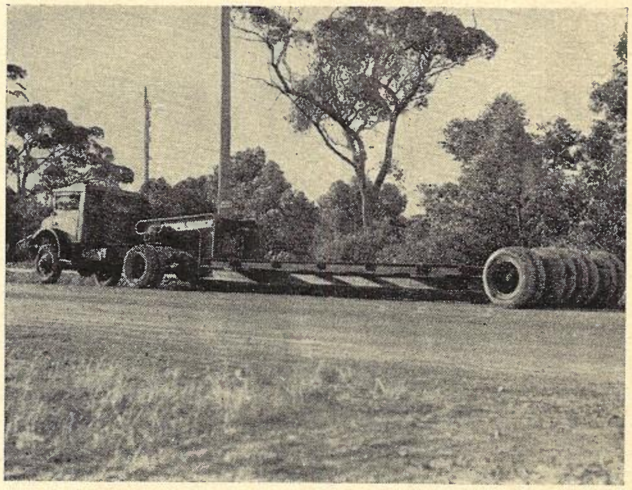

Fig. 1.—Trailer used to transport exchanges.

Method of Loading: The portable exchange building was built in the Departmental Workshops on a hard-wood stage, which raised the building approximately 2′ 6″ from the ground. This was done to facilitate the operation of loading, and to allow mechanical jacks to be fitted underneath the building. By their use, the building was raised to a sufficient height above the stage to allow the trailer to be backed underneath, and the building was then lowered on to the trailer. The stage was designed in such a way that it did not obstruct the trailer during this operation.

Method of Fixing Building on Trailer: A steel rail was fixed underneath the steel base on each side of the building, parallel to the girders of the trailer. A special channel iron bed was constructed and welded to the main girders of the trailer, providing a wider and more secure base on which to rest the load. When the building was lowered on to this base, hardwood packing blocks were placed between the rails and the trailer, to prevent lateral movement of the building. As a further precaution, a "bow tightener" was fitted between each girder and the steel base of the building; see Fig. 2.

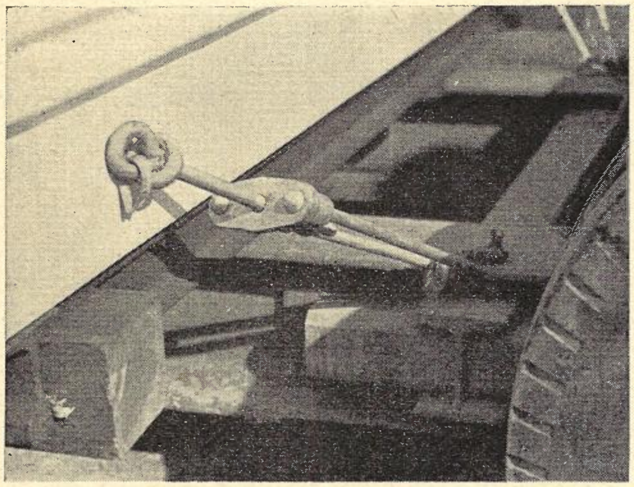

Fig. 2.—Bow tightener, in position.

Transport of Building: To check the width of the bridges and overhead clearances, the entire route was surveyed several days before the building was transported. The closest overhead structure was a foot-bridge, where a 2″ clearance was obtained; see Fig. 3. The equipment inside the building was specially braced to the steel base of the building by means of wire ropes and "bow tighteners." A technician kept watch inside the building to observe any unforeseen happening, and a magneto telephone service was provided between the inside of the building and the driver's cabin so that the driver could be notified immediately if any accident occurred to the equipment. The trip, however, was uneventful.

Moving on to the Site: The first real problem of the movement occurred when the trailer had to cross over the footpath at the site. Beyond the footpath, the ground sloped downwards so steeply that one end of the trailer would not have cleared the ground. This was foreseen, however, in the survey of the route made previously, and hardwood packing pieces were available to place under the front wheels of the trailer, thus raising the trailer sufficiently to clear the footpath; see Fig. 4. The tractor was moved forward very slowly and, as it advanced, the wood packing was removed from the rear to the front of the wheels,

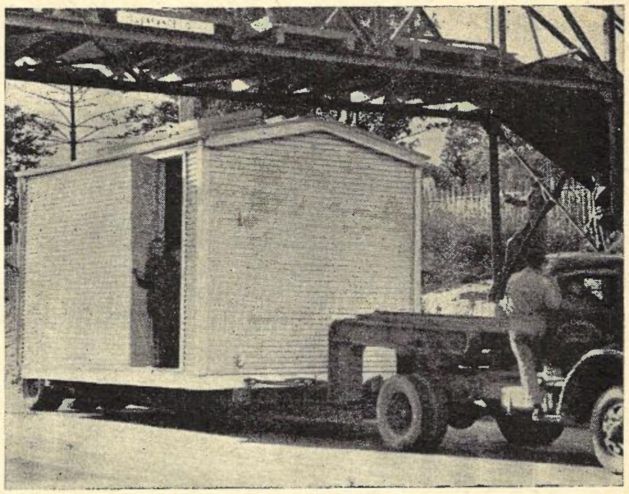

Fig. 3.—Vehicle under bridge with low clearance.

and this manœuvre was repeated until the trailer had crossed the footpath.

Moving on to the Foundations: Concrete foundations had previously been erected, and were so placed as to allow the tractor and trailer to pass between them without fouling. The slope of the ground made it necessary to build up the front of the trailer in a similar manner to that adopted to clear the footpath, so that the base of the building would clear the end foundation piers; see Fig. 5. This was done, as previously described, with the use of hard-wood slabs. When the building was finally manœuvred into the correct position over the foundations, the weight was taken on four mechanical jacks. The rear wheels of the trailer were then removed and the trailer was lowered to the ground and dragged from under the building. The jacks were then lowered

Fig. 4.—Crossing footpath.

and the building was allowed to settle on the foundations. Accurate levels were obtained on the foundations by using packing pieces of mild steel sheet, which were covered by a galvanised iron cap turned down at the edges over the concrete to protect the packing against rust.

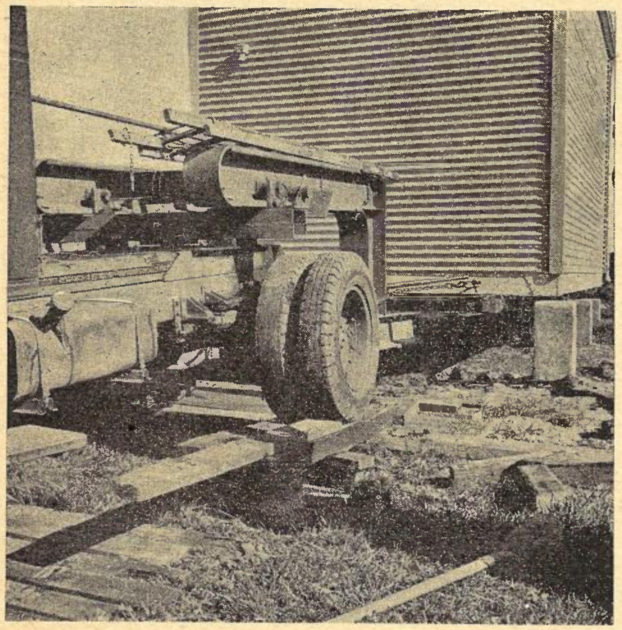

Fig. 5.—Building raised to pass over foundation piers.

Transport of R.A.X. and Building from Blacktown to Kurrajong

Position on Site: The R.A.X. building had been erected in a corner of the site, and it was not possible to back the trailer under the building because three rows of foundation pillars had been used. In addition, access to the building by the trailer was blocked by a mound of soil covering the cable pit, which served the R.A.X., and is now used for the new exchange. Because of the construction of the building, it was necessary to strengthen the base for transport. Four lengths of 6" x 4" hard-wood were bolted lengthwise underneath the base frame of the building, to facilitate handling, each length extending about 1 ft. beyond the end of the building; see Fig. 6. The scheme for loading, in this instance, was to raise the building above the level of the cable pit and to move it, on rollers, to the trailer, which was backed into position as close as possible to the cable pit.

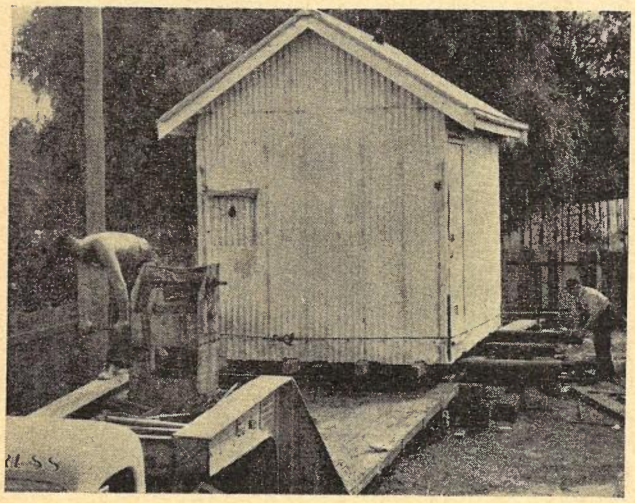

Fig. 6.—Hauling building on to trailer.

Method of Loading: Using jacks of the "Wallaby" type, the building was lifted at the four corners and the supporting foundations were smashed. Heavy timbers were then laid, alternately lengthwise and crosswise, and the building was lifted above the level of the cable pit, and left supported on these timbers. By the simple method of laying heavy timbers on the ground, a platform was erected from the building to the trailer. Planks were then laid from the building to the trailer, so that it could be hauled to the trailer on rollers; see Fig. 6.

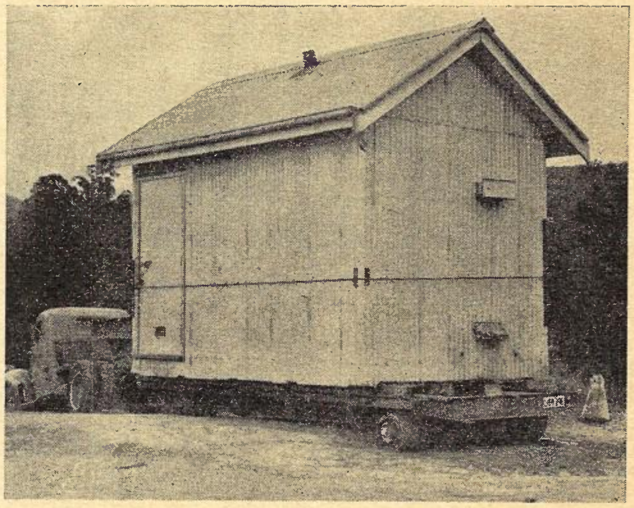

Fig. 7.—Building in transit.

It will be noted that it is a different type of vehicle to that already described, the principal difference being that the rear wheels are mounted underneath the trailer platform.

The wire rope from the winch on the trailer was placed completely around the lower portion of the building and stressed by the winch. The end of the building nearest the trailer was then raised about a foot, and a hard-wood roller, 6" in diameter, placed underneath; the building then being lowered on to the roller. The haul on to the trailer was commenced and, as the building moved forward, a further two rollers were placed in position, just over one-third of the length of the building apart. As a roller was freed at the rear, it was returned to the front. When in position on the trailer, the building was lifted and the rollers removed. It was held in position on the trailer platform by the rope from the winch and by chains which were passed completely under the trailer chassis and over the timber extensions to the building, and tightened and locked by heavy duty strainers; see Fig. 7.

Transport of Building: A survey of the route was made, with a vehicle to which was fixed a light bamboo rod so that the top of the rod was 3" higher than the highest portion of the building loaded on the trailer. There were many overhead crossings of telephone and power wires to be negotiated, and this method quickly determined

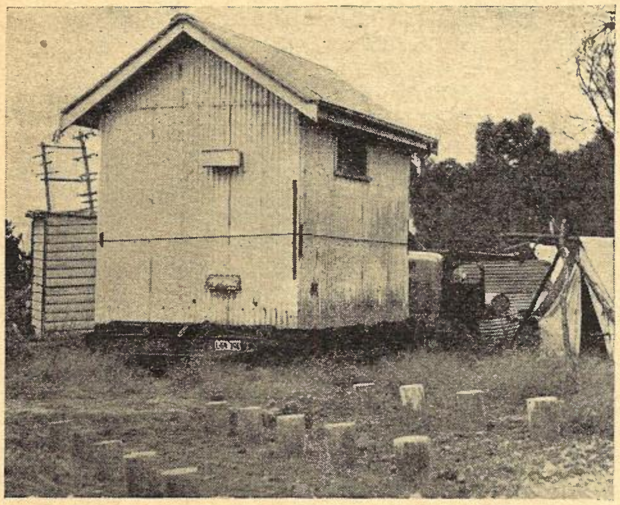

Fig. 8.—Manœuvring building on to foundations.

that the route was clear and that the trailer could be moved at a uniform speed. The type of trailer used, which was the only one available at the time, was not satisfactory for the relatively long haul, and will not again be used for this purpose. It was of the low-loading type, with 8 solid rubber tyred wheels, and the bearings were of the plain bronze type. The heat generated in the bronze bearings caused the tyres to become soft, and two were lost, with the result that the building and equipment were subjected to violent shaking and vibration for almost half of the journey, and it was necessary to proceed at a reduced speed. The damaged trailer wheel can be seen in Fig. 7. On arrival at the destination, it was found that one turn buckle, to which was attached a steel wire holding the R.A.X. equipment to the floor inside the building, had been broken but, fortunately, no damage resulted. On arrival at Kurrajong it was necessary to negotiate the steep bank, also shown in Fig. 7, in order to gain access to the site. Several attempts to negotiate this bank resulted in the framework of the trailer resting on the road. Eventually it was decided to approach the bank with some speed, so that the trailer framework could slide or skid over the bank, and this proved successful.

Unloading the Building: The foundations, which had been prepared beforehand, are shown in Fig. 8. It will be noted that three rows of foundation pillars were necessary because of the construction of the building. Due to the slippery nature of the sloping ground and the restricted access more than an hour was required to back the unit into position for a run-off on to the foundations. This backing process is illustrated in Fig 8. At this stage of operations it commenced to rain heavily, and the rain continued for the rest of the day. For off-loading from the trailer to the foundations, timber was placed lengthwise along the outer rows of the foundation pillars and a sloping platform prepared for the run down from the trailer to the foundations. The platform was supported at intervals by short lengths of timber. The rear end of the building was then jacked up and the roller used for the loading operations was placed underneath. Whilst held with the winch, the building was pushed off the trailer, using two jacks, one on either side, the jacks being placed between the framework of the trailer and the building. As the building rolled down the incline, under the restraining control of the winch, other rollers were placed underneath.

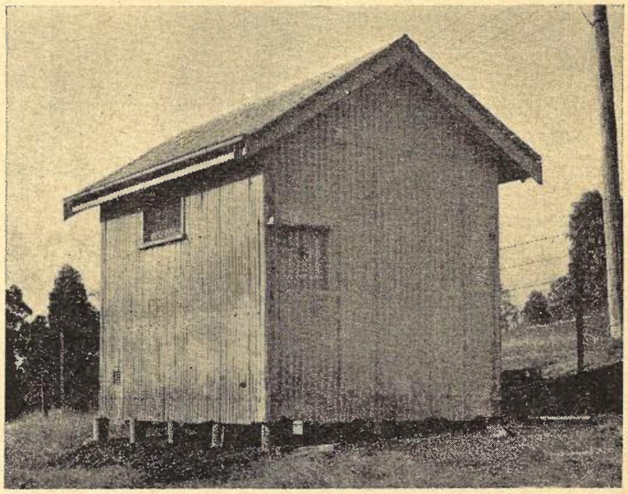

Fig. 9.—Building in position.

When completely over the foundations, the building was not squarely in position, but was easily pushed into position by means of jacks used between a shallow hole in the ground and the side of the building. By alternately lifting first one end and then a side, the supporting timbers were removed until the building rested on the prepared foundations, as shown in Fig. 9.

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 give information which a candidate should have to enable him to give answers which would secure high marks.

EXAMINATION No. 2643—ENGINEER—NATURAL SCIENCE

E. Palfreyman, B.E.

Q. 6.—A coil having an inductance of 10 mH and an effective resistance of 10 ohms is used, as shown in the diagram (Fig. 2), to introduce infinite loss in a circuit at a frequency such that $\omega = 100{,}000$ radians per second. Determine the capacitance of each of the condensers C (of equal value) and the resistance R.

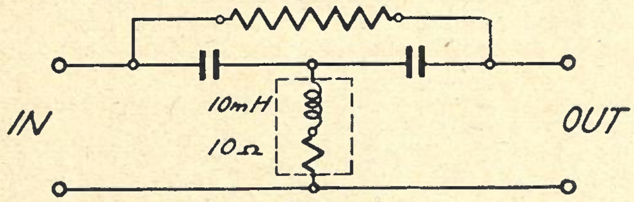

Fig. 2.

A.—Since loss is infinite the current in the output mesh and also the output voltage are each zero.

The J mesh gives $(R + 2\,jX)\,J - j\,X\,I = 0$

$$\text{i.e., } I/J = \frac{R + j\,2X}{+\,j\,X}$$

also output mesh gives $jK.J + (10 + j\,1000)\,I = 0$

$$\text{i.e., } I/J = \frac{-\,jX}{10 + j\,1000}$$

$$\text{Thus } \frac{R + 2\,jX}{jX} = \frac{-\,jX}{10 + j\,1000}$$

$$\text{i.e., } \frac{R + 2\,jX}{X^2} = \frac{1}{10 + j\,1000} \times \frac{10 - j\,1000}{10 - j\,1000}$$

$$= \frac{10 - j\,1000}{1{,}000{,}100}$$

$$\text{Thus } \frac{2X}{X^2} = \frac{-\,1000}{1{,}000{,}100} \text{ equating imaginaries}$$

$$\text{and } \frac{R}{X^2} = \frac{10}{1{,}000{,}100} \text{ equating reals.}$$

Thus $X = -\,2000$ ohms approx.
giving $C = 1/\omega X = 0.005\ \mu F$
and $R = 40$ ohms approx.

Q. 7.—A radio-transmitter draws a load current, under a condition of no-modulation, of 5 amps from a 50 C.P.S., 6,000 volt public supply at a lagging power factor of 0.866. Calculate the power in kilowatts drawn from the mains.

It is proposed to fit a power-factor correction condenser to raise the power-factor to unity. Calculate the capacitance required and indicate the line current under the new conditions.

A.—(1) $P = E1 \cos\theta = 6{,}000 \times 5 \times 0.866$
$= 25.98$ kilowatts .... (1)

(2) $Z = E/I = 6{,}000/5 = 1200$ ohms
$\cos\theta = 0.866$. Hence $\theta = 30°$ and $\sin\theta = 0.500$.
Hence $R = Z$ as $\theta = 1200 \times 0.866 = 1039$ ohms.
and $X = Z\sin\theta = 1200 \times 0.500 = 600$ ohms.

The series reactance required to make the load a pure resistance is thus:

$X' = -\,600$ ohms (i.e., capacitance).
Thus $C = 1/\omega.|X'| = 1/(2\pi \times 50 \times 600)$
$= 5.3\ \mu F$ .... (2a)
And in this case $I' = E/R = 6{,}000/1039$
$= 5.8$ amps .... (2b)

Q. 8.—With regard to the ionised regions known as the ionosphere, BRIEFLY describe the layers that exist, their diurnal, seasonal and longer period variations and their effect on radio transmission.

A.—Three main layers occur in the ionosphere, denoted as the D, E and F layers, in order of increasing height.

The D Layer occurs about 30 miles above the earth's surface and is responsible for the reflection of low frequency signals in the range 20 to 500 Kcs. This layer is relatively stable and shows only small changes.

The E Layer is about 60 miles above the earth and reflects broadcast frequencies in the range 500 to 1500 Kcs. Strong sunlight causes such intense ionization in this layer that it exhibits very great absorption for these frequencies and it is only at night that these frequencies are reflected with an effective strength. The layer is also more effective in winter than in summer for this same reason.

The F Layer is responsible for the reflection of frequencies from 1.5 to 30 Mcs. It occurs at about 120 miles altitude during the day but at night it divides into two layers denoted as F1 and F2, the F1 retaining the day-time altitude while the F2 occurs at about 170 miles altitude. The seasonal changes in this layer are similar but more marked than in the E layer.

In addition, the layers show changes that follow the cycles of sunspot activity.

For further information, refer to "Shortwave Wireless Communication," by Ladner and Stoner.

Q. 9.—State Brewster's Law for the complete plane polarization of monochromatic light by reflection from the polished flat surface of a non-metallic medium (e.g., glass).

For a sample of flint glass it was found that complete polarization occurred when the angle between the incident ray and the surface was 30°. Draw a diagram showing the angular position of the incident, reflected and refracted rays. What is the refractive index of the glass?

A.—Brewster's Law states that when a ray of light meets the plane surface of a non-metallic medium in such a way that the reflected and refracted rays are at right angles, then both of these rays are plane polarized. Under these conditions the tangent of the angle of incidence is equal to the refractive index of the second medium relative to the first medium.

In the example quoted the paths of the rays are as shown:—

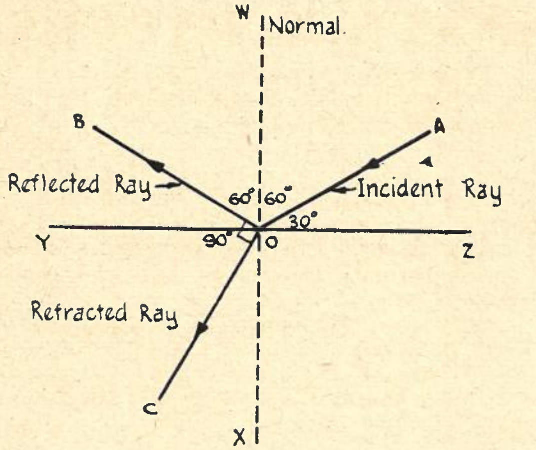

Fig. 3.

$\angle AOZ$ is quoted as 30°
and, since Brewster's Law applies,
$\angle BOC$ is 90°.

Therefore, the other angles about 0 are as shown in the sketch.

Since $\angle WOA$ equals 60° and is the angle of incidence,
then $\mu = \tan 60° = \sqrt{3} = 1.73$.

Q. 10.—(a) Define Simple Harmonic Motion (S.H.M.) and illustrate with simple sketches the variation with time of:—

(i) the displacement,
(ii) the velocity,
and (iii) the acceleration

of a body moving in a straight line with S.H.M.

(b) If, for a body moving with S.H.M., the amplitude of the displacement is 10 cms. and the period is 2 seconds, what are the maximum values of the velocity and of the acceleration?

A.—Simple Harmonic Motion is described by a body when the force acting on the body is directly proportional to its distance from a certain point and is directed towards that point.

For a body moving with S.H.M.

$x = A \sin \omega t$.

Where x is the displacement at time t,
A is the amplitude or maximum displacement
and ω equals 2π divided by the periodic time.

Thus the velocity $= dx/dt = A\omega \cos \omega t$
and the acceleration $= d^2x/dt^2 = - A\omega^2 \sin \omega t$.

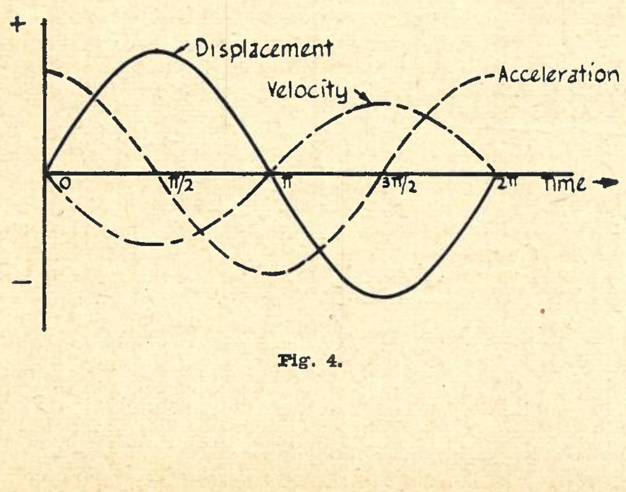

Fig. 4.

The graphs below illustrate the variation of displacement, velocity and acceleration with time:—

(b) If A 10 cms. and period 2 seconds,
then $\omega = 2\pi/2 = \pi$.

Maximum values of $\cos \omega t$ and $- \sin \omega t$ are 1 in each case;
therefore maximum velocity $= A\omega = 10\ \pi$ cm/sec.
and maximum acceleration $A\omega^2 = 10\ \pi^2$ cm/sec.^{2}

Q. 11.—Write a SHORT account on the subject of isotopes, with special reference to the differences and similarities in the atomic structure and properties of the isotopes of any one particular element.

A.—When two atoms have different atomic weights but identical chemical properties, they are said to be isotopes, one of the other. Isotopes show a difference in the total number of protons and of electrons contained in their atoms, but exhibit identical arrangement of their extra-nuclear electrons.

The simplest case of isotopes is the two well-known isotopes of hydrogen. Normal hydrogen atoms consist of a single proton about which a single electron revolves in an orbit. The other "common" isotope of hydrogen is deuterium or heavy hydrogen. The atoms of this consist of a central nucleus containing 2 protons and one electron about which another single electron revolves. Since the deuterium atom contains twice as many elementary particles as the normal hydrogen atom, its atomic weight is 2 relative to 1 for normal hydrogen. Since the physical properties of an element are a function of the atomic weight the two atoms will exhibit dissimilar physical properties. On the other hand, the chemical properties of an element are determined by the number and arrangement of the electrons that revolve about the nucleus and, since both atoms show one electron only, their chemical properties will be similar.

Q. 12.—Estimate the necessary weight of active material in the positive and negative plates of a lead-acid secondary cell per ampere-hour output.

Atomic weight of lead 207
Valency 2
Electrochemical equivalent of hydrogen
0.00001 gram per coulomb.

A.—The reaction at the negative plates during discharge may be written thus:—

$$Pb + H_2SO_4 \longrightarrow PbSO_4 + H_2$$

and at the positive plates

$$PbO_2 + H_2SO_4 \longrightarrow PbSO_4 + H_2O + (O)$$

entailing the reaction of two electrochemical equivalents in each case.

Calculation and substitution of the appropriate molecular weights in the above equation show that
207 grams of lead would liberate 2 grams of hydrogen and that
239 grams of PbO_2 would liberate 16 grams of oxygen which would combine with the 2 grams of hydrogen to yield 18 grams of H_2O.
Now 1 coulomb will liberate 0.00001 gram of hydrogen.

Therefore, 200,000 coulombs will liberate 2 grams of hydrogen which would entail the consumption of 207 grams of lead and 239 grams of lead peroxide.
Now 200,000, coulombs = 200,000 ampere-seconds.
$= 200{,}000/60 \times 60 = 55.5$ ampere-hours
Therefore 1 ampere-hour requires
207/55.5 = 3.72 **grams of lead**
and 239/55.5 = 4.31 **grams of PbO_2.**

EXAMINATION No. 2721—ENGINEER—NATURAL SCIENCE

S. Chivers, B.Sc., P. R. Brett, B.Sc.

PART 1

Q. 1.—(i) Define $\log_a M$ and prove—

(a) $\log_a \left(\frac{M}{N}\right) = \log_a M - \log_a N.$

(b) $\log_a M^r = r \log_a M.$

(ii) If $\log_{10} x = p$ and $\log_{10} y = 3p$

express $\log_{10} \left(\frac{x^{-4}y^3}{y^{-1/3}}\right)$ in terms of p.

A.—(i) $\text{Log}_a M$ is defined as the power to which the number "a" must be raised to give the number M.

Suppose $x = \log_a M$

then $M = a^x$

and x is called the logarithm of M to the base a.

(a) Suppose $\log_a \left(\frac{M}{N}\right) = x$

$$\text{then } \frac{M}{N} = a^x.$$

Now suppose $y = \log_a M$ and $z = \log_a N$

then $M = a^y$ and $N = a^z$.

$$\text{Therefore } \frac{M}{N} = \frac{a^y}{a^z} = a^{y-z}$$

i.e., $a^x = a^{y-z}$.

Taking logs of both sides we get $x = y - z$,

$$\text{i.e., } \log_a \left(\frac{M}{N}\right) = \log_a M - \log_a N.$$

(b) Suppose that $\log_a M = x$

$$\begin{aligned} \text{then } M &= a^x \text{ and } M^r = a^{rx} \\ \text{then } \log_a M^r &= rx \\ &= r \log_a M. \end{aligned}$$

(ii)

$$\begin{aligned} x^{-4}y^3/y^{-1/3} &= (y^{3+1/3})/x^4 = y^{10/3}/x^4 \\ \text{then } \log_{10} (x^{-4}y^3/y^{-1/3}) &= \log_{10} (y^{10/3}/x^4) \\ &= \log_{10} y^{10/3} - \log_{10} x^4 \\ &= (10/3) \log_{10} y - 4 \log_{10} x \\ &= (10/3)\ 3p - 4p \\ &= 10p - 4p = \mathbf{6p}. \end{aligned}$$

Q. 2.—(i) Assuming $\underset{\theta \to 0}{\text{Lt}} \frac{\text{Sin } \theta}{\theta} = 1$, deduce the derivative of $\sin \theta$ with respect to θ where θ is the measure of the angle in radians.

(ii) Verify the following differentiations:—

(a) if $y = x^m e^x$ then $\frac{dy}{dx} = (x + m)\ x^{m-1}e^x$

(b) if $y = \frac{\sin x}{1 + \tan x}$ then $\frac{dy}{dx} = \frac{\cos^3 x - \sin^3 x}{(\sin x + \cos x)^2}$

A.—(i) Suppose $y = \sin \theta$

$$\begin{aligned} \text{then } y + \Delta y &= \sin (\theta + \Delta\theta) \\ \Delta y &= \sin (\theta + \Delta\theta) - \sin \theta \\ &= 2 \cos (\theta + \Delta\theta/2) \sin (\Delta\theta/2). \end{aligned}$$

$$\text{Therefore } \frac{\Delta y}{\Delta\theta} = \frac{\cos (\theta + \Delta\theta/2) \sin (\Delta\theta/2)}{\Delta\theta/2}$$

Consider the behaviour as $\Delta\theta \to 0$

$$\underset{\Delta\theta \to 0}{\text{Limit}} \frac{\Delta y}{\Delta\theta} = \frac{dy}{d\theta}$$

$$\cos (\theta + \Delta\theta/2) \to \cos \theta$$

$$\text{and } \frac{\sin (\Delta\theta/2)}{\Delta\theta/2} \to \frac{\Delta\theta/2}{\Delta\theta/2} = 1.$$

Therefore in going to the limit we get as $\Delta\theta \to 0$

$$\frac{dy}{d\theta} = \cos \theta$$

i.e., if $y = \sin \theta$

$$\text{then } \frac{dy}{d\theta} = \cos \theta$$

(ii) (a) Using the rule for the differentiation of a product—

$$y = x^m e^x$$

$$\begin{aligned} \text{then } \frac{dy}{dx} &= mx^{m-1}e^x + e^x x^m \\ &= (x + m)\ x^{m-1}e^x \end{aligned}$$

(b) Using the rule for the differentiation of a quotient we get—

$$\frac{dy}{dx} = \frac{(1 + \tan x) \cos x + \sin x \sec^2 x}{(1 + \tan x)^2}$$

Replacing tan x by sin x/cos x

$$= \frac{\cos x + \sin x + \sin x/\cos^2 x}{(\sin x + \cos x)^2/\cos^2 x}$$

$$= [\cos^3 x + \sin x(1 - \sin^2 x) + \sin x]/(\sin x + \cos x)^2$$
$$= [\cos^3 x - \sin^3 x]/(\sin x + \cos x)^2$$

Q. 3.—Verify the following indefinite integrals—

(i) $\int x\, e^{x/a}\, dx = a\ (x - a)\ e^{x/a} + C.$

(ii) $\int \frac{\sin x}{\cos^5 x}\, dx = \frac{1}{4} \sec^4 x + C.$

A.—(i) Using the formula for integration by parts, viz.—

$$\int u \frac{dv}{dx}\, dx = uv - \int v \frac{du}{dx}\, dx + C \text{ .... 1.}$$

$$u = x \therefore \frac{du}{dx} = 1$$

$$\frac{dv}{dx} = e^{x/a} \therefore v = ae^{x/a}$$

Substituting these values in Equation 1, we get—

$$\begin{aligned} \int xe^{x/a}dx &= xae^{x/a} - \int ae^{x/a}dx + C \\ &= xae^{x/a} - a^2e^{x/a} + C \\ &= ae^{x/a}(x - a) + C. \end{aligned}$$

(ii) $\int \frac{\sin x}{\cos^5 x}\, .\, dx = \frac{1}{4} \sec^4 x + C$

$$\text{Left-hand side} = \int \frac{\sin x}{\cos^6 x}\, dx$$

$$= \int \frac{-1}{\cos^5 x} \, \frac{d(\cos x)}{dx} \, dx$$

$$= \tfrac{1}{4} \sec^4 x + C$$

OR

Let $y = \tfrac{1}{4} \sec^4 x + C$

then $\dfrac{dy}{dx} = \sec^3 x . \sec x . \tan x = \dfrac{\sin x}{\cos^6 x}$

Q. 4.—Express Sinh x and Cosh x as exponential functions of x and also as infinite series in terms of x.

Using the exponential forms prove that—

$$2 \cosh^2 x - 1 = \cosh 2x.$$

A.—Sinh x is defined as equal to $\dfrac{e^x - e^{-x}}{2}$

and cosh x is equal to $\dfrac{e^x + e^{-x}}{2}$

$$\text{Since } e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \dots \dots \dots$$

$$\text{and } e^{-x} = 1 - x + \frac{x^2}{2!} - \frac{x^3}{3!} + \dots \dots \dots$$

$$\therefore \sinh x = x + \frac{x^3}{3!} + \frac{x^5}{5!} + \dots \dots \dots \dots \dots$$

$$\text{and } \cosh x = 1 + \frac{x^2}{2!} + \frac{x^4}{4!} + \dots \dots \dots \dots \dots$$

Prove $2 \cosh^2 x - 1 = \cosh 2x$

$$2 \cosh^2 x - 1 = \frac{2(e^x + e^{-x})^2}{2^2} - 1$$

$$= \frac{e^{2x} + e^{-2x} + 2e^{x-x}}{2} - 1$$

$$= \frac{e^{2x} + e^{-2x}}{2}$$

$$= \cosh 2x.$$

PART 2

Q. 5.—Prepare two sketches showing:—

(i) For the ordinary ray, the equivalent height of the E, F_1 and F_2 layers of the ionosphere as a function of frequency for a typical midday condition. Indicate on the sketch the critical frequencies for each of the layers.

(ii) For a sunspot maximum and also for a sunspot minimum, the general nature of the variation in critical frequency of the F_2 layer as a function of time for a 24 hour period.

A.—(i)

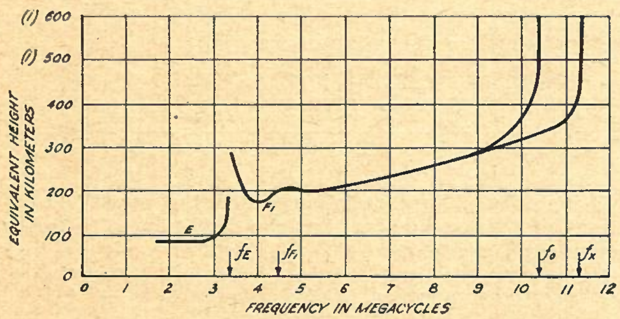

Fig. 1.

(ii)

f_E = critical frequency for E layer

f_{F1} = critical frequency for F_1 layer

f_o = critical frequency for F_2 layer (ordinary wave)

f_x = critical frequency for F_2 layer (extraordinary wave).

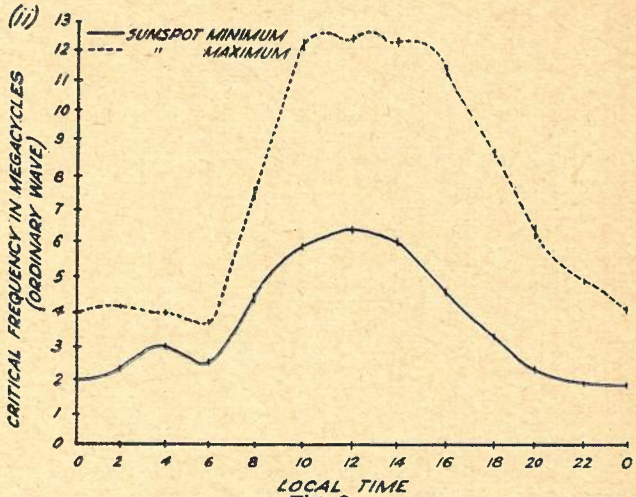

Fig. 2.

Q. 6.—Draw an outline diagram of a Cathode-ray Oscilloscope tube, showing the electrical elements involved in its operation. The purpose of each element should be briefly stated.

A sinusoidal voltage is applied to the pair of horizontal plates and a linear sweep circuit voltage of the same periodicity is applied to the vertical plates. Draw a diagram of the screen trace. What is the effect on the trace of halving the sweep circuit periodicity?

A.—

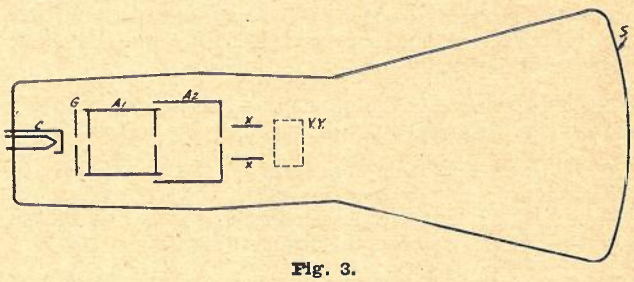

Fig. 3.

H—Heater—functions to heat cathode to a temperature at which electrons are freely emitted.

C—Cathode—emits electrons when heated by heater.

G—Grid—controls number of electrons passing through the apertures in A_1 and A_2, i.e., controls intensity of electron beam.

A_1—focussing anode) both maintained at high posi-
A_2—final anode) tive potential with regard to cathode. Electrostatic field between these two anodes causes the electrons to be confined in a thin beam.

X-X and Y-Y—pairs of deflecting plates—potential applied across each of these pairs of plates causes deflection of the electron beam in vertical or horizontal plane respectively.

S—Screen—coated internally with a material having the property of emitting light when struck by electrons.

The horizontal plates in an oscilloscope cause vertical deflection. The pattern obtained by a sine wave on the horizontal plates and a linear sweep on the vertical plates would be thus.

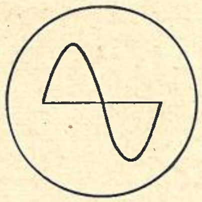

Fig. 4.

Halving the periodicity of the sweep would give a pattern thus.

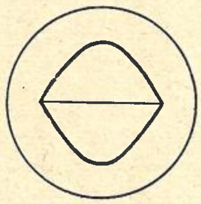

Fig. 5.

Q. 7.—Explain the following terms in relation to condensers: Dielectric Constant, Dielectric Strength, Capacitance, Power Factor, Insulation Resistance.

The distance between the circular plates of a parallel plate air condenser is 5 mm. A charge of 0.02 microcoulombs raises the potential difference across the plates by 1000 volts. Calculate the diameter of the plates (fringing may be neglected).

A.—The Dielectric Constant is the ratio of the capacitance of the condenser when the dielectric is used to the capacitance when air is used.

The Dielectric Strength is the maximum potential per unit thickness which can be applied to the dielectric before breakdown.

The Capacitance is the quantity of electricity required to raise the potential of the condenser by one unit.

The Power Factor is the ratio of the power lost in the condenser to the product of the R.M.S. values of voltage and current, or, more simply, the cosine of the angle by which the current leads the voltage.

The insulation Resistance is given by the ratio V/I where V is the D.C. potential between the plates, and I is the leakage current flowing between them after the condenser has been fully charged to a potential V.

The capacitance of the condenser is

$$\frac{0.02 \times 10^{-6}}{1000}$$
$$= 0.02 \times 10^{-9} \text{ farads}$$
$$= 0.02 \times 10^{-9} \times 9 \times 10^{11} \text{ E.S.U.}$$
$$= 18 \text{ E.S.U.}$$

The formula for the capacitance of a parallel plate air condenser is

$$C = \frac{A}{4 \pi d} \text{ E.S.U.}$$

where A is the area of each plate in square cms and d is the distance between them in cms.

Therefore $A = 4 \pi Cd$
$= 4 \times \pi \times 18 \times 0.5.$

Therefore diameter of the plates

$$= \sqrt{\frac{4 \times \pi \times 18 \times 0.5 \times 4}{\pi}}$$
$$= 12 \text{ cms.}$$

Q. 8.—In the following network, having ideal elements, demonstrate the conditions under which the impedance Z between terminals A and B becomes a pure resistance at all frequencies:—

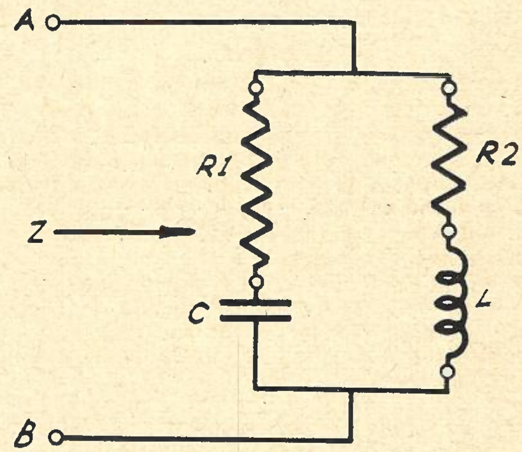

Fig. 6.

A.—

$$\frac{1}{Z} = \frac{1}{R_1 + \dfrac{1}{j\omega C}} + \frac{1}{R_2 + j\omega L}$$

$$= \frac{j\omega C}{1 + j\omega R_1 C} + \frac{1}{R_2 + j\omega L}$$

$$= \frac{j\omega C\,(R_2 + j\omega L) + 1 + j\omega R_1 C}{(1 + j\omega R_1 C)\,(R_2 + j\omega L)}$$

$$\therefore\ Z = \frac{R_2 + j\omega L + j\omega R_1 R_2 C - \omega^2 R_1 CL}{j\omega R_2 C - \omega^2 LC + 1 + j\omega R_1 C}$$

$$= \frac{(R_2 - \omega^2 R_1 CL) + j\omega(L + R_1 R_2 C)}{(1 - \omega^2 LC) + j\omega C(R_1 + R_2)}$$

Rationalising the denominator we get

$$Z = \frac{\{(R_2 - \omega^2 R_1 CL) + j\omega(L + R_1 R_2 C)\} \times \{(1 - \omega^2 LC) - j\omega C(R_1 + R_2)\}}{(1 - \omega^2 LC)^2 + \omega^2 C^2 (R_1 + R_2)^2}$$

If Z is to be a pure resistance then the reactive component of Z must be zero, i.e., the coefficient of j in the numerator must be zero.

The reactive component in the numerator is—

$$\omega(L + R_1 R_2 C)\ (1 - \omega^2 LC) - \omega C(R_1 + R_2)\ (R_2 - \omega R_1 CL)$$

By inspection it is seen that if $R_1 = R_2$ this becomes

$$\omega\,(1 - \omega^2 LC)\ \left\{ (L + R_1^2 C) - 2\,R_1^2 C \right\}$$

$$= \omega\,(1 - \omega^2 LC)\ \left\{ L - R_1^2 C \right\}$$

This is equal to zero at all frequencies if

$$L - R_1^2 C = 0,\ \text{i.e., } R_1 = \sqrt{\frac{L}{C}}$$

The network is equivalent to a pure resistance at all frequencies if $R_1 = R_2 = \sqrt{\dfrac{L}{C}}$

PART 3

Q. 9.—Define Latent Heat of Fusion and Specific Heat. A meteorite enters the earth's atmosphere with a temperature of −100°C. and a velocity of 13 x 10⁴ cm/sec. Calculate the velocity when the meteorite has just been melted, assuming that all the energy lost by friction is dissipated in heating it.

The following values should be assumed for the material of the meteroite:—

Specific Heat	**0.1 cal. grm. $^{-1}$ deg. $^{-1}$.**
Melting Point	**1,400°C.**
Latent Heat of Fusion	**30 cal. grm. $^{-1}$.**

The Mechanical Equivalent of Heat should be taken as 4 x 10^7 ergs. cal. $^{-1}$.

A.—The Latent Heat of Fusion of a substance is the number of calories required to convert one gram of the substance from the solid to the liquid condition, the temperature being constant at the melting point of the substance.

The Specific Heat of a substance is the number of calories required to raise the temperature of one gram of the substance through one degree on the Centigrade scale.

Let m be the mass of the meteorite.

Then energy is required to raise the temperature from -100°C. to 1400°C., which will require 1,500 x 0.1 x m calories.

In addition, the heat required to melt the meteorite will be 30 x m calories.

Total 150 m + 30 m = 180 m calories.

This is equivalent to $150\ m \times 4 \times 10^7$ ergs.

$= 6 \times 10^9 \times m$ ergs.

Kinetic energy of the meteorite $= \frac{1}{2}\, mv^2$

$= \frac{1}{2}\, m \times (13 \times 10^4)^2$ ergs on entering the atmosphere

$= \dfrac{169}{2}\, m \times 10^8$ ergs.

If V be the velocity when particle is just melted then Kinetic energy $= \frac{1}{2}\, mV^2$.

Therefore

$$\tfrac{1}{2}\, m\, V^2 = \left(\frac{169}{2}\, m \times 10^8\right) - (6 \times 10^9 \times m \text{ ergs})$$

$$= m\ (24.5 \times 10^8) \text{ ergs.}$$

$$\therefore V^2 = 49 \times 10^8$$

$$V = 7 \times 10^4 \text{ cms/sec.}$$

Q. 10.—A uniform ladder rests against a vertical wall with the lower end on a horizontal floor, the co-efficient of friction at the floor being $\dfrac{1}{2\sqrt{3}}$.

Find the greatest angle that the ladder can make with the wall without slipping—

(i) If the wall is smooth.

(ii) If the wall had a coefficient of friction = $2\ (\sqrt{3} - 1)$.

A.—(i)—

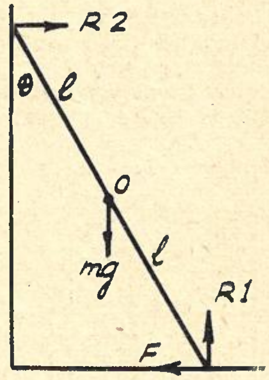

Fig. 7.

Forces acting on the ladder are as shown.

At point A the frictional force F and reaction R_1 are such $\dfrac{F}{R_1} = \dfrac{1}{2\sqrt{3}}$ when ladder is on the point of slipping.

Taking moments about 0 we have

$R_2\, l \cos\theta + F \cos\theta = R_1\, l \sin\theta$.

Also $F = R_2$ and $R_1 = 2\sqrt{3}\,F$

$\therefore F\cos\theta + F\cos\theta = 2\sqrt{3}\,F\sin\theta$

$$\therefore \tan\theta = \frac{1}{\sqrt{3}}$$

i.e., $\theta = 30°$.

(ii)—

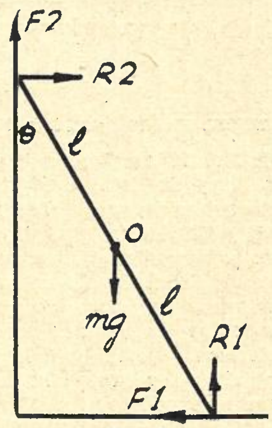

Fig. 8.

Again taking moments about 0.

$R_2\, l\cos\theta + F_1\, l\cos\theta + F_2\, l\sin\theta$.

$= R_1\, l\sin\theta$.

$R_1 = 2\sqrt{3}\,F_1$ and $F_2 = R_2\, 2\,(\sqrt{3} - 1)$

Also $F_1 = R_2$.

$\therefore F_2 = F_1\, 2\ (\sqrt{3} - 1)$

Substituting in the equation above

$2\,F_1\cos\theta + 2\,F_1\,(\sqrt{3} - 1)\sin\theta = 2\sqrt{3}\,F_1, \sin\theta$.

$$\therefore \frac{\sin\theta}{\cos\theta} = 1 = \tan\theta$$

$$\theta = 45°.$$

EXAMINATION No. 2721—ENGINEER, TELEPHONE EQUIPMENT

W. B. Wicking

GROUP 1

Q. 1.—(a) Prepare a simplified trunking diagram of a U.A.X. No. 13.

(b) State the numbering scheme provided by a U.A.X. No. 13 and indicate the normal capacity of the U.A.X. for subscribers' lines, trunk lines, &c.

(c) Describe how an incoming trunk circuit call from an associated U.A.X. is dialled into the equipment of a U.A.X. No. 13.

A.—1.—(a)—

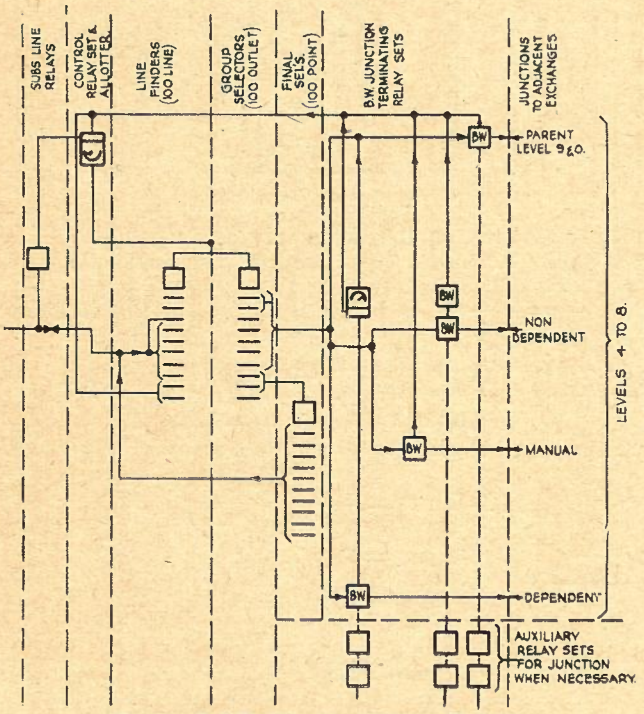

Fig. 1.—U.A.X. No. 13 trunking diagram.

(b) The U.A.X. No. 13 employs a 3 digit numbering scheme for subscribers and single digit codes for outgoing calls to adjacent exchanges. The subscribers' line capacity is normally limited to 200 lines utilising 100 line final selectors arranged in two groups and trunked via the second and third levels of group selectors. Additional subscribers' capacity can be provided by allotting extra selector levels and providing further groups of final selectors. Normally 7 levels of the group selectors are available for junction and trunk lines. Levels 9 and 0 are reserved for junctions to the parent exchange, level 9 for auto. and level 0 for manual service. This leaves levels 4, 5, 6, 7 and 8 available for junctions to other adjacent exchanges. Junction equipment is mounted on special B type racks which can be added independently of the subscribers' equipment, which is mounted on A type racks. The number of junctions provided for normally is 40.

(c) **At Associated U.A.X.**

The subscriber at the associated U.A.X. lifts his receiver, operating his line relay, which marks his line on the line finder bank, and starts the line finder search. On locating the calling line, the line finder extends the call to the associated group selector, which transmits dialling tone to the calling subscriber, who thereupon dials the code of the required exchange. The selector steps to the appropriate level and seizes a trunk or junction line to the local exchange of the required number.

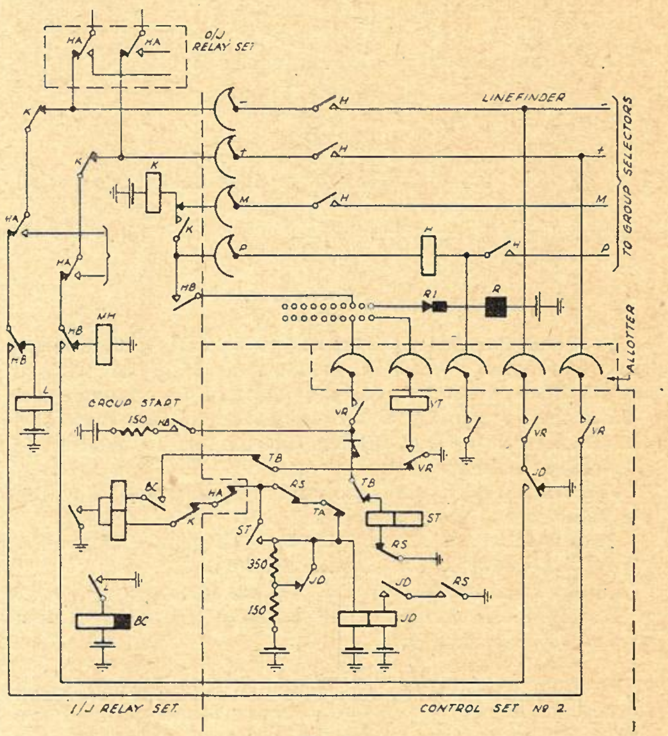

Fig. 2.

At the Local Exchange

The local exchange end of the junction is connected via changeover contacts of relay HA in the outgoing junction relay set to a line relay L in the incoming junction relay set, and thence to contacts on line finder banks, levels 1 and 2. On the outgoing end of the junction being seized, relay L in the incoming junction relay set operates over the looped junction line. L1 operates BC, contacts of which offer the switching relays HA and HB respectively to the first choice control relay set. Assuming HA has its control set busy, and that the second choice to which HB normally switches is free, battery is extended via relay JD and contacts of TA and RS in the control relay set, and contacts of HA and K in the junction relay set, to operate HB, contacts of which mark the line finder bank, extend battery to operate the start relay in the control relay set, connect the negative and positive trunks via contacts of VR and JD to the group selector and disconnect relays HA and L in the junction circuit. When the line finder finds the marked contact the positive and negative trunk is connected to the group selector via the line finder bank, and K relay, in the junction relay set, operates, disconnecting the pre-dialling path, and the call is extended over the line finder bank contacts. Further digits dialled by the subscriber operate the group and final selectors in the normal manner, completing the call. Release of all circuits takes place when the calling subscriber restores the receiver.

Q. 2.—(a) State the essential components of a standard departmental pattern type C unit P.A.B.X.

(b) Sketch the schematic trunking diagram of the type C P.A.B.X. and explain what occurs when a P.A.B.X. extension makes a call outgoing to the associated auto-

matic exchange: This parent exchange for the P.A.B.X. should be assumed to be of the 2,000 type. Your description should not extend beyond the equipment provided at the P.A.B.X. itself.

A.—2.—(a) Following are the essential components of a standard departmental C type unit.

- Line Circuit (L and K relay).
- Link Finders (uniselectors 25 pt).
- Link Selectors.
- Exchange Line Finders (uniselectors 50 pt).
- Exchange Line Relay Sets.
- Level 9 Finders (uniselectors 50 pt).
- Level 9 Relay Sets.
- Attendant's Cabinet and Circuit.
- Attendant's Relay Set.
- Call Back Relay Set.
- Ringing and Tones Relay Set and Miscellaneous Equipment.
- Fuse Panel.

(b)—

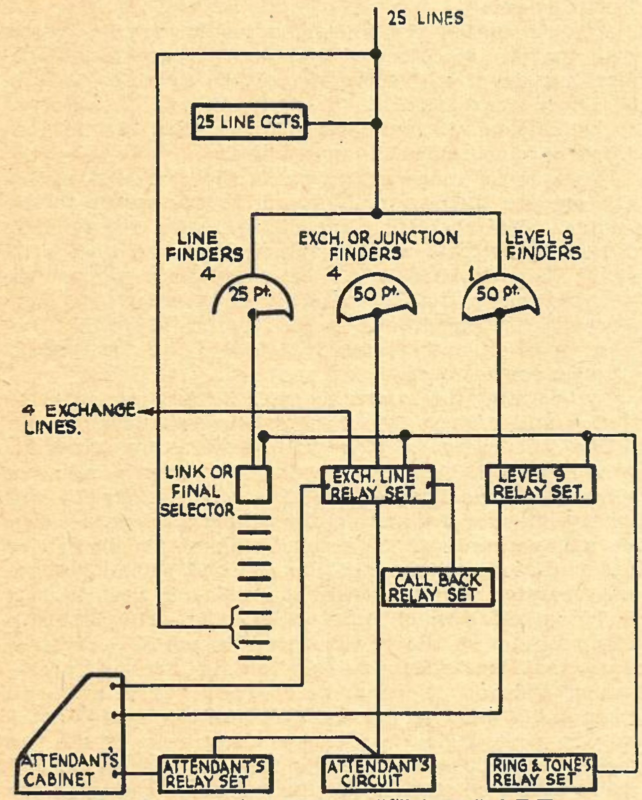

Fig. 3.—Trunking diagram "C" type P.A.B.X.

When an extension loops the line, the line relay L operates, marks the line finder bank in the link circuit with a 200 ohm battery, and completes the circuit to the start relay LS, which connects ground to the A relays of all disengaged link circuits. Relays A and B in the link circuits operate and the line finders search for the calling line. On the first finder reaching the calling line the associated test relay FT operates to the test potential on the line finder bank. In the line circuit, K operates and L is held, the positive and negative lines are cleared, and the start circuit of associated finders opened, causing the remaining finders to cease stepping. Relays K and C operate to prepare the path for the vertical magnet.

On receipt of the local dial tone the extension dials "0." The switch step vertically, C releases at the end of the impulse train, G operates to the "0" level start lead (if disengaged), and marks the J bank of the exchange line finder. BS relay in the start circuit operates with G, returning ground to the F relays of all disengaged exchange line circuits. The junction finders search for the calling extension. When the marked contact is reached FT operates via J lead from the link finder, and puts a low resistance ground on J, which releases the link finder. H operates, holds the L and K relays (line circuit) operated and switches the extension to LG which operates via the extension loop. BR operates and releases F. L operates via the ex-

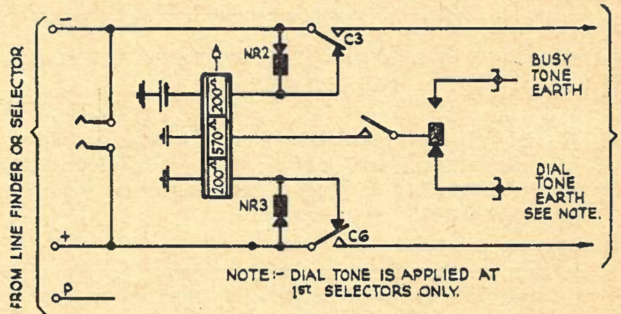

Fig. 4.

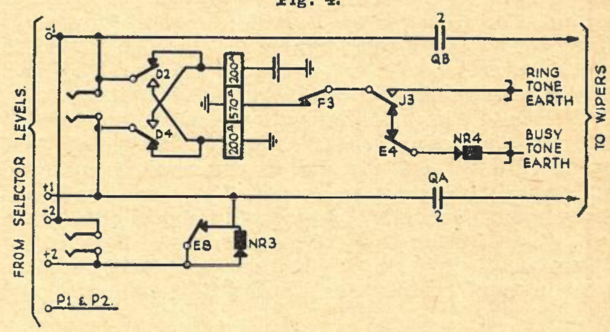

Fig. 5.

change loop and closes the circuit for Z, which releases LG. The extension is now switched through to the exchange with through circuit for dialling.

On receiving the exchange dial tone, the extension dials the required number and the call is then under the control of the extension. When the receiver at the extension is replaced, the selectors in the parent exchange are released and the line circuit is restored to normal. At the C type unit, relay L releases, followed by Z, clearing alternating current is sent over the exchange line via LG contacts normal, CL operated, Z normal, Condensers QA and QB in parallel to exchange. As the exchange line is unbalanced, relay AC operates, releasing CL which, in turn, removes the clearing AC from the line and releases the remaining operated relays to clear the circuit. While clearing AC is on the line the supervisory lamp in the attendant's cabinet glows.

Q. 3.—In an exchange of the 2,000 type the following tone signals are provided:—

(a) Ringing tone;
(b) Busy tone;
(c) Dialling tone.

Explain, by means of schematic sketches of the relative circuit elements, how the tones are applied at the switching stages concerned in a main exchange employing switches for 6 digit calls.

A.—3.—In a 6 digit main 2,000 type auto, exchange the Dialling, Ringing and Busy tones are applied at the stages and in the manner shown in the following sketches:—

Stage or Switch	Tone Applied	Sketch
1st Group Selector	Dialling Tone Busy Tone	See Fig. 4
2nd Group Selector) 3rd Group Selector) 4th Group Selector)	Busy Tone	See Fig. 4
Final Selector	Ring Tone Busy Tone	See Fig. 5

EXAMINATION No. 2721—ENGINEER, TELEGRAPH EQUIPMENT

A. F. Hall

Q. 1.—Describe in detail the operation of a multiplex "run in" preparatory to handing the quadruple multiplex system to the Traffic staff. Explain the reasons for the effects that would be observed.

A.—Preparatory:—

It is assumed that the preparatory work on equipment at both stations has been completed, that each station has carried out a "local run," that, at the corrected station, the send plug has been advanced to the position which satisfactorily compensates for "line lag," that the local plug has also been adjusted and that the speed of each phonic motor is within working limits.

At each station all transmitters must be closed to transmit continuous "space" from all channels. Since segment 21 at both stations is permanently connected to "marking" battery to provide the "marking" pulse of the correction cycle, one marking signal only can be transmitted during each revolution of the brushes.

The line switch at both stations will now be placed in the normal position for transmitting to line.

Operation:—

We will consider the reception of the marking signal at the corrected station and assume it is first received at the leading edge of segment 6 of the receive ring at that station.

The five magnets of the printer on channel 1 are connected to receive segments 1-5. Similarly, channel 2 printer is associated with segments 6-10, channel 3 printer with segments 11-15 and channel 4 printer with segments 16-20.

Reception of a marking signal causes the application of potential from the receive relay contacts to the receive ring but, when a spacing signal is received, no potential is applied to the receive ring.

The marking signal received on segment 6 will cause the operation of magnet No. 1 of the printer of channel 2, and letter E will be printed.

The speed of rotation of the phonic motor at the corrected station is greater than that of the motor at the correcting station, so that each revolution of the former will have carried the brushes slightly further when the marking signal is received.

There will, therefore, be a slow progression of the signal as related to the receive segments at the corrected station.

Segments on the receive ring are shortened segments, but the transmitted signal is a full length signal. Therefore, during the progression, magnets connected to two adjacent segments will be simultaneously operated two or three times in succession. The number of times that each successive magnet is operated is an indication of the relative speed of the phonic motors at the two stations and, if necessary, the vibrator at the corrected station should be adjusted to obtain the correct speed of rotation of the phonic motor. On a quadruple multiplex, individual magnets should operate 18 to 20 times.

The effects observed in this case on printers 2, 3 and 4, in turn, will be E (firsts), A (firsts and seconds), Line Feed (seconds), I (seconds and thirds), Letter Space (thirds), N (thirds and fourths), Carriage Return (fourths), O (fourths and fifths), T (fifths).

Having passed through these printers in turn, the marking signal will finally reach the correction segment and ultimately operate the correction magnet to which this segment is connected. Operation of the correction magnet will retard the brushes 1½ degrees. The indicator of the correction magnet will show the frequency of its operation.

Consider now the effect at the correcting station. The marking signal transmitted from segment 21 at the corrected station will be received on segment 15 on the receive ring at the correcting station. The fifth magnet of the printer on channel 3 will be operated and letter T will be printed.

At this station the phonic motor is running slower than that at the corrected station. A regression of the marking signal will occur, i.e., T, O, Carriage Return, N, Letter Space, I, Line Feed, A, E, will be observed on printers on channels 3, 2 and 1, in turn, as the condition of synchronism is approached.

When the stations are in phase the corrected station will operate the Reversals switch to transmit reversals to line. The correcting station will similarly respond. Outgoing reversals will be observed on the differential meter in each send loop. Incoming reversals will be observed on a similar meter in each receive loop to ascertain the condition of the carrier channel. Any bias condition will be removed before the "Reversals" switches are restored.

By operating the reversals switch 3 times the corrected station will request thirds on the first channel.

The correcting station will restore his reversals switch and will hold to "marking" the third contacts of his first channel transmitter. The corrected station will observe his first channel printer, which may letter space. He will now adjust the receive ring of his plateau in a clockwise direction until the received marking signal just operates simultaneously the 3rd and 2nd magnets of his printer, which will occasionally print letter I. The position of the receive ring is noted, and it is moved anti-clockwise until similar simultaneous operation of 3rd and 4th magnets occurs. The printer will occasionally print letter N. This position is also noted and the receive ring is placed midway between the two positions. This adjustment is termed "Orientation."

The corrected station will then transmit thirds on the first channel for a similar orientation at the correcting station.

With V.F. carrier systems last channel distortion is rarely experienced but, if it is suspected, each station will take a second orient with the last channel transmitter open (marking) to ascertain if this distortion is present. A marked variation of orient will indicate the condition.

If so, the Webster segment will be switched in at either or both stations, and the orients checked with each last channel open. Minor adjustment, if necessary, will be made to the receive ring position.

Trials will be conducted with all channels working simultaneously. If these are satisfactory, the system will be handed over for traffic.

Q. 2.—(a) Give a description of the Morkrum printer on a multiplex set describing the mechanical functions by means of which it produces printed characters.

(b) Draw a schematic circuit showing the connections of a Morkrum printer enabling it to operate in association with a channel of a multiplex installation.

A.—(a) **Description:—**

The Morkrum printer used on a multiplex set is a page printing mechanism which receives electrical impulses from the multiplex distributor and converts them into printed characters or the functions of letter space, line feed, carriage return, case shift, bell. The machine comprises the selecting unit, the mainshaft driven by a small electric motor, the type basket and the platen, which moves across the latter as the machine letter spaces. A cast iron frame supports these parts and mechanism necessary for printing and functional operation. Power is transmitted to the mainshaft by means of a single revolution clutch. The following seven cams are thus brought into operation—code bar lock cam, spacer cam, striker bail cam, safety cam, depressing bail cam, reset cam and clutch throwout resetting cam.

Mechanical Functions—Selection:—

The machine operates in conformity with the 5 unit code. The selecting unit is therefore furnished with 5 selector magnets, which are connected to 5 segments of the receiving ring of the distributor, and which operate on reception of marking signals. Each magnet armature, when operated, moves a selector plunger. The latter strikes a selector latch which disengages from a selector lever and permits it, under spring control, to push to the left a corresponding code bar having a series of slots on the lower side. The selection of the particular character or function depends on the alignment of slots on the 5 code bars, one series of slots being aligned for each character combination.

Restoration of any operated selector lever is performed early in the printing operation, by the selector lever restore bail, which engages a projection at its upper end.

Code bars are restored by spring tension.

Printing:—

After selection is completed, the printing operation is initiated by a cadence pulse received from the local or cadence ring of the distributor. This pulse operates the 6th pulse magnet armature, which permits disengagement of the clutch throwout lever. Driving and driven clutches then engage and the mainshaft commences its single revolution. The following sequence of operations then occurs:—

The code bar lock cam permits the code bar lock lever to lock the code bars in their respective positions. The selector lever reset cam causes the selector reset bail to restore the selector levers on their respective latches, enabling a subsequent selection while the printing operation is proceeding.

The depressing bail cam allows the depressing bail to rise. Under spring tension the push bars endeavour to follow, and the selected one rises in the aligned code bar slots into the path of the striker bail.

The striker bail cam permits the striker bail to be pulled by its spring against the selected push bar, which is driven forward.

The type bar, connected by links to the push bar, is thus thrown against the platen. The striker bail, operating through an arc, disengages itself from the push bar before the type strikes the platen.

Immediately after the striker bail has completed its forward movement the depressing bail cam moves the depressing bail downwards to hold all push bars clear of the code bars to permit their succeeding selection.

The operation of the machine to achieve functions other than printing is not described.

(b)—

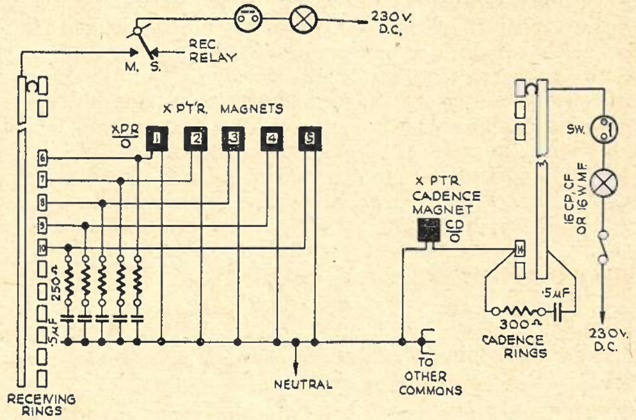

Fig. 1.

EXAMINATION No. 2721—ENGINEER, LINE CONSTRUCTION

W. Kemp

Part A.—General

Q. 1.—Briefly list the main specification requirements of P.I.L.C. local type star quad cable. What are the main constructional differences between local and trunk types of star quad cable?

To what extent is antimony sometimes added to the lead of the sheath, and for what reasons?

A.—This question is answered on pages 193-195 of the February, 1939 (Volume 2, No. 3), issue of the "Journal," which contained answers to Questions 7 and 8 of Examination No. 2106.

Q. 2.—Detail the differences in the properties of hard drawn and cadmium copper wire.

Explain the conditions under which each class of wire is used and indicate whether any particular properties of the material are associated with such use.

What are the approximate breaking strains of 200 lb. H.D.C. and 237 lb. C.C. wire?

A.—Hard drawn copper wire (H.D.C.) is made from electrolytically pure copper bar, which is cold drawn down in a series of dies until the correct diameter is obtained. This treatment hardens the material and gives it greater strength and resistance to fatigue. In this way the tensile strength of the copper wire when hard drawn may be doubled (i.e., from 15 tons per sq. inch to 30 tons per sq. inch).

Cadmium copper wire (C.C.) contains 0.8% of cadmium. This cadmium copper alloy when cold drawn in a similar way to that described above has a tensile strength of 45 tons per sq. inch.

In choosing the most suitable of these materials for use, three factors are considered—conductivity, strength and cost.

Comparing C.C. with H.D.C. for the same wire diameter, the electrical resistance of C.C. is 18.5% more, the strength is 47% greater, the weight is 1% more and the cost is 42% higher. For the same conductivity a larger C.C. conductor is required, and this would be 62% stronger, whilst the cost would be 46% greater. The impact resistance of C.C. wire is greater, and it suffers less from abrasion, is not so liable to fatigue failure, but is much more resilient and harder than H.D.C. wire.

For some transmission requirements, such as important trunk lines, H.D.C. wire is generally more economical and, therefore, C.C. wire is used only where conditions are abnormal, such as long spans, exposed conditions, timbered areas, or where large flocks of birds alighting on wires may cause breakages, and require a stronger conductor than H.D.C. wire.

For subscribers' lines where economic factors require high gauges of wire, and constructional standards are not as high as on main trunk routes, C.C. wire, 40 and 70 pounds per mile, are used. Although H.D.C. wire would be cheaper, its greater tendency to breakage makes C.C. wire in these sizes more economical, due to trouble-free service.

The following table summarises the general conditions governing choice of wire:—

	Types of Wire Used
Subs. Lines	
(a) General.	Cadmium copper weighing 40 lb. per mile.
(b) Long lines (severe conditions) or subscribers' routes of over 3 chain spans.	Cadmium copper weighing 70 lb. per mile.
Trunk Lines	
(a) General.	Cadmium copper weighing 70 lb. per mile H.D.C. weighing 100 lb. per mile; 200 lb. per mile; 300 lb. per mile. (According to transmission requirements.)
(b) Long lines (severe conditions)	Cadmium copper weighing 118 lb. per mile; 237 lb. per mile (According to transmission requirements.)

Breaking Strains:—

200 lb. per mile H.D.C. = 640 lb.
237 lb. per mile C.C. = 1040 lb.

Q. 3.—You are required to investigate a serious accident to a lineman, when working on a pole, due to each of the following causes:—

(a) The pole being defective and falling.

(b) Electric shock due to a telephone wire contacting an electric power wire.

Detail the various aspects to which you would give attention when making your inquiries.

If the accident in case (b) was fatal, what additional inquiries would you make?

A.—General—The investigation of a serious accident should be directed so as to obtain the full relevant details as concisely as possible. The data when assembled should indicate the main cause or causes, as well as any contributory factors. The facts revealed in this way may serve as a basis for laying down additional precautionary measures to prevent a similar accident happening.

Part (a)—In the case of an accident due to a defective pole, the following factors would be important.

Structural

(i) Type and condition of pole. Nature and cause of defect or defects. Date of erection may be important, if available.

(ii) Depth of pole in ground. Whether the pole was overloaded in any way, involving consideration of type, material, etc.

(iii) Number of arms and their spacing, gauge of wires, whether the pole an angle or terminal pole, or stayed or unstayed.

Inspections, Tests, etc.

(i) When was the pole inspected last and the result of this inspection? Was the nature of the weakness such that the inspection should have revealed it? If the pole was marked for renewal or as dangerous to climb, what action was taken for its renewal? Also, what precautions did the officer in charge take to make the pole safe to climb? Responsibility for adequate tests rests on the officer in charge. Were pikes or temporary stays applied, and were the steps taken adequate, in view of the condition of the pole?

(ii) What tests did the victim of the accident apply to the pole before climbing? Were there any witnesses who could substantiate the statements by the interested officers? The tests which should be applied to a pole before climbing are as follow:—

(a) Sound the pole at the wind and water line with a tomahawk or sharp tool.

(b) Try to push the pole over across the line of wires by means of a ladder or pike.

(c) If there is any doubt, the ground should be opened up for 12″ to 15″ in depth and a bore driven in to determine the condition of the timber.

(d) If still doubtful, bore the pole to further determine the condition of the timber and whether a pipe or heart rot exists.

Was any undue strain applied to the pole by the workmen, e.g., due to removal of stays or retensioning or untying of wires?

Supervision

Reports from the officer in charge should show what nature of work the victim was employed on. Whether he was physically fit and if there were any special circumstances at the time of the accident. Were there any contributing causes such as faulty material, tools or workmanship?

Part (b)—Where a man has been shocked from a commercial power source the following aspects should be closely examined. Firstly, in what manner did the contact come about? Was it due to a Departmental or outside agency? Was there any reason to suspect that there might be a risk of contact? Were rubber gloves available and did the victim wear them? Were any other precautions, such as rope tails, used to restrain wires which might cause fleeting contacts? Were earth wires attached to the wire reels?

Structural

What general precautions were taken since the power circuit was in proximity to the Departmental construction? What was the position of the P.M.G. construction in relation to the power circuit involved? Did this construction ensure the clearances laid down? These should have been as follow:—

Up to 650 volts—Where E.L. wires are attached directly or by means of a pole raiser to the P.M.G. construction, the nearest E.L. wires to P.M.G. wires must be not less than 4′ 0″. At every point the minimum clearance between wires must be 2′ 0″ between the wires in all directions.

650-11,500 volts—The wires must cross above and the minimum clearance must be 4′ 0″, provided in all directions.

11,500-66,000 volts—As for 650-11,500, but the minimum clearance to be 6′ 0″.

Over 66,000 volts—As for 11,500-66,000, but the minimum clearance to be 8′ 0″.

Inspections, etc.

When was the pole inspected last and what was the result of that inspection? Was the nature of the construction such that this inspection should have drawn attention to it? Was the inspection made during hot or cold weather? In the event of the inspection revealing a deficiency, what steps were taken to rectify it?

Supervision

As for part (a), but adding what were weather conditions at the time of the accident.

In the event of the accident proving fatal, it should be ascertained whether urgent steps were taken to apply pole top resuscitation or, if the man was on the ground, was artificial respiration applied, and for how long (four hours is not excessive). Also, what steps were taken to summon a doctor or medical aid quickly, and the result?

Instruction

If artificial respiration was not applied, enquiries should verify why not, and whether instruction in its application had been given, and the most recent date of such instruction.

EXAMINATION No. 2721—ENGINEER—TRANSMISSION—LINE AND RADIO

J. C. Wadsworth

SECTION 2

Q. 6.—(i) A two-wire radio-frequency transmission line has a distributed inductance of 3mH per mile and a distributed capacity of 0.00833 μF per mile. What is the characteristic impedance of the line?

(ii) Describe a suitable method of connecting the line to a transmitting dipole aerial having an impedance of 100 ohms and operating in the high frequency band.

A.—(i) The characteristic impedance of a two-wire transmission line is given by the formula:—

$$Z_o = \sqrt{\frac{R + j\omega L}{G + j\omega C}} \text{ ohms}$$

where Z_o is the characteristic impedance of the line.
R is the resistance/unit length in ohms.
G is the leakance/unit length in mhos.
L is the inductance/unit length in henries.
C is the capacitance/unit length in farads.
$\omega = 2\pi \times$ frequency.

Since, in the case of such a transmission line, R and G are small compared with ωL and ωC, the characteristic impedance may be taken to be:—

$$Z_o = \sqrt{\frac{L}{C}} \text{ ohms}$$

$\therefore$ If $L = 3 \times 10^{-3}$ Henries/mile
and $C = 833 \times 10^{-11}$ Farads/mile

$$\text{then } Z_o = \sqrt{\frac{3 \times 10^{-3}}{833 \times 10^{-11}}}$$

$$= \sqrt{360{,}000}$$

$$= 600 \text{ ohms.}$$

(ii) In order to connect this transmission line having an impedance of 600 ohms to a transmitting dipole having an impedance of 100 ohms, it is necessary to employ a form of impedance matching device which will have the following characteristics:—

(a) Be capable of handling the power of the transmitter.

(b) Have a low insertion loss at the frequency involved.

(c) Be robust and stable in its adjustment under adverse weather conditions.

(d) Be simple in design and construction.

One form of matching which fulfils these conditions is known as a stub or building-out section. The transmission line is connected directly to the aerial and a suitable shunt reactance, usually a short length of transmission line, known as a stub, is placed at a point within a wavelength or less of the aerial. The point at which the stub is placed is such that when the impedance looking towards the aerial is paralleled by the stub, the impedance of the combination is a resistance equal in magnitude to the characteristic impedance of the transmission line. The stub line may be of one of two forms.

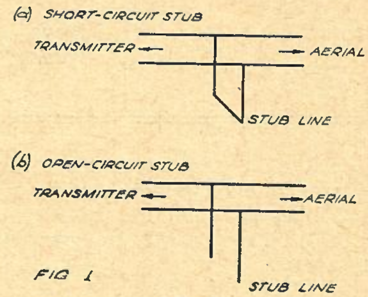

Fig. 1.

The former is generally preferable, as it has the following advantages over the open circuit type of stub:

(a) Is of smaller physical length.

(b) No high voltages are present at the end and, therefore, no insulation and personnel safeguard problems are encountered.

(c) The S/C stub may be earthed at its far end in order to prevent the formation of static charges on the transmission line.

The length of the stub and its placement on the transmission line may be calculated but, in practical applications, it is preferable to adjust the position and the length of the stub by experiment.

By the use of a trolley meter, the position of the current maxima and minima and the ratio between them may be determined. Whether the line impedance is greater or less than the aerial impedance, the stub must be attached to a point within $\lambda/8$ of a current maximum. By correctly positioning the stub, its length will be less than $\lambda/8$ long. If it is desired to use an open circuit stub, then this must be placed on the input side of the current maximum, and on the opposite side if it is to be a closed circuit stub. The stub must now be precisely adjusted, as to length and position, in order to reduce the standing-wave ratio to below 1.5: 1.0.

This is done by measuring the standing waves on the transmitter side of the stub and ascertaining the position of the current maximum or minimum nearest the stub. Next adjust the length of the stub, as indicated in Table 1, in order that a current maximum or minimum occurs at the point $\lambda/4$ from the stub. The final adjustment is then to reduce the standing wave ratio by adjusting the position of the stub on the line and simultaneously altering its length in accordance with Table 1.

TABLE 1

Standing Wave Condition on line —Transmitter side of line	Type of Stub			
	S/C		O/C	
	Position	Length	Position	Length
I_{max} between stub and $\lambda/4$ point	—	Shorten.	—	Shorten.
I_{min} between stub and $\lambda/4$ point	—	Lengthen.	—	Lengthen.
I_{max} at $\lambda/4$ point	Move Stub towards transmitter.	Shorten.	Move stub from transmitter.	Lengthen.
I_{min} at $\lambda/4$ point	Move stub from transmitter.	Lengthen.	Move Stub towards transmitter.	Shorten.

From the outline of the adjustment and in order that the length of line on which standing waves exist be kept as small as possible, the initial placement of the stub must be relative to the first current maximum back from the aerial.

Q. 7.—Describe how the selectivity, overall audio-frequency response and harmonic distortion of a high-grade broadcast radio receiver can be measured.

A.—To measure the selectivity, overall audio-frequency response and harmonic distortion of a high-grade broadcast receiver, the following instruments are required:—

(i) Standard signal generator.
(ii) Dummy aerial.
(iii) Power output meter.
(iv) Wave analyser or noise and distortion measuring set.

These instruments must be of sufficient accuracy and stability to permit the measurement of the required characteristics of the receiver which may be measured using the circuit shown in Fig. 2 (a), (b) and (c). The results must then be adjusted to allow for any inaccuracies in the measuring instruments. This is straightforward and will not be discussed under each heading.

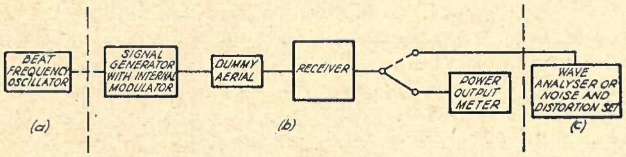

Fig. 2.

(a) **Selectivity**

With the instruments connected as in Fig. 2(b), proceed as follows:—

(i) Tune the receiver to the signal generator and immobilize the A.V.C. circuit.
(ii) Adjust the signal generator output to a reasonable level, and the receiver audio-frequency level control, to obtain the designed output of the receiver.
(iii) Detune the signal generator in steps on either side of the test frequency, and raise the signal generator output to give the previous receiver audio-frequency output.
(iv) Continue detuning the signal generator thus until the signal generator output attenuator provides maximum output.
(v) From the results, a curve may be plotted. As the signal generator is in microvolts, this unit may be used for one axis, but it is preferable to convert to decibels and plot a graph of frequency above or below the resonant frequency, versus decibels below the resonant frequency output.
(vi) Some typical values which may be expected from a receiver of this type are:—

Departure from resonance	Attenuation
± 8 Kc/s	— 20 db.
± 10 Kc/s	— 30 db.
± 12 Kc/s	— 40 db.
± 14 Kc/s	— 60 db.

(b) **Overall Audio-frequency Response**

Fig. 2 (a) and (b) indicates the connection of the equipment for this measurement.

(i) Tune the B.F.O. to give an output of 1000 c.p.s., sufficient to modulate the signal generator to a depth of 30% (this is the average programme level).
(ii) Adjust the output of the signal generator to a reasonable value in the centre of the A.V.C. working range of the receiver.
(iii) Tune the receiver to the signal generator frequency and adjust the audio-frequency gain to give the designed output.
(iv) Without altering any of the control settings tune the B.F.O. to frequencies between 30 c.p.s. and the upper limit of the receiver's response, say, 8000 c.p.s.
(v) Plot a graph of frequency versus level in decibels above or below the output level at 1000 c.p.s.

(vi) A typical response curve for this type of receiver would be:—

Frequency (c.p.s.)	30	50	100	1000	3000	6000	7000
Response (db)	—14	—5	—2	0	+1	—4	—14

(c) **Harmonic Distortion**

The measuring instruments should be set up as in Fig. 2 (b) and (c):—

(i) Adjust the 400 c.p.s. internal oscillator of the signal generator to modulate the output to a depth of 30%.

(ii) Adjust the output of the signal generator to the same level as for the previous test.

(iii) Tune the radio receiver to the signal generator output and adjust the gain of the receiver to give an output 5 db. below the designed maximum output.

(iv) Measure the harmonic output with the noise and distortion set or, preferably, with a wave analyser.

(v) Although distortion is usually specified at this 30% modulation value, the test should be repeated without altering any control settings other than increasing the modulation percentage to 90%, which is the limit of most signal generators. This test gives an indication of the distortion which is achieved during peaks of modulation on broadcast transmitters.

(vi) Typical values of distortion which will be encountered are:—

30% modulation — 1%
90% modulation — 5%

The measurements which have been described must be made in each frequency band in which the receiver is designed to operate.

Q. 8.—It is necessary to construct a medium-sized broadcasting studio on a city site, adjoining existing studios, to accommodate orchestras up to 25 pieces.

Discuss the desirable characteristics of a studio of this type and describe the main features of construction.

A.—The consideration of the characteristics and features of construction of a medium-sized broadcasting studio on a city site, adjoining existing studios, to accommodate an orchestra of up to 25 pieces must be under two headings:—

(i) The interior, which is influenced by the purpose for which the studio is designed.

(ii) The exterior, which is influenced by the proximity of the orchestral studio to the existing studios, and by the location on a city site.

1. **The Interior of the Studio**

(a) **Size**

The studio must accommodate a 25 piece orchestra and would require an area of approximately 40 feet by 30 feet. An adequate ceiling height would probably be about 15 feet. If it were necessary to accommodate an audience, the studio would require a greater area.

(b) **Reverberation Time**

The reverberation time of the studio is the length of time taken for a sound created in the studio to be attenuated to a value of 60 db. below its original steady state level. This time would be very long, were the room to be lined with normal structural materials, due to sounds being reflected from the walls, ceiling and floor. The effect of a long reverberation time would be:—

(i) The original sound would be sustained for a considerable period, due to reflections.

(ii) Depending on the different distances of the reflection paths and, consequently, upon the times of arrival of the sounds at the microphone, three conditions will appear:—

(a) Sound reinforcement, when the difference between the times of arrival of the direct and the reflected sounds at the microphone is less than 0.03 seconds.

(b) Interference, which deteriorates the intelligibility (about 0.03 seconds).

(c) Echo, which is also undesirable (about 0.05 seconds).

The reverberation time must, therefore, be reduced so that the reflected sounds are sufficiently attenuated before arriving at the microphone. The complete lack of echo will cause the studio to sound flat and unnatural so that the attenuation should not be too high, i.e., the reverberation time should not be too short. A compromise must tbe reached and a time of 0.8 to 1.3 seconds is preferable for this type and size of studio.

(c) **Achieving Reverberation Time**

The desired reverberation time having been decided, it is only necessary that sufficient sound absorbing material be provided around the studio to achieve this desired period. This may be calculated from the formula:—

$$T = \frac{kV}{a}$$

where T is the reverberation time in seconds.
k is a constant having a value of 0.05 at normal room temperatures.
V is the volume of the studio in C ft.
a is the number of absorption units (Sabins).

As all absorbing materials have a frequency characteristic, the expression "a" is, in practice, taken at 512 c.p.s., above which value the absorption characteristic is more linear.

The reflecting surfaces of the room, or as much as necessary, must be covered with a sound-absorbing material such that, when the absorption value of the applied material, carpets, curtains, clothing of occupants, etc., is accounted for, the expression "a" has the desired value. A form of treatment which would be suitable for this type of studio would be to line the walls with perforated ply-wood, formed into concave surfaces, and the space behind filled with rock wool. This treatment should be applied to the walls, whilst the flat surface of the ceiling should be broken up.

2. **The exterior of the Studio**

Noise due to traffic, etc., may be introduced through:—

(i) Window, door or ventilating duct openings.
(ii) Refraction or transmission through partitions.
(iii) By the diaphragm action of walls.
(iv) By conduction through solids.

The means of overcoming each of these defects are:—

(i) For windows, two or more panes of glass set in felt and with air spaces between them are of assistance, whilst the provision of double doors to form an air lock reduces this interference. Ventilating ducts are a little more difficult, however, but the selection of slow speed, quietly-running fans, or the provision of acoustical attenuating materials, such as rock wool, within the air ducts, is the solution.

(ii) This effect is negligible when the studio walls are constructed of brick or stone which, in themselves, provide sufficient attenuation to this type of noise.

(iii) This may be obviated by the same method as (ii).

(iv) This is, perhaps, the most difficult type of noise to attenuate, and it may arise due to lifts, noise within adjacent buildings, city traffic or underground railways where the sound is transmitted via the foundations or solid structural members of the building. Two principal methods may be used to overcome the problem. The studio may be floated within the building structure, or a method, which is favoured in Australia as well as overseas, is to provide the studio with its own foundations independently of the main building foundations. The former method, however, must be used where the noise is carried through the ground; for example, due to underground railways, etc. In either method, all wiring, piping and cabling into the studio must be flexible, in order to prevent conduction through this means.

All these features must be amalgamated into the design to produce the required studio.

For further information see—
Pender & McIlwain,
Electrical Engineer's Handbook, Volume 5, Section 9.

POSTAL ELECTRICAL SOCIETY OF VICTORIA

Annual Report, 1947

A bi-monthly lecture programme was arranged for the year under review, and lectures were delivered, both by members of the Society and engineers from the Department of Civil Aviation. The Society was also fortunate to be able to arrange for a talk by Mr. A. J. Leyland, Joint Managing Director of the Automatic Telephone and Electric Co., of Liverpool, England, who was visiting Melbourne, and to view a moving picture, "Where There's a Will," depicting the activities of this factory, both in peace and war.

Appreciation for delivery of lectures during the year is expressed to the following gentlemen: Messrs. A. J. Leyland, F. O'Grady, R. M. Badenach, E. J. Bulte and R. W. Boswell.

The lectures were held in the Radio Theatre, Melbourne Technical College, by the courtesy of the Principal, Mr. F. Ellis, M.A., B.E., and Mr. R. R. Mackay, M.I.R.E., and we are indebted to them and Mr. Permewan for the material assistance they are rendering the Society.

At a meeting held on 8.9.47, Mr. S. H. Witt, who was the first president of the reconstituted Society, was appointed a Life Member, and farewelled on the eve of his departure for an extended period overseas. The President, on behalf of the Society, expressed our best wishes to Mr. Witt, and presented him with a polished wooden ash tray as a memento.

As a first step in arranging for more articles for the "Journal" from engineering officers in other States, Mr. E. Sawkins, of Sydney, was appointed a Sub-Editor to the "Telecommunication Journal," and has already rendered valuable assistance in obtaining articles.

To assist in increasing the circulation of the "Journal" in N.S.W., Mr. E. Parle was appointed representative of the Society in that State.

The resignation of Mr. J. A. Kline from the Board of Editors, on his promotion to another department, was received with regret. Mr. Kline was one of the original editors of the "Telecommunication Journal," and, in recognition of his long and faithful services, the Committee has appointed him a Life Member of the Society.

Mr. J. W. Pollard and Mr. C. J. Griffiths are not seeking re-election to the Committee next year, and we wish to pay tribute to the fine service these gentlemen have rendered the Society, as Treasurer and Committeeman, respectively.

The Committee heard with deep regret of the untimely death of Mr. A. R. Gourley, Life Member of the Society. Mr. Gourley was the first Secretary of the reconstituted Society, and served in that capacity, also as a member of the Board of Editors, for many years. The success of the "Telecommunication Journal of Australia," and the growth of the Society, are primarily due to his untiring efforts, and his name will always be associated with these activities.

The number of Members and Subscribers at 30.4.47 is:—

Members	1153
Subscribers	1660
	2813

These include over 200 oversea subscribers who are located in England, U.S.A., Canada, South Africa, New Zealand, Kenya Colony, Sweden, Switzerland, India, Malaya, Egypt and Palestine.

Appreciation is expressed to Miss I. Owens for the valuable services rendered as Distribution Manager during the current year. It is desired to express thanks to the authors of articles and members of the drafting staff, who have given freely of their time in preparing articles and illustrations for the "Journal," and also to those members who have so willingly assisted in collecting subscriptions.

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