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The

Telecommunication Journal of Australia

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THE EVOLUTION OF THE INTERNATIONAL TELECOMMUNICATION CONVENTION

J. C. Harrison

Introductory: The provision of international telecommunication services, of various types, probably requires a greater degree of co-operation beteen officials of different countries, in order to ensure their proper performance, than is the case in any other kind of activity. The speedy exchange of telegraphic or telephonic communications, via land-line or radio-electric channels, between all the civilised countries of the world, necessitates the observance by all administrations throughout the entire globe of uniform rules. If each country attempted to insist on its own rules and procedure, independent of the views of other administrations, chaotic conditions would arise. Moreover, agreement must be reached regarding the technical means to be employed for the circulation of communications without unnecessary delay. This implies not only the provision of connecting wires, submarine cables, and radio communication channels but also the determination of operating procedures, including telegraph codes.

The organisation which has been established to permit the free exchange of telegraph and telephone communications between any two people in any two civilised countries is known as the International Telecommunication Union. This was created as a result of a conference which met in Madrid in 1932 to draw up the International Telecommunication Convention, which replaced the International Telegraph Convention of St. Petersburg (1875) and the International Radiotelegraph Convention of Washington (1927). Before proceeding further with the discussion concerning the Telecommunication Convention, a brief description of the international understandings prior to 1932 would probably be of interest.

In 1855 certain Central European Governments made an agreement relating to the transmission of telegrams between their countries, the covenant being revised in 1858. From these understandings there developed the International Telegraph Convention of 1865, which was made at Paris, and this is regarded as the first International Convention, 20 European Governments being parties thereto. Subsequent Conventions were made at Vienna in 1868, Rome in 1872, and St. Petersburg in 1875, the last-mentioned remaining in operation unchanged for 57 years. The International Telegraph Regulations, annexed to the St. Petersburg Convention, concerning details of service, were, however, amended by Administrative Conferences which were held periodically, namely, at London, 1879; Berlin, 1885; Paris, 1890; Budapest, 1896; London, 1903; Lisbon, 1908; Paris, 1925; and Brussels, 1928.

Details of the classes of service, bases of tariffs, and the procedures to be observed in the international telephone service were first incorporated in the Regulations of 1903 in a chapter of 59 paragraphs. In the 1896 Regulations only 5 paragraphs were devoted to the telephone service, stipulating, in effect, that the tariffs and details of operation shall be fixed by special arrangements between Administrations.

The first International Radiotelegraph Convention was made at Berlin in 1906, 27 countries being represented. Associated with this Convention was a group of service regulations, their scope being confined to the treatment of telegrams between radiotelegraph installations on land and on ships. Prior to the Berlin Conference of 1906, representatives of nine nations met at Berlin, in August, 1903, to draw up for consideration by their respective Governments, certain general principles on which an International Convention might be based. Subsequent Radiotelegraph Conventions were drawn up at London in 1912 and Washington in 1927.

The Commonwealth formally adhered to the Telegraph Convention on January 1, 1903, and to the Radiotelegraph Convention on July 1, 1908. Prior to the creation of the Commonwealth, however, each of the Australian States had formally joined the International Telegraph Union on the respective dates mentioned hereunder:—

South Australia, 27/5/1878; Victoria, 1/7/1880; New South Wales, 25/2/1884; Tasmania, 8/7/1885; Western Australia, 1/1/1894; Queensland, 9/4/1896.

Preparatory Work in Connection with the

Telecommunication Convention: For some years prior to the Madrid Conferences, many interested parties in a large number of countries had urged that the existence of two independent Conventions, with separate sets of regulations, was not satisfactory, bearing in mind the great development in the use of radio-electric channels for the transmission of telegrams, following on the advances made with short-wave radiotelegraph systems. Moreover, the view was strongly expressed in many quarters that a revision of the Telegraph Convention was long overdue. At the Telegraph Conference held at Paris in 1925, proposals were discussed for the combination of the Telegraph and Radiotelegraph Conventions into one instrument, but the delegates came to the conclusion that they did not possess the necessary power to act in this direction. Further consideration was given to the question at the Radiotelegraph Conference held at Washington in 1927. As a result of these discussions it was agreed that arrangements should be made for the next Telegraph and Radiotelegraph Conferences to be held simultaneously at Madrid in September, 1932.

Invitations were subsequently issued by the Spanish Government to all the other interested Governments, through the diplomatic channels, to send plenipotentiaries, equipped with full power, to the Madrid Conferences. Independently the International Telegraph Bureau, 12 months before the conferences were set down to take place, requested Administrations and telegraph companies to forward propositions for consideration at the conferences. The Bureau undertook the collation, publication, and distribution of the propositions to the Administrations some months before the conferences were due to take place, so that they might be fully considered before the delegates assembled. The total number of propositions affecting the telegraph service represented 1,287, while 171 related to the telephone service and 1,375 to the radiocommunication activities. Additional propositions were distributed up to the time the conferences were in session.

The propositions were printed in French only, and on receipt in Australia it was necessary for an English translation to be made of all the proposals, by the departmental translator, before their scrutiny could be commenced. The task of examining the propositions was one of some magnitude, because of the need for the effect of each proposal to be closely studied. In the Commonwealth, experts of the Telegraph, Telephone, and Wireless branches at Central Office were responsible for examining the proposals affecting their respective branches and for indicating their views thereon, the advice of other branches being sought, of course, on issues affecting them (e.g., the Chief Engineer's Branch in connection with technical aspects, and the Finance Branch as regards accountancy arrangements), the considered opinions of the Administration ultimately being shown against each proposal for the guidance of our delegate.

The Madrid Conferences: The conferences commenced on September 1, 1932, and extended over a period of 14 weeks, during which the Convention, as well as four sets of regulations, were drawn up, namely:—

(1) The Telegraph Regulations;
(2) The Telephone Regulations;
(3) The General Radiocommunication Regulations;
(4) The Additional Radiocommunication Regulations.

A number of important changes concerning the telegraph and radiocommunication services were decided upon, including the following:—

(a) Abandonment of 10-letter code words;

(b) Abolition of weekend letter telegrams and an increase in the tariff for daily letter telegrams to one-third of the rate for ordinary telegrams, with a minimum charge as for 25 words;

(c) Reduction in the tariff for urgent telegrams from triple to double that of the full rate;

(d) The introduction of an urgent Press telegram service at a tariff 50 per cent. below that of urgent private telegrams;

(e) Prohibition of the use of spark transmitters on ships;

(f) Re-allocation of frequency bands (wavelengths) in the radiocommunication services.

Seventy-three Governments were represented at the conferences, and, in addition, representatives of 58 cable and radiocommunication undertakings, as well as 31 other authorities, were present. Only the representatives of the Governmental Administrations had a right to vote, the Convention being made between the plenipotentiaries of the Governments. The total number of representatives in attendance at the conferences was approximately 680, this number including the Government delegates, and also the representatives of the cable and radiocommunication undertakings, broadcasting, aeronautical and marine interests, as well as radio amateur organisations, Chambers of Commerce, and certain other folk.

The importance which certain leading Administrations attached to the Madrid Convention is reflected by the numerical strength of their delegations. The United States of America despatched the largest number of representatives, namely, four full delegates, and a number of experts, secretaries, interpreters, and stenographers, totalling in all 31 Government officials and 30 representatives of other United States interests. Great Britain despatched 16 delegates, 10 from the British Post Office and six from other Government departments, including the Admiralty, Air Ministry, War Office, and the Board of Trade. In addition to these official delegates, 33 representatives of other British interests were in attendance, namely, Cable and Wireless Ltd., 8; Marconi International Marine Company, 7; Radio Communications Company, 4; British Broadcasting Corporation, 3; Marconi Wireless Telegraph Company, 3; International Radio Maritime Committee, 3; Chambers of Commerce, 3; International Shipping Conference, 2. France was represented by 37 delegates; Japan, 21; Germany, 19; Poland, 14; U.S.S.R. and Holland, 13 each; Italy, 11; Denmark and Sweden, 10 each; while the Dutch East Indies and Norway each sent 5 representatives. The Commonwealth was represented at the Madrid Conference by Mr. J. M. Crawford, who was then Chief Engineer of the Postmaster-General's Department.

The formulation of the International Telecommunication Convention was undoubtedly an outstanding achievement, bearing in mind all the varying requirements which had to be satisfied. For example, while the representatives of the United States of America and Canada were prepared to sign a Convention and certain Regulations relating to the radiocommunication services, they were not agreeable to bind themselves so far as the Telegraph Regulations were concerned, on the ground that the internal telegraph services of their countries were not operated by their Governments but by private enterprises; the Governments of those countries were therefore not prepared to bind the companies to observe those Regulations. Incidentally, although the American telegraph companies have not formally undertaken to conform to all the obligatory clauses of the Telegraph Regulations annexed to Convention, they have notified the Bureau that they intend to conform in a general way with the provisions of such Regulations. Moreover, certain Administrations outside Europe, including Australia, were not prepared to sign the International Telephone Regulations, because the conditions incorporated therein were not altogether appropriate to the radiotelephone services in operation between their countries and places overseas.

These difficulties were overcome by inserting in the Convention a provision that the regulations are binding only on those contracting Governments which have undertaken to apply them. Acceptance of one, at least, of the sets of Regulations, however, was made obligatory for signatories to the Convention or those who subsequently acceded to the Convention. By adoption of this course the Convention was made acceptable to all the civilised nations. Of the 73 countries whose representatives executed the Convention, 69 signed the Telegraph Regulations, 61 committed themselves to the Telephone Regulations, 69 subscribed to the General Radiocommunication Regulations, and 66 accepted the obligations of the Additional Radiocommunication Regulations.

Committees: As there were approximately 680 people taking part in the proceedings it was obviously imperative that the work of the conferences should be subdivided into various committees if conclusions were to be reached in a reasonable period. Seven main committees were appointed to deal with (a) the Convention; (b) the Telegraph Regulations; (c) the Telegraph Tariffs; (d) the Telephone Regulations; (e) the Radio Regulations; (f) the Radio Tariffs; and (g) Technical aspects. These committees delegated certain questions to a number of subcommittees, and the latter bodies followed this example and appointed sub-sub-committees in many cases where highly contentious and difficult issues were involved. These committees and sub-committees actually undertook the great bulk of the work of the conferences.

Voting: Some difficulty was experienced in reaching agreement on the voting power of the respective delegations in the Plenary Assembly, but eventually a compromise was agreed upon, for application solely at Madrid, namely, that one vote should be accorded each independent country and to each independent Dominion and India, one additional vote to Germany and U.S.S.R. respectively on traditional grounds because such had always been accorded in the past, and one extra vote to Great Britain, France, U.S.A., and other countries having colonial possessions. During the committee and sub-committee meetings each separate country or dependency represented at the conferences was accorded one vote.

Language: For many years prior to the Madrid Conferences, determined efforts had been made by British and other delegates to obtain approval for the use of English as an official language at International Conferences in addition to French. It is interesting to note that at the Paris Conference of 1925 the Japanese delegates put forward such a proposition, which, however, was defeated. English was admitted co-equally with French at the Washington Radiotelegraph Conference, because the Convention was held in an English-speaking country. The Madrid Conferences agreed to permit the use of English as well as French during the discussions, but proposals to secure publication of the documents in both languages did not succeed. The Convention stipulates that all documents of the Union shall be drawn up in French.

Monetary Equivalent: The International Telegraph Regulations which were in existence immediately prior to the Madrid Convention included a provision that in order to ensure uniformity of charges each contracting Government should fix an equivalent in its local currency approximating as nearly as possible to the value of the gold franc, and that this equivalent might undergo in each country changes corresponding to the rise and full of the currency. No action was taken by the Administrations of Great Britain, Australia, and New Zealand to vary their equivalents when the gold standard was departed from in 1931, on the grounds that it was not obligatory to do so and that such an alteration would result in telegraph users being required to pay substantially increased charges at a time when those Governments were doing their utmost to reduce costs. As the Madrid Conference decided to retain unchanged the provisions regarding the modification of the monetary equivalents, the British, Australian, and New Zealand plenipotentiaries signed the Telegraph Regulations with a reservation that their Governments accepted no obligation in regard to such adjustments. A similar freedom of action was then claimed by 31 other Governments, the reservations being included in a Final Protocol.

Frequency Allocation: Two of the most difficult and complex problems before the Madrid Conferences related to the re-allocation of frequency bands (wave-lengths) between the various types of radio-electric services and the limitation of power for radiocommunication installations. Demands were made for additional facilities by a number of varied interests, including shipping, aeronautical, meterological, and broadcasting services, while others refused to surrender any portion of their existing allocations. The number of frequency bands available was not sufficient to enable all requirements to be met. The limitation of power was closely linked with that of frequency allocations, because of the general tendency to increase power so as to secure an extension in range and the fact that such increases had in many cases caused interference in regions outside the country of emission. Ultimately agreement was reached on a general allocation of wave-lengths, but so far as Europe was concerned a final settlement of the issues involved was referred to a special European Conference to be held at Lucerne in 1933.

Outline of the Convention: Undoubtedly the conferences selected a very appropriate title for the Convention. The term "telecommunication" is defined in the annexe to the Convention as any telegraphic or telephonic communication of signs, signals, writing, facsimiles, and sounds of any kind. Since the adoption of this term by the conferences it has been brought into use for a variety of purposes in many countries. For example, it has been incorporated in the title of this journal.

The Convention is composed of 40 Articles, 12 of which relate to the implementation of the Convention, while the subject matter of the other clauses is outlined hereunder:—

1: Organisation of the Union—Regulations; Special arrangements on matters of service not concerning the Governments in general; Relations with non-contracting States; Arbitration in event of disputes; Establishment of International Consultative Committees; Establishment of the Bureau of the International Telecommunication Union.

2. Conferences; Dates of Conferences; Rules of Procedure at Conferences; Official Languages.

3. General Provisions—Public Service; Responsibility; Secrecy; Provision of Channels; Stoppage of Telecommunications; Suspension of Services; Investigation of Infringements; Charges and Free Services; Priority for Government Telegrams; Use of Secret Language; Monetary Unit; and Accountancy Arrangements.

4. General provisions for Radiocommunications — Intercommunication; Interference; Distress Calls and Messages; Suppression of False Distress Signals; Restricted Service; and Installations for National Defence.

In accordance with a resolution passed at the Madrid Conference, the Bureau published in an appendix to the Convention the declarations and resolutions of the Conference, including a reference to certain resolutions adopted by a conference held in London in 1913, amplifying the Convention for the Protection of Submarine Cables made at Paris in 1884. The British Parliament passed an act known as "The Submarine Telegraph Act 1885" to give effect to the decisions of that Convention, and as no Commonwealth law is in existence relative to the matter the provisions of that Act are applicable to the Commonwealth.

Outline of the Telegraph Regulations of Madrid: The Telegraph Regulations adopted at Madrid are divided into 32 chapters, comprising in all 98 articles and 860 paragraphs, and they prescribe in detail the procedure to be followed in the preparation of telegrams as well as in their acceptance, transmission, and delivery. They also lay down the method of counting, the basis of charging, and prescribe the various codes, morse, teleprinter, and baudot, to be used on international circuits. The regulations also set out the conditions applicable to urgent, multiple, and other special telegrams, as well as the accountancy procedure to be observed and the practice to be followed in furnishing certified copies of telegrams.

Outline of the Telephone Regulations of Madrid: The Telephone Regulations adopted at Madrid are divided into 13 chapters, comprising in all 39 articles and 235 paragraphs. The provisions of these regulations apply only to international telephone services within the European system. The regulations set out the principles to be observed in the provision and maintenance of circuits; fixation of the hours of service; determination of legal time; compilation and supply of directories; classes of calls; operational procedure in booking of calls; establishment and disconnection of calls and limitation of duration of calls; tariffs and basis of charging; refunds; and accountancy arrangements.

Outline of the Radiocommunication Regulations of Madrid: The Radiocommunication Regulations are divided into two sets. The first group is known as "the General Radiocommunication Regulations" and the second set is entitled "Additional Radiocommunication Regulations."

The General Radiocommunication Regulations are divided into 33 articles, comprising in all 567 paragraphs. These regulations prescribe in detail the requirements to be complied with in regard to the following matters:—

Secrecy measures; issue of licences; classification and qualities of emissions; allocation of frequency-bands (wave-lengths) between the various radio services—broadcasting, fixed land stations, mobile (ship and aircraft) stations, aeronautical, radiobeacons, direction-finding, and experimental — in different regions; special conditions to be observed by amateur, experimental, and mobile stations; issue of operators' certificates; inspection of stations; distribution of call signs between the various countries; notification and publication of frequencies; general radiotelegraph procedure in the mobile service, including routing arrangements; measures to prevent interference; distress messages and the special procedure associated therewith; accountancy arrangements; special services relating to meteorology, time signals, direction finding and radiobeacon facilities; frequency tolerances; abbreviations to be used in radiocommunications.

The Additional Radiocommunication Regulations contain 13 articles, which are divided into 111 paragraphs. These regulations deal in detail with the procedure to be observed in the transmission of radiotelegrams to and from mobile radio stations (ship or aeronautical); the basis of charging to be applied in respect of such messages; the method of indicating the time of lodgment; method of address; retransmission and nondelivery procedure; ship letter telegrams; special radiocommunications and radiocommunications to several destinations.

Ratification of Convention and Approval of Regulations: The plenipotentiaries all signed the Convention in a single copy, which remains in the archives of the Government of Spain, a copy being delivered to each Government. Similarly, the plenipotentiaries signed a single copy of each set of regulations which they accepted, and this document was also retained by the Government of Spain. In harmony with the provisions of the Convention, each signatory Government was required to forward to the Spanish Government, through the diplomatic channels, its ratification of the Convention. Each contracting Government was also required to notify to the Bureau its approval of each of the sets of regulations which its delegates had signed.

Work of the Bureau: On completion of the Conferences, the Bureau of the International Telecommunication Union undertook the publication, in French, of the Convention and the Regulations annexed thereto and distributed copies to all the contracting Governments. The British Post Office arranged for the issue of an official English translation of these books, and these translations are used also in the Commonwealth service. In addition to the work it performs in connection with International Conferences, before assembly, during the progress of the meetings, and subsequently, the Bureau also renders valuable assistance to Administrations in acting as a clearing house for the circulation of information between the contracting parties.

For example, an Administration which imposes censorship and in accordance with Article 27 of the Convention suspends the transmission of messages in code or cipher, forwards a notification to the Bureau, and the latter then immediately despatches a circular telegram containing the advice to all the other contracting Governments. This notification, in turn, is communicated to the telegraph offices in each country, so that messages which do not comply with the restrictions may be rejected when tendered. It is important for this to be done because, generally, when censorship is applied, a declaration is made by the Administration concerned to the effect that telegrams are accepted at the sender's risk, and that they may be stopped, delayed, or otherwise dealt with, without reference to the sender, and that no claims for refunds will be entertained.

The Bureau distributes to Administrations particulars communicated to it of other restrictions applied, variations of tariffs and interruptions to international channels, in accordance with notifications made to it by the authorities concerned. It also issues a number of periodical publications, including the monthly "Journal des Telecommunications," a bi-monthly notification to Administrations, and an Annual Report, all of which furnish interesting information. Other important publications circulated by the Bureau regarding the telegraph service include the Official List of Telegraph Offices; a summary of the optional telegram categories admitted by the various Administrations; the legal time observed by each country, as well as the languages recognised as plain languages (there are 68 such languages); tables indicating the terminal and transit charges of Administrations and Companies; conditions applied by Administrations in regard to various phases of telegraph service; particulars of submarine cables and international telegraph channels; and schematic maps of international telegraph routes. Supplements to these documents are issued from time to time, and fresh editions are printed as required. On the radiocommunication side the Bureau publishes lists of ship, coast, land, aeronautical, broadcasting, and other radio stations with particulars of frequencies and types of equipment employed by them and other data of interest, supplied by Administrations; a list of the frequencies employed by radio stations, in numerical order; particulars of station calls, and nomenclature of radiocommunication services between fixed points. The material incorporated in these documents is compiled from official statements furnished by Administrations, and it is of great value to the authorities responsible in each country for the allocation of radio frequencies.

Expenses of the Bureau: The receipts and expenditure of the Bureau are maintained in two separate accounts, one for the telegraph and telephone services and the other for the radio-electric service. For the purpose of apportionment of these expenses the Governments of the Union are divided into six separate classes, each contributing on the basis of a fixed number of units. Administrations included in the higher classes are entitled to receive, free of charge, a greater number of copies of the documents issued by the Bureau than those included in the lower groups. Beyond the fixed number of free copies, each Administration may purchase additional copies at cost price. Each Government decides in which class its country should be placed, and so informs the Bureau. In each case the Commonwealth is contributing on the basis of Class 1, and for the year ended 31/12/1942 its payment to the Bureau represented less than £900 altogether for both the telegraph and radio services.

International Consultative Committees: The Convention provides for the establishment of Consultative Committees to study questions relating to telecommunications. Under this provision, Telegraph, Telephone, and Radiocommunications Consultative Committees have met from time to time and have furnished valuable reports and recommendations on technical and other questions which have been submitted to them for advice. Copies of the conclusions reached by these Committees are distributed by the Bureau to all Administrations.

Revision of Convention and Regulations: Revision of the Convention may be undertaken only by a Conference of plenipotentiaries of the contracting Governments. In order to ensure that changing conditions may be cared for, it is obviously necessary that the regulations should be reviewed from time to time, and the Convention therefore contemplates that the Regulations shall be subject to revision periodically, and for that purpose that administrative conferences shall be held every five years, each conference fixing the place and date of the next meeting.

Cairo Conferences: Two Administrative Conferences were held simultaneously in Cairo in 1938, one being for the purpose of revising the Telegraph and Telephone Regulations, while the other was called to review the provisions of the Radiocommunication Regulations. These Conferences opened on January 29, 1938, and extended until April 8, 1938. Altogether, 723 representatives of 72 countries were in attendance, and 850 propositions affecting the Telegraph Regulations, 104 relating to the Telephone Regulations, and 484 concerning the Radiocommunication Regulations were placed before the conferences. The Commonwealth was represented at these gatherings by Messrs. J. Malone, then Chief Inspector (Wireless), and E. J. Stewart, Assistant Supervising Engineer of the Postmaster-General's Department.

As at Madrid, much of the work of the Cairo Conferences was delegated to committees and sub-committees, the most important committees being:—

(1) Telegraph Conference—(a) Tariffs (b) Regulations.

(2) Radio Conference—(a) Technical (b) Regulations (c) Rates and Traffic.

The more important propositions adopted by the Telegraph Conference at Cairo were:—

(a) Extension of the Press tariff to telegrams addressed to broadcasting undertakings and containing material intended for broadcasting;

(b) Incorporation of detailed rules relating to the transmission of phototelegrams in international relations;

(c) Recognition of the right of countries in the European system to organise private wire teleprinter services by special arrangements between the Administrations concerned, subject to regard being paid to the recommendations of the International Telegraph Consultative Committee.

The Telephone Regulations were revised by a special committee, but as the provisions of these regulations apply principally to European conditions, the Australian delegate did not sign the revised regulations, this attitude being in alignment with that which was adopted at Madrid in 1932.

The principal proposals adopted by the Radio Conference related to:—

(a) Re-allocation of frequency bands (wavelengths) between various services;

(b) Variations in traffic procedure in the light of developments in aeronautical and marine services; and

(c) Reduction in frequency tolerances.

The Conference also drew up certain directives for a conference to revise the European Broadcasting Convention made at Lucerne in 1933.

In conformity with the Convention, the official documents of the Cairo Conferences were printed in French only. During the conferences, however, English translations of the official conference documents were made by the United States delegation and supplied free to any delegate who applied for them, 28 delegations taking advantage of this offer. Towards the end of the conferences a proposal was adopted to the effect that at the next conference the Bureau should provide a similar facility, subject to the costs involved being recovered from those delegations which participate in the arrangement.

Proposals for the unification of the tariffs for ordinary telegrams expressed in plain language, code, or cipher were placed before the Conference, but were defeated, it being found impracticable to reach agreement in regard to traffic outside the European system.

Delegates of 55 Administrations (including Australia) when signing the Telegraph Regulations at Cairo made a reservation freeing their Governments of any obligations to adjust their monetary equivalents, this being similar to the action taken at Madrid by the representatives of a number of Governments.

Implementation of the Decisions of the Union: It will no doubt be of interest to indicate how the various acts of the Union are implemented, so far as the Commonwealth is concerned. The Commonwealth Government does not itself operate telegraph channels with any country overseas. Cable and Wireless Ltd. holds a franchise to operate cable channels between Australia and certain places overseas, thus linking this country, via the world-wide undersea network of that vast undertaking, with all other lands. In addition, Amalgamated Wireless (A/asia) Ltd. is licensed to operate direct radiotelegraph services between Australia, the United Kingdom, and Canada, and these channels also connect with a great many countries. The latter company also acts as an agent of the Commonwealth in operating direct radiotelegraph services between Australia, the United States of America, India, and China, these additional outlets having been introduced to meet wartime contingencies.

Prior to the outbreak of war, radiotelephone services were operated between Australia, the United Kingdom, New Zealand, Java, and the United States of America, utilising radio installations of Amalgamated Wireless (A/asia) Ltd. These services have been suspended, excepting certain special calls, for the duration of the war.

In accordance with the Telegraph Regulations annexed to the Convention, private enterprises which connect two or more of the contracting countries are required to conform to the obligatory clauses of the Conventions and Regulations, private telecommunication enterprises working within the frontiers of a contracting country being regarded as forming an integral part of the telegraph system of that country. Cable and Wireless (A/asia) Ltd., as well as Amalgamated Wireless (A/asia) Ltd. have formally undertaken to conform to the provisions of the Convention and Regulations, and they act in harmony with the policy of the Commonwealth as regards the admissibility of optional services. Those organisations have offices in only a limited number of places in the Commonwealth, but international telegrams are accepted at, and delivered from, any of the 10,000 telegraph offices of the Postmaster-General's Department. There is, consequently, very close collaboration between the departmental officials and the companies.

The Commonwealth Telegraph Regulations provide that international telegrams are in all cases accepted subject to the provisions of the International Telecommunication Convention and the Telegraph Regulations annexed thereto. In amplification of this Statutory provision, departmental rules are incorporated in the Post Office Guide setting out the conditions which are applicable to telegrams between Australia and countries overseas. Amendment of these rules is made by the Central Administration in accordance with variations to the International Telegraph Regulations decided on by the Union. This arrangement is a convenient one, as amendments to the rules may be effected without the necessity to secure Statutory approval for any changes in the International Regulations. The Central Administration also arranges for explanatory matter to be incorporated in the departmental rules published in the Post Office Guide or in footnotes to such rules, so that telegraph officials may be in a position to advise patrons.

As the Commonwealth is not a party to the International Telephone Regulations, it is not necessary to include any of the provisions of those regulations in the Commonwealth Statutory Rules. After each International Radiocommunication Conference it is necessary for the amendments made to the Radiocommunication Regulations to be examined in great detail in order to determine what variations are necessary to the Commonwealth Regulations made under the local Wireless Telegraphy Act and other Acts relating to Radiocommunication.

Postponement of Rome Conferences: At the Cairo Conferences it was decided that the next Telegraph and Telephone and Radiocommunication Conferences should be held at Rome in the spring of 1942. The Italian Government in July, 1940, however, notified the Bureau of the International Telecommunication Union that in view of the international situation it was necessary to defer the conference. It would, of course, be contrary to customary practice for representatives of countries at war to meet in a conference of such a nature. It may be anticipated, however, that on the conclusion of hostilities, representations will be made for a further conference to be held in order to revise the provisions of the various regulations, in view of developments since 1938. Bearing in mind the technical advances which have occurred during the war period and the political upheavals, it is possible that there will be many major changes in the sphere of international telecommunications.

CABLE DISTRIBUTION BY MEANS OF LARGE OUTDOOR TERMINAL PILLARS

L. D. Calame

Part I.—Construction and Installation

Necessity for Flexible Means of Main Pair Distribution. — An underground telephone cable extends some distance from the main frame of the exchange to which it connects before it begins to distribute. This main cable varies in length, which may extend up to one mile or more in metropolitan areas, and the number of pairs usually contained in such main cables varies generally between 800 and 1400. The distribution of the cable pairs of main cables to individual subscriber's premises demands some means whereby flexibility in the use of the pairs of the main cable can be attained. Otherwise, when determining the number of pairs to be contained in the main cable, wasteful provision would have to be made to allow for telephone fluctuation, the inevitable over-provision of pairs in distribution cables on account of standardised cable sizes, survey inaccuracies, and the necessary provision of cable to meet 20-year requirements in the smaller distribution cables.

Means of Obtaining Flexibility. — Flexibility was given in early cable reticulation by terminating distribution cables at boxes varying in capacity from 5 pairs up to as high as 104 pairs, fitted to poles from which aerial leads distributed to individual residences. In the metropolitan areas the practical limit to the size of such boxes is probably 10 pairs owing to difficulties encountered with heavy aerial routes in city streets, and also for economic reasons, which favour underground reticulation to residences where telephone density is heavy. This means of distribution is still in use and is considered to be the correct method to use in certain metropolitan localities referred to later.

In practice it has been found with a main cable distributed with small cable boxes erected on poles that, owing to the large number of such boxes required (an 800 pair main cable may require over 150 of an average capacity of 10 pairs each), the comparatively small area served by each, and the variations from the telephone development forecast in each of these small areas, the use of pairs in the main cable is probably limited to the order of 75 per cent. of the total pairs in the cable, unless expensive and frequent rearrangement work is resorted to. Such re-arrangement work is extremely wasteful also, as it quickly ruins cable joints and introduces a high fault incidence. This is particularly evident with cable joints containing conductors of 6½lb. per mile weight. To improve the pair availability of main cables, which is a matter of major importance when it is noted that at the present time approximately 250,000 main cable pairs are terminated on main distributing frames in Sydney suburban exchanges, an outdoor pillar terminal with a total capacity of 120 pairs was introduced early in 1932 (and is still in general use by the Department with some modifications) for distribution of main cable pairs. Practice has shown that the use of the 120 pair pillar terminal, on which a greater number of main pairs can be terminated than was the case with the pole boxes, has resulted in the main pair availability increasing somewhat beyond 80 per cent. The number of main pairs terminated on the 120 pair panel may vary under different conditions referred to later, the number generally terminated being 40 or 50 according to the type of area served by the cable.

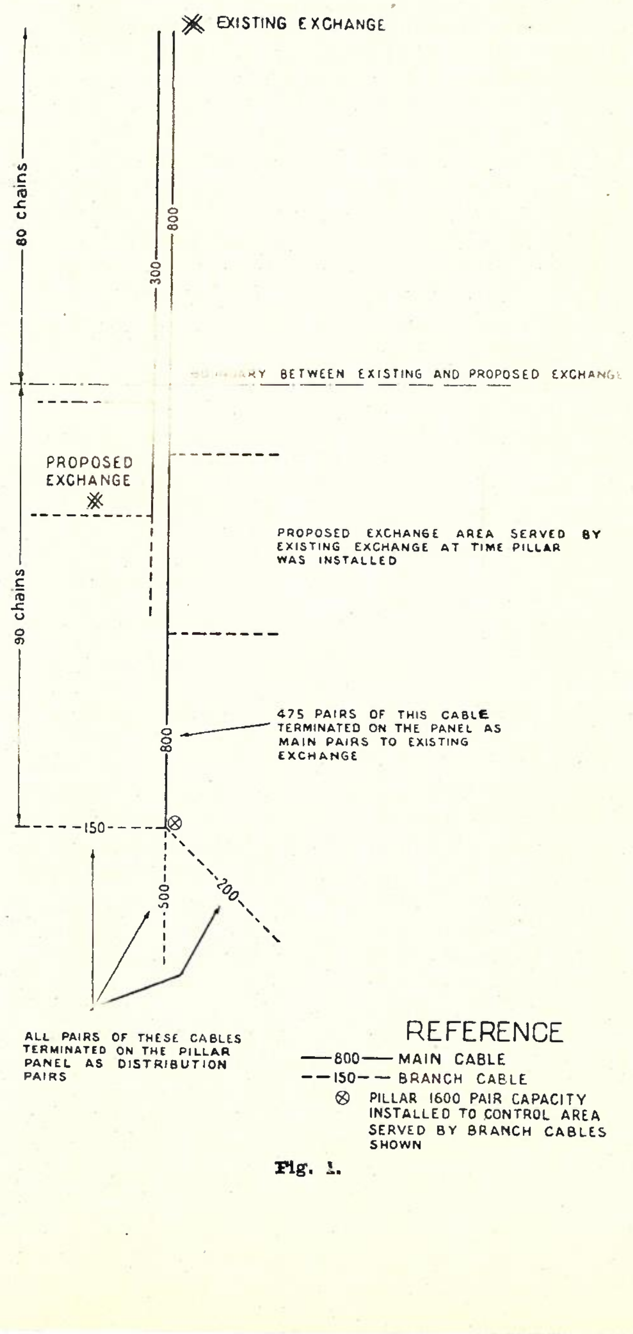


Fig. 1.

Introduction of the Large Outdoor Pillar Terminal.—During 1935 it became apparent that cable plant serving a proposed exchange area in the Sydney telephone network would, within a year or so, become so heavily loaded that, unless additional main cable was laid or some special means of distribution adopted, the area would have to be closed, as the large number of main pairs and working lines involved made it impracticable to resort to ordinary cable alterations to meet the situation pending the initial installation of the exchange.

In figure 1 is shown schematically the relevant particulars of the case. To meet the position it was decided to design and instal a large terminal pillar of 1600 pair capacity to control a good class residential area having a uniform standard of excellent residences where telephones, when once installed, could reasonably be expected to remain in service. The capacity of the pillar panel was sufficient to meet 20-year requirements for both the main and secondary cables. The working lines in the area served by the pillar when installed in June, 1936, were 440, and the main pairs connected to the panel were 475 in number, leaving 625 available for the remainder of the proposed exchange area. It will be noted that the main pairs were deliberately arranged to be 93 per cent. loaded at installation, the purpose being twofold :—

(a) To release as many spare pairs as possible to serve the remainder of the proposed exchange area. Actually 100 were released by the pillar; and
(b) to observe the effect of the large terminal both on the main and secondary side.

During the 12 months following the installation of the pillar 61 lines were connected and 51 lines had become spare, involving the running of 35 new jumpers and transferring of jumpers on 26 occasions, leaving 25 spares at about June, 1937. Thus the large terminal, in this case, had made it possible to provide 61 lines over a period of 12 months without cable alteration of any kind on either the main or secondary cable, the main cable being 93 per cent. loaded when the pillar was installed.

This pillar, for the design and installation of which Mr. Hanly, Engineer of this Department, was responsible, continued to enable new lines and disconnections in the area served by it to be handled without cable alteration until cutover of the proposed exchange in November, 1939, and, by virtue of the main pairs released by the pillar installation, also enabled development to be met in the remainder of the proposed exchange areas until cutover of the new exchange.

The successful achievement of the primary object of this installation, viz., to conserve main pairs by obtaining 100 per cent. access to a large group, led to the installation of further outdoor pillar terminals, which closely follow the original design, the majority of which serve the same primary object, while also being suitable for normal distribution. A few have been installed for normal cable distribution purposes only. At the present time 60 outdoor pillar terminals of sizes varying from 400 pairs to 1800 pairs have been installed in the Sydney network, and examples of cable layouts showing distribution of main pairs via 120 pair pillars and via large type pillars will be given and discussed later.

Design of the Large Outdoor Pillar Terminal.—The complete pillar consists of the following principal sections :—

(a) Vertical angle iron framework with flat iron struts welded to a base plate—see Fig. 2. The vertical angles are 1in. x 1in. x $\frac{1}{8}$in. MS, the top angle $1\frac{1}{2}$in. x $1\frac{1}{2}$in. x $\frac{1}{8}$in. MS. The flats are 1in. x $\frac{1}{4}$in. MS bars and the base consists of a 10 gauge MS sheet with $1\frac{1}{2}$in. x $1\frac{1}{2}$in. x $\frac{1}{4}$in. MS angle welded around its edges. All members are welded where joined. The front face of the angle

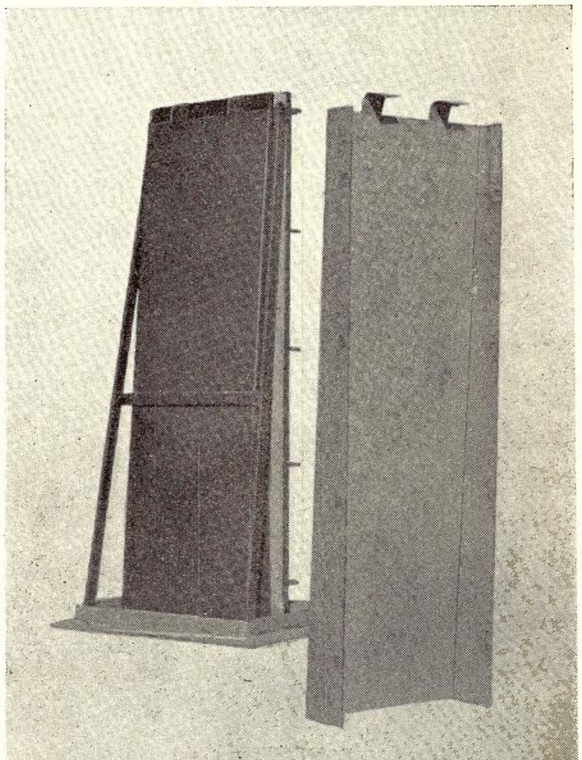


FIG. 2

Fig. 2.—Frame and Sealing Compound Box Assembly.

iron is drilled to take jumper rings holding the ebonite panel. The side face of the angle iron is drilled to take bolts holding the 24 gauge iron sheet which supports the sealing compound. The struts are drilled to take bolts holding flat iron straps which serve to stiffen the iron sheet and withstand pressure from the sealing compound.

The sides of the base are drilled and threaded for the screws which hold the case in position. The base plate and angle iron are drilled for 1½in. lewis bolts which hold it to the concrete base. The base plate is also drilled for tinned brass ferrules through which the cable tails pass and to which the cable sheath is ball wiped. It might be noted that the base is filled with sealing compound to the level of the sides after the cable tails are connected.

(b) 24 gauge iron sheet which retains the sealing compound in position behind the panel. In Fig. 2 the sheet is shown alone and also in position on a panel to which cable tails have been connected. Note the sheet is held in position, in this case, with one stiffening strap across it bolted to each strut. Subsequent to this installation the number of such straps has now been increased to 4.

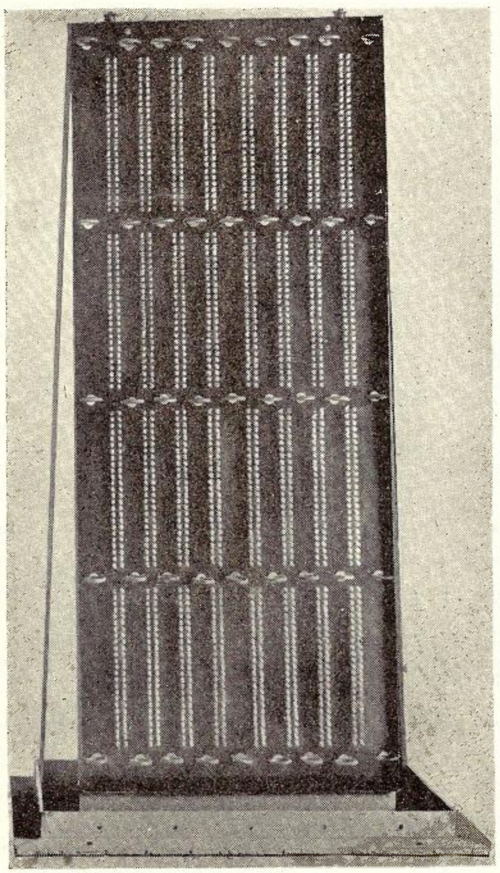


Fig. 3.—Panel Assembly.

(c) Bakelite panel ½in. thick, drilled for jumper rings (portion of which hold it to the angle iron frame), and fitted with tinned brass terminal tags and jumper rings—Fig. 3. The terminal tags, which are the bifurcated type, are fitted in pairs in the same manner as with the 120 pair terminal assembly, except that the cable conductor and jumper terminals of each tag are fitted vertically instead of horizontally. Each vertical on the panel consists of 4 sections of 25 tags each. The height of the large type pillars has been standardised for each vertical strip on the panel to contain 100 tags, in 4 sections of 25 each, and the total capa-

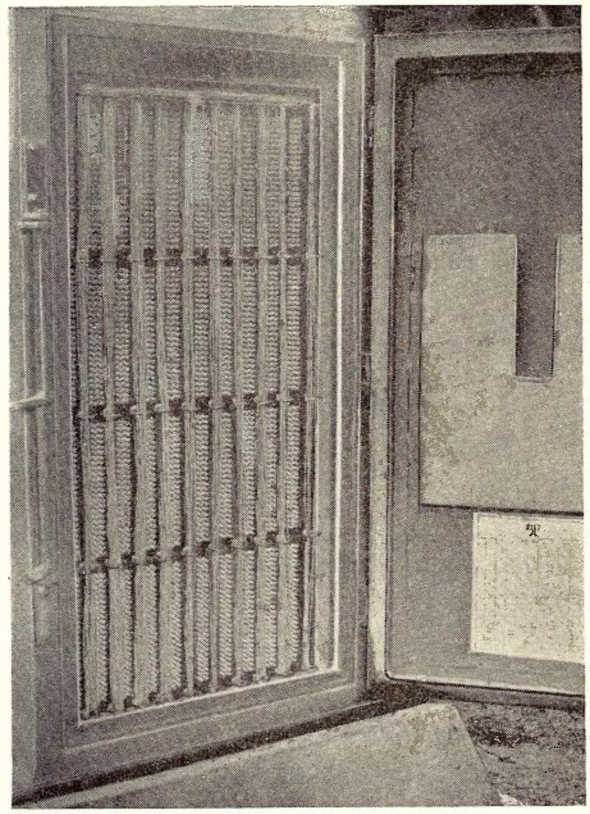


Fig. 4.—Jumpering Arrangement.

city of any terminal is then obtained by providing the necessary number of vertical strips. This height, 3ft. 2⅜in. for the panel and 3ft. 10¼in. for the overall outer dimension of the case, has been found from experience to be a safe and practical one for street use. Jumper rings are fitted as shown. Figure 4 shows a 1000 pair panel with the jumpers for 170 working services in position.

(d) Tinned brass ferrules which bolt to the base plate of the framework.

(e) Outer steel case of 16 gauge MS sheet, with door of 10 gauge MS sheet reinforced with 1in. x 1in. x 3-16in. MS angle iron, fitted with locking device and rubber gasket. After the cable tails are connected and the panel sealed with compound, and the panel jumpered, the case is slipped over the framework and screwed to the base. The locking device levers the door against the rubber gasket with considerable pressure, thus ensuring that the case is quite airtight.

A completed 1000 pair terminal pillar in position in the street is shown in Figure 5. Note the concrete base, sealing compound around steel base, height of pillar and locking device.

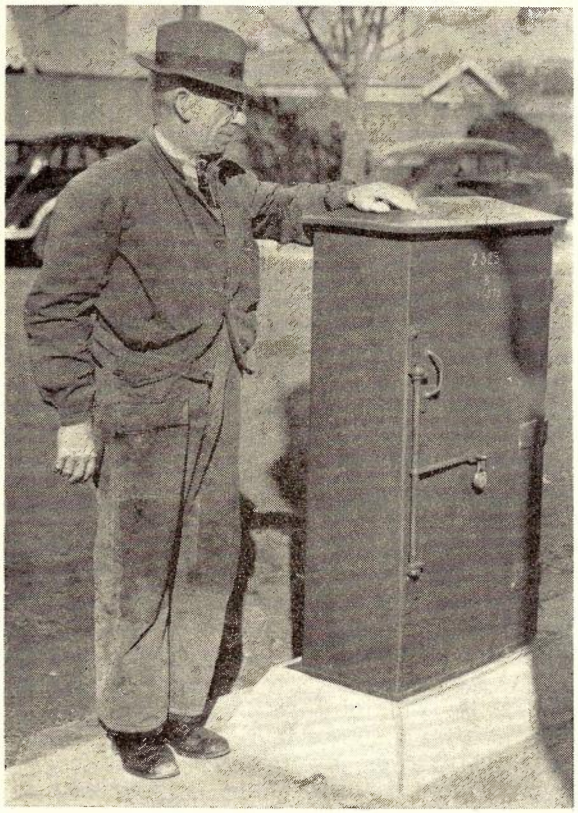


Fig. 5.—Complete Pillar.

The concrete base is sunk about 18in. below ground level and is of an average height of 12in. Of importance is the seal seen round the base of the steel case. The concrete is formed with a rectangular hollow at the top and of sufficient size to take the steel base of the pillar. After seating the pillar base therein, this hollow is filled with compound, thus effectively sealing and protecting the bolts holding the case to the frame.

Method of Installation.—It is assumed that:—

(a) The design for the distribution of main pairs of the cable concerned has been decided upon and the main pairs to be terminated at the pillar have been selected.

(b) The pillar diagram (including the layout of jointing arrangements at the pillar manhole), has been prepared.

The locations for the pillar and for the pillar manhole are first selected. It is preferable to place the pillar close to the building alignment, as this obviously lessens possibility of damage, but it has been necessary to erect several pillars close to the kerb alignment, such cases being generally governed by the fact that the Council concerned has partly concreted the footway with a strip against the building alignment, and the pillar would unnecessarily obstruct pedestrian traffic unless erected near the kerb. The base, in these cases, is placed about 12″ back from the kerb alignment. Thirty-seven large type pillars (including one installed in 1936, and five installed in 1939) have been erected on the kerb alignment and to date no damage has occurred. The Municipal Council concerned is consulted and its agreement obtained to the pillar location, and this has involved negotiation with six Sydney Councils from time to time during the past eight years, and in every case ready assistance and co-operation have been forthcoming from Municipal authorities, and no objection to the installations has been raised, either by Councils or members of the public. The finishing coat of paint is of any colour desired by the Council, but to date the mid-green adopted as a standard has met with general approval. The manhole position is usually fixed by existing construction and the pillar is placed as close as practicable thereto.

For pillars of 600 pair capacity and upwards, a 4′ by 4′ manhole is used to give adequate space for cable handling and jointing work during construction, and to give a finished job of high standard. The manhole is drained and suitably belled to allow for the lay-up of main cables, secondary cables and cable tails from the pillar, care being taken to provide lintel walls above bells with a minimum depth of 12″ so that cable bearers will have walls of sufficient strength to adequately support them. Figure 6 shows a pillar manhole indicating typical belling for main and secondary cables and pillar tails.

Before the jointer proceeds with any jointing work a complete list of every working service in the pillar area is obtained from exchange records together with the main pair used by each.

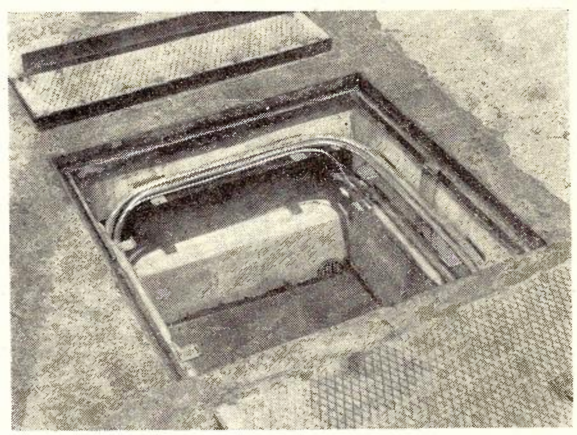


Fig. 6.—Manhole Arrangement.

A list is then prepared in duplicate showing each working service with:—

(a) its existing main pair,
(b) its proposed main pair,
(c) its proposed secondary pair,
(d) location of the service,

the second copy of which is given to the exchange mechanic who is thus made fully aware of the work proposed and what transpositions will be necessary during its progress.

Having determined the pillar and manhole positions and the layout of cables in the manhole, the length of the pillar cable tails are then measured and cut. The pillar frame and panel are then set-up on the bench in the workroom at the line depot and the terminating of the cable tails to the panel proceeded with. The main pairs and secondary pairs are each contained in independent cable tails, and to facilitate jumpering, main pairs and secondary pairs are staggered on the panel.

The cable tails are air-tested, megger-tested and bell-tested, after which they are wiped to the ferrules, and terminating proceeds in accordance with the layout in the same manner as with the 120-pair panel. Before fitting the 24-gauge iron sheet and filling with compound, each cable is again tested, then sealing is completed, care being taken by use of thermometer that the proper temperature is observed when heating and pouring the sealing compound. After the compound has cooled the cable tails are again tested, then sealed.

Before the panel is moved from the bench all jumpers are permanently run and soldered in accordance with the previously-prepared list of working services with their allotted main and secondary pairs.

Note.—The construction of the pillar bench top is of interest. It consists of three sections. The rear section (consider we are facing the panel) is fixed. The centre section, placed so that a space of 4″ is left between it and the rear section, is in two pieces, both removable, and held in position by loose steel pins or bolts. The front section, which butts against the centre section, is removable similarly to the centre section, but is in one piece. The objects are:—

(a) The 4″ space allows one or more 120-pair or large type pillars to be set up with their cable tails dropping through.
(b) After completion of the work of terminating the cable tails to the panels, the centre and front pieces can be removed and the completed pillars with cable tails can be readily removed from the bench.
(c) If both halves of the bench are in use, and it is required to remove a completed pillar from one half only, one half of the centre section together with the front section of the bench top are removed. The required pillar with its cable tails can then be readily taken off without interfering in any way with the other pillar.

The concrete pillar base is then constructed in its selected position in the street. The size is determined by the pillar base, $2\frac{1}{2}$″ extra being provided in length and width. The height usually adopted is 12″. The base is recessed at the top to a depth of about $1\frac{1}{4}$″ to allow the screws holding the case to the base to be enclosed in sealing compound. The base is then formed with a hollow, belled to meet the troughing or split pipes laid between the pillar and the manhole. Each pillar base when constructed has a steel template with it. This template is used to accurately set in position in the concrete base, the bolts which will hold the steel piller base to the concrete base. The completed pillar, with the case screwed in position, is then taken from the workroom at the line depot and bolted to the concrete base, the tails being fed through the belled hollow of the base, along the troughing or pipe and through the manhole bell. After the pillar is fitted, the forming of the base is completed to give a smooth finish and to provide the recess round the pillar into which sealing compound is poured. The width of this recess is 1″.

The jointer then proceeds with the work of cutting over the pillar terminal, having previously arranged with the exchange mechanic regarding transpositions of main pairs for working services where these are being altered by the pillar installation. Usually double jumpers are run on the exchange main frame, in advance of the pillar cutover, for working services whose main pairs are to be transposed, thereby overcoming the necessity for the jointer to wait at any time for jumpers to be run and thus avoiding any delay in the jointing work.

The main and secondary cables and the pillar cable tails are set up in accordance with the manhole layout by the cable jointer, who then places the cable bearers in position and leads them. The cable tails are then identified and tabbed. The main pairs allotted to the pillar are then identified and tested with the exchange and all working lines cut through the pillar (the panel of which has previously been jumpered) on their allotted main and secondary pairs, the spare mains being cut on to the panel in conjunction with this work. The main cable is now finished with so far as the pillar installation is concerned and the main joint is permanently sealed and tested.

The secondary cables, which in practically all cases are working cables, are then dealt with. At every breakdown of the secondary cables, the pillar diagram indicates the joints at which identification is to be done. Starting at such a joint nearest the pillar, the jointer identifies, from the joint at the pillar manhole, the spare secondary pairs, which will be stubbed in such joint, and then seals the joint. This work is continued throughout the pillar area until all manholes or jointing pits containing secondary cable joints, which are to be identified, are dealt with.

The spare pairs of the secondary cables are then jointed through to the panel in the pillar manhole on their relative tabbed pairs in the cable tails of the pillar. The secondary cable joints in the pillar manhole are then permanently sealed and tested.

It is vital in implementing the procedure that suitable instructions are issued to the line staff and more vital that such instructions are understood by the staff and energetically enforced.

Records.—The method of recording cable details of pillars of the larger type is similar in principle to that in general use for the 120-pair pillar.

CABLE No. 4 .... MAIN PAIRS: 1 .. TO 300.				
RISER No	SUBS. No	MAIN PAIR	PILLAR TERML No	LOCATION.
0201	JA 4872	201	401	34 ADELAIDE ST.
0202			402	STUB 0 PIT IN 30 ADELAIDE ST
0203	JA 7028	203	403	30 ADELAIDE ST.
0204	JA 2034	204	404	28 ADELAIDE ST.
0205	JA 1266	206	405	26 ADELAIDE ST.
0206			406	STUB 0 PIT IN 22 ADELAIDE ST.
0207	JA 2468	207	407	22 ADELAIDE ST.
0208			408	STUB 0 PIT IN 18 ADELAIDE ST
0209	~~JA 1283~~	209	409 DISC 10-7-43.	18 ADELAIDE ST.
0210	JA 3458	210	410	16 ADELAIDE ST.
0211	JA 1238	211	411	14 ADELAIDE ST.
0212			412	STUB 0 PIT IN 10 ADELAIDE ST.
0213	JA 3842	213	413	10 ADELAIDE ST.
0214			414	STUB END 15 PR 14 ADELAIDE ST.
0215			415	STUB END 15 PR 14 ADELAIDE ST
0216	JA 1355	215	416	2 ADELAIDE ST.

Fig. 7.—Part of Pillar Record Plan.

Figure 7 shows part of a typical pillar card giving particulars of secondary pairs for a pillar layout of the larger type. It will be noted that the locations of every pair are shown, whether working or spare, to facilitate its location on the pillar plan. Where an aerial pole head is associated with the secondary cables, the pairs terminating at that head are clearly indicated. As the installation of the pillar may cover a lengthy period it is necessary for the jointer to be kept informed of connections and disconnections during progress, and this is best effected by collaboration between the jointer and the statistical officer at the Line Depot, the latter giving weekly advice to the jointer of such alterations and additions. A similar card is also kept giving particulars of main pairs for a pillar layout of the larger type. This record may appear to be unnecessary as it largely duplicates the cable recorder's details of main pairs. On the other hand it is prepared only once, and takes comparatively little time to make, and is found in practice to be of invaluable aid in quickly tracing the location of faults in secondary cables, as the exchange report gives main pairs only affected. This card can be held and kept up to date by the Statistical Officer at the Line Depot and is, therefore, available on immediate demand by the area foreman who can, without waste of time, directly determine the secondary pairs associated with the main pairs affected, and thereby locate the section of the secondary cables in which the fault exists. When a disconnection occurs, the pillar panel jumpers associated with the service are not disturbed and the pillar cards are marked in the manner indicated, i.e., a pencil line is drawn through the subscriber's exchange number and the pairs made spare are marked "dis" in pencil. If the same residence requires a service later, the pillar cards indicate that a jumper is in situ at the pillar and that a test through from residence to exchange only is required. After re-connection the new exchange number is inserted on the cards and the "dis" notations erased.

In addition to the pillar record cards, there is a cabling diagram showing the reticulation of the area controlled by the pillar. This follows the normal practice adopted for the preparation of pillar plans for 120 pair pillars, the chief difference being that the cable sizes and the area controlled are larger.

(To be Continued)

(Editor's Note.—In the second part of this article the Author will discuss the use of large pillars and will indicate his views on the advantages to be obtained therefrom.)

R.A.X. INSTALLATIONS

F. H. Morgan

This article deals with the following aspects of Rural Automatic Exchanges :—

(1) The main factors that are considered when a proposal is submitted for the installation of an R.A.X.
(2) Sites and Buildings. Arrangements of equipment of various types and capacities, together with some general features.
(3) General features of the equipment.
(4) Recent developments in wind-driven power plant.

Rural Automatic Exchanges are usually installed to improve the service given by small manually operated magneto exchanges in country districts. Sometimes, however, an area developing away from the nearest exchange is best served by an R.A.X. as a new exchange, as it is economical both to the Department and the subscribers concerned. There have been other instances where R.A.X. installations have been provided to overcome the difficulty of obtaining suitable staff to manage the existing exchange.

The type of equipment replaced by an R.A.X. is the non-multiple magneto type of switchboard usually installed in the premises associated with the local store or in a private house, except when the town is large enough to justify an official office. The operating costs of small magneto exchanges are relatively high compared with the amount of business transacted. To meet this it is normal to give restricted hours of service, based on the revenue. However, the following figures could be regarded as average for the hours of service with respect to the number of subscribers :—

Up to 25 Subs.	9 a.m. - 6 p.m.
25 - 35 Subs.	9 a.m. - 8 p.m.
35 - 45 Subs.	8 a.m. - 10 p.m.
45 Subs. and Over	Continuous

Individual cases may differ considerably from these average figures.

Restricted hours of service have resulted in many requests to the Department for a continuous service or an extension of the existing hours. These requests are understandable, as two of the main advantages of the telephone, particularly to country subscribers, are its usefulness in times of emergency and during leisure hours. The installation of an R.A.X. solves the problem regarding a continuous service, and also provides for secrecy for local calls, which is a further definite advantage for both business and private considerations.

Despite these advantages the economics of any proposed R.A.X. installation must be considered, and in all conversions so far carried out the economics have been a vital factor. A comparison is made of the annual charges of the existing magneto installation compared with the proposed R.A.X. installation. The items considered are :—

(a) Maintenance costs.
(b) Interest on Capital.
(c) Depreciation.
(d) Sinking Fund to cover equipment to be replaced.
(e) Savings, e.g., Operating costs.

As the result of the examination of the annual charges for a number of exchanges of various sizes, it has been found that the lower economic limit in average conditions is in the vicinity of 20 lines. In some cases R.A.X.'s have been installed in places where there were less than 20 subscribers on account of special considerations, such as difficulty in finding suitable staff to conduct the office, but in such cases it is often found that the theoretical loss does not occur because, as a result of the improved service provided by the R.A.X. the revenue increases due to new subscribers and a higher calling rate.

From a number of cases considered, the average annual savings that might be anticipated by replacing magneto exchanges with R.A.X. equipment are :—

25 Subs.	30 Subs.	35 Subs.	40 Subs.	70 Subs.
£20	£35	£40	£45	£100

These figures only serve as a guide, as the savings that might be effected in any individual case depend on a number of factors regarding the facilities available, e.g.: power supply, suitable site, condition and adequacy of existing line plant (particularly trunk line). Besides the economics, there are other aspects which sometimes influence the final decision, such as—

Whether the reduction in allowances would inflict undue hardship on the non-official Postmaster.

Whether the non-official Postmaster is a disabled returned soldier.

Whether the P.M. has recently incurred appreciable expense in improving the office.

Although up to the present the foregoing considerations have been the principal factors in determining where R.A.X. equipment would be provided, it may be necessary to waive either wholly or in part their application to individual cases should post-war national policy require the extension of continuous, automatic service to country subscribers generally.

Sites : In some cases R.A.X.'s are installed in official buildings or on land owned by the Commonwealth, but in most cases it is necessary for a new site to be acquired. The usual dimensions of an R.A.X. site are 20ft. by 20ft., therefore, in farming country the amount of land required for an R.A.X. does not materially affect the usefulness of the adjacent land, nor does it affect its value to any appreciable extent, and in some instances the land required has been made available to the Department free of cost.

Some of the factors to be considered in the selection of a suitable R.A.X. site are :—

(a) Accessibility to cater for the immediate and ultimate needs of the R.A.X. regarding cabling and the handling of equipment.
(b) Cost involved in the diversion of subscribers' and trunk lines to the R.A.X.
(c) Effect on subscribers' rentals.
(d) Drainage.
(e) Proximity of power supply.
(f) Amount of levelling and clearing required.
(g) Fire and flood risks.
(h) Soil formation so far as it may affect building foundations.

Buildings : R.A.X. buildings have been standardised in size, 9ft. x 9ft. is the size for a 50-line R.A.X., and 14ft. x 9ft. for an R.A.X. with an ultimate capacity of 200 lines. The ceiling height is 9ft. The material used in the construction of the walls of the building is determined after considering the following points :—

(a) Initial cost.
(b) Appearance.
(c) Resistance to fire.
(d) Maintenance costs.

The buildings usually have wooden floors built on concrete stumps fitted with a galvanised iron capping as a prevention against the possibility of attack on the floor bearers by termites.

Many of the early R.A.X. buildings had walls of corrugated galvanised iron, but a number of the more recently constructed buildings have walls of "Weathered" iron (painted) or asbestos cement sheets, both of which provide a good appearance at a reasonable cost. In northern areas asbestos cement is favoured on account of its heat-resisting qualities, and it is preferred for seaside places as it does not suffer any ill-effects from the sea air. One disadvantage of asbestos cement is its liability to damage by straying cattle, but this can be easily prevented by providing fencing comprising posts, top rail, and wire, the entrance having 3 posts spaced 1 foot apart. Another feature of the R.A.X. building is that the battery cupboard is built in as part of the structure. Access to the batteries can be gained by the removal of wooden shutters, and there is an adequate system of ventilation to keep battery fumes out of the building. It might be mentioned here that every year at about the beginning of the summer season arrangements are made for the land around and under the building to be cleared of anything that may become a fire risk during the bush fire period.

Arrangement of Equipment : There are two types of units :—

(i) Exchanges where it is estimated the ultimate number of lines will not exceed fifty (50).
(ii) Exchanges where it is estimated the ultimate number of lines will not exceed two hundred (200).

For the former class exchanges, the equipment is contained in one enclosed unit, and is classified as a Type "B" Unit, which is not extensible beyond 50 lines capacity. This unit is complete so far as the automatic equipment is concerned, and the only other apparatus required for the installation is a Main Frame, a battery, and some means of charging the battery. For the latter class exchanges the equipment, which is designed to cater for an ultimate capacity of 200 lines, is built up with 50-line units plus, in the case of the Siemens equipment, an additional unit known as the Common Apparatus Rack (C.A.R.). The first 50-line unit is classified as a "C" Type Unit, and the subsequent Units as "D1," "D2," and "D3," respectively. Although the rack capacity of each unit caters for 50 lines, the units are equipped only with the approximate number of line equipments required, which are arranged in four or five circuits per base, accoding to the manufacturer's method.

General Features : With the exception of a few early experimental units, the R.A.X. equipment at present in use has been developed to the Department's specification by British telephone manufacturers. Four firms have supplied equipment, namely, Automatic Telephone Manufacturing Company, British General Electric Company, Siemens Bros. Ltd., and Standard Telephones and Cables Company. Each manufacturer's equipment provides similar facilities, and, in general, comprises line circuits on which the subscribers and junction lines terminate, connecting circuits comprising a line finder linked to a final selector for establishing connections between subscribers or between subscribers and trunk lines, allotters for associating a connecting circuit with a calling subscriber's line, and common circuits such as ringing tone and alarm equipment.

The switching arrangements employed are of two distinct kinds. A.T.M. and B.G.E. use the step by step method of setting up connections, i.e., when the calling line is found the final selector is operated direct from the calling subscriber's dial, the testing, ringing, and metering equipment being incorporated in the final selector as in standard Strowger practice. Siemens and S.T.C. systems employ special common control equipment of the mechanical operator type, which is associated with a connecting circuit only during the setting up of the call, being freed for use with other connecting circuits as soon as the called subscriber answers. This equipment accepts the dialled impulse, operates the final selector to locate the called line which it tests, and, if clear, applies ringing current and when the subscriber answers, registers the call against the calling subscriber then disengages itself from the connecting circuit. The latter method is designed to simplify the connecting circuits, of which there are usually 6 for each 50 subscribers, by concentrating the common equipment in one or two common groups; thereby reducing the total amount of equipment required. A fuller description of the equipment was published in Vol. 2, No. 2, page 70, of the Journal.

Numbering Scheme: The R.A.X.'s that are not extensible beyond 50 lines' capacity use 2 digits for subscribers' call numbers, whilst a 3-digit system is employed for installations that have an ultimate capacity of 200 lines. An additional digit is introduced when it is necessary to provide "Code Ringing" for calling intermediate stations on multi-office trunk lines and for ringing an individual party connected to a party line.

Power Supply : R.A.X. equipment is operated by secondary batteries, with a normal voltage of 48 volts, but the equipment will operate satisfactorily over a relatively wide range in battery voltage variation, viz., 43 to 60 volts.

Battery Charging Arrangements : At places where a suitable commercial power supply is available, experience has shown that the most satisfactory and economical method of charging R.A.X. batteries is by means of an automatically controlled floating transrector or rectifier, but when a local power supply is not available one of the following methods is adopted :—

(a) Charging over trunk line from the parent or other exchange.
(b) Servicing of batteries from Mechanic's head station or most convenient charging source.
(c) Using a petrol electric charging set at R.A.X.
(d) Using a wind driven generator at the R.A.X.

Method (a) has the objections that it tends to cause electrolytic troubles in the cable distribution system and adds circuit complications which result in additional maintenance.

For method (b) duplicate sets of 8-six volt car batteries are used; the discharged battery is taken by the Mechanic to the charging source, while the other set is carrying the R.A.X. load. By providing suitable clamping connecting lugs and a make before break battery change over switch, the time spent in changing the batteries is reduced to a minimum, and this method is considered satisfactory, except in cases where the distance between the R.A.X. and mechanic's head station is excessive.

Method (c) involves extra building and additional maintenance costs for the engine and generator, and added fire risks. The engine may be started by hand or by dialling from the parent exchange. In the latter case a special circuit available only to the mechanic enables the battery at the R.A.X. to be connected to the generator, which works as a motor to turn over the engine. Simple safeguards are provided to ensure minimum drain on the battery.

Method (d) is the latest attempt to improve the position regarding the charging of R.A.X. batteries where a local power supply is not available. It necessitates the provision of a larger site than 20ft. x 20ft., and is subject to variations in weather conditions. This method is dealt with more fully in a subsequent paragraph.

Ringing Power and Tones : With the B.G.E. and S.T.C. systems ringing current is obtained from a ringing vibrator of the reed type, and is supplied through a ringing transfomer. The standard ringing interruptions are furnished by the suitable stepping of a uniselector. The "Tone" equipment in these installations consists of a high-speed buzzer or relay, which is designed to supply a 400-cycle tone. Owing to the difficulty of maintaining a satisfactory tone, the buzzers have been largely replaced by valve oscillators. In the Siemens Units, ringing current and tones are furnished by a ringing dynamotor, fitted with interrupter drum and cams, and driven from the R.A.X. battery. These machines are of the "Jack In" type, and it is usual for 2 machines to be supplied for each installation.

Registration of Calls : The registration of "Local" calls is automatic and takes place immediately the called subscriber answers. Calls made to the "Parent" exchange are registered against the calling subscriber as soon as a plug is inserted in the answering jack at the "Parent" exchange. If a call made to the "Parent" exchange is ineffective, or is for information or complaint purposes only, this system necessitates the use of a rebate docket in order that the subscriber will not be charged for the call. The standard equipment also provides for code ringing and individual registration of calls on party lines up to 3 parties. Calls made between parties on the same party line are not registered, as they are not chargeable.

Fault Alarm Extension : Provision is made to extend the "Urgent Fault Alarm" to the "Parent" exchange or some other suitable centre. When an urgent fault condition occurs, the alarm equipment causes the ordinary calling signal to be operated at the Manual Exchange. The telephonist answers the call in a normal way, and for a fault alarm call, distinctive tones are heard to acquaint her with the particular type of fault. In some cases the "Non-urgent" alarm is also extended. A Fault Docket is prepared by the telephonist for all alarm signals received, and, in addition, urgent faults are immediately reported by the telephonist to the mechanical staff for urgent attention.

Recent Developments in Wind-driven Battery Charging Plant : One of the chief obstacles to the installation of R.A.X. equipment in many centres is the absence of a suitable source of power. The various methods adopted for

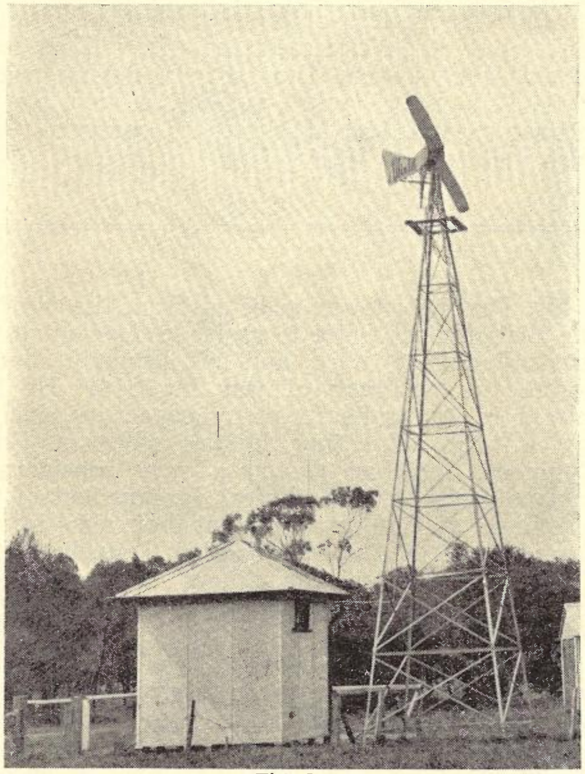


Fig. 1.

supplying power where it is not available locally are outlined briefly above. None of these methods is entirely satisfactory in all cases, and to meet requirements in remote localities a trial is being made of wind-driven generators with the object of proving their suitability for this purpose. During the past 12 months, three trial units have been erected in Victoria, and further installations in other States are contemplated.

To avoid complexity in the equipment and at the same time to obtain the benefits associated with large-scale production for commercial purposes, the type of plant selected for trial is the ordinary house lighting type as produced by Australian manufacturers, modified to give a 50 volt D.C. output instead of the usual 36 volts used for house lighting. The output of the trial units is rated at 250 watts. Two types of wind generators are covered by the trials. In one the output is controlled in the conventional manner by the tail, which turns the propeller out of the wind as the generator reaches its specified maximum output. The tail of this machine is of the single-vane type, and permits considerable hunting to occur due to the effect of the slip stream from the propeller. The other type has a two-bladed propeller of the air foil type, the pitch of which is varied by a centrifugally operated governor to control the output. This governing mechanism comprises a round steel arm fastened to each blade, the arms being housed behind a hardened steel ring on the main shaft and held in position by a strong governing spring and two adjustable nuts. The pitch of the blades depends on the speed of rotation of the propeller, the maximum output being given when the mill reaches a speed equivalent to a wind velocity of 20 miles an hour. The output can, however, be varied by altering the tension of the governing spring by means of the adjustable nuts provided for the purpose. A general view of one of the trial installations of the latter type, showing the 40ft. high steel supporting tower, is shown in Fig. 1. The vee-shaped tail provided with this type is designed to prevent hunting, and has the effect of directing the propeller steadily into the wind. A description of this part of the equipment was published in Vol. 3, No. 2, page 81, of the Telecommunication Journal.

The measured performance figures of the two types of wind-driven generators, previously described, and as recorded at the trial installations by means of a specially developed instantaneous reading anemometer, are :—

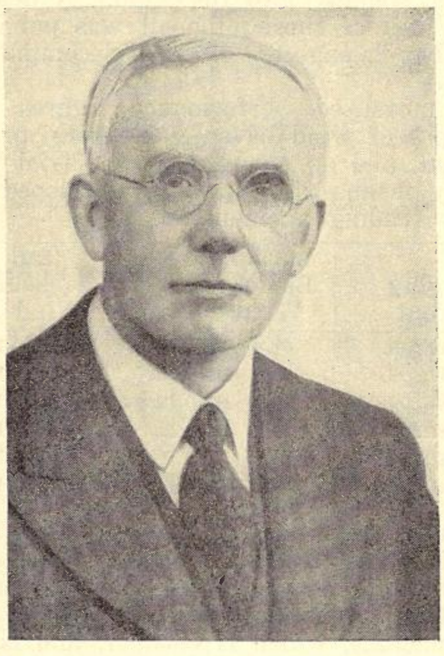
Charging Current	Variable Pitch Blades Machine Wind Speed	Tail Controlled Machine Wind Speed
0.5 amps.	4.5 m.p.h.	7.3 m.p.h.
1.0 amps.	5.4 m.p.h.	8.4 m.p.h.
1.5 amps.	6.0 m.p.h.	8.8 m.p.h.
2.0 amps.	7.2 m.p.h.	10.2 m.p.h.
2.5 amps.	8.4 m.p.h.	10.5 m.p.h.
3.0 amps.	9.6 m.p.h.	11.4 m.p.h.

From the above figures it can be seen that the variable pitch machine performs better with light wind, but experience has demonstrated that good service is also being given by the other machine, which is cheaper, and is located at an R.A.X. where ample wind is available.

In order to take care of periods of light winds or calms, a reserve battery capacity larger than that normally considered necessary is required where wind-driven generators are used. The arrangements adopted for the trial installations comprise two 48-volt motor-car type batteries of approximately 100 ampere hour capacity each. The batteries are arranged in parallel and are connected to the wind generator via a Salford cutout switch. The parallel arrangement has the advantages that it reduces the discharge rate per battery during times of heavy discharge, and also permits the removal of a battery to the mechanics' head station for recharge should this be warranted during periods of low wind velocity. To prevent serious overcharging of the batteries during the periods of high wind velocity and at the same time to obtain the maximum output from the wind generator during relatively calm periods, the field winding of the generator is brought out to a terminal permitting the insertion of a suitable rheostat to control the generator output. Experience in the particular locality should enable a satisfactory setting of the rheostat to ensure that the battery is maintained in a fully charged condition without undue overcharging. In districts where there is a marked seasonal variation in wind velocities, it will be possible by varying the regulator setting to ensure a reasonably constant output from the generator under all conditions. A further refinement contemplated in connection with this feature is the provision of a high-low voltage relay group arranged to cut in and out a portion of the field rheostat automatically controlling the charging rate to the battery. Up-to date insufficient experience is available regarding the results obtained with this arrangement, but it is expected that it will at least considerably extend the periods during which the R.A.X. may be left without a visit by the mechanic, and should therefore materially reduce maintenance charges.

R. N. PARTINGTON

The Postal Electrical Society of Victoria owes much to the sympathetic understanding of its



aims and the appreciation of its work by senior officers of the service, and to none more than to Mr. R. N. Partington, who has recently retired from the position of Deputy Director, Posts and Telegraphs, for the State of Victoria.

Mr. Partington was selected from the staff of the British Post Office to assist in developing the Australian Post Office, and left England shortly before the outbreak of war in 1914. He has served in Australia in many capacities, including a term of acting in the office of Chief Engineer, and has played a very considerable part not only in the technical development of the telephone and telegraph plant but also in the organisation of the Engineering Branch of the P.M.G. Department throughout Australia, and, in latter years, in the wider field of general Post Office administration.

In 1932 Mr. Partington played a prominent part in reviving and reconstituting the Postal Electrical Society, and since then has taken a keen interest in its progress. He was well aware of the advantages to the Department of encouraging and helping officers in the acquisition of greater technical knowledge, and particularly of making available to officers of all grades information to enable them to appreciate and understand the reasons for Departmental practices.

Throughout his career Mr. Partington's outstanding characteristics were his kindly nature, his courtesy and consideration for the feelings of others, and his ability to get to the root of the many problems presented to him. These characteristics made him not only a valuable Departmental officer but a man who won the affection of all with whom he came into contact.

We wish him and Mrs. Partington many happy years together.

AERIAL LINE CONSTRUCTION

A. S. Bundle

Part VIII. (continued).

Staying Ground Anchors

Theoretical Strength : Provided that the soil is uniform over the area concerned it may be assumed that the force required to uplift a buried block is equal to the weight of a prismoid of earth based on the block and in which the sides form an angle with the vertical equal to the natural angle of repose of the soil. See Fig. 93.

The weight,

$$W = d\,w\,(l\,d \tan\theta + {}^4/_3\,d^2 \tan^2\theta + d\,b \tan\theta + lb) \quad \ldots\ldots \quad (39)$$

where d = depth of soil to upper surface of block
w = weight per cubic ft. of soil
l = length of block
θ = natural angle of repose of the soil
b = breadth of block.

If l is nearly equal to b, the weight of the prismoid will be found from:—

$$\frac{d\,w}{3}\,(A_b + A_s + \sqrt{A_b\,A_s}) \quad \ldots\ldots \quad (40)$$

where A_b = area of the upper surface of the block
A_s = area of the prismoid at the surface of the soil

$$= (b + 2\,d \tan\theta)\,(l + 2\,d \tan\theta) \quad \ldots \quad (41)$$

Unless θ and w are known they may be taken safely as 30° and 100 lbs./cu. ft. respectively.

In actual practice this condition would only apply where the soil has all been excavated and backfilled after the stay block or plate was installed. There is usually a considerable difference between the behaviour and resistance of virgin soil and disturbed soil. In practical staying, as far as possible, advantage is taken of the added strength of the virgin soil; and much of the strength of the anchor depends upon the nature of the soil, the shape of the block and the shape of the hole that is dug, so that precise calculation is difficult. This aspect will be touched upon in later paragraphs dealing with the different forms of ground anchors.

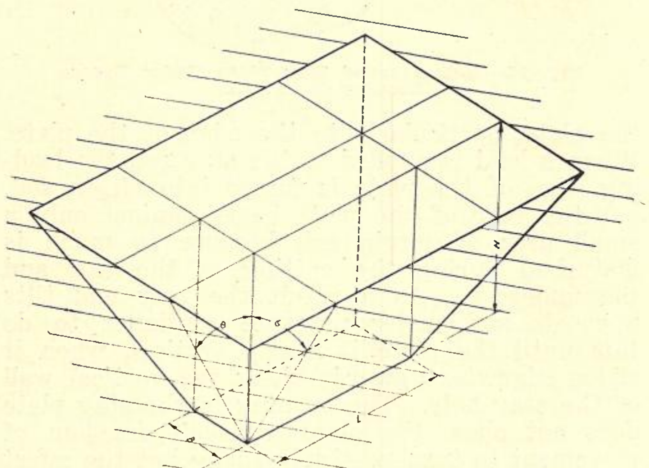
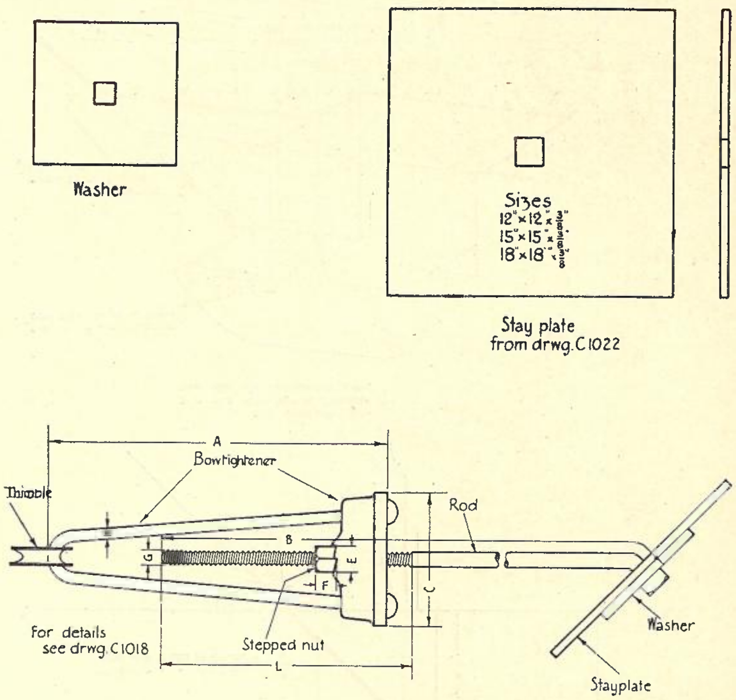


Fig. 93.—Theoretical Soil Load Opposing Uplift on Stay Block of Area l × b and Depth h.



Stay rod	A	B	C	E	F	G	H	L	washer	washer hole	weight of bowtightener approx.	Tensile strength of rod complete.
5/8"×6'0"	1'4"	6'0"	5 1/4"	1"	11/16"	5/8 D	1/2"	1'0"	4"×4"×1/4"	3/4" Sq.	36 1/2 Ozs.	12,300 lbs.
3/4"×8'0"	1'4"	8'0"	6 1/2"	1 1/4"	7/8"	3/4 D	9/16"	1'0"	6"×6"×5/16"	7/8" Sq.	63 Ozs.	19,300 lbs.
1"×8'0"	1'5"	8'0"	7"	1 11/16"	1 1/16"	1 D	3/4"	1'0"	6"×6"×5/16"	1 1/8" Sq.	93 Ozs.	32,500 lbs.

Fig. 94.—Present Standard Form of Stay Rod Used in Australian Post Office (shown with stay plate assembled).

Stay Rods : The standard forms of stay rods used in the Australian Post Office are illustrated in Fig. 94. The rods are made from mild steel — except for the crosshead in the bow which is cast iron—and are galvanised. The strength of the rods is least at the trough of the screw thread, and on this basis the breaking loads may be taken as:—

6 ft. x 5/8 in. diam. rod	....	12,300 lb.
8 ft. x 3/4 in. diam. rod	....	19,300 lb.
8 ft. x 1 in. diam rod	....	32,500 lb.

For estimating working loads a factor of safety of 3 to 4 on the breaking load is considered advisable in view of the liability to corrosion.

The lower end of the rod is bent through 45 deg. to permit of the installation of the rod at an angle of 45 deg. to the ground when attached to a steel stay plate which is installed horizontally.

The stay plates are made from ⅜ in. mild steel and are stocked in three sizes, viz.: 12 in. x 12 in., 15 in. x 15 in., and 18 in. x 18 in.

Installation of Stay Rods and Plates: The object of using a square plate is to obtain the maximum surface area with a minimum both of excavation and of disturbed soil in the area affected by the upward thrust of the plate. The installation of the plate is very important, however, and requires considerable care. The plate is installed horizontally and not at right angles to the stay rod as might at first be expected. The stepped stay hole (see Fig 95) is made as narrow as practicable and the plate installed at the end nearest the pole. In this way the minimum of soil is disturbed in the critical area which will be affected by the pressure of the plate. The width of the hole must be shoulder-width for the lineman to permit of working in it, particularly when making the undercut. The use of a stepped hole provides shovel and working space with minimum excavation. It is necessary to cut a slot to allow the stay rod to assemble in line between the stay plate and the point of attachment to the pole. The slot must be cut carefully and the rod tried in position and lined up to ensure that it will settle in line with the stay wire and not have to cut its way into position when the load is applied and thereby allow the head of the pole to move in the direction of the load. The cutting of this slot tends to break the soil away at the end of the hole, and it is best therefore to take this slot down as the hole is excavated.

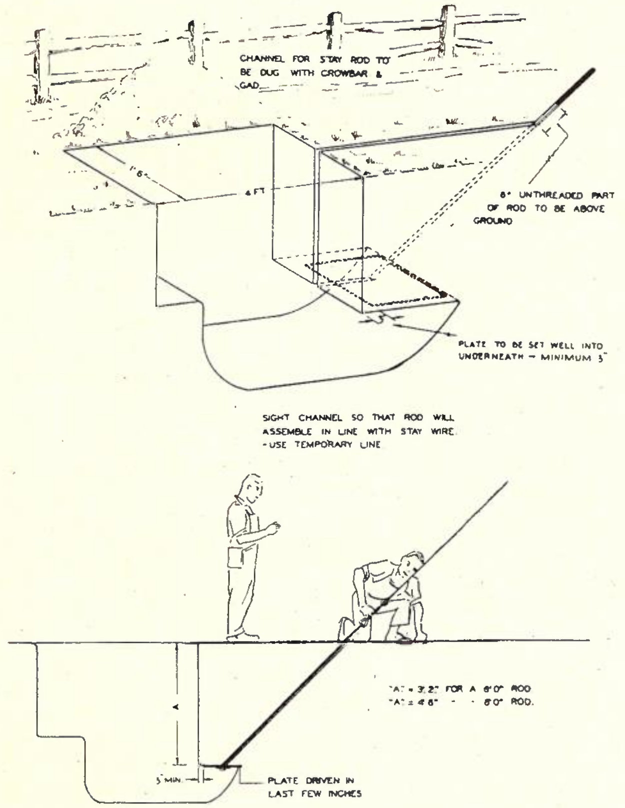


Fig. 95.—Installation of Standard Ground Anchor.

The undercut is made last and requires considerable care to prevent the soil falling away near the slot. The undercut must be made at least 3 in. longer than the depth of the plate and might well be still longer. This long undercut is the difficult part of the installation but is particularly important. At this stage it is advisable to describe the behaviour of a plate installed horizontally in stiff clayey soil without proper care in installation.

The virgin soil is stiff and resistant but the back-filled soil offers very little opposition to

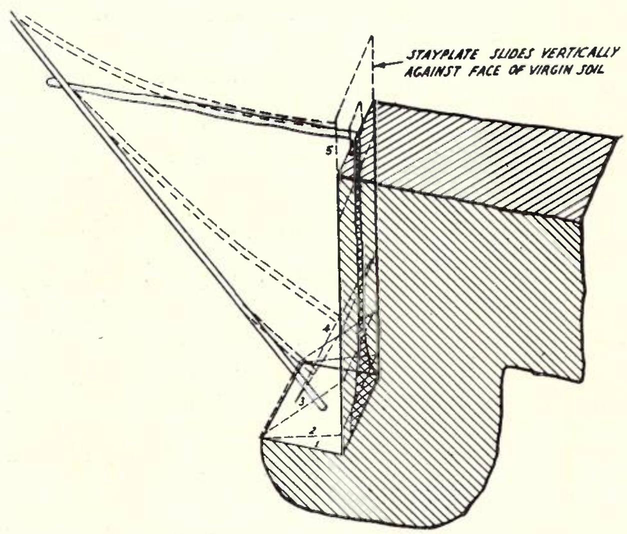


Fig. 96.—Behaviour of Stay Plate Under Excess Loading Conditions.

the plate, particularly to the edge of the plate. When a load is applied to the stay rod the leading edge of the plate is forced into virgin soil, but the rear of the plate bears against only a small area of virgin soil because so much is disturbed during the cutting of the slot and the undercut. As a result the rear end tilts upwards and under pressure continues to do this until the plate is nearly vertical, when it slides edgewise upwards along the vertical wall of the stay hole. The opening in the stay plate does not allow the plate sufficient freedom of movement to turn vertically easily but the effect described is so pronounced that the stay rod itself becomes permanently bent in the process. The writer has observed several dozen stays pulled beyond their capacity, and except in the case of very light sand the effect has been as described, the stay plate coming out of the ground turned vertically and with the stay rod bent. (See Fig. 96.) Obviously if the stay plate is set at right angles to the rod—as would at first appear to be preferable—then the plate will turn vertically more readily and leave the ground under less loading. If, however, the plate is installed horizontally and the undercut made longer than the plate and care taken to disturb as little as possible of the virgin soil at the corners formed between the slot and the vertical face and the undercut, then the plate will give the strength value equivalent to its bearing area against the soil.

Stay Logs and Blocks: Prior to the introduction of the steel stay plate, wood logs were used. Their installation, however, required a considerably larger stay hole and consequently more time to instal. Moreover, there were cases occurring of stay rods becoming corroded by the acids in the wood, while in other cases the wood decayed and allowed the rod and washer to pull out. The steel stay plate was adopted to reduce the excavation necessary and provide a simple and neat item which was easily stored. In salty soils, however, there is a galvanic effect in which the damp salty soil acts as an electrolyte with the upper end of the zinc-covered stay rod as one pole and the black steel stay plate as the other; the resulting galvanic action causes a reduction of the cross-sectional area of the stay rod at various points, usually about 12 in. to 18 in. below ground level. There is also a greater tendency with a steel plate for some initial movement in the stay under load, until the plate settles against firm soil.

In the British P.O. creosoted wooden stay blocks are used. These are 10 in. x 5 in. cross-section and are in three sizes, "Light," "Medium" and "Heavy," being respectively 2 ft., 2 ft. 10 in. and 3 ft. 6 in. long. Having regard for the features mentioned in the previous paragraphs, it is possible that a somewhat similar block will be adopted in Australia.

Trials of reinforced concrete blocks have shown that they must be very heavy to give adequate strength and are then very awkward to instal. Moreover, considerable care is necessary in mixing and working the concrete and this work could not safely be left to the various individual workmen in local line depots unless a very large safety factor were provided for in the design, while to concentrate the work at central depots would involve high freight costs.

To protect the stay rods against the galvanic effect mentioned or the effects of corrosive agents in the soil, various methods have been tried but the most effective so far is that illustrated in Fig. 97. The lower end of the stay rod and the stay rod washer are dipped into heated coal tar pitch which must be obtained from horizontal retorts and is stocked under the title of "Compound, Sealing Cable Box." The stay plate is then assembled over the rod and washer, followed by a special porcelain stay rod ferrule which in turn is followed by a piece of $1\frac{1}{2}$ in. G.I. pipe. The rod with this additional assembly is then set into the hole and the soil filled in to a point several inches above the undercut and rammed. The heated coal tar pitch is then poured into the G.I. pipe so as to completely fill it, and the second porcelain ferrule is slipped into place, to hold the rod in the centre of the tubing: there is some contrac-

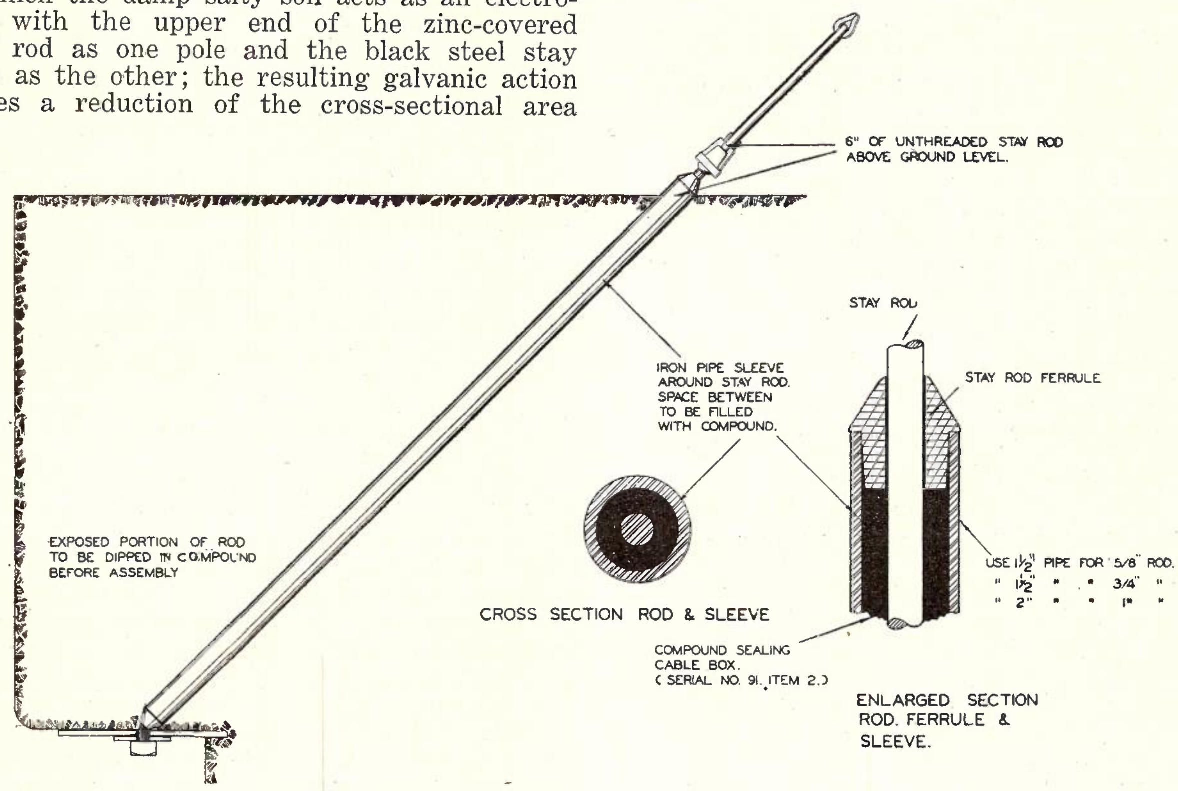


Fig. 97.—Protection for Stay Rod in Corrosive Ground.

tion of the pitch as it cools and a degree of "topping up" is necessary before the upper ferrule is fitted. The rest of the soil can then be filled in and rammed when the pitch is cooled. The rod is thus insulated from the salty soil (if present) and is protected from the corrosive agents which may be in the soil, first by the walls of the tubing and then by the layer of pitch. The treatment is rather expensive and is justified only if previous trouble has been experienced or there is evidence present of the corrosive nature of the soil.

Patent Anchors: Several forms of anchors have been developed which can be installed in the ground without requiring the extensive excavation that is necessary for the usual stay blocks, logs or plates. These anchors reduce labour costs and also reduce the degree of disturbance to the virgin soil. The satisfactory and economical use of patent anchors depends upon selection of the correct type for the particular circumstances.

Screw Anchors: These consist of a long rod with a helical-shaped plate (usually cast iron or cast steel) at one end. As this plate is turned, it cuts its way into the soil, disturbing only a helical channel about a central hole, the latter being formed by the boss of the plate and creating a channel for the rod to pass into the ground. The form of screw anchor used in the Australian P.O. is shown in Fig. 98. It will be seen that the rod and anchor plate are separate units which can be assembled for installation; a special installing key is assembled over the rod and turns the plate, and can be withdrawn when the anchor has been installed. In another form of screw anchor the plate and rod are in one piece; the rod is very stout and is formed into an eye at the upper end. A crowbar is inserted in the eye and is used to turn the rod and plate. In a typical case the plate is 7 in. diam., the rod is 5 ft. long and $1\frac{1}{8}$ in. diam., and the complete unit weighs 30 lb. By comparison, the type shown in Fig. 98, including adjustable bow tightener, weighs 17 lb. with 6 in. diam. plate and $17\frac{3}{4}$ lb. with 8 in. diam. plate.

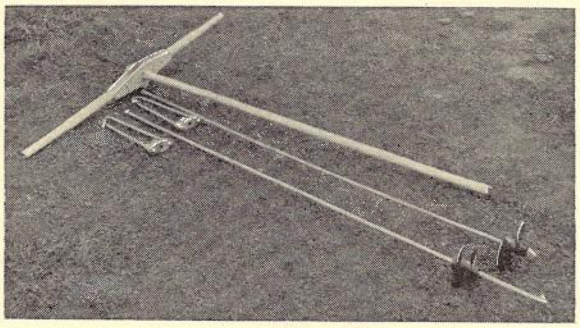


Fig. 98.—Screw Anchors and Installing Key.

Tests with a considerable number of these anchors in various types of soils conducted by the writer gave the following results:—

Type of Anchor	No. of Tests	Average Loading	Estimated Safe Loading
6″ diam. screw anchor	18	5240 lbs.	1745 lbs.
8″ diam. screw anchor	22	6400 lbs.	2130 lbs.

Nineteen tests carried out concurrently with the above tests on 12 in. x 12 in. stay plates in the same areas as the screw anchors showed that the average loading was 5600 lb. from which a safe loading of 1857 lb. is estimated.

Time test for the installation of screw anchors in very hard marle, which was considered the most difficult soil that it would be possible for screw anchors to be used with, gave the following results:—

Test No.	Screw Anchor	Men Std. Key	Std. Key Ext. Handles	Installn. Time Mins.	Total Man Mins.
1	6″	2		15	30
2	6″	2		20	40
3	8″		4	13	52
4	8″		2	22	60
			4	4	

The successful use of these screw anchors requires a degree of practice in their installation. A vertical starting hole of conical shape is reamered in the soil with a crowbar so that the plate can enter the top of the hole (Fig. 99). The initial screwing is made with the rod vertical, but as soon as the plate has obtained a grip in the soil and is 12 in. to 18 in. below the surface the rod is worked over at the required angle during the screwing process and the rest of the screwing is done at this angle. The use of water in the hole greatly assists the work and reduces the effort required for installation. Some persistence is required and a few initial failures should not be allowed to condemn these anchors.

A larger form of these screw anchors is particularly suitable in swampy country. The plate is of the order of 10 in. to 15 in. diam. The rod or shank consists of sections of steel pipe which are threaded each end and provided with screw couplings. The anchor is screwed in with two large pipe wrenches acting on the piping and additional lengths of piping are added until the anchor enters firm soil and cannot be screwed further. This type of anchor has not been used in the Australian P.O.

Expanding Plate Anchors: This form of patent anchor is somewhat more costly and requires a post hole digger which will bore a cylindrical hole along the line which the rod is to take. The anchor is inserted in the hole, and by tamping with a bar on a collar situated about 8 in. from the base, plates are forced laterally out from the anchor into the soil.

These anchors are satisfactory for use in average soil.

Plate Anchors: These consist of a form of plate which is inserted in a hole (about 8 in. diam.) bored at right angles to the stay wire. The stay rod is driven through the soil and the plate guided down the bored hole on to the end of it. When the lower end of the rod passes through the large portion of a key-hole in the plate the latter is forced slightly lower

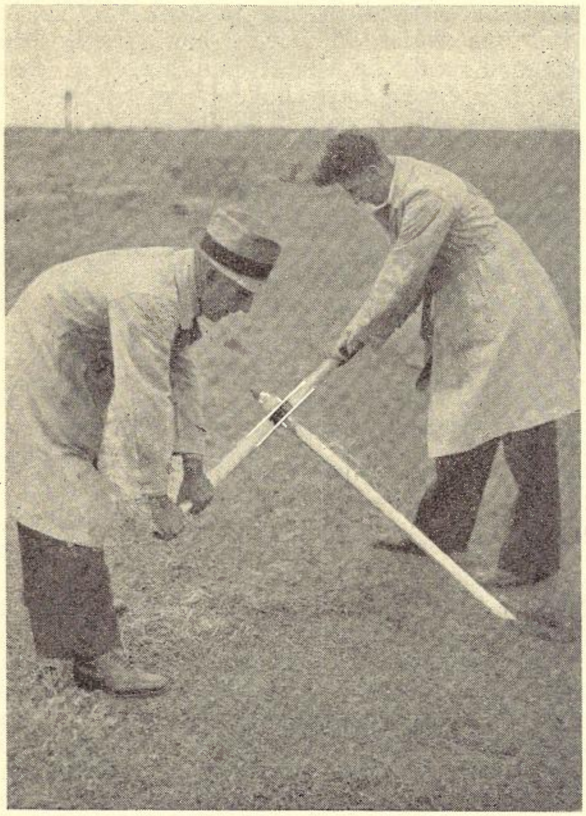


Fig. 99.—Installing Screw Anchor with Ratchet Handle.

so that the enlarged end of the rod cannot pass back through the plate. These anchors are satisfactory in soils which are a mixture of sand and clay but are not generally as economical as the expanding type, requiring at least the same degree of excavation and some care and skill and time in lining up and assembling the rod and plate.

Cone Type Anchors: These require a cylindrical hole of 6in., 8in. or 12in. diam. bored along the line of the stay rod. The anchor consists of a rod to the lower end of which is attached a metal cone with a base of 6in., 8in. or 10in., and of similar height, pointing upwards. The anchor is inserted in the hole and stones about 1½in. diam. are filled in the hole to a distance of about 1ft., being inserted in small lots and well rammed. The hole is then carefully filled with soil which is thoroughly rammed. Such anchors are economical only where suitable small stones are readily available.

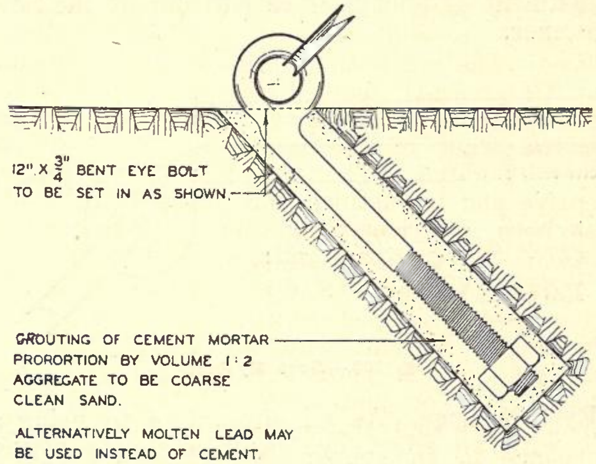
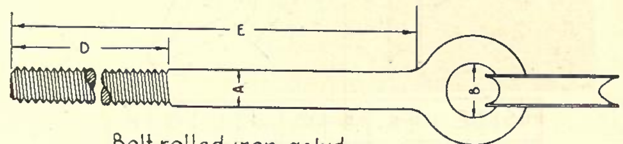


Fig. 100.—Ground Stay in Rock.

Ground Anchors in Rock: Except where the rock is completely solid it is advisable to dig or blast a hole and instal a ground anchor as previously described. Where the rock is solid a hole should be drilled at right angles to the stay and an eyebolt or stayrod inserted and the cavity filled in either with cement grounding or molten lead, Fig. 100. In very hard rock an eyebolt of minimum length 12in. is advisable while in softer rock a stayrod should be inserted in a longer hole (of the order of 2ft. 6in.), and bent at right angles so that the rest of the rod assembles along the line of the stay.



Bolt rolled iron galvd

A	B	D	Thread
5/8"	15/16"	6"	11 to 1"
3/4"	1 1/8"	6"	10 to 1"
1"	1 1/2"	6"	8 to 1"

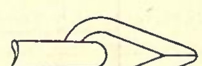


Fig. 101.—Straight Eyebolt.

Stay Attachments.

Eyebolts. Of recent years the usual form of attachment for stays to wood or steel beams or rail poles has been the eyebolt. If the wire is approximately at right angles to the axis of the pole (as is usually the case with headstays) straight eyebolts (Fig. 101) are used. By allowing for extra threaded length at each bolt adjustment of tension is provided. A "bent" eyebolt (Fig. 102) in which the "eye" is offset 45 degrees to the axis of the bolt, is used for attaching groundstays which are usually at an angle of between 30 degrees and

60 degrees to the axis of the pole. In this case the eye is bedded firmly against the pole and adjustment of tension is carried out at the bow tightener.

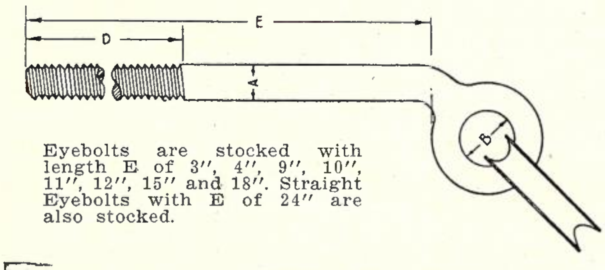
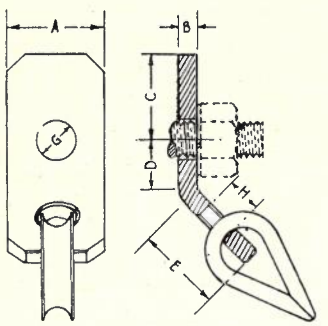


Fig. 102.—Bent Eyebolt.

Eyebolt Lugs. As an alternative to using a bolt with an offset eye in it a simple fitting shown in Fig. 103 is used. This fitting may be used at the nut end of an eyebolt where two stays are to be attached on opposite sides of a pole, or one or two of them may be used with an ordinary bolt. On prices ruling during the past few years the eyebolt lug and ordinary bolt is cheaper than the eyebolt, and it seems likely that the eyebolt will be superseded.



SIZE	A	B	C	D	E	G	H
1"	2½"	½"	2"	1¼"	2"	1 1/16"	7/8"
3/4"	2	3/8"	1¾"	1	1¾"	13/16"	11/16"
5/8"	1¾"	3/8"	1½"	7/8"	1½"	11/16"	9/16"

Fig. 103.—Eyebolt Lug.

Stay Bolt Shackle. To obtain an equivalent substitute for straight eyebolts a shackle fitting has recently been developed and will probably be put into use in the near future.

Check Bars. Where suitable eyebolts or eyebolt lugs and bolts are not available, the stay wire may be wrapped twice around the pole and then made off about itself. In this case the centre of the "eye" formed by the stay wire is at the highest point on the pole, and is on the same side of the pole as the stay; the wires cross behind the pole and come together to form the neck of the loop on the same side of the pole as the stay wire. It is necessary to prevent the wire slipping down the pole and thus allowing the pole to move over to the load; this is achieved by using a "check bar" of ½in. diam. mild steel rod either driven into the pole immediately below the centre of the top of the loop and in line with the stay, or through the centre of the pole at right angles to the stay and projecting each side immediately under the wires as they leave the pole to form the neck of the loop. The latter method is the one covered in the present engineering instructions which, however, has largely been superseded, and the writer has heard of cases where the check bars have been sheared off on each side of the pole under excessive loading.

Stay Wire.

Characteristics. The form of stay wire used in Australia consists of seven strands of Galvanised steel wire with a tensile strength of approximately 60 tons per sq. in. of cross section. Six gauges of wire are stocked, viz.:

Common Title	No. of Strands	Gauge of Each Wire	Diam. of Each Wire	Total Wt. per Yd.	Total Breaking Load
7/10	7	10 S.W.G.	0.128 in.	0.980 lbs.	13,070 lbs.
7/12	7	12 ,,	0.104 ,,	0.635 ,,	9,100 ,,
7/14	7	14 ,,	0.080 ,,	0.375 ,,	5,156 ,,
7/16	7	16 ,,	0.064 ,,	0.242 ,,	3,710 ,,
7/18	7	18 ,,	0.048 ,,	0.136 ,,	2,100 ,,
7/20	7	20 ,,	0.036 ,,	0.076 ,,	1,190 ,,

Making-Off. Apart from the method used to hold the wire to a stay fitting a thimble (Fig. 101) is necessary to prevent the wire chafing against the fitting. There is usually some degree of movement between the staywire and the attachment, and this over a long period is sufficient first to wear away the galvanising and perhaps permit rusting or else to continue wearing the comparatively small steel wire strands which then part, one at a time. Great care should therefore be taken to ensure that a metal plate (in the form of a thimble) is available to bear against the attachment and to move freely with the wire.

The stay wire is usually secured to attachments by binding the unstranded ends of it about itself in the manner illustrated in Fig. 104. An alternative method is sometimes used in which after the requisite number of turns has been made with a single strand, the end is laid along the strand and wrapped in the following wire as it is bound around, thereby locating the end and preventing any tendency to unravel. Tests have shown, however, that the binding used in the former method has adequate strength and the wires will break elsewhere under excess loading. The former method, if done properly, is somewhat neater and takes slightly less time.

A third method is by cramping the end and the main strand together between a form of U-bolt and cross-piece otherwise referred to as "Bull dog clips" or "Crosby clips." These fittings are designed for use with wire rope and do not function as satisfactorily with the stiffer and

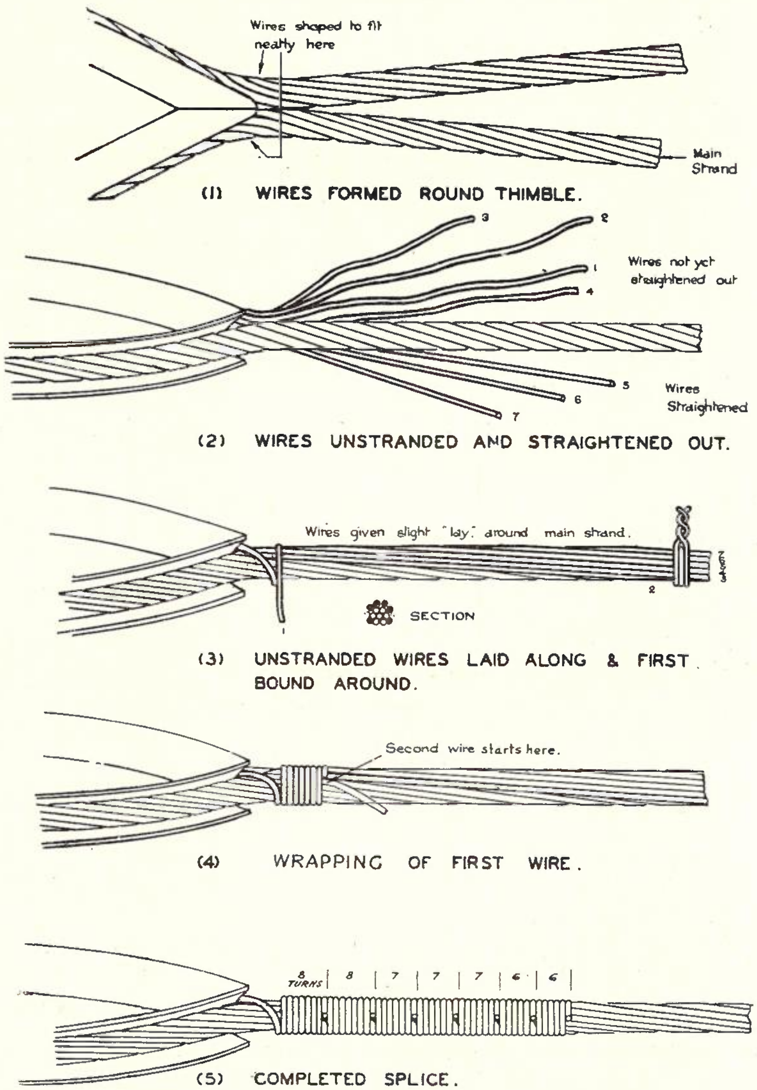


Fig. 104.—Making Off 7-Strand Wire.

stouter strands of stay wire which cannot be jammed together so well. Consequently 3 or 4 such clips are needed to make off each end, and their cost and time of fitting do not justify any change from the previous method.

In the U.S.A. the usual method of attaching a stay wire to a fitting is by means of a "Guy wire clamp." This clamp (see Fig. 105) securely holds the main strand and the end of the bight after passing through or round the fixture. By pulling the end with a suitable wire grip, releasing the nuts on the clamp, and then tightening after any slack has been taken up, a means of adjustment is provided which dispenses with need for bow tighteners or other special devices. Normally one 3-bolt clamp would be provided but on the heaviest wire (slightly stronger than our 7/10) two such clamps would be used.

Several forms of patent fitting have also

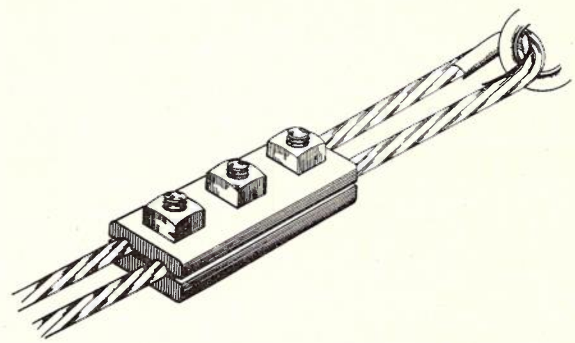


Fig. 105.—Form of Guy Wire Clamp Used in U.S.A.

been devised in which the load on the wire forces a wedge into a tapering cavity in such a way that as the load increases the wire is held the tighter. One form of these devices used by the Australian Army and known as the "Bowden Splice Eliminator" is covered by Aust. Provisional Pat. 8327/43, and provides for a fitting such as the type indicated in Fig. 106. Principal difficulty with wire clips and clamps and patent fittings is that of different sizes being required to fit various sizes of stay wire, with resultant problems of supply and storage.

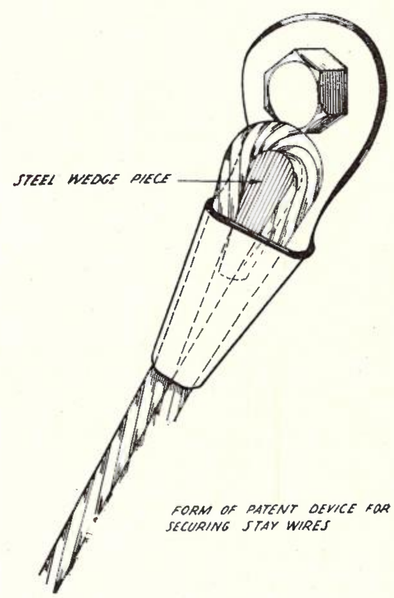


Fig. 106.—Form of Patent Device for Securing Stay Wire.

Stay Crutch. With the several different types of arms and pin spacings it is not always a simple matter to keep the stay wire for a ground stay adequately clear of the line wires; a minimum of 2in. is desirable. Usually the best condition is with the eyebolt 3in. above the cross arm bolt, and the stay wire at 45 degrees to the pole. It is advisable to try this position with a line before either the eyebolt or the stay rod are fitted, and care is necessary that wires on future arms are also considered. For those circumstances where the stay rod cannot be (or has not been) fitted in the most desirable place, and some deflection of the stay

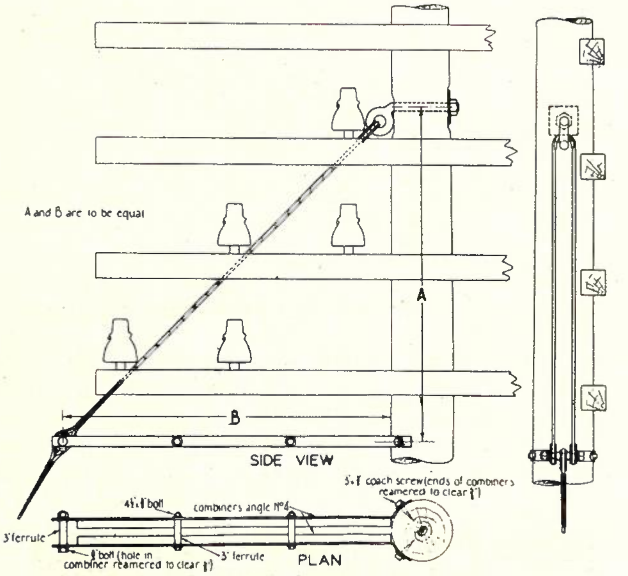


Fig. 107.—Stay Crutch.

wire is required to obtain satisfactory clearance, one method offering is to fit a stay crutch (Fig. 107).

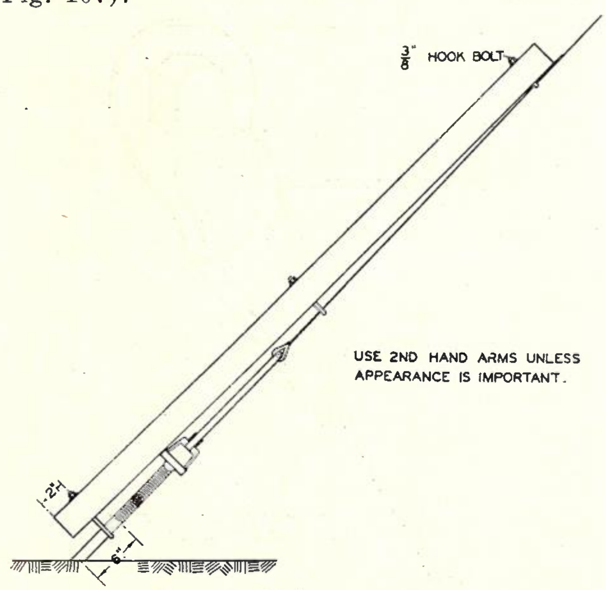
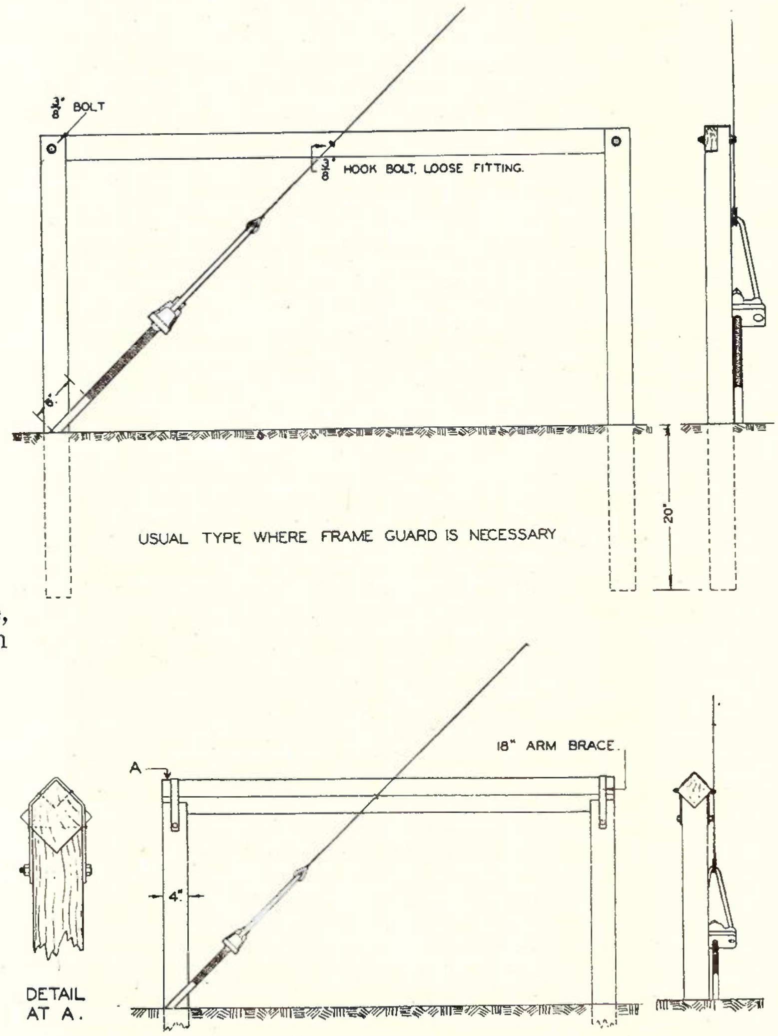


Fig. 108.—Sloping Stay Guard.

Stay Guards.

It is frequently necessary to fit some form of structure in the vicinity of the ground, for a ground stay, either to protect it from damage or to prevent persons or animals from injuring themselves by walking, riding or driving into the stay. The chief requirement is usually to make the presence of the stay more noticeable, and the secondary requirement is that the structure shall be strong enough to remain in position for a lengthy period. A third requirement sometimes is to prevent passers-by, passing under the stay where they may either hurt themselves or the stay. Forms of stay guards to meet these requirements are shown in Figs. 108 and 109. To aid in making the presence of the stay quite prominent these



Special type when strength and appearance are important.

Fig. 109.—Frame Type Stay Guards.

guards could be painted white. In the case of the frame type guard the upright pieces should be painted white down to within 12in. of the ground, the lower section being creosoted to the full depth below ground to protect the timber from decay and termites.

In some areas cattle and camels and other animals use the stay wires or the sloping stay guards to scratch themselves. If the animal is heavy and the stay or the pole is light the animal may uproot it, or otherwise damage it. The best protection against this hazard is to make the stay unsuitable as a scratching post, and this can be done by slipping a length of G.I. pipe (about $\frac{3}{4}$in. bore) over the stay wire before it is made off. This piping will rotate as the animal rubs against it and will not scratch its hide. The inner corners of the pipes should be well chamfered to prevent chafing of the wire.

MAGNETO EXCHANGE INSTALLATION— NARACOORTE, SOUTH AUSTRALIA

A. W. Emery

A new switchboard was recently installed in the exchange at Naracoorte and some of its features may have a general interest. Naracoorte is in South Australia, just across the border from Victoria. It is on an important highway between the two States and at the junction of main roads leading from the north to rich lands in the south of the State and the south-west of Victoria. The name is derived from Narkoot, the native word for a large water hole.

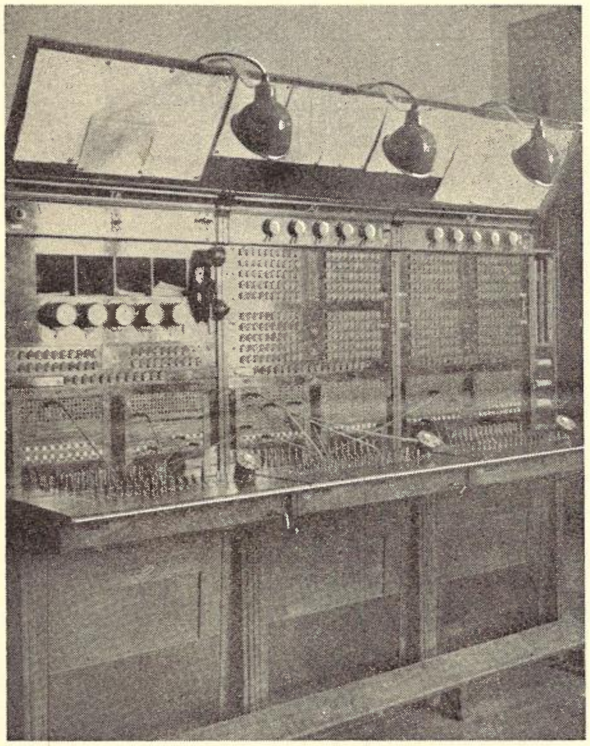


Fig. 1.—Switchboard, General View.

A township was first surveyed here in 1848 by a pioneer, William McIntosh, who called the settlement Kincraig after his birthplace. Later the Government surveyed an adjoining township called Naracoorte and, in 1870, the two were united under the latter name. Many thriving sheep runs form the backbone of the district's prosperity. The town now has a population of about 1800, while that of the district is about 3700.

A telephone exchange was opened in October, 1908, and trunk lines were built to connect it to large towns in the vicinity. In 1925, there were 100 subscribers and, in 1927, direct service was given to Adelaide over a phantom group of 3 circuits. A few years ago a 3 channel carrier system was installed and VF dialling was provided on the Adelaide circuits. The extent of the trunk traffic is shown by a recent check, which showed that only 14 per cent. of the total traffic was entirely local. A new switchboard became necessary to meet development and it was clear that conditions called for special consideration of the trunk facilities. The board was, therefore, designed so that trunk calls could be handled from the subscribers' positions, which have a universal cord circuit. Also, the key shelf is broad enough to facilitate the ticket work which will be necessary.

The switchboard consists of 3 Stromberg-Carlson 200 line magneto positions. These were recovered boards which have been re-designed for this particular installation. One of these positions has been converted solely for trunk operating, giving access to the complete subscribers' multiple either on the trunk position or adjacent subscribers' position. Fig. 1 is a general view of the switchboard. The 2 rows of keys will be noticed, that nearest the operator is the ordinary speak and ring key, the other being the speak answer—speak call key.

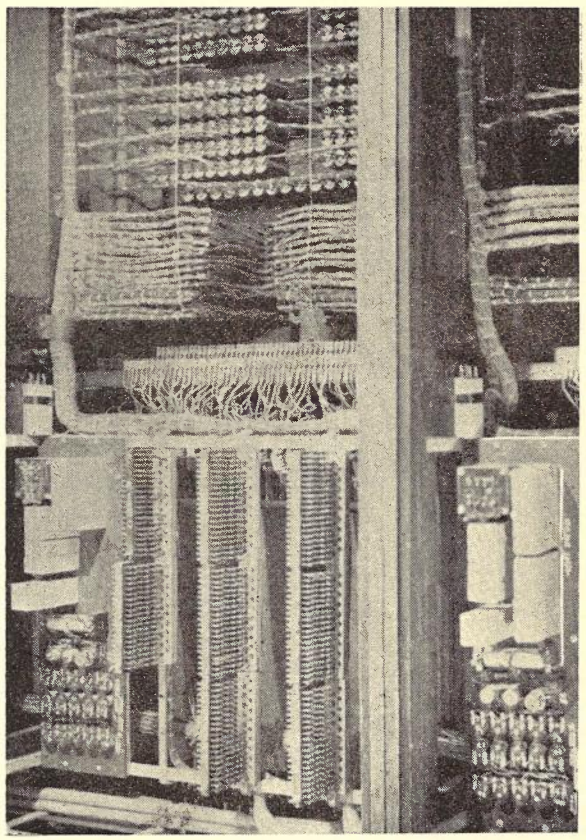


Fig. 2.—Rear View, Switchboard Wiring.

Fig. 2 is a rear view of the re-wired subscribers' position.

In South Australia there are many long distance, direct dialling, circuits, e.g., Alice Springs dials over a line of 1000 miles into Adelaide. Similarly, Port Lincoln 410, Broken Hill 343, and Mt. Gambier 310 miles out, dial their metropolitan numbers direct. Naracoorte being a mere 230 miles distant from Adelaide, naturally does likewise. In each case voice frequency is used. This is the first step in attaining the Department's objective of using one operator only for any trunk call.

Cord and Operator Circuit (Fig. 3).—Three part plugs and jacks are used, the 3rd conductor being necessary for the engaged test, which is obtained from earth on the cord sleeve to battery via the 10,000 ohm resistanceYD connected to the centre point of the transformer in the operated circuit. On local calls the "speak and ring" key only is used. On trunk calls the second row of keys enables connections to be completed without the annoying and time-wasting practice of changing cords, as is done on all boards not so equipped. All positions being similarly equipped, outgoing trunk calls

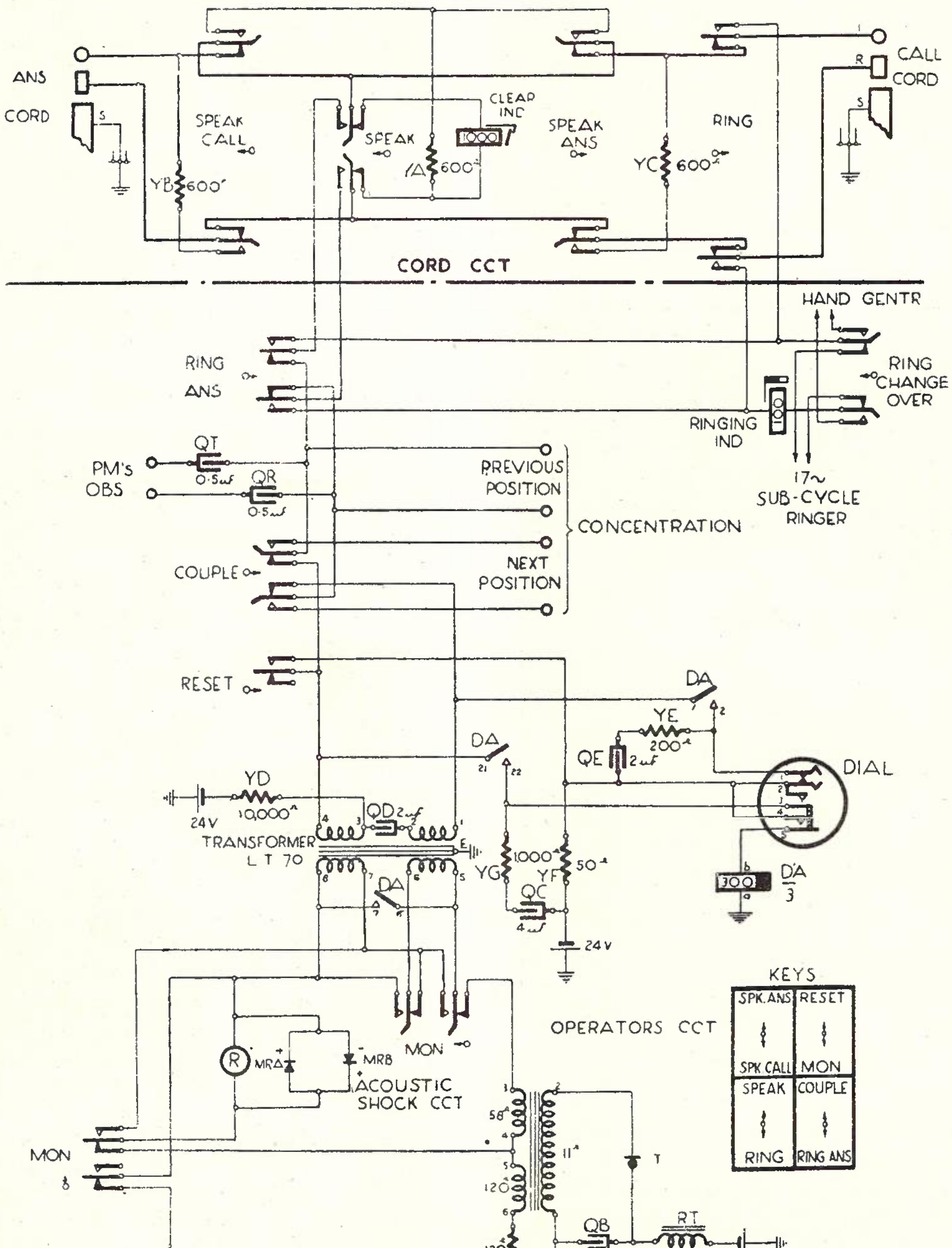


Fig. 3.—Cord and Operator's Cct.

are normally set up by the A operator. In a typical case of an Adelaide call, the operator answers and ascertains the wanted number using the S. & R. key in the normal manner, then finding that a trunk call is required, throws the other key to "speak call," plugs an Adelaide trunk, dials the wanted number, advises the wanted party that a trunk line is calling, throws the second key to "speak answer," advises the caller that his number is waiting, restores that key and introduces the parties. When a slight delay occurs in the completion of a trunk call, the operator may leave the lines plugged but keep the "answer and call" sides of her circuit separated by leaving the second key thrown to "speak call," restoring the S. & R. key, and attend to another call. Confusion of parties through two S. & R. keys being left thrown is thus avoided. Under all conditions of divided cords, loop terminations are provided both ways. With the "speak call" key thrown, resistance YB is connected across the "answer" cord and YA across the "call," with "speak answer" thrown YA is across the "answer" cord and YC across the "call," with the "speak" key and either "speak call" or "speak answer" thrown the operator's telephone is across one cord and either YB or YA across the other cord. Operation of the common monitoring key disconnects the operator's induction coil, changes the operator's transformer from unity ratio to 2/1 step-down and connects her receiver only to it.

VF Dialling Relay Set (Fig. 4).—Insertion of a plug in an Adelaide jack operates the corresponding S relay from earth on the cord sleeve through contacts R2/1 and 600 ohm res. YC. S is bridged by a 500 μF condenser QB which slows both its operating and releasing times while the condenser is charging and discharging respectively. S connects earth to relay R at S2/3 and it operates while 500 μF condenser QC is charging. R operates relay M to earth at its contacts 5/4, and lights the guard lamp (Seize and Release) associated with the switchboard jack. R also disconnects the operating circuit of S, connecting it to earth through its own contacts, and shorts the line at contacts R8/9 to screen clicks. Relay M connects earth into the VF Ringer panel, causing 2200 cycle current to be transmitted as a seizing signal, bringing about the engagement of a 1st group selector in Tandem Exchange in Adelaide. R releases after about 1½ seconds but the selector is held by the VF dialling receiving relay set in Adelaide until a releasing signal is eventually transmitted to it. The operator hears dial tone from the selector and the guard lamp goes out; this is her signal to commence dialling. Forward rotation of the dial closes its O.N. contacts (Fig. 3) operating relay DA to battery through res. YF50. Contacts DA 21/22 extend the same battery feed through O.N. contacts 2/3 and the tip side of the operator's cord, and line circuits, to operate relay M through its 250 ohm winding. Simultaneously this battery is also extended through the dial impulsing contacts, contacts DA 1/2, and the ring side of the operator's cord, and line circuits, to operate the impulsing relay A 250/250. Relay M causes the VF ringer to prepare to transmit 2200 cycle current, but this is short circuited by contacts A1/2 until, during the return of the dial, A opens its contacts in accordance with the number dialled, thus transmitting that number of periods of 2200 cycle

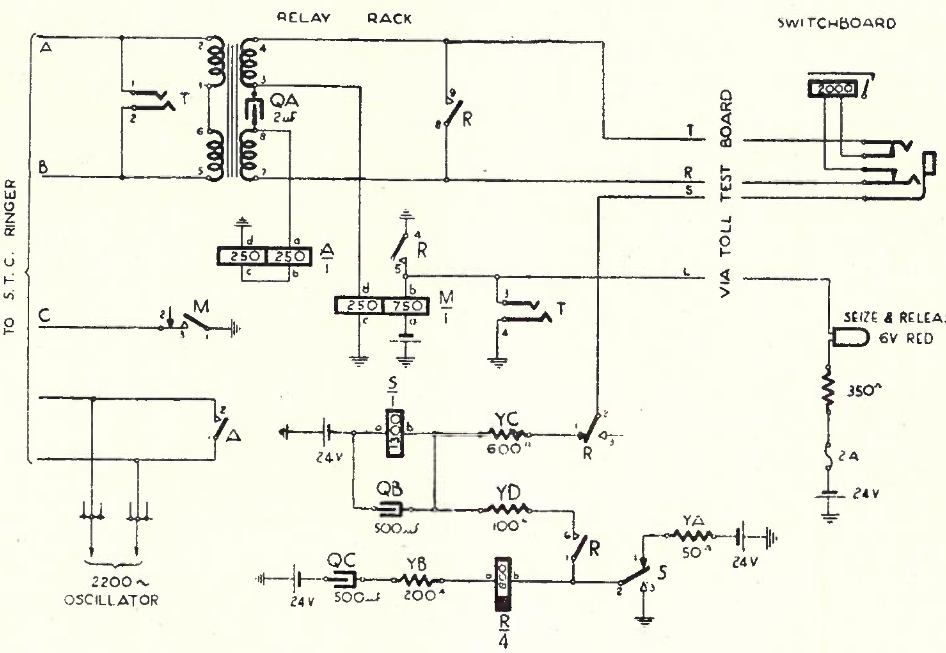


Fig. 4.—Keyless V.F. Dialling Cct.

current to the VF receiver in Adelaide. This faithfully repeats into the train of automatic switches engaged as the call is built up in the same way as does an A-A repeater. Relay M releases after each digit is dialled, with the opening of the dial ON springs (Fig. 3), and simultaneously slow releasing DA relay circuit is opened, but its slow release holds relay A to ensure that M has removed the earth at M1/3 before A1/2 removes the short circuit from the 2200 cycle current, thus preventing the possibility of extra impulses being transmitted. Withdrawal of the plug releases relay S after condenser QB discharge period. Contacts S 1/2/3 restoring cause condenser QC to discharge through relay R operating it for the discharge period. Contacts R 4/5 operate M to transmit the releasing signal which brings about release of the automatic switch train and also light the guard lamp, warning the operator not to re-insert the plug until it goes out with the release of R. As stated earlier, Relay S is made slow both to operate and to release by means of res. YC and condenser QB respectively. It is also held through R6/7 and S2/3 while R is operated. This provides a safeguard against the effects of the line being unplugged during a seizing signal or replugged during a releasing signal. Should either of these operating errors be committed, the circuit will first complete the operation stated and then after a pause set itself in accordance with the then existing condition. However, in the event of an "out-of-step" condition arising from any cause, a common "Reset" key is provided (Fig. 3), to enable relay M to be operated without A, thus transmitting 2200 cycle current for as long as the key is held operated. The out-of-step condition will become evident to the operator through absence of dial tone and her use of the Reset Key will perform the same function that the the first operation of relay R normally performs. It can also be used by a mechanic to send a test signal for checking of the receiver. Strowger type relays were used for the VF dialling relay sets.

Timing Signals.—It will be seen from Fig. 1 that the Zenith timing clocks on the A positions are above the operator's normal line of vision and although each is equipped with a lamp lit from its contacts and a timer pilot is installed, a momentary audible signal is also provided. This is accomplished by the operation of a relay through a 500 μF condenser from the timer pilot relay, thus sounding the buzzer for the charging period of the condenser. Timing clocks sometimes have to be mounted in awkward positions and this is a means of ensuring quick attention to them.

It is an advantage to have historical records of important units of plant such as telephone exchanges. At present it is largely necessary to rely on private records and the memory of individual officers. In this connection, my thanks are due to Senior Mechanic J. Murdock, also to others who have contributed information included in this article.

THE DESIGN AND CONSTRUCTION OF UNDERGROUND CONDUITS FOR TELEPHONE CABLES

A. N. Hoggart, B.Sc.

PART I.: LAYOUT OF CONDUIT ROUTES

Introduction.—Where lead-covered cables are laid underground, it is generally necessary to provide some form of protection against mechanical damage to the cable. This protection can be achieved in a variety of ways, but the provision of a pipe or conduit into which the cable can be drawn is the method which has found greatest application, combining as it does economy with other advantages.

In addition to mechanical protection, conduits provide the following facilities:—

(a) Ready means for maintaining or repairing cables, e.g., a faulty cable can be readily replaced by drawing in a new section.

(b) By the provision of additional pipes or ducts, future cables can be drawn in as required without re-opening the ground.

(c) Manholes or joint boxes provided at intervals along the route serve to house joints and provide access to the cable for repair or re-arrangement work, or for drawing in of new cables.

It will be appreciated that the above facilities are of prime importance where cables are required under expensive pavings as are used particularly on the roadways and footways of all large cities and towns.

Underground conduits are, therefore, the foundation on which modern underground communication systems are built, while the economical provision and maintenance of underground cable is dependent on the proper design and soundness of construction of the conduit system. Methods by which these desirable features of conduit construction can be achieved are discussed in these articles.

In the first instance, it would be well to review the qualities of a good conduit run. These are:—

(a) The construction should be strong and mechanically stable, e.g., not subject to subsidence and consequent breakage of the ducts.

(b) Adequate provision (spare ducts) for future development should be made.

(c) Manholes or jointing chambers should be provided at suitable intervals for convenient drawing in and jointing of cables.

(d) The construction should permit of cable being drawn in with minimum effort and without damage to the cable. The ducts should, therefore, be as straight as possible, and quite smooth on the interior surface.

(e) To reduce electrolytic and chemical corrosion hazards, the conduits should be as dry as possible—this involves grading of the conduits and drainage of manholes.

Preliminary Survey.—Preliminary and detailed Surveys are generally necessary when designing a conduit route. The purpose of the preliminary survey is to determine the route to be followed after examination of alternatives and generally outline the work required.

Selection of Route.—This will be determined by a careful scrutiny of the area to be served or the points to be linked, after possible alternative routes have been outlined on a map. Local knowledge of conditions will generally be most helpful in this phase. In selecting the route the following should be taken into account:

(a) Generally the route should be as short as practicable provided other requirements are met.

(b) The opening of streets with expensive pavements should be avoided where satisfactory alternatives exist. In addition to the extra costs of excavation and reinstatement in such cases, it is frequently extremely difficult to restore the surface to its original condition without reinstating a considerably greater area than was covered by the excavation. In some cases it will be necessary to compare costs of an indirect route involving low reinstatement costs and of a direct route where reinstatement is expensive.

(c) It is preferable to lay conduits in footways rather than roadway because—

(i) Excavation and reinstatement costs are lower.

(ii) Less depth of cover is required.

(iii) Less expensive types of manholes can be used.

(iv) Under present-day traffic conditions roadway manholes constitute a danger to traffic and workmen.

(d) Presence of obstructions, e.g., cellars, sewers, subways, underground mains. This aspect will require closer examination at the detailed survey, but at this stage any known obstructions likely to affect the choice or practicability of a route should be taken into account.

(e) Wet, unstable or made-up or broken ground should be avoided where practicable, otherwise special steps are necessary to ensure stability of the structure.

(f) Future road or street alterations which may later necessitate shifting or altering the conduits.

(g) Facilities for drainage of manholes and ducts.

(h) Crossings under railway and tramway tracks are expensive and should be avoided as far as possible.

(i) In the case of trunk or junction routes, their suitability also for subscribers' distribution purposes, bearing in mind at the same time the primary requirement.

After examination of possible routes in the light of the above, it should be possible to fix the most suitable route. In special cases, however, it may be necessary to prepare comparative costs for alternatives.

Determination of Duct Provision.—At this stage it will also be necessary to fix the number of ducts to be provided in various sections of the route. Economic studies have shown that it is normally economical to provide initially conduits to meet requirements 20 years ahead. Therefore, it is necessary to estimate the number of cables required along the route in 20 years' time. This will be assessed from the development figures obtained by a survey of the area in the case of subscribers' lines and a special traffic study for junction and trunk lines.

Two factors will require consideration, namely:

(a) Maximum size of cable of conductor weight obtainable, i.e., 1,400 pairs of $6\frac{1}{2}$ lb. conductor, 1,100 pairs (in special cases 1,200 pairs) of 10 lb. conductor, 540 pairs of 20 lb. conductor, and 250 pairs of 40 lb. conductor.

(b) Economic period for which it is economical to provide cable in advance of requirements. This varies from approximately eight years for larger cables to 20 years for smaller cables. An examination of economics may be necessary to determine whether the provision of an additional duct or ducts is justified to enable cable to be provided on a more economical basis.

For example, if the development figures along a particular subscribers' route are: Present, 375; 8 years, 880; 20 years, 2300 (usually written as 375/880/2300), and 10 lb. cable is required, then it is apparent that 3 cables will be required to meet the 20-year development. In cases where large or important cables are required along a route it is wise to provide an additional duct to ensure that a spare will be available for maintenance purposes, etc.; therefore, in this case, 4 ducts should be provided.

Take as a second example the case of a section of a junction route on which the development figures are: — Junctions, 200/480/1250; Subscribers, 350/530/850.

To meet transmission requirements 20 lb. cable is assumed to be necessary for junctions and 10 lb. for subscribers' lines. As the largest 20 lb. cable is 540 pair, 3 ducts will be required for junctions. In regard to subscribers' cable it would not be economical to provide the ultimate cable immediately, so that 2 cables would be necessary ultimately. Therefore, the conduit provision would be on the basis of 6 ducts, namely, 3 for junctions, 2 for subscribers' cable and 1 spare. Where the 20-year development is of the order of 400 pairs or less of 10 lb. cables or 200 pairs of 20 lb. cable, one 4 inch pipe will usually suffice, as even if the ultimate cable is not provided initially a second cable can be drawn into the same duct where such small cables are involved.

Detailed Survey.—The purpose of the detailed survey is to lay out the work in detail, fix locations in footway of duct runs and manholes, prepare working drawings and details for estimating material and labour quantities and to determine methods of draining manholes, etc. It is necessary at this stage to obtain all available information regarding the location of other underground services which might be encountered along the route so that a track as far as possible clear of them can be mapped out. The various authorities concerned (water, gas, sewerage, etc.) should be consulted, if necessary, for particulars. The exact location of a duct run in a footway will frequently depend on the presence of other services on obstructions, but the following requirements should be met as far as practicable:—

(a) Where there is a nature strip between the made footpath and the curb, this should be used in preference to opening up the pavement.

(b) A position close to the building alignment is generally to be avoided (except in the case of small iron pipes laid shallow for cable distribution), as greater inconvenience is likely to be caused to pedestrian traffic, particularly at entrances to premises, when making the excavation. A deep excavation in such a position may, in some cases, endanger the foundations of buildings erected on the street alignment. Generally a location 6 ft. to 12 ft. from the building is to be desired if otherwise suitable.

(c) The following clearances should be maintained as far as practicable from other service mains:—

Other mains except electric power	6 ins.
Electric power mains, low voltage (under 650 volts)	6 ins.
Electric power mains, high voltage (over 650 volts)	12 ins.

Where these clearances from electric power mains cannot be maintained, a layer of concrete should be placed between the conduits and the mains.

In some areas agreement has been reached between various authorities concerned, allocating definite portions of the footway to various services for underground plant. In these cases the location of the conduits should conform to the space allocated for telephone purposes, except where some exceptional conditions prevail, when the other parties to the agreement should be advised of the proposed change.

An actual measurement of the route should now proceed, at the same time the positions of manholes fixed and pegged. The location of manholes should take into account the following:

(a) While short spacing between manholes tends to increase costs of both conduit and cable work, excessive lengths mean greater strain placed on the cable during pulling in and, therefore, should be avoided. Generally lengths from 300 to 360 ft. are most suitable if other requirements are met. Lengths greater than 450 ft. should not be adopted.

(b) Position of certain manholes will automatically be fixed at break-off points for existing or future branch runs, e.g., at street intersections, also at changes in direction of runs, etc.

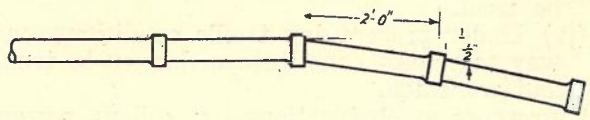
(c) Drive entrances in footways should be avoided, otherwise roadway type construction may be necessary.

(d) Manholes should be located in roadways only if unavoidable, and then should be placed in a position least hazardous in regard to road traffic.

(e) Where loaded cables are to be accommodated the spacing should be co-ordinated with the spacing of loading coils. Similar action may be necessary for balanced trunk cables.

(f) Facilities for drainage of ducts and manholes may influence the choice of locations, e.g., a manhole may be placed at the bottom of a rise near a storm-water channel solely for the purpose of draining the route, the manhole being in turn drained to the storm-water channel.

(g) In some cases where specially deep construction is necessary to pass an obstruction, it may be advisable to provide one or two additional manholes adjacent to obstruction to avoid extending costly deep excavation unduly.



SKETCH SHOWING MAXIMUM DESIRABLE OFFSET IN CONDUIT.

Fig. 1.

Conduits should be run in a straight line from manhole to manhole, as curves in the run increase considerably the strain on the cable during the pulling-in process. Where distances between manholes are not great, a slight curve of as great radius as possible may be introduced if a straight run is not practical. "S" curves, however, should be avoided unless absolutely unavoidable. The extent of curvature permissible in any run is dependent on:—

(a) Distance between manholes, the shorter the length the greater the curvation permissible.

(b) Size and number of cables to be drawn in. Generally greater curvature is allowable on a minor run, into which a single small cable is to be drawn in as compared with a main multi-duct route into which several maximum sized cables are proposed.

(c) Class of duct. The coefficient of friction for concrete conduits is greater than that of earthenware conduits, consequently the latter will permit of greater curvature.

(d) Method of jointing ducts. Some types of ducts will permit of greater offset at the joints than others.

Generally the curvature should not exceed an offset of ½ in. per 2 ft. of duct. (See Fig. 1.)

Curves may be made either in vertical or horizontal plane, but where they are in the vertical plane any hollows or depressions in which water or silt can collect must be avoided. Water in the ducts considerably increases the corrosion and electrolytic hazards to the cable, while the presence of silt will render rodding and cable-drawing operations difficult, if not impossible.

The results of the survey should be included in a field book in which the following information should be recorded:—

(a) Centre to centre distances between manholes.

(b) Distance from building line.

(c) Notes re obstructions to be avoided.

(d) Notes re class of excavation, e.g., soil, rock, etc.

(e) Quantity and class of reinstatement necessary.

(f) Notes re actual location of manholes.

(g) Particulars of method of drainage to be adopted. (Methods of draining conduits and manholes will be discussed in a later article.)

(h) Class and size of manhole.

Plans of the route should then be prepared showing the proposed construction. (See Fig. 2.) These will usually be traced from 2 or 4 chain standard street maps.

In order to ensure that conduits are properly graded so that any water will drain out, it is helpful to take levels and prepare a longitudinal section showing depths and grading of the run. This is also advisable where obstructions such as other pipes and mains have to be crossed. Levels are taken at all manholes and other points of consequence by means of a dumpy or engineer's level and measuring staff. The method of using this equipment has previously been described by Mr. A. S. Bundle in "Aerial Line Construction, Part IV." (Telecommunication Journal, Vol. 3, No. 6). All levels are reduced to levels relative to a datum which may be the level of some known point or assumed, i.e., relating to no particular point, but taken as a certain distance below one of

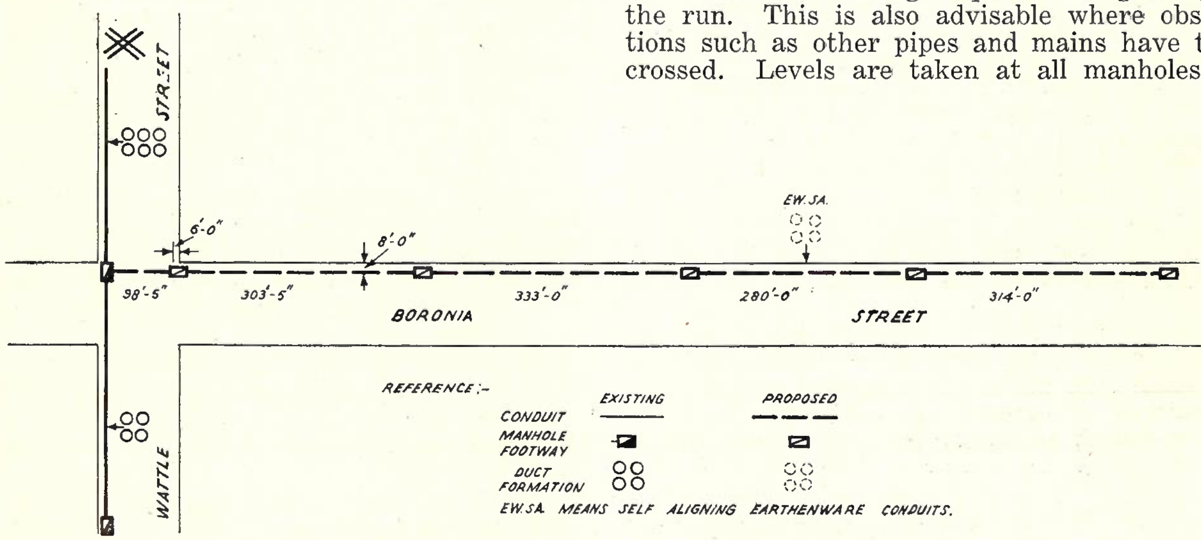


Fig. 2.—Typical Plan of New Conduit Line

Levels taken for new conduits going from........................to........................
Datum........................day of........................19

Peg	Continuous Chainage	Back Sight	Intermediate Sight	Fore Sight	Rise	Fall	Reduced Levels	Remarks
Ex. MH753 ..	—	7.6					33.0	Across roadway.
C/L Roadway ..	49		7.0			.6	32.4	
1	98.5′		6.0			1.6	31.4	
2	402′			0.4	5.6		37.0	Drain to kerb.
3	735′		7.4		1.9		38.9	Drain under ducts.
4	1015′		7.4		—		38.9	
5	1329′		8.2			.8	38.1	

Fig. 3.—Typical Field Sheet of Levels for Conduits.

the points on the route. The datum should preferably be below the lowest point on the route so that all reduced levels are shown as rises.

Fig. 3 is a typical field sheet showing how the results of the level survey are recorded.

From this information a longitudinal section of the route in the form of Fig. 4 is prepared, in which will be noted that the vertical scale is exaggerated compared with the horizontal scale, suitable scales being:—

Horizontal .... 100 ft. = 1 in.
Vertical .... 10 ft. = 1 in.

In laying out the trench details the aim should be to provide a uniform grade between manholes of not less than 1 in 200 so that ducts will drain readily.

The depth of trench should be sufficient to provide the following minimum cover over the types of conduit indicated:—

	Under Roadways	Under Footways
Single earthenware or concrete pipes	18 ins.	9 ins.
Multiple earthenware self-aligning conduits	18 ins.	9 ins.
Multiple earthenware square conduits	24 ins.	12 ins.
Wrought iron pipes	18 ins.	4 ins.

In certain circumstances where, owing to obstructions, these depths cannot be maintained, these may be reduced provided there is no danger of damage to the conduit from traffic loads. Otherwise it will be necessary to adopt special measures, such as concrete cover over the conduits or use steel pipes.

(To be continued.)

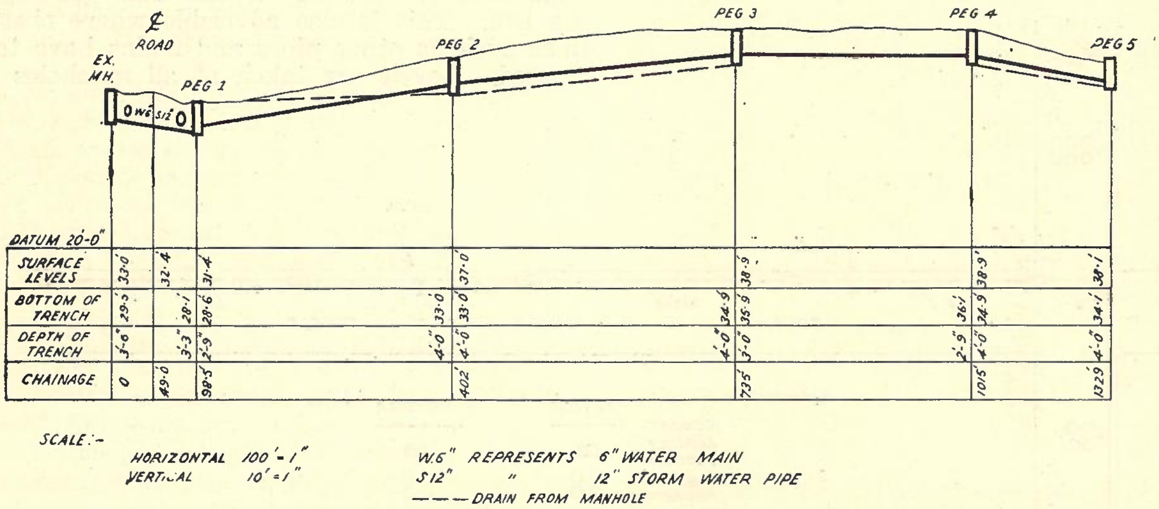


Fig. 4.—Typical Longitudinal Section showing Levels for Conduits.

AUTOMATIC ROUTINERS IN TYPE 2000 EXCHANGES

T. T. Lowe

In previous issues of the Journal (Vol. 4, Nos. 2, 3, 4 and 5) earlier sections of this article describing Automatic Routiners in Type 2000 Exchanges appeared. The article is concluded in this issue.

Routine Testing and Manual Routine Test Sets were first briefly referred to. The considerations which justify the provision of automatic routiners were then discussed, followed by notes on their design and development. The automatic routine testing equipment which is installed at Rockdale Exchange, Sydney, was then described briefly.

The operation of the Final Selector Automatic Routiner at Rockdale when testing P.B.X. Final Selectors was then described in detail. It was considered that a full description of the operation of one automatic routiner, including its associated access equipment, would assist considerably with other routiners. Figs. 1 to 29 referred to the operation of the Access Control Equipment and its associated Alarms. In Figs. 30 to 75 the operation of the routiner when testing 200 outlet, 2 to 10 line P.B.X. Final Selectors is described. A complete list of the tests performed by the routiner on final selectors was included on pages 226 and 227, Vol. 4, No. 4, Tests 1 to 10 (Figs. 30 to 45) being included in that issue. Tests 11 to 26 (Figs. 46 to 61) were included in Vol. 4, No. 5.

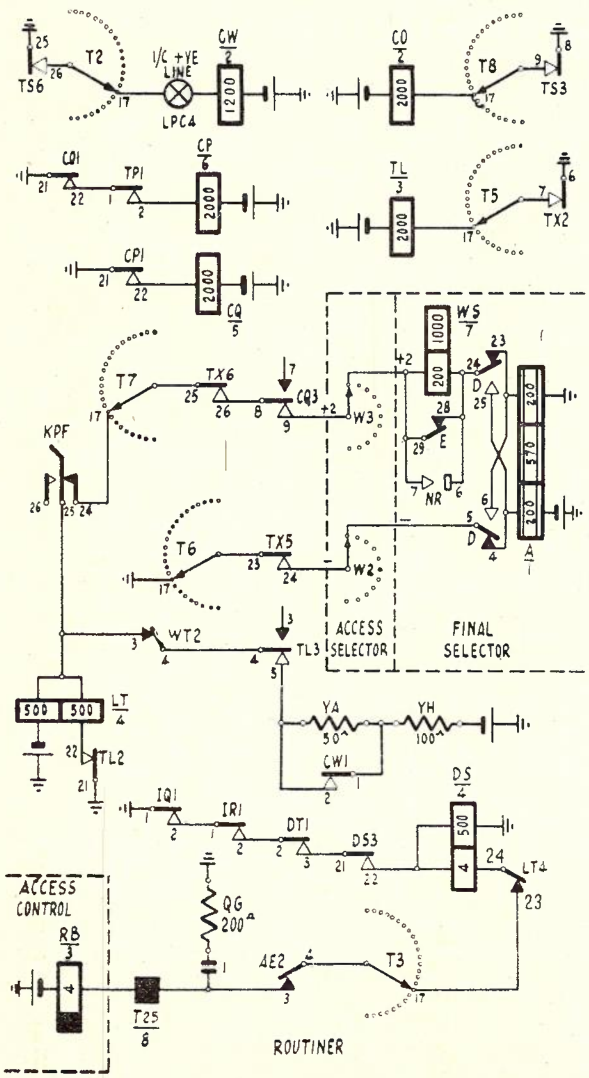


Fig. 62.

In this issue of the Journal, Final Selector Routine Tests Nos. 27 to 40 (Figs. 62 to 75) are included. Space, however, will not permit a similar description of other automatic routiners in use in 2000 type exchanges but the methods of testing and the tests performed follow closely those which have been described for the Final Selector Routiner.

Automatic Exchanges of the 2000 type in N.S.W. are equipped with Automatic Routiners for Final Selectors, Group Selectors and Repeaters, where these switches are installed, separate Access, Access Control and Routiner Equipment being provided for testing each type of switch. In each case the testing equipment is mounted on routiner racks adjacent to the switches to be tested to reduce cabling costs.

An automatic routiner for Discriminating Selector Repeaters is now being installed in Eastwood 2000 Type Automatic Exchange in Sydney.

Test Switch Position 17—Incoming Positive Line (2nd Choice—200 Outlet Selectors) (Fig. 62).—When the test switch steps to position 17 the "Incoming Positive Line" (2nd +2 choice) lamp LPC4 lights from ground via TS25-26 operated, T2 wiper and bank, lamp LPC4, CW1200 to battery. Relay CW operates and CW1-2 short circuits YA50. Relay CO operates from ground via TS8-9 operated, T8 wiper and bank, relay CO 2000 to battery. Relay TL operates from ground via TX6-7 operated, T5 wiper and bank, relay TL2000 to battery.

When testing 200 outlet selectors relay TP will be operated and the operation of relay CO will operate CP from ground via CO21-22 operated, TP1-2 operated, relay CP2000 to battery. CP21-22 operated, connects ground to relay CQ which operates. CQ8-9 operated, connect +2 lead to relay LT.

If 200 ohms ground potential is found on +2 lead, relay LT will not operate (see Figs. 36 and 37), and test switch drive magnet will be energised from ground via IQ1-2 operated, IR1-2 operated, DT2-3 operated, DS21-22 operated, relay DS4, LT23-24 normal T3 bank and wiper, AE3-4 normal, T magnet to battery. T magnet operates and when its circuit is broken at IQ1-2 normal, after a delayed step it releases and steps test switch to position 18.

Test Switch Position 18—Impulsing Long Line —Final Selector Steps up 9 and in 10—Auxiliary Test Switch Steps to Position 15 (Fig. 63).—When the test switch steps to position 18 the "Impulsing Long Line" lamp LPC5 lights and relay LL operates in series from ground via TS25-26

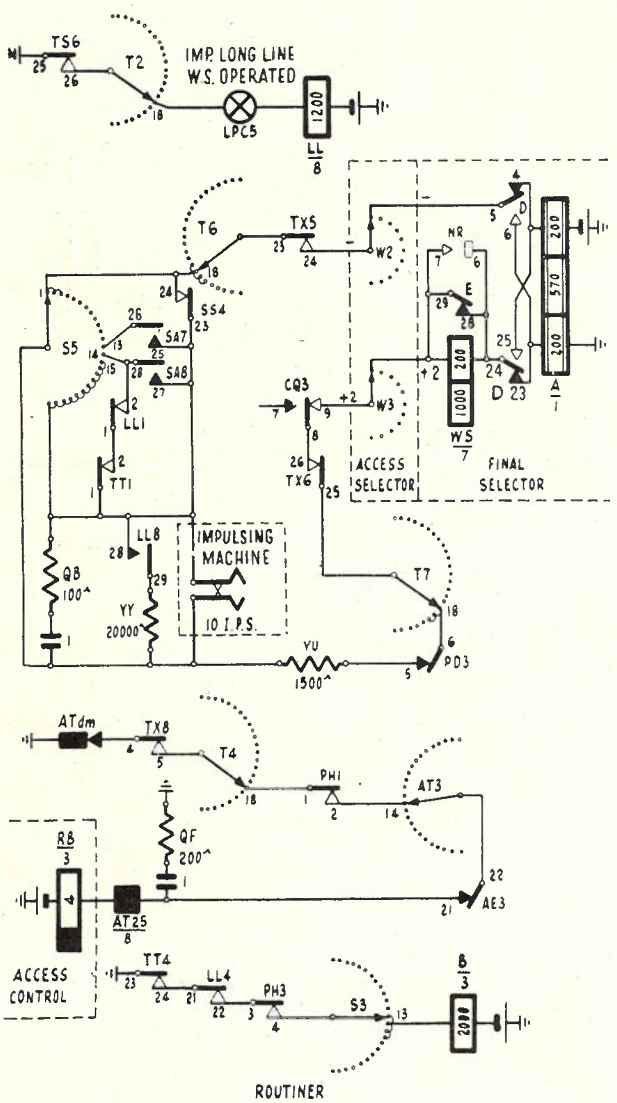


Fig. 63.

operated, T2 wiper and bank, lamp LPC5, relay LL1200 to battery. LL relay operating disconnects YY20,000 in leak and the selector is impulsed under long line conditions, i.e., on 1500 ohm loop to "A" relay of final seelctor.

In the case of straight line final selectors, impulsing will be as described in Figs. 43 to 46, but for P.B.X. final selectors 9-0 is dialled and the selector hunts to 9-11 (see Fig. 64 for this operation).

When the sending switch reaches position 25 relay SA operates and in operating closes the circuit to relay PH. Relay PH operates and closes the circuit to auxiliary test switch drive magnet, from ground via ATdm, TX4-5 operated, T4 wiper and bank, PH1-2 operated, AT bank and wiper, AE21-22 normal, AT magnet to battery. AT operates and breaks its own circuit at ATdm and in releasing steps the AT switch to position 15.

The sending switch functions as described in Fig. 43 and nine impulses are sent to the "A" relay of final selector under long line conditions. The impulsing circuit is from "A" relay, —lead, TX23-24 operated, T6 wiper and bank, SS23-24 operated, 10 IPS springs, YU 1500, PD5-6 normal, T7 wiper and bank, TX25-26 operated, CQ8-9 operated, +lead to "A" relay.

When S switch operates the second time 10 impulses are sent to the selector as the 14th contact on S5 is short circuited by LL1-2 operated, TT1-2 operated, S5 wiper and bank.

The S switch on reaching contact 13, closes the circuit to B relay from ground via TT23-24 operated, LL21-22 operated, PH3-4 operated, S3 wiper and bank, B2000 to battery. B relay holds while sending switch is stepping to contact 16.

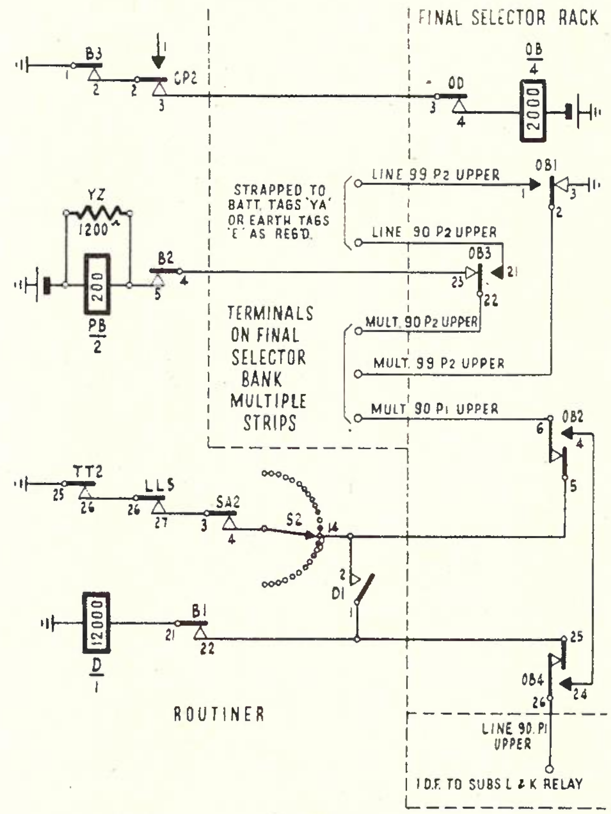


Fig. 64.

Test Switch Position 18—Impulsing Long Line —Final Selector Steps from 10th to 11th Bank Contact (Fig. 64).—When relay B operates, relay OB on final selector rack operates from ground via B1-2 operated, CP2-3 operated, OD3-4 operated, relay OB2000 to battery. Relay OB in operating divides the 99 P2, 90 P2 and 90 P1 multiple or bank wiring from the line or discriminating tags. Ground via OB 2-3 operated, converts 99 into the last line of a working P.B.X. group. Battery via relay PB200, B4-5 operated, OB22-23 operated to 90 P2 multiple lead converts 90 upper bank into the first line of a test P.B.X. group. Ground via TT25-26 operated, LL26-27 operated, SA3-4 operated, S2 wiper and bank, OB5-6 operated to 90 P1 lead converts 90 into a busy first line of a test group. Ground on 90 P1 lead prevents H relay in the final selector operating, but allows HS relay in final selector to operate from battery via PB 200 on 90 P2 lead. HS in the final selector operating causes the final selector to step to bank contact 11. If the line 90 is disengaged, relay D operates in series with the K relay of 90 line (L and K relay set) and D1-2 operated reconnects the 90 P1 line and multiple to permit during test access to 90 line.

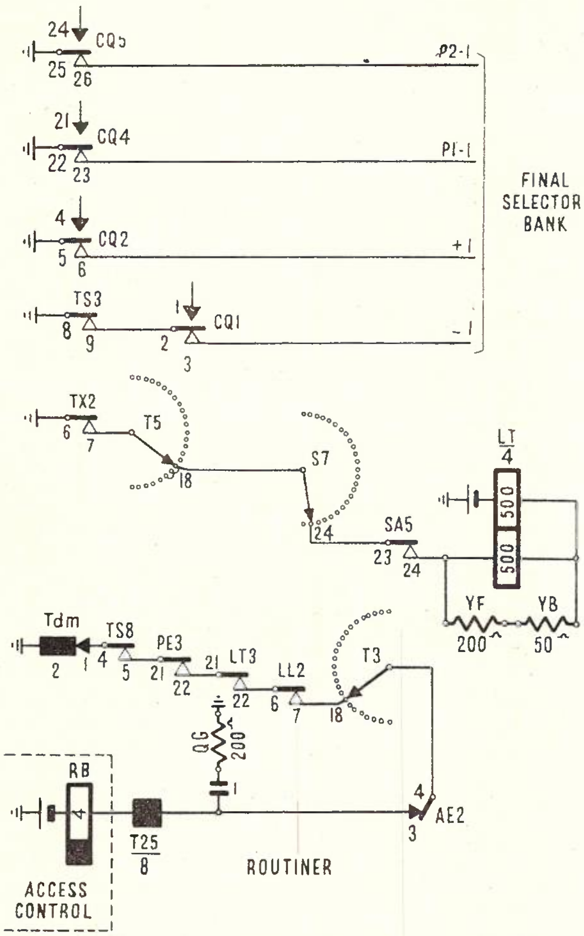


Fig. 65.

If the line 90 is engaged relay D does not operate and the final selector steps to the 11th bank contact. PB relay operates in series with the HS relay in the final selector but does not play any part at this stage.

Test Switch Position 18—Impulsing Long Line —First Test Line Busied (Fig. 65).—For 200 outlet final selectors the 2nd test line is used and the 1st test line is busied by the operation of relay CQ.

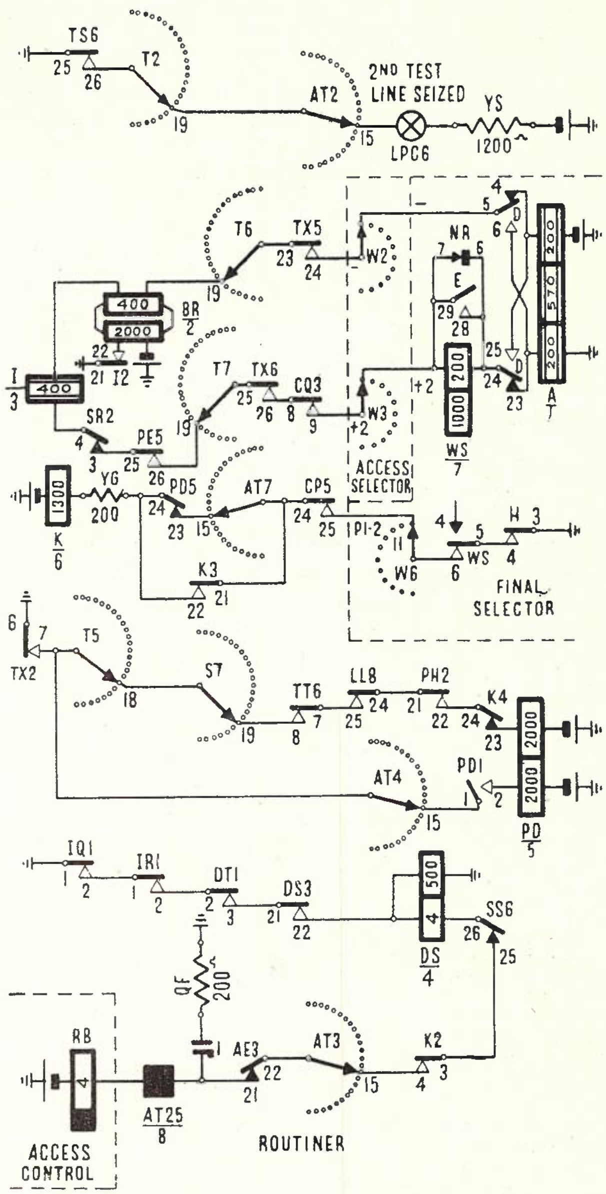


Fig. 66.

CQ5-6 operated, CQ22-23 operated, CQ25-26 operated, extend ground to +1, P1-1 and P2-1 test leads respectively and TS8-9 operated extends ground via CQ2-3 operated to —1 lead.

On the completion of impulsing, relay LT operates from ground via TX6-7 operated, T5 wiper and bank, S7 wiper and bank, SA23-24 operated, YF200 and YB50 in parallel with LT500 to battery.

Test switch drive magnet is energised from ground via Tdm, TS4-5 operated, PE21-22 operated, LT21-22 operated, LL6-7 operated, T3 bank and wiper, AE3-4 normal, "T" magnet to battery.

Test switch drive magnet operates and breaks its own circuit at Tdm and in releasing steps switch to position 19.

Test Switch Position 19 — Auxiliary Test Switch Position 15—2nd Test Line Seized (Fig. 66).—When test switch steps to position 19 and auxiliary test switch is on position 15 the "Second Test Line Seized" lamp LPC6 lights from ground via TS25-26 operated, T2 wiper and bank, AT2 wiper and bank, lamp LPC6, YS1200 to battery. The final selector loop circuit is transferred to hold from battery via "A" relay, D4-5 normal, access selector bank and wiper, TX23-24 operated, T6 wiper and bank, relay BR400, relay I400, SR3-4 normal, PE25-26 operated, T7 bank and wiper, TX25-26 operated, CQ8-9 operated, access selector wiper and bank, NR6-7 operated, D23-24 normal, A relay to ground.

If the selector fails to seize the test line and operate relay K from ground via H3-4 operated, WS5-6 operated, W6 wiper and bank, CP24-25 operated, AT7 wiper and bank, PD23-24 normal, YG200, K1300 to battery, before the S switch reaches position 19, then relay PD will operate from ground via TX6-7 operated, T5 wiper and bank, S7 wiper and bank, TT7-8 operated, LL24-25 operated, PH21-22 operated, K23-24 normal, PD2000 to battery. PD operating prevents K operating and the AT switch will not step off position 15.

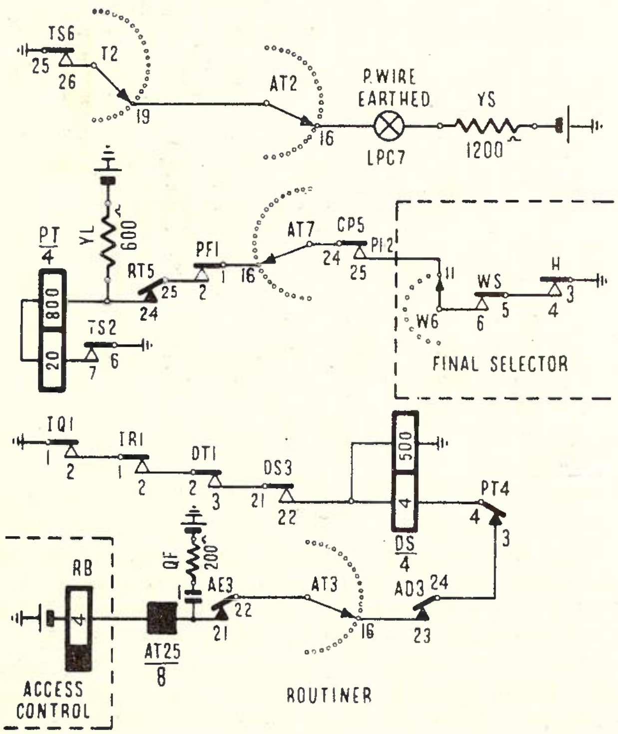


Fig. 67.

K relay operating closes a circuit from ground via IQ1-2 operated, IR1-2 operated, DT2-3 operated, DS21-22 operated, relay DS4, SS25-26 normal, K3-4 operated, AT3 bank and wiper, AE 21-22 normal, auxiliary test drive magnet to battery to operate AT magnet. After a delay period AT magnet releases and steps AT switch to position 16.

Test Switch Position 19—Auxiliary Test Switch Position 16—P. Wire Earthed (Fig. 67).—When the test switch is on position 19 and the auxiliary test switch steps to position 16, the "P. Wire Earthed Lamp" lights from ground via TS25-26 operated, T2 wiper and bank, AT2 wiper and bank, lamp LPC7, YS1200 to battery. Ground on the test line private P1-2 shunts relay PT via CP24-25 operated, AT7 wiper and bank, PF1-2 operated, RT24-25 normal, relay PT800 +20 TS6-7 operated to ground. Relay PT will not operate and the auxiliary test switch drive magnet will be energised from ground via IQ1-2 operated, IR1-2 operated, DT2-3 operated, DS 21-22 operated, relay DS4, PT3-4 normal, AD23-24 normal, AT3 bank and wiper, AE21-22 normal, AT drive magnet to battery. After a delayed step when its circuit is broken at IQ1-2 normal, AT drive magnet releases and steps AT switch to position 17.

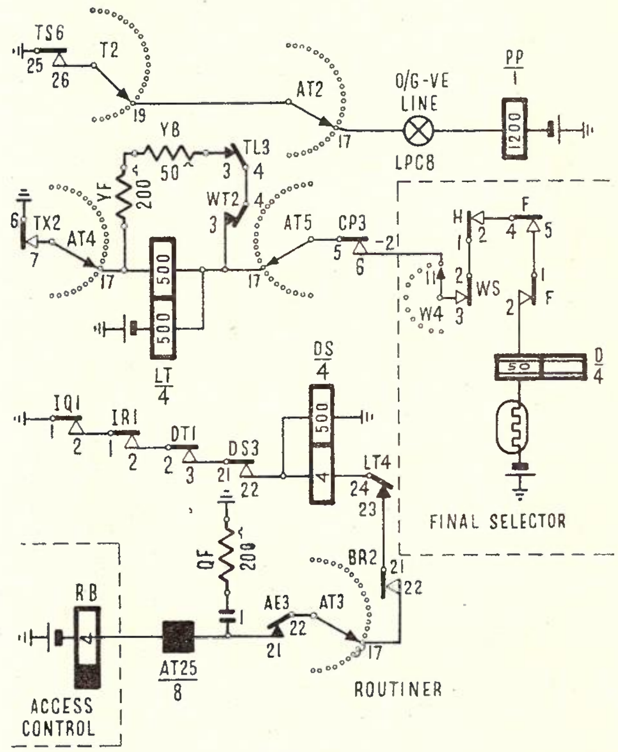


Fig. 68.

Test Switch Position 19—Auxiliary Test Switch Position 17—O/G Negative Line (2nd Choice) (Fig. 68).—With test switch on position 19 and auxiliary test switch on position 17 the "Outgoing Negative Line (2nd Choice)" lamp lights from ground via TS25-26 operated, T2 wiper and bank, AT2 wiper and bank, lamp LPC8, relay PP1200 to battery.

The ring from final selector is tripped from ring on negative 2 lead via CP5-6 operated, AT5 wiper and bank, relay LT500 to battery.

If correct potential is on negative 2 lead, relay LT will not operate and AT drive magnet will operate from ground via IQ1-2 operated, IR1-2 operated, DT2-3 operated, DS21-22 operated relay DS4, LT23-24 normal, BR21-22 operated, AT3 wiper and bank, AE21-22 normal, AT drive magnet to battery. AT magnet releases after a delayed step and steps AT switch to position 18.

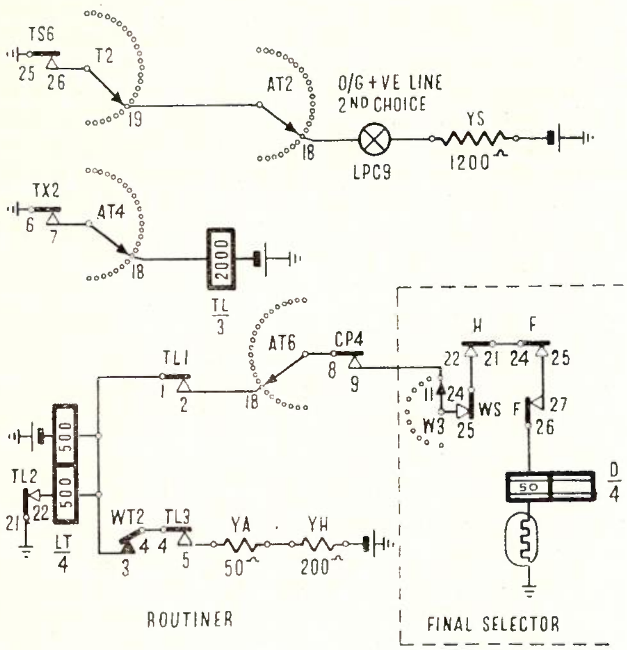


Fig. 69.

Test Switch Position 19—Auxiliary Test Switch Position 18 — O/G Positive Line (2nd Choice) (Fig. 69).—With test switch on position 19 and auxiliary test switch on position 18, the "Outgoing Positive Line (2nd Choice)" lamp LPC9 lights from ground via TS25-26 operated, T2 wiper and bank, AT2 wiper and bank, lamp LPC9, YS1200 to battery.

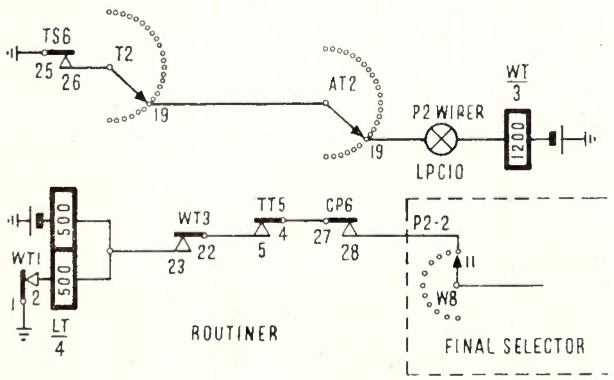


Fig. 70.

Ground is extended via TX6-7 operated, AT4 wiper and bank, relay TL2000 to battery. Relay TL operates and connects ground via TL21-22 operated through relay LT500 +500 to battery.

If correct ground potential is extended from positive 2 lead via CP8-9 operated, AT6 wiper and bank, TL1-2 operated to relay LT, relay LT being differentially wound will not operate and the AT switch will step to position 19 after a delayed step as described in Fig. 68.

Test Switch Position 19—Auxiliary Test Switch Position 19—P2/2 Wiper (Fig. 70).—With test switch on position 19 and auxiliary test switch on position 19 the "P2 Wiper" lamp LPC10 lights and relay WT operates in series from ground via TS25-26 operated, T2 wiper and bank, AT2 wiper and bank, lamp LPC10, relay WT1200 to battery.

WT1-2 operated connects ground via relay LT500 +500 to battery. The P2-2 test lead is also connected to relay LT via CP27-28 operated, TT4-5 operated, WT22-23 operated. If the P2-2 lead is clear of battery and ground relay LT will not operate, and after a delayed step the AT switch steps to position 20 via the circuit described in Fig. 68.

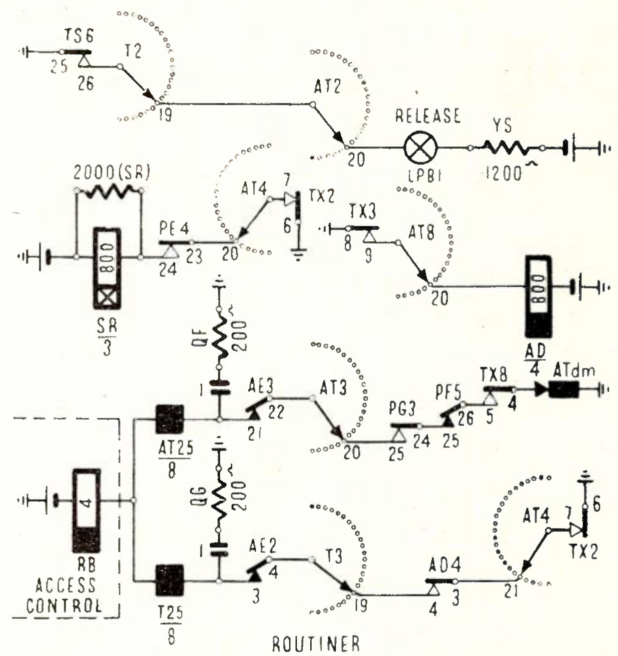


Fig. 71.

Test Switch Position 19—Auxiliary Test Switch Position 20—Release (Fig. 71).—With the test switch on position 19 and the auxiliary test switch on position 20 the "Release" lamp LPB1 lights from ground via TS25-26 operated, T2 wiper and bank, AT2 wiper and bank, "Release" lamp LPB1, YS1200 to battery. Relay SR operates from ground via TX6-7 operated, AT4 wiper and bank, PE23-24 operated, relay SR800 to battery. Relay AD operates from TX8-9 operated, AT8 wiper and bank, relay AD800 to battery.

Relay SR operating removes the loop from "A" relay of final selector (see Fig. 66) and relays I and BR release. Final selector "A" and "B" relays release and remove ground from the private lead and relays PE and K release (see Fig. 66). When earth is re-applied to the private by the final selector, relay PG operates (see Fig. 61). When the final selector has returned to normal, ground is removed from the private and PF releases (see Fig. 61). The auxiliary test drive magnet is energised from ground via ATdm, TX4-5 operated, PF25-26 normal, PG24-25 operated, AT3 bank and wiper, AE21-22 normal, AT drive magnet to battery and in operating opens its own circuit at ATdm and drives the AT switch to position 21.

Relay AD releases, its circuit being broken at AT8 bank, but during its slow release period a circuit is closed for the test switch drive magnet

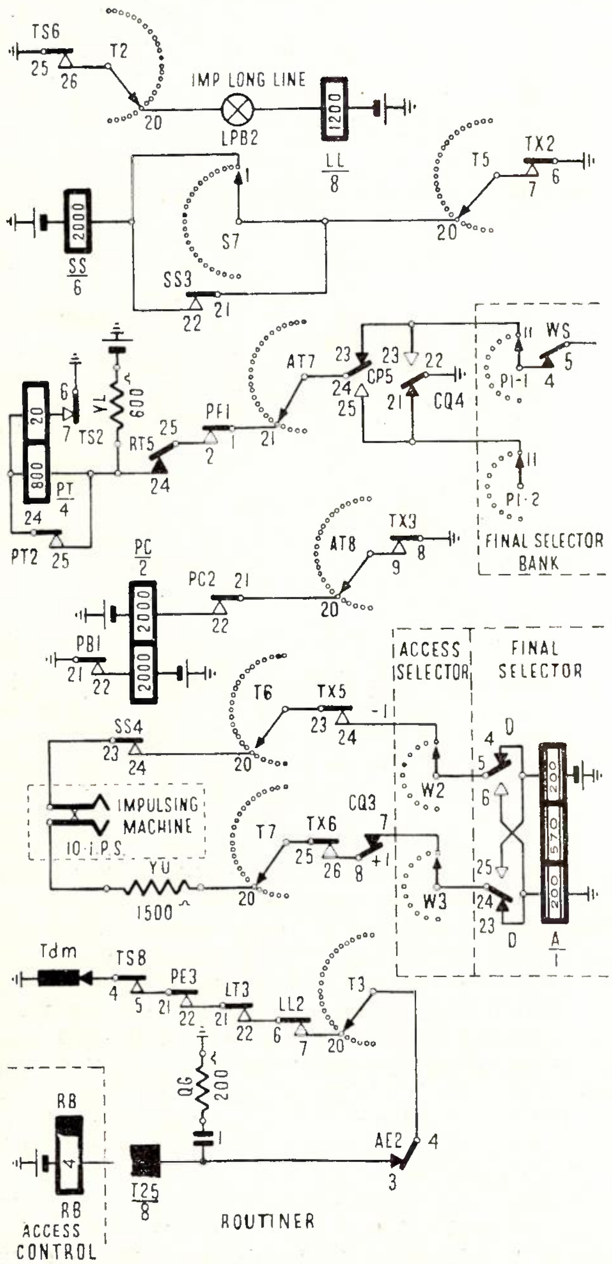


Fig. 72.

which operates from ground via TX6-7 operated, AT4 wiper and bank, AD3-4 operated, T3 bank and wiper, AE3-4 normal, T magnet to battery. When AD releases AD3-4 opens the T magnet circuit which releases and steps the test switch to position 20.

Test Switch Position 20—Impulsing Long Line (Fig. 72).—When the test switch steps to position 20 the "Impulsing Long Line" lamp LPB2 lights from ground via TS25-26 operated, T2 wiper and bank, lamp LPB2, relay LL1200 to battery. Relay LL operates and removes the 20,000 ohms shunt. Relay SS operates from ground via TX6-7 operated, T5 wiper and bank, S7 wiper and bank, relay SS2000 to battery. SS21-22 closes a locking circuit for SS relay. The final selector "A" relay is looped from battery via relay A200, D4-5 normal, TX23-24 operated, T6 wiper and bank, SS23-24 operated, 10.1.P.S. springs, YU1500, T7 bank and wiper, TX25-26 operated, CQ7-8 normal, D23-24 normal, A relay 200 to ground. The final selector switch is stepped to 9-0 and hunts to 9-11 on P.B.X. selectors and to 9-11 direct on ordinary selectors (see Figs. 63-65). This test is carried out on the 1st test line, relays CO, CP and CQ having released.

The P1-1 test line is busied from ground via TS6-7 operated, relay PT20, PT24-25 operated, RT24-25 normal, PF1-2 operated, AT7 bank and wiper, CP23-24 normal, to P1-1 lead. P1-2 lead is busied from ground via CQ21-22 normal. When the selector reaches 9-11 it meets ground via relay PT20 on P1-1 lead and selector will not switch.

In the case of P.B.X. final selectors relay PB operating (see Fig. 64) operates relay PC from ground via PB21-22 operated. PC relay locks from ground via TX8-9 operated, AT8 wiper and bank, PC21-22 operated, relay PC2000 to battery.

When the sender switch reaches Position 24 relay LT operates (see Fig. 65) and closes the circuit for test switch from ground via Tdm, TS4-5 operated, PE21-22 operated, LT21-22 operated, LL6-7 operated, T3 bank and wiper, AE3-4 normal, T magnet to battery. Tdm operating breaks the circuit to test switch drive magnet and T magnet releasing steps test switch to Position 21.

Test Switch Positions 21 and 22—Busy (Fig. 73).—When the test switch steps to Position 21 the "Busy" lamp LPB3 lights from ground via TS25-26 operated, T2 wiper and bank, lamp LPB3, YT1200 to battery. When the test switch steps to position 22 the same circuit keeps LPB glowing. Busy tone is fed from the selector and the circuit functions as described in Fig. 59.

The test switch drive magnet stepping circuit is from ground via KBT normal, TU21-22 operated, BS1-2 operated, PB1-2 normal (PC1-2 operated, in case of P.B.X. final selectors) (TT 27-28 normal, in case of ordinary selectors), T3 bank and wiper, AE3-4 normal, T magnet to battery. With the interaction of relays BS and

TU, BS operates and opens circuit to the T magnet which releases and steps T switch to

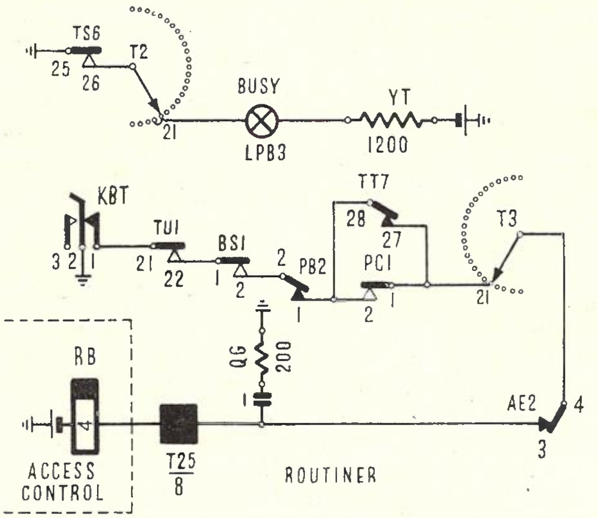


Fig. 73.

position 22. With the next surge of busy tone this sequence is repeated and T switch steps to position 23.

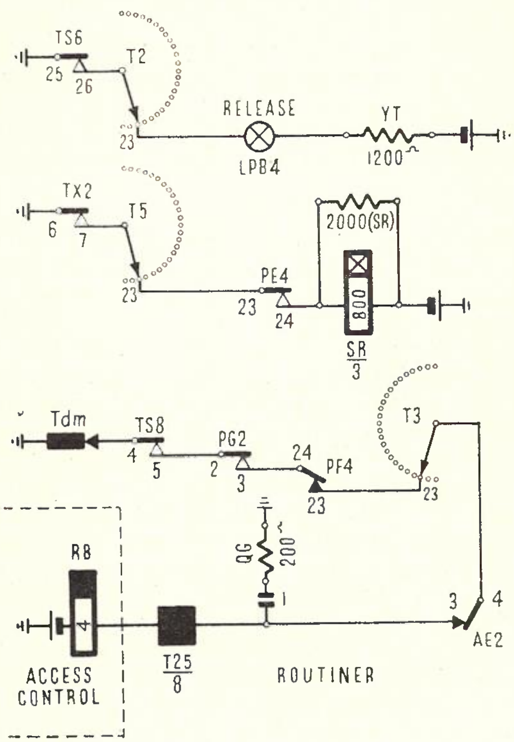


Fig. 74.

Test Switch Position 23—Release (Fig. 74).—When the test switch reaches position 23 the "Release" lamp LPB4 lights from ground via TS25-26 operated, T2 wiper and bank, lamp LPB4, YT1200 to battery. Relay SR operates from ground via TX6-7 operated, T5 wiper and bank, PE23-24 operated, SR800 to battery.

When the T switch reaches position 23 the loop to A relay in selector is removed and the selector releases. Relay PE releases, PG operates and relay PF releases as shown in Fig. 61.

The Test Switch drive magnet is energised from ground via Tdm, TS4-5 operated, PG2-3 operated, PF23-24 normal, T3 wiper and bank, AE3-4 normal, T magnet to battery. The circuit is broken at Tdm and the T magnet releases and steps test switch to position 24.

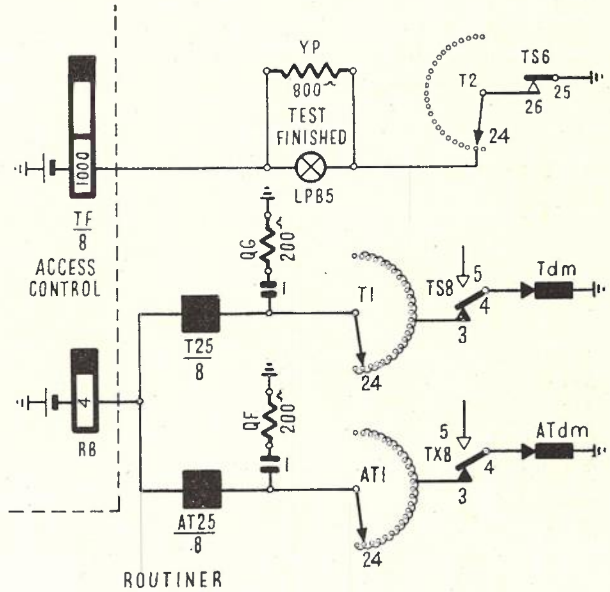


Fig. 75.

Test Finished—Test Switch Position 24 (Fig. 75).—When the Test Switch reaches Position 24 the "Test Finished" lamp LPB5 lights and relay TF in access control set operates in series from ground via TS25-26 operated, T2 wiper and bank.

TF operating releases ground from TS lead, which releases all relays in the test circuit (see Fig. 8).

The Test Switch self-drives to No. 1 position from ground via Tdm, TS3-4 normal, T1 bank and wiper, T magnet to battery and opens the circuit to relay TF which releases. The Auxiliary Test Switch self-drives to its home position from ground via ATdm, TX3-4 normal, AT1 bank and wiper, AT drive magnet to battery.

THE TUBULAR STEEL RADIATOR AT 4QR

V. F. Kenna

Early in 1942 it became necessary to provide a radiating system on a new site to permit of the removal of one of the Brisbane National Broadcasting Transmitters. Shortage of materials and manpower were even then factors to influence the design of a structure of this type, and the finished radiator represents more an example of wartime engineering than an ideal antenna system. It has, however, performed well electrically, and its design and erection have provided an interesting experience.

Radiator Design.—The structure was designed about a main member of the grade of steel tubing known as "Bore Casing," which is a thin walled pipe of good quality steel used for casing artesian and sub-artesian bores. The casing is supplied in lengths of from 18ft. to 20ft., approximately, and each length is screwed with a male and a female end, the latter being expanded for a length of about 4in.

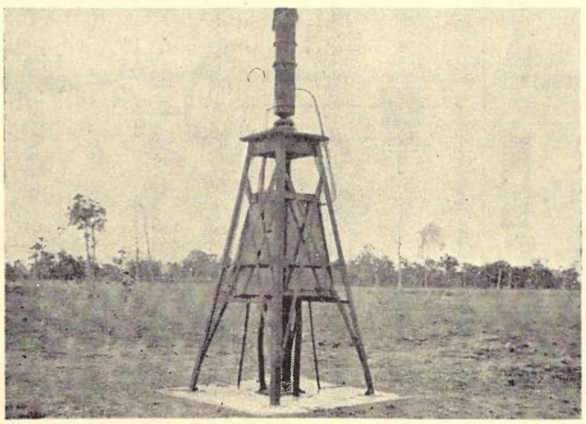


Fig. 1.—Stub Tower and Tuning Box.

The length of the radiating portion of the structure is 262ft., which is a physical 90deg. section at the operating frequency of 940Kc. As the velocity of propagation along a conductor is less than in free space, the electrical length is approximately 95deg. The reactance at the base is therefore slightly positive, which is advantageous, as the amount of inductance in the coupling circuit is reduced accordingly.

In the design, 6in. casing is utilised from the masthead downwards to a point where the factor of safety, which decreases for each 40ft. section, approaches a value of 4 at maximum wind loading. At this point there is an 8in. to 6in. reducing fitting, and from there to the base insulator the size of casing is 8in. A ball and socket fitting is installed between the 8in. tubing and the insulator to relieve the porcelain of stresses other than compression. The base insulator is supported some 8ft. above ground level on a short steel tower (see Fig. 1), within which is a copper box, housing the tuning and coupling circuits, and also the mast lighting filter. The floor of the box is located well above ground level as a precaution against damage from flood water which, on one occasion at least, has covered this portion of the site.

The base insulator consists of portion of a standard type of insulator designed to support heavy busbars. The normal metal end fittings were removed and the top and bottom surfaces ground plane and parallel to suit the special mountings, which consist of recessed steel plates. The insulator is retained in the mounting by normal pressure only and is not bedded in cement. Direct contact between porcelain and steel is prevented by waxed pasteboard discs.

The insulator now in service and one of the spares were tested in the laboratory of the Railway Department to a pressure of 45,000 pounds, but in a later test a second spare was subjected to a stress of 98 tons without apparent indication of fracture. The calculated compression on the insulator at maximum windload is 11,268 pounds.

The guy insulators are a large type of "strain" insulator, and a sufficient number is installed in series at each point to secure a safe electrical stress in the porcelain. The calculated R.M.S. voltage on the mast, for 2 kilowatts corrected for modulation, varies between 2,700 at the head to 420 at the base, and accordingly the number of insulators at the points of attachment of guys varies between 6 and 3. The guys are sectionalised by single insulators at approximately 60ft. intervals.

Guying is provided in four directions at six points located at 40ft. intervals from the base, leaving the highest section of 22ft. unsupported at the top. Although, no doubt, the most economical design for a mast of this type would require that the structure be guyed in three directions only, the procedure of providing the four sets of guys was decided upon to simplify erection, it being then possible to use two sets of guys to maintain the mast in the same plane as the jury and the erection tackle anchor block. To assist in erection also, the eyebolts in the guy anchor blocks were installed in the same horizontal plane as the centre of the main base pivot pin, adjustments to the side guys during the erection process being then unnecessary.

The greater portion of the manufacture of the mast was carried out in the Brisbane workshops, and the staff concerned was responsible for some very creditable work. Although a "built-up" design was prepared for the 6in. to 8in. coupling, the company concerned with its construction undertook to swage a coupling from

8in. casing. Details of the method used are not known, but the finished article is accurate and well finished.

Considerable difficulty was encountered in assembling the lengths of 8in. casing. The threads are very accurately cut to support the great weight of many lengths of casing, supported vertically in an artesian bore. This fact, together with the large diameter of the casing, rendered the screwing together of the sections

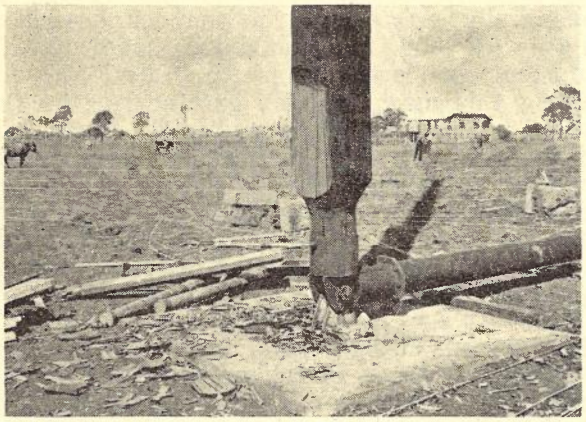


Fig. 2.—Erection Pivot.

whilst in the horizontal very difficult unless the sections were maintained in accurate longitudinal alignment. It was necessary to lay down a series of concrete bases, faced with wooden blocks, and accurately levelled before success could be achieved.

The mast is equipped with duplicated aircraft warning lights at the head, each fitting being wired separately within the mast. The twin tough-rubber cables are attached at regular intervals to a 7/22 steel supporting wire by phenol fibre clamping blocks, and can be removed for replacement by removing the base and masthead caps, after first raising the mast with jacks and removing the base insulator.

A number of special fittings for use during the erection of the mast had to be manufactured. These included a pivot assembly (shown in Fig. 2) to receive the lower ends of the mast and the jury, and a heavy concrete anchor for the erection tackles. The latter was liberally designed on a dead-weight basis to resist the vertical component of the erection load—some 4 tons—and an ample factor of safety was secured by the shape, which provided an effective key into the ground.

The Erection of the Mast.—The maximum compression for a jury 70ft. in length was of the order of 10 tons, and as a heavy spar was therefore necessary a well-seasoned, dressed, ironbark pole, 10in. in diameter at the head and 22in. at the butt, was obtained. The butt was trimmed to suit the pivot socket, and a steel cap, with the necessary heavy eyes and lugs, was fitted to the head.

The butt of the jury was then fitted to the erection pivot asembly, and the tackle, lateral stays, and mast bridles fitted to the head cap. The main tackle consisted of treble purchase, 7-ton blocks, and the $1\frac{1}{4}$-inch flexible wire rope was led to a winch bolted down on the main anchor block. Lateral stays of 7/14 steel wire were made off to guy anchor blocks in suitable locations. The jury was then erected in the usual manner, using pikes and jacks, assisted during the final stages by a head tackle.

The vertical alignment of the jury was adjusted until the flanges of the coupling, which connected the erection pivot assembly to the lower portion of the mast, were parallel, and the coupling bolts were then inserted. The head of the jury was then sighted on the crosswires of a theodolite, set up in the direction of one of the lateral stays, and during the rigging of the bridle wires connecting to six points in the length of the mast, it was retained in this position by adjustments to the main tackle to prevent undue stresses on the pivot assembly.

The guys were then attached to the mast and lateral and back guys shackled to respective anchor blocks. The lateral guys were adjusted to a comfortable tension, as these stabilised the complete unit. The relationship of the jury to the mast remained fixed, the top of the jury being hauled over during erection.

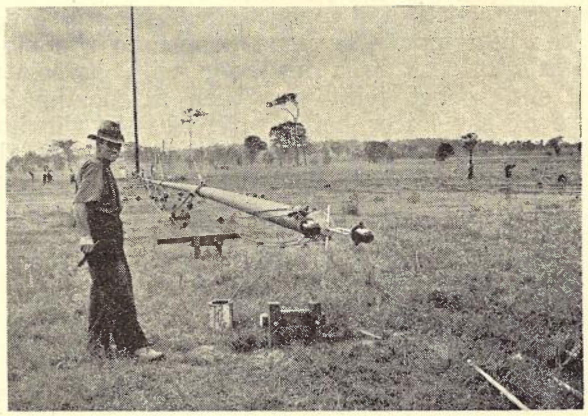


Fig. 3.—Mast About to be Erected.

When all rigging had been completed the main tackle was hove in until the complete mast was supported from the jury head by the six bridles, and this condition was allowed to exist overnight. (See Fig. 3.) In the morning, minor adjustments were made and the erection was commenced.

After approximately 3 hours the mast had been elevated to a point where the complete assembly, consisting of the mast on one side and the jury on the other, balanced about the pivot pin, and from that time onwards the increasing weight of the jury had to be taken on jacks and buoys. The balance point had been calculated to occur when the mast was 18deg. from the vertical, and a light tackle had been rigged to the 80ft. mast level for control until the jacks were safely in operation. When the mast was approximately vertical, the front guys were shackled to their respective guy blocks, the front and back guys adjusted approximately and the jury disconnected from its butt and head caps. At this stage the lower end of the mast was supported on the temporary erection pivot. The method of fitting the stub tower and insulator will now be described.

Fittings. — Before being finally connected to the erection pivot, the lower portion of the mast had been passed through a 10in. circular aperture in the top plate of the stub tower, which, during erection, was eased down the mast until finally it could be secured to the four studs set into the concrete base. The exact locations of these had been previously fixed with a template.

After the jury had been removed a special clamp was fitted to the mast above the top plate of the tower, and the weight of the mast taken on two bottle jacks placed between the clamp and the top plate of the tower. Temporary guys had been fitted above the clamp to prevent lateral movement of the mast at this point, whilst on the jacks. The pivot pin was then withdrawn, and the pivot assembly dismantled, also an 8ft. dummy section of 8in. casing which, during erection, had connected the female thread at the bottom of the mast proper to the pivot assembly. The base insulator with associated ball and socket joint was then fitted, the top plate of the latter being screwed into the bottom of the mast and the bottom plate of the insulator being fitted into the 10-inch aperture in the top plate of the tower. The jacks were then eased off and the mast was supported on the insulator.

After being placed in service the effectiveness of the mast as a radiator was measured, and the value obtained — 187mV/metre for 1 kilowatt at a mile—is close to the theoretical figure.

From experience gained during the planning and erection of this radiator, it is thought that structures of much greater height could be economically erected in the manner described. Lengths of 300 feet could be handled with equipment no larger than that designed for erecting this mast, but for greater lengths the cost of gear would increase rapidly, and it is believed that the best method for large masts would be to erect 300 feet with a jury, and then add sections from beneath, while the complete structure is raised with a heavy tackle or jacks. A simple system of blocks would be required to permit the guys to be slackened off as the mast was raised.

The present design could be improved upon by guying in three directions only and by reducing the number of guy positions by substituting struts and bracing in order that the number of insulators might be reduced. For a mast designed for higher power, a saving in insulator weight would be well worth while.

The ideal material for tubular masts would be steel of a grade similar to that used in the radiator described, but supplied with flanged ends to facilitate assembly and permit of complete galvanising. With threaded joints, the exposed portions of the threads cannot be protected by galvanising and corrosion must occur here eventually. As the interior of the casing cannot be inspected, complete galvanising would be very desirable.

INFORMATION SECTION

A C.B. CORDLESS SWITCHBOARD

This article outlines a general description of a $\frac{2 + 4}{6}$ cordless switchboard designed at, and manufactured in the Postal Workshops, Melbourne. The case is manufactured from seasoned Australian hardwood, stained walnut, and finished with a dull polish, the inside of the case being treated with two coats of shellac. The dimensions of the switchboard are:—Width, 1ft. 1⅝in.; depth, 11½in.; height, 1ft. 1¼in.

The design differs from the usual type in that the lid and base are set back from the front and sides by ⅜in. The lid is hinged to the back, and the front panel is hinged to the base. Tongues on the side members fit into grooves cut in the front panel, and two locking screws fitted in the front panel screw into brackets fitted on the lid, thus securely fastening both front and lid. Provision is made to accommodate a circuit which is glued on to the inside of the lid.

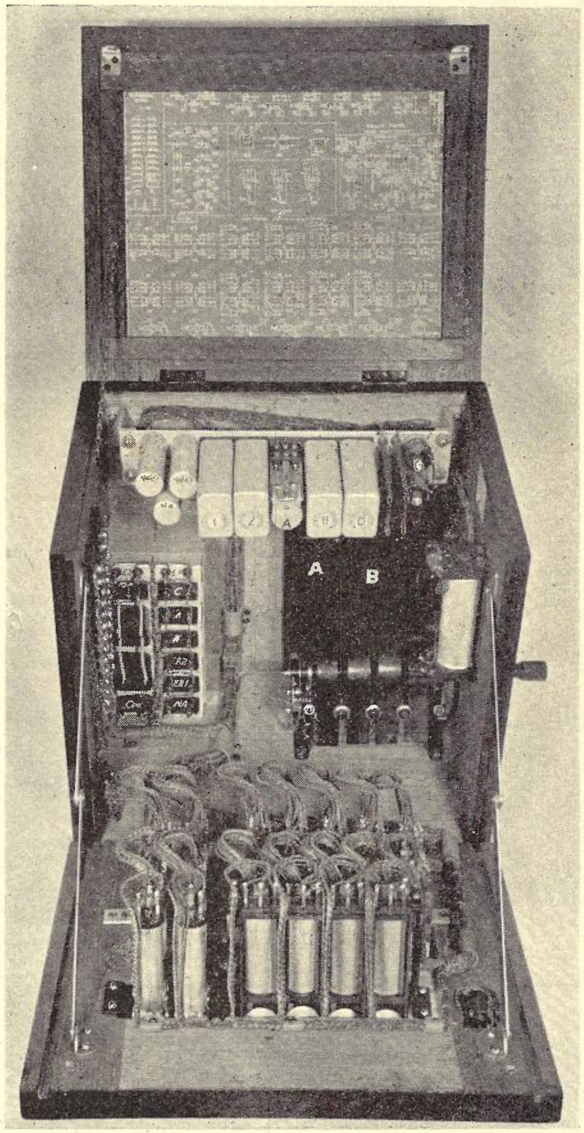
Equipment.—Most of the equipment in present use was obtained by dismantling a number of old $\frac{1 + 3}{4}$ C.B. switchboards. The exchange line indicators are of the 1,000 ohm drop type wholly manufactured by the Department. The indicator mounting was designed to mount both the exchange and extension indicators in one unit. The switching keys are also mounted in one unit.

The associated figure shows the switchboard assembled and wired, with the lid up and the front open.

Wiring.—The 10 M.F. condenser is built up in some cases with 5 — 2 M.F. condensers and in other cases with 2 — 4 M.F. and 1 — 2 M.F. condensers according to availability and connected in parallel. This reduces the space occupied by the condensers, and also the fault liability due to L.I.R. in the condenser bank.

In the majority of cordless switchboards returned to the workshops for repairs, it has been noticed that the 2,000 ohms N.I.R. across the exchange line indicator has been disconnected. This has probably been done because of the difficulty of getting a satisfactory adjustment on the exchange line indicator due to the shunting effect of the resistance. This condition has been overcome by connecting a copper oxide rectifier 1/12 A. (Serial 285/15) in parallel with the resistor and indicator. The indicator connected in this manner operates with a current of from 10 to 12 milliamps. The usual snap on tumbler switch for switching off the power has been replaced by a small toggle switch of the moulded type, mounted in line with the indicators.

The wiring on the key panel is so arranged that any key can be removed from its mounting and taken out of the front or back of the board as required. In wiring the keys the A and the B side of the line are kept on the same side of the key throughout the bank of keys, the A side being on the right-hand side and B on the left-hand side to conform with the key spring assembly.—R.S.M.



ANSWERS TO EXAMINATION PAPERS

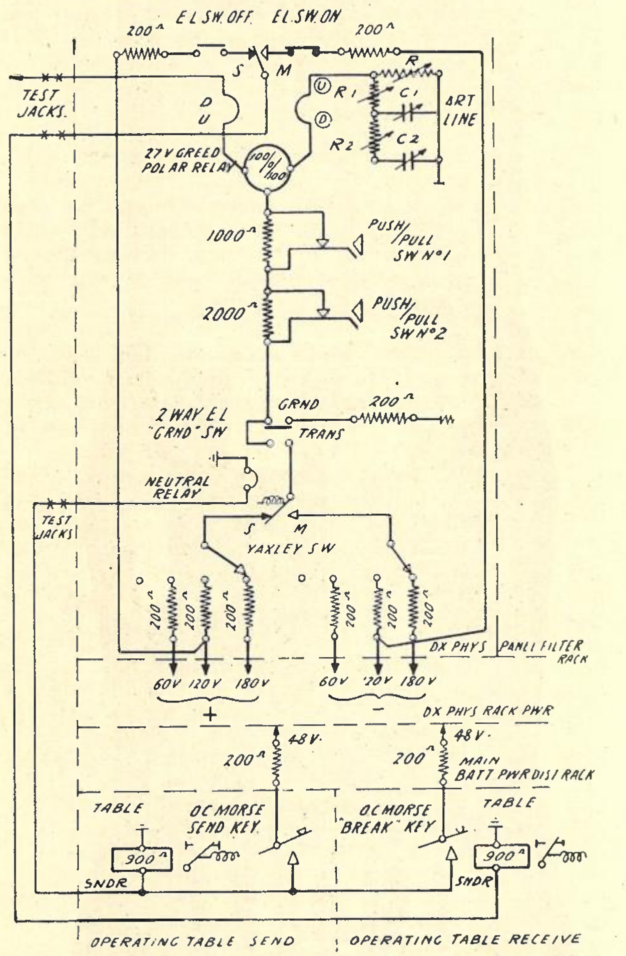
The answers to examination papers are not claimed to be thoroughly exhaustive and complete. They are, however, accurate so far as they go and as such might be given by any student capable of securing high marks.

EXAMINATION No. 2434—MECHANIC, GRADE 2, TELEGRAPH MAINTENANCE

R. C. Henry.

Q. 1.—Draw a schematic circuit diagram of a differential duplex telegraph set and explain the function of each piece of equipment shown.

A.—Differential duplex telegraph circuits are used for working over long physical telegraph lines and cailho circuits.



DIFFERENTIAL DUPLEX PHYSICAL TELEGRAPH SET

Q. 1, Fig. 1.

Figure 1 shows in schematic form the circuit of a hand speed differential duplex set, which is panel equipped and rack mounted. The component parts of the circuit have been tabulated under two main headings as follow:—

Duplex Physical Panel	**Operating Table**
Artificial Line	Send Key
Differential Relay	Send Sounder
Differential Milliammeter	Receive Sounder
Polechanger	Break Key
Resistors: Battery Feed	
Line Limiting	
Earthing	

Function of Each Circuit Component

Artificial Line.—This is a network of resistors and capacitances so arranged and capable of adjustment, that it simulates the physical line characteristics of distributed capacity and resistance, and thus renders duplex working practicable.

Differential Relay.—The polarised relay of a differential duplex set is required to be differentially wound in order that its armature remains unaffected by the transmission of signals from the terminal station at which it is situated. In the case of reception, however, the relay tongue responds to the marking and spacing signals from the distant station, its operation being determined by the direction of current preponderating in either of the two windings. In this manner the simultaneous transmission and reception of telegraph signals is therefore possible.

Differential Milliammeter.—The provision of a differential milliammeter is essential for the adjustment of the artificial line during "balancing" tests for duplex working. Its operation is almost identical to that given under the heading "differential relay" except that it affords a visual indication of circuit conditions during testing as well as transmission and reception.

Polechanger.—The polechanger or transmitting relay is for reversing the signalling battery potentials during the transmission of double current Morse signals. Since the polechanger is spring and magnetically controlled, and its operation governed by the send key in the telegraphist's local circuit, its use permits a greater degree of uniformity in the quality of signals than when direct transmission from an open circuit type of Morse key is employed.

Battery Feed Resistors.—The primary function of battery feed resistors is to prevent any tendency of the signalling battery fuses to overheat due to sparking between the polechanger tongue and contacts; they also limit the flow of current to safe values, in the event of accidental grounding of the telegraph equipment.

Limit Resistors.—The two resistors designated 1000 and 2000 ohms and provided with short circuiting switches are to limit the line and artificial line current values to a maximum value of 30 milliamperes respectively, should the set be required to work over short lines. The introduction of added resistance in such cases, in conjunction with the distributed capacity of the line tends to neutralise the inductance of the distant relay, thereby obviating the necessity of adding a compensating inductance in the artificial line circuit.

Ground Switch.—The purpose of the Ground Switch is as follows:—

(i) It permits the terminal duplex set to be earthed, via a resistance equal to that of the signalling battery, for "balance" adjustments.

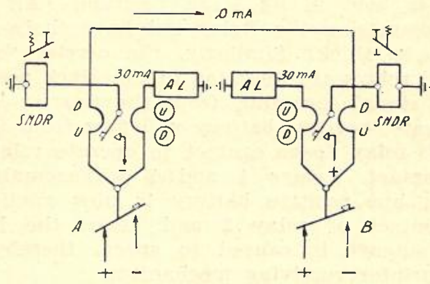
(ii) It allows the signalling battery to be disconnected from the line.

(iii) It enables line current measurements to be made and also facilitates the detection of foreign currents.

Operating Table Equipment.—The "Send" key controls the operation of the polechanger or transmitting relay, and the "Send" sounder allows the sending telegraphist to hear his own signals. Also, the "receive" sounder is for use by the receiving telegraphist who is also provided with a "break" key to interrupt the distant "send" telegraphist in connection with queries and corrections.

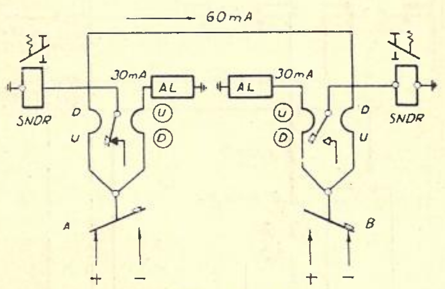
Q. 2.—Describe the condition which would exist in the set shown in the answer to Question 1, if it were connected over a physical line to a similar set at the distant end, and adjusted for work. Assume that the morse key of the set shown is open while that at the distant end is closed.

A.—It is assumed that the two terminal stations have batteries of equal voltages, and are connected to a physical line having an insulation resistance equal to infinity between itself and earth.



Q. 2, Fig. 1.

Current Distribution in circuit. Stations A and B send keys normal.—Figure 1 indicates that the two terminal sets are connected in accordance with the opposition method. Since the artificial line of each terminal simulates the physical line, a standard current of 30 milliamperes will flow in each, and in such a direction through their respective relay windings as to cause their armatures to space. Neglecting leakage, no current will flow in the line under these conditions.



Q. 2, Fig. 2.

Station A send key normal. Station B send key depressed.—Figure 2 indicates that the current flowing in the line will rise to 60 milliamperes since both terminal batteries now assist instead of oppose. The direction of current through the artificial line circuit at Station B is therefore reversed. Thus 60 milliamperes of positive battery will flow from Station A via the line windings of the polar relays at A and B, thence negative battery to earth.

Station A Sounder Circuit.—At Station A, the 30 m.a. of positive battery flowing in the artificial line circuit via the polar relay winding D circle to U circle will tend to operate the relay armature to Space, but 60 m.a. of positive battery flowing in the line circuit via the polar relay winding U to D, will overcome the magnetic effects of the D circle U circle winding, and cause the relay armature to Mark. Hence the sounder at Station A will be energised.

Station B sounder circuit.—At station B 30 m.a. of negative battery flowing in the artificial line circuit via the polar relay windings D circle to U circle will tend to operate the relay armature to Mark, but 60 m.a. of positive battery flowing in the line circuit via the polar relay windings D to U, will overcome the magnetic effects of the D circle U circle winding, and cause the relay armature to remain in the Space position. Hence the sounder at Station B is unaffected.

Q. 3.—Calculate the gears you would use to cut a screw thread of 18 threads per inch in a lathe with a lead screw of 4 threads per inch. Show by means of simple sketches the difference between simple and compound gearing.

A.—If a simple example be considered in which the required thread to be cut equals the number of threads per inch of the lead screw, it will be seen that the lathe spindle will be required to revolve once for each revolution of the lead screw. Therefore, both of the required change wheels will have an equal number of teeth.

Suppose now, the threads to be cut are twice those per inch of the lead screw. In this case the lathe spindle must revolve twice for each revolution of the lead screw, which means that the lead screw gear wheel will have twice the number of teeth of the wheel fitted to the lathe spindle (or stud).

In both cases an equality of the ratios exists between the "Thread per inch of the lead screw" to the "Threads per inch to be cut" and the "Number of teeth in the stud wheel" to the "Number of teeth in the lead screw wheel." This may be written as follows:—

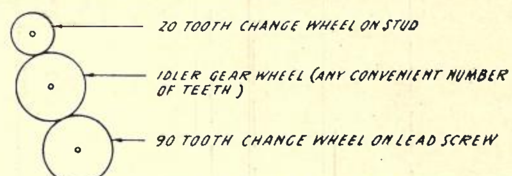
$$\frac{\text{Threads/inch of lead screw}}{\text{Threads/inch to be cut}} = \frac{\text{Number of teeth in stud wheel}}{\text{Number of teeth in lead screw wheel}}$$

$$\text{Therefore } \frac{4}{18} = \text{do.}$$

Multiplying top and bottom of the ratio by any number, say 5, to obtain a suitable pair of wheels.

$$\frac{4 \times 5}{18 \times 5} = \frac{20}{90} = \frac{\text{Number of teeth of stud wheel}}{\text{Number of teeth of lead screw wheel}}$$

The arrangement of gear wheels is shown by Figure 1, and constitutes a simple gear train.



Q. 3, Fig. 1.

If the available gear wheels on hand cannot be arranged as a "simple" train, use must be made of "compound" trains to obtain the desired results.

As an example, suppose the 20 tooth stud wheel were not available in the associated set of lathe gear wheels, similar results would be obtained as follows:—

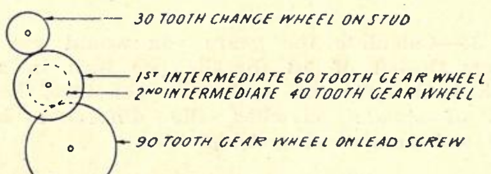
$$\frac{4}{18} = \frac{\text{Number of teeth in stud wheel}}{\text{Number of teeth in lead screw wheel}}$$

$$\frac{12}{54} = \frac{\text{Number of teeth in stud wheel}}{\text{Number of teeth in stud wheel}}$$

Rearranging as before, but this time using compound factors.

$$\frac{(3 \times 10)}{(6 \times 10)} = \frac{30}{60} \text{ and } \frac{(4 \times 10)}{(9 \times 10)} = \frac{40}{90}$$

That is, the 30 and 40 tooth wheels are the drivers, and the 60 and 90 tooth wheels are the driven.



COMPOUND GEAR WHEEL TRAIN

Q. 3, Fig. 2.

Figure 2 shows the wheels arranged as a compound train.

Q. 4.—Draw a schematic circuit of a long distance teleprinter relay set as used to extend a carrier channel to a local teleprinter 7C, and briefly explain its operation. Monitoring and Observation facilities need not be shown.

A.—Figure 1 shows the schematic circuit of a Long Distance Teleprinter Relay Set for extending a local 7C Teleprinter to a carrier channel.

Circuit Description.—The operation of the circuit is as follows:—

In the normal condition, i.e., with the battery switched on and the circuit at rest, relays 1 and 2 will have their armatures operated to Mark by 15 milliamperes of positive battery flowing through the 200 ohm battery feed resistor—PR.10 relay windings U to D (two in series)—bias battery meter switching key—bias battery adjusting resistors to earth.

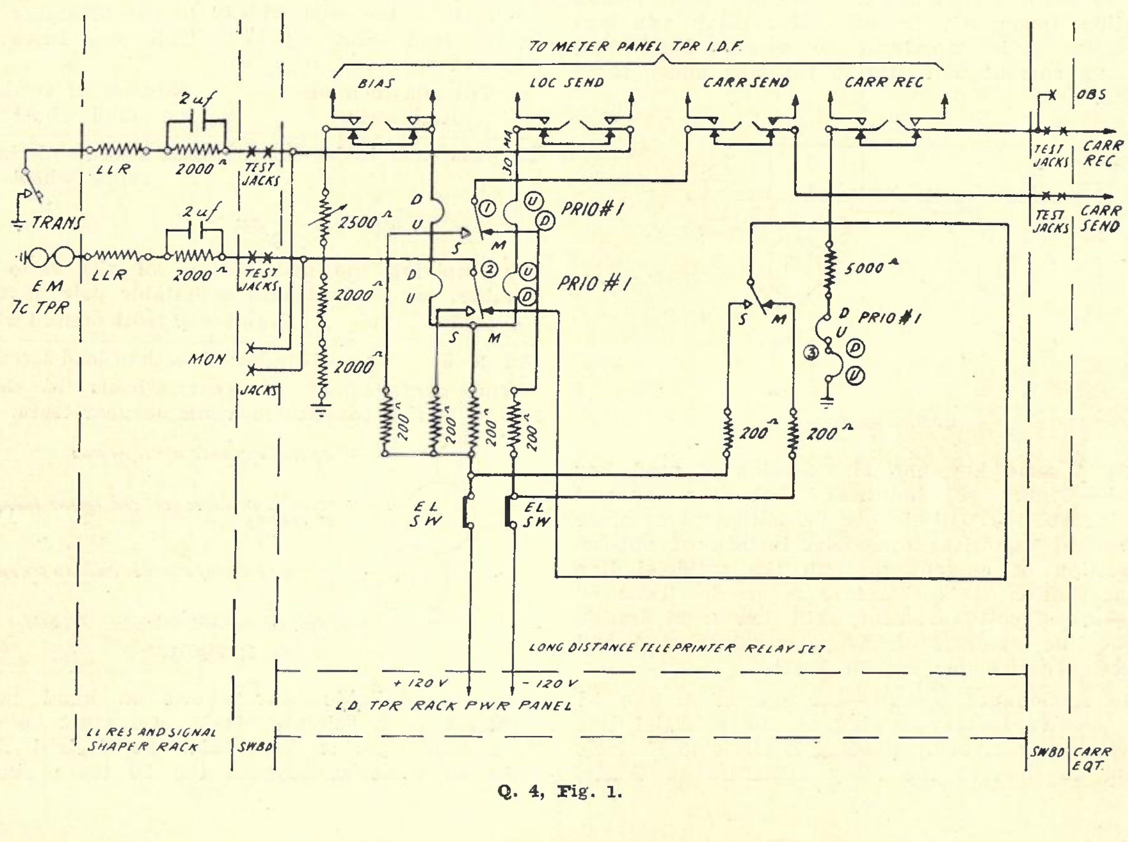
Relay 3 will also have its armature held to Mark by negative battery flowing via the carrier "Receive" relay tongue-test jacks of the telegraph switchboard—5,000 ohm resistor—PR.10 relay winding D and U circle to earth.

The Home Record Relay (relay 2) has its Mark contact connected to negative battery via the tongue of relay 3.

Thus with the circuit at rest the local teleprinter magnet is held in its Mark position. All telegraph relays comprising the Relay Set have their armatures operated to Mark. Similarly, the carrier "send" and "receive" relays are operated in the Mark position.

Space signal incoming from the Carrier channel.—In this case, positive battery will flow from the carrier "receive" relay Space contact to operate relay 3 to its space contact. Relays 1 and 2 will remain steadily operated, but positive battery is now applied to the Mark contact of relay 2 and hence the local teleprinter magnet is caused to space, thereby starting the teleprinter receiving mechanism.

Local Teleprinter transmits a Space signal.—The signals generated by the keyboard transmitter will cause 30 milliamperes of positive battery to flow through the 200 ohm battery feed resistance—PR.10 relay winding D circle to U circle (2 in series) local send meter key—Telegraph Switchboard jacks—2000 ohm plus 2 microfared condenser in parallel—line



Q. 4, Fig. 1.

limiting resistance to earth via the local teleprinter transmitter contacts.

The direction and magnitude of the current through the line windings of relays 1 and 2 overcome the magnetic effect of the steady Bias current and thus operate their armatures to space. Thus relay 1 will repeat the local teleprinter signals to operate the carrier send relay in accordance with the transmitted signals, similarly, relay 2 will operate the local teleprinter magnet to provide a home record copy of the transmission. Also, relay 3 being unaffected by the local transmission, remains steadily held on its Mark contact.

Q. 5.—With the aid of sketches describe the construction of a micrometer gauge and explain its operation.

A.—This question has been previously answered in the "Telecommunication Journal of Australia," Vol. 3, Page 181.

Q. 6.—Describe the operations you would perform to "run in" a Murray Multiplex set, assuming that you are at the corrected station.

A.—The purpose of the "run in" is to synchronise the speed and phase relationship between the correcting and the corrected distributors, in which case the former runs at a constant speed while the latter rotates at a speed which is slightly faster.

Assume that the two terminals of a 4 channel Multiplex system are connected to a Type B carrier circuit and that the "Run in" is about to commence; the operations to be carried out by the corrected or home station would then be as follow:—

Adjustment for line lag.—The corrected station will ensure that the send plug of the Murray terminal box has been set in its working position, i.e., moved in an anticlockwise direction which is equivalent to advancing the send segments of the plateau a predetermined number, which, in most cases, is equal to two or three.

Transmitter Setting.—Both the home and distant stations will ensure that all Murray transmitters are set to space by operating their associated start-stop levers to their "down" position.

Correction Signal.—The distant or correcting station automatically transmits a mark and space signal element from send segments 21 and 22 respectively. This is called the correction signal.

Reception of the Correction Signal.—The corrected station observes the sequence in which the printer magnets are operated and adjusts the vibrator speed until one printer magnet is operated consecutively for 18 to 20 times before the correction impulse moves forward, e.g., say from printer 2 to printer 4, until finally the correction magnet is operated and synchronism maintained.

Reversals.—Once synchronism is established, the home station signifies this by operating the Murray terminal box switching keys to "reversals" thereby causing 50 cycle square topped waves of positive and negative current, supplied from the office reversal generator, to the transmitted to the distant station.

The distant station on observing that reversals are incoming to him will, in turn, transmit reversals to the home station.

Checking Bias of Receive Relays.—Both stations will, if bias is apparent, co-operate with the respective Carrier attendants in its removal, or will effect any necessary adjustment to the telegraph receive relay.

Orientation.—This consists of setting the receive segments to their best position for the reception of signals. When the home station is satisfied with the received reversals he signifies his approval to the distant station by operating his terminal box reversal switching keys 3 times, when the distant station, if ready, will transmit "thirds" by holding the 3rd lever of the first arm transmitter to its mark contact.

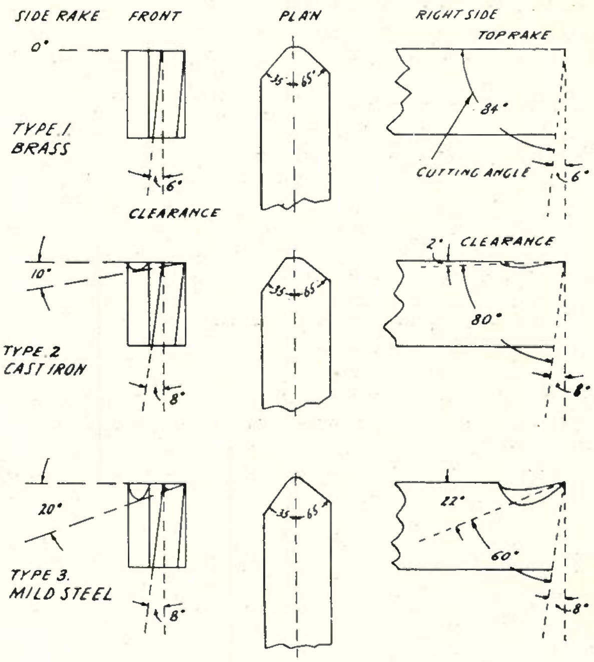
The corrected station will now carefully and slowly adjust the receive ring of the plateau until the 4th printer magnet is, in addition to the 3rd magnet, intermittently operated, i.e., the letter N is printed. This position is then marked. The receive ring is again rotated in the opposite direction until the 2nd and 3rd printer magnets are operated in a similar manner, which results in the printing of the letter I. Finally the receive ring is set to a position midway between the two marked positions.

The corrected station now transmits "thirds" to the distant station who also orients the receive ring of the plateau in a similar manner.

Trial Tapes.—At the completion of the above-mentioned tests both stations will transmit trial tapes on a duplex basis, and if satisfactory, the Multiplex system is ready for traffic.

Q. 7.—Show by means of sketches three different types of Lathe turning tools indicating the purpose for which each type would be used. Explain what is meant by the terms "rake," "clearance" and "keenness" as applied to turning tools.

A.—The diagram shows three types of lathe turning tools that are suitable for turning brass, cast iron and mild steel. In this connection, however, experience is the guiding factor in determining cutting angles, rakes and clearances for the class of



MATERIAL	CUTTING ANGLE	CLEARANCE ANGLE	SIDE RAKE	TOP RAKE
BRASS	84°	6°	—	—
CAST IRON	80°	8°	10°	2°
MILD STEEL	60°	8°	20°	22°

Q. 7, Fig. 1.

work in hand. For example, at high speeds, the tool shape is of great importance on account of the heavier strains involved. Therefore the shapes indicated by Figure 1 are representative of typical tools suitable for use with an ordinary screw cutting engine lathe fitted with sliding and surfacing mechanism and taking medium sized cuts.

Rake.—This is the angle which the top face of the tool makes to the horizontal. If the tool is at right angles to the work, then the angle made to the horizontal and in the direction of the tool is called "top rake," also when the angle to the horizontal is in a direction along the axis of the work, it is given the name of "side rake."

Rake has a great influence on the rate at which the cuttings are removed from the work and also the power required to accomplish its removal. Thus, if a piece of mild steel be turned between lathe centres, and a tool be used without top or side rake, an excessive amount of power will be required. If the tool be given side rake the power consumption becomes less and the surface appearance of the work improves. Giving the tool its correct degree of side and top rake results in further improvement to surface finish with the necessary power being reduced to a minimum. Therefore top and side rake combine to form the cutting edge of the lathe tool.

Clearance.—The angle which the front face of the tool makes with the vertical is called clearance. As in the case of the rake, it consists of two forms, viz., "side" and "front" clearance. If a lathe tool is mounted horizontally in its tool holder and its cutting edge be at a height equal to that of the lathe centres, it will be appreciated that without clearance the front face of the tool will rub against the surface of the work without actually cutting. If now, front clearance is added, cutting takes place. Similarly for sliding operations side clearance is also necessary if the tool is to serve its purpose efficiently.

Keenness.—A lathe tool that is correctly tempered and ground, so that its rake and clearance angles are suitable for the work in hand, will retain its keenness for a considerable period providing the cutting speeds and feeds adopted are within the limits prescribed for the work. In general, both the cutting speed and feed will depend upon:

(a) Toughness and hardness of the material.
(b) Amount of metal to be removed.
(c) Quality of the surface finish.
(d) Rigidity of the lathe.

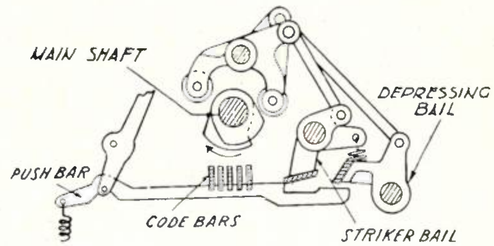
Q. 8.—Describe the "line feed" mechanism of a Morkrum Printer, explaining how the paper is fed upwards when the "line feed" signal is received in the printer. Use sketches to illustrate your answer.

A.—Operation of the Printer Main Shaft.—On the code bar combination corresponding to a "line feed" signal being set up, the sixth pulse magnet of the printer is energised by an impulse from the local ring of the plateau. The sixth pulse magnet armature in operating moves a clutch throwout lever out of engagement with a projection on the periphery of the driven clutch. This allows the driving clutch which is continuously rotating at constant speed to engage with the driven clutch and drive the main shaft one complete revolution.

Main Shaft Cams.—The main shaft of the printer is fitted with seven cams, each of which performs a particular part in the translation of the "line feed" signal.

Code bar locking cam.—The diagram shows how the cam operates a lever and allowing its free end to move into engagement with the notches in the upper edges of the five code bars and thus hold them rigidly in their set position.

Depressing bail cam.—The "line feed" signal having been set up by the code bars and locked in position, will have the slots in the bottom edges of the code bars aligned to form a channel for the line feed push bar to enter when the depressing bail is raised by the depressing cam. Thus all push bars will rise under their own spring tensions, but, in this case, only the line feed push bar will enter the selected code channel formed by the slots in the code bars.

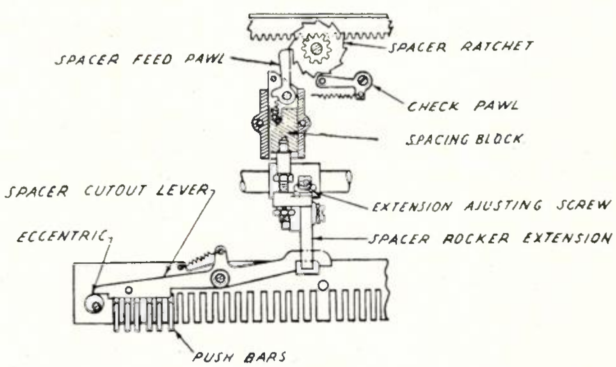


Q. 8, Fig. 1.

Striker Bail Cam. See Figure 1.—Reference to the diagram will show how the striker bail rocker is initially raised against the tension of a spring and then suddenly released at a correct part of the cycle on account of the contour of the main shaft striker bail cam. Therefore, the striker bail moves forward through an arc due to the stored energy of the striker spring and thus strikes the projection of the "line feed" push bar and moving it forward to operate the line feed mechanism. However, a line feed function requires additional power to that supplied by the striker spring and the means of supplying this is described hereunder.

Safety Cam.—The safety cam is fitted next to the striker bail cam on the Main Shaft.

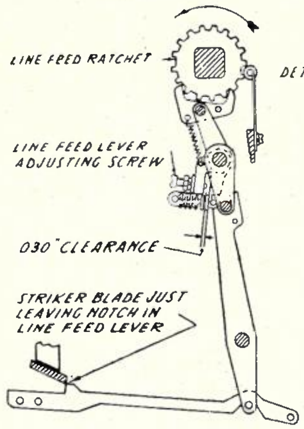
Certain functions such as figures, letters and the bell signal, in addition to the "line feed," require greater power to that for the printing of a character. This is accomplished by means of an extension of the striker rocker being acted on by the safety cam so that when the striker bail is first operated by the energy from the striker spring, the safety cam in following through operates on the extension of the striker rocker and supplies the extra power required to complete the function.



Q. 8, Fig. 2.

Spacing Cam. See Figure 2.—The "line feed" function is not followed by a carriage space as in the printing of a letter. In this case the downward motion of the spacer rocker is prevented by its extension striking the blocking lever and hence the "line feed" function is unaccompanied by a carriage space feed.

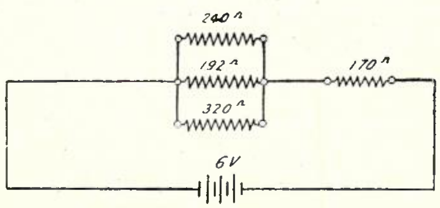
Clutch Throwout Resetting Cam.—All that remains now is to arrest the motion of the main shaft at the completion of its revolution. During the revolution of the main shaft its reset cam restores the clutch throwout lever to its normal position so that the projection on the driven clutch sleeve will, by virtue of its shape, cam itself to the right as it moves into the slot in the throwout lever, thus disengaging the driving clutch and preventing further motion of the main shaft.



Q. 8, Fig. 3.

Detailed description of the line feed mechanism. See Figure 3. — On the feed push bar being operated by the striker bail, the lower end of the pivoted vertical lever moves forward, and hence its upper end in moving backwards will carry with it the lower end of the pivoted short lever. The short lever has fitted to its upper end a double ended feed pawl, whose leading tip engaged with the line feed ratchet wheel and moves the platen forward whilst the trailing tip of the double ended pawl also engages the rear teeth of the ratchet when the forward motion of the platen is completed. Thus constant feeds of the platen are provided for. Also, a detent is arranged to engage between two teeth of the ratchet wheel for each feed position to ensure correct positioning. On the striker bail returning to its normal position the line feed mechanism is also returned to normal under the action of retractile spring tension.

Q. 9.—In the following circuit, what would be the value of the current flowing through the 192 ohm path? The internal resistance of the battery may be disregarded.



Q. 9, Fig. 1.

A.—In Figure 1 let the circuit be designated as follows:—

R1, R2, and R3 = 240, 192 and 320 ohms respectively connected in parallel.
Rp = joint resistance of R1, R2 and R3.
Rs = the series resistance of 170 ohms.
R = total resistance of the circuit.
I = total current in the circuit.
E = E.M.F. of battery.

It can be shown that the total conductance of a number of paths in parallel is equal to the sum of their separate conductances we have:

$$\text{Conductance} = \frac{1}{\text{resistance}} \text{ mhos}$$

$$\text{Joint Conductance} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} \text{ mhos}$$

$$\text{Joint Conductance} = \frac{1}{240} + \frac{1}{192} + \frac{1}{320} \text{ mhos}$$

$$\text{Joint Conductance} = \frac{12}{960} \text{ mhos} \quad \ldots\ldots \quad (1)$$

$$\text{Where Rp} = \frac{960}{12} \text{ ohms}$$

$$= 80 \text{ ohms}$$

$$R = Rp + Rs \text{ ohms}$$

$$= 80 + 170 \text{ ohms}$$

$$= 250 \text{ ohms}$$

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

$$= \frac{6}{250} \text{ amperes}$$

$$= 0.024 \text{ amperes}$$

It can be shown that a current divides between a number of paths in parallel in direct proportion to their respective conductances, from (1) we see that it is divided into 12 parts, 5 of which flow through the 192 ohm branch. Therefore the current in the 192 ohm branch is found by simple proportion, thus:

$$12 : 5 :: 0.024 : X$$

$$\text{Where } X = \frac{5 \times 0.024}{12} \text{ amperes}$$

$$= .010 \quad ,,$$

$$= 10 \text{ milliamperes.}$$

Q. 10.—With the aid of sketches, describe the construction of any polarised differential telegraph relay with which you are familiar and explain its operation.

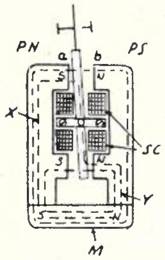
A.—The following refers to the Model No. 27 Creed Polar Relay which is a type of instrument capable of working at high speeds, as required by machine telegraph systems.

Construction.—The complete relay assembly consists of four components, all of which are interchangeable. The cover, frame and electro-magnetic unit form the relay which is removable from its base or fourth component.

The contact screws are platinum tipped and provided with large bakelite knurled heads with faces that are divided into main divisions corresponding to a movement of 0.002 inches. Each main division is again subdivided, thereby allowing adjustments of armature travel to 0.001 inch being effected.

In addition, contact screws are automatically clamped, by a spring loaded friction device, to any set position.

Bias adjustment is carried out by shifting the electro-magnetic unit bodily in relation to the relay contacts by the operation of a screw which is fitted with a large bakelite knurled head, on which is engraved an arrow to denote centrality. Two additional arrow heads are also provided on the bias adjustment screw head to indicate the direction of notation for working spacing adjustment.

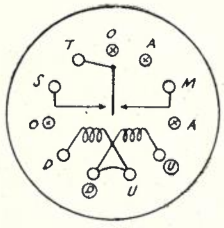


Q. 10, Fig. 1.

Operation.—Fig. 1 shows the armature which is of laminated stalloy centralling pivoted and operating between the laminated stalloy pole pieces, PN and PS, and within the air core of the signalling coils SC. The bar magnet M provides the polarising flux.

When a current flows in SC it produces a flux greater than the component XY due to the permanent magnet, with the result that the armature is operated with increasing velocity in the direction of travel and in accordance with the polarity produced in its extremities by the signalling current, i.e., the armature is shown attracted and repelled at "a" and "b" respectively. Such action results in short transit periods of the relay tongue.

It will be clear that appreciable contact pressure exists due to the polarising flux alone; this feature assists in the elimination of contact bounce, and it is claimed that with signalling speeds of 250 words per minute and operating currents of 6 m.a., only one bounce occurs at each transit of the armature.



Q. 10, Fig. 2.

Figure 2 of Question No. 1 shows the application of differential relays in a differential duplex circuit.

If the artificial line has been correctly adjusted, the passage of current, via the transmitting pole-changer, through the relay windings will be equal in magnitude and phase during each instant of time. Thus the differential winding will produce equal and opposite magnetic effects and, as a result, the relay armature is unaffected during transmission but, in the case of reception, the armature responds to the difference in current values in the two windings.

Figure 2 shows the base connections of a Model No. 27 relay in which terminals designated OO and AA are for use with the auxiliary windings supplied with the Model No. 27V Creed relay.

EXAMINATION NO. 2377.—ENGINEER—TRANSMISSION

J. E. Freeman, B.Sc., A.I.R.E.(Am.)

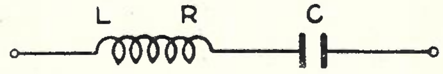
Q. 2.—Describe and illustrate with a diagram the simple form of (1) an acceptor, and (2) a rejector circuit.

Give the formula for the impedance of the combination in each case and indicate the values of impedance at resonant frequency.

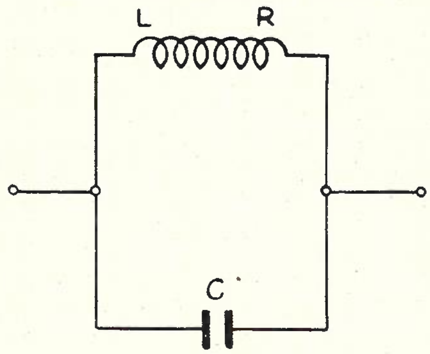
Show by a diagram the impedance versus frequency characteristics of each combination.

Indicate by a schematic diagram at least one method of application of acceptor and rejector circuits in practice.

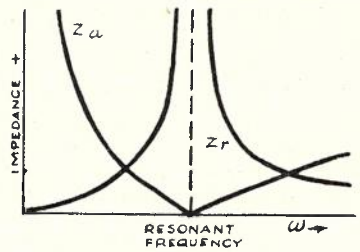
A.—An acceptor circuit has a low impedance at a certain critical frequency and higher impedance at all other frequencies. A rejector circuit has a high impedance at a certain critical frequency and lower impedance at all other frequencies.



Q. 2, Fig. 1.—Acceptor Circuit.



Q. 2, Fig. 2.—Rejector Circuit.



Q. 2, Fig. 2A.

Figs. 1 and 2 illustrate a simple type of each of the two circuits. For the acceptor circuit (a series resonant circuit),

$$Z_A = R + j\omega L + \frac{1}{j\omega C}$$

$$= R + \frac{1 - \omega^2 LC}{j\omega C}$$

At the critical frequency, $\omega^2 LC = 1$ and $Z_A = R$.
For all other frequencies, $Z_A > R$.
The rejector circuit is a parallel resonant circuit and

$$Z_R = \frac{1}{j\omega C + \dfrac{1}{R + j\omega L}}$$

$$= \frac{R + j\omega L}{1 - \omega^2 LC + j\omega CR}$$

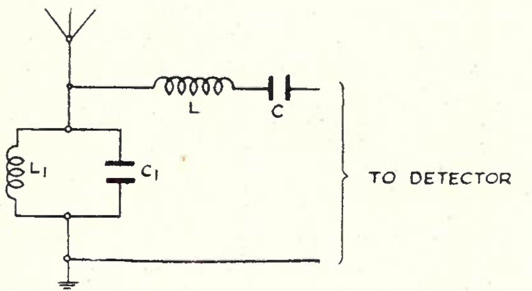
At the resonant frequency

$$Z_R = \frac{R + j\omega L}{j\omega CR}$$

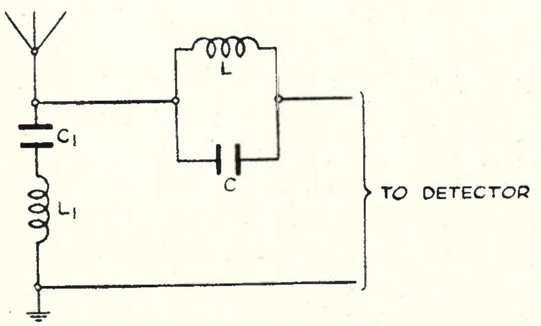
and if R is small compared with ωL, Z_R is approximately equal to $\frac{L}{CR}$.

In the ideal case $R = 0$ and the curves give the impedance versus frequency characteristic of the two types of circuits under these conditions.

Figs. 3 and 4 give two methods of applying simple acceptor and rejector circuits. In Fig. 3 an acceptor circuit L, C is associated with a tuning circuit L_1C_1. The acceptor circuit is tuned to the wanted signal and tends to reduce all interfering signals. Fig. 4 shows a rejector circuit L, C associated with a tuning circuit L_1C_1. In this example the rejector may be tuned to any particular unwanted signal which is thus reduced without affecting the wanted signal.



Q. 2, Fig. 3.

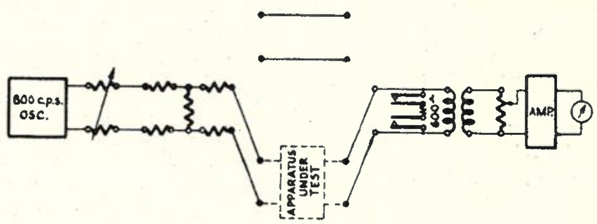


Q. 2, Fig. 4.

In later types of radio receivers, the acceptor and rejector circuits are more complicated, e.g., the intermediate frequency transformer in a superheterodyne set where both the primary and secondary windings are tuned to the required frequency.

Q. 3.—Describe with the aid of an explanatory schematic diagram a transmission testing set suitable for the measurement of transmission equivalents of circuits or apparatus and repeater gains at audio frequencies. Explain the operation of the set.

A.—A transmission measuring set suitable for the measurement of transmission equivalents of circuits or apparatus at audio frequencies is illustrated schematically in the block diagram below. The set consists of an 800 cycle oscillator and a sensitive alternating current voltmeter usually of the copper oxide rectifier type. This combination will provide for measurements at a single fixed frequency of 800 cycles. If measurements are desired over the complete voice frequency range an additional oscillator giving fixed frequencies (300, 500, 800, 1,000, 1,400, 2,000, 2,400 cycles) will be necessary.



Q. 3, Fig. 1.

The receiving unit of the instrument contains a balanced transformer to provide a high impedance input (between 20,000 and 100,000 ohms), and this transformer is terminated in a resistance network to allow the sensitivity of the receiving unit to be varied in 5db. steps. A 600 ohm resistance can be connected across the primary of the transformer to provide for loss measurements. When the resistance is disconnected the set is suitable for level measurements. The resistance divider across the secondary winding of the input transformer is followed by an amplifier with a flat gain characteristic from 200 cycles to 3,000 cycles, and this amplifier is terminated in a copper oxide rectifier type meter. The oscillator consists of a single valve oscillator followed by attenuation pads and a 3-position key. When in use the measuring set is switched on and a period allowed for the valves to warm up. The three-position key on the output of the oscillator is thrown in the upper position, and this connects the oscillator to the input of the receiving circuit so that the output of the oscillator can be adjusted to one milliwatt. The key is then returned to the one milliwatt or —10db. positions. These positions give an output from the oscillator of one milliwatt or —10db. below one milliwatt, and the output of the oscillator is then applied to the apparatus or repeater to be measured. The tone from the output of the equipment under test is connected to the input of the transmission measuring set and a direct loss measurement can be taken. Normally a "calibrate" potentiometer is provided on the receiving portion of the transmission measuring set, but in later types of sets where considerable negative feed back is used to stabilise the gain of the amplifier, it should be necessary to adjust this gain control only at rare intervals. If the apparatus under test is already terminated in 600 ohms, the measuring set is used in the level position and a level measurement taken across the termination of the apparatus.

SECTION 2.—RADIO TRANSMISSION AND ACOUSTICS

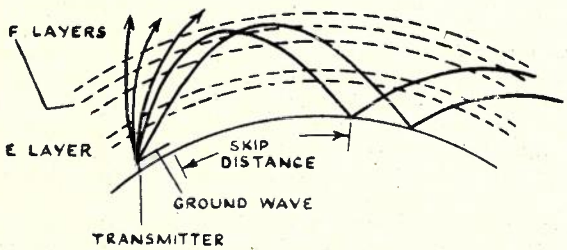
Q. 4.—Describe briefly the part played by the ionosphere in the progagation of short waves. Explain the term "skip distance," and indicate the changes that take place in propagation conditions over long distances as between daylight and darkness.

A.—When electromagnetic waves are transmitted from an antenna, the waves are radiated into space in all directions. In the case of short waves the wave travelling horizontally (the "Ground Wave") is quickly attenuated, and the effective area for reception by means of the Ground Wave is small.

Waves transmitted at an angle to the horizontal are affected by ionized layers which occur above the earth's surface. The earth is surrounded by a layer composed of various gases, the pressure decreasing as the height above the earth increases. It is thought that some of the molecules of these gases are ionized by the ultra violet light of the sun and free electrons are produced. Thus, ionized layers of gas are formed above the earth's surface, although the boundaries of these layers are not well defined. When an electromagnetic wave enters such an ionized layer, the wave is both attenuated and bent by the free electrons in the layer. Low frequency waves are attenuated to a greater degree than high frequency waves in these layers. The amount of bending which occurs in the layer depends on the free electron density in the layer and the frequency of the wave. The complement (β) of the angle of incidence, the free electron density (N), and the frequency (f) are approximately related by the formula:

$$\cos \beta = 1 - \frac{81N}{f^2}$$

If the electron density decreases, it is apparent that the frequency must be reduced if the angle of incidence is to remain fixed. The diagram illustrates the areas covered by the waves from a transmitter.



Q. 4, Fig. 1.

If the angle of incidence is too small, the electromagnetic wave is not returned to the earth at any point. There is thus created (beyond the area covered by the ground wave but too close to the transmitter for indirect radiation to reach a receiver) an area in which only very weak signals are received. These weak signals are due to scattered re-radiation of waves from the upper ionized layers, and the distance between the boundary of the area in which the ground ray is effective and the nearest points at which bent waves return to earth is called the "skip distance."

During the night, the electron density in the ionized layers decreases due to the absence of ultra violet radiation from the sun, and it may be necessary to lower the frequency of the radio wave to permit satisfactory reception in the required area. The electron density rises to a maximum during the day and falls to a minimum during the night.

Q. 5.—It is desired to construct a 10 kilowatt broadcasting transmitter for operation in the medium-wave band.

The transmitter will be required to be in operation continuously for 18 hours daily. Give a description of the principal points in design which you consider should be incorporated in the various stages, and power supply, to ensure high efficiency and stable operation of the transmitter.

A.—A transmitter which is to operate 18 hours per day throughout the year must be designed to operate satisfactorily in the climatic conditions prevailing at the site named. The design, workmanship, materials, and finish should be of the highest quality, and the latest developments and best features of electrical communication practice should be embodied. All parts of the transmitter should comply with the specifications of the Standards Association of Australia where such exist, and wiring should meet the requirements of the S.A.A. Wiring Rules. Smoothing Inductances should stand a test voltage of twice the working voltage when applied between the winding and frame.

The transmitter should be constructed on a unit basis both electrically and mechanically. Each unit should be capable of being lined up independently and without interaction on other units, and the power converters for filament, grid bias, and anode circuits should be associated with the unit. The coupling between the final amplifier and the transmission line should be of the balanced type (R.F. transformers with electrostatic screens). The transmitter must be capable of being tuned over a specified range (usually plus or minus 10 per cent. of a nominal frequency), and must be capable of working over the whole band when tuning inductances and tuning condensers have been suitably altered.

The following conditions apply to the master oscillator in order that the carrier frequency of the transmitter shall remain as close as possible to the specified frequency:—

(a) The master oscillator should be of the piezo-electric crystal type, and the temperature coefficient should be less than two parts in a million per degree Centigrade—the temperature of the crystal should be oven controlled.

(b) The tuning range of the master oscillator should be plus or minus 30 cycles.

(c) The frequency drift for all operating conditions of voltage variation, tube replacement, ambient temperature changes, and changes from artificial aerial to radiator shall be less than plus or minus 10 cycles.

Measuring instruments should be provided for the following purposes:—

(a) To check plate currents of every tube except rectifiers.

(b) To check grid and screen current for each R.F. tube (size 20 watts or more).

(c) Measurement of circulating R.F. currents in every amplifier stage output (size 20 watts or more).

(d) To check output voltage for each power converter (filament grid bias or anode).

(e) To measure the R.F. current in the artificial aerial or transmission line.

(f) To check the voltage of the 3-phase power supply.

(g) Water flow meters to ensure the efficient operation of the cooling system.

(h) Meters to indicate leakage currents in the cooling system.

(i) "Elapsed time" meter to indicate the total operating time of the transmitter in hours.

All meters should be easily visible from the front of the transmitter.

All tubes should be readily replaceable, and where hot cathode mercury rectifier tubes are used, one spare of each type should be provided (wired so that the filaments are always hot). All condensers should have a working rating of at least 750 volts. The working voltage should be 25 per cent. greater than the voltage applied under 100 per cent. modulation conditions, and condensers for rectifiers should be rated at 25 per cent. above the maximum working voltage. All condensers in rectifiers should be fused.

It is desirable that anode, grid bias, and filament supplies should be obtained from power converters and not rotary machines. Filament transformers should be tapped and large tubes should have individual filament voltage controls. The final output stage should be designed to feed an 80 ohm coaxial transmission line or an artificial aerial, and the artificial aerial should be water cooled where necessary. The water cooling system should be provided with duplicate water pumps, and air cooling should be provided by means of dust-proof cabinets with forced draught ventilation. The contractor should supply spare parts where considered necessary (in the case of tubes normally 100 per cent. spares).

A control system should be provided to give remote control by means of push buttons, and so interlocked that the transmitter cannot be damaged by faulty operation (i.e., a warming-up period should be provided for filaments; pumps and fans then operated, and then the anode voltages applied with automatic time delays). In the case of anode voltages between 2,000 and 6,000 volts the application of the anode voltage should be made in two steps. For anode voltages above 6,000 volts switching should be accomplished in three stages and removed in a similar manner.

Facilities should be provided on each stage after modulated amplifier for audio frequency monitoring, and a diode rectifier should be connected across the output stage to provide for loud speaker monitoring and a modulation indicator.

Relays and other security devices should be supplied to give visual and audible alarms. Safety switches should be provided on doors and enclosures to give complete protection to personnel operating the transmitter. Covers, cages, or doors should be provided for all dangerous apparatus.

The transmitter should conform with the following transmission requirements. The overall response of the transmitter between 30 and 10,000 cycles should lie within plus or minus 1 db. (using 1,000 cycles as reference), and it should operate from a power of 6 milliwatts delivered to the speech input equipment. When measured at 400 cycles and with the transmitter 80 per cent. modulated, all audio frequency harmonics should be 30 db. below the fundamental, and at 96 per cent. modulation the harmonics should be 26db. below the fundamental. The signal to noise ratio of the transmitter below 250 cycles and at 40 per cent. modulation should be greater than 52db., and greater than 60db. for 100 per cent. modulation. Above 250 cycles the signal to noise ratio should be greater than 62db. for 40 per cent. modulation, or greater than 70db. for 100 per cent. modulation. The voltage of the dominant harmonic of the radio frequency output of the transmitter should not exceed .2 per cent. of the fundamental and when the transmitter is terminated in an artificial aerial, stray radiation should be very small. The transmitter should be designed for ease of maintenance and routine tests.

Q. 6.—Explain why it is necessary to provide special treatment for the interiors of rooms which it is proposed to use as broadcasting studios. Describe a form of treatment suitable for an average sized studio for musical productions.

Why would it be unsatisfactory to provide identical treatment in all studios irrespective of their size and purpose?

Earlier types of studios often suffered from a trouble described as "boominess." What would you expect to be the cause of this trouble, and how could it be avoided?

A.—When sound emanates from a source in a closed room it is partly absorbed and partly reflected by the ceiling, walls, floor, and other objects and materials in the room, just as light is reflected by a mirror. Ordinary materials, such as timber, plaster, glass, etc., reflect over 95 per cent. of sound striking them, so that in a room finished in these and other reflecting materials a great many reflections occur before the sound becomes inaudible.

There are two effects of this multiple reflection, the first being a building up of intensity to a level greater than would be produced by direct sound alone, due to addition of sound intensity of reflected waves. The amount by which the direct sound intensity will be increased will, of course, depend on the percentage of absorption which occurs at each reflection. However, in the acoustics of the studio we are concerned with the quality of sound rather than the quantity, so this effect need not be given further consideration.

The second effect may be described as follows:—After the sound source ceases to operate reflections continue, and the intensity decreases or decays in accordance with an exponential curve (i.e., it decreases by equal percentages in equal time intervals as some of the energy is absorbed with each reflection). This phenomenon is described as reverberation, and it will be excessive in a room having surfaces of low absorptive values. In either music or voice production, the prolonged sound will cause very bad blurring and overlapping of syllables or notes.

The reverberation time may be defined as the time necessary for the average intensity to decay to a value one-millionth of its initial average intensity. The reverberation time depends, therefore, not on the intensity but on the quantity of absorbing materials in the room and their absorbing capacity. It is necessary, then, to analyse the studio and see that enough sound absorbing surfaces are provided to ensure a suitable reverberation time. The reverberation time is usually calculated by the Sabine formula:—

$$t = \frac{0.05V}{a}$$

where t is the reverberation time, V the volume of the room in cubic feet, and a the number of absorption units.

The unit of absorption is one square foot of a material which absorbs all sound that strikes it. Such a surface is said to have a coefficient of 1.0, or an absorptivity of 100 per cent. The number of units provided by a particular material is found by multiplying its area by its coefficient. In calculating the reverberation time it is essential that only effective areas of absorption be used. For example, in an auditorium, calculations are made for reverberation times under various conditions and an average used; when the theatre is empty the absorption afforded by upholstered seating might be included, but when an audience is present the units allowed previously for seats now occupied must be omitted and the units provided by the audience substituted.

For the smaller types of studio in which the reverberation time is less than one second a correction to the Sabine formula is necessary, the form then being:—

$$t = \frac{0.05V}{-S \log_e (1 - a_1)}$$

where S is the total surface area of the room and a_1 is the average coefficient of absorption obtained by dividing S by a.

An approximation of this is:—

$$t = \frac{0.05V}{a} - \frac{.027V}{S}$$

As the reverberation times of studios are required to vary according to their uses and volumes, it is not possible to set down any set scale of values, but the following ranges for different volumes would be suitable for the most usual types of studios:—

Speech studio	3,000 cub. ft.	—0.5 to 0.7 sec.
Small dramatic studio	7,000 ,,	,, —0.6 to 0.8 ,,
Small music studio	7,000 ,,	,, —0.6 to 0.9 ,,
Orchestral studio	50,000 ,,	,, —0.8 to 1.2 ,,
Public participation studio	50,000 ,,	,, —0.8 to 1.3 ,,
Auditorium (concert)		—1.0 to 1.4 ,,

In the last two cases the reverberation time will vary according to the size of audience present.

As the amount of absorption by an acoustic material varies somewhat according to the frequency, it is necessary to adopt an average. Usually the coefficient of absorption at 512 cycles is employed, and the above reverberation times are calculated using such a value.

Having decided upon the reverberation time and the number of absorption units required for a new studio of specific purpose, the types of absorbing materials to be employed and their positions are next to be considered. An acoustic material with very high absorbing capacity is not necessarily the best for a particular studio, as, theoretically, only a small area of this material would be required to give a satisfactory reverberation time, perhaps only enough to cover part or the whole of one wall, in which case sound would be reflected backwards and forwards between two other parallel reflecting walls for too long a period. As a general principle, of two opposite and parallel or nearly parallel surfaces, one should be reflecting and one absorbent.

A form of treatment suitable for an average sized studio for musical production can be obtained by lining the walls with perforated plywood. The plywood is usually arranged to form concave surfaces and the space behind the plywood is filled with rock wool.

In summing up, it might be said that different studios require different treatments because of:—

(a) The different reverberation times which have been found best suited for studios of various purposes.

(b) The differences in quantity and quality of absorbing materials necessary in different studios according to their volumes and positions and forms of reflecting surfaces.

"Boominess" occurs in small speech studios when one dimension of the room coincides with the distance between successive nodes of a standing wave at a particular frequency. The studio then resonates at that frequency, and this tone will have greater amplitude than the remainder of the voice frequencies. A similar effect is also produced when the material used for sound treatment has a low coefficient of absorption at the low frequencies compared to that at high frequencies. Draping with curtains or the use of certain of the older types of sound absorbent materials gives this effect. "Boominess" can be reduced by placing a screen of perforated zinc (lined with rock wool) behind the speaker, but, in new studios, the dimensions of the room would be chosen so that "boominess" would not occur.

EXAMINATION NO. 2377—ENGINEER—TELEGRAPH EQUIPMENT

A. R. Glendinning

Q. 3.—Describe the Murray Multiplex system generally, and explain with the aid of simple sketches how the code when perforated on the tape is transmitted to line, and how the received signals are translated into printed characters.

A.—The Murray Multiplex is a multi-channel telegraph system for simultaneous transmission and reception of intelligence between widely separated points. There may be 2, 3, or 4 duo-directional channels available depending on the type of system installed and the requirements of the traffic load offering at the point connected. The number of channels provided is also limited by the class of circuit over which the system is to operate.

The transmission of a signal is effected by means of a perforated tape which is fed directly into the transmitter at the perforator position. This tape is of the paper type used on automatic telegraph apparatus, but the 5-unit code is perforated across the tape. The tape is fed forward in the usual manner by a feed wheel engaging in a perforated centre line.

The reception is of the direct page printing type, and each printer is actuated by the line impulses received through the line relay. The channel speed is normally set at 45 words per minute, transmitting and receiving; i.e., 90 words per minute per channel. As all channels of the system are allotted equal portions of the line time in turn by means of a distributor, the effective output of a 4-channel system is 360 words per minute.

The distributor consists of 3 segmented brass outer rings and 3 continuous inner rings, over which 3 brushes, spaced at 120deg., revolve. One segmented ring and one continuous ring form a pair which, when shorted by a revolving brush, complete a circuit. The brush arms are driven by a phonic motor controlled by a vibrator. By sending a correction signal from a correcting segment on the second, or transmitting ring, from one station to the other, synchronism between the brushes is maintained. This correction signal operates a correction magnet connected to a special segment in the receiving ring. On operating, the correction magnet thrusts a pin into the path of a star wheel which is geared to the brush. This gear train is driven by the phonic motor. The gears are so arranged that the action of the pin has the effect of retarding the brush arms 1½deg. relative to the phonic wheel, but the speed of the wheel is uniform and is not affected by the correction operation. Only one station will send correction, and it follows that the corrected station must run faster than the correcting station. This speed difference is about 0.2 per cent.

To correct for line lag the receive ring on the distributor is movable. By this means the receive segments are moved relatively ahead so that the distant receive brush will reach the corresponding receiving segment relative to the transmitting segment at the send end at the instant the signal arrives.

The printer used is of the Morkrum page printing type, and is essentially a motor driven typewriter. The incoming signals from the five segments appropriate to the channel on the receiving ring are passed through by the receive brushes, in sequence, to five selector magnets which operate code bars notched on the underside. According to the number of code bars operated in response to the code combinations, certain notches are brought in line and a push bar controlling the type bar is allowed to rise, following the cam operation of the depressing bail, into the slot formed. These push bars are linked to the type bars, and the code signals have thus set up a letter for printing. From this point the printing of the letter requires the operation of the 6th pulse magnet which receives an impulse from segments on the 3rd, or local ring, at each revolution of the brush. This magnet controls the operation of the clutch on the driving spindle, and when operated connects the motor to the spindle, setting up a sequence of mechanical oprations.

The clutch is only engaged when the 6th pulse magnet is fully operated. This magnet is restrained from fully operating at each revolution of the brushes, which necessarily complete the magnet circuit and energize the magnet, by a mechanical link with the selector magnets. On operation of any selector magnet this link, known as the cut-out lever, disengages from an extension of the 6th pulse magnet armature which is then allowed to move freely and throw the main shaft into engagement with the driving shaft. When the selector magnets have set up the code bars, their armatures with their selector levers immediately restore to await the next code impulse combination. The code bars are held in the set up position by a locking lever until the sequence of mechanical operations subsequent to the operation of the 6th pulse magnet are complete. The striker bail thrusts down on the push bar which, through a link, starts the end of the type bar carrying the pallet towards the platen. The striker bail does not transmit a thrust to the type bar throughout the whole of this travel, and the energy of the sudden blow is sufficient to carry the type bar the remaining distance to the platen.

The sequence of mechanical operations begun by the operation of the 6th pulse magnet can be summarised thus:—

(1) Causes the main shaft to revolve which:

(a) locks the code bars;

(b) operates a cam and reset bail, which releases the selector levers to their unoperated position;

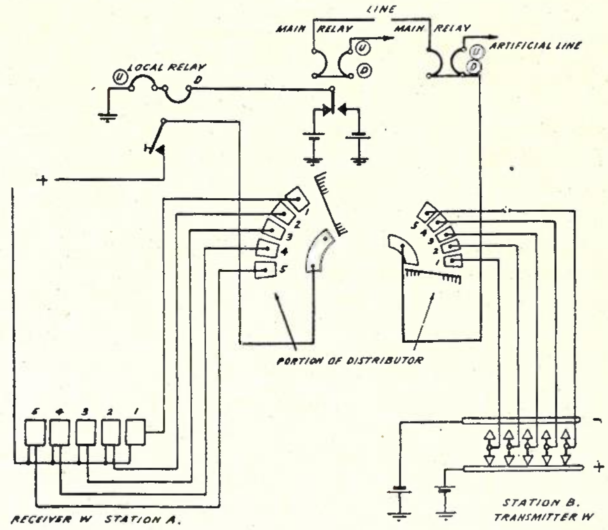
(c) Operates the cam which raised the depressing bail and allows the push bars to rise until the one selected by the code combination is forced by its spring into the path of the striker bail;

(d) operates striker bail;

(e) releases lock on code bars and restores depressing bail which clears push bars from code bars.

(2) Finally, the main shaft is thrown out of engagement.

The printer carriage is automatically fed forward and all cams, links, and shafts return to their normal position until the 6th pulse magnet operates again. Carriage return, space, line feed, and figure shift are all transmitted by code combinations.



Q. 3, Fig. 1.

Figure 1 shows the elements of the circuit for the operation of one transmitter controlling a distant printer. The selector needles which control the contact levers in the transmitter pass through the perforations in the tape and set up combinations of marking and spacing signals on the five transmitting ring segments comprising the particular channel, and these are swept into the line by the brushes. The tape is fed forward by the energising of the cadence magnet from the local ring. The signals are received via the appropriate receiving segments at the receiving end, and the printer operates as described above.

Q. 4.—A teleprinter installation is required in which two local offices and one distant office require full intercommunication.

(1) Prepare a schematic diagram of the circuit arrangements you would suggest.

(2) Prepare a list of apparatus you would require for the installation of the relay set at the control C.T.O.

Assume the line to the distant station will be provided over one channel of voice frequency telegraph carrier system.

A.—(1) See Fig. 1.

(2) The components required for the installation of the relay set at the C.T.O. are:

3 Polarised relays (such as Creed 27 V., No. 1 or 2 winding, or PR. 10, No. 1 winding),

6 200 ohm vitreous resistances,

1 adjustable resistance, 8,000 ohms or more,

6 adjustable resistances, 2,000 ohms,

6 2,000 ohm vitreous resistances,

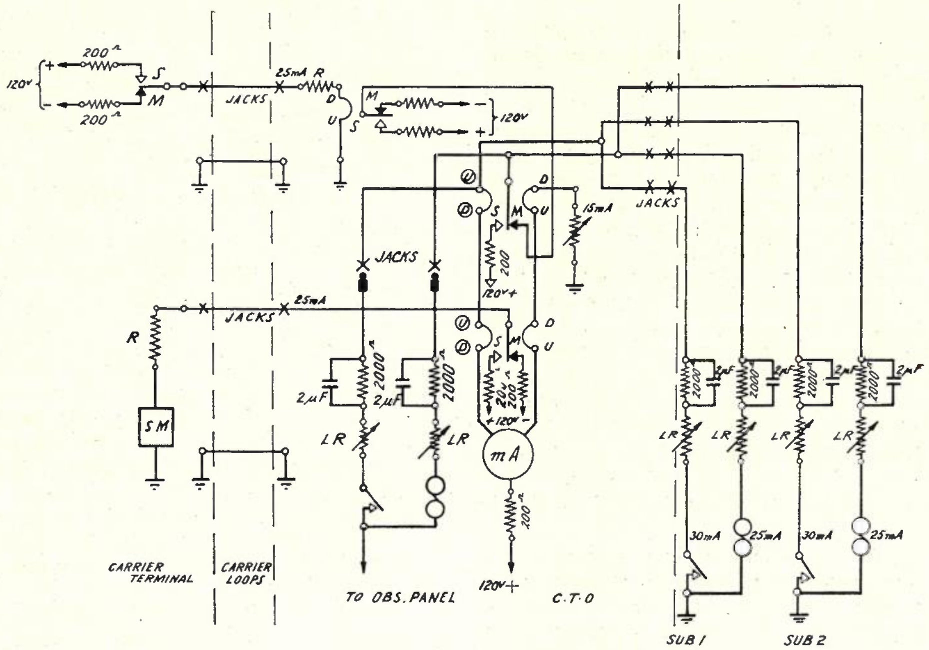
1 5,000 ohm vitreous resistance,

6 2mfd condensers,

1 milliammeter, 50-0-50 scale.

It is assumed that leads are taken to the observation panel jacks for monitoring and use made of the common equipment.

Washing and drying equipment for machine parts would be provided, also a storage bin for parts and tools, and another storage bin suitable for storing



Q. 4, Fig. 1.

materials of an inflammable nature, such as oils, etc.

Q. 5.—Prepare a list of equipment you would require to establish a telegraph maintenance workshop at a large C.T.O. where Murray Multiplex, Teleprinter, Manual Duplex, and Simplex apparatus is installed.

A.—The equipment provided can be divided generally into two groups under the heading of Repair and Maintenance equipment and Test equipment.

1.—Repair and maintenance will require the installation of:

General purpose bench vices, 3in. jaw	8
Work benches, 7ft. x 3ft.	8
4½in. motorised S.C. lathe, floor type, 36in. bed	1
Milling attachment for above	1
Tool grinding head for above	1
4½in. motorised precision lathe, bench type, w/o screw cutting facilities, 20in. between centres	1
Quill chucks, 1/32in.-⅜in.	1
Independent 4-jaw chuck	1
Universal 3-jaw chuck	1
Drilling machine, motorised, sensitive, pedestal type, ½in. chuck	1
Drilling machine, motorised, sensitive, bench type, 3-16in. chuck	1
Set drills, ¼in. to ½in.	1
Sets taps and dies:—	
Whitworth	1
A.S.M.E.	1
B.A.	1
Set reamers, ⅛in. to ½in.	1
Set reamers, adjustable	1
Screw thread gauge	1
Small anvil, blowpipe, and forge	1 each

All machines and attachments to be complete with tools and cutters. In addition, provision should be made for miscellaneous gauges and calipers, and one each micrometer, internal and external, 0in. to 2in., to be supplied.

2. Requirements for testing telegraph equipment are as follow:—

1 power panel, providing:
(a) A.C. voltages from town mains.
(b) D.C. voltages: 4 V., 6 V., 24 V., 30 V., 120 V., and 240 V.

2 Teleprinter test sets.
2 Murray Mux test sets.
1 Wheatstone test set (if this system in use).
1 Reversal generator.
1 Test panel, equipped with:
Wheatstone Bridge, 500 V. megger, voltmeter A.C., 0-500 V.; voltmeter, D.C.; 0-240 V.; ammeter, 0-100 amps. Milliammeter 50-0-50 ma.; relay test set, and distortion measuring set.

2a. Portable test equipment, comprising the items listed below, are required to test fixed equipment on tables and office wiring:

1 Bridge megger, 500 V.
1 Avometer.
1 Portable tone generator or test buzzer.

Q. 6.—Between a C.T.O. and a large country centre where a voice frequency telegraph system is available, discuss the apparatus you would require to dispose of a peak hour traffic load consisting of 16,000 words in each direction.

A.—Assuming that an 18-channel V.F.T. system is in existence between the offices, the question becomes one of providing the most economical and efficient means of handling the traffic load. Manual operation would be rejected, as this would be wasteful both in manhours and channel provision, so the use of machine telegraph systems is indicated. For an 18-channel system the maximum specified transmission speed is 66 bauds, and transmission speeds in excess of this limit cannot be considered. Because of this variation in speed, the use of the triple Murray Multiplex, which operates at a transmission speed of 76.5 bauds, could not be entertained.

1. The systems to be considered, therefore, are:
(1) Double Murray Multiplexes, phonic motor speed 270 r.p.m., transmission speed 54 bauds.
(2) Teleprinters, 7C transmitters, and 8C receivers, transmission speed 50 bauds.
(3) Teleprinters, transmitting by tape from 6S transmitters, and 8C receivers, transmission speed 50 bauds.

The speed in words per minute per transmitter for (1) is 45 words. Although the keyboard transmission speed of a 7C teleprinter is theoretically 71 w.p.m., due to the use of the 7-unit code, in practice it is not considered possible to maintain a continuous rate of operating greater than 45 w.p.m., and (2) has been rated accordingly. For (3) the transmission from the 6S Transmitter is on the basis of 7½ signal elements per character, which at 50 bauds corresponds to 66 w.p.m.

2. The carrier channels required to move the load under each proposal are:
(1) Double mux sets; 45 w.p.m. per transmitter,
= 45 x 2 x 3 for three systems
= 270 w.p.m. or 16,200 words per hour on three carrier channels.
(2) Teleprinters 7C, 45 w.p.m. per transmitter,
45 x 6 = 270 w.p.m. from 6 transmitters
= 16,200 words per hour on six carrier channels.
(3) Teleprinters, tape, 66 w.p.m.
66 x 4 = 264 w.p.m. from 4 6S transmitters,
= 15,840 words per hour on four carrier channels.

3. Personnel required for operation:
(1) 6 perforating and transmitting, 6 receiving. Total 12.
(2) 6 transmitting, 6 receiving. Total 12.
(3) 2 feeding transmitters, 6 perforating, 6 receiving. Total 14.

It is estimated that at 66 w.p.m. per receiver, two more operators than there are positions would be required to handle the traffic, and on the transmitting side 6 operators perforating at a speed of 45 words per minute would be necessary to keep four 6S transmitters fed at 66 w.p.m.

4. For the comparison of equipment costs it will suffice to discuss the provision of one office.

Equipment cost:

(1) 3 Double Multiplexes

3 Plateaux at £38 each	£114	0	0
3 Vibrators at £36 each	108	0	0
3 Phonic motors at £78 each	234	0	0
6 Morkrum Printers at £185 each	1110	0	0
6 Perforators at £45 each	270	0	0
6 Transmitters at £36 each	216	0	0
3 Distributor boxes at £21 each	63	0	0
	2115	0	0
Plus 25 per cent. for spares	528	15	0
	£2643	15	0

(2) Teleprinters:

6 7C transmitters at £130 each	£780	0	0
6 8C receivers at £110 each	660	0	0
	1440	0	0
Plus 25 per cent. for spares	360	0	0
	£1800	0	0

(3) Teleprinters, tape, transmitting:

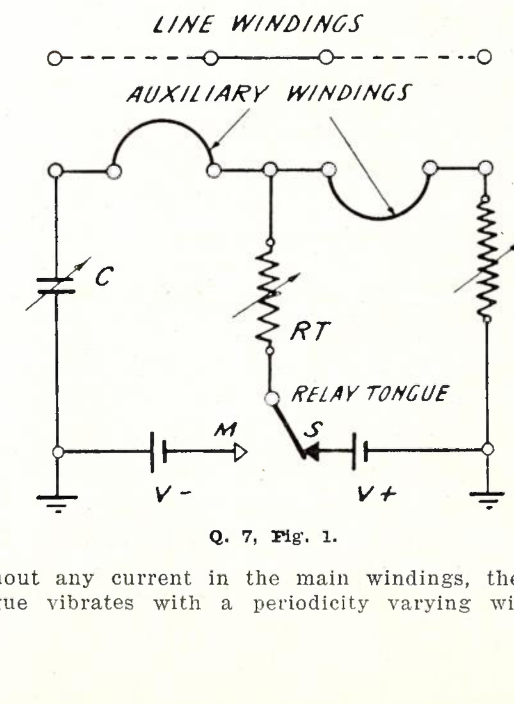
4 8C receivers at £110	440	0	0
6 perforators at £45	270	0	0
4 6S transmitters at £45	180	0	0
	890	0	0
Plus 25 per cent. for spares	222	10	0
	£1112	10	0

5. On a comparison of equipment cost alone, No. 3 is the most economical, but the number of personnel required for operating is highest, and four channels are required. From the operating disabilities alone this proposal would be passed over.

Proposals (1) and (2) are equal as far as the number of operating personnel is concerned, but No. 2 is much better on equipment cost. The carrier channels required for No. 1, however, are only half the number required for No. 2, and from consideration of the traffic load between the terminals there would be other circuits, such as news service, private teleprinter, and other telegraph circuits to be provided. Thus the annual charges on the difference in equipment cost (say £800) would be £80 at 10 per cent., and this small amount is nowhere near the earning capacity of three telegraph channels. Proposal No. 1 is therefore to be preferred.

Q. 7.—Describe fully the operation of a vibrating gulstad relay.

A.—The gulstad relay is of the polarised differential telegraph type with the addition of an auxiliary winding. This winding is connected to a local circuit as shown in Fig. 1. When allowed to run freely, i.e.,

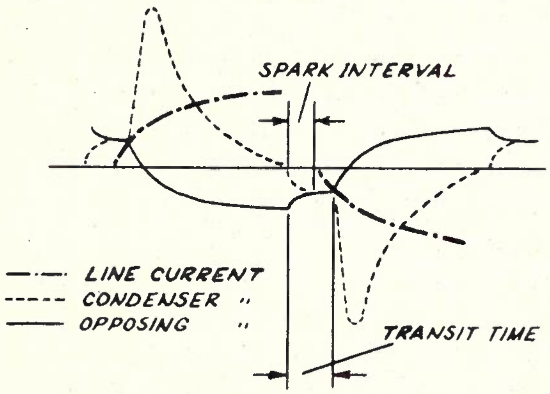


Q. 7, Fig. 1.

without any current in the main windings, the relay tongue vibrates with a periodicity varying with the charge and discharge rate of the condenser C and the time required to build up the operating current in the right hand coils. The periodicity is controlled by the condenser value, and voltage applied, and the resistances Rt and R. The design of the relay may vary with the different manufacturers, but the gulstad principle is fundamentally the same in all.

Should the battery be switched on with no current through the main windings of the relay and the tongue resting on contact S, condenser C begins to charge through the left hand winding in such direction that the tongue is held on the spacing contact; but this charging current is only transient, and current flows through the right hand coils. When the latter current exceeds that of the condenser charging current the relay tongue moves across from space to mark. As soon as the tongue leaves the contact the condenser discharges through both windings in series, thereby assisting the steady current in moving the tongue across the gap.

With the tongue on the marking contact the condenser is again charged, but with the opposite polarity, and the charging current through the left-hand coils moves the tongue across to spacing. The condenser discharge again assists the magnetisation by passing through both coils in series. This cycle continues as long as voltage is applied. The currents in the auxiliary windings should be so limited that they are not great enough to take control when the line coils are energised or the incoming signals will be broken up. The rate of vibration should be set to equal that of the distant transmitter. Thus when received dots are so attenuated by the line that they would fail to operate the relay these dots are inserted by the local vibrations and signalling speed thereby increased. Although the vibrations are suppressed during the reception of a dash the signal is improved by the reduction in transit time of the tongue



Q. 7, Fig. 2.

and the transient condenser currents tend to hold the tongue on the contact and reduce contact bounce. Fig. 2 shows the relation of the various currents which control the relay operation. Chain dotted curves indicate the line currents which suppress the vibratory action as long as they are of sufficient strength.

When marking current is in the line the position is as follows:—

1. Line current keeping relay to mark.
2. Accelerating coil current keeping relay to mark.
3. Opposing coil tending to space. Condition 2 is only transient and the final condition is 1 and 2 in opposition.

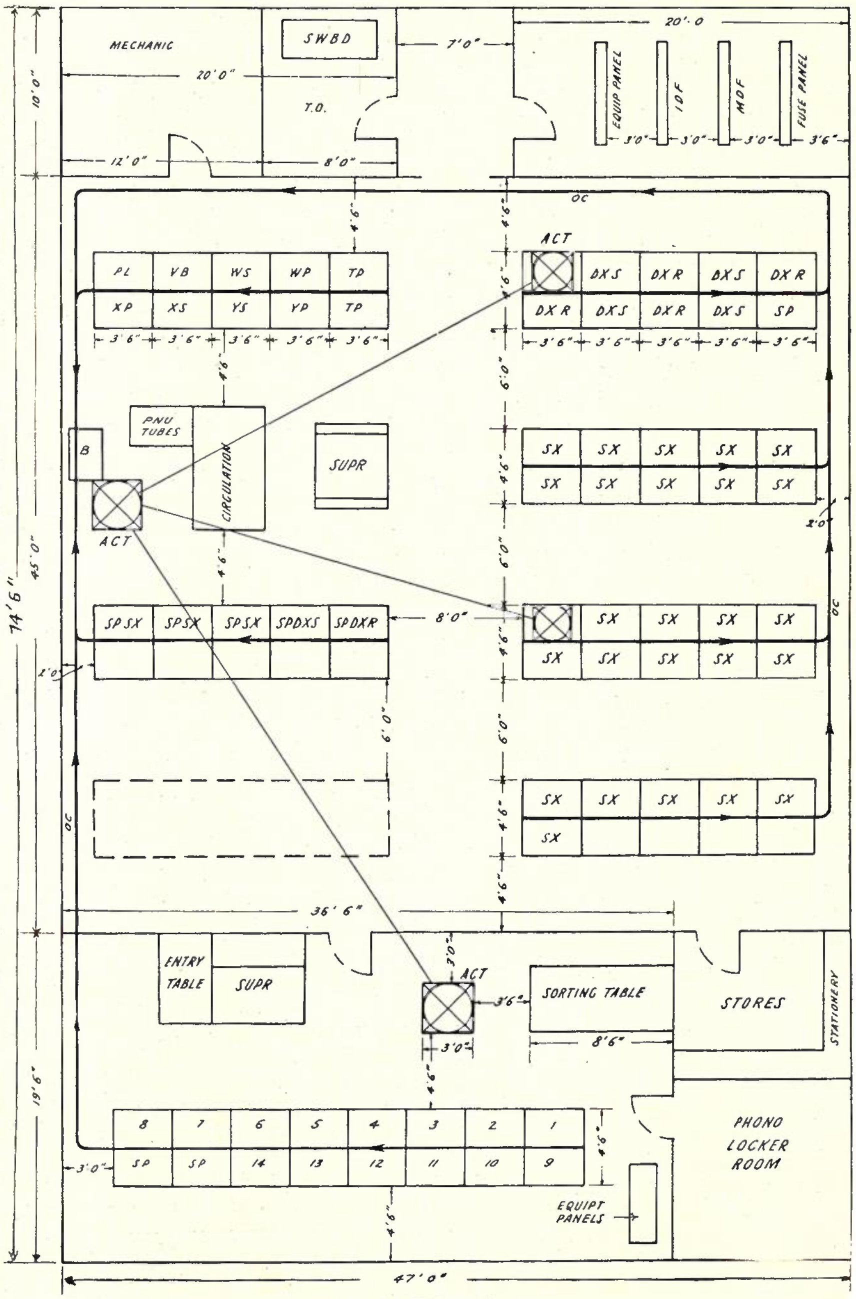
Q. 8.—Prepare a floor plan layout for a large telegraph office to be equipped as follows:—

1 triple Multiplex system.

4 manually operated duplex sets.

25 Simplex sets.

15 Phonogram positions.



Q. 8, Fig. 1.

A.—A floor plan is shown in Fig. 1. For development 15 telegraph positions have been provided as spares; five of these have been equipped for emergency. Space is available for another table. In the phonogram section two spare positions (unfitted) have been provided and space for two additional positions.

FIG. 1 LEGEND

A.C.T.—Kickback Carrier Terminal.
O.C.—V Belt Conveyors.
T.P.—Multiplex Test Positions.
V.B.—Vibrators.
P.L.—Plateau.
D.X.—Duplex.
S.X.—Simplex.
B.—Bin.
S.P.—Spare position.

EXAMINATION NO. 2377—ENGINEER—TELEPHONE EQUIPMENT

E. J. Bulte, B.Sc.

Q. 1.—Correction to answer in Vol. 4, No. 5, p. 320. Part (b) (iii). The calls lost will be those originated during the 6 minutes all switches are engaged, i.e., 0.1 of busy hour. The 72 calls connected must have been originated during 0.9 of the busy hour, therefore calls lost =

$$\frac{72}{0.9} \times 0.1 = 8.$$

(iv.) $\text{Grade of Service} = \frac{\text{calls lost}}{\text{calls offered}} = \frac{8}{80} = 0.1.$

the following in a 2,000 type automatic exchange:—

(i) primary start relay set;
(ii) primary control relay set;
(iii) primary allotter;
(iv) primary finder.

(b) What arrangements are made for the simultaneous hunting of primary line finders?

(c) How is the simultaneous allocation of two primary controls to the one primary line finder prevented?

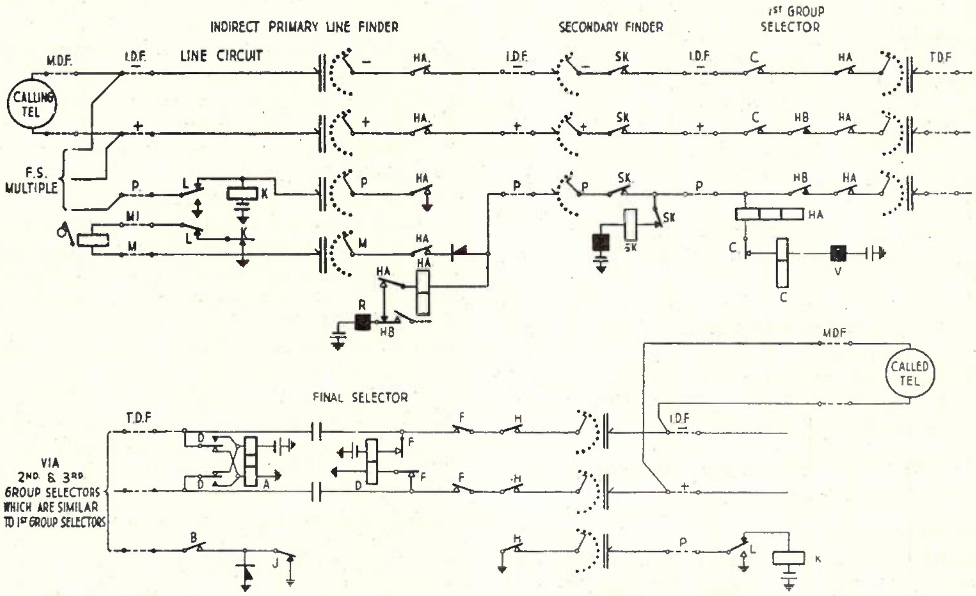
(d) Indicate the main functions of six of the following relays in a primary control relay set:—ST, LK, VR, SF, SFR, VT, RS, G, TA, TB.

A.—(a) (i) One primary relay set is provided for each group of 200 subscribers' lines to perform the following functions:

1. Detects when calls originate in one or more of 5 sub groups of 40 lines and starts circuit operation of primary control relay sets, one of which is brought into use for each sub group in which a call is waiting. If two or more calls are waiting in the same sub group only one at a time can be handled.

2. Detects when all direct primary finders in the group are engaged and causes subsequent calls to be routed via indirect primary finders until a direct finder again becomes available.

3. When neither a direct nor an indirect channel is available prevents calls from seizing the primary control sets, stops useless hunting by the primary allotter and measures in seconds on a meter the period during which congestion continues. Normal conditions are restored to the allotter immediately



Q. 2, Fig. 1.

a primary or secondary channel becomes available.

(ii) A primary control relay set—

1. Causes its associated allotter to preselect a primary finder.

2. On receipt of a start signal controls searching action of the finder and, when the calling line is found, causes the allotter to move its wipers to the next free finder.

3. If the allotter wipers are connected to an indirect finder when a call originates, it extends the start signal to the start circuit of a secondary finder

Q. 2.—Draw the —, +, and P wire connexions of a local call in a 5 figure 2,000 type automatic main exchange, showing schematically the through circuit from calling telephone to called telephone under talking conditions. Show M.D.F., I.D.F. and other frame connexions and assume the call is routed through an indirect primary finder. Name each piece of apparatus and designate all relay contacts shown.

A.—See Fig. 1.

Q. 3.—(a) Describe the main functions of each of

control set and marks the bank contacts of the secondary finder which must connect a first selector through to the primary finder before the latter commences to search for the calling line.

4. Provides an alarm and passes the start signal on to another primary control relay set should the primary finder fail to function correctly.

(iii) The primary allotter is an 8-level uniselector, one being associated with each primary control relay set. Its banks are connected to the primary finders of the group and it drives when necessary under the control of the primary control relay set as described under (ii) above.

(iv) A primary finder—

1. Under the control of the primary control apparatus steps vertically and rotates to find the contacts marked by the calling subscriber.

2. Upon finding the calling line, switches it through to the first selector and frees the primary control apparatus for use with other finders.

3. Restores to normal when the call is concluded.

(b) By providing more than one control set per group. Three are generally sufficient for a group and these are brought into use as explained under (a) (i).

(c) By providing low resistance (11 ohms) test in relays which will not operate when two are connected in parallel via allotter bank contacts to the same marking battery circuit (150 ohms). Should two controls test in simultaneously on the same bank contacts, the allotters keep rotating until they get out of step, thus permitting individual testing and cutting in.

(d) ST—start relay—starts circuit operation.

LK—Test in relay—Locates a free finder.

G—operates in conjunction with the allotter magnet to ensure preselection of a free line finder.

TA and TB—Time delay relays—They provide an alarm and cause a call to be transferred to another control set if the finder fails to function correctly within the specified time delay period.

VR—Maintains start conditions and prepares for vertical stepping.

SF—Operates when the secondary finder is switched through to the primary finder and completes circuit of SFR relay.

SFR—Completes the circuit for vertical stepping of the line finder and closes the vertical bank testing circuit.

VT—Vertical test relay—Locates the marked level.

RS—Rotary stepping relay—Controls the rotary stepping of the finder.

EXAMINATION NO. 2377.—ENGINEER—LINE CONSTRUCTION

J. R. Newland

Q. 6.—What are the general causes of Cathodic and Anodic corrosion of lead covered telephone cable, and what means would you adopt to prevent this action?

At what points or places do these troubles occur generally, and what tests would you make to ascertain the location of potential troubles from these causes? What is meant by intercrystalline fracture in lead-covered cables; what are the causes and what precautions would you take to minimize or prevent them?

A.—Anodic corrosion is electrolytic in origin and may be due to earth currents, local galvanic conditions, earthed return P.B.X. or other battery leads, or D.C. supply systems, but is chiefly due to the action of stray currents from traction systems on the cable sheathing. These stray currents occur as the return currents to the power station seeking the path of least resistance and using subterranean metallic structures as conductors in preference to the rails. In areas where the cable is positive to the surrounding soil due to the presence of these currents, the tendency is for current to leave the cable. This is the anodic condition and the corrosion is referred to as "anodic corrosion." Anodic conditions occur generally in proximity to the power stations where the cable route passes close to or under the rails.

To minimize the causes of anodic corrosion, consideration should be given to see first that favourable conditions for such do not exist. So far as the cable system is concerned, everything practicable should be done to increase earth resistance. Manholes and conduits should be well drained and any broken conduits repaired. Blockage or leakage from water and drainage systems should be attended to by the proper authorities. The traction network should be examined to discover discontinuity of rail bonds and decrease in track leakage resistance. Efficient loading between sub-stations feeding in parallel and an adequate number of negative feeders is also necessary.

"Cathodic corrosion" was the term applied to that form of corrosion experienced when the cable is encased in iron pipes. The theory nowadays, however, regards this condition as "alkaline corrosion," and is brought about by the electrolytic action set up between the lead and iron when damp alkaline soil is present in the pipe, the lead forming the cathode. The trouble may be minimized by attention to the drainage of the conduit system and applying a liberal coating of petroleum jelly to the cable when it is being drawn in to the pipe. The pipe entrances should be sealed to prevent the ingress of water and silt. In severe conditions, consideration should be given to the use of jute-covered cable or non-metallic conduit.

As the result of a thorough electrolytic survey, anodic conditions may be overcome by using drainage bonds between the rails and cable system, or boosted drainage should be installed. The former consists of a direct metallic connection through a rectifier and limiting resistance at anodic points between the rails and cable in order to overcome electrolytic conditions. Boosted drainage is used where effective drainage to a traction system is not practicable. In this case increase of cable potential is obtained by an E.M.F. and the transfer of currents discharged to the rails or an adjacent earth plate. The E.M.F. is produced by a step down transformer and rectifier connected to the supply mains. Insulating joints in the cable sheathing are sometimes used, but when doing so care must be taken to see that the earth resistance is as high as possible, otherwise subsidiary anodic points may occur as the current by-passes the joint.

Areas of electrolytic corrosion are usually known from past experience. The extent of the area affected is determined as the result of an electrolytic survey. This survey consists of the taking of potential readings in the cable network to earth plates or other service reticulations: these readings are of the order of up to one volt. Potential readings of the rails of the traction system to the cable or earth plates are also taken and may be of the order of five volts. The direction of current flow along the cable sheathing may also be determined. Soil resistivity and earth plate resistances should be known. To obtain overall daily conditions use is made of a recording voltmeter. From the chart so obtained the "soil line," that is the normal potential due to natural conditions, is found on the closing down of traffic for the night, and the potential due to traction systems determined.

Intercrystalline Failure.—Pig lead such as was used in sheathing the earlier types of cable, but is now restricted to larger size cables, is made up of a conglomeration of fairly large crystals of the order of 2 to 4 millimetres diameter. When this lead is exposed to the sun temperature, such as when the cable is suspended on walls, or is subject to vibration such as occurs at bridges, the sheath is liable to fracture between the boundaries of the crystals. This is well illustrated when the lead is etched with dilute nitric acid. In time, these fatigue cracks extend through the thickness of the sheath and allows the ingress of moisture to the core.

As a preventive in locations where vibrations or exposure to sun cannot be eliminated, the lead sheath is alloyed with 1% Antimony. This has the effect of greatly reducing the crystal size, which lessens fatigue effects, also the sheath is rendered stiffer and consequently movement in the cable itself is minimized. However, all precaution should be taken during the installation of the cable to see that it is located in such a position to reduce exposure and vibration as much as possible.

Q. 7.—An open wire trunk loop 2 miles in length into a carrier repeater station is to be replaced by a 40 lb. conductor coil loaded star quad trunk cable.

The route accommodates 4-3 channel and 3-1 channel carrier systems, 2 V.F. programme circuits, 10 V.F. telephone circuits.

(a) State whether one or two cables should be laid and give reasons for the number you would select.

(b) Indicate briefly the necessity for loading the trunk cable.

(c) Draw a lay-out diagram showing the locations of the loading pots and indicate:—

(i) Inductance of coils to be used;
(ii) Spacing between loading pots;
(iii) Number of coils per loading pot.

(d) If the spacing between loading pots be increased beyond the allowable tolerance, what would be the effect on the electrical characteristics of the circuits in the cable, and state in general terms what modifications would be necessary to the layout?

A.—(a) Two cables should be laid, i.e., one to accommodate the circuits branching each side of the repeater station. This course is necessary, otherwise if only one cable was laid difficulty would be experienced with near end crosstalk from circuits outgoing from the repeaters disturbing the low level circuits in-coming. The screening effect of the individual cable sheaths for the "go" and "return" circuits would obviate this trouble.

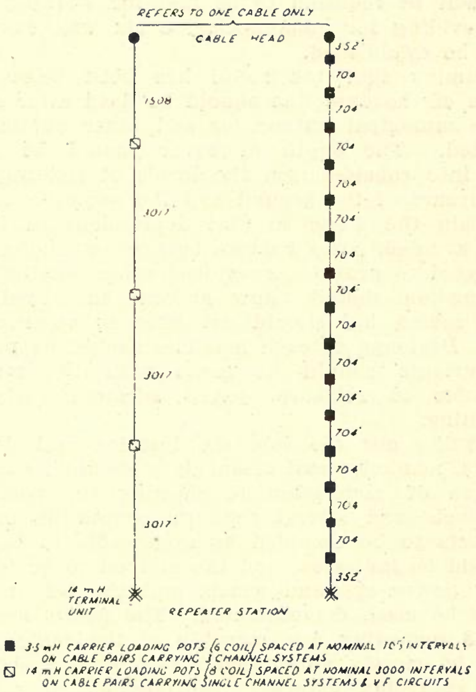
(b) The principal objectives of loading the trunk cable in this instance are:—

(i) To obviate reflection by matching the cable and open wire impedances and consequently improve the far end crosstalk condition.

(ii) The reduction of attenuation loss due to reflection.

(iii) The reduction of attenuation of unloaded cable pairs.

(c) It is presumed that the number of channels mentioned exist each side of the repeater station and does not refer to the total number in the loop. This being the case, two 14 pair cables would be laid to accommodate the twelve V.F. channels, the carrier systems being superimposed on seven of these, leaving two spares. The pairs carrying the 3-channel systems would be loaded with 3.5 mH carrier loading coils made up into a pot of six coils, the two spare coils being placed on the spare cable pairs to provide for emergencies. These would be spaced nominally at 705 feet. The remaining eight cable pairs would be loaded with 14 mH carrier loading coils made up into a pot of eight coils spaced nominally at 3000 feet. The actual spacing would be as indicated in Fig. 1.



Q. 7, Fig. 1.

(d) If the spacing between loading pots be increased beyond the allowable tolerance, the effect would be to reduce the impedance of the cable, which would result in reflection losses due to mismatching of impedances between the open wire and cable. The cut-off frequency would also be lowered. Therefore, there would tend to be an increase in attenuation and a lowering of quality of the circuits, particularly in the higher frequency carrier bands. The remedy to the foregoing would be to review the spacing by providing extra manholes as far as local circumstances would permit.

Q. 8.—It is necessary to lay cable along a new route on which the subscribers' telephone development is 828 present, 1290 in 8 years, 1840 in 15 years, and 2460 in 20 years.

It is anticipated 200 junction lines, which will be accommodated in separate 20 lb. conductor cable, will be required on this route in 5 years, and a total of 800 junction lines in 20 years.

What size cables and conduits would you provide initially, and for what reasons? You are required to prepare an estimate for the work and lay out the job

for the workmen. Discuss the considerations to which you would pay particular attention and furnish an estimate of the material and tools required, assuming the length of the section is 1 mile.

A.—Assuming that the subscribers' cables may be worked up to 80% of their capacity, and that 6½ lb. cable fulfils transmission requirements, it will be necessary immediately to draw in one 1400 pair subscribers' cable. To provide for the development over the 20 year period two more subscribers' cables will be needed. The maximum standard size 20 lb. cable is 540 pairs, therefore to provide for the initial requirement a 300 pair 20 lb. cable should be drawn in, to be followed at a later stage by a 540 pair. Thus 5 ducts will be required to be laid for working cables, and providing for emergencies, a six way duct route should be established.

Presuming that the route has been selected, the position of the duct line should be fixed after consulting the municipal authorities and other public bodies interested. The depth of cover should be defined, taking into consideration the levels of roadways, etc., the contours of the ground and the necessity to grade and drain the ducts so that depressions in the line will be avoided. The distance between manholes should be selected to provide convenient cable lengths. Manhole location should allow natural entry points for lateral cables, but should not offer an obstruction to traffic. Drainage of each manhole should be provided. Arrangements should be made with the municipal authorities to reinstate paved surfaces early after back filling.

In laying out the job, the location and depth of conduits, manholes and drain pipes should be specified. A sketch of each manhole showing the position of main ducts and lateral conduits should be provided. The ducts to be occupied by each cable to be drawn in should be indicated, and the method to be followed, i.e., by power or hand winch, and the set up of the gear to be used, demonstrated. The points mentioned in Q. 3 regarding workmanship of the cable jointing should be closely supervised. Instructions should be issued regarding external identification of cables to avoid later confusion. Capacity unbalance tests should be made on the junction cable and the lengths to be tested indicated. Sheets showing cross jointing as dictated by the capacity tests should be issued.

Material Required:—

Conduit Work:

Conduit, E.W., 4", Self-aligning, 6 way x 30"		2130
Conduit, E.W., 4", Untested (for manhole drainage, move as required)		400
Manhole Cover and Frame Footway Chequer Plate, 4' x 3' 9½"		16
Grating for Manhole Sump		16
Iron, Anchor		16
Beaver Cable, Movable, 3 joint		32
Channel Iron Support, 2 way		16
Step, Manhole		32
Cement	bags	120
Sand	c. yds.	12
Stone	c. yds.	18

Cable Work:

Cable, P.I.Q.L., 1200 pr./10	yds.	1780
Cable, P.I.Q.L., 500 pr./20	yds.	1780
Lead, Sheet, 7 lb.	cwt.	6
Solder, Wiping	lb.	56
Sleeve, Paper, 20 lb., s.q.		20,000
Sleeve, Paper, 10 lb.		50,000
Paper, Cable Jointing, 4"	rolls	30
Sperm	lb.	5
Compound, Cable Covering	cwt.	3½
Acetylene	c. ft.	800

Kerosene, Cotton Waste, Carbon Dioxide, Resin, etc.

Tools Required:—

Conduit Work (assuming a 12-man party):

Bar, Sinking	3	Trowel, Plasterers'	2
Broom, Bass	3	Trowel, Pointing	2
Key, Manhole .... pr.	2	Pick, Rock (as required).	
Lamp, Trench	10	Post, Barrier	12
Level, Spirit	2	Rails, Barrier, 12'	12
Level, Line	1	Rails, Barrier, 6'	4
Measuring Tape	1	Wheelbarrow, 4 c. ft.	3
Pick, Double Ended	15	Mould	2
Rammer, Wood	6	Timber for Manhole Moulds.	
Rods, Boning .... set	1	Pneumatic Compressor and Accessories.	
Saw, Hand	2		
Shovel, L.H.	12		
Square, Try, 10"	1		
Trowel, Brick	2		

Cable Work (assuming three jointers with mates and cable drawing party):

Air-Acetylene Equipment	3	Pliers, Half Round, Stripping Nose	3
Block, Snatch, Wire Rope	2	Pressure Testing Outfit.	
Brush, Wire, Scratch	3	Rods, Conduit .... ft.	400
Lead	3	Rope, Wire, 1½" .. ft.	400
Grip, Cable, No. 5	4	Rule, Steel, 2'	3
Guard, Manhole	6	Saw, Hack	3
Hammer, Cross Pene	3	Sheet, Canvas	6
Hook, Shave	3	Snips, Straight, 10"	3
Jack, Cable Drum and Spindle	2	Swivel, Chain	2
Knife, Lead	3	Tent, Jointers', 4' x 4'	6
Lantern, Hurricane	6	Winch, Crab, D.P. (or motor truck with power take-off)	1
Mirror and Case	3	Identification, Site	3
Moleskin .... yd.	½	Buttinski, or Portable Telephone	3
Pliers, Drag, Cutting, 5"	6		

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All communications should be addressed to:—

A. R. GOURLEY,
Hon. Secretary, Postal Electrical Society of Victoria,
G.P.O. Box 4050, Melbourne.

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