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MELBOURNE C.C.I.T.T. MEETINGS

GENERAL REVIEW OF AUSTRALIAN TELECOMMUNICATION ENGINEERING PRACTICES

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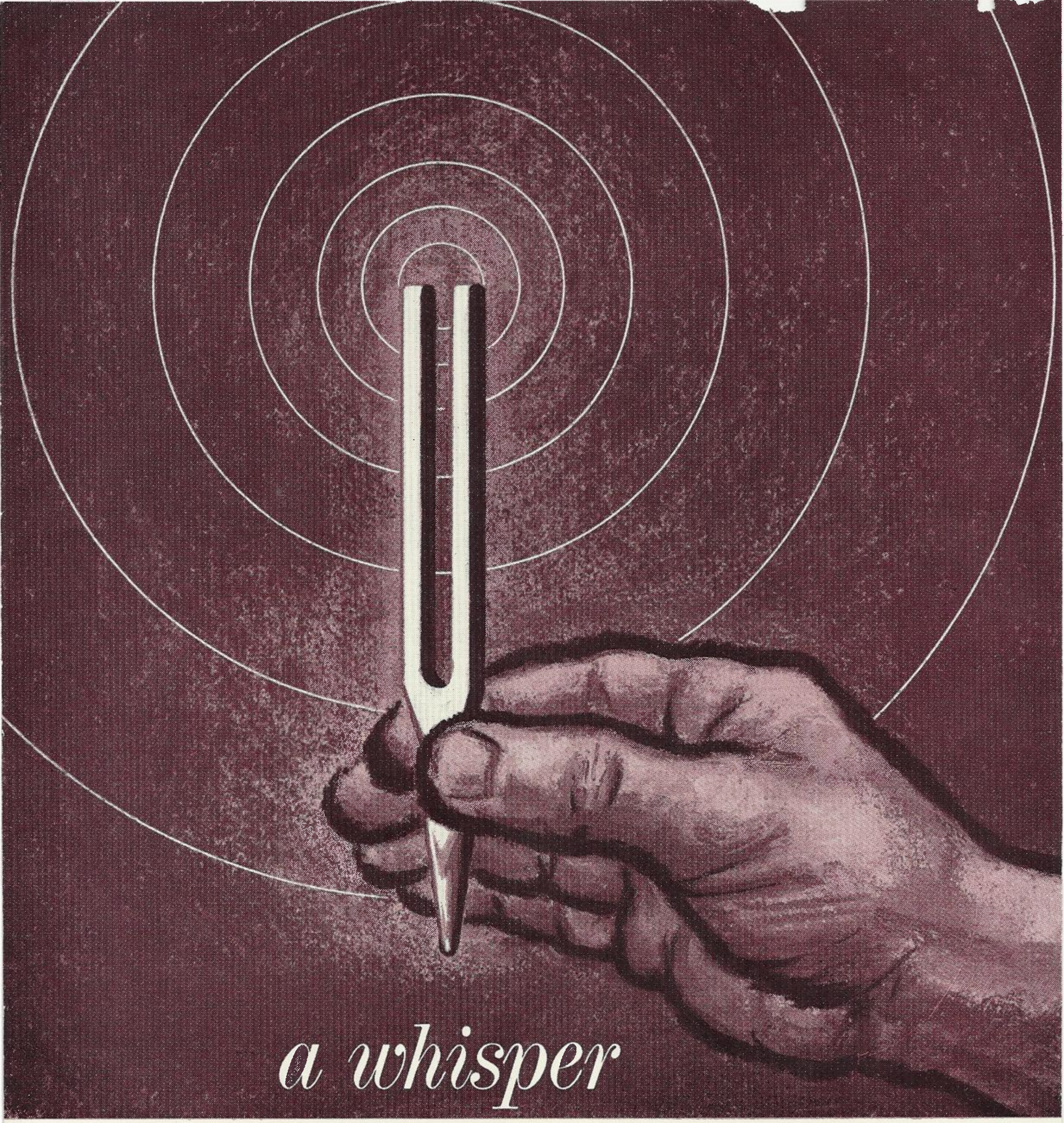

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The

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of Australia

VOL. 14, No. 2

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CONTENTS

	Page
Foreword	**86**
C.C.I.T.T. Study Group Meetings in Melbourne, October, 1963 E. SAWKINS, B.Sc., A.M.I.E.Aust. and E. R. BANKS, B.E.E., A.M.I.E.Aust.	**87**
Australian Telecommunication Authorities C. J. GRIFFITHS, M.E.E., M.I.E.E., M.I.E.Aust.	**92**
Australia's Overseas Telecommunications Network T. J. PETRY, A.M.I.E.E.	**96**
Australian Telephone and Telegraph Networks R. W. TURNBULL, A.S.T.C. (Elec. Eng.), M.I.E.Aust. and G. E. HAMS, B.Sc., A.M.I.Aust.	**102**
Some Aspects of External Telephone Plant in Australia W. H. WALKER, B.E., A.M.I.E.Aust.	**109**
Telephone Equipment Plant Practices in Australia K. B. SMITH, B.Sc., A.M.I.E.Aust.	**122**
Review of Line Transmission Equipment in Australia N. M. MACDONALD, B.Sc., M.I.E.Aust.	**135**
Some Aspects of the Use of Radio Systems in the Australian Internal Network D. A. BROOKE, B.Sc., E. L. BROOKER, B.Sc., A.M.I.R.E.Aust. and L. D. SEBIRE, A.M.I.E.Aust., A.M.I.R.E.Aust.	**146**
Australian Telegraph Engineering Practices R. K. McKINNON, B.E., D.P.A. and D. J. RICHARDSON	**152**
The Research Laboratories of the Postmaster-General's Department L. M. HARRIS, B.Sc.	**160**
Our Contributors	**166**

FRONT COVER
THE SOUTHERN CROSS HOTEL—VENUE OF THE MELBOURNE MEETINGS
(Photograph by courtesy of Athol Shmith)

This Journal is issued three times a year by the Telecommunication Society of Australia. A year's subscription commenced with the June issue; succeeding numbers are published in October and February. A complete volume comprises six numbers issued over two years, and a volume index appears in No. 6 of each volume.

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*For addresses see page 165.

FOREWORD

IT is with considerable pleasure that Australia will act as host Administration for forthcoming International Telecommunication Union C.C.I.T.T. Study Group meetings in Melbourne between the 7th and 25th October. Australia, even though still a developing nation, has had a long association with the I.T.U., being one of its oldest members. Prior to the federation of the Australian States in 1901, each of the six States had joined the Union as independent members, the first being South Australia. At Federation, the posts and telegraph powers of the States were handed over to the Commonwealth of Australia, which then carried on Australia's membership of the Union.

Australia has long been deeply concerned in problems of communication because of its widely separated community centres. We trust that the experience which we have gained in long distance communications within our domestic network can be related to problems encountered on inter-continental circuits of more recent origin.

Communication facilities have always been regarded of prime importance to Australia. In 1859 our first submarine cable was laid across Bass Strait, linking Tasmania with Victoria, only nine years after the original trial of the first cable between Dover and Calais. With the completion of the laying of a cable between Java and Darwin in 1871, permanent communication was established with the Northern Hemisphere for the first time. The submarine cable in Darwin was linked to Adelaide by means of the Overland Telegraph which was erected in the face of extreme difficulties and when completed in 1872, represented an outstanding milestone in the history of the telegraph. The line measured 1,973 miles (further than from Paris to Moscow) over difficult and inhospitable terrain, and its establishment was largely due to the efforts of the then Postmaster-General of South Australia, Charles Todd (later Sir Charles).

The development of the telephone service has been characterised by rapid progress and Australia is presently in the top seven countries of the world on the basis of telephones per head of population. The magnitude of the area covered by Australia's domestic telephone network, with operator dialling conditions existing over these distances, may be unknown in many countries. For example, equivalent telecommunication channels, such as those existing in Australia between Cairns and Perth, would stretch overseas from say London to Karachi.

Our interest has not only been concentrated on line transmission. Prior to Federation, Postal Engineers had experimented with wireless telegraphy. By the turn of the century, communication had been effected with ships in Sydney Harbour and outside Port Phillip. One of the great advantages which wireless has conferred on Australia is its ability to provide a unique communication service for residents in the vast inland regions where the ordinary landline services would be prohibitively expensive. The development of inland services was mainly due to Rev. John Flynn of the Australian Inland Mission who conceived the idea, but it was the work of Mr. Alfred H. Traeger, an electrical engineer of Adelaide, who in the 1920's enabled Flynn's dreams to come true when he invented the now famed inexpensive low power pedal-operated radio transmitter. These sets were installed in outlying centres for the transmission and reception of public telegrams and medical calls. These stations were the forerunner of the several extensive networks of services now conducted by the Royal Flying Doctor Service of Australia. Nearly 1,000 remote centres serving missions, pastoralists, homesteads, etc., are now equipped with wireless stations. Though the prime purpose is to assist those in need of medical aid, the inland radio system also provides daily communication facilities, enables the provision of regular meteorological information, makes possible educational facilities for the children, and does much to relieve the sense of isolation experienced in the Australian "outback".

Provision of Australia's telecommunication facilities is the joint responsibility of the Postmaster-General's Department, and the Overseas Telecommunications Commission (Australia). The Post Office is responsible for the development, operation and maintenance of our domestic public communication network while communications outside Australia are the concern of the Commission. Both bodies maintain close liaison with each other to ensure the effective integration of the internal and external services.

World progress has increased the sense of a shrinking globe with continents and neighbouring countries being drawn closer together and has emphasized the need for compatability of operation of national telecommunication networks. It has been accentuated by the emergence of a new concept of vast significance, that is, the possibility of semi-automatic and automatic transmission on a global basis. The work of the Union and the C.C.I.T.T. in particular is contributing a great deal towards achievement of this goal. The three basic Groups which will meet in Melbourne, Study Group XI (Signalling and Switching), Study Group XIII (Automatic Telephone Operation) and Special Committee B (World Wide Telephone Networks), are considering different aspects of this problem.

It is hoped that the Melbourne meetings will enable the visitors to see at first hand some aspects of the Australian communications scene. We trust that these meetings will be a forerunner to other similar gatherings in Australia, allowing for the interchange of information on the mutual objectives of efficient world-wide telecommunication services.

In order to assist visitors at the meetings, as well as to enable a better understanding of the general problems of communications by people in Australia, this special issue of the Telecommunication Journal of Australia has been prepared. We hope that it will provide valuable background knowledge in the achievement of the objectives of the meetings.

F. P. O'Grady

Director-General,
Postmaster-General's Department.

C.C.I.T.T. STUDY GROUP MEETINGS IN MELBOURNE, OCTOBER, 1963

E. SAWKINS, B.Sc., A.M.I.E.Aust.
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INTRODUCTION

It is with considerable pleasure that the Australian Post Office will act as host Administration to the C.C.I.T.T. (International Telegraph and Telephone Consultative Committee) in a series of Study Group meetings to be held in Melbourne between 7th and 25th October of this year. The three Study Groups to meet are Study Group XI (Signalling and Switching), Study Group XIII (Automatic Telephone Operation) and Special Committee B (World Wide Telephone Networks). The C.C.I.T.T. is a permanent organ of the International Telecommunications Union (I.T.U.) which itself is the specialised agency of the United Nations in the field of telecommunications. Details of the organisation of the I.T.U. and the relationship of the C.C.I.T.T. to the Union have been covered in a recent article in this *Journal* (1).

The C.C.I.T.T. was formed in 1956 by combining the C.C.I.F. (telephony) and the C.C.I.T. (telegraphy) and it is the telephone side of the organisation which will be represented at these meetings. Before the amalgamation, the telephony committee was the oldest of three Consultative Committees, all of which were formed in the 1920's, primarily to provide an international forum for the discussion and resolution of problems relating to all aspects of designing, specifying and operating international communications services. The main interest at that time centred on the European international services.

* See page 166.

TABLE 1

C.C.I./C.C.I.F. PLENARY MEETINGS

*IInd	Conference	Paris	November-December	1924
IIIrd	Conference	Paris	November-December	1925
IVth	Plenary Assembly	Paris	November-December	1926
Vth	Plenary Assembly	Como	September	1927
VIth	Plenary Assembly	Paris	June	1928
VIIth	Plenary Assembly	Berlin	June	1929
VIIIth	Plenary Assembly	Brussels	June	1930
IXth	Plenary Assembly	Paris	September	1931
Xth	Plenary Assembly	Budapest	September	1934
XIth	Plenary Assembly	Copenhagen	June	1936
XIIth	Plenary Assembly	Cairo	February	1938
	C.C.I.F.	Activities suspended	during War	
XIIIth	Plenary Assembly	London	October	1945
XIVth	Plenary Assembly	Montreaux	October	1946
XVth	Plenary Assembly	Paris	July	1949
XVIth	Plenary Assembly	Florence	October	1951
XVIIth	Plenary Assembly	Geneva	October	1954
XVIIIth	Plenary Assembly	Geneva	December	1956

C.C.I.T.T. PLENARY MEETINGS

Ist	Plenary Assembly	Geneva	December	1956
Special	Plenary Assembly	Geneva	September-November	1958
IInd	Plenary Assembly	New Delhi	December	1960

* Presumably a preliminary meeting earlier in 1924 agreed to the formation of the group.

The meetings will extend over a period of three weeks, five days being allocated to each of the three Study Groups. For these Study Groups, the Melbourne meetings will represent the last major series of meetings before the C.C.I.T.T. Plenary Assembly which is to be held at Moscow in May, 1964. At the meetings the three Study Groups will aim to complete their programmes of work and to prepare reports for presentation to the Plenary Assembly.

These meetings have a special significance, since they mark the end of a period of intense activity related to the formulation and development of basic plans for the orderly introduction of worldwide automatic telephony. This work was commenced immediately following the 1960 Plenary Assembly in New Delhi and quickly acquired urgency as a result of the rapid developments taking place in intercontinental telephone communication with the exploitation of the new submarine cables and the research into the possible use of satellites.

The development of the submarine telephone cable is of special significance to Australia, since until now Australian telephone communication with the northern hemisphere has been over radio channels. The introduction of submarine cables linking Australia with Europe and North America at the end of this year will mark the beginning of a new era of closer contact between Australia and the "old world".

This article includes a brief review of the development and growth of the C.C.I.T.T., a summary of the stage reached by the various Study Groups in their development of world-wide plans, and an indication of the possible outcome of the Melbourne meetings.

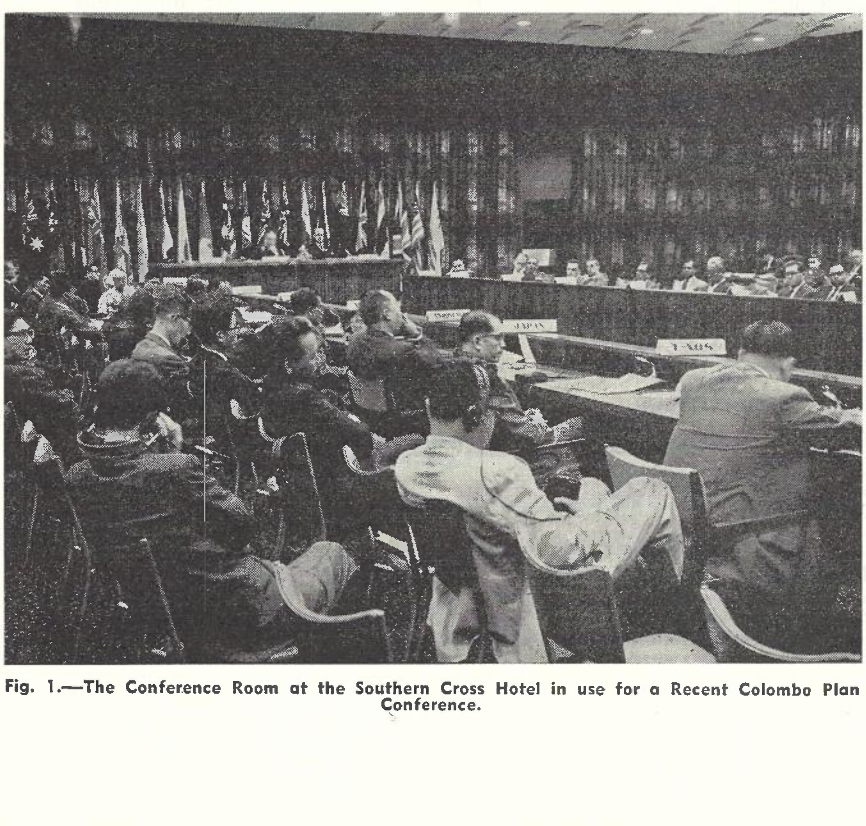


Fig. 1.—The Conference Room at the Southern Cross Hotel in use for a Recent Colombo Plan Conference.

HISTORY OF THE C.C.I.T.T.

Although the C.C.I.T.T. is now a permanent organ of the I.T.U. these bodies had separate beginnings. The I.T.U. was formed in 1885 from the International Telegraph Union which had been founded 20 years earlier. The C.C.I.T.T. has evolved directly from the

C.C.I. (The International Consultative Committee for Long Distance Communications) which was first established in 1924 as an independent body. At this time the problems for study by the C.C.I. were confined to European telephony.

In 1925 the C.C.I.T. (telegraphy) was also formed and, to distinguish the two bodies, the telephone group was re-termed the C.C.I.F. Both these bodies were combined with the I.T.U. at the 1925 Administrative Conference in Paris. In 1956 the C.C.I.T. and the C.C.I.F. were combined to form the C.C.I.T.T. Table 1 lists the Plenary meetings which the C.C.I.T.T. and its precedents have held throughout their existence.

With the exception of the recommendation prepared on operating methods and transmission performance, most of the work of the C.C.I.F. and the C.C.I.T. up to 1956 had particular application to the international communication problems existing in Europe. In fact, even in the fields of operating and transmission, the primary concern of these bodies was with European international working. However, in 1956 the first trans-Atlantic submarine telephone cable was commissioned successfully, with two immediate results:

1. From a technical standpoint there

TABLE 2: LIST OF STUDY GROUPS SET UP BY THE SECOND PLENARY ASSEMBLY OF THE C.C.I.T.T.

Abbreviated Designation of Study Group	Title	Chairman	Vice-Chairman
I	Telegraph operation and tariffs (Telex service included).	Mr. Perry (Netherlands)	Mr. Vargues (France)
II	Telephone operation and tariffs.	Mr. Terras (France)	Mr. Balchandani (India)
III	General tariff principles. Lease of telecommunication circuits.	Mr. Langenberger (Switzerland)	Mr. Garrido (Spain)
IV	Maintenance of the general telecommunication network.	Mr. Valloton (Switzerland)	Mr. Postelnicu (Roumania)
V	Protection against dangers and disturbances of electromagnetic origin.	Mr. Riedel (F. R. of Germany)	Mr. Mikhailov (U.S.S.R.)
VI	Protection and specifications of cable sheaths and poles.	Mr. Halstrom (Denmark)	Mr. S. M. Muqtadir (Pakistan)
VII	Definitions and symbols.	Mr. Gella (Spain)	Mr. Bigi (Italy)
VIII	Alphabetic telegraph apparatus and local connecting lines.	Mr. R. D. Kerr (Australia)	Mr. Savitzky (Ukrainian S.S.R.)
IX	Quality of telegraph transmission; specification of channel equipments and directives for maintenance of telegraph channels.	Mr. Roquet (France)	Mr. R. N. Renton (United Kingdom)
X	Telegraph switching.	Mr. Jansen (Netherlands)	Mr. Faugeras (France)
XI	Telephone signalling and switching.	Mr. W. J. E. Tobin (United Kingdom)	Mr. Vassilieff (U.S.S.R.)
XII	Telephone transmission performance and local telephone networks.	Mr. Swedenborg (Sweden)	Mr. Kroutl (Czechoslovakia)
XIII	Semi-automatic and automatic telephone networks.	Mr. Lambiotte (Belgium)	Mr. Chovet (France)
XIV	Facsimile telegraph transmission and apparatus.	Mr. Fijalkowski (Poland)	Mr. Bitter (F.R. of Germany)
XV	Transmission systems.	Mr. Job (France)	Mr. Gagliardi (Italy)
XVI	Telephone circuits.	Mr. R. H. Franklin (United Kingdom)	Mr. Claeys (Belgium)
Sp. A.	Data transmission. (Special Study Group).	Mr. J. Rhodes (United Kingdom)	Mr. V. N. Vaughan (United States, American Telegraph and Telephone Co.)
Sp. B.	World-wide semi-automatic and automatic network (Special Study Group).	Mr. W. E. Bloecker (United States: American Telegraph and Telephone Co.)	Mr. Bjurel (Sweden)
Sp. C.	Noise. (Special Study Group and Joint C.C.I.T.T.-C.C.I.R. Study Group, under the administration of the C.C.I.T.T.).	Mr. H. Williams (United Kingdom)	Dr. R. Kaiser (F.R. of Germany)
CMTT	Television transmission. (Joint C.C.I.R.-C.C.I.T.T. Study Group, under the administration of the C.C.I.R.).	Mr. Angel (France)	Mr. R. H. Franklin (United Kingdom)
PLAN	General plan for the development of the international network. (Joint C.C.I.T.T.-C.C.I.R. Committee, under the administration of the C.C.I.T.T.).	Mr. Antinoci (Italy)	Mr. A. Hamid (Pakistan)
S.-Com. Plan Africa	Plan Sub-Committee for Africa. (Joint C.C.I.T.T.-C.C.I.R. Sub-Committee, under the administration of the C.C.I.T.T.).	Mr. Tedros (Ethiopia)	Mr. Mili (Tunisia)
S.-Com. Plan Asia	Plan Sub-Committee for Asia. (Joint C.C.I.T.T.-C.C.I.R. Sub-Committee, under the administration of the C.C.I.T.T.).	Mr. C. P. Vasudevan (India)	Mr. Matsuda (Japan)
S.-Com. Plan Latin America	Plan Sub-Committee for Latin America. (Joint C.C.I.T.T.-C.C.I.R. Sub-Committee, under the administration of the C.C.I.T.T.).	Mr. Nunez (Mexico)	Mr. Ospina (Colombia)

was an end to the period of virtual telephone isolation of the North American continent and the European continent which had existed with manual radio channel type working.

2. The possibility arose of introducing semi-automatic and automatic telephony on a worldwide basis.

In the period between 1956 and 1960 the first steps were taken by Administrations to exploit the new facility.

PRESENT ORGANISATION OF THE WORK

It was realised at the second Plenary Assembly of the C.C.I.T.T. held in New Delhi, in December, 1960, that the introduction of world-wide automatic telephony represented a major challenge to the C.C.I.T.T. and that co-ordinated recommendations for world-wide numbering, switching, signalling, transmission and operation would be required very quickly in view of the intense activity by those Administrations and operating agencies which were developing intercontinental communication systems. As a result of this situation, a special Study Group (Special Committee B) was established to organise and oversight the investigations which would be necessary. The task was to prepare a series of co-ordinated recommendations on worldwide telephony. This Committee was asked to co-ordinate the studies of the existing Study Groups, each one of which was required to examine the impact of worldwide telephony on its particular area of responsibility.

Study Groups are the operative bodies of the C.C.I.T.T. and there is a Study Group to cover each of the specialist areas of responsibility in the telephone and telegraph fields. Table 2 sets out a schedule of the Study Groups at present set up within the C.C.I.T.T.

All Administrations which are members of the I.T.U. (and therefore of the C.C.I.T.T.) are eligible to take part in the work of the Study Groups and, as can be seen from the table, the Chairmen and the Vice-Chairmen of the Study Groups are representatives of Administrations. The Study Groups are each assigned a list of questions by the Plenary Assembly and, between Plenary Assemblies, these Groups meet to prepare co-ordinated recommendations in answer to each of these questions. For example, Special Committee B was assigned one question for the Plenary period, which read simply:

"What changes are necessary to existing recommendations or what new recommendations are necessary to provide for semi-automatic and ultimately fully automatic telephone operation on a world-wide basis?"

This question was followed by a note which referred Special Committee B to particular questions being studied by Study Groups XI, XIII, XVI and a Working Party of Study Group IV (2). Before looking in more detail at the work of Special Committee B and the Study Groups XI and XIII which are meeting in Melbourne, it is first desired to refer briefly to two other activities of the C.C.I.T.T.

One is the responsibility in the technical assistance field. At the 1959 Plenipotentiary Conference, the charter of the C.C.I.T.T. was extended to include a definite responsibility in the field of documentary technical assistance to new and developing countries. This work was also discussed at length at the 1960 Plenary Assembly and one result was that a special Working Party of Study Group XI was formed to prepare a series of guiding principles to aid developing countries in the development of National Automatic Networks.

Secondly, the C.C.I.T.T. has a joint responsibility with the C.C.I.R. in the planning field. This is implemented through the Plan Committee of the I.T.U. and its Sub-Committees. The responsibilities of the Plan Committee include the development of plans for the introduction of international telephony and naturally this work also has been given impetus and urgency by recent happenings.

STUDY GROUPS TO MEET IN MELBOURNE

From the foregoing the significance of the forthcoming meetings of Study Groups XI, XIII and Special Committee B in Melbourne will have become apparent. At the Melbourne meetings Study Groups XI and XIII will take stock of the work so far completed, and will prepare final consolidated recommendations in their own fields of responsibility for presentation to the Moscow Plenary Assembly. Special Committee B, which meets after Study Groups XI and XIII, will then review the complete field of recommendations for world-wide automatic telephony. The following paragraphs indicate, for each of the Study Groups, the stage which has been reached in their deliberations and the likely area of work which will be covered during the Melbourne meetings.

STUDY GROUP XI—SIGNALLING AND SWITCHING

(Chairman—Mr. W. J. E. Tobin, U.K.)

Study Group XI has the responsibility for specifying the signalling equipment and the boundary conditions for the switching equipment which is to be used on international circuits. Since the New Delhi Plenary Assembly, Study Group XI has examined the problem of specifying an intercontinental signalling system.

Three aspects of the problem have already been reconciled as far as possible. Initially, certain basic principles were investigated and as a result key decisions were taken concerning the desirable technical characteristics of an intercontinental signalling system. These decisions depended largely on the current state of development of the signalling and switching arts. Secondly, Study Group XI received from Study Group XIII a statement of necessary and desirable facilities which the signalling system should provide in order to meet the operating requirements for intercontinental working. Finally, Study Group XI had to take account of the existing intercontinental signalling system developed for use on the Atlantic cables to provide semi-automatic working.

The trans-Atlantic signalling system complied with most of the basic technical principles established initially by Study Group XI, but did not accommodate all the facilities specified by Study Group XIII. Study Group XI, has, therefore, through a special Working Party, devoted considerable attention to determining the extent to which this signalling system might be modified and also the use that can be made of the system in the intercontinental network. In addition, this Working Party has prepared for final consideration by Study Group XI some basic principles which would guide studies in the development of a new signalling system.

At the October meeting, Study Group XI will take account of the progress that has been achieved in the recommendation of a suitable signalling system for intercontinental working. In so doing, the Study Group will also have to consider the next steps which should be taken, immediately following the Moscow Plenary Assembly, in the development of a standardised intercontinental signalling system to give all the required facilities.

Another field of work in which Study Group XI is involved, the first part of which will probably be brought to conclusion at the Melbourne meeting, concerns the provision of technical assistance of a documentary nature to new and developing countries. This work has been the responsibility of a special Working Party, the Working Party on National Automatic Networks, which is chaired by Mr. E. R. Banks of Australia. The working party has prepared a volume of guidance on the basic principles which must be taken into account when plans are prepared for the development of an automatic network in a national area, and the factors to be considered when specifying and ordering switching equipment for use in such an automatic network. This volume and a covering report will be considered by the full meeting of Study Group XI.

Finally, Study Group XI has been considering several other questions which relate to certain detailed aspects of signalling system specification and operation, and tentative answers to these questions have been prepared. These answers will no doubt be reviewed and finally endorsed by the Study Group in preparation for the Moscow Plenary.

STUDY GROUP XIII—AUTOMATIC TELEPHONE OPERATION

(Chairman—Mr. M. M. Lambiotte, Belgium)

Study Group XIII has been responsible in the last three years for the study and preparation of the basic plans for the introduction of intercontinental automatic telephony. In order to tackle this considerable task, the Study Group formed itself into five Working Parties each of which has taken a particular aspect of the problem and studied it in detail prior to submitting a report to the full Study Group for comment and adoption. The five Working Parties are Working Party 1

(Signalling Facilities), Working Party 2 (Numbering), Working Party 3 (Routing), Working Party 4 (Maintenance) and Working Party 5 (Traffic Engineering).

Working Party 1 completed its task early in the period and it was on the basis of the facility specification forwarded by this Working Party to Study Group XI that this Study Group has proceeded with its investigations as discussed previously. Working Party 2 developed a numbering plan which has been considered at previous meetings of Study Group XIII and was accepted by the Study Group at the last meeting in Montreal in July, 1962, subject to any comments which might be forwarded by Administrations prior to the Melbourne meeting. Therefore, Study Group XIII will be required, during the Melbourne meeting, to take account of any comments which have been forwarded by Administrations and consider final endorsement of the recommended numbering plan.

For a variety of reasons the routing plan being prepared by Working Party 3 is not as close to finality as the numbering plan. Perhaps the most important reason is that the routing plan is closely related to the actual cables which are being laid by various Administrations, and to the switching centres which are being established on these cable routes. Consequently, the development of a recommended routing plan is tied much more closely to short term implementation problems than is the numbering plan. Further it is becoming increasingly apparent that an important element in the world routing plan is the advantage that can be taken of time differences between various countries. In addition it is very difficult at this stage to predict short and long term traffic flow patterns in the world network. Finally although the draft routing recommendations have restricted the number of intercontinental links in tandem to a maximum of 5 (Ct_3 to Ct_3—see Reference 1) there is a growing opinion that additional four wire transit switching between higher order centres can be tolerated. Study Group XIII therefore must endeavour to take stock of the progress that has been made on routing plans and to report to the Plenary Assembly on the further action which it considers should be recommended in this area.

The Maintenance Working Party has been considering general problems associated with the introduction of intercontinental automatic and semi-automatic service, and in conjunction with the Working Party of Study Group IV, which is responsible for circuit maintenance, has been developing practices and procedures for the technical operation of the intercontinental network. In addition, the Maintenance Working Party has been developing recommendations for service observation practices for the intercontinental network.

The Traffic Working Party has been investigating the detailed problems associated with measuring the traffic flowing on the various circuit groups and has been endeavouring to develop accurate indicators by means of which the performance of a group of circuits can be specified and the number of circuits required to meet this performance standard can be determined. This is a much more difficult problem than in the national field, because the busy hour characteristics of international traffic are more complex than in national networks and the circuits are considerably more costly.

SPECIAL COMMITTEE B

(Chairman—Mr. W. E. Bloecker, U.S.A.)

As its name implies, this Study Group was established especially to oversight and co-ordinate the work of the other main specialised groups, each of which had a particular contribution to make to the development of plans for intercontinental telephony. In Melbourne, Special Committee B will be required to review the work which has been achieved by Study Group XI and Study Group XIII and, in addition, to consider the results of the work of Study Group XVI (Transmission). Study Group XVI held a meeting in Geneva during July, 1963, and will presumably forward a report to Special Committee B. It will no doubt be the task of Special Committee B to ensure that the various recommendations prepared by the specialist Study Groups are compatible, and to prepare a report to the Plenary Assembly on the progress achieved and the further work still remaining.

GENERAL ARRANGEMENTS FOR THE MEETINGS

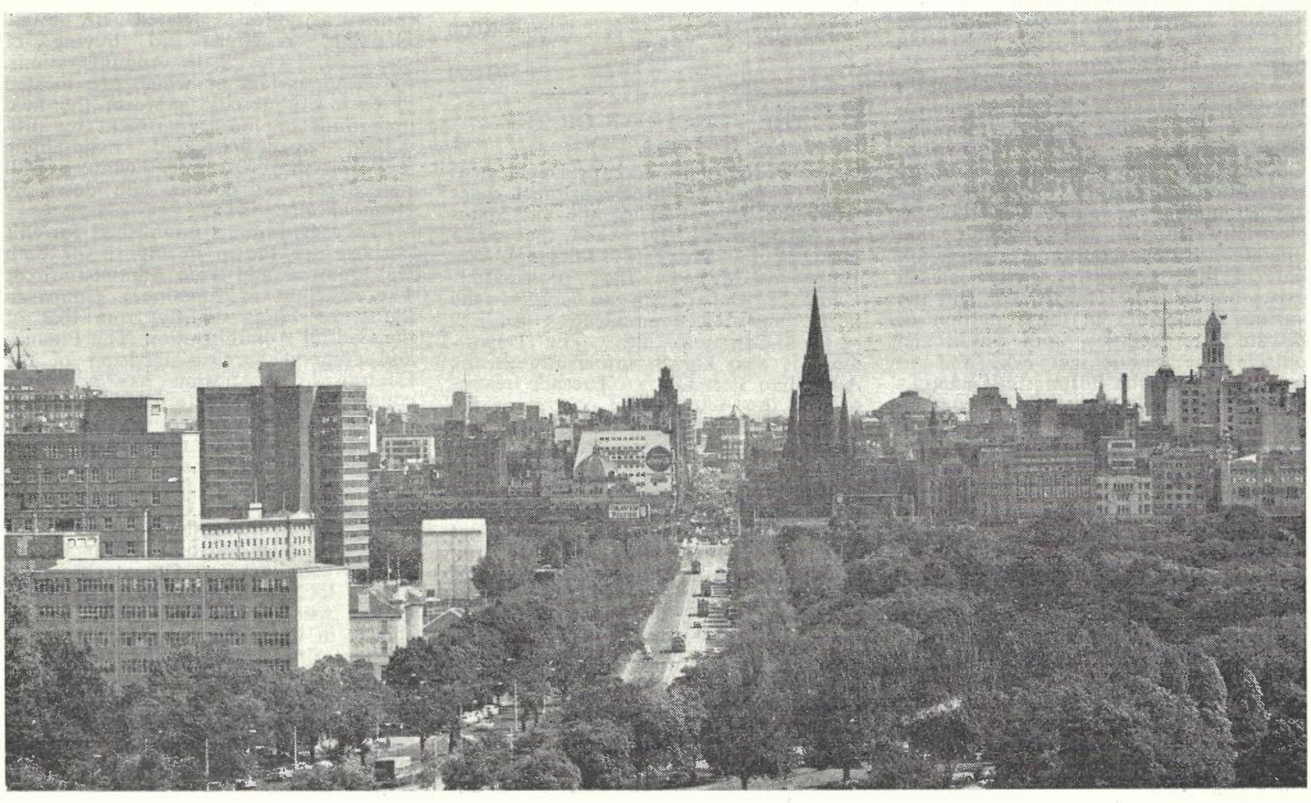
The Melbourne meetings will be held in the Southern Cross Hotel which is shown on the front cover of this issue. Facilities are being provided at the hotel for the Conference Room, Working Party Rooms, and for the necessary offices, documentary production and information services for the Secretariat and the delegates. Fig. 1 shows the Conference Room in use for a recent Colombo Plan meeting. Immediately after the Melbourne series of meetings, a four-day visit has been arranged to Sydney to provide delegates with the opportunity to see at first hand representative firms in the telephone switching and electronics industries, and to visit technical installations and facilities of the National and International telephone service. It is expected that about 60 delegates will attend from overseas and it is hoped that their visit to Australia will be both interesting and rewarding.

REFERENCES

1. E. Sawkins, "World Automatic Telephone Network"; Telecommunication Journal of Aust., Vol. 13, No. 5, page 363.

2. "Questions of Study Groups XI, XIII and Special B"; C.C.I.T.T. Red Book, Vol. VI, IInd Plenary Assembly, New Delhi, December, 1960, page 169, et seq.

VIEWS OF MELBOURNE



AUSTRALIAN TELECOMMUNICATION AUTHORITIES

*C. J. GRIFFITHS, M.E.E., M.I.E.E., M.I.E.Aust.**

INTRODUCTION

The Postmaster-General's Department is the principal authority concerned with telecommunication services in Australia, and co-operates closely with the Overseas Telecommunications Commission in the provision of overseas telecommunications serving the Australian network. In the broadest sense there are two other authorities which provide telecommunication services, namely, the Australian Broadcasting Commission and the Australian Broadcasting Control Board.

The functions of the Australian Broadcasting Commission are to provide the national radio and television programmes throughout the Commonwealth, including studio services that are required in the production of these programmes. The transmitters and programme lines are provided and maintained by the Postmaster-General's Department. The Australian Broadcasting Control Board is responsible for the establishment and control of standards for the operation of the national radio and television services, including the cultural level of programmes, the technical standards of transmission reception, and the licensing of commercial radio and television channels. It is not the intention in this article to consider further the activities of these two authorities.

The responsibilities of the Overseas Telecommunications Commission for external telecommunication services between Australia and overseas countries are described in a separate article in this issue of the *Journal.*

Although the Postmaster-General's Department provides all telecommunications for the public network, including many private wire services for various Government Departments, statutory authorities and private companies, there are a number of authorities such as electricity supply and railways that operate private networks as a necessary part of their systems. A close liaison exists between the Department and the various authorities in the provision of private wire facilities, both within and outside the public network, and in particular cases the Postmaster-General's Department makes use of facilities in the private networks to provide trunk channels in the national network, for example, the Railways pole routes in outlying areas.

Of particular interest are the Royal Flying Doctor and similar networks which play such a valuable part in providing communication links between isolated centres in the outback of Australia (1). These are not directly connected into the national network, but nevertheless form an important adjunct thereto.

The present article will outline the role of the Department and its organisation, and in particular the operations of its Engineering Division, as background information to the survey of plant practices in the various fields of telecommunications which forms the major part of the papers in this issue of the *Journal.* A map showing the main trunk line network of Australia has been included on page 103 of this issue; this gives a ready reference to the geography of Australia and will assist in the understanding of subsequent references to States and capital cities. To illustrate the extent of the Australian telecommunications network some selected statistics have been included in Table 1. More detailed statistics are given in other articles in this issue.

TABLE 1. SELECTED STATISTICS OF THE TELECOMMUNICATION NETWORK—JUNE, 1963

Telephones in service	2,512,000
Telephones per 100 population	22.8
Exchange services	1,812,000
Percentage automatic	79
Number of exchanges in service—	
Standard automatic	510
Rural automatic	1,500
Manual automatic	5,100
Public telephones	25,500
Trunk channels	26,300
Trunk channel miles	1,550,000
Number of telegraph offices	9,200
Telex subscribers	1,400
Telephone calls per annum	1,800,000,000
Telegrams per annum, local and overseas	21,500,000

THE FUNCTIONS OF THE DEPARTMENT

The Postmaster-General's Department as a Commonwealth Department dates from the federation of the six States of Australia in 1901 when the enactment of the Post and Telegraph Act 1901 established the Postmaster-General's Department to control the postal and telecommunication services of the Commonwealth. The Department is also known informally as the Australian Post Office. The administration of the Act and the control of the Department are vested in a Postmaster-General, who is an elected representative of the people in Parliament and is a Minister of State. The Director-General of Posts and Telegraphs is the Permanent Head of the Department who, under the Postmaster-General, exercises control throughout the Commonwealth. Each of the six States comprising the Commonwealth operates under the control of a Director, who has an overall responsibility to the Director-General for all postal and telecommunications activities in his State.

The Northern Territory, the control of which is vested in the Department of Territories, is attached to South Australia for administration of postal and telecommunication facilities.

Postal and telecommunication facilities in the Territory of Papua-New Guinea are separately controlled by a Post and Telegraph Department which is responsible to the Department of Territories. However, a close liaison exists between the Post and Telegraph Department and the Postmaster-General's Department, and a considerable amount of co-operation in technical and administrative matters in both postal and telecommunications fields has been and is being rendered to the Papua-New Guinea Administration.

In addition to the provision and operation of the postal and telecommunication services, the Department, mainly because of the widespread distribution of post offices, undertakes certain other services such as payment of pensions, transaction of Commonwealth Bank Savings Bank business and issue of broadcast listeners' and television viewers' licences.

ORGANISATION OF THE DEPARTMENT

To meet the requirements set out under the previous heading an organisation has been developed consisting of two main elements, a Central Headquarters and State Administrations. The Headquarters, presently located in Melbourne, but eventually in Canberra, the national capital, formulates and directs policy and procedures and centralised activities associated with design, planning, research and buying of materials. The State Administrations, the headquarters of which are located in each capital city, perform the field operations of the Department by providing, operating and maintaining facilities in conformity with overall procedures and policies laid down by Headquarters.

The organisations established for this purpose are shown in Fig. 1 for both Headquarters and State Administrations. The split up of functional groups in the latter varies slightly from that of the Central Administration. The Finance and General Services Division of the Central Administration has no exact counterpart in the State Administrations, the finance functions being performed in the Accounts Branch. The Stores Branch in the States is a separate entity responsible to the Director and the functions of the Organisation and Methods Branch at the State level are covered by the Personnel Branch.

An Australian Post Office representative is located in London to facilitate liaison with overseas countries, particularly in the European area.

The Engineering and Telecommunications Divisions operate in the telecommunications areas and the Postal and Transport Services Division on postal matters, while the remaining groups have an overall interest in the Department's activities.

* See page 166.

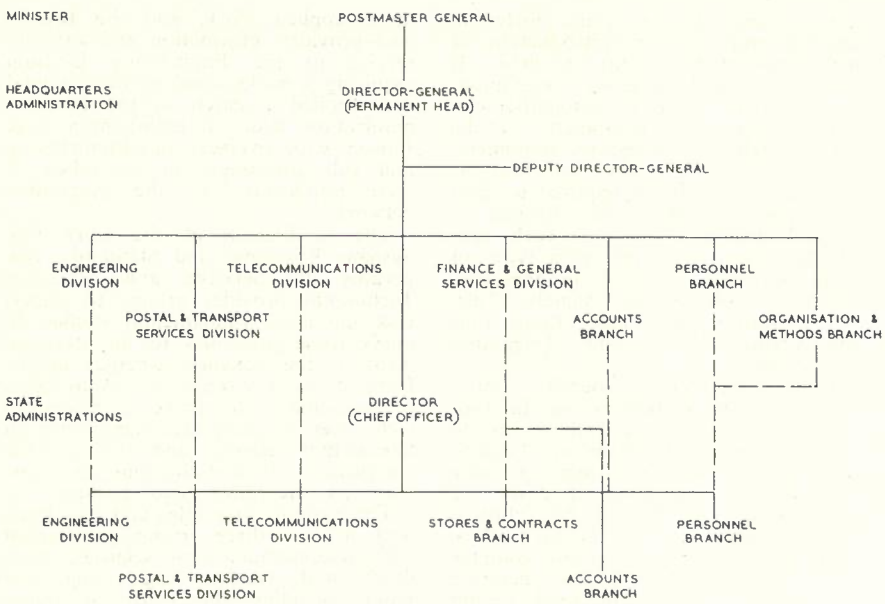


Fig. 1.—Organisation of Postmaster-General's Department.

In addition to the direct line of responsibility from the Director-General to the State Directors there are parallel lines of communication between heads of Divisions and Branches at Headquarters and their counterparts in the States to ensure close liaison and coordination in the specialised functions of each group. The following paragraphs outline the relationship of Headquarters and the States in somewhat more detail.

THE GENERAL ROLE OF HEADQUARTERS IN RELATION TO THE STATES

The role of Headquarters can be divided into external and internal. In its **external** role Headquarters serves Parliament and the Minister in relation to such matters as the implementation of the Post and Telegraph Act, the Broadcasting Act and any other Statutes determined by Parliament as necessary for the functioning of the telecommunications network. It is responsible for the establishment of policy in relation to the public, including a broad interpretation of the standards of service that will be provided and the extent and manner in which uneconomical services will be provided in the development of the country as a whole.

It is responsible for policy in relation to other Government Departments and instrumentalities such as the Public Service Board, the Treasury, the Departments of Defence, Works, Interior and Civil Aviation, and instrumentalities such as Overseas Telecommunications Commission, Australian Broadcasting Commission and Australian Broadcasting Control Board.

It lays down policy in relation to State Governments, taking into account that the laws of the various States may differ in detail and have different impacts on Commonwealth Telecommunication Acts and Regulations. It has special and increasing responsibility in relation to overseas matters such as relationships with United Nations agencies, for example, the International Telecommunication Union and the Universal Postal Union; in addition, there is a great deal of contact with overseas administrations in relation to such matters as the Colombo Plan and overseas scholarships. The Headquarters Administration is the main point of contact with industrial organisations, particularly in matters of major policy, and in the development of material requirements for the Australian network.

The **internal** role of Headquarters is concerned in the first instance with overall management of the activities of the States and in this there is a mutual dependence between Headquarters and the States involving feedback from the States to Headquarters to ensure that optimum conditions are achieved. In exercising this management function it has to promulgate policies, determine appropriate delegations of authority, set up the most efficient organisations in the various States and establish a leadership in the postal and telecommunications fields. It has important centralised functions in the technological, financial and staffing fields to ensure that the most effective results are achieved in the operations of the Department as a whole.

Each State has the important responsibility for the efficient provision, maintenance and operation of the postal and telecommunications facilities, including the engineering, commercial, financial and personnel management that this involves. A high degree of delegation of responsibility from Headquarters to the States has been established.

FUNCTIONS OF THE TELECOMMUNICATIONS DIVISION

There is complementary relationship between the functions of the Telecommunications and Engineering Divisions involving close liaison at all levels both in the Headquarters and in the States in the operation of the two Divisions.

The Telecommunications Division is the requiring authority for telephone and telegraph services and in conjunction with other Divisions and Branches ensures that the needs of the public and the broad telecommunications policy of the Department are implemented.

Its functions include the study of the extent and nature of the public demand for telecommunications services and facilities, determination of the conditions governing subscribers' telecommunication services, oversight of standards of service and determination of manual operating procedures for telecommunications services.

It is responsible also for the planning and allocation of frequencies and licensing conditions for all classes of radio communication services, together with associated monitoring and frequency measurement.

FUNCTIONS AND ORGANISATION OF THE ENGINEERING DIVISION

General

The functions of the Engineering Division within the Department can be stated briefly as follows. It is responsible for the engineering research, planning, development and extension of the national telecommunication network, for the management and control of works, for the technical operation and maintenance of telephone and telegraph plant and for the quality of service given thereby. It is responsible for the provision and maintenance of radio and television transmitting stations and relay facilities required for the national broadcasting services.

The organisations which have been developed at Headquarters and in a typical State to perform these functions are shown in Figs. 2 and 3 respectively. Headquarters operates on a functional basis and the States are subdivided both functionally and territorially. For this reason and because there are some Headquarters functions which have no counterpart in the States, there are necessarily some differences between the two organisations.

Headquarters Organisation

At Headquarters the Engineering Division is headed by the Engineer-in-Chief, assisted by a Deputy Engineer-in-Chief, under whom operate 16 Engineering Sections grouped into four technical Branches, Planning, Plant, Research and Services, respectively, controlled by Assistant Engineers-in-Chief, and one Administrative Branch. See Fig. 2.

Planning Branch: This Branch is responsible for the technical planning of the national telecommunications network, including local arrangements for inter-operation with overseas countries. A constant appraisal of world trends is maintained with participation in C.C.I.T.T. and C.C.I.R. activities, as well as liaison with other authorities as required. The Branch is divided into three Sections dealing with Fundamental Planning, Transmission and Line Planning, and Switching and Facilities Planning.

The Fundamental Planning Section is concerned with the development of long term national plans, objectives, the determination of overall technical standards for national systems planning, development and research in traffic engineering, including methods of traffic measurement, forecasting, trunking and circuit estimating, and the development of new planning techniques using automatic data processing.

The Transmission and Line Planning Section is concerned with the preparation and maintenance of engineering plans in the fields of radio, telephone, transmission, equipment and lines, including the specialised technical and economic aspects relating to planning principles and standards. A particular function is that involved in ensuring the compatibility of items of plant equipment for the development and interworking of transmission networks. It is also responsible for project planning, which provides a guide to the programming, supplies, and construction activities of the Engineering Division as a whole.

The Switching and Facilities Planning Section is concerned with the preparation of co-ordinated engineering plans for the development of switching networks and operating facilities for the telecommunications services. In addition, the broad specification and economic application of switching, signalling, call-registration and message accounting equipment, and the introduction of new facilities for subscribers' apparatus in the fields of telephone, telegraph, public telephones and switchboards, are responsibilities of this Section.

Plant Branch: This Branch is responsible generally for the standards of design of all plant used in the network and the development of techniques and practices in the provision, maintenance and technical operation of all classes of internal and external plant, including detailed work on the introduction of new types of plant into the field. It also plans the installation programmes for the major items of automatic telephone switching equipment, cable, carrier, radio and telegraph equipment, prepares the necessary specifications and assesses quantities required to meet programme needs. This Branch is divided into five Sections, each concerned with one of the main types of plant activities involved in the telecommunication system, namely, Telephone Equipment, Lines, Long Line Equipment, Radio, and Telegraphs and Power.

Each Section has generally similar responsibilities in relation to the type of plant controlled and these are to establish design standards and specifications for the plant used, develop methods and practices, set down the engineering principles to be followed in the implementation of major projects, arrange supplies for the more complex items of material, oversight operation results and efficiency of work output and develop organisation, management controls, staffing and training standards. In addition to the requirements for the normal public network the Radio Section is responsible for the provision and maintenance of transmitting stations for radio and television broadcasting, and the Radio and Long Line Equipment Sections for the provision of programme circuits for these stations.

Research Branch: The activities of this Branch include the development and proving of fundamentally new systems and facilities required over the range of telecommunication services provided and maintained by the Department. They also include similar work in connection with other services provided by the Department. In addition, the work of the Research Laboratories includes research where necessary to provide a basis for its more applied work, and the Branch also provides information and advisory service to the Engineering Division requiring a background of fundamental and applied research in the telecommunication field. It maintains a close liaison with overseas developments so that full advantage can be taken of their application to the Australian network.

The subdivision of the work into Systems Principles and Standards, Apparatus and Services, and Advanced Techniques provides groups to undertake the more fundamental studies, to apply these principles to the development of the network, whether in the form of major systems or various items of equipment, to make advances in techniques of particular significance in telecommunications, and to provide complementary investigations and services to the other two groups.

The Systems Principles and Standards Section has three groups concerned with telecommunication sciences, standards and systems engineering, the latter including the fields of radio, pulse and electronic switching systems. The Apparatus and Services Section has three groups dealing with physical sciences, equipment development and laboratory services. The Advanced Techniques Section has two main groups dealing with the more fundamental concepts of microwave techniques and transmission media.

Services Branch: This Branch consists of a group of five Sections which provide services which are auxiliary to the operation of other Engineering Branches, namely, Material Services, Engineering Management Services, Workshops and Automotive Plant, Buildings, and Drafting. In addition, it is responsible for the provisioning of programmes for engineering works and services, and the general oversight of such programmes in the current year.

The Material Services Section ensures that adequate supplies of suitable material, tools and plant (other than those major items covered by the Plant Branch) are available when and where required for the conduct of the works programmes. It also carries out acceptance inspection work on all items of equipment where standards have been prescribed.

The Engineering Management Services Section is concerned with the development and review of tools of management, involving methods study, operational research and similar techniques. It is concerned with the general assessment of performance, output and efficiency and the training of professional and technical staff. It is also the production centre for Engineering Instructions, training publications and suchlike.

The Workshops and Automotive Plant Section has the responsibility of providing and maintaining the motor vehicle and mechanical aid fleets and managing the workshops engaged in manufacture, repair and reconditioning of plant. It also manages the engineering services associated with buildings, such as light and power, lifts and air-conditioning and installs and main-

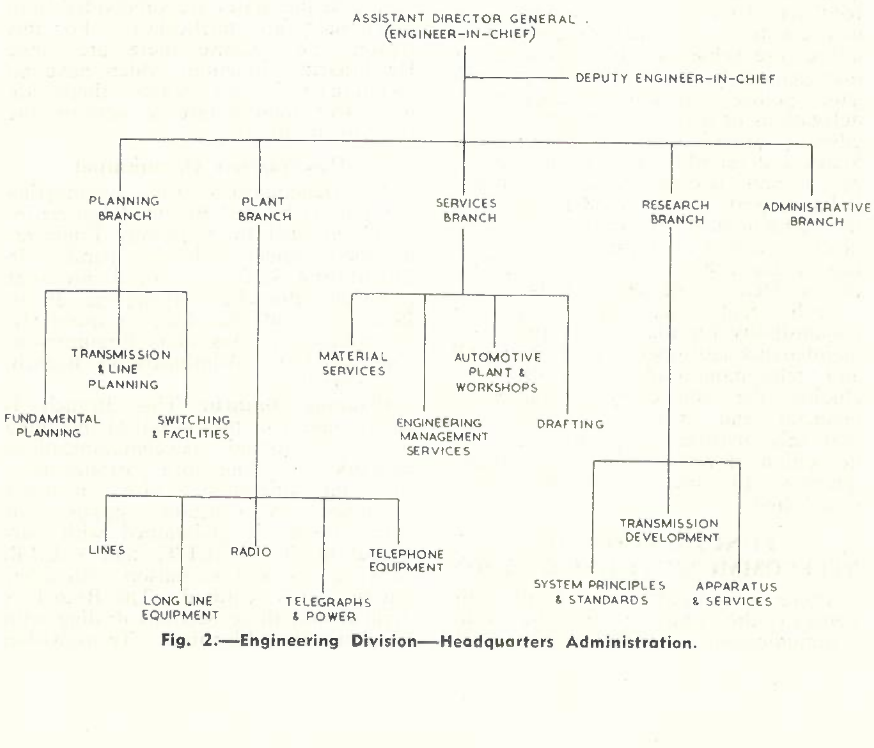


Fig. 2.—Engineering Division—Headquarters Administration.

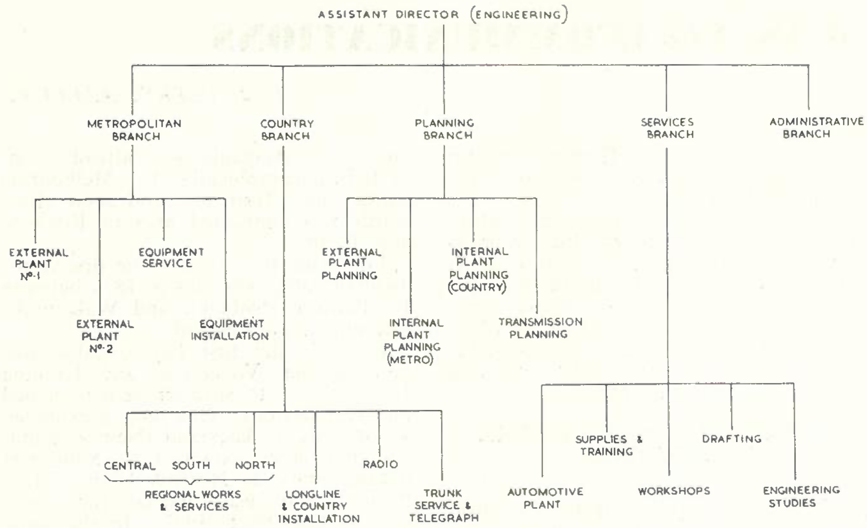


Fig. 3.—Engineering Division—State Administration.

tains mail handling plant for Postal Services. It provides civil engineering design service for special structures such as radio and television aerials and towers.

The Buildings group is concerned with the provision and maintenance of all Departmental buildings, either postal or telecommunication, and forms a co-ordinating point for preparation of designs to meet the requirements of the various Branches of the Engineering Division or other Divisions and Branches, some or all of which may be involved in particular building accommodation. It is responsible for the development of sites and buildings works programmes and liaison with the associated Commonwealth Departments of Interior (sites) and Works (buildings).

The Drafting Section provides drafting, art, reproduction and surveying facilities for various Branches of the Engineering Division and other Divisions and Branches. It prepares and maintains records of all engineering plant.

Administrative Branch: This Branch has the responsibility of co-ordinating the activities of clerical staff distributed throughout the various technical Branches. In addition, it has various centralised functions such as staff and industrial matters, costing, budget control and organisation and establishment.

State Organisation

The main functions of the States are the construction, provision, technical operation and maintenance of telecommunication, broadcasting and television facilities in accordance with principles and standards laid down by Headquarters. This involves the control of a staff, mainly technicians and linemen, of nearly 40,000 throughout the Commonwealth. Because of the great distances involved in Australia this gives rise to many and varied technical, staff and supply problems in performing these functions. It is worth recording that a subscriber in north-west Western Australia uses 6,860 miles of open wire, microwave, carrier cable and coaxial cable to talk to a subscriber at Thursday Island, north Queensland. Practically all known climatic and geographical conditions are represented, from tropical to ice and snow, from heavily timbered areas to treeless plains and deserts.

The State organisation shown in Fig. 3 applies to the two largest States of the Commonwealth from a telecommunication point of view, New South Wales and Victoria. In the other smaller States some merging of Branch functions occurs; for example, in Queensland and South Australia the Services activities are under the control of the Metropolitan Branch, but are retained as an integrated Section performing similar functional activities as in the case of the Branches in the larger States.

The State organisations are controlled by an Assistant Director (Engineering), and each Branch is in charge of a Superintending Engineer. In the case of New South Wales and Victoria, the Superintending Engineers, Metropolitan and Country Branches, are assisted by Deputy Superintending Engineers.

Planning Branch: The overall functions of the Planning Branches generally parallel the work of that Branch in the Central Administration. In the State the functions are concerned with the development of engineering plans on a State-wide basis in accordance with principles and practices laid down by Headquarters. This involves short term, intermediate and long term planning as well as review of completed plans to meet short term fluctuations in requirements. Short term and intermediate term planning is involved to a much greater extent than at Headquarters. The work of the Branch is subdivided functionally into Sections dealing with external plant, internal plant and transmission planning respectively. Because of the volume of internal plant work this is subdivided territorially into Sections dealing separately with metropolitan and country areas.

Metropolitan and Country Branches: In broad terms the functions of these Branches correspond with those of the Plant Branch at Headquarters. They are responsible for the provision, maintenance and performance of telecommunication plant in the State in accordance with procedures and standards laid down by Headquarters. In the larger States, staff controlled in each Branch ranges from 4,000 to nearly 6,000, and an important responsibility is the organisation of the work to ensure maximum efficiency.

As the name implies, the Metropolitan Branch is concerned with the capital city network, that is, Sydney, Melbourne, etc., and the Country Branch with the remainder of the State. To facilitate overall co-ordination of trunk line projects these are handled by the Country Branch, including the installation and maintenance at the capital city end.

The work in the Metropolitan Branch is divided into Sections on a functional basis, involving external plant, telephone equipment service and telephone equipment installation (both subscribers' and exchange). Within each of these Sections the work is distributed on a territorial basis into divisions with staff totals in the range 100-300 men.

In the Country Branch the Sections are partly territorial and partly functional. Sections controlling "Regional Works and Services" cover the State on a territorial basis and are responsible for the maintenance and for installation work other than that performed by the specialised functional Sections catering for trunk service and telegraph, radio and long line and country installation. As in the case of the Metropolitan Branch, the work in the specialist Sections is distributed on a territorial basis into divisions with staff numbers in the range 100-300 men.

Services Branch: This Branch in the State closely parallels the similar Branch at Headquarters, with responsibility for providing engineering services to other Branches in the fields of material supplies, training, workshops, automotive plant, engineering studies, buildings and drafting.

Administrative Branch: The State functions of this Branch are very similar to those of Headquarters.

CONCLUSION

It is difficult in this short article to cover adequately all aspects of the work of the Postmaster-General's Department and in particular the Engineering Division. The operations of the Department are an essential part of the life of the community and its constant endeavour is to develop and improve its facilities in accordance with technological advances and the requirements of the people it serves. The aim is development of a "live" organisation with a continuous review of functions, policies and performance.

REFERENCE

1. L. F. Pearson, "The Australian Outpost Radio Communication System," Telecommunication Journal of Australia, Vol. 13, No. 6, page 456.

AUSTRALIA'S OVERSEAS TELECOMMUNICATIONS NETWORK

*T. J. PETRY, A.M.I.E.E.**

INTRODUCTION

The history of the Overseas Network can be said to have commenced with the opening of the first submarine telegraph cable connecting Darwin, Australia, with the outside world in 1871. This cable was followed by others and later by radio services, at first for ship to shore communication, then for telegraphy, telephony and eventually international telex. A very considerable growth in all facilities has taken place and Australia is now being linked with many other countries by submarine telephone cables. The completion of the trans-Pacific (COMPAC) cable, which is scheduled for 3rd December, 1963, will end an era of major reliance on long distance radio communication.

For many years the overseas communications were operated by separate companies, but in 1946 all services were amalgamated under public ownership with the formation by the Commonwealth Government of the Overseas Telecommunications Commission (Australia) (O.T.C. (A.)). Since that time the Commission has been responsible for the provision and operation of all external services with the exception of the switching of telephone traffic. Until recently the Postmaster-General's Department undertook the switching and control terminal operation for all telephone traffic, but the Overseas Telecommunications Commission (Australia) is now responsible for the switching of transit traffic and the Department will switch only the traffic originating or terminating in Australia. The Department is, of course, also responsible for handling international telex traffic once this traffic enters the internal network. The Commission also operates the overseas services from Papua/New Guinea.

This article traces the general history of the development of the overseas service, and the growth of traffic. It also gives a general outline of the types of facilities operated by the Overseas Telecommunications Commission (Australia) and the main technical developments which have been occurring in the Commission's plant.

EARLIER HISTORY OF MAIN SERVICES

General

In the period following the establishment of radio services, both the submarine telegraph cable network and the radio network tended to be separate entities and were in fact competitive. Eventually a stage was reached where the advantages of combining the networks into a single network became so real that amalgamation was inevitable. The stage before the amalgamation occurred represents a fairly distinct phase in the history of the overseas service, and it is the stage that will be covered in this section of the article.

Submarine Telegraph Cables

By 1870, following the successful laying of the first trans-Atlantic telegraph cable in 1866, and the laying of a cable linking England with the Far East, including Singapore, the decision was made to extend this link to Australia. This cable landed at Darwin, via Java, and the first message was transmitted to London on 20th November, 1871. The cable service was extended into the Australian network when the overland telegraph was completed from Darwin to Adelaide a year later (1). Adelaide was already connected telegraphically to Melbourne, Sydney and Tasmania, and soon afterwards was connected also to Brisbane and Perth.

Following this success, the first trans-Tasman cable was laid in 1876 between La Perouse (Sydney), and Wakapuaka (Nelson), New Zealand.

In 1902, the first Pacific cable was laid between Vancouver and Fanning Island, thence to Suva where it branched into two sections. One section extended southwards to Auckland (New Zealand) and the other extended to Southport (Queensland) via Norfolk Island. This Pacific cable was opened for traffic on 7th December, 1902. In the same year, the England/South Africa cable was extended via Mauritius, Rodriguez and Cocos Island to Cottesloe, near Perth, and thence to Adelaide.

In 1912, a more modern cable was laid between Sydney and Auckland, and in 1917, the La Perouse cable office was closed, and the cable was linked directly with Sydney. The cable terminal at Southport was linked to Sydney in 1923, and in 1926, the Vancouver/Suva cable was duplicated with a loaded cable, and the Cocos/Cottesloe cable was also duplicated in a similar way.

From early 1900, however, experiments with wireless had shown that this would become a practicable and less costly way of communicating over long distances. In Australia, experiments in the use of high frequency radio waves culminated in the opening of the "Beam Service" to London in 1927, and from this time on, no new submarine cables were laid in Australian waters. The cable network existing at that time was substantially the same as the present network, which is shown in Fig. 1.

* See page 167.

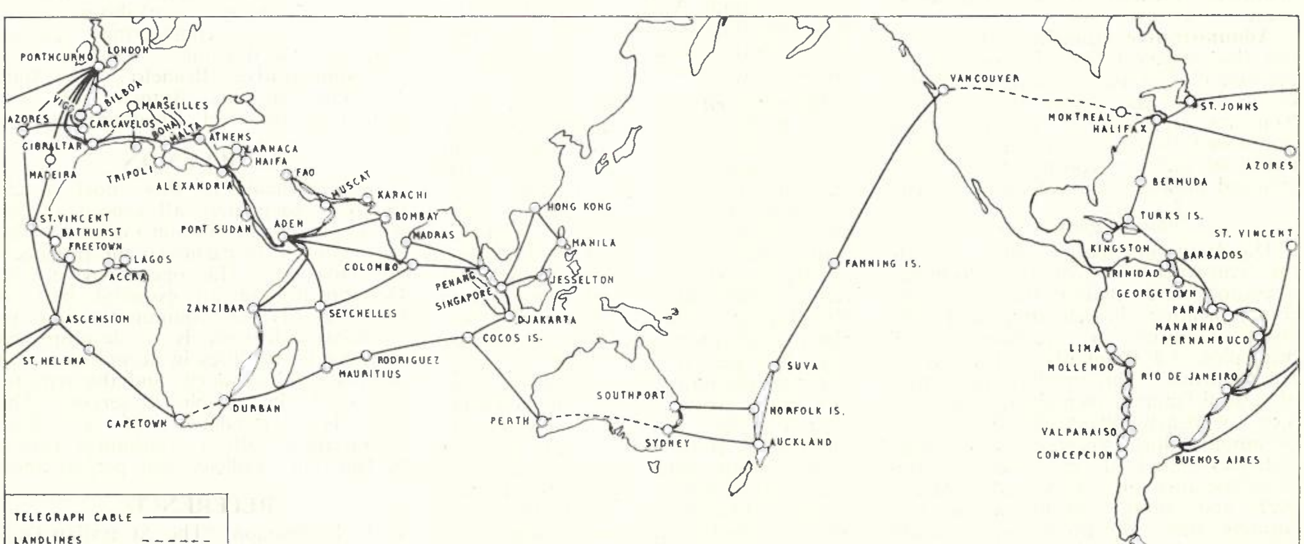


Fig. 1.—Submarine Telegraph Cable Network.

Radio Telegraph and Telephone Services

The first wireless station in Australia was established in Sydney in 1910 for the purpose of communicating with ships at sea. The service, licensed by the Postmaster-General's Department, was operated by the Australasian Wireless Company, which was later to become known as Amalgamated Wireless (Australasia) Ltd. (A.W.A.).

At about this time the Commonwealth Government decided to establish its own radio stations, mainly for the purposes of defence, but also for commercial telegraphic service with ships at sea, and for meteorological intelligence service. The first of these stations was established at Pennant Hills, near Sydney, in 1912, followed shortly afterwards by a similar station at Perth. Permanent wireless communication was thus established across Australia. These stations were operated by the Commonwealth Government initially, thence by the Department of Navy until 1922, when control was transferred to A.W.A.

From early wireless experiments carried out to and from Australia, it was known that direct communication with Europe could be achieved by using "high frequency". The experiments enabled a decision to be taken on the frequency to be used, and the type of directional aerial. In 1925 work commenced on a new transmitting centre at Fiskville (Victoria), which was completed the following year, together with the complementary receiving station at Rockbank (Victoria). Franklin uniform aerials, having a directional pattern, were also installed.

On 8th April, 1927, the "Beam Service", as it was known, opened for commercial telegraph traffic to the United Kingdom, in competition with the cable services. A year later, a similar service was opened to Montreal (Canada) on 16th June, 1928. At about this time, the wireless station in Sydney was expanded both at the transmitting station (Pennant Hills) and at the receiving station (La Perouse). The first radio-telephone services to the United Kingdom commenced from this station in 1930.

Improvements to plant and equipment were continually being made, together with inducements to the public to use the services. This resulted in a steady growth of traffic, and included the introduction of the picturegram service on 17th October, 1934. In October, 1939, a 24-hour circuit was established between Fiskville and Sydney, and in 1941, rhombic receiving aerials were erected, directed on the United Kingdom, for reception on frequencies not covered by the uniform arrays. Also, direct transmission commenced to Singapore, and later to the R.C.A. station in San Francisco.

In 1942, several new services were opened including those to China, India, Honolulu, and Cairo, followed in 1943 by further new services including the Barbados, and Perth relays, and the direct service to Port Moresby. An exclusive press channel—the first leased circuit—was inaugurated to Australia from the United Kingdom. In 1944, the Colombo relay was established, a circuit was opened to Hollandia, and the Honolulu circuit was transferred to Monterey.

Formation of Overseas Telecommunications Commission (Australia)

When the "Beam Service" was established in 1927, wireless and cable services were operating in direct competition both in Australia and overseas, and to meet this economic threat to the cable systems, an Imperial Wireless and Cable Conference was held in 1928, in London. This resulted in the merging of the wireless and cable interests in the United Kingdom, with the formation of one body first known as Imperial and International Communications Ltd., and then from 1934 as Cable and Wireless Ltd. In Australia however, this merger did not take place, and the wireless interests operated by A.W.A. continued to function in competition with the cable interests until 1946.

However, it had become clear that the two services were in fact complementary, rather than competitive, since the submarine cables would generally function at times when radio propagation conditions were unsatisfactory, and radio facilities were not subject to the same lengthy interruptions as the cables, even though these interruptions were very infrequent.

In 1945, agreement was reached at an Empire Telecommunications Conference in London on a plan for amalgamation of the British Commonwealth cable and radio services, and for their transfer to public ownership. In Australia, this resulted in the formation of the Overseas Telecommunications Commission (Australia) on 7th August, 1946, by Act of Parliament, and this Commission commenced to acquire the communications assets of A.W.A. and Cable and Wireless Ltd., which until then had operated the overseas wireless and cable services respectively.

DEVELOPMENTS FOLLOWING ESTABLISHMENT OF O.T.C.(A)

General

When the Commission was formed in 1946, its purpose was "to provide for the establishment and operation of Overseas Telegraphic, Telephonic and other like Services by the Common-

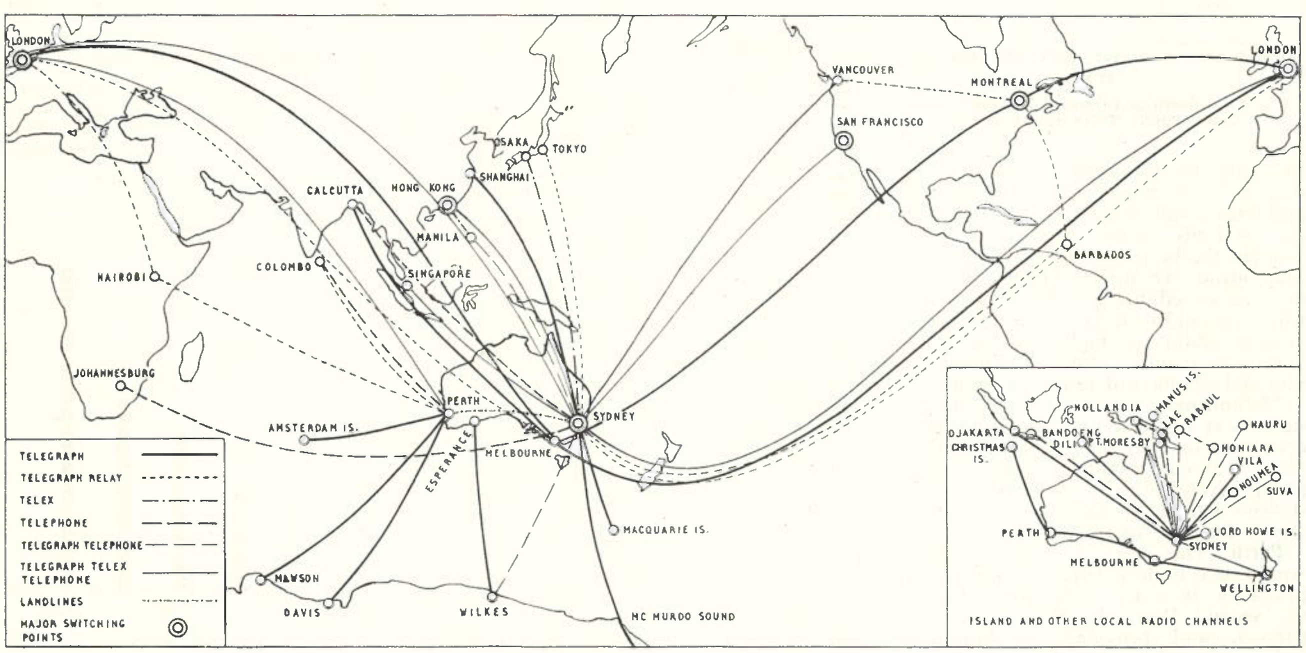


Fig. 2.—Radio Telegraph and Telephone Routes.

wealth, and for other purposes." At that time great advances had been made in the general field of radio communication for military purposes, but these techniques had not yet been applied commercially. Also, many of the coast stations in Papua/New Guinea had been destroyed and abandoned, and it was essential to re-establish these as early as possible. At the same time, now that the wireless and cable interests had been merged, it was necessary to provide a unified operational control to fully exploit both means of communications.

Expansion of International Radio Stations

Since the Commission was established, the extent of the overseas radio services has grown considerably, and the routes now operated are shown in Fig. 2. There have also been a number of changes at the individual stations and these are described briefly in the following paragraphs.

Sydney: In order to take advantage of the communications development during the war, the Commission realised that the existing sites of the Sydney international radio station at Pennant Hills and La Perouse would be too small to accommodate new high gain directive aerials. Accordingly, new sites were acquired in 1949 at Doonside and

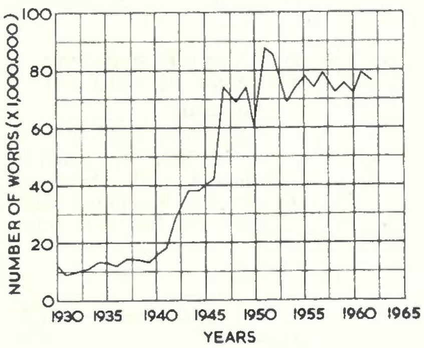


Fig. 3.—Growth in International Radio and Cable Public Telegraph Traffic.

Bringelly, for transmitting and receiving stations respectively, and work on the buildings commenced in 1953. By 1956, the stations were operational, and enabled the large volume of traffic from Melbourne Olympic Games to be handled expeditiously. In 1959, a new wing was added at Doonside to accommodate additional high powered transmitters to handle increasing volumes of radio-telephone and telegraph traffic.

Melbourne: The original "beam" stations at Fiskville and Rockbank have continued to operate. Improvements to plant and equipment have been made progressively and in particular, these stations handle all radio pictures entering or leaving Australia.

Perth: The original radio station at Applecross, built in 1912, had functioned primarily as a Coast Station. During the second War, the station was expanded, and provided an important radio relay for the Australia/United Kingdom services, the complementary

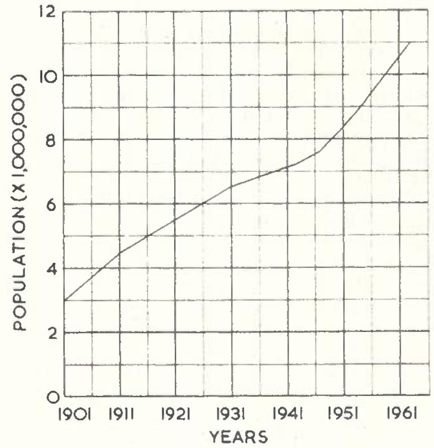


Fig. 4.—Growth in Australia's Population.

receiving station being built at Bassendean. The relay was closed down in 1946, but was re-opened in 1951, and Perth has remained an important relay station since. Telephone operation was commenced from Perth in 1956 (2). Of particular interest is the part this station plays in the world-wide chain of tracking stations established by NASA in 1961.

Papua/New Guinea: As part of the Commission's expansion and development programme, the stations at Port Moresby have been completely modernised, with new buildings and the most modern plant and equipment. The station at Rabaul has been re-established after the war, and present programming allows for completely new station buildings, and equipment in 1964. A new station has been established at Lae, with direct radio-telephone circuits to Sydney, similar to Port Moresby and Rabaul.

Traffic Developments

Telegraph Traffic: Up to 1939, there had been a steady growth of telegraph traffic as shown in Fig. 3. This growth was in keeping with the general population growth of Australia, which is shown in Fig. 4. During the war, telegraph traffic increased enormously due to military needs and those of the Press. This traffic was carried over public traffic channels, and required messages to be handled by numbers of people prior and subsequent to transmission. This volume continued to grow after the war as trade expanded. To facilitate the handling and clearing of this traffic, the Commission established modernised operating rooms in Sydney and Melbourne, which had direct access to both the cable and radio services.

Traffic development kept pace with technical developments, and message handling by teleprinter was gradually introduced. This again expedited the clearance of telegraph traffic, but growth continued at an increasing rate. The introduction of error-correcting devices in 1956, however, enabled the heavy users of the public telegraph circuits to be provided with their own private (leased) circuits to fixed points overseas on a 24-hour basis. By 1956, the number of leased subscribers, such as Press, Airline Companies, etc., had increased to a considerable extent, and this contributed to a levelling off in the public traffic directly handled by the Commission. The growth in traffic on the leased services is shown in Fig. 5.

In 1954, the Postmaster-General's Department introduced a national **telex** service, and in 1958, the Commission introduced the International Telex service on a manual basis. This enabled subscribers who did not require a 24-hour leased circuit to nevertheless communicate with their counterparts overseas on a direct subscriber-to-subscriber basis for limited periods. The growth of the telex traffic, which is shown in Fig. 6, has had its effect on public traffic and brought about a stabilising of this traffic over the past few years.

Telephone Traffic: As indicated previously, operation of the radio telephone traffic services is carried out by the Postmaster-General's Department mainly from the overseas radio-telephone terminal and exchange in Sydney, but also from a similar centre in Perth. The Commission provides the necessary radio bearers, channelling equipment, etc., and has provided the necessary equipment to enable the steady demand to be met, as shown in Fig. 7. It is now also responsible for switching international transit traffic.

The telephone traffic has grown primarily because of the general improvement in quality of the circuits, and availability. The upward trend is likely to continue, and Fig. 8 shows the tremendous growth in telephone traffic between Australia and New Zealand, with the introduction of high quality submarine cable circuits in July, 1962. It is expected that the telephone traffic will increase tremendously when the COMPAC cable is opened to Europe in December, 1963.

Technical Developments

Radio: Up to 1939, radio telegraphy used a system of "on-off" keying, which meant that one transmitter could only carry one telegraph channel at a time.

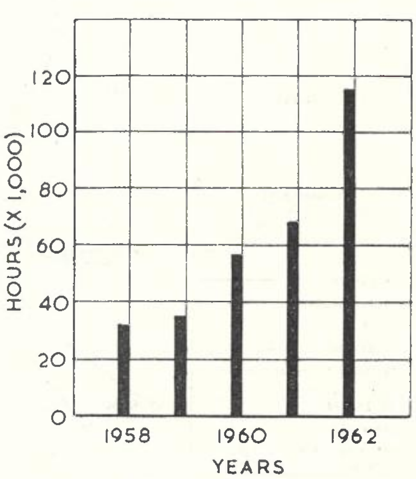


Fig. 5.—Growth in Traffic on Leased Telegraph Channels.

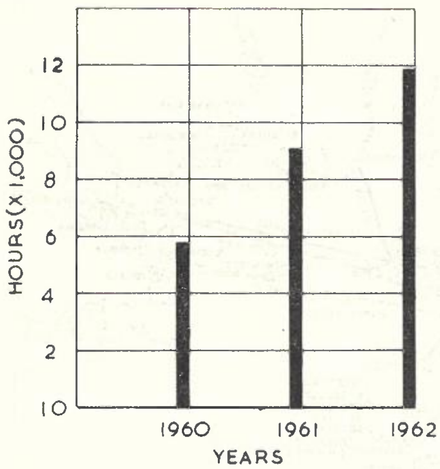


Fig. 6.—Growth in Traffic on International Telex Services.

A subsequent refinement comprised the use of "frequency shift keying (FSK)" which improved the merit of the signals but still restricted the transmissions to a single channel. Similarly, only one radio-telephone channel could be carried on one transmitter, because of the "double-sideband" method of modulation. During the War, telecommunications development produced the "single-sideband" method of modulation, and efforts were directed in providing several telegraph channels for one transmitter, as had been achieved on landlines by carrier telegraphy. Aerial development produced the rhombic array, which was a wide-band aerial, and could be used over a wide frequency range. This had advantages over the uniform array, which was essentially a fixed frequency aerial. The "single-sideband" method (SSB) led to the independent sideband method (ISB), which enabled four telephone channels to be carried on one transmitter. The first circuit from Australia using ISB transmission opened to San Francisco early in 1946.

When the Commission assumed responsibility for the overseas network in 1946, every effort was made to use the latest techniques in radio communication. As a result, rhombic aerials were constructed both in Sydney and Melbourne, and orders placed for the most modern types of transmitters and receivers.

The first channelling of the telegraph circuits employed four frequency diplex which was a development of the FSK system, permitting two independent telegraph channels to be derived from one transmission. This has now been largely superseded by the use of FSK tone telegraph channels, several of which can be applied to one of the sidebands of an ISB transmitter, leaving the other sideband for telephony. Corresponding refinements were necessary at the receiving stations and developments of techniques in transmission and reception were complementary. The power of transmitters also increased until at the present time 30 KW transmitters are used on most of the major overseas circuits. Automatic tuning was also introduced.

Development continued in attempting to conserve bandwidth, due to the rapid growth of radio communications, and the need to avoid interference from other stations. Bandwidth could not be reduced for telephony, but in telegraphy the bandwidth was reduced by progressively reducing the amount of frequency-shift necessary. The practical limit has been nearly reached, as it is now possible to signal at speeds of 85 bauds using a frequency shift of $\pm$ 42.5 c/s. Other developments in telegraphy led first to error-detection systems in 1950, thence to error-correction systems, which are now in current use. These error-correction systems led to the growth of leased circuits and international telex as mentioned previously.

The Commission has kept pace with all the latest developments, although this has meant that equipment has often become obsolete before the end of its useful life. However, long distance radio communication can only be carried out over a fairly limited frequency

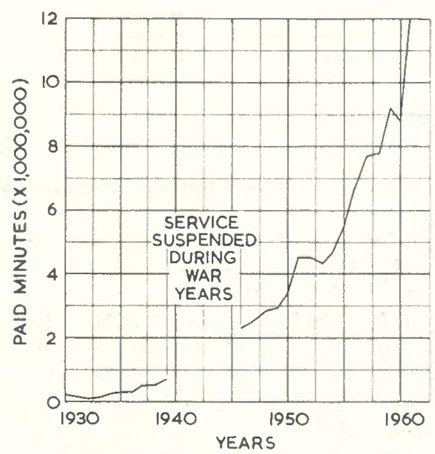


Fig. 7.—Growth in International Radio Telephone Calls.

range, 4-30 Mc/s. Also, due to the regular cycle of sunspot activity, the frequencies above 20 Mc/s cannot always be used, particularly at sunspot minimums, which occur every 11 years. At the same time, with the post-war emergence of new nations, the demand for frequencies is constantly increasing, which increases the likelihood of interference.

Submarine Telephone Cables: Refinements in radio communications had reached a stage in 1958 where further major improvements were unlikely. Development overseas had therefore concentrated for some years previously on designing and manufacturing a coaxial type of submarine cable, with amplifiers placed at regular intervals along its length, and capable of carrying a number of telephone channels. This type of cable had been successfully laid across the North Atlantic in 1956, and at a conference in Sydney in 1959 between representatives from the United Kingdom, Canada, New Zealand and Australia, it was decided to proceed with a similar submarine cable across the Pacific. Thus the "COMPAC" project was begun, details of which were contained in a previous issue of this *Journal* (4). The extent of the network which has now been provided or is planned for completion in the near future is shown in Fig. 9.

Submarine Telegraph Cables: Although no new submarine telegraph cables have been installed in Australian waters since 1927, most of the original cables have been retained in service. With the rapid development of techniques following the second World War, and the need to send more and more traffic at faster speeds, various means of increasing the signalling speed over the submarine telegraph cables have been developed. The original cables had a signalling speed of about 10 words per minute, using one-way working. Later techniques, including two-way working, regenerators, loading, and submerged repeaters (3) have raised the speed to about 60 words per minute.

Operational Developments

Operational developments have concentrated on making the maximum use of available equipment, and the use of alternative routes, in order to clear traffic as soon as possible.

Soon after the formation of the Commission in 1946, the two operating rooms serving the radio and cable routes in Sydney were merged, so that either route could be used if one or the other failed, or alternatively if either route was operating at maximum capacity. In Melbourne, a similar arrangement was made, except that access to the cable routes was over a landline system to Sydney. As signalling techniques became more refined, so that one transmitter could carry a number of channels, it became necessary to improve the quality of the circuit.

Since the major Australian radio circuits were to the United Kingdom, the problems were more severe than that of most countries, because of the long distances involved. Improvements to quality were achieved by careful selection of suitable frequencies, and

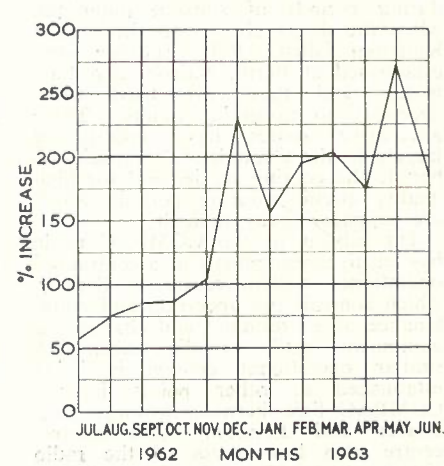


Fig. 8.—Increase in Telephone Calls between Australia and New Zealand since the Tasman Section of COMPAC was Opened.

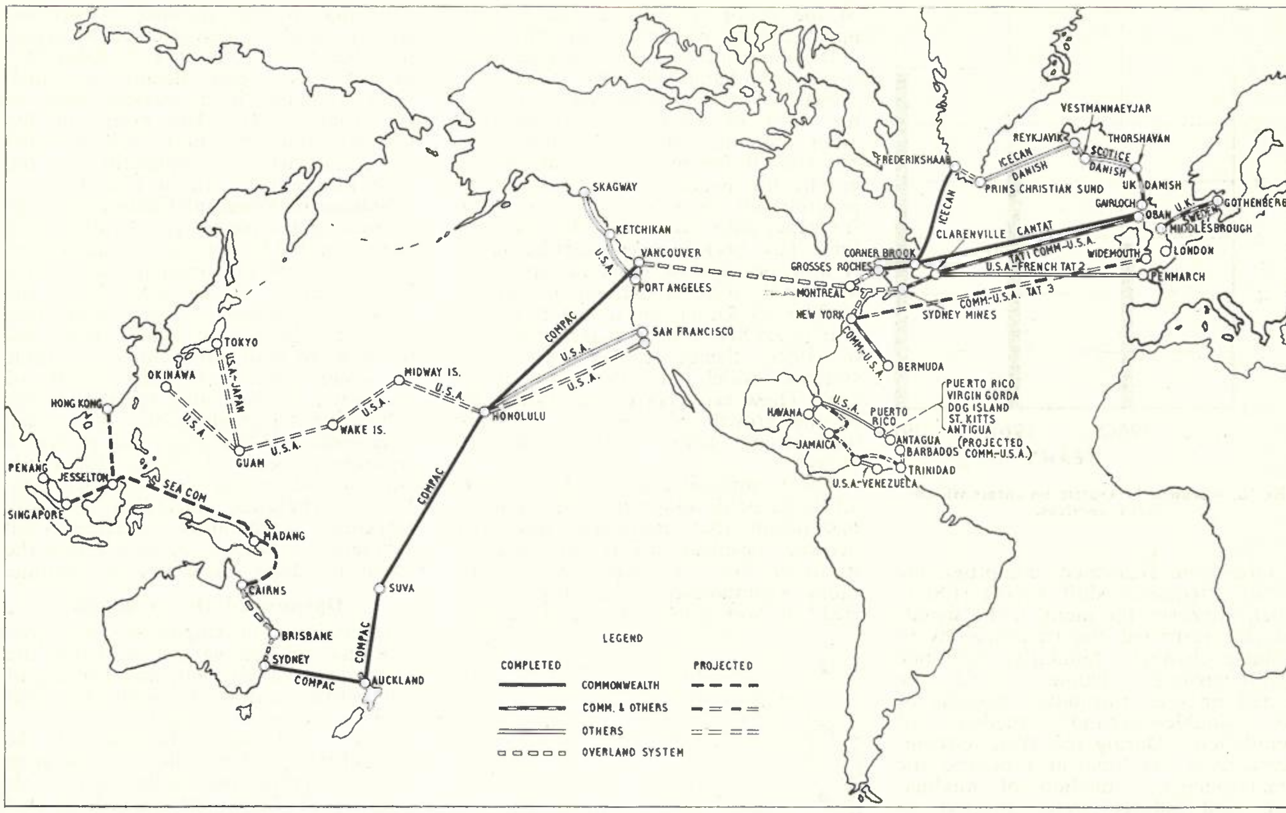


Fig. 9.—Existing and Planned Submarine Telephone Cables.

provision of automatic tuned transmitters to facilitate rapid changes. Dualling of transmitters is also carried out during the frequency changeover period to prevent loss of the circuit.

At the same time, the Commission developed higher and longer rhombic aerials for the lower frequencies. By design of the aerial pattern, side lobes were minimised to reduce interference from neighbouring stations.

Since radio communication is dependent on reflections from the ionosphere, and the sunspot cycle, it became necessary to establish radio-relay stations during periods of sunspot minimum, when the direct circuits to the United Kingdom failed. Relay stations were established at Perth, Nairobi and Barbados, and these are used when necessary to maintain circuits. These alternative routes have contributed largely to the Commission's capacity to handle the continuous demand for high quality circuits, during periods which are propagationally difficult.

The advent of the COMPAC cable has led to developments of a centralised operational control centre in Sydney, which controls the operation and maintenance of all terminal and channelling equipment used on the cable. A similar operational control is being established at other points in the COMPAC link, between Sydney, Vancouver and London. This control centre also has access to the radio circuits, to enable rapid changeover in the event of cable failure. Existing radio circuits will be used to augment the present circuits to Asia and the Far East, and channel these circuits on to the cable.

THE COASTAL RADIO SERVICE

No article on the overseas network would be complete without reference to the Coastal Radio Service.

The primary function of coastal radio stations is to maintain a continuous listening watch on the maritime distress frequencies, using medium frequency for large ships, and high frequency for small ships. In addition to the Distress standby watch, coastal radio stations broadcast navigation warnings, storm warnings, daily weather reports and time signals. They also provide a ship/shore R.T. service, radio medical service, and conduct traffic circuits with ships at sea.

A long distance high frequency communications service between certain British Commonwealth coast stations and British merchant shipping is in operation, known as the Area Scheme. Sydney Radio is one of the Area stations from which radio-telegrams are transmitted to ships at scheduled periods throughout the day.

The first of the coastal stations, Sydney Radio, commenced operations in 1912, and by 1914 coastal stations had been established at Adelaide, Brisbane, Broome, Cooktown, Darwin, Esperance, Flinders Island, Geraldton, Hobart, Melbourne, Mt. Gambier, Perth, Port Moresby, Rockhampton, Roeburne, Thursday Island, Townsville and Wyndham. Stations were later operated at King Island (1916) and Samarai (1917). Following the capture of the German radio station at Rabaul, in 1914, by Australian forces, installations were set up by the Australian Government in that Territory at Aitape, Kavieng, Kieta, Madang, Manus, Morobe, and Woodlark Island. These stations operated under the Department of Navy from 1916-1920, and were later taken over for a short period by the New Guinea Administration. In 1922, control was transferred to A.W.A. which continued to operate the service until 1946. When the Overseas Telecommunications Commission was formed by the Commonwealth Government at this time, control of the Coastal Radio Service was transferred at the same time as the Beam Service. As many of the coastal stations in Papua/New Guinea had been destroyed or abandoned during the second World War, new stations were established in the late 1940's. Among these were Lae (1945) which replaced Salamaua, and Wewak (1948) which replaced Aitape. Other stations were re-established at Rabaul, Manus, Samarai, Madang and Kavieng.

An additional service conducted by coastal radio stations is that to certain outpost radio stations (5). The most important station in this regard is Darwin Radio, and about 250 outpost stations are licensed to operate into this network. Darwin Radio provides a direct Radio Medical Service between the Health Department doctor and outpost operators and also provides a regular news service twice daily.

Rockhampton Radio is gradually extending its outpost service into Western Queensland, and has 17 stations in its network.

The Aeradio Service at Thursday Island is operated on behalf of the Department of Civil Aviation by the Coastal Radio Service staff. Conversely, the Department of Civil Aviation operates the Coastal Radio facilities at Wyndham and Cairns, in conjunction with aeradio facilities. Perth Radio conducts services to various points such as Christmas Island, and the Antarctic.

At present, 24 coastal radio stations are operated by O.T.C. (A) around Australia and its Territories. These extend from Cocos Island in the west, to Willis Island in the east, and from Hobart in the south to Rabaul in the north.

As a result of a review of Coastal Radio Services in 1956, a decision was made to re-site some stations, and to re-equip all stations with modern equipment. Engineering specifications were prepared, equipment ordered, and installation is now in progress. The stations are being equipped with the most modern type of auto-tuned transmitters, both for the M.F. and H.F. services. Reception on the distress frequencies is by means of Codan receivers which are normally muted until a signal is received. Centralised control of both transmitters and receivers is provided in a console, for each operator, for ease and speed of working. Quadrant aerials are used for the H.F. services, providing a wide-band omnidirectional beam, and vertical masts are used for the M.F. radiators. The complete installation programme is scheduled for completion in 1965, and this will provide Australia with one of the most modern Coastal Radio Services in the world.

FUTURE DEVELOPMENT

The opening of the COMPAC cable on 3rd December, 1963, will mark the end of an era of radio development which commenced with the Beam Service in 1927. Future development will be to establish further high quality submarine cable routes in the Pacific area. Plans are already well advanced to lay a new cable to South-East Asia (SEACOM), and this is scheduled for completion in 1966 (Fig. 9).

The availability of high quality international circuits will enable greater use to be made of existing landline techniques, which were not applicable to radio circuits. Cable multiplexing equipment will shortly be installed, together with a semi-automatic exchange for international telex, in 1964. Later, full automatic working will be introduced. For international telephone calls, semi-automatic working will be introduced in 1963.

In the field of satellite communications (6, 7) the Commission is actively engaged in discussions with other countries in the administrative, technical, and economic problems associated with a global system.

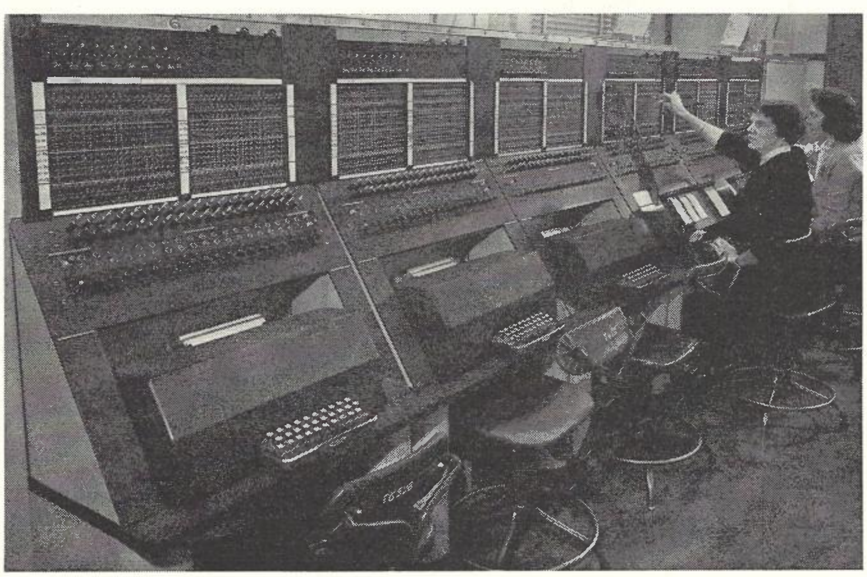
REFERENCES

All References are to articles in the Telecommunication Journal of Australia.

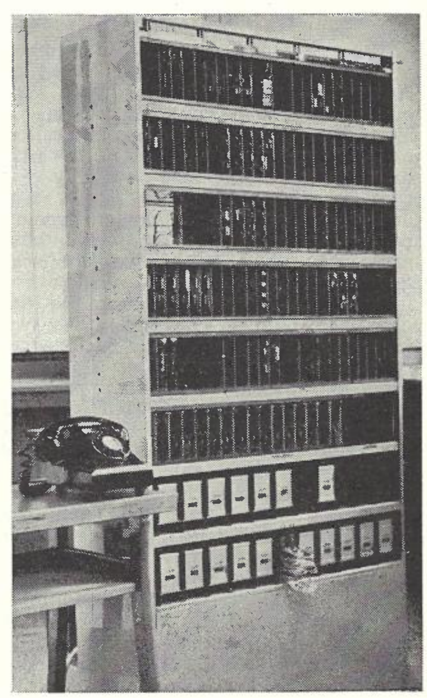
1. R. C. M. Dale, "Alice Springs and the Overland Telegraph Line"; Vol. 2, No. 3, page 161.
2. N. A. Brayley, "Perth Terminal of the Australia-London Radio Telephone Link"; Vol. 12, No. 4, page 265.
3. R. E. Knightley, "Cocos-Cottesloe Undersea Telegraph Repeater"; Vol. 11, No. 3, page 65.
4. R. E. Knightley, "COMPAC: Vancouver-Sydney 60/80 Channel Submarine Cable System"; Vol. 13, No. 4, page 272.
5. L. F. Pearson, "The Australian Outpost Radio Communication System"; Vol 13, No. 6, page 456.
6. F. P. O'Grady and E. R. Craig, "Radio Communication by Artificial Satellites"; Vol. 13, No. 1, page 2.
7. E. Sawkins, "World Automatic Telephone Network"; Vol. 13, No. 5, page 363.

PHOTOGRAPHIC SUPPLEMENT

Scattered through the following pages are some pictures which show a few interesting features of the Department's engineering activities and illustrate some typical Australian conditions.



Part of the manual teleprinter exchange (Telex) used for switching teleprinter messages between subscribers.



An experimental electronic telephone exchange.

AUSTRALIAN TELEPHONE AND TELEGRAPH NETWORKS

*R. W. TURNBULL, A.S.T.C. (Elec. Eng.), M.I.E.Aust. and G. E. HAMS, B.Sc., A.M.I.E.Aust.**

INTRODUCTION

The Australian Telecommunication System is being developed to meet the needs of a rapidly growing nation. A high rate of population growth and substantial development in the fields of primary and secondary industries, together with the administrative, commercial and social needs of the community, have created conditions in which there is continuing pressure for expansion of telecommunication services. Among the problems being faced in the general economic development of the nation is that of the best possible distribution of capital resources to cover many requirements which must be met simultaneously. In the field of telecommunications, record levels of demand for new facilities are being experienced and strenuous efforts are being made with the resources available to the Postmaster-General's Department to provide and maintain high quality services to all parts of the continent. In terms of growth statistics, Australia now ranks among the larger systems of the world.

This paper is intended to present a brief outline of Australian conditions, to record the growth of services with statistics of the present system and its traffic handling capacity, and to describe in summarized form the policies and long-term plans which have been adopted to guide the future development on modern and economic lines.

CLIMATE AND POPULATION DISTRIBUTION

The Australian continent is comparable in size to the United States of America, having an approximate area of 3,000,000 square miles, with maximum distances in the east-west direction of 3,000 miles and in the north-south direction of 2,000 miles. Eighty per cent of the continent is of an arid nature, supporting less than one person per square mile. The most habitable areas are found on or near the seaboard and 54% of the population live in the six State capital cities and the national capital at Canberra. The two largest cities are Sydney and Melbourne, each having a population exceeding 2,000,000 people. Thirty-eight per cent of the total population live in and around these two cities. Fig. 1 shows the populations of the larger cities, and Fig. 2 the general population distribution in Australia. The population distribution results generally from the continental conditions of climate, soil fertility, water supply and natural harbours. Fig. 3 gives an indication of the principal climatic conditions. The population of 10.9 million is growing at 2½% per annum as can be seen from Fig. 4 on page 98 of this issue.

It is of interest that a wide coverage of the problems generally met in the development of telecommunication systems is experienced in Australia, and that because of its particular conditions of great size, range of climatic conditions, population distribution and economic development, there are unique features also. Some of these are covered in more detail in other articles in this issue.

GENERAL REVIEW OF EXISTING TELEPHONE NETWORK

The Australian telephone network at June, 1963, had 2,510,000 telephones connected, representing a telephone density of 22.8 telephones per 100 people. Eighty per cent of telephone services are automatic.

Service to all settled areas of the continent has been achieved by the provision and interconnection of 7,000 exchanges. Five thousand of these exchanges, mostly at small rural centres, are still manually operated. Another 1,500 are small automatic exchanges of less than 200 lines in rural areas whilst the remainder are larger automatic exchanges in metropolitan or provincial centres.

The local telephone networks in the State capitals, Sydney (615,000 telephones), Melbourne (520,000 telephones), Brisbane (152,000 telephones), Adelaide (144,000 telephones), Perth (98,000 telephones), and Hobart (28,000 telephones) are fully automatic, the networks using predominantly bimotional switching equipment and step-by-step trunking. The large scale use of crossbar equipment has been commenced.

Automatic switching techniques have been applied to the trunk line system as long-distance dialling has become possible, and the trunk service now is highly mechanised under operator control using motor uniselector switching and a two voice-frequency signalling system employing decadic codes. Initial installations of subscriber trunk dialling have been made; for example, subscribers in Canberra dial directly into the Sydney network and by the time this issue of the *Journal* is printed will also have access to the Melbourne network. This facility is being extended under a plan for full mechanisation, which is summarised later in this article.

After detailed investigations, crossbar equipment of the L. M. Ericsson design was selected in 1959 as the Australian standard for switching in both the local and trunk networks for the next phase of expansion (1). A range of crossbar exchange types is being used or developed to meet the needs of metropolitan and provincial centres, for service in sparsely-settled areas, and for trunk switching centres of various sizes.

Arising from its diverse features of national development, Australia has gained broad experience in many methods of circuit provision, both for subscribers' and trunk lines. Cable reticulation is highly developed in the major cities, incorporating such features as control cabinets and distribution pillars to achieve flexibility in subscriber plant usage. Gas pressure protection of junction cables is employed to improve reliability. At the other extreme, service to subscribers living in remote and sparsely-settled areas has required a considerable use of party lines and long subscribers' lines, some of which exceed 50 miles in length. In such areas many of the lines are provided by a co-operative effort in which the Department and the subscribers both undertake part of the construction work.

The great distances to be spanned have placed emphasis on the use of carrier techniques since the mid-1920's. More recently the capacity of open wire trunk routes has been increased rapidly by the application of 12-channel carrier systems, but the stage was reached when the growth of trunk traffic on many important routes exceeded the maximum capacity which could be provided. A feature of current importance is a rapidly growing television service which requires the provision of relays from studios in the capital cities to all the large country centres. This has stimulated the introduction and continuing development of broadband bearer systems. Coaxial cables and microwave radio systems are being installed to meet overall demands in accordance with a general plan which prescribes the interconnection of all main centres of population. During the next five years the large scale increase in the traffic carrying capacity of the trunk line system resulting from the provision of broadband systems will naturally be a most significant factor in preparing for the development of nationwide automatic telephone service. Fig. 4 shows the main trunk routes

TABLE 1: GROWTH OF THE TELEPHONE NETWORK

As at 30th June	No. of Telephones	Telephones per 100 people	% Auto.	No. of local calls	No. of Trunk calls	Total Calls	No. of Trunk Lines
1950	1,109,984	13.57	57	889 x 10^6	68 x 10^6	957 x 10^6	8,150
1956	1,703,622	18.07	69	1,186 x 10^6	99 x 10^6	1,285 x 10^6	13,024
1962	2,382,478	22.25	79	1,650 x 10^6	77 x 10^6*	1,727 x 10^6	23,601

*The sizes of local areas were increased in 1960 and calls between many centres became local instead of trunk calls.

* See page 167.

Fig. 1.—Map of Australia showing States, Principal Cities, and Main Trunk Routes.

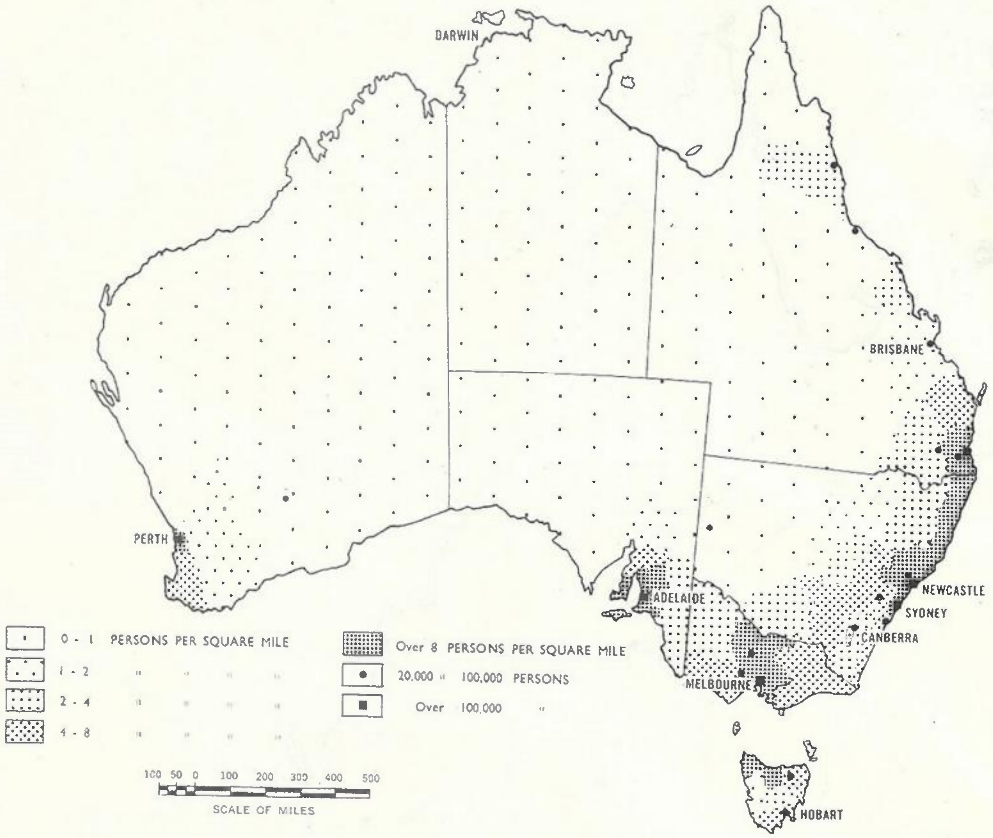


Fig. 2.—Australia's Population Distribution.

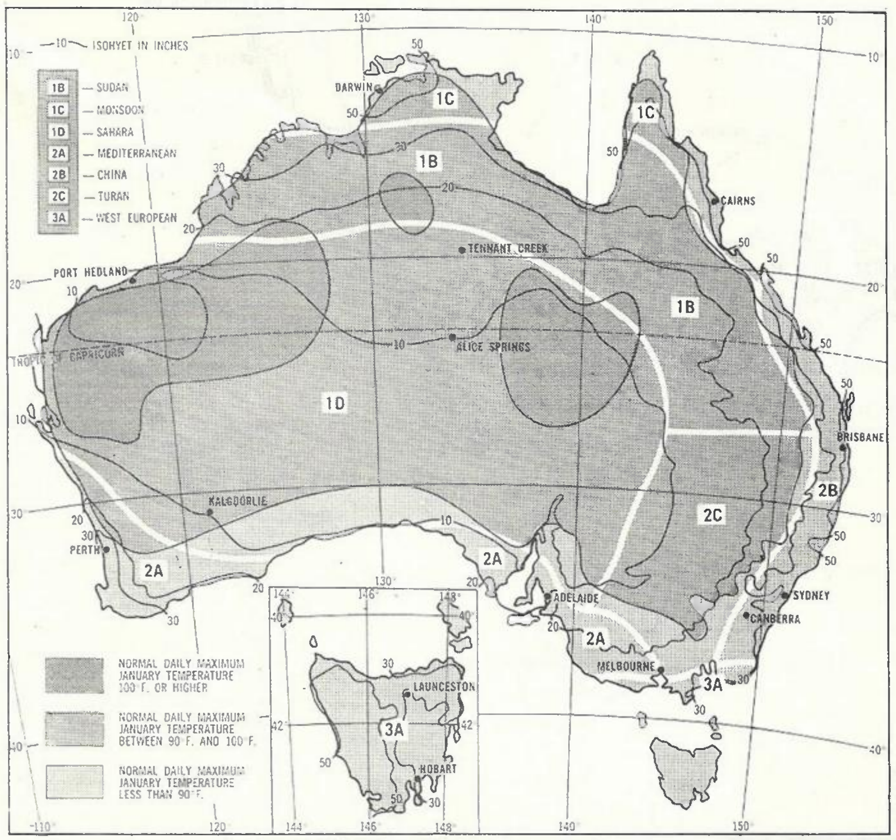
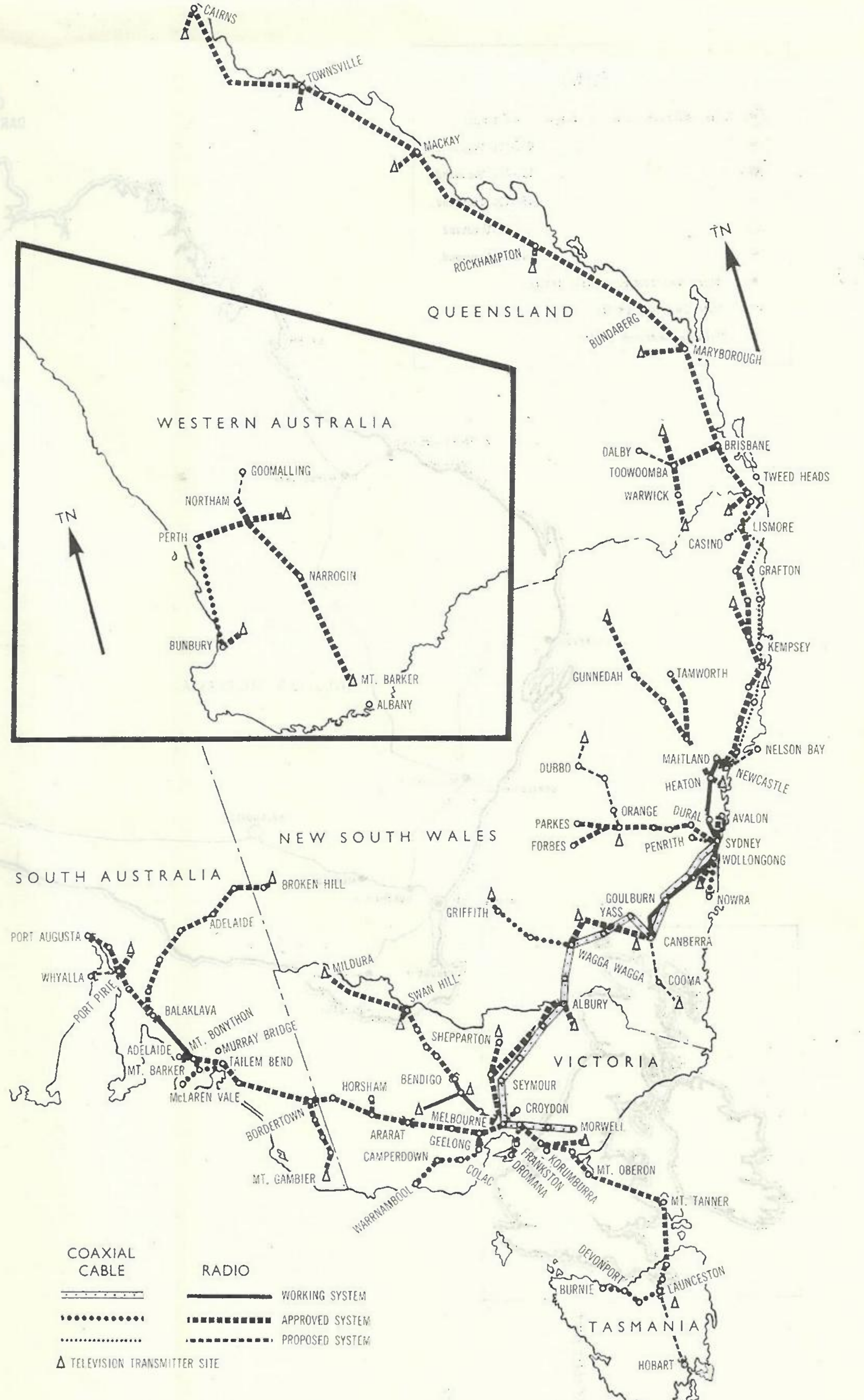


Fig. 3.—Climatic and Geographic Conditions.



BROADBAND BEARER SYSTEMS

Fig. 4.—Existing and Projected Broadband Cable and Radio Systems.

TABLE 2: TELEPHONE CALL CHARGES

Local Calls: 4 pence per call.
Trunk Calls:

Charging Distance	S.T.D. Operation		Manual Operation		
	Time for 4 pence		Each three minutes or part of three minutes		Particular Person Fee
	Between 9 a.m. & 6 p.m.	Between 6 p.m. & 9 a.m.	Between 9 a.m. & 6 p.m.	Between 6 p.m. & 9 a.m.	
	Secs.	Secs.	s. d.	s. d.	s. d.
Not exceeding 25 miles	45	60	1 4	1 0	1 0
Exceeding 25 but not exceeding 30 miles	36	60	1 8	1 0	1 0
Exceeding 30 but not exceeding 50 miles	30	45	2 0	1 4	1 0
Exceeding 50 but not exceeding 100 miles	15	20	4 0	3 0	2 0
Exceeding 100 but not exceeding 200 miles	10	15	6 0	4 0	2 0
Exceeding 200 but not exceeding 300 miles	6	9	10 0	6 8	4 0
Exceeding 300 but not exceeding 400 miles	5	6	12 0	10 0	5 0
Exceeding 400 miles	4	5	15 0	12 0	6 0

which are already equipped with broadband bearer systems and those which are in the process of being so equipped.

The decision as to whether a cable or a radio system should be provided on any route is made after a detailed investigation of economic and other factors, which apply in the particular case, has been carried out. Table 1 summarises the general growth of both local and trunk networks.

Throughout Australia a two-part telephone tariff system is employed, in which the subscriber pays an annual rental and a separate charge for each call. The basic rental payable depends on the number of telephones accessible at the local call rate, and whether the service is classified as being for business or residential purposes. In the largest cities, Sydney and Melbourne, rentals for business and residential services are £17/5/- and £14/-/- respectively. Call registration is effected by the provision of a call meter for each automatic telephone service. Trunk line calls are docketed when connected manually and multi-metered, using periodic metering, when dialled by the subscriber. Table 2 shows the existing call charges.

GENERAL REVIEW OF EXISTING TELEGRAPH NETWORKS

The telegraph network is well developed and three distinct types of service are provided, as described hereunder:—

(i) **The Public Telegraph Service** consists of facilities for handling telegrams. The switching system employed is an automatic message storage and retransmission system, known as TRESS, and is used for transmitting telegrams from Post Offices where they are lodged to other offices from which they are delivered.

(ii) **Private Wire Services** are services leased and operated by subscribers. They vary in magnitude and complexity from point-to-point services to larger networks such as the meteorological network, stock exchange and airline systems. In these cases, the subscribers lease both the terminal equipment and the interconnecting lines.

(iii) **The Telex Service** is a direct switching teleprinter exchange network provided as a public network for interconnecting teleprinter subscribers. It functions similarly to the telephone service except that teleprinters are used instead of telephones. It will be noted that this system differs from TRESS in that it is used for directly interconnecting lines and does not provide for storage of messages. At present the service is manually switched but a fully automatic nationwide system is planned and crossbar automatic telex exchanges have been ordered. The system is scheduled for introduction in 1965.

Table 3 summarises the general growth of the telegraph networks.

THE OUTPOST RADIO SYSTEM

Supplementing the conventional telephone and telegraph networks is the Australian outpost radio system (2) which provides communication to the sparsely populated regions of the continent. The system was initiated primarily to assist in the provision of medical aid and advice to residents in these locations, but as now operated it enables telegrams to be passed to the public telegraph network, and conversations to be held between outposts; it also provides a means of supplementing normal educational facilities.

The system is not operated by the Postmaster-General's Department, but by a number of organisations. The largest is the Royal Flying Doctor Service which operates 477 of the 2,283 outpost and portable stations.

TABLE 3: GROWTH OF THE TELEGRAPH NETWORK

As at June 30th	Public Telegraph Network—No. of Telegrams	Private Wire Services			Telex		
		Local Networks	Trunk Networks	Total	Subscribers	Local Calls	Trunk Calls
1955*	22.713,173	172	204	376	95	463	4.715
1959	19,762,568	292	319	611	502	5,960	228,561
1962	18,739,011	388	231	619	1,215	36,210	696.482

* Telex service was introduced on 1st August, 1954, in Sydney and Melbourne.

THE FUTURE TELEPHONE SYSTEM

General

A characteristic of Australian national development is the existence of well-defined communities centred on the main country towns and on the State capital cities. The plan for fully automatic operation of the telephone system (3, 4, 5) is based on the development of separate regional automatic networks to serve each of these communities and of a national switching system interconnecting them. The plan contains four inter-related elements—the Numbering Plan, the Switching Plan, the Transmission Plan and the Call Charging Plan. The main features of these elements are described in the following paragraphs.

The Numbering Plan

The automatic equipment in the future telephone system will determine the method of routing a call and will select the appropriate charge to be applied by examination of the digits dialled by the calling subscriber. The numbering plan is, therefore, a controlling factor in the complexity and cost of the automatic equipment. The numbering plan has the following main features in order to keep this cost and complexity to a minimum and yet allow simple calling instructions for the public:

(i) The principle of closed numbering is being used on two levels—the regional network numbering and the national numbering.

(ii) There will be only two dialling procedures. Subscribers will dial the number shown in the directory for calls within their own regional network. For calls beyond their own network, the National number will be dialled.

(iii) Subscribers in each of the automatic networks which will be developed throughout Australia will have directory numbers consisting of up to 5, 6 or 7 digits depending on the size of the particular network.

(iv) Each of the networks is assigned a distinguishing regional code which will be dialled when calls are made between networks. It includes the Trunk Access Code O. The National number, made up of this area code plus the subscriber's directory number, does not exceed nine digits in length.

(v) The numbering plan is arranged on a systematic basis with the aim of reducing to a minimum the amount of digital examination necessary to decide the routing and charging of calls. Fig. 5 shows the allocation of the primary digits of the national numbering.

"A" DIGIT ALLOCATION

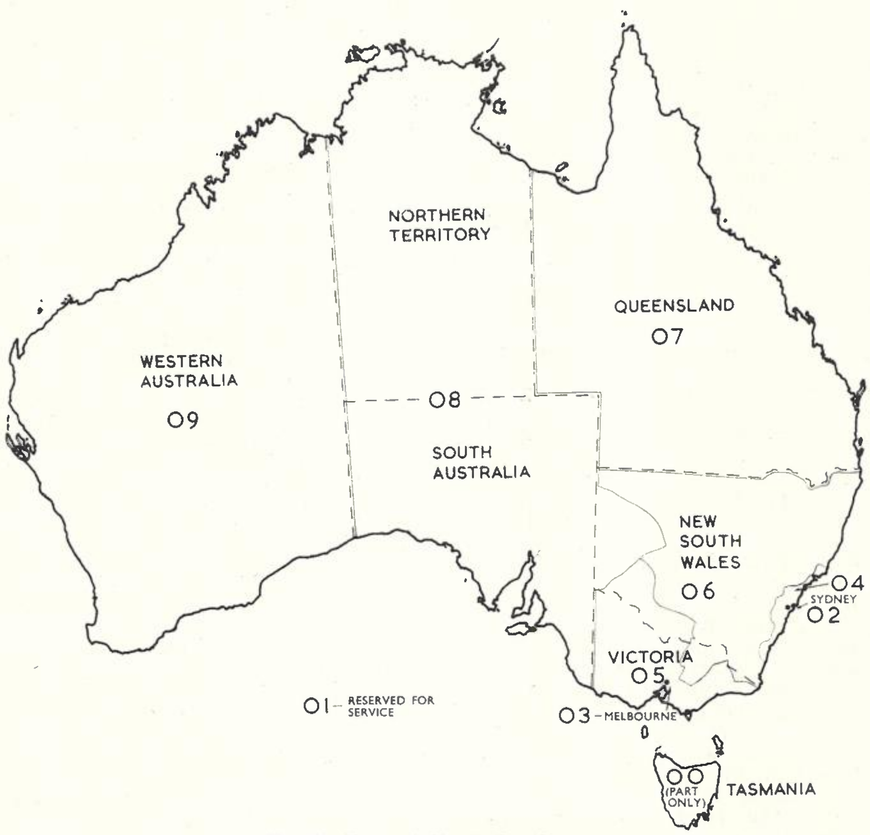


Fig. 5.—National Numbering Plan.

The numbering is designed to provide for an estimated 50-year requirement of 15 million telephones, with adequate reserve capacity to cater for future international operation and for development, at present unpredictable, which may arise from exploitation of mineral deposits or revitalisation of waste lands as a result of scientific developments.

The Switching Plan

The Switching Plan is designed to achieve the most economic disposition of plant required for the interconnection of all telephone exchanges throughout the Commonwealth. Briefly, it lays down:

(i) The systematic manner in which the individual trunk routes will be connected together in the routing of calls throughout Australia. Automatic alternate routing will be used extensively—the most direct route to the required destination will be tested first and, if busy, the call will be automatically offered to alternate paths to that destination. The particular pattern of interconnection in which as many as nine links could be switched in tandem, arises from the distribution of the Australian population throughout the continent and from the nature of telephone traffic. Fig. 6 shows the basic routing pattern.

(ii) The switching method and the associated signalling system to be used for the setting up of connections. The simple numbering and the complex interconnecting system are made compatible by the use of a common control switching technique.

Multi-frequency code signalling will be used for the transfer of digital information between crossbar exchanges at a rate of 10 digits per second in order to avoid unprofitable occupancy of plant and excessive post-dialling delays for subscribers. A compelled sequence mode of operation will be used.

The location of manual assistance centres will be determined by service and economic factors. Present planning favours the concentration of the assistance facilities at centres of Secondary trunk switching status or higher to serve each surrounding regional network. Standard service codes have been allotted in the national numbering so that eventually subscribers will be able to gain access uniformly through Australia to any of the service facilities, including manual assistance on trunk calls.

The Transmission Plan

The Transmission Plan for the system is summarised in Table 4 and Fig. 7. Table 4 shows the subscribers' plant design limits used with the latest telephone (5) and Fig. 7 sets out the link losses in the interconnecting network. The maximum basic loss of switched inter-exchange connections is 15 db. Direct connections between terminal exchanges are designed to be less than 12 db.

TABLE 4: SUBSCRIBERS' PLANT DESIGN LIMITS WITH 800 TYPE TELEPHONE

	4 lb. cable	6½ lb. cable	10 lb. cable
Ohms	1,150	920	770
Miles	2.62	3.41	4.37

Echo suppressors will be provided in the long circuits connecting main centres to Western Australia and to Darwin. Crossbar automatic trunk switching centres will provide for four-wire switching at Main, Primary, Secondary and most Minor switching centres.

The Call Charging Plan

The call charging system is designed to achieve simplification and hence economy in the cost of automatic charging equipment, consistent with the provision of charges which are not only equitable but will also appear reasonable to the public.

Summarised, its main features are:

(i) Charges for subscriber-dialled trunk calls are recorded by repeated operation of the meters provided to record local calls from each subscriber's service.
The system known as periodic multi-metering is used. The rate at which the meter is pulsed depends on the distance over which the call is made, as shown in Table 2. The pulse rates have been chosen so that a subscriber-dialled call of 3 minutes' duration is charged the same as a 3-minute manually controlled call.

(ii) Exchanges are grouped to form charging units. This reduces charging equipment costs in two

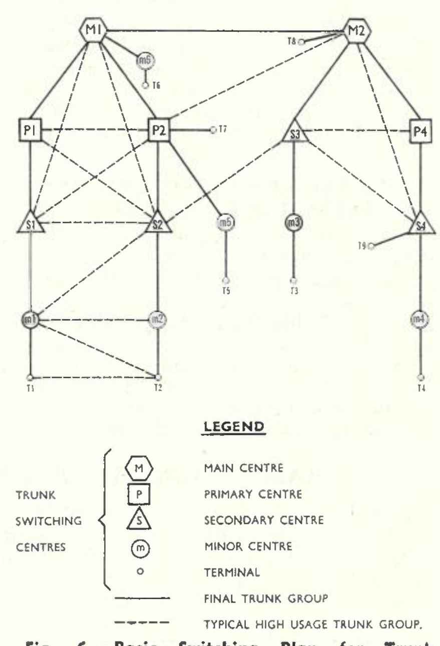
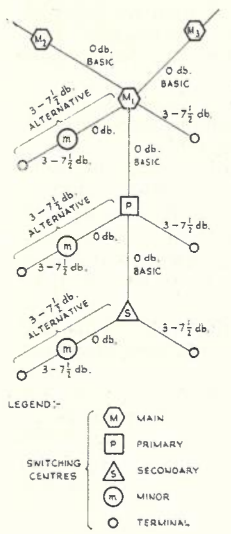


Fig. 6.—Basic Switching Plan for Trunk Network.



NOTE 1.

NOMINAL OPERATING LOSS OF 0 db. BASIC LOSS CIRCUITS NOT FITTED WITH ECHO SUPPRESSORS.	
LENGTH OF CIRCUIT (MILES)	NOMINAL OPERATING LOSS (db)
< 350	0
350 - 750	0·5
> 750	1·0

NOTE 2.
THE NOMINAL OPERATING LOSS OF 0 db. BASIC LOSS LINKS REQUIRING ECHO SUPPRESSORS IS TO BE 0·5 db.

NOTE 3.
THE MAXIMUM PERMISSIBLE TOTAL LINE LOSS OF 3 - 7½ db. TERMINAL LINKS IS 6 db. THE REMAINDER (1½ db.) IS A FIXED ALLOWANCE FOR EXCHANGE LOSS (SEE TEXT).

Fig. 7.—Transmission Plan for Links interconnecting Exchanges.

ways. Firstly, the number of destination points in the Australian scheme which need to be recognised is greatly reduced—from over 7,000 with the former exchange to exchange charging to approximately 200 with group charging. Secondly, it becomes possible to centralise the charging equipment at the group centre. The charges for trunk line calls from this centre and its dependent exchanges within the group will be computed by the centralised equipment and the metering impulses fed back by special signalling means to the originating exchanges. Two categories of grouping are in use. Exchanges are grouped to form Zones which are used as the charging unit for short distance calls. These Zones are grouped to form Districts which are the basis for the charging of long distance calls. The groups chosen have been carefully related to the switching and numbering plans, both national and regional, and ensure that automatic charging can be made with the minimum of digital examination. Fig. 8 shows the group charging basis adopted.

(iii) Further simplification was achieved by the reduction of the number of charging rates in the trunk line schedule from 22 to 8.

Implementation of the Plan

Good progress has been made with the basic preparations for progressive achievement of the planned telephone service. The group charging plan already described was introduced on 1st May, 1960. Basic engineering designs of crossbar exchanges to provide all categories of local service and trunk switching are well advanced, bulk supplies of equipment are coming forward, and major trunk routes are being equipped with broadband systems.

Automatic trunk exchanges are planned for all capital cities and many country centres by 1972 and this will permit at least 50% of Australian trunk traffic to be subscriber-dialled by this date. The Sydney exchange will be installed in 1965 bringing trunk dialling facilities to subscribers in Australia's largest network.

To ensure the necessary co-ordination of planning imposed by new policies and new plant, outline development plans are being prepared for each regional network and for the trunk network interconnecting them. These plans define the course of development to be followed to achieve the fully automatic service envisaged. The period of eight years ahead is covered in some detail in each regional plan so that they may be used as a basis for co-ordinated works' programmes and, taken together, will also provide a means of controlling progress toward system objectives.

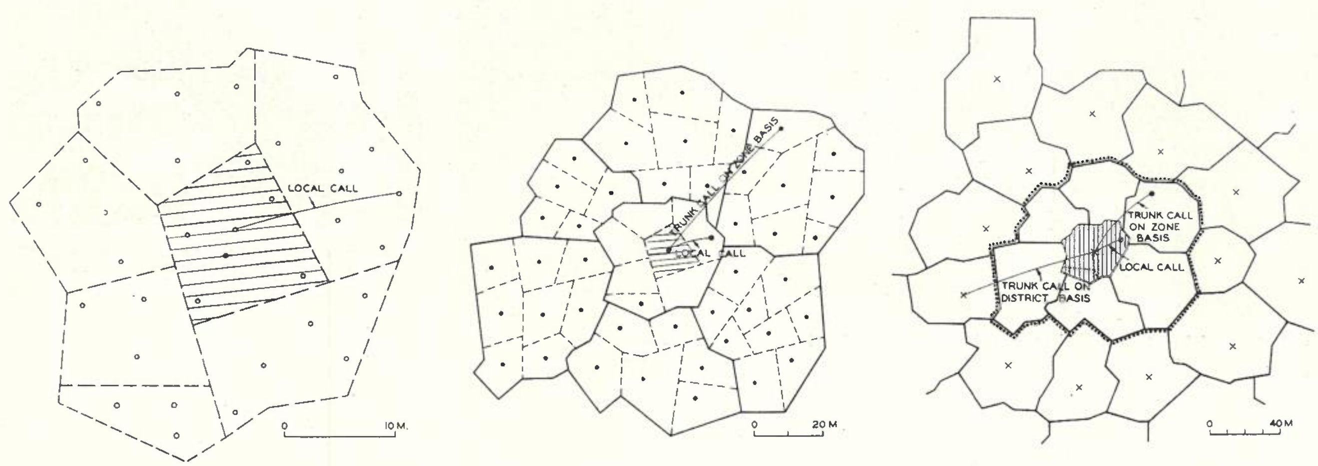
THE FUTURE TELEGRAPH NETWORKS

Telegraph service is expected to be provided during the next decade by separate private wire, public telegraph and telex networks.

The public telegraph traffic is continuing to fall slightly in volume and thus the present telegraph message handling system is expected to meet requirements for the foreseeable future. Telex is the expanding telegraph service and growth in the private sector of the telegraph service has been in telex services rather than leased private wire facilities. The telex network and private wire facilities will provide a means for low speed data transmission. Higher speeds will be handled via the switched telephone network or by leased channels of appropriate bandwidth.

A fully automatic nationwide telex system will be introduced, commencing in 1965. It is described in more detail in a later article in this issue, and will have the following main features:

Numbering: Each telex subscriber will be given a five digit number in a single five digit closed numbering scheme serving the whole of Australia. The initial digits in these numbers will have a regional significance with the first generally defining a particular State or the main networks of Sydney and Melbourne. All telex centres will be designated by the first two or three digits of this numbering.



LOCAL CHARGING

EXCHANGES ARE GROUPED TO FORM ZONES.
CALLS WITHIN A ZONE AND TO ADJACENT ZONES WILL BE TREATED AS LOCAL CALLS.

TRUNK CHARGING ON ZONE BASIS.

ZONES ARE GROUPED TO FORM DISTRICTS.
CALLS (OTHER THAN LOCAL CALLS) WITHIN A DISTRICT OR TO ADJACENT DISTRICTS WILL BE CHARGED AT TRUNK RATES BASED ON THE MILEAGE BETWEEN ZONE CENTRES.

TRUNK CHARGING ON DISTRICT BASIS

CALLS BETWEEN DISTRICTS WHICH ARE NOT ADJACENT WILL BE CHARGED AT TRUNK RATES BASED ON THE MILEAGE BETWEEN DISTRICT CENTRES.

Fig. 8.—Call Charging Plan.

Switching and Transmission Plan: Telex connections may use up to five channels in tandem in the ultimate scheme but initially the system will be developed with the maximum number limited to four. Alternate routing facilities are to be provided at transit exchanges.

Charging: As for the telephone system, charging in the automatic telex system will be by periodic metering. Telex exchanges will be grouped for charging purposes but, because of the characteristics of telegraph traffic dispersion in Australia, satisfactory charging can be provided by dividing Australia into 50 charging districts. This contrasts with the group charging plan for the telephone system which requires small zone groupings for short range traffic and some 200 larger charging districts for long-distance traffic.

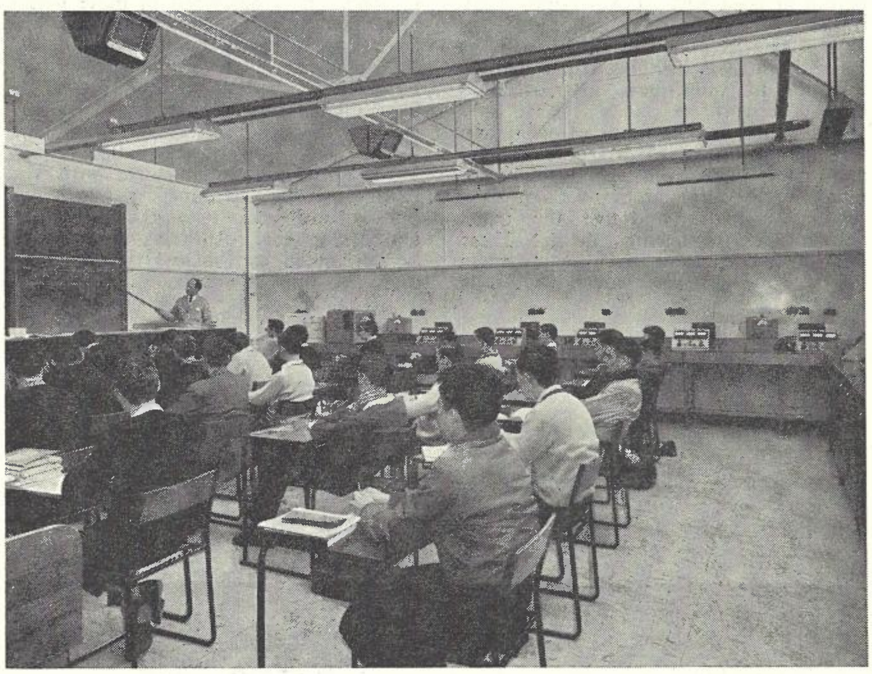
CONCLUSION

The internal telephone and telegraph services in Australia are being expanded rapidly in a decade of unprecedented national growth. Both the telephone and the telegraph networks are in process of conversion to nationwide automatic operation. New developments in communications, technology and practice are constantly being applied to improve the service and reduce costs. Participation in the development of I.T.U. Recommendations and their application within the national system are regarded as increasingly important in Australia as the new world network is evolved to meet the rising demands for international communications.

REFERENCES

All references are to articles in the Telecommunication Journal of Australia.

1. E. R. Banks, "Crossbar Switching Equipment for the Australian Telephone Network"; Vol. 13, No. 2, page 85.
2. L. F. Pearson, "The Australian Outpost Radio Communication System"; Vol. 13, No. 6, page 456.
3. F. P. O'Grady, "Developments Leading to Subscriber Trunk Dialling in Australia"; Vol. 12, No. 2, page 63.
4. R. W. Turnbull, B. F. Marrows, and W. J. B. Pollock, "Nationwide Dialling System for Australia"; Vol. 11, No. 5, page 134.
5. R. W. Turnbull, G. E. Hams, and W. J. B. Pollock, "National Telephone Plan—
Numbering"; Vol. 12, No. 1, page 3.
Charging"; Vol. 12, No. 3, page 143.
Switching"; Vol. 12, No. 4, page 226.
6. R. J. Kolbe, "The Type 801 Telephone"; Vol. 13, No. 6, page 434.



A lecture—laboratory room at the Melbourne Technicians-in-Training School. The provision of laboratory benches in the lecture room facilitates integration of theory and practice. After one year full time at the school, trainees undergo mixed school and on the job training for a further four years.

Bushfires are a menace to aerial plant, particularly in the heavily wooded coastal areas.

SOME ASPECTS OF EXTERNAL TELEPHONE PLANT IN AUSTRALIA

*W. H. WALKER, B.E., A.M.I.E.Aust.**

INTRODUCTION

This article gives a general review of the design, installation and maintenance of external plant in Australia, with emphasis on those aspects where the Australian approach differs from that in other countries in a way which gives it some features of special interest.

The term "lines" or "external plant" is applied in Australia to the local and long distance networks of cable and open wire and associated plant. It does not include terminal or repeater or other indoor equipment associated with the lines. The term "lines" in Australia applies only to the external plant and has the same meaning as "outside plant" in North America.

FACTORS INFLUENCING EXTERNAL PLANT

General

An important distinction exists between internal and external plant because of the location of the plant. Internal plant (switching equipment, carrier, radio, television apparatus, etc.) is usually installed in secure air-conditioned buildings, safe from the vagaries of climate and from interference by outsiders. For this reason, good design and practice which has been proven in one part of the world can usually be accepted with confidence for use in other parts of the world which have very different climatic and other conditions. This is not true of external plant; it is installed outdoors in the public domain and is exposed to the full effects of the local climate; it must share its location with the plant of other public utilities and must be installed subject to the legal and other restrictions necessary to allow all public utilities to provide their services with reasonable efficiency and level of cost from the community's point of view.

A second point of difference is the relative complexity of design and manufacture of internal and external plant. Manufacture of the major items of internal plant, particularly automatic switching equipment, requires a large capital investment both in developing the design and in tooling to make the apparatus. Hence only a limited number of designs of switching equipment are made throughout the world. To a lesser degree the same problems of high developmental costs and tooling costs apply to carrier and radio apparatus, and again the choice of design available to the telephone administration is somewhat limited. External plant on the other hand is made up of a large number of items which are relatively simple in design and manufacture and which can be made with a relatively modest investment in design and tooling. Hence the external plant engineer is much less bound down by design and tooling costs, and has much greater opportunity to develop new and novel designs which take advantage of local manufacturing resources and are especially adapted to local conditions of service.

For these reasons, while the principles of external plant engineering are probably the same throughout the world, details of design and of installation and maintenance practices must tend to be adapted to local circumstances and therefore differ from country to country.

A number of factors which influence external plant practice in Australia are now discussed. There is some further discussion of this topic in Reference 1.

Factors Affecting External Plant in Australia

Climate: The continent of Australia is situated between the latitudes of 11°S and 39°S; about 39% of the land mass is situated in the Tropical Zone, and 61% in the South Temperate Zone. The climate therefore tends to be warm to hot, although in a land area of 3 million square miles a wide variety of climatic conditions is to be expected and in fact does exist. Most of the population and therefore most of the telephone plant is situated in the coastal areas (see map on page 104) where the climate tends to be temperate. A certain amount of plant, particularly open wire aerial trunk plant, is installed in the inland areas where it is subject to hot arid conditions. More specifically, much of the external plant is subject regularly to an ambient or shade temperature range of 50° to 100°F with extremes of 30° to 120°F. In a few localities temperatures go down to 20°F. Sun temperatures (that is, the temperature of direct ultra-violet radiation as distinct from ambient temperature) are much higher and any exposed plant is liable to experience sun temperatures of 150°F ranging up to 180°F in some localities. Plant is exposed to a wide range of humidity including, in many coastal areas, high relative humidity combined with summer temperatures. High winds, floods and heavy lightning storms occur but they are not sufficiently common as to constitute a problem. In the inland areas, aerial plant is exposed to persistent winds.

The particular points of interest are that most of the plant is installed in warm to hot humid areas where conditions are conducive to breakdown of plant due to corrosion of metal and attack by fungi, and where insect attack on lead and on organic plant components must be expected. A further factor is that sun temperatures are much higher than those experienced in countries with high telephone densities in the Northern hemisphere, as these countries are situated further from the equator. Snow and ice loadings are not normally considered a problem, and storm damage also is not usually a serious problem except in a few specific areas. The main difference between external plant design in Australia and that in other well established countries is that, in Australia, the plant must cope with higher temperatures combined with humidity but is not exposed to temperatures low enough to cause snow and ice problems. Conditions for external plant in Australia have much more in common with those in, say, India or the African continent than with those in Western Europe, North America or Japan. At the same time it must be emphasised that in a continental area of 3 million square miles, a large variety of climatic conditions must exist and these remarks are therefore generalized.

Geography: Australia has a population of 11,000,000 in an area of three million square miles. There is considerable mal-distribution of population as the maps on page 104 show. This population distribution is largely determined by climatic (particularly rainfall) conditions, the unpopulated area being largely desert country. Included in the map is the 10 inch rainfall isohyet, which, it will be noted, coincides with the limits of population in the southern portion of the continent. This is not so in the northern portion; in this region there are many areas where the rainfall is higher but there the precipitation/evaporation ratio (2) is so low that cultivation of the land over much of the area has not yet proved possible. Furthermore, a large proportion of the population is concentrated in a number of cities, the largest of which are Sydney (2 million plus) and Melbourne (2 million). The main problem is to provide economically an adequate trunk telephone service between the scattered communities. The map on page 103 shows the main trunk line routes, some of which traverse long distances over inhospitable desert terrain.

The cities are characterised by the fact that most of the inhabitants live in houses on their own separate block of land (typically four to eight houses per acre), with the result that the cities cover very large areas in proportion to population and the telephone density **on an area basis** is low; **on a population basis** however it is high. The result is that a large quantity of cable and associated plant is required to provide service in metropolitan areas and the number of services provided is small, compared to other countries, in relation to the amount of plant installed.

Legal Framework

The Commonwealth of Australia has a Federal constitution with three levels of Government, namely Commonwealth (Federal), State, and Local. The Postmaster-General's Department is a Commonwealth Government Department: its authority to provide telecommunication service is contained in the Post and Telegraph Act which endows it with authority for this purpose, including the

* See page 167.

TABLE 1—FINANCIAL STATISTICS

Capital Value of and Expenditure on Telephone Plant

	Nett Capital Value at 30/6/1962 (£m.)		Expenditure during year 30/6/1962 (£m.)	
External Plant				
Cable and Conduit	198.5	40%	24.4	44%
Aerial Open Wire	90.7	18%	6.6	12%
Internal Plant				
Exchange Equipment	102.0	20%	9.8	18%
Other	108.2	22%	14.6	26%
Total	499.4	100%	55.4	100%
Motor Vehicles and Mechanical Aids	12.5		1.9	
Other Movable Plant	8.5		.7	
	21.0		2.6	

Material Purchases during Year ended 30/6/1963:

	£m.
External Plant	
Cables	6.7
Conduits	1.0
Copper Wire	.6
Other Items	2.4
Telephone Switching Plant	6.8
Other Internal Plant	8.1
Miscellaneous	.9
Total	26.5

TABLE 2.—EFFECT OF COST REDUCTION PROGRAMME

	1952	1962	Change
Linemen employed	14,200	15,500	+ 9%
Plant installed during the year:			
Cable—single wire miles	447,000	1,011,000	+116%
Aerial Wire—single wire miles	43,000	34,000	— 21%
New Subscribers Connected (gross)	114,500	189,500	+ 76%
Plant Maintained:			
Cable—single wire miles	4,421.000	10,330,000	+134%
Aerial Wire—single wire miles	1,112,000	1,381,000	+ 24%
Subscribers	938,800	1,718,600	+ 83%
Cost per Subscriber's Line Installed:			
Labour	£40 2 4	£37 0 4	— 8%
Material	£44 14 9	£72 4 9	+ 60%
Incidentals	£5 0 9	£14 1 3	+180%
Total	£89 17 10	£123 6 4	+ 37%
Cost per Subscriber's Line Maintained	£8 15 0	£6 2 0	— 30%
Index of Money values:			
Australian Wage Index (all industries)	87	145	+ 67%
Australian Wholesale Price Index	297	333	+ 12%

right to establish and safeguard its external plant. Other public services in Australia—electricity, water, sewerage and drainage, roads, transport—are provided by State or Local government authorities or by private companies. In Australia, Federal authority takes legal precedence over State and Local authority and this places the Department in a very satisfactory position for providing its services: for instance, few problems arise in finding suitable sites for telephone exchanges or in siting conduits, poles and other plant in the streets. The position is particularly satisfactory in regard to inductive interference from power lines, as discussed later under "Co-ordination"; the elaborate precautions taken by the Bell Telephone System, for example, to protect its plant from undue interference by power operators, is unnecessary in Australia because power systems are operated in a way which takes much more recognition of the legitimate needs of the telephone system.

Economic Factors

Three important points must be mentioned here. The first is that labour is and always has been relatively scarce and expensive in Australia; hence there has always been a pressure to use mechanized in place of manual methods of work. Secondly, the telephone density is relatively high and the telephone is installed in most houses in the urban areas and most farms in the rural areas. Thirdly, the growth of population has always been rapid, for example the population has trebled since 1900 and has increased by 40% in the last 15 years; this rate of growth has kept a constant pressure on all public utilities, including the telephone service, to provide additional facilities.

Another economic factor is the relative maturity of secondary industry in Australia. All items of external plant material are produced in Australia as are the raw materials for their manufacture — steel, aluminium, copper, lead, polythene, P.V.C., epoxide resin, etc. The telephone cable industry has been established over 40 years. The only imported items, apart from a few cables and other items imported for experimental reasons, are the dust cores required for some types of loading coils. This industrial position means that the external plant material designer has access to a large range of manufacturing processes and well-informed advice on new materials and processes, and this is an important factor in the progressive design of external plant material mentioned later.

PLANT STATISTICS

Some details of volume of external plant in Australia are given in Tables 1 and 2. It will be noted that the largest proportion, both of the total capital invested in the Australian telephone service and of the annual expenditure on providing new plant, is in external plant.

DEVELOPMENT OF TRUNK FACILITIES

General

It is difficult to select the most significant year in the development of trunk facilities in Australia but 1858, when the telegraph line from Sydney to Melbourne was completed, and 1872, when the overland telegraph line from Adelaide to Darwin was finished, are important dates. The latter (3, 4) connected with a newly completed submarine cable to Singapore which completed the link from England to Australia. Probably the next significant step forward was the establishment of trunk telephone services between Melbourne and Sydney in 1907 and between Melbourne and Adelaide in 1914 (5).

As communication techniques and knowledge improved, Australia was well to the forefront, particularly in the development of open wire facilities which best suited the characteristic features of a country of vast distances and small population. The first carrier telephone system to be installed was a 3-channel open wire system placed in service between Melbourne and Sydney on 10th September, 1925; it was the first in the British Commonwealth. Development in the use of carrier systems was rapid and is described in another article in this issue.

Trunk Cables

A submarine telephone cable was installed between Victoria and Tasmania in 1935, but it was not until 1938 that a land trunk cable system was laid over any significant distance. This cable was provided between Melbourne and Geelong (6), a distance of 45 miles and was planned for voice frequency operation; however, allowance was made for future carrier working by laying of separate "go" and "return" cables. Shortly afterwards two 24 pair 40 lb./mile carrier type cables with 17-channel carrier systems operating at frequencies up to 72 kc/s in each direction of transmission were installed on the Sydney-Maitland route (7, 8), a distance of 118 miles. Essentially similar arrangements were later installed on other routes and a total of 489 route miles (978 sheath miles) of carrier type cables has been laid.

Australia was late in the coaxial cable field because trunk circuit requirements on even main routes were, until recently, comparatively small and the high initial cost was not economically justified. Laying of the first coaxial cable between Melbourne and Morwell (9, 10, 11) commenced in 1959. This was followed by the Sydney-Melbourne cable project (12) which was completed in 1962 and included 604 miles of 6-tube coaxial cable at a completed cost of £6,890,000. Table 3 shows the magnitude and growth of the coaxial cable network. This network includes 4, 6 and 8-tube cables and currently the first 12-tube coaxial cable is being installed. All coaxial cables installed to date have been designed to carry initially a bandwith of 6 Mc/s, but the design of cable systems will readily permit the bandwidth to be extended to 12 Mc/s in the future. Small diameter coaxial cable has not yet been used in Australia but several trial routes are under consideration.

Coaxial cable is installed in ducts in built-up areas, and elsewhere is directly buried at a depth of 48 inches in soil for security reasons and 24 inches in solid rock. Trenching is in general carried out by mechanical plant, including a large range of special equipment and vehicles. In the early coaxial cable installations, minor trunk requirements beyond the capacity of the interspace and core pairs (after control pairs had been allocated) were provided by separate trunk cables laid in the same trench. In later installations similar requirements were met by providing a single layer of 10 or 20 lb. voice frequency pairs and now several multi-layer cables are under construction and programmed. In open country where coaxial cable is directly buried, lengths of up to 500 yards are commonly installed.

In recent years there has been an extensive installation programme of short distance minor trunk cables throughout the Commonwealth, generally parallel to existing open wire routes. This is due to normal growth and the effect of the national telephone switching plan where circuit quantities have reached magnitudes most economically catered for by cable. Paper insulated lead sheathed plastic jacketed cable is used exclusively for minor trunks; at this stage the performance of plastic insulated, plastic sheathed cable is considered too unpredictable, due to the adverse effects of moisture penetration on electrical values, for it to be used for trunk purposes. These cables usually connect minor switching centres to terminal exchanges where circuits have an allowable loss of up to 6 db, and on direct links between terminals where circuits of up to 12 db are provided. The cables are loaded with 88 mH coils at a nominal spacing of 6,000 feet. A number of selected pairs are left unloaded to allow for future carrier working. These carrier pairs are preselected on the basis of their physical separation and variation of length of lay. Two-wire amplified circuits with repeaters of the negative impedance type are used where they are economical. In many cases, particularly where amplified circuits are used, the loop resistance is too great for satisfactory D.C. signalling unless special equipment is used.

The minor trunk cables were formerly laid by mole plough to a depth of 18 inches but with better types of ploughs and more powerful machinery (13), it is now possible to lay at a much greater depth. Whilst 2 feet depth is accepted as a minimum at present, it is proposed to standardise at 3 feet for minor trunk cables. The cable is supplied and installed in 500 yard lengths in the buried sections, this being convenient for balancing and voice frequency loading, but shorter lengths are generally used where the cable is drawn into ducts.

TABLE 3.—COAXIAL CABLE PROGRAMME AT 30/6/1963

Route	Size of Cable	Miles
Cable Installed		
Melbourne-Dandenong	6 tube	20.9
Dandenong-Morwell	4 tube with 80/10 layer	75.0
Sydney-Canberra-Melbourne	6 tube	603.8
Adelaide-McLaren Vale	4 tube with 54/20 layer	25.7
Brisbane-Lismore	4 tube with 54/20 layer and 4 tube without layer	106.3
Dandenong-Dromana	4 tube with 54/20 layer	31.3
Mt. Bonython-Mt. Barker	4 tube with 54/20 layer	13.0
Radio Terminal and TV Relay	8 tube	23.3
	6 tube	20.5
		919.8
Cables being Installed		
Perth-Bunbury	4 tube with 80/10 layer	117.4
Wagga-Griffith	4 tube with 54/20 layer	119.6
Radio Terminal and TV Relay	12 tube	9.0
	8 tube	7.5
	4 tube	3.9
		257.4
Cables approved: Installation not commenced		
Launceston-Burnie	4 tube with 54/20 layer	92
Geelong-Warrnambool	4 tube with 54/20 layer	121
Taree-Kempsey	6, 4 and 2 tube with layer	85
Melbourne-Croydon	8 tube and 6 tube with layer	20.4
Wollongong-Nowra	4 tube with 54/20 layer	45
Radio Terminal and TV Relay	12 tube	15.7
	8 tube	36.0
	4 tube	10.3
		425

Open Wire Route Design

Most open wire trunk routes in Australia were originally designed for voice frequency operation and employed wire and arm spacings of 14 inches. Reconstruction and retransposition of these routes to cater for 3-channel (30 kc/s) and later for 12-channel (143 kc/s) systems has been proceeding for many years. In general, reconstruction of existing routes is based on the provision of 32 poles per mile, 9 inch wire spacing, and 28 inch spacing between arms. (See Fig. 1).

Initially when routes were converted from a voice frequency transposition scheme to a 3-channel scheme an individual transposition scheme was designed for each route, and similarly when 12-channel carrier working was required, selected pairs were retransposed to cater for the higher frequency working. This involved considerable engineering effort and when the Bell Telephone System produced their J2, J5 and J5A transposition schemes, these were used as a basis for developing Australian standard schemes (14).

Consideration is being given at present to the use of frequencies up to 300 kc/s on a particular open wire route, and near end type unbalance frequency values up to a line angle of 4,860 degrees have been calculated, using a computer, and near end type unbalance curves have been prepared from these values. These tables and graphs are an extension of those produced in the Bell Monograph No. 2520.

In recent years several new open wire routes have been erected with 4-chain pole spacing and 9 inch wire spacing, utilising standard Australian transposition schemes which are made up of double and triple extra transposition types. Every pole is a transposition pole in this design. Substantial savings are possible, even though slightly taller poles are required to cater for the increased sag due to the longer spans. As 9 inch wire spacing is used with these spans, the threshold of contact wind velocity at 90°F is approximately 43 miles per hour which has proved satisfactory on the routes already erected. Some 1,400 miles of new route has been or is being erected to this spacing.

A new route to be erected shortly north of Broken Hill in New South Wales in semi-desert country will have span lengths of 8 chains with 14 inch wire spacing and 56 inches between

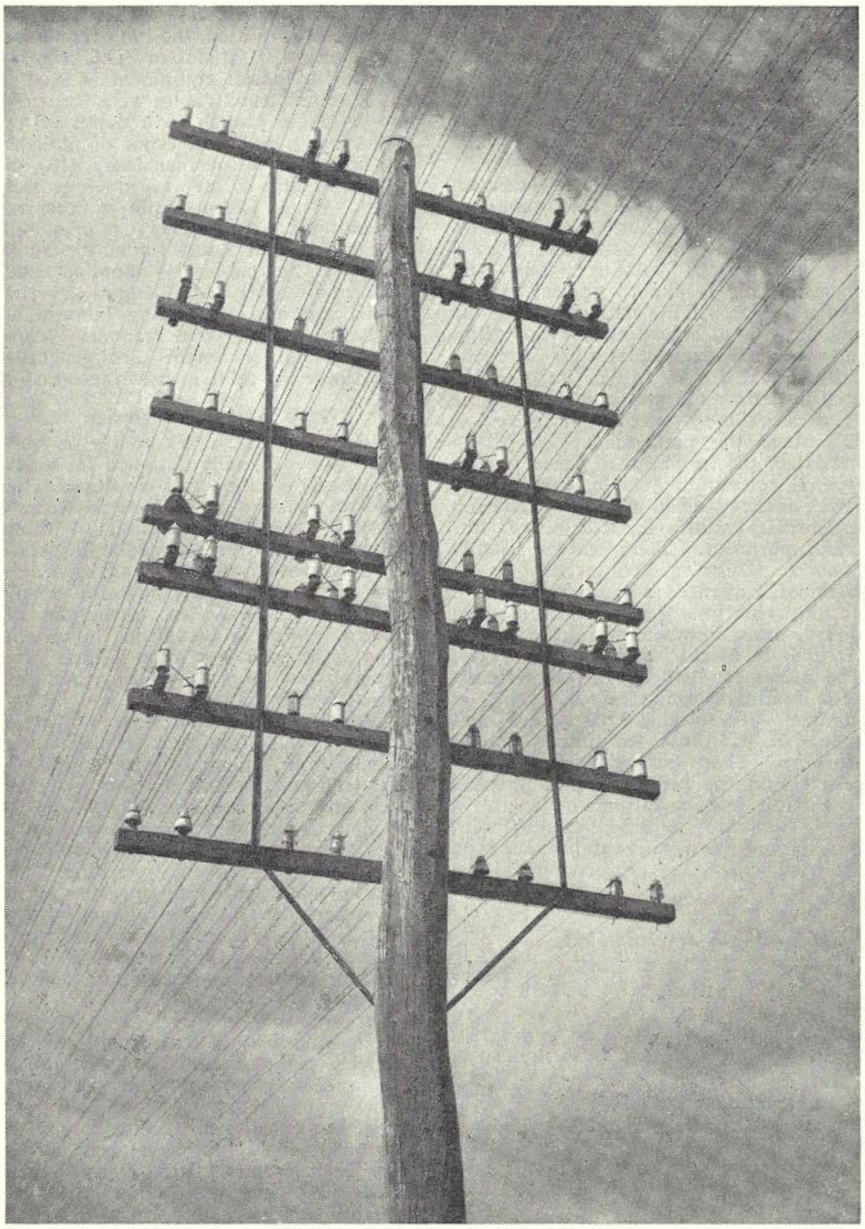


Fig. 1.—Trunk Telephone Route. In the newest construction, braces, as used on the lowest arm, are used for all wide spaced arms in place of the combiners shown.

pairs and will utilize two pairs of steel core aluminium wires, weighing 199 lbs. per mile with a breaking strength of 1,400 lbs. Insulators on this route will be shackle type power insulators with preformed deadends to support the wires. The two pairs of wires will be transposed to transposition types b_1 and P_1 for E sections of 6.4 miles. This route will serve a sparsely populated area and will include the use of two rural carrier systems to cater for both trunk and subscribers' development. It is planned to use full length pressure treated pinus radiata poles treated with a waterborne salt. This treatment should produce 95% penetration and the poles (which are to be of small section) should prove suitable in this arid area. If the designed results are realised, this type of construction will be applied to other outback areas where much of the aerial plant at present consists of single wire earth return circuits.

Since the advent of rural carrier systems, there has been a demand for a simple type of transposition scheme which could take full advantage of the compandors inbuilt in this type of equipment rather than retransposing an existing line to a costly 12-channel carrier transposition scheme. A new transposition scheme has, therefore, been developed for use in conjunction with rural carrier systems which will enable a number of short haul 12-channel and rural carrier systems to operate simultaneously on the same route and which incorporates a much reduced number of transpositions. This scheme is undergoing field trials at present and results to date have been satisfactory. It is planned to apply this scheme to minor routes where carrier development will not be heavy but, in the event of unexpected development, the arrangement will permit ready conversion to normal 12-channel operation. The transposition types for E sections (8 or 6.4 miles) applied to the standard configuration are shown in Fig. 2.

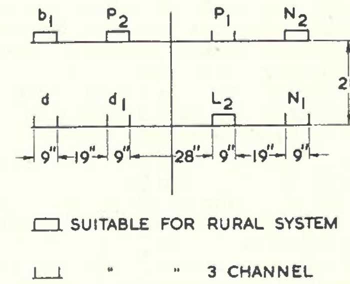


Fig. 2.—Transposition Scheme for Short Haul Carrier Working.

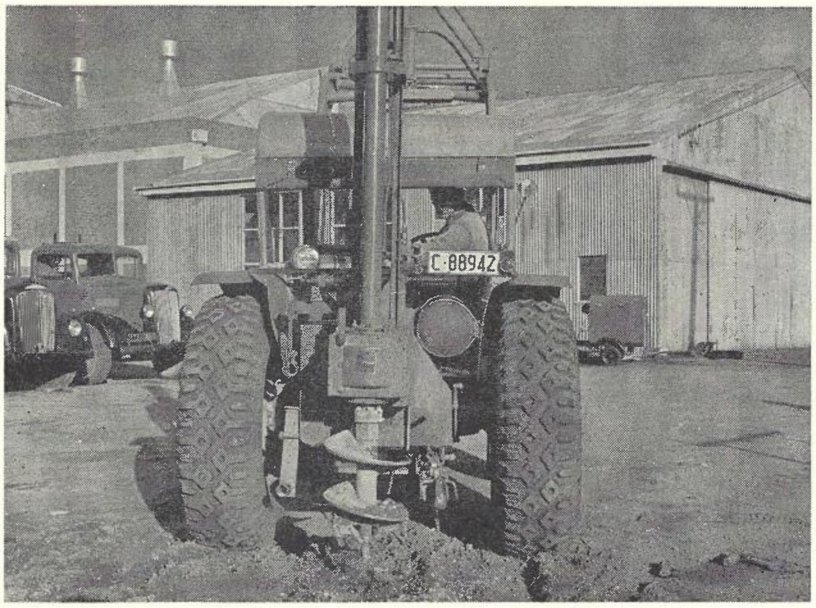
Open Wire Route Installation

New trunk routes erected in recent years have utilized mainly full length pressure treated wooden poles, rolled steel joists or recovered rail poles. Poles are usually erected in holes excavated by a post hole borer equipped with a lifting mechanism (Fig. 3). The cross-arms used are 3 x 3 inch timber, pressure treated with creosote, and for trunk purposes are 9 feet in length, braced by a pair of flat galvanised braces. The intensity of staying is governed by the wind exposure and in some instances, where cyclones are experienced, every pole is supported transversely and every fourth pole longitudinally. However, the normal location of stays is at every eighth pole transversely ($\frac{1}{4}$ mile) and every 16th pole ($\frac{1}{2}$ mile) longitudinally. The most commonly used conductors are hard-drawn copper of 100 lb./mile, 200 lb./mile and in certain circumstances, if required for attenuation reasons, 300 lb./mile. Where additional strength is required, 118 and 237 lb./mile cadmium copper wire is used. In special cases where ice loading is experienced, steel core aluminium wire is used and, as mentioned earlier, this type of wire is to be used on long span construction. Wires are tensioned by the "weights" method (15), and tension is checked by means of the "beat" method in which, to check tension, a wire is struck by the hand and the time interval for a number of vibrations to travel the length of the span and back is timed and checked against tables prepared for this purpose.

DEVELOPMENT OF SUBSCRIBERS' FACILITIES

Urban Areas

Urban areas in Australia are fairly densely settled and as indicated previously the residential districts provide for about 2,000 to 4,000 houses per square mile. Exchange areas range in size from over 10.000 lines in the inner city areas to 3,000 lines in the outer



(a)

(b)

Fig. 3.—Pole Erector. The unit consists of a 35 h.p. tractor equipped with a hole borer (a) at the rear and a jib crane (b) in front, capacity 15 cwt. at 8 ft. The jib can be used as a work platform as shown in (b).

areas. The establishment of exchanges is primarily governed by the cost relationships between subscribers' external plant, exchange equipment and buildings and junctions. Australian practice is to delineate exchange areas so that these costs for a group of exchanges are a minimum when costed over a 20-year period. The actual determination of the size and the boundaries of exchange areas is affected by such features as anticipated rate of development, existing plant, and availability of space for equipment in existing buildings. Large exchange areas involve heavy external plant costs, because heavier gauge subscribers' cables are necessary to meet transmission limits and because the pair-mileage of cable required increases rapidly with the size of the area. On the other hand, internal plant, building and junction costs are minimal when the exchanges are as large as possible. Exchange area planning calls for considerable foresight and early action; it is generally necessary to delineate exchange areas in the very early stages of development if the fullest economic benefits are to be derived as, if large duct routes or cables are extended from an existing exchange into a developing area, then the economic advantages of establishing a new exchange is largely lost. If the development in the area is doubtful then portable exchanges are often provided, permanent exchange building provision being deferred until the development is more certain. If the demand does not eventuate as anticipated the portable exchange is recovered at little cost. Considerable use has been made of portable exchanges in Australia (16, 17), about fifty of them, in sizes of 600 to 1.000 lines, being in use; they have enabled service to be given in a number of areas much earlier than would otherwise have been possible.

In residential areas the exchange is divided into smaller areas called distribution areas; these areas vary in size depending primarily on the subscriber density, street layout and main cable reticulation. The average distribution area contains approximately 80 to 100 building lots and is served by a cross-connecting unit called a cable terminal pillar (Fig. 4). A pillar is virtually an above-ground accessible joint where cross-connections can be made between any main pair and any distribution pair appearing in the pillar. A proportion of main pairs appears in several pillars to increase the flexibility of the main cable.

Main cables are those on the exchange side of the pillar and which terminate at the exchange Main Distribution Frame; they are provided on a short term basis. Distribution cables are those on the subscribers' side of the pillar and are provided on a long term basis. The pillar enables the main cable pairs to be used efficiently and allows unforeseen demand in the distribution area to be met without resorting to complicated multipling arrangements in the main joint. Further, the pillar provides an access point for testing and simplifies rearrangement of main cables.

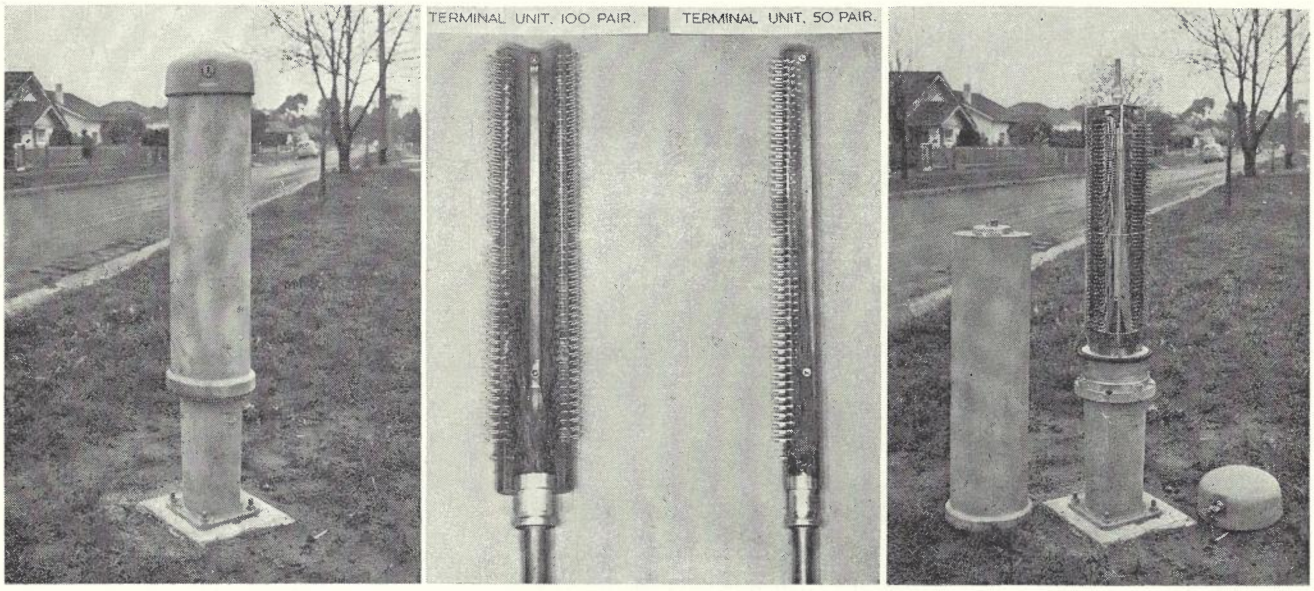
Larger type cross-connecting units commonly called "cabinets" are also used and are capable of housing up to 1.800 pairs of cable. In some instances they are used in the same way as pillars as described previously, but in other instances they are used to provide a cross-connecting point at locations such as future exchange sites, or alternatively to control several pillars (18). In the business areas of large cities, outdoor pillars and cabinets are not normally used, the distribution being made by direct taps of 100 to 800 pairs from the main cables; these direct taps frequently terminate on indoor terminating frames from which the internal cabling of the buildings is extended. A typical layout of cable plant in an urban exchange is indicated in Fig. 5.

The distribution plant is generally 100 pair or smaller cable and is predominantly plastic insulated, plastic sheathed cable laid underground. Subscribers are fed either by small underground lead-in cables tapped off the distribution cable or by aerial covered wire (drop wire) leads from poles served by the distribution cable (Fig. 6). The common feature of both these methods of distribution is that they are provided on a long term basis. The material cost of the cable is approximately 15-25% of the total cost of provision and it is therefore uneconomic to augment the plant at frequent intervals; distribution plant is therefore provided nominally to cater for the 20-year demand.

Main Cable Plant

Main cables are generally much larger than 100 pairs and they are paper insulated, lead sheathed (P.I.L.C.) and normally laid in ducts. These cables are available in 4 lb. (.016 inch), 6½ lb. (.020 inch), 10 lb. (.025 inch) and 20 lb. (.036 inch) gauge wire and in a variety of sizes up to 2,400 pairs. The cost of material for these large cables is a substantial proportion of the total cost of the installed cable, and it is therefore most economical to install these cables on a relatively short term basis (5-10 years).

These cables are installed in conduit runs consisting of one or more ducts. The number of ducts provided is determined primarily by the expected development in the area and the sizes and gauge of cables that will serve the area. with allowance for unforeseen demand and for emergency purposes for replace-



(a) (b) (c)

Fig. 4.—300 Pair Cable Terminal Pillar (a) assembled, (b) terminal units for fitting into pillar, and (c) lid removed. The terminal units are made by fanning out cable pairs, sweating tags to ends of wires, and encapsulating in epoxide resin.

ment of faulty cable. The marginal cost of providing ducts is relatively small compared to cable costs and it is therefore wise to over-provide rather than under-provide ducts.

Four inch internal diameter asbestos cement ducts in 13 feet lengths are the standard and will readily accommodate a cable 3.5 inches in diameter. In the past, manholes were spaced typically 80 yards apart, and the ducts were laid between manholes with little deviation from the straight line. The reason for this practice was primarily for ease in hauling cables into ducts, but extensive investigations into this subject in recent years have resulted in much longer hauls being made, up to 250 yards of 3 inch diameter P.I.L.C. cable being hauled in one unbroken length, the cable being hauled through intermediate manholes involving substantial changes in direction. As a result, manhole spacings in new conduit runs are being made up to 200 yards and sharper curves are permitted. This development is leading to cheaper conduit construction due to fewer manholes, and cheaper and better cable installation due to a substantial reduction in the number of joints. Another development now commencing is the use of thin wall (.040 inch) hard PVC ducts set in concrete in place of asbestos cement ducts. This is a technique developed in France and indications are that it may lower the capital cost of conduit routes. At the same time it may provide better conduit routes because the joints of the PVC ducts can be very effectively sealed to keep water and dirt from entering at the joints, which is a difficulty with asbestos cement ducts.

Rural Areas

Most residents in rural areas in Australia, except in the very remote areas, are connected to the telephone network of the Postmaster-General's Department. The telephone density ranges from 30 or more subscribers per square mile to one subscriber or less every 30 square miles. The provision of external plant in these areas is very costly, and the Department has a system whereby it will provide plant for a certain distance from the exchange depending on the number of subscribers; beyond this point the subscribers must provide and maintain their own aerial routes. These aerial routes are required to comply with specifications which are less stringent than the normal Departmental specifications. This system, known as "part private construction", has made the telephone available to many country residents who would otherwise be denied service because of the prohibitively high capital costs involved, even though the standard of service provided is not as high as the official standard. Table 4 indicates the extent of this type of service.

TABLE 4.—PART PRIVATELY ERECTED TELEPHONE LINES

Length of Privately Erected Line	No. of Private Lines	
	Party Lines	Exclusive Service
0—2 miles	2,600	10,400
2—5 miles	2,950	6,050
5—20 miles	4,000	2,200
over 20 miles	1,400	350

The majority of these services have earth return circuits, the insulation resistance to earth is low and they are connected to magneto exchanges. Using magneto signalling and a local battery telephone, however, a reasonably satisfactory service can be provided, the

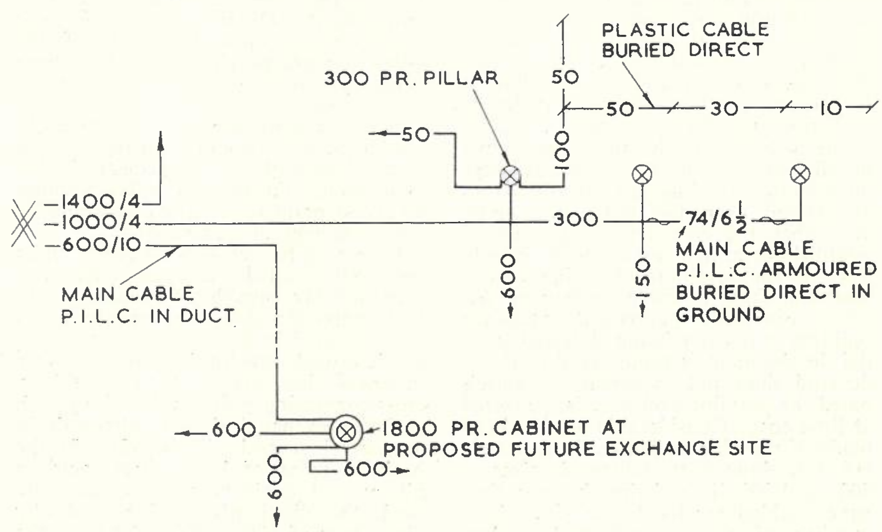


Fig. 5.—Typical Exchange Area Cable Layout.

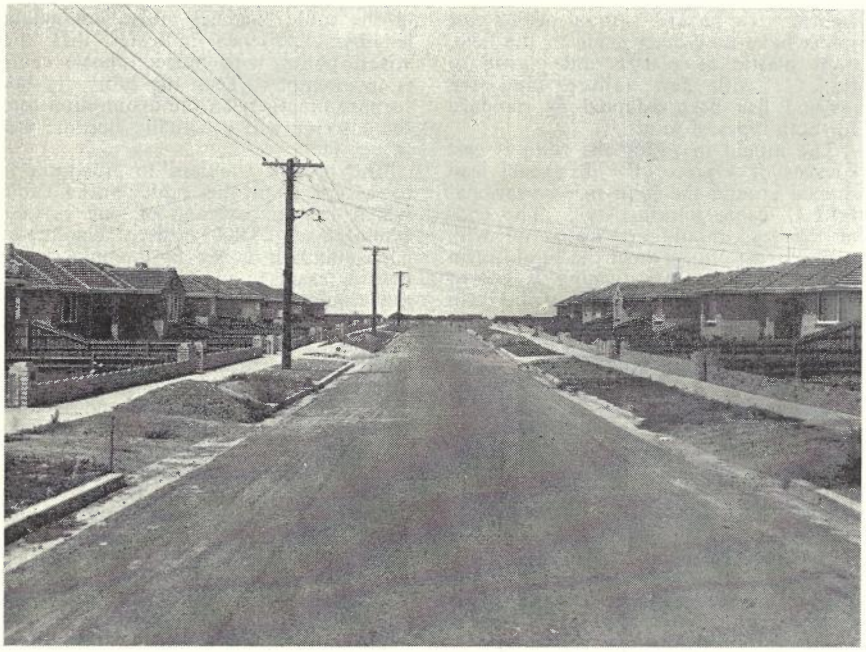


Fig. 6.—Distribution of Telephones to Residential Subscribers by Aerial Drop Lead. Underground plastic distribution cable feeds terminal box on each pole to which drop wire leads are connected. This is joint-use construction; the poles belong to the Power Authority and carry both telephone and power wires. In some cases a separate line of telephone poles is erected along the free side of the street.

main problems being due to bad joints, earth faults, crossed wires, and to an increasing extent, power induction. In general the standards of private construction have to be improved considerably before the subscribers can be connected to automatic exchanges. To assist these subscribers, the Department makes available technical advice and suitable line construction material. The remoteness and dispersion of subscribers in some areas presents difficult problems, and consideration is being given to the possible use of subscribers' carrier systems or V.H.F. radio to provide an economical service in these areas.

The standard method of providing Departmental lines in rural areas has been by open wire, but with the wider usage of mechanical aids and the introduction of plastic cable, there is an increasing tendency to use underground cable (13) as this can usually be provided and maintained more cheaply than an open wire route.

EXPERIENCE WITH PLASTIC CABLE

General

Polythene insulated, polythene or P.V.C. sheathed (plastic) cable was introduced on a large scale in 1956 and is now standard for distribution area cables. It is purchased in sizes from 10 to 100 pair and has largely replaced P.I.L.C. cable in these sizes. Annual usage is now about 5,000 sheath miles (300,000 wire miles) and some 25,000 sheath miles are in service. It is normally used buried directly in the ground without external protection; joints are placed underground in small jointing pits. Plastic cable laid by plough is also used in rural areas; this type of cable is also used as aerial cable, in both urban and rural areas, and is erected on telephone poles and on power poles (joint use). Very little plastic cable is used for trunk purposes or for amplified or loaded circuits because of problems caused by change of mutual capacity of the pairs if water or moisture enters the cable along its length.

Plastic cable is used because of its very favourable purchase and installation cost compared to P.I.L.C. cable. Its maintenance performance overall is also expected to be superior. The size has been restricted to 100 pair and below, partly because the greatest cost advantage is in the small sizes, and partly because these sizes allow its use to be confined to the subscribers' side of the cable terminal pillar, so avoiding the problem of jointing plastic cable into large P.I.L.C. cable.

Design

The standard design, until recently, consisted of a layer twin core and a single sheath of polythene. The present standard design is a fully colour coded unit star quad formulation made up in units of five quads (10 pairs). An electrostatic screen of aluminium or copper foil is not provided except in integral bearer (figure eight) aerial cable which is mainly erected on power (joint use) poles. The twin cable was only partially colour coded and jointers had to use "prickers" to identify wires and the resulting pinholes in the conductor insulation, which cannot be effectively sealed, proved to be a maintenance hazard if the cable became moist or wet in service. Unit quad formation in units of five quads (10 pairs) was adopted in preference to the well known 25 pair fully colour coded unit twin type because, apart from the electrical advantages of star quad, the five quad units "cable" together very well to form a round cable core without need for sub-units and fillers or undue distortion of the units.

It will be noted that the overall cable design is a very simple one providing a minimum of mechanical protection. In spite of the fact that most of this cable is directly buried underground, experience has shown conclusively that the design is mechanically adequate except only in some circumstances of insect attack as discussed later.

Jointing

Earlier Standards: The original method introduced in Australia in 1956 was the British Post Office (B.P.O.) method (19). It was replaced by a rubber sleeve joint (19) which had the advantage of lower price and required fewer stock items of material. For the next five years the sleeve joint with a number of variations, including the use of a plastic or lead tube in place of the rubber tubing, was the standard for underground joints.

Wire joints were originally made as in P.I.L.C. cable—a twist joint covered by a polythene sleeve open at each end. These proved inadequate if moisture entered the jointing area and were superseded by silicone grease filled sleeves (19) in 1958 and by the hot-twist joint (20) about a year later. Both methods, if properly performed, proved capable of providing a high standard of insulation resistance in a wire joint indefinitely, both in a moist atmosphere and when fully immersed in water. To prevent moisture entering the joint from the cable, water barriers were provided at the junction of the cable and the joint. These consisted of rubber mastic forced under the sheath of the cable and around the conductors to form a solid plug. They proved only moderately successful and have been superseded by an epoxide resin technique as explained later.

During the period 1959/62 the standard method for plastic cable jointing was hot-twist jointed conductors inside rubber, plastic or lead sleeve joints. This combination has given reasonably good service. The sleeve type of sheath joint, the water barrier, and the hot-twist joint have all proved reasonably watertight although demanding a high standard of workmanship. However where workmanship and supervision has not been satisfactory, failures in the joint have occurred to an unacceptably high extent in climatically wet areas. In these areas above ground jointing has been used as an expedient, usually by means of a B.P.O. jointing cap mounted on a post or convenient pole. Overall however the plastic cable jointing position was satisfactory, and accidental mechanical damage of the buried cable was the largest source of faults. However, a pressing problem was caused by the need to joint plastic to P.I.L.C. cables. Initially, plastic cables were confined to exclusive "all plastic" areas but it was soon found necessary to allow plastic cable to be used in established P.I.L.C. areas.

For plastic to P.I.L.C. jointing, both the B.P.O. joint and the sleeve joint were used but neither could maintain adequate insulation resistance of the paper insulated wires in the joints under all circumstances, and many failures occurred. Most joint failures in the plastic cable network did, in fact, occur in plastic to P.I.L.C. joints although there were many more plastic to plastic joints in service. The expedient of mounting the joint above ground was not satisfactory because moist air could enter these joints and cause failure of the paper insulation.

Present Standard: The difficulties experienced with the previous jointing methods have been overcome by encapsulating the whole jointing area in epoxide resin (21, 22). With this technique, even if the joint is permanently immersed in water, the conductor twist joints and the paper insulated wires retain high insulation resistance values; further, the resin effectively seals off the end of the P.I.L.C. cable and prevents moisture and water from entering. There are difficulties in using epoxide resin in the field (19) but the potential value of such a method was realised early, and the development of field methods was commenced in 1958. As an interim measure, factory-made epoxide resin water barriers were introduced, such as the one shown in Fig. 7. The present standard field pack of epoxide resin for use by jointers was introduced in 1961. It is a two-part pack consisting of a thin wall polythene bottle containing the resin and another bottle containing the appropriate quantity of hardener and modifier. The hardener is poured into the resin bottle where the two are mixed by kneading the bottle, a "no touch" handling technique being used. The formulation is satisfactory over the range of ambient temperatures met in Australia and the technique has proved free of toxic hazard. About 40,000 cast joints have now been made in the field, both plastic to plastic and plastic to P.I.L.C., with few failures and the method has been adopted as standard for both types of joints.

The mould in which the resin is cast consists of a piece of 4 lb. sheath lead shaped around the joint in conventional P.I.L.C. cable jointing style. The ends of the lead mould are sealed off with rubber mastic to prevent the liquid resin from escaping. An opening is left at the top of the lead mould and the resin is poured into this. The lead mould has the advantage that it can be tailored to fit any size and type of cable joint. Alternatively a factory-made plastic mould is used.

One obvious problem with this technique is that once the resin sets, the cable pairs are not accessible except by cutting the cable. Initially this was regarded as a serious handicap but field experience has shown it to be much less a problem than expected. The cable pairs are accessible at the pillar and in the aerial terminal boxes and in a mixed plastic P.I.L.C. area the P.I.L.C. cable joints can still be opened; a special "openable" joint is now being developed in case it proves to be necessary.

Pinholes

This term is used to describe all defects in the polythene insulation of the conductor which endanger the insulation resistance of the conductor. In addition to the pricker marks mentioned earlier, they are also caused by accidental damage to the insulation during manufacture and, to a minor extent, during installation. Experience in Australia has demonstrated, in the most positive terms, that few pinholes can be tolerated in underground cable, otherwise there will be a high fault incidence. The problem only arises if the interior of the cable becomes moist, but again, lengthy experience indicates that the wisest policy with buried plastic cable is to attempt to keep the cable dry but to base practices on the assumption that the interior will eventually become wet in service.

The present standard in Australia is to accept from the cable works cable which has an average of one or less pinholes per 25,000 yards of conductor. This standard is set by manufacturing considerations and is expected to be made more rigid in time.

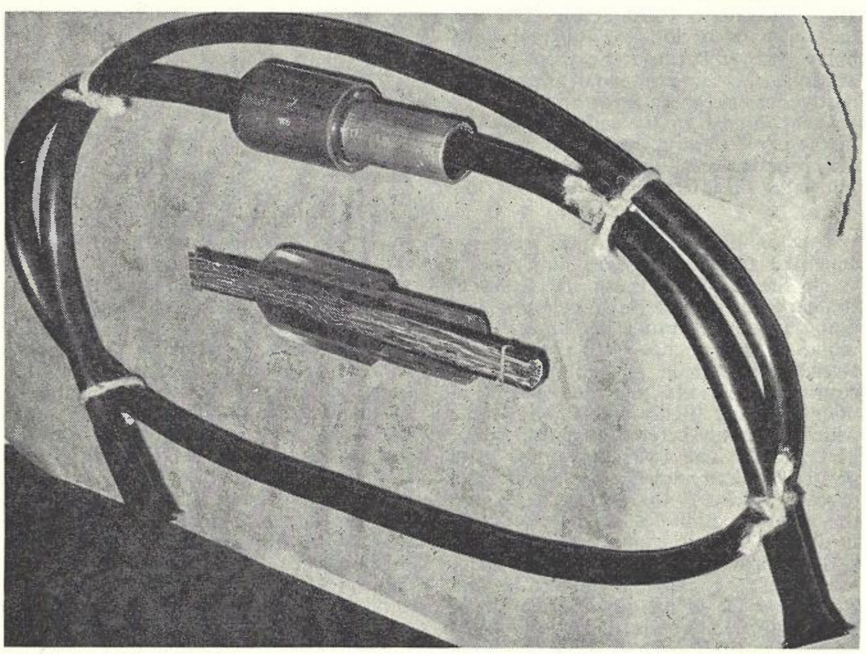


Fig. 7.—Factory Made Epoxide Resin Plastic to P.I.L.C. Cable Joint and Water Barrier.

Insect Attack

This is a hazard which appears to be peculiar to Australia amongst the major Telephone Administrations and is due, no doubt, to the fact that this Administration has large quantities of cable installed in tropical and sub-tropical areas. The problem will be the subject of a forthcoming article in this Journal, but briefly it is the experience that termites and ants will attack buried plastic cable in many areas scattered throughout the warmer parts of the country. They penetrate the sheath and make holes in the conductor insulation. In most areas the degree of attack is mild and no special precautions are taken. In a few areas, however, buried plastic cable cannot be used; plastic cable can be safely used aerially in these locations but steel tape armoured P.I.L.C. cable is required for underground use.

Exensive investigations into the problem have taken place and two main conclusions can be drawn: firstly, insecticide and chemical materials, whether incorporated in the cable sheath or applied externally, have not been effective for any length of time, and secondly, insects cannot penetrate a plastic material which is harder than their own mandibles. The latter is most important; for example softer grades of polythene are more prone to attack than harder grades and a thin outer jacket of nylon, which is a hard plastic, extruded over the polythene sheath has so far proved very effective. This may be made the standard sheath formulation for use in bad insect areas.

Other Applications

Small quantities of plastic cable in sizes above 100 pair have been used for special purposes. An example is given in Reference 23. This type of use is expected to increase.

GAS PRESSURE ALARM SYSTEMS

Gas pressure alarm systems were introduced in Australia (9, 24, 25) in 1939, and it is now standard practice to apply them to trunk, junction and subscriber cables. Most trunk and junction cables and a small percentage of the subscribers' cables are under gas pressure; work on placing other subscribers' cables under pressure is now in progress. There is no intention at present of gassing the small plastic distribution cables on the subscriber side of the pillar. The increase in the sheath miles of cable maintained under gas pressure since 1956 is shown in Fig. 8.

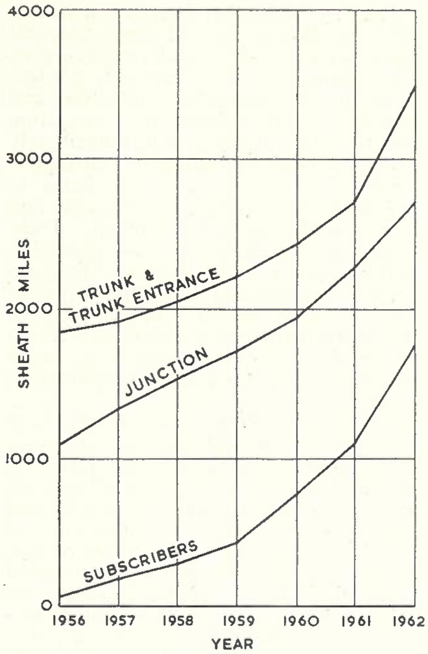


Fig. 8.—Sheath Miles of Cables under Permanent Gas Pressure.

Early systems were operated as sealed systems, that is, gas-tight seals were inserted at all terminations, air applied to the cable and then all leaks located and repaired until the cable sheath was gas tight. Many systems are now being operated as continuous flow systems (26, 27, 28). In this system, the ends of the cable are sealed and all major leaks repaired. A source of air, either a dehydrator unit or a bank of cylinders containing compressed air, is connected to the cable or system of cables and then leaks repaired until a positive pressure is obtained at all points of the cable. Minor leaks are not located as the cable is completely protected by the air pressure in it. In both types of system, contactors are placed at regular intervals so that an alarm is given if the air pressure at a contactor drops below a predetermined value. The original contactors had a bourdon tube as the operating unit but all units now have a sealed bellows. Contactor gauges, that is, a normal bourbon tube gauge fitted with auxiliary contacts, are used at exchanges to give an alarm when the pressure falls to a predetermined level, and also to provide a means to quickly ascertain the pressure in the cable. With the introduction of the continuous flow system it has been necessary to provide flow meters in the air leads to the cable or cables. These meters indicate the normal rate of air flow to the cable and an increase indicates that a sheath failure has occurred. The development of a meter that will automatically indicate a rate of flow and give an alarm when the rate increases is now in hand.

A number of aids are used for fault location. These include gauges to obtain pressure gradients and air flow meters to determine the direction of flow at a joint. On other occasions, especially for cables buried directly in the ground, radon gas is injected into the cable and its passage through the cable and the point of exit are determined by a geiger counter (29). In another method freon gas is injected into the cable and escapes into the earth at the point of the sheath failure. The actual position is determined by making small holes in the earth above the cable and sampling the air in each with a halide gas detector.

CO-ORDINATION OF OPERATIONS WITH OTHER AUTHORITIES

General

Under the terms of the Post and Telegraph Act the Postmaster-General's Department has the power to place and maintain plant as is necessary for the conduct of its business provided that the free use of any land is not unduly impeded; provision is made for the payment of compensation by the Department to any party who suffers as a result of the Department's activities. In addition the Act stipulates that if the activities of any local authority necessitate the removal or alteration of any Departmental plant the net costs shall be borne by the authority.

These wide legal powers are rarely exercised and either formal or informal co-operation with other utilities is relied on instead. For example, street opening committees are in operation in the capital cities and main country centres to handle such aspects as the co-ordination of works, the allocation of space in footpaths and the reinstatement of surfaces. In addition, work is planned to cause as little interference as possible to the public and to the countryside. In city areas work is performed as rapidly as possible, sometimes out of normal hours. Tunnelling operations and under-road borers are used to obviate road opening. In the country, tree clearing is minimised and lines are often erected on private property to preserve the appearance of the roadways.

Two important examples of co-operation with other authorities are now described.

Interference from Power Circuits

Initially, co-ordination of power and telephone lines in Australia was restricted to the control of noise in telephone circuits and the safeguarding of the telephone lines from direct contact with the power lines. As power systems increased in extent and capacity and the telephone network extended, the danger associated with the induction of voltage on both aerial and cable telephone lines during earth fault conditions on the power line (30, 31, 32) became a more difficult problem, and in 1954 a Joint Committee for Power Co-ordination was formed to develop suitable codes of practice. Committees consisting of power and telecommunication engineers were formed in each State and their work was co-ordinated by a Central Joint Committee. Since then the following codes of practice produced by the Committees have been implemented:

- "Code of Practice for Crossing of Electric Power Lines and Telecommunication Lines",
- "Code of Practice for the Protection of Telecommunication Lines against Energised Stay Wires",
- "Conditions Covering the Use of Single Wire Earth Return High Voltage Electric Power Lines Operating at Voltages up to 22 kV in Respect of Interference to Telecommunication Circuits."

At present the Committees are engaged on the development of joint use construction, the extension of single wire earth return power systems, and the co-ordination of power lines and part-privately erected lines.

The work of the Joint Committees has had a very important influence in the successful co-ordination of the rapidly expanding electric power and telecommunication networks in Australia during the post-war era. The contributions of these Committees in the general power co-ordination field has created considerable interest overseas and has resulted in the presentation of a paper (33) by two members of the Central Joint Committee at the C.I.G.R.E. Conference in Paris in 1962.

Electrolysis Control

Direct current electric traction railway and tramway systems have been operating in Australia for many years and consequently corrosion of lead cable sheaths by stray traction currents is a continual problem. Local committees to study the problem have been formed in each area; they consist of representatives from the traction authorities and bodies operating underground pipes and cables. Investigations have resulted in the installation of electrical drains from the underground pipes and cables to the traction authority's running rail or substation negative bus-bar, and the extent of corrosion has been greatly reduced. Close co-operation between all parties has been maintained to ensure that benefits gained by one authority are not obtained to the detriment of another authority. The closing down of some traction systems has eased the problem, but routine checks and the regular maintenance of all bonds are still necessary. In addition, electrolysis surveys and the installation of remedial measures, if then required, are also carried out in areas where traction systems are extended or closed down, or where substantial changes are made to the underground network of pipes and cables.

Currents of galvanic origin also cause electrolysis of cable sheaths and this problem has been brought into prominence in recent years by the closing down of traction systems, the increase in size of subscribers' cable networks and the installation of long distance telephone cables. Electrolysis surveys of the cable networks are carried out and preventive measures taken in areas where corrosion is likely to occur. Earliest measures consisted of burying zinc plates near the cable and connecting them to the cable with an insulated conductor, but magnesium anodes have largely replaced the zinc plates. Magnesium anodes with a special back fill to reduce the resistance to earth and any polarization effects are generally used, but care in selecting sites to bury the anodes is necessary to obtain the maximum results. These anodes only give a small protecting current and where larger currents are required cathodic drainage installations using a 230 volt A.C. supply, tapped transformer, and full wave rectifier, are provided. Tests are also carried out to determine the effect of these installations on other underground structures and modifications are made when required.

Plans for laying additional long trunk cables, mainly coaxial cables, are in various stages and all future cables will be metal sheathed with a plastic jacketing to reduce electrolysis attack, in place of the previous standard of tape or wire armoured lead sheathed cables. Because of possible pinholes in the plastic insulation or subsequent damage to the insulation by mechanical action, the installation of cathodic drainage schemes is being planned. However because of the insulated sheath, protective currents of a low value will generally be satisfactory, and the effects will extend over longer lengths of cable than is possible with armoured cable.

COST REDUCTION PROGRAMME

General

The major objective in external plant engineering in Australia since the end of the period of shortages following the second World War has been to reduce the installation and maintenance costs of telephone service without in any way degrading the service given to the subscribers. As a study of Table 2 will reveal, considerable success has been achieved in spite of rising labour and material costs and the increasing quantity of material required per subscriber. The table relates only to subscribers' services; substantial advances have also been made in trunk line services but it is not possible to separate the gains due to improved external plant practices from those due to improved equipment techniques.

The cost reduction programme is applied in three district spheres. These are firstly the design of new and the redesign of existing items of cable, material and fittings, secondly improving productivity from staff in respect of established materials and methods by introducing new mechanical aids, etc., and thirdly the reduction of the manhour content of work by improvements in material design and in installation organisation and methods. Considerable success has been achieved in each sphere.

Cable and Material Design

The design of new items and the redesign of existing items to reduce their cost is the most concrete phase of a cost reduction programme as it leads to an immediate reduction in the outlay on the purchase of material. Table 1 lists the annual outlay on line materials and illustrates the gains possible from even a small percentage reduction in material costs. The gain is immediate and specific and is not dependent on the reorganisation and retraining of manipulative staff as is the case with the introduction of mechanical aids and other means of improving staff output. The post-war era has been a particularly fruitful one for this purpose because of the variety of new raw materials and manufacturing processes that have been developed, the most valuable being the use of polythene in place of paper and lead for cable manufacture. Intensive investigation is made of these developments to determine if they are applicable to line material and they are adopted if they will reduce manufacturing or installation costs or remedy any service weakness in the existing designs.

The largest savings have been due to changes in cable design, particularly the use of plastic in place of P.I.L.C. cable. In 1956/57 240,000 pair miles of cable were bought at an average cost of £11.7 per pair mile, the corresponding figures in 1962/63 were 700,000 pair miles and £8.25, showing a saving for the year compared to the prices in 1956/57 of some £1.6 million, about 60% of which is due to the purchase of plastic cable. The movement in cable manufacturing costs over this period tended to be upward and the gain was entirely due to technical development. As cable costs are such a large item in the total costs of a telephone network (see Table 1) every effort is being made to reduce them. As part of this effort a long term programme is in hand to investigate different designs of cable with the objectives of reducing purchase, installation and maintenance costs. Substantial trial installations have been made of aluminium sheathed cable of various designs, steel sheathed (Hackethal process), and "stalpeth" cable and installation is commencing of large size foam polythene insulation (PEF) cable of Japanese manufacture. The use of plastic sheathing with an aluminium foil barrier ("Glover" sheath) for large paper insulated cable is also being investigated.

Dealing with other items of material, prior to World War II most external plant materials used steel forgings, grey iron castings, sheet or bar steel fabrications for the strength components, and porcelain and rubber for insulating components. During and immediately after the war, production restrictions resulted in redesign of some items to use available production capacity and raw materials to best advantage. Techniques used included the use of malleable cast irons rather than steel forgings or fabrications and the application of plastics to insulation. The success of this work led to more widespread efforts to use the newer raw materials. Some of the most successful applications include:

Aluminium: This is used in the form of permanent mould gravity castings of the aluminium silicon alloy LM.6 to British Standard 1490. This alloy gives high physical properties, low weight and extremely good corrosion resistance at low cost with ready availability of raw material and competitive production capacity. There have been no service failures due to corrosion, although discolouration occurs in some areas, particularly near the coast and in some industrial locations. Typical applications include (Fig. 9) pole hardware replacing forged steel, single piece transposition plates replacing pressed steel plates with forged steel spindles (36), and cable box, pillar and cabinet components replacing steel castings and fabrications (Fig. 4).

Epoxide Resin: Since 1957 epoxide resins have been used for factory sealing the paper insulated tail cables of cable boxes, pillars and cabinets. In the designs now standard the epoxide forms the terminal block as well as sealing the tail cables. The required electrical and physical properties are

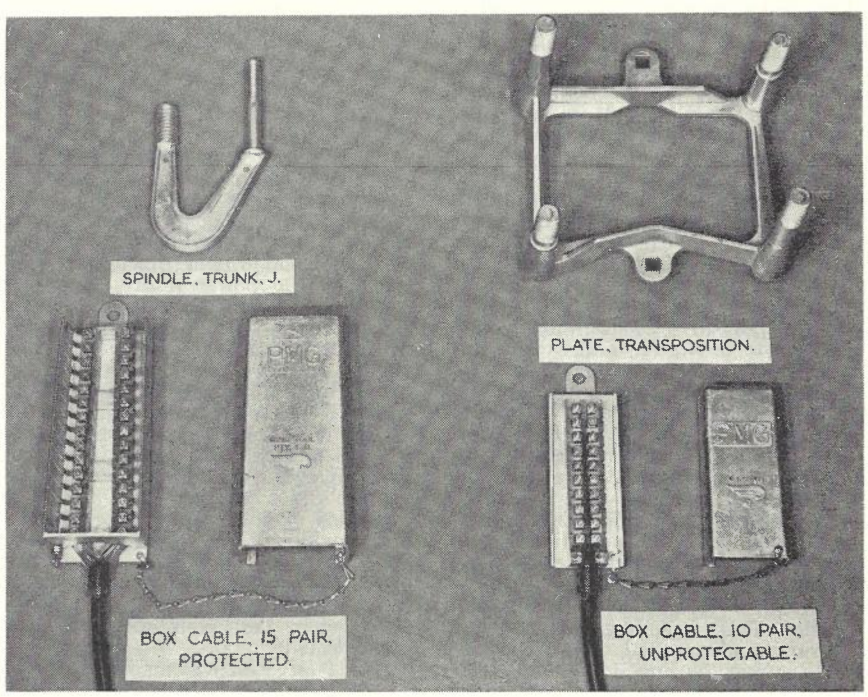


Fig. 9.—Typical Cast Aluminium Pole Fittings.

readily obtainable using commercially available resins, hardeners and plasticisers, resulting in cheap, highly satisfactory finished products. The cabinets in Fig. 4 are made of aluminium casting and epoxide resin components resulting in a low cost, aesthetically pleasing, mechanically strong and electrically efficient article.

P.V.C.: P.V.C. is successfully used for insulating drop wire (35, 36), the problems of cold flow of the plastic at terminations having been solved by using a separate steel bearer wire. The cost of the P.V.C. coated wire is much less than that of alternative designs using synthetic rubber.

These developments have substantially reduced the purchase and installation cost of material and have resulted in improved service to the subscribers. An example is the use of epoxide resin in place of bituminous and similar materials for sealing paper insulated cables. Epoxide resin designs are substantially lower in all costs and inherently provide a much higher standard of insulation resistance than the older materials.

A major problem with designing external plant material is to ensure that it does not present any problems in installation or maintenance. Furthermore, any deficiency should be promptly reported back to the designer for correction. Experience has shown that these are difficult problems; firstly, even the most careful and experienced designer cannot ensure that a newly introduced design will be satisfactory in all respects for field use, and secondly it is very hard in a big organisation to ensure that prompt and accurate reports of design weakness are reported to the designer. Field engineers are familiar with the way that badly designed material tends to be supplied to the field for many years before its deficiencies are put right. Considerable attention has been given to this problem in recent years, notably by means of controlled field trials of new designs (37), by reports on factory problems from the Material Inspection staff, and more recently by a field fault sampling system. A new design is first introduced on a limited scale in the field test areas and modified in the light of the information made available from these tests. The item is then issued widely and a special performance analysis form prepared which goes to all users so that early notice of any weakness in design comes to the notice of the designer. This latter procedure was only recently introduced but has brought to notice faults which had been present in items for some years.

An important factor in the success of the cost reduction programme is that all items of line material are designed by the Department's engineers with advice on manufacturing points from contractors. This is because there are no manufacturers specialising in this field in Australia (apart from cable and loading coils) and the material is made by firms whose business is generally engineering, plastic moulding, etc., and not specifically the manufacture of external telephone plant. There are advantages however with user design, basically because of the ability of the user-designer to cope with the problems discussed in the previous paragraph. Moreover, allowing that the manufacturer-designer may be better informed on production technique, he cannot have the expertness and awareness of field needs of the user-designer. Even where the manufacturer is also the installer, and there is a good liaison between his manufacturing and installation departments, he is still divorced from the maintenance and service field.

A further factor favouring user-design is the greater speed with which advantage can be taken of new raw materials and processes. The user-designer is more seized with the urgency of taking advantage of the cost reduction or superior performance possible by exploiting the new raw material or process while to the manufacturer-designer, its introduction may mean scrapping a satisfactory production line with amortized design and tooling costs, and possibly losing an advantage over his competitors.

Mechanical Aids

An interesting development shown by Table 2 is the greatly improved productivity of labour. Over the 10-year period, labour employed has increased by 9%. This is the force available both for maintenance of the plant and for all of the construction and installation work required for the extension of the telephone service. Very little external plant work is done by outside contractors and this is not a relevant factor. The impressive point is that this slightly increased labour force has been able to more than double the rate of installation of plant and simultaneously carry out the maintenance work on a much greater quantity of plant. The biggest factor in improved productivity is the substantially increased use of mechanical construction aids as discussed later. The cost of mechanical aids appears in the item "Incidentals" in Table 2 and most of the increase of 180% in this item is due to mechanical aids. Studying the Table will reveal that the cost of the mechanical aids is small compared to the saving in labour costs, particularly considering the 67% increase in unit wage costs that occurred in the period.

The Department operates and maintains a considerable number of mechanical aids. The policy is to hold sufficient of each type to meet the normal requirements for installation and maintenace, and to augment the fleet by the use of plant hired from private contractors and other Government Departments or authorities. The most valuable machine in terms of improved productivity is probably the light ditcher, a machine designed specially for telephone work, which was introduced in 1956. Table 5 lists the most important types of mechanical aids in use; it does not include transport items such as low loaders or cable drum trailers nor smaller general purpose devices such as concrete mixers and water pumps.

Work Improvement

This progressive application of mechanical plant to telephone external plant construction has resulted in a major increase in productivity and a greatly increased work output from an essentially static number of personnel. However, over the past three years, it has been realised that, as mechanisation approaches saturation, no further spectacular improvements in productivity can be expected from this source. During the same period attention has been focussed on the organisational problems associated with a high degree of mechanisation and increasing engineering effort is being applied to problems of programming, work organisation and material supply, as for example the study of meteorological conditions in relation to work (2).

Concurrently work study of field operations has been introduced for the purposes firstly of reducing the time and

TABLE 5.—MECHANICAL AIDS IN USE AT 30/6/1963

	No.	Typical Machine in Group	Typical Capacity
Pole Hole Borers	89	Proline borer mounted on rear of Chamberlain tractor. Hoist in front.	35 B.H.P. at 1,500 r.p.m. 30 m.p.h. road speed. Digs 30 inch hole 7 ft. deep. Hoists 15 cwt. at 8 ft. outreach.
Light Ditchers	179	"Ditch Witch" M4	4-8 in. trench x 36 in. deep, 2 ft./min.
Medium Ditchers	61	Parsons 77	6-18 in. trench x 60 in. deep, 6-8 ft./min.
Heavy Ditchers	14	Barber Greene 784	18-24 in. trench x 96 in. deep, 6-15 ft./min.
Back Hoes	34	John Deere 51	16-24 in. bucket width, 13 ft. 6 in. deep trench
Wheel Tractors	97	Light . . . . Ferguson 35 Heavy . . . . Chamberlain Industrial	½ yard front end loader. 5-8 ton mobile crane or 1 yard front end loader.
Crawler Tractors	53	Light . . . . Caterpillar D4 Heavy . . . . Allis Chalmers HD16 DC	Light Clearing. Cable ploughing to 3 ft. depth, ripping to 4 ft. Heavy clearing.
Compressors	316	Broomwade WR120	120 c.f.m. (FAD) at 100 p.s.i.

effort required to perform tasks, and secondly to redesign tools and material to make them more suitable for use in the field.

The first application is the best known use of work study and is widely used in factories. The technique was applied to an extensive investigation of quad cable wire jointing with considerable success; the new manipulative technique developed enabled jointers to increase their output by 50% in typical cases with considerably less fatigue and with a higher average standard of quality. It has also provided, unexpectedly, an excellent training technique for new jointers. An interesting sidelight on the study was that it showed that most jointers suffered from bad backs and excess fatigue due to being seated in the wrong position in relation to their work. Accordingly, an adjustable height collapsible stool has been developed for their use. Cable jointing is probably the only operation in external plant work suitable for the factory type of work study because of the absence of repetitious movements in most external plant operations. Accordingly work study has now been directed more towards organisational aspects of the work, such as improving the efficiency of teams of men engaged in tasks such as hauling cable or erecting aerial wire.

The main effort to date has been to study cable hauling in all its implications. The study is having a far reaching effect and has led to a major engineering investigation of the mechanism of cable hauling and subsequently to the design of conduit runs and manholes and to the design of cable drums and cable drum transporting equipment. In two years the average length of large cable hauled has increased from 80 yards to 150 yards with hauls up to 300 yards now being made with the largest size lead sheathed cables.

Concurrently, manhole spacing on conduit runs is being increased to take advantage of the larger length of haul and, overall, considerable economies have been made and more are expected.

SERVICE STANDARDS

In recent years a great improvement has been achieved in the reliability of the subscribers telephone service due to three main factors. The first of these is the use of gas pressure alarm systems on large cables which has reduced the number of faults which have affected service in these cables almost to nil. In fact, the rare catastrophic failure such as the cable being hit by large construction plant is the only source of failure of these cables. As the gassing programme is progressively implemented, experience proves that service failures from P.I.L.C. cables which make up the bulk of the network will become negligible. Secondly, there has been the replacement of bituminous and similar sealing compounds by epoxide resin for use in those situations where paper insulated cables have to be terminated for access, such as at the exchange Main Distribution Frame, cable terminal pillars and aerial cable terminal boxes. Breakdown of cable insulation in the bituminous seal was the second largest source of service failure after major cable breakdown and has been largely eliminated by the use of epoxide resin seals. The third factor is the replacement of large quantities of subscribers' aerial wires, particularly in the more closely settled rural areas, by cable with a subsequent substantial gain in grade of service due to absence of wind and storm effects.

Many other improvements have been made, some of which will now be briefly mentioned:

(i) A study of fatigue failures of trunk wires led to the introduction of vibration dampers and alterations in wire tensions; these measures have led to a marked reduction in the number of failures.

(ii) A study has been made of protection requirements and superior types of arresters, both gas filled and solid, have been introduced with marked success.

(iii) A serious point of failure with covered aerial wire is known as "drip point corrosion"; the problem has been under close study for some years (37), and a number of successful remedial measures have been applied.

(iv) Plastic jacketing as described previously is being applied to all important P.I.L.C. cables to reduce the incidence of corrosion.

A service problem has existed due to difficulties with earlier installations of plastic cable, due to inadequate jointing methods, particularly paper to lead joints and also due to excess pinholes in the conductor insulation. These problems have now been largely overcome.

At the same time as these engineering improvements have been effected, there have been difficult service problems arising from external sources, particularly the increased incidence of mechanical damage to cables due to the increased activities of other public authorities with the rapid growth of the Australian economy. Considerable efforts are being put into this problem and methods being used to reduce the incidence of mechanical damage include the careful selection of cable locations, deeper burying of cable which is made possible by the improved mechanical aids now being used, and a publicity campaign to alert other bodies to the presence of buried telephone cables (38). Other problems arising in a more intensive form are power induction and electrolytic and galvanic corrosion but these problems are being dealt with vigorously in the way described previously.

The question of reliability of the telephone service is regarded as most important, and continual efforts are being devoted to the problems of ensuring continuity of service to the subscriber. The External Plant Engineer is concerned basically with the reliability of service rather than electrical performance standards such as attenuation and crosstalk limits. Nevertheless electrical performance is also important, and as far as subscribers' services are concerned, attention is now also being given to a regular programme of testing of all external plant by means of automatic testers in the telephone exchange. These would check all lines regularly to ensure that they meet the required standards of insulation resistance, crosstalk, and conductor resistance.

ACKNOWLEDGMENT

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REFERENCES

All References are to articles in the Telecommunication Journal of Australia.

1. D. P. Bradley, "Impressions of an Overseas Visit by a Lines Engineer"; Vol. 13, No. 1, page 19.
2. F. J. Harding, "Cross Country Cable Construction-Installation Programming Based on Predictable Climatic Conditions"; Vol. 14, No. 1, page 36.
3. R. C. M. Dale, "Alice Springs and the Overland Telegraph"; Vol. 2, No. 3, page 161.
4. A. B. Cameron, "The Story of the Overland Telegraph Line"; Vol. 5, No. 4, page 189, and No. 5, page 283.
5. A. H. Kaye, "The Sydney-Melbourne Cable Project"; Vol. 13, No. 3, page 167.
6. A. S. MacGregor, "The Melbourne-Geelong Trunk Cable"; Vol. 2, No. 2, page 93.
7. C. J. Griffiths, "The Sydney-Maitland Cable"; Vol. 2, No. 5, page 274.
8. W. Engeman, "The Sydney-Newcastle-Maitland Cable"; Vol. 2, No. 6, page 384, Vol. 3, No. 1, page 22, and No. 2, page 100.
9. J. F. Sinnatt, "The Melbourne-Morwell Cable"; Vol. 12, No. 1, page 15.
10. C. H. Hosking, "Installing the Melbourne-Morwell Coaxial Cable"; Vol. 12, No. 6, page 402.
11. Various Authors, "The Melbourne-Morwell Coaxial Cable"; Vol. 13, No. 4, page 291, and No. 5, page 405.
12. Various Authors, "The Sydney-Melbourne Cable Project"; Vol. 13, No. 3 (complete issue).
13. D. MacQueen, "The Design and Use of Cable Ploughs"; Vol. 13, No. 6, page 459, and Vol. 14, No. 1, page 52.
14. W. H. Walker, "Standard Carrier Transposition Schemes"; Vol. 7, No. 2, page 96.
15. C. H. Hosking, "New Method of Regulating Aerial Wires"; Vol. 8, No. 4, page 213.
16. D. J. Mahoney and S. J. Davie, "Transport and Handling of Portable Type Exchanges"; Vol. 6, No. 6, page 366.
17. D. Henshaw, "Transport of Portable Exchange"; Vol. 13, No. 6, page 493.
18. L. E. Calame, "Cable Distribution by Means of Large Outdoor Terminal Pillars"; Vol. 4, No. 6, page 328.
19. V. J. White, "Jointing of Plastic Insulated and Sheathed Telephone Cables"; Vol. 11, No. 5, page 156.
20. Technical News Items, Vol. 12, No. 3, page 194, and Vol. 13, No. 2, page 105.
21. H. J. Ruddell, "Epoxide Resins"; Vol. 12, No. 2, page 108.

22. H. J. Ruddell and K. W. Wallace, "The Townsville-Magnetic Island Submarine Cable"; Vol. 12, No. 6, page 460.

23. R. D. Johnston, "Installation of an 1,800 Pair Polythene Insulated and Sheathed Cable"; Vol. 14, No. 1, page 66.

24. E. W. Corless, "Gas Pressure Alarm System — Melbourne-Seymour Cable"; Vol. 5, No. 1, page 22.

25. S. J. Byrnes, "The Installation of a Gas Pressure Alarm System on Aerodrome Control Cables—Darwin"; Vol. 7, No. 4, page 226.

26. J. W. Pollard, "The Application of Gas Pressure Alarm Systems to Coaxial Cables"; Vol. 13, No. 1, page 63.

27. F. J. Harding, "Sydney-Melbourne Coaxial Cable: The Gas Pressure Alarm System"; Vol. 13, No. 3, page 205.

28. N. G. Ross, "Theory and Design of Gas Pressure Alarm Systems for Telecommunication Cables"; Vol. 14, No. 1, page 70.

29. P. R. Brett, "New Methods of Location of Leaks in Gas-Filled Cables"; Vol. 9, No. 5, page 241.

30. W. E. Weaver, "Power Interference to Telephone Circuits"; Vol. 9, No. 2, page 80.

31. W. H. Walker and others, "Co-ordination of Power and Telecommunication Systems"; Vol. 10, No. 3, page 65.

32. W. O'Keefe, "Exchange Fault Caused by High Induced Voltage on Junction Cable"; Vol. 13, No. 5, page 418.

33. J. L. W. Harvey and H. T. Davis, "Co-ordination of Power and Telecommunication Systems in Australia"; Vol. 13, No. 6, page 440.

34. Technical News Item, Vol. 13, No. 4, page 290.

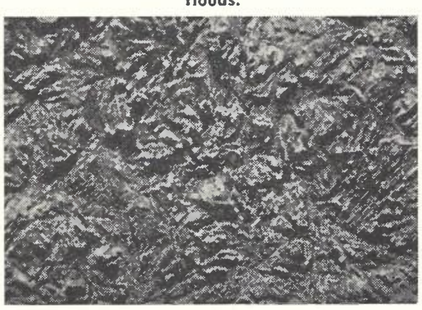
35. D. P. Bradley, "Drop Wire with Integral Steel Bearer Wire"; Vol. 11, No. 2, page 58.

36. Technical News Item, Vol. 12, No. 4, page 274.

37. V. J. White, "Controlled Field Testing of Drip Point Corrosion"; Vol. 12, No. 6, page 444.

38. L. R. Stephens, "External Plant Aspects of Coaxial Cable Maintenance"; Vol. 14, No. 1, page 16.

Linemen fit plastic vibration dampers on a 1,600 ft. aerial wire span over the Hunter River, New South Wales, an area of regular floods.

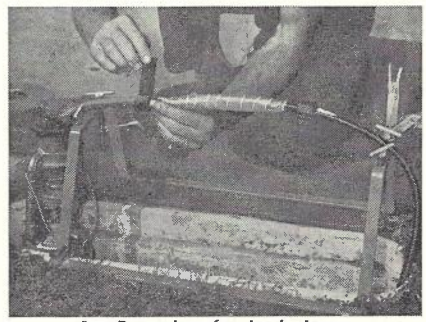


Termite attack on sheath of lead cable. Characteristic mandible markings readily identifiable under X10 magnification.

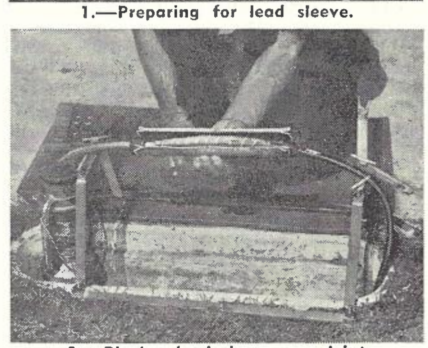
A cable jointer working on cables for the Woomera Rocket Range beats the heat of the Nullarbor Plain in a novel manner.

Termite attack on a test pole and crossarm in Northern Queensland—one of a series in a field trial of preservative measures.

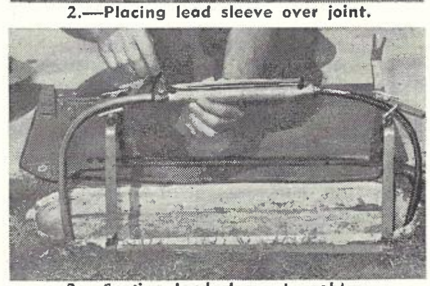
SEALING PLASTIC CABLES WITH EPOXY RESIN



1.—Preparing for lead sleeve.



2.—Placing lead sleeve over joint.



3.—Sealing lead sleeve to cables.

4.—Pouring mixed resin.

TELEPHONE EQUIPMENT PLANT PRACTICES IN AUSTRALIA

*K. B. SMITH, B.Sc., A.M.I.E.Aust.**

INTRODUCTION

Australia's first telephone exchange was opened in Melbourne four years after Dr. Alexander Graham Bell invented his telephone in 1876. In the eighty-three years which have elapsed since this first exchange was established (1), the number of subscribers has grown from the original twenty-three to 1,812,000 in June, 1963, connected to 7,000 exchanges throughout the Commonwealth. Australia was not far behind the rest of the world in adopting the automatic system of telephony. The first Australian automatic exchange was placed in service at Geelong, Victoria, in August, 1912, this being the first automatic exchange in the Southern Hemisphere, and the second in the British Empire. Australia now has 510 automatic exchanges, not including small rural automatic exchanges with less than 200 lines, of which there are now 1,500 in service.

The early exchanges were magneto local battery (L.B.) type, which were superseded in large centres by central battery (C.B.) exchanges a few years before automatic working was introduced. Extensive use is still being made of magneto local battery exchanges in country areas, and although the old switchboards are being progressively replaced by modern automatic equipment, Australia still has many local battery subscribers. Table 1 shows the distribution of the various types of subscribers' services between metropolitan and country areas.

An important event in Australia's telephone history was the cutover of the first semi-automatic trunk exchange in Melbourne during 1939 using equipment made by Siemens Bros., England (2). When it was installed the Melbourne trunk exchange was the most modern and the largest of its type in the world. The 2VF trunk signalling equipment which was introduced with the exchange, and the gradual establishment of the transit trunk switching network have done much to improve the trunk service in Australia. They have permitted the development of the single operator control principle for handling trunk calls on demand.

In the early days of telephony in Australia, American equipment was used; later, and until recently, the Department's equipment has followed, or been inspired by, British Post Office (BPO) designs. With the growth of Australian manufacturing potential during the past ten years the Department has not only come to rely more and more on Australian companies as a source of supply, but has also encouraged a trend towards the development of special designs to meet local requirements.

TABLE 1: DISTRIBUTION OF THE VARIOUS TYPES OF SUBSCRIBERS' SERVICES BETWEEN METROPOLITAN AND COUNTRY AREAS AT JUNE, 1962

		Metropolitan	Country	Total
ORDINARY EXCHANGE SERVICES	Automatic	832,322	261,509	1,093,831
	Manual	551	329,404	329,955
	Total	832,873	590,913	1,423,786
DUPLEX SERVICES	Automatic	89,078	1,952	91,030
	Manual	—	252	252
	Total	89,078	2,204	91,282
PARTY LINE SERVICES	Automatic	1	1,260	1,261
	Manual	—	13,193	13,193
	Total	1	14,453	14,454
PRIVATE BRANCH EXCHANGE SERVICES	Automatic	130,046	18,998	149,044
	Manual	—	14,795	14,795
	Total	130,046	33,793	163,839
PUBLIC TELEPHONES	Automatic	13,879	4,311	18,190
	Manual	—	7,018	7,018
	Total	13,879	11,329	25,208
TOTAL	Business Automatic	408,515	169,829	578,344
	Business Manual	12	246,671	246,683
	Residence Automatic	656,811	118,160	774,971
	Residence Manual	539	118,032	118,571
	Total Services	1,065,877	652,692	1.718,569

EXCHANGE EQUIPMENT

Manual Switchboards

Most of the L.B. and C.B. manual exchanges in service in Australia are very small, although there are still some multiple boards in service (3, 4). One of the most common types of local battery exchange is the pyramid cordless switchboard which has a capacity for ten lines (5). These ten line boards are found mainly in small non-official Post Offices and telephone offices usually conducted as part of the service provided by a local store in the country areas. It is of interest to note that of the 7,056 exchanges which were in service on the 30th June, 1962, 1,316 had less than 10 subscribers, and only 3,339 (or less than half) had more than 40 subscribers. Table 2 is of interest, as it shows the development of small and large exchanges over the past twenty years.

The physical and electrical design of the manual switchboards has undergone considerable change, with the result that there are many different circuits used throughout Australia at the present time. This has presented the Administration with a considerable amount of difficulty in integrating new equipment into the Australian network. There has been considerable development of the C.B. switchboards which

TABLE 2: GROWTH OF EXCHANGES OF VARIOUS SIZES

Year	Exchanges with Less than 10 lines	Exchanges with 10 to 40 lines	Exchanges with more than 40 lines	Total
1939	4,773	332	1,228	6,333
1945	4,635	383	1,362	6,380
1946	4,591	439	1,361	6,391
1947	3,540	466	1,413	6,419
1948	2,537	2,475	1,464	6,476
1949	2,417	2,620	1,547	6,584
1950	2,344	2,721	1,655	6,720
1951	2,182	2,882	1,787	6,851
1952	2,281	2,846	1,863	6,990
1953	2,194	2.806	2,060	7,060
1954	2,156	2,735	2,263	7,154
1955	2,044	2,722	2,467	7,233
1956	1,969	2,761	2,545	7,275
1957	1,849	2,734	2,701	7,284
1958	1,739	2,687	2,900	7,326
1959	1,673	2,610	3,043	7,326
1960	1,565	2,523	3,158	7,246
1961	1,432	2,475	3,254	7,161
1962	1,316	2,401	3.339	7.056

* See page 168.

were purchased by the Department, and some new developments in this circuit have been described recently (6).

Rural Automatic Exchanges

In the country areas, small manual switchboards have been progressively replaced by rural automatic exchanges (RAX's). Early RAX's installed were company types, but the Department used the experience gained with these to develop a non-extensible 40 line and an extensible 50-200 line RAX specially dimensioned to suit Australian conditions and requirements (7, 8). The development of these RAX units represented a starting point in a major RAX program, which grew from 69 exchanges in 1939 to 1,500 in 1963. These years have seen considerable development and modification to the original design, but basically they have not changed a great deal. Most of the changes have centred around the improvement of the RAX units as system building blocks; they have been used in automatic networks having a trunk exchange associated with the central step-by-step automatic exchange as a parent. Other improvements in the remote testing and alarm signalling facilities have been aimed at reducing service costs, and at providing a more reliable and continuous service to subscribers.

The 40 line or B type RAX is a self-contained enclosed unit which requires only the addition of an M.D.F. and power supply to complete an installation. The extensible RAX is built up in 50 line increments, the first 50 line unit containing the essential auxiliary equipment such as ringers. As with the B type RAX, the addition of a floor type M.D.F. and power supply is required to complete the installation. In the larger RAX, provision was made for party line operation with code ringing and separate metering for up to ten parties per line.

Both types of RAX have been installed in standard buildings, 9 ft. x 9 ft. for an installation of 50 lines capacity, and 14 ft. x 9 ft. when growth above 50 lines can be foreseen during the planned life of the RAX.

RAX's will from now on be superseded by crossbar terminal exchanges which will provide a wider range of facilities of which Subscriber Trunk Dialling (STD) is perhaps the most important. The RAX was designed as a unit with a closed numbering scheme, and was not readily adaptable for use in a large network.

Larger Automatic Exchanges

In the metropolitan areas, manual services have been almost completely eliminated. Table 3 shows how automatic services have grown during the past 20 years, with the compensating reduction in manual services in metropolitan areas.

Prior to 1936 the Department's metropolitan networks, except Brisbane, were largely built up of Strowger step-by-step automatic exchanges, initially using Keith plunger line switches followed by 100 line boards with rotary line switches. In the Brisbane metropolitan area Siemen's No. 16 equipment (Fig. 1) was used for the automatic network. This is a step-by-step bimotional type system which uses battery testing, a different signalling method to the Strowger system, a battery feed at the first switching stage, and ten outlet non-homing uniselector line switches. The line switches, trunked as first and second preselectors, are driven by an external pulse source because they have no self-interrupted drive.

The No. 16 equipment has been an extremely reliable and robust system capable of operating under much wider network limits than the Strowger system or its 2,000 type successor. A number of No. 16 exchanges are still working in Brisbane although they are being extended with more modern equipment.

Realising the advantages to be gained by standardising the design of automatic exchange equipment, the Department decided in 1936 to use only the then new BPO standard 2,000 type equipment for all new exchanges (9).

TABLE 3: GROWTH OF TELEPHONE SERVICES

Year	Metropolitan Exchanges		Country Exchanges		All Exchanges	
	Automatic	Manual	Automatic	Manual	Automatic	Manual
1942	290,155	40,774	17,108	183,038	307,263	223.812
1943	298,541	40,205	17,425	184,090	315,966	224,295
1944	309,704	40,247	19,658	187,463	329,362	227.710
1945	319,747	40,965	19,670	197,395	339,417	238,360
1946	334,249	41,444	21,088	210,694	355,337	252,138
1947	358,826	40,062	22,973	226,015	381,799	266,077
1948	383,344	39,861	25.535	239,608	408,879	279,469
1949	413,798	34,315	27.441	258,944	441,239	293.259
1950	453,132	32.272	32,841	276,349	485,973	308.621
1951	501,260	29,615	43,713	295,260	544,973	324,875
1952	545,586	29,037	54,770	309,396	600,356	338,433
1953	583.567	28,772	62,419	326,606	645.986	355,378
1954	632,290	22.832	72,082	342,891	704.372	365,723
1955	688,913	17,035	85,687	361.295	774,600	378,330
1956	746,257	13,914	106,750	372.662	853,007	386.576
1957	795,284	12,780	125,881	384,110	921,165	396,890
1958	855.399	9,582	157,355	384,211	1.012,754	393.793
1959	912,641	4,177	189.843	384.656	1,102.484	388,833
1960	961,021	2,352	223,456	375,139	1,184,477	377,491
1961	1,006,110	1,510	255,666	366.980	1,261,776	368,490
1962	1,065,326	551	288,021	364,671	1,353,347	365,222

This equipment as originally designed used bimotional line finders in 200 line groups with partial secondary working, but most of the Australian 2,000 type exchanges installed since 1945 have used homing type uniselector line switches.

Although 2,000 type equipment (Fig. 2) was used for all new exchange installations from 1936, the Department continued for some time to buy Strowger equipment to extend the existing exchanges. One reason for this was that many of the older exchange buildings had ceiling heights which were too low for a convenient cabling of the 10 ft. 6 ins. high 2,000 type racks; also in many exchanges the Strowger equipment had been spread over the whole switchroom area to provide for the smooth growth of each exchange to the full capacity of the building. The difference in heights of the pre-2,000 type and 2,000 type equipment racks made the insertion of the new racks in amongst the old an impracticable engineering task.

The quantity of Strowger equipment installed has not been increased since 1952 as, by that time, most of the pre-2,000 type exchanges had been filled, and in other buildings which had sufficient ceiling height, it was possible to close up the pre-2.000 type equipment so that the exchanges could be extended with 2,000 type. In still others, building extensions were made with a ceiling height suitable for the 2,000 type racks.

Automatic Equipment Supplies

During the pre-2,000 type era most of the switching equipment used in the Australian network was purchased overseas. Some items, such as switch parts, switch banks and iron work, were made in Australia by small manufacturing companies, but the quantities purchased locally were very small. The adoption of the BPO 2,000 type system heralded the rapid development of the Australian capacity to manufacture switching equipment. Before long both Standard Telephones & Cables Pty. Ltd. (STC) and Telephone & Electrical Industries Pty. Ltd. (TEI) were making all parts of an exchange with the exception of the bimotional switch. Soon after the end of the second World War the Department stopped installing new exchanges with bimotional line finders, and changed over to the homing uniselector line switch. The two Australian companies quickly tooled up for these switches, producing an Australian version of the General Electric Co. No. 3100 switch, which was bought instead of the bimotional line finders for the high calling rate City West Exchange in Melbourne, one of the first 2.000 type exchanges installed in Australia.

To round off the switching equipment production capacity of the Australian factories, it was decided to make the bimotional selector locally and the General Electric Co. SE50 (10) (BPO 4,000 type) switch was chosen instead of the BPO 2,000 type because it was felt that this selector, a development of the 2,000 type, was a better design. In this switch the designers had reverted

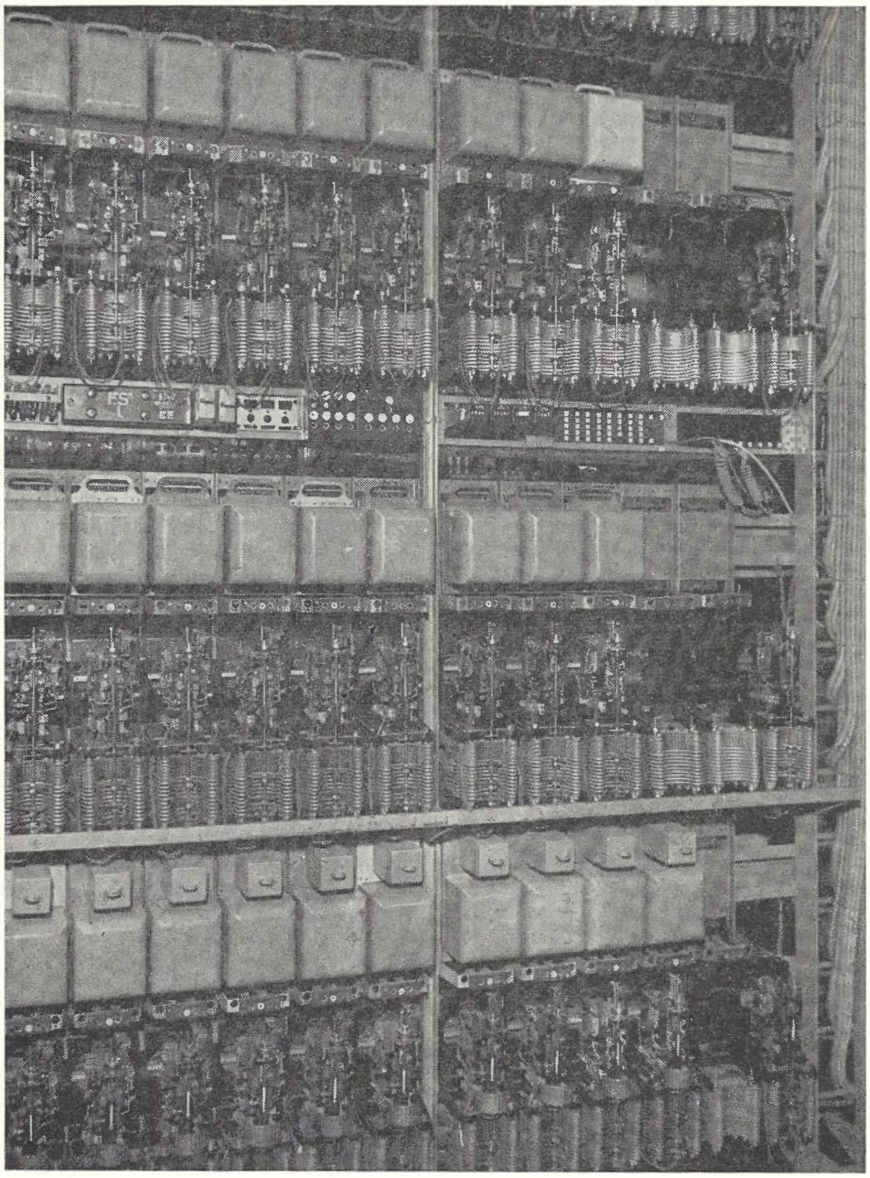


Fig. 1.—Siemens No. 16 Equipment Final Selector Rack.

to the backward release principle which, being very fast, has distinct advantages over the 2,000 type square release for the discriminating switches used extensively in the Australian network. With the production of the SE50 switch in Australia the Department could obtain supplies of the complete switching system from Australian factories, and was no longer plagued by the uncertainties resulting from shipping delays, etc.

The alternative of changing to a completely new switching system was considered at the time when it was decided to go ahead with the SE50 switch. It was realised that, for the development of the Australian network as a complete automatic unit, a common control system would be necessary. However, a complete changeover to a new system at that stage would have taken many years and it would have been necessary to rely upon overseas supplies of the vital units in the exchanges while the Australian factories were preparing to manufacture a new system. As they were already tooled up for the racks, shelves and banks for the SE50 switch, it was logical that the local factories should make use of the development work already completed instead of starting again to make a new system which would have required completely new racks, switches, and relay mountings.

The decision has proved to be a wise one, because the Department has now been able to adopt a crossbar common control system, which has been engineered to operate as a complete nation-wide dialling system. This was not available in 1952.

Many aspects of the design of the Australian step-by-step networks have been described in several previous articles in this *Journal* (11). Briefly the network has been built up of main exchanges and branch exchanges, the latter using first rank switches of the discriminating - selector - repeater (DSR) type. This basic principle of network design was adopted before 2,000 type selectors were introduced, but the DSR was brought to its peak of development with the introduction of the SE50 type DSR.

The modern DSR developed for the Australian network provides direct routing so that by careful selection of numbering, it is possible to cross-switch to branch exchanges in another main exchange group. An Australian development also provides for alternate routing, the route through the main exchange being used as an overflow route when the direct junctions are all engaged (12).

While this DSR provided fairly well for the development of the step-by-step network, frequent, costly and subscriber disturbing number changes were necessary as the network was rearranged to cope with the unpredictable surges of development in the outer metropolitan suburbs. It has also been apparent for some years that for the design of an economical nation-wide subscriber trunk dialling system the step-by-step principle would be quite inadequate. The Department therefore decided some five years ago that a common control switching system should be introduced as soon as possible to meet the needs of the future, and the survey of available switching systems which had been going on for some years was intensified. It was decided that the L. M. Ericsson crossbar system comprising ARF for metropolitan, ARK for country and ARM for trunk switching exchanges came closest to meeting all the requirements for the orderly development of the Australian network. The considerations which led to the adoption of the L. M. Ericsson crossbar system are dealt with in detail in several recent articles published in the *Journal* (13, 14 and 15). The first two ARF102 exchanges were recently placed in service (see Fig. 3), and from now on most of the exchange development will be carried out with crossbar equipment. Further information on crossbar equipment will be given in future issues of this *Journal.*

SUBSCRIBERS' EQUIPMENT

General

In the subscribers' equipment field, the Department has used instruments and switchboards obtained from a number of sources. In recent years, while the equipment designs have been basically similar to the BPO standard items, they have been changed in detail to suit Australian requirements whenever this has been necessary.

Telephone Instruments

Moulded handset telephones were introduced into the Australian automatic telephone network in 1935 (16, 17). Although there are still some of the old automatic telephones in service the quantities are now very small. Magneto wall telephones of the older type are still being recovered from country areas; this will continue for some time as there are still nearly 400,000 magneto telephones in service. The total magneto telephones in service did not start to fall until 1959.

Some 300,000 table handset telephones of the early BPO 162 and 232 type were installed in the Australian network, but the introduction of the BPO 300 type telephone in 1939 (18) started the era of the modern handset telephone as we know it today. Australian manufacture of the 300 type telephone commenced during 1947. This telephone was used as the standard Australian automatic telephone for approximately 20 years, when improved exchange equipment and the adoption of the new rocking armature receiver, developed by Standard Telephones and Cables Pty. Ltd., made the 1,000 ohm loop telephone possible. Even when equipped with the special BPO 2P receiver, the 300 type telephone could not be used on transmission loops much in excess of 650 ohms.

As there was no development in transmitter inset comparable with the receiver improvement, the introduction of the rocking armature receiver inset called for a new telephone circuit, so that the new telephone would not be unbalanced in relation to all other telephones in the network. Details of the common 300 type telephone circuit and the 400 series telephone are shown in Fig. 4.

Although the 400 series telephones had very much better transmission performance than the earlier types, they suffered from the drawback that on very short loops the sidetone and receiving level were uncomfortably high. It can be seen from the circuit that no automatic compensation for short loops was provided. After they had been in service for a short time it was apparent that something would have to be done about this difficulty, and it was decided that subscribers' loops below 200 ohm resistance should be built out with a 300 ohm resistance fitted in the telephone terminal block. While this did not correct the additional sidetone it did make the new telephone tolerable on very short loops. Another difficulty was the accentuation of the clicks and general noise in the network, by the much higher sensitivity of the rocking armature receiver. It was found that transmitter insets had to be replaced very much more frequently, because with this receiver inset, frying noises in the transmitter insets could be heard much more clearly than with the earlier 1L receivers.

This year the Department introduced the first of the new 800 series of telephone instruments. The 801 automatic telephone, which has been described in a recent issue of this *Journal (19)* and elsewhere (20), has been designed for high transmission performance, subscriber convenience, low maintenance and low manufacturing costs. The 800 series telephones have overcome most of the previous difficulties by the inclusion of automatic compensation for short line loops and an acoustic shock absorber across the receiver.

With the production of a local version of the BPO Dial No. 12 in 1957, Australia ceased to be reliant on overseas supplies of any parts for automatic telephones. Although first deliveries of the new 801 telephone were fitted with imported dials, a new locally made dial is being tested and before the end of 1963, deliveries of telephones completely made in Australia will commence.

Simultaneously with the introduction of the 801 telephone, the Department arranged to purchase a trial number

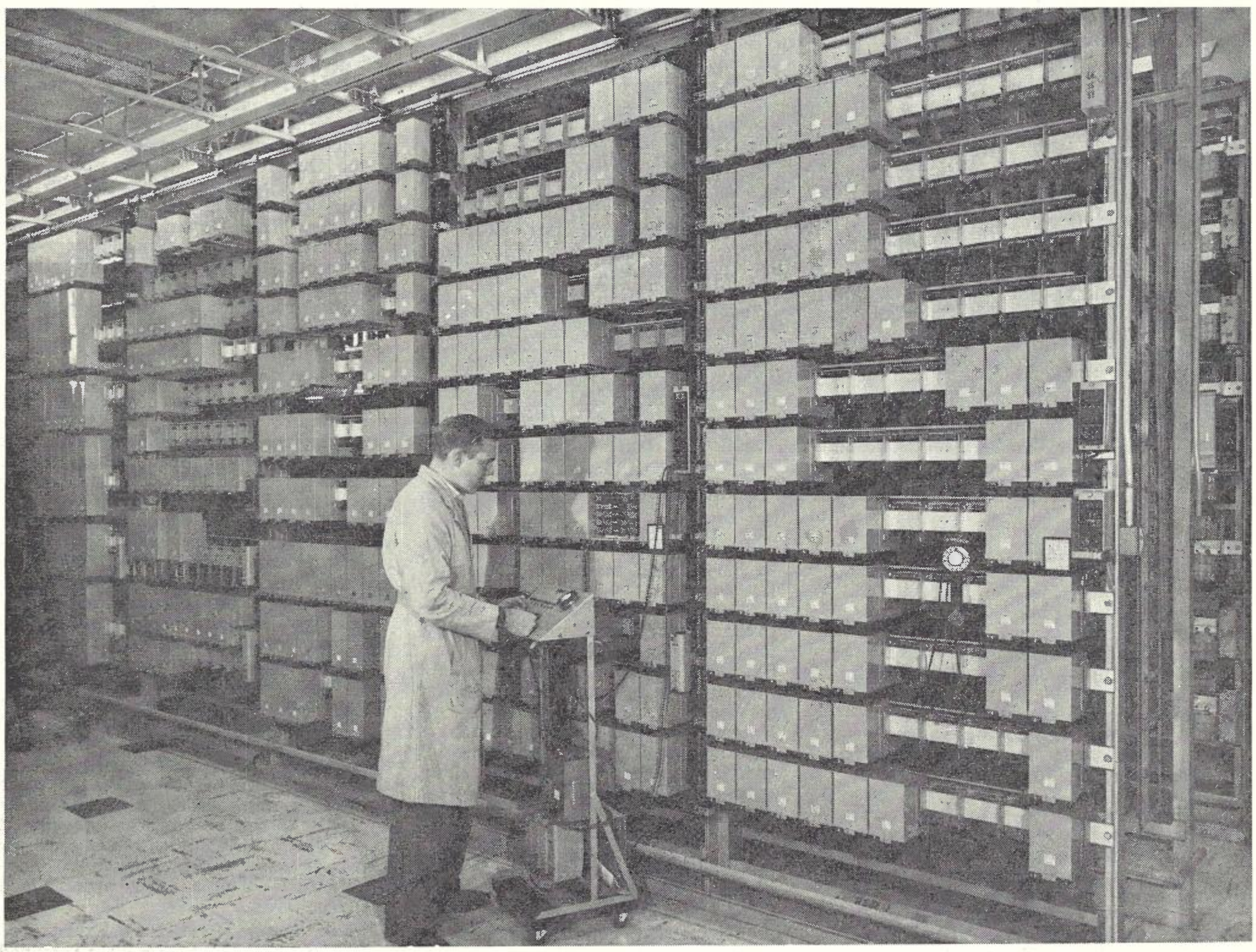


Fig. 2.—2,000 Type Equipment Racks.

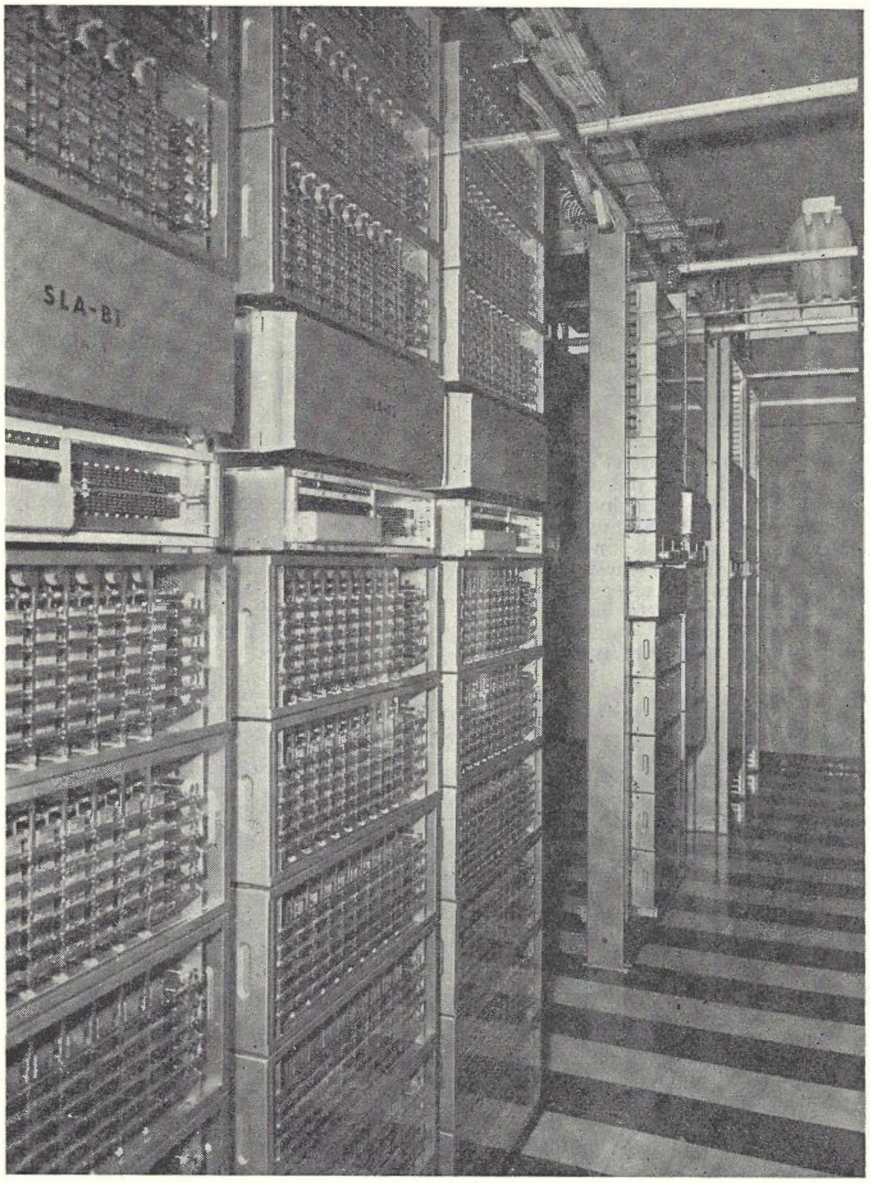


Fig. 3.—Cleveland Exchange, Queensland (cutover 23/6/63). This is the first exchange in service to use Australian-made Crossbar Equipment.

of Ericofons from L. M. Ericsson, Sweden. These telephones are now available to subscribers.

For the subscriber who requires additional facilities such as extension services, the Department provides the following range of standard Plan facilities:

(a) Parallel telephones—Line from public exchange terminating on two or more telephones in parallel without signalling facilities between telephones.
(b) Portable telephone—Line from public exchange with portable telephone.
(c) Parallel and portable telephones—Line from public exchange terminating on a fixed telephone with a portable telephone in parallel.
(d) Alternative telephones—Line from public exchange with two telephones controlled by a changeover switch.
(e) Extension switch—Line from public exchange with main and extension telephones.
(f) Extension switch—Line from public exchange with main and two parallel telephones on extension.
(g) Extension switch—Line from public exchange with main and portable service on extension.
(h) Extension switch—Line from public exchange with main and extension switch together with alternative extensions controlled by changeover switch.
(j) Shared telephone service—Line from manual central battery or automatic public exchange serving two subscribers without secrecy.
(k) Duplex telephone service—Line from manual central battery or automatic public exchange serving two subscribers with secrecy.
(l) Party line service—Line from public exchange serving two or more parties without secrecy.
(m) Call-back switch—Two lines terminating on one telephone with hold facilities.
(n) Executive unit—A service with one-way non-switched calling lines to subordinates.
(o) Concentration unit—A common answering point for several lines.
(p) Secretarial unit.
(q) Private manual branch exchange.
(r) Private automatic branch exchange.
(s) Intercommunication equipment — 1 Exchange line plus 6 extensions or 2 exchange lines plus 11 extensions.
(t) Telephone with operator's headset.
(u) Control lock.
(v) Hearing aid equipment.

Special Attachments

In addition to the standard facilities provided by the Department on a rental basis, the connection of a number of special attachments is authorised by the Department. Some examples of these are:

Coin Telephones.
Automatic Dialling Burglar Alarms.
Telephone Answering Devices.
Loudspeaking Telephones.

This special apparatus is sold or rented to the subscriber by private contractors and the Department accepts no responsibility for the maintenance or performance of this equipment. However, before any of these special devices are included in the list of authorised attachments to the telephone service, a sample is carefully examined in the Department's laboratories to ensure that it will not interfere with the proper functioning of the telephone network. The Department takes the view that, while it does not accept any responsibility for any inconvenience caused to the owner of a special facility, it must safeguard as far as possible other subscribers who have no control over its use.

Private Branch Exchanges

The standard cord and cordless switchboards used in the Australian network are fairly conventional in design, although the standard C.B. lamp-signalling PBX (21) has some novel facilities. The circuit of this switchboard has been improved over the years to eliminate some minor operational defects, but it has still been possible to get all the facilities into the board without resorting to external mounting for the relay sets. To facilitate handling, all relay sets are built on jacked-in bases which are supplied separately to the main switchboard carcase. C.B. multiple PBX's are required less frequently than non-multiple switchboards and it has been the Department's practice to build these up as required from exchange type multiple switchboards. A rather novel approach to this problem was developed in New South Wales where a multiple unit was used to combine three non-multiple PBX's at a single switchboard (22).

Private Automatic Branch Exchanges

Before 1957 all PABX's were provided by the Department on a rental basis

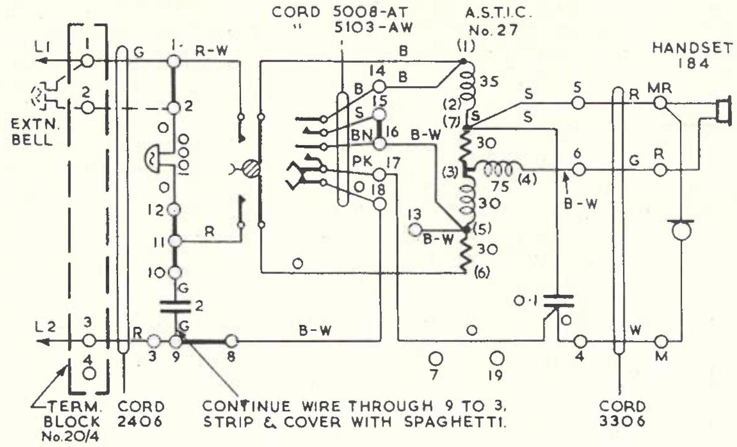


Fig. 4(a).—300 Type Telephone Circuit.

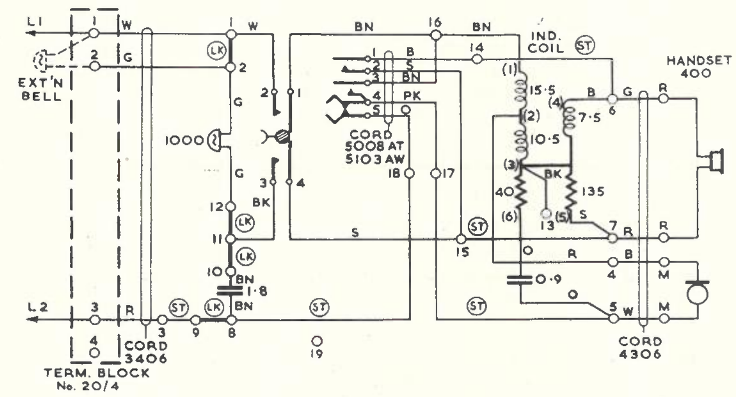


Fig. 4(b).—400 Type Telephone Circuit.

and standard PABX's of the step-by-step type were used extensively. For installations with up to 50 extensions, unit type C and CA PABX's were used (23). The C unit has a capacity of four both-way exchange lines and 25 extensions and four links; with an extension unit of similar capacity added, the C becomes a CA unit. The line-finders are 25 point non-homing uniselectors and 100 outlet 2,000 type bimotional final selectors are used. The manual board for these PABX's takes the form of a small table console which has a row of ten digit keys for setting up calls to the extensions.

These unit type PABX's were only suitable for subscribers with modest telephone requirements. Those who required more extensions than 50 or whose originating traffic was too high for the unit type were provided with line-finders or line-switch installations on open type racks (24). The E and F type line-finder installations were standardised to handle 50 and 90 extensions, and 16 and 30 exchange lines respectively. When fully loaded they could handle a maximum calling rate of 0.12E/extension.

After 1957 all new PABX's were sold directly to private subscribers by approved contractors who also did the installation work. Between 1957 and 1962 the installations were all Departmental standard types but with the adoption of crossbar for the public network a number of crossbar PABX's have been approved and installed. The smallest size PABX approved to date is the 10 line unit, L. M. Ericsson type ARD 520 (25).

The Department still uses the standard types for the Government PABX's which it installs, but future purchases for this purpose will also be of the crossbar type.

Duplex Services

In order to overcome the large backlog of unsatisfied applications for telephone service, the Department in 1947 introduced the duplex type service. This provided two telephone services with full secrecy, individual message registers and selective ringing over one pair. A number of different duplex circuits have been developed and tried since the first was introduced. Some used only one lineswitch for the two services while others used two complete line circuits. Fig. 5 shows the latest circuits used with the special 400 series duplex telephones which are fitted with a press button for calling.

Due to the high installation and maintenance charges, duplex service is not an economical method of providing telephone service, and for this reason it is only being used to provide relief in areas where there is an acute cable shortage.

PUBLIC TELEPHONES

It is the policy of the Department to provide public telephones wherever a survey shows that there is a need for one. The test of this need in metropolitan areas is that there must be a potential annual revenue from calls of £30, and if there is another public telephone within half a mile the potential revenue must be £50. In country areas the corresponding revenue figures are £16 and £30 respectively.

The Department has in service three basic types of public telephone instruments:

(i) The local call automatic type which accepts four pennies for local calls. This type is shown in Fig. 6.

(ii) The multi-coin type which accepts four pennies for local calls and provides facilities for trunk calling with the assistance of an operator. The instrument is generally similar to the BPO Coin Collecting Box No. 14, and accepts coins of three denominations (26). Fig. 7 shows the latest circuit for automatic areas.

(iii) A manual type which accepts one penny at a time, signalling the acceptance of each coin to the manual exchange operator.

During recent years all public telephone development has been met with multi-coin type instruments in order to provide trunk calling facilities to as many public telephone users as possible.

Because of the high level of vandalism the revenue of public telephones, which are generally located in street cabinets (Fig. 8), does not pay the cost of maintenance. It was decided recently to raise the public telephone local call fee from fourpence to sixpence, to make this service profitable. Although this increase raises the charge by 50%, the single coin operation is much more convenient to users. The local call type public telephones will be modified to accept a single sixpenny coin and the multi-coin type will also be modified to operate on a single sixpence for a local call. The penny slot in the multi-coin instrument will be changed to accept two shilling coins for the convenience of users who are making high rate trunk calls.

A short time ago the Department issued a tender schedule for automatic subscribers' trunk dialling public telephones. It was proposed at the time to adopt this type as a national standard as had been done in other countries. However, the extension of the subscribers' local call areas to include adjoining charge zones has greatly reduced the number of trunk calls made from public telephones, and it now appears that a general change-over to the expensive STD type instrument would not be economical. There may be use for small quantities of this type of instrument in some STD areas such as holiday resorts which are likely to generate a higher than normal proportion of trunk calls from public telephones.

In addition to public telephones, the Department will provide subscribers who wish to make their telephone available for public use, with a coin attachment for an annual rental of £5. The mechanisms operate on sixpence a call, of which the Department collects fourpence.

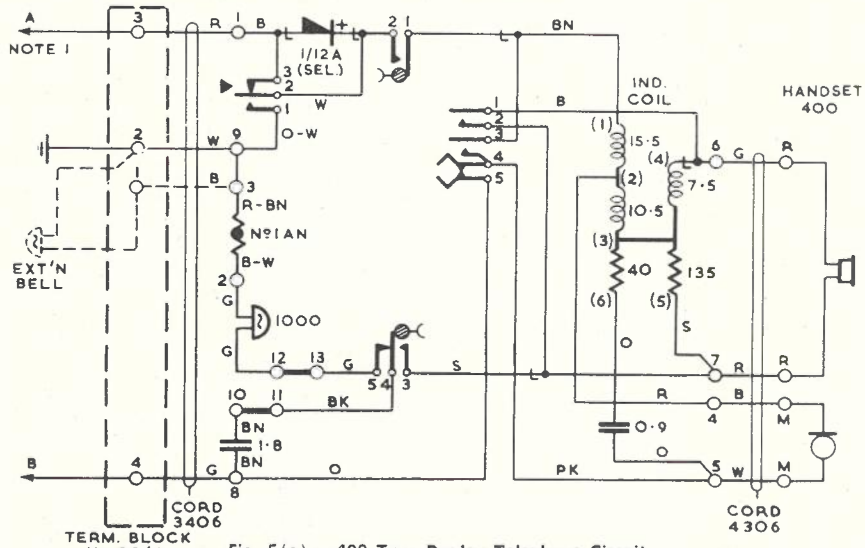


Fig. 5(a).—400 Type Duplex Telephone Circuit.

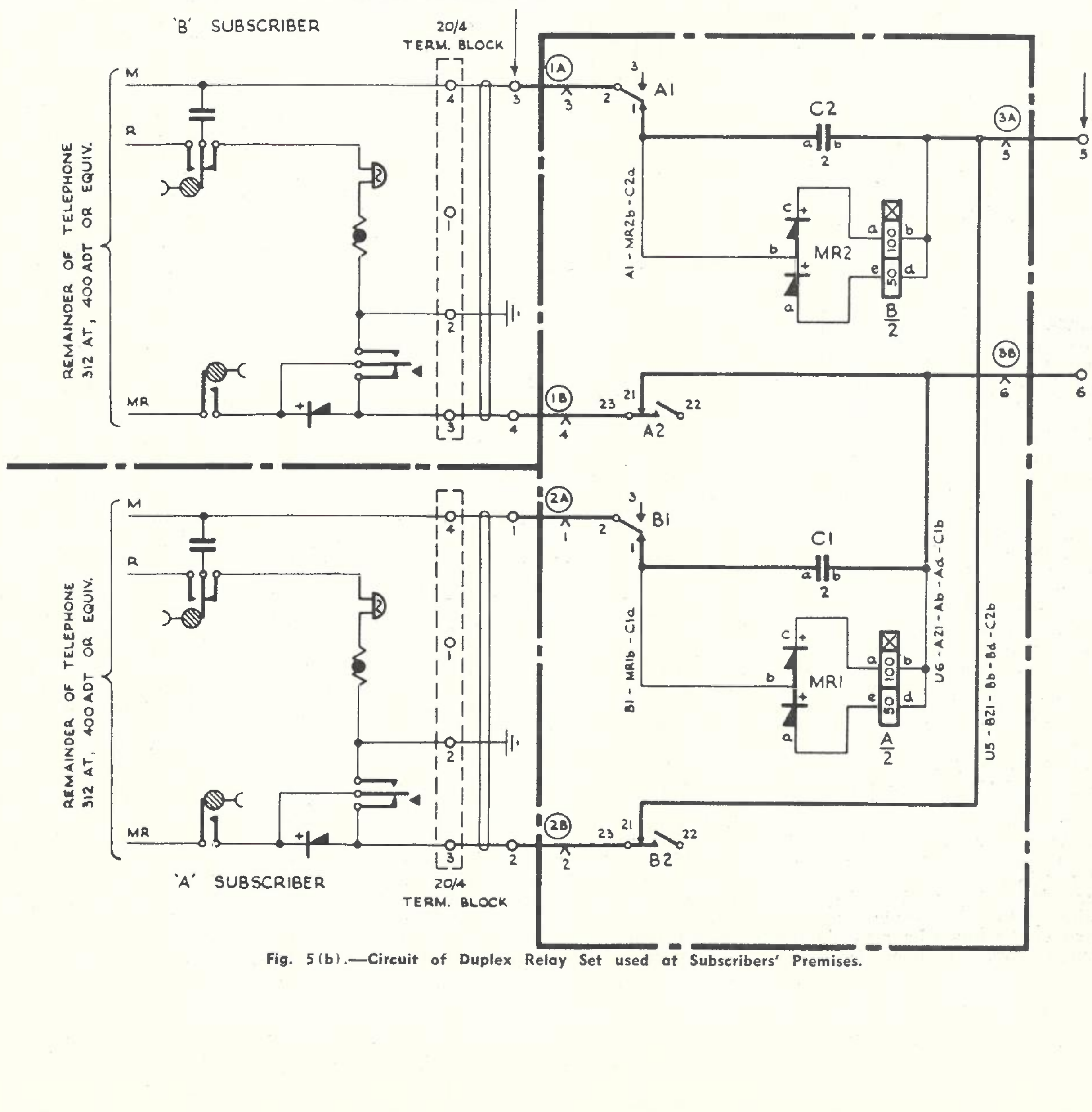


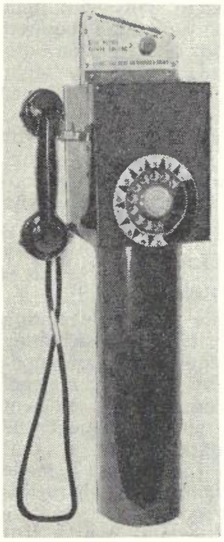
Fig. 5(b).—Circuit of Duplex Relay Set used at Subscribers' Premises.

POWER

Power for Exchanges

An essential part of the basic telephone apparatus in an exchange is the power supply equipment. The arrangements made for exchange and subscribers' apparatus power supplies have been largely conditioned by the security of the commercial supply. In the past when breakdowns in the commercial supply were frequent, it was essential to provide adequate reserve of power to bridge the gaps; this was achieved by using large secondary batteries with sufficient capacity to store power to provide service for as long as twelve hours during a break in the supply. Subscribers' equipment which required a power supply was supplied over power leads from these same batteries. The development of exchange power plant has been well documented in early issues of this *Journal* (27, 28, 29, 30).

The increased security of the commercial supply and improvement in the starting reliability of liquid fuel engine alternators gradually changed the pattern of exchange power supply arrangements. The development of quick starting diesel



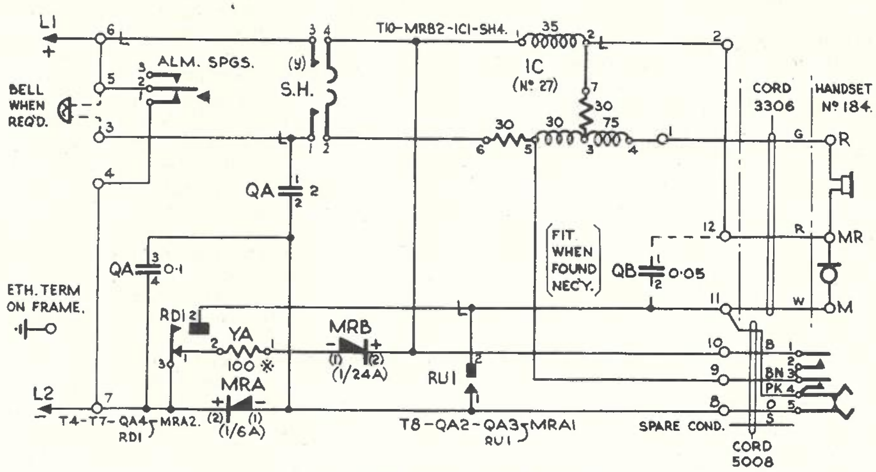


Fig. 6.—Local Call Type Public Telephone.

engine alternator sets, with control equipment which can be relied upon to start within a second or so of a mains failure, has allowed the size of batteries to be very greatly reduced. In fact the size of the exchange battery is now governed more by its ability to supply the peak current demand while the engine starts, than by any question of capacity to provide power for a long period of time.

The dry or semi-conductor rectifier is rarely given credit for the major part it has played in telephone engineering. Before the advent of this component, Australia, in common with the rest of the world, relied upon motor generators to convert the AC mains power to a DC supply for exchange batteries. Although low powered electronic rectifiers of the mercury vapour type were developed for battery charging, only small units of this type were used in Australia (31). The dry rectifier heralded a new era in exchange power plant design. First the small Westat and Transrector units were used to cover the off peak loads, but these were quickly followed by larger controlled power rectifiers which replaced, rather than supported, the rotary machines. Although there are a few machines left, modern Australian exchanges are now equipped with static individually controlled rectifier power supplies. The very close control over output voltage possible with this equipment makes it particularly suitable for continuous floating of the batteries.

The Department is now engaged on the development of integrated power suites (Fig. 9) for the larger exchanges. These suites will have one or more high capacity DC channels, which will be controlled by AC regulators on the input side of the rectifiers. It is hoped to publish more details of this new development in the near future.

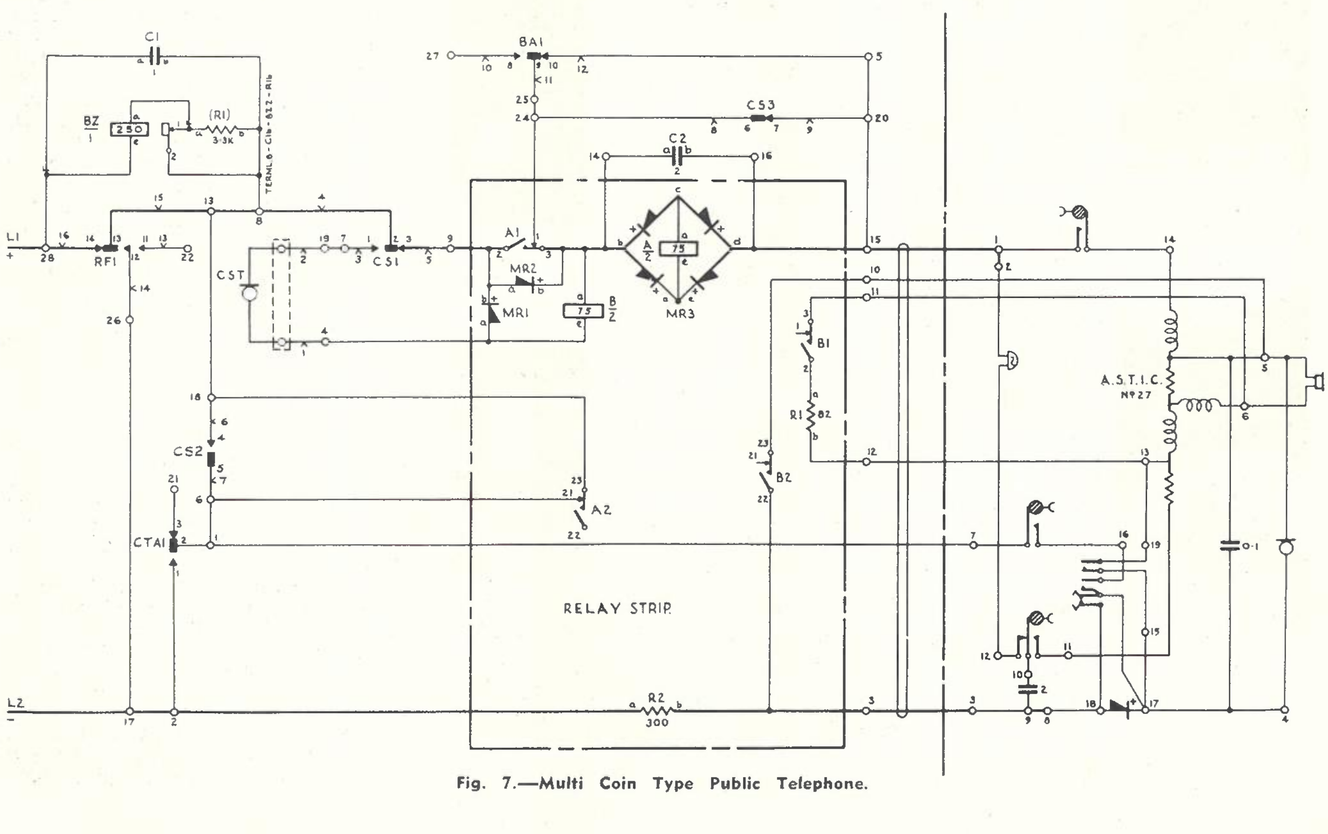


Fig. 7.—Multi Coin Type Public Telephone.

RAX Power Supply Arrangements

In areas where a commercial power supply is not available, special arrangements have to be made for charging the batteries. The number of RAX's in this category is being steadily reduced as the commercial supply reaches out into the more remote country areas of Australia. The following methods have been adopted to meet the power supply problem, and each has its field of application:

(a) Charging batteries over trunk lines from an exchange with power available.
(b) Replacement of batteries and recharging at a convenient station.
(c) Charging from petrol or diesel electric charging sets, manually or remotely controlled.
(d) Charging by wind driven generators.

The use of wind driven generators received considerable attention some years ago (32, 33) and the method is suitable in certain areas where there are reliable winds and no hurricanes.

Power for Subscribers' Equipment

For many years it was customary to provide DC power for switchboards and other small apparatus from the exchange central battery. This "power lead" technique ensured a reliable supply but frequently required the allocation of a comparatively large group of pairs to avoid excessive voltage drops on long or heavily loaded leads.

Appreciable savings have been effected by the use of small battery eliminators (unregulated) in sizes of 0.4, 0.75 and 1.5 Amp. where power leads were previously employed. These units were purchased with an auxiliary transformer winding providing 50 c/s. AC at 65V for bell ringing power. Experience showed that 50 c/s. ringing current was suitable only for more modern bells with light movements, and many of these required critical adjustment for operation on both 50 c/s. and 16 2/3rds c/s. under "night switched" conditions. Future purchases will incorporate a recently developed ringing converter supplying 25 c/s. or 16 2/3rds. c/s. AC on the 1.5 Amp. eliminators, and separate ringing convertors will be available for use with the smaller units.

Fig. 8.—Aluminium Public Telephone Cabinet.

INSTALLATION

General

The Department's policies relating to the installation of telephone switching and subscribers'. equipment are conditioned primarily by the basic concept that it is more economic and efficient to plan, engineer, and implement the capital works program with a staff under one control. Limited use is made of installation by contractors where this procedure is more economic.

Expenditure on capital works for subscribers' telephone services has increased from £2.44 million in 1938-39, to £40.1 million in 1962-63. This expenditure provided for a net increase of 22,000 services in 1938-39 and 93,600 in 1962-63. The gross connections of telephone services in 1962-63 exceeded 260,000. The program of switching and subscribers' equipment installation currently requires an expenditure of 4,000,000 manhours annually.

Exchange Equipment

The Department purchases supplies of telephone switching equipment in bulk, rather than in units for specified locations. Contract installation by manufacturers of switching equipment generally requires more rigid planning of installations and also the purchase of material in engineered blocks for particular exchanges. The bulk purchase method provides greater flexibility and facilitates changes to the program which are frequently required due to unavoidable delays between ordering material and delivery. The Department's installation staff carries out the final detailed design and planning of particular installations, prepares estimates of labour and material requirements, and secures approval for the expenditure required to complete the work. Material is drawn from Central Stores as required and installed in accordance with standard Departmental methods and practices.

For a number of years the Department has progressively increased labour productivity in the installation field, and the big increase in the volume of work necessary to provide telephone services has been achieved with a relatively small increase in the number of staff employed.

Normal wastage of staff is being replaced with staff recruited through the Technician-in-Training scheme, which provides for five years' training. This scheme caters for the requirements of staff for maintenance purposes as well as for installation, and also for other types of internal plant. Trainees are allocated to field work at the end of the first training year, and initially

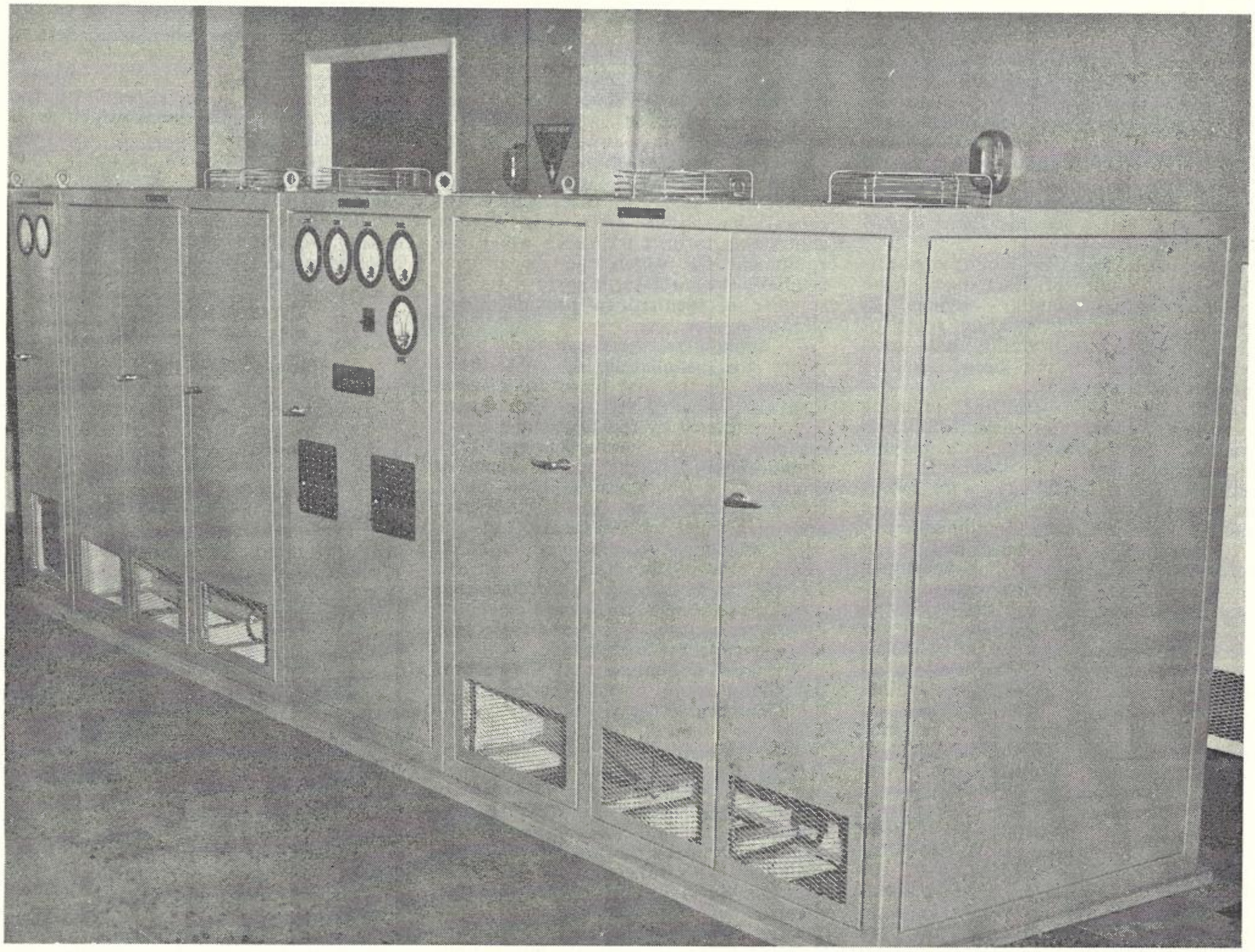


Fig. 9.—AC/DC Conversion Suite.

This consists of two automatically regulated 52 volt, 1,500 Amp. rectifiers with parallel operation facilities, and a 300 Amp. manually operated battery charging rectifier.

carry out installation work such as rack erection and assembly, cabling, wiring and terminating which do not require a high degree of skill. They are given work requiring a progressively higher degree of skill until they emerge as fully trained technicians at the end of the training period. Good supervision and leadership of installation staff is of paramount importance if high productivity and a good standard of work is to be attained, and Supervising Technicians are selected for qualities of initiative and leadership as well as technical competence.

The number of permanent positions for installation technicians is determined from the number of manhours required to install each item of plant and the works program for the year. Apart from providing a basis for the provision of the technical establishment, the "justified manhours" also provides a reference useful for the measurement of productivity in the installation field.

The grades of staff include in order of skill: Technicians-in-training, Technicians' Assistants, Technicians qualified from the training scheme, Senior Technicians who are Technicians further qualified by examination, and Supervising Technicians of varying grades who are promoted without further examination. Generally there is a Senior Technician for each group of four installers engaged on switching equipment installation and each group of seven installers engaged on subscribers' equipment installation. The grading of Supervising Technicians' positions is determined primarily by the degree of responsibility carried.

The Department has from time to time conducted trials to test the economics and efficiency of contractor installation of telephone switching equipment in public exchanges. Although trials are still being conducted, no change in the Department's basic policy of installing its own public exchanges is proposed.

For many years the standards of installation used by the Department were based directly on the methods and practices used by the BPO. During the past fifteen years the Department has tended to develop equipment quite independently of the BPO, and a corresponding development of local installation standards has been necessary. Standards are promulgated in the form of installation drawings, descriptions, engineering instructions, specifications, information booklets, and pamphlets for use by the Department's staff and contractor's installation staffs. In addition, a publication has been prepared for the information of architects and builders, to assist and encourage them to look upon the telephone as another service to be provided at the time of construction of the building. Convenient handbooks containing miscellaneous information useful in dealing with subscribers, and illustrating standard modes of connection of a wide range of subscribers' equipment facilities, are prepared and issued to Technicians.

The policy of engineering and installing exchanges with Departmental staff has had a profound effect on the Australian philosophy of exchange design. The early 2,000 type exchanges used full Intermediate Distributing Frames (IDF's) through which were taken all the exchange cabling. The selector gradings were carried out on separate racks, and because all the cabling had to pass through the central IDF, there was no point in closely associating racks of switches which were cabled together.

In locally engineered exchanges, the large centralised IDF has been replaced by local rack type IDF's. The decentralised subscribers' IDF on the back of the Final Selector rack has replaced the full subscribers' IDF; switches were first brought together on adjoining racks, and subsequently a composite uniselector/final selector rack was designed.

All these changes in design, engineering and layout of exchanges have resulted in substantial savings in material and labour. While some of the changes reduce flexibility, with good planning this has not been found a great disadvantage.

With the same aim of reducing installation costs, many new installation methods have been tried with varying degrees of success. In Queensland for example several exchanges were cabled at ground level (34) but the use of the method has not been continued.

Other changes in exchange installation engineering are now being developed and applied to the new crossbar installations. A trial installation of an exchange cabled in troughs has just been completed successfully. This method of cabling will be used in all future installations where the cabling density is low enough. Cabling on conventional type runways will continue to be used in new busy city exchanges where troughing is unsuitable. To reduce installation labour, cable runs will be glued instead of laced.

Since it costs less to have work done on the factory production line than by higher paid installation staff, the Department's aim is to have as much wiring and cabling as possible done before the equipment comes into the hands of the installer. However, recognising that even when this is done the installer still has a lot of cabling and terminating to do, the Department is constantly looking for methods and designs which will reduce the time taken to terminate cable. The special wiring tags and terminating methods developed by L M Ericsson for the latest design of their crossbar equipment are a significant advance in this direction (35).

A trial exchange with wire-wrapped connections has been placed in service to test the performance of the technique, which even though it may not save a lot of installation time, could reduce contacts due to solder splashes and dry joints.

Subscribers' Equipment

It is the Department's policy to provide, install and maintain all subscribers' telephone facilities with the exception of PABX's. The Department provides PABX's for Government and semi-Government authorities, but private PABX's are now installed by contract. Although PABX's installed by the Department and private contractors have until recently been of the step-by-step type, during the last twelve months a number of crossbar type PABX's have been approved for installation by private contractors, and already many of these are in service. In future the Department will also use this type for Government and semi-Government installations. In all installations performed by private contractors, the Department insists that the work should be done in accordance with its specifications which cover the performance standards as well as the quality of workmanship.

The Department maintains all PABX's; however, in cases where approval has been given for private contractors to install PABX's which use equipment for which the Department normally does not carry spare parts, the supplier is required to provide maintenance spares.

To summarise, there are three categories for installation of subscribers' services. In the first there are services that are provided by the Department and maintained by the Department, and are covered by a standard annual telephone rental. In the second category are PABX's which are sold or rented to subscribers by an outside contractor and maintained by the Department, for which an annual maintenance fee based on the size of the PABX is charged. In the third category are authorised attachments which are owned or rented by the subscribers who make their own arrangements for maintenance.

The local manufacture of subscribers' equipment during recent years has given the Department the opportunity to incorporate features which help the installer do his job more efficiently. It was decided recently to use plug and socket connections for all telephone instruments to reduce installation and maintenance time. Two springs of the jack are arranged to "make" when the plug is withdrawn, thus providing extreme flexibility in circuit arrangements.

Until recently it was the standard practice to fit all portable installations with a fixed bell set whether the subscriber required this facility or not. This was to guard against the possibility of all telephones being left unplugged. After tests on a number of services installed without fixed bell sets, it was concluded that this costly additional wiring and equipment was not necessary and all portable services are now installed without a fixed bell set unless one is specially requested by the subscriber.

To reduce travelling time and avoid delays in handling stores, the Department has adopted policies of decentralisation of subscribers' equipment installation work to depots (36). Similarly, a high degree of mobility of staff is given by appropriate provision of installation vehicles. Procedures and organisations are being constantly reviewed to meet changing conditions and to provide increasingly higher standards of service to subscribers.

The Department is now paying much more attention to the rationalisation of quality levels of the material received from suppliers with the quality level required for economic installation and service. For some items such as automatic exchange equipment which are very thoroughly tested before being placed in service it may be more economical to adopt higher permissible levels of defects than for subscribers' equipment. On the other hand, defects in telephone instruments which now receive a very limited test on installation can result in an expenditure for adjustment or replacement which is a very significant percentage of the purchase price. The view taken is that the optimum quality level for new equipment can be determined only by equating the marginal cost of increasing quality, with the resultant reduction in installation and maintenance costs.

MAINTENANCE

Exchange Equipment

Prior to 1957 the Department used preventive maintenance of exchange equipment. For example, twice daily, group selectors were checked for PG, and "Off-normal without conversation"; twice a week they were routine tested; every six months the mechanism was lubricated, the banks were cleaned, and the wipers were adjusted; and every year the mechanism was overhauled. Little or no attention was given in this system to checking end-to-end performance of plant, apart from taking telephone service observations of "live" traffic at subscribers' line circuits. Early in the 1950's, trials were conducted with a scheme for the centralised repair and overhaul of bimotional switches in the State Workshops. The idea was not pursued, primarily because the high cost involved was not commensurate with the improvement gained in plant performance.

In 1957, following a series of field trials in Sydney and Melbourne "Qualitative Maintenance" (37, 38, 39, 40) was introduced throughout Australia. It was realised at the time that a great deal of work would be necessary to successfully introduce the new maintenance concept. The original Engineering Instruction issued in 1957 did little more than define Qualitative Maintenance and the Indicators which might be used to apply it. Frequent routine testing of switches, and regular bank cleaning, switch lubrication, and wiper inspection, were retained and the main changes in procedure introduced at that time were:

(i) the abandonment of regular overhauls of switching mechanisms, and
(ii) the introduction of an individual switch history record to indicate when a mechanism needed overhaul.

A further series of field trials in "Total Qualitative Maintenance" was launched in 1957. This has culminated in the issue of new Engineering Instructions which give a comprehensive coverage of Qualitative Maintenance and the Indicators required to apply it. It is planned to have the new instructions fully effective within the next twelve months.

Realising that reliable Indicators for quality of service are necessary for total Qualitative Maintenance work, the Department has investigated and developed most of the Indicators which have been used in overseas countries. Local management is encouraged to use its initiative in determining the extent of application of the various approved Indicators, whilst Headquarters concentrates on the application of over-all performance Indicators to obtain a picture of the quality of service given by the various networks throughout Australia. Some of the Indicators being used at present are discussed briefly in the following paragraphs.

Telephone Service Observations: These are conducted by the Telecommunications Division to measure over-all network performance. They are also used to a limited extent to detect network trouble spots, but this technique is not relied upon solely. The telephone service observations which survey "live" traffic, appear to be the most important Indicator of over-all service performance from both the engineering and subscriber point of view. It is therefore proposed to increase the accuracy and range of application of telephone service observations. Improved observation equipment is being developed to give the operator a better cross-section of traffic. Sampling techniques are being revised so that the results obtained will be statistically more accurate and therefore comparisons more reliable. One of the problems of service observations is to obtain uniformity of assessment amongst the observers; this aspect is being given special attention.

Traffic Route Testing: Testing with artificial traffic generated by Traffic Route Testers, Artificial Traffic Equipment (41, 42) or Call Through Test Sets as they are sometimes called overseas, has been developed to produce a most effective Indicator for measuring end-to-end performance of traffic routes through the network. Not only does it reveal trouble spots and defects previously unlocated, but it also gives the Supervising Technician in charge of an exchange a convenient means of measuring service quality on any traffic route. The Department has developed a new 100 line Traffic Route Tester with provision for calling ten external test numbers; full details will be published in a latter issue of this *Journal*. A start will be made in the near future to equip all exchanges over 2,000 lines with these instruments and already many Traffic Route Testers with limited facilities are working in the various networks.

Subscribers' Requests for Assistance and Repair Service: The analysis of subscribers' requests for assistance has proved to be a useful tool for indicating trouble spots in the large automatic telephone networks (43). The analysis of technical assistance requests is centralised at one service co-ordination centre for each of the larger networks, and the metropolitan centre also handles the analysis of assistance requests from country networks, even though these may be located several hundred miles distant. Teleprinter links are used to relay the reports to the analysis centre.

Statistics of repair and technical assistance rates are a useful measure of subscribers' satisfaction, but as subscribers' complaining habits vary from place to place these statistics must be used with caution. It has been found that an increase in the number of complaints is a reliable indication of deterioration of service in a particular area, but the absence of complaints cannot be taken as an indication that service is satisfactory.

Investigations are being conducted to determine the desirability of using an electronic computer for the analysis of the above data.

Testing of Switches and Relay Sets: The Department does not favour purely routine testing of equipment unrelated to performance. It requires that all testing should be done in accordance with the real service needs of the plant. The frequency of testing must be constantly reviewed in the light of results from checks with the Traffic Routes Testers, service observations results, and other service Indicators.

Fault Recording: The fault recording system provides an individual switch history fault record, and at the same time permits the ready detection of fault patterns in an exchange. Each fault is recorded on a card, which is flagged with a metal signal to indicate the type of fault; these cards are filed in an open type filing cabinet which holds the fault dockets for the previous twelve months. Local management is encouraged to set its own targets for an acceptable fault incidence, based on conditions which have produced a satisfactory service performance.

Analysis of Dead-Level Traffic: Much useful information has been derived by monitoring and questioning subscribers who arrive on dead-levels. The information obtained by this analysis is a useful supplement to that obtained by service observations.

Sample Visual Inspections: When indicators point to a general source of trouble in a particular type of plant, sample visual inspections are made.

Centralised Supervision of the Telephone Network: An important feature in Qualitative Maintenance is the development of centralised analysis of all data which might assist in localising the source of trouble, such as subscribers' repair and technical assistance requests, Traffic Route Tester results, and service observation results. This information is analysed on a network basis at the Service Co-ordination Centre in each telephone network. There is a Service Co-ordination Centre in each capital city, and additional centres for the trunk network and provincial centres are proposed.

Network Performance: Telephone service observation results show that small Australian telephone networks have a call failure rate of between one and two per cent due to plant defects. In the larger networks such as Sydney and Melbourne, this call failure rate is higher at about three per cent. The improved maintenance techniques which have been applied during the last few years have resulted in a general improvement in all networks.

Subscribers' Equipment

Until about five years ago subscribers' complaints positions (service desks) were decentralised to the main exchanges and sometimes to the branch exchanges. Quite frequently subscribers' requests for repair service and technical assistance were received on test desks directly from the public. In some respects this procedure was advantageous because in general the test desk ultimately had to carry out the tests and control the corrective activities. In order to achieve greater efficiency and reduce the time taken to clear subscribers' faults, there has been a general move in recent years towards centralised handling of repair and assistance traffic. The number of service centres which will be established in each of the networks has not yet definitely been determined, but for a trial three or four centres will be established in the large networks. These centres pass on requests for technical assistance to the Service Co-ordination Centres for analysis of possible network defects, and the repair requests are passed to subscribers' equipment maintenance staff for attention.

In most areas subscribers' equipment maintenance staff are attached to, and directed from, the local telephone exchanges. In areas served by small exchanges, subscribers' equipment is maintained by staff from the nearest large exchange. Experiments are now being undertaken with a system of centralised despatch of subscribers' equipment faultmen. In Sydney it is planned to associate a despatch centre with each of the proposed service centres mentioned previously. This arrangement gives more efficient usage of staff and enables quicker attention to be given to "no-service" faults.

Testing of the subscriber line is now done at the local exchange, but the practicability of centralising testing at the despatch centres is being examined. The Department has noted that automatic test desks (Line Robots) are used extensively in other countries and some of these units have been purchased.

The bulk of repair work on subscriber's equipment is performed by the repair man at the subscriber's premises. However, if a faulty component has to be unsoldered or if the instrument needs reconditioning the complete instrument or the faulty sub-assembly is returned to the depot or workshop for repair. .

CONCLUSION

During the past ten years the Australian Telephone Network has almost doubled in size, the expenditure on automatic exchanges alone amounting to approximately £70,000,000. An even more remarkable change has been the transformation of the system from a large number of loosely interconnected local networks into a comprehensive nation-wide telephone network, using operator trunk dialling through transit switching centres. Adoption of the crossbar common control switching system will permit the conversion of the existing operator controlled trunk switching network into a nation-wide subscriber trunk dialling network. In another ten years the size of the system should not only redouble, but the provision of nation-wide dialling for all subscribers should also be well advanced.

Realising that the existing step-by-step equipment will remain in service for many more years, the Department has recently developed equipment which will provide for Subscriber Trunk Dialling from these exchanges.

With the firm establishment of local manufacture the Department has control over the design of the apparatus used in the telephone network. It is to be expected that, in future, subscribers' equipment will also be produced locally to meet the needs of the Australian telephone public.

The author wishes in conclusion to acknowledge the valuable assistance rendered by the members of the Headquarters Telephone Equipment Section in preparing this article. It is hoped that readers who require more detail will refer to the many excellent articles which have been published in previous issues of this *Journal.*

REFERENCES

Unless otherwise stated, all references are to articles published in the Telecommunication Journal of Australia.

1. R. M. J. Kerr, "The Early History of the Telephone in Victoria"; Vol. 13, No. 5, page 354.
2. L. Paddock, "The New Melbourne Trunk Exchange"; Vol. 3, No. 4, page 211.
3. A. W. McPherson and R. W. Turnbull, "C. B. Non-Multiple Switchboard—Combined 'A' and Trunk Position"; Vol. 8, No. 2, page 65.
4. J. S. Silvester and J. L. Harwood, "Manual C. B. Multiple Exchanges and Sleeve Control Trunk Switchboards. Part 3: Trunk Line Circuits"; Vol. 8, No. 6, page 336.
5. A. W. McPherson, "The Magneto Cordless Switchboard—Pyramid Type"; Vol. 6, No. 2, page 96.
6. D. S. Watson, "New Developments in Sleeve Control Switchboards"; Vol. 12, No. 2, page 104.
7. R. R. P. Nelder, "Development of the Standard A.P.O. 40-Line 'B' Type RAX"; Vol. 7, No. 5, page 270.
8. W. B. Wicking, "The Standard A.P.O. 50/200 Line RAX"; Vol. 6, No. 3, page 141.
9. W. A. Phillips, "The British Post Office Type 2,000 Line Finder System"; Vol. 1, No. 4, page 114.
10. W. R. Rose, "The Development of the S.E. 50 Selector"; Vol. 10, No. 4, page 97.
11. R. V. McKay, "Automatic Telephone Switching—Application of Recent Developments to the Commonwealth System"; Vol. 1, No. 3, page 92.
12. D. P. Bradley, "Overflow Trunking of Switching and Discriminating Selector Repeaters"; Vol. 9, No. 5, page 254.
13. N. A. S. Wood, "Automatic Switching Systems—The Key to Economic Telephone Networks"; Vol. 12, No. 1, page 7.
14. F. P. O'Grady, "Australian Post Office Adopts Crossbar Automatic Switching System"; Vol. 12, No. 1, page 6.
15. E. R. Banks, "Crossbar Switching Equipment for the Australian Telephone Network"; Vol. 13, No. 2, page 85.
16. T. T. Lowe, "A New Magneto Handset Wall Telephone, 233 M.W."; Vol. 2, No. 3, page 147.
17. T. T. Lowe, "The C.B. and Automatic Handset Wall Telephone—237 C.B.W. and 237 A.W."; Vol. 2, No. 5, page 308.
18. T. T. Lowe, "The 300 Type Handset Table Telephone"; Vol. 2, No. 2, page 57.
19. R. J. Kolbe, "The Type 801 Telephone"; Vol. 13, No. 6, page 434.
20. "The A.P.O. Telephone 801"; A.P.O. Telephone Equipment Information Bulletin No. 9.
21. J. Silvester, "Switchboard C.B. P.B.X.—Lamp Signalling Cord Type, 37-50 Volts"; Vol. 5, No. 2, page 108.
22. A. B. Wilson, "A C.B. Multiple P.B.X."; Vol. 12, No. 6, page 449.
23. A. R. Gourley, "Private Automatic Branch Exchange Equipment—Unit Type"; Vol. 2, No. 1, page 21.
24. A. R. Gourley, "Line Finder Equipment for P.A.B.X.'s, Types E and F"; Vol. 3, No. 1, page 36.
25. W. Adenstedt, "Crossbar Private Automatic Branch Exchanges (P.A.B.X.) for 10 and 16 Extensions"; Ericsson Review, Vol. 39, No. 1, page 19.
26. C. Cruttenden, "Multi-Coin Public Telephone Attachment"; Vol 2, No. 1, page 16.
27. A. R. Gourley, "Power Plant in Telephone Exchanges"; Vol. 1, No. 3, page 99.
28. L. L. Cross, "Features in the Supply of Power to Automatic Exchanges"; Vol. 3, No. 5, page 269.
29. E. J. Bulte and K. A. G. McKibbin, "Telecommunication Power Plant in Telephone Exchanges"; Vol. 9, No. 2, page 65.
30. R. C. M. Melgaard, "Developments in Power Plant for Telephone Exchanges"; Vol. 10, No. 5, page 139.
31. W. Gray, "Tungar Rectifiers for Battery Charging"; Vol. 2, No. 5, page 305.
32. H. Hawke, "Wind Driven Generators for Remote Repeater Stations"; Vol. 3, No. 2, page 81.
33. F. H. Morgan, "R.A.X. Installations"; Vol. 4, No. 6, page 334.
34. C. M. Lindsay, "Exchange Installation Methods, Queensland"; Vol. 9, No. 4, page 191.
35. N. D. Strachan, "Toowoomba Crossbar Exchange"; Vol. 12, No. 4, page 231.
36. M. J. Power, "Sub-Station Installation Management and Practices in Sydney Metropolitan Area"; Vol. 12, No. 6, page 451.
37. W. King, "Maintenance Problems in Automatic Networks"; Vol. 9, No. 1, page 28.
38. H. T. Wright, "Qualitative Maintenance"; Vol. 11, No. 2, page 41.
39. G. Moot, "Some Developments in Qualitative Maintenance"; Vol 12, No. 2, page 77.
40. W. A. Stirling, "Qualitative Maintenance in Manual Exchanges"; Vol. 12, No. 5, page 365.
41. W. R. Dedrick, "Artificial Traffic Equipment"; Vol. 9, No. 3, page 145.
42. J. B. Taylor and J. K. Petrie, "Generation of Artificial Traffic by Automatic Routiners"; Vol. 11, No. 6, page 175.
43. D. J. Omond, "An Introduction to the Analysis of Subscribers' Complaints"; Vol. 13, No. 6, page 446.

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*For addresses see page 165.

REVIEW OF LINE TRANSMISSION EQUIPMENT IN AUSTRALIA

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INTRODUCTION

Because of the long distances between major centres of population in Australia, carrier systems and other line transmission equipment have played an important part in the trunk line network for many years. This article gives a general historical review of the use of such equipment, outlines present practices, discusses some developments which have been originated in Australia, and endeavours to predict trends in the future.

HISTORY OF DEVELOPMENT

Use of Different Types of Systems

Before the middle 1920's, all trunk circuits were of open wire physical construction, using heavy gauge wires of up to 600 lb. per mile on the longer routes. Two-wire voice frequency repeaters were introduced on an experimental basis on the Sydney-Melbourne route in 1922. The Postmaster-General's Department watched closely the development of carrier systems in the United States of America, and the first open wire system, a Type B 3-channel telephone system of Western Electric manufacture, was installed between Sydney and Melbourne in 1925. This system was a transmitted carrier system. Similar systems were soon installed on other routes, and Type B telegraph systems and Type CF single-channel open wire telephone systems were also introduced. The Type B telephone system was superseded after a few years by the Western Electric C2 3-channel open-wire system with suppressed carrier transmission. The Type D single-channel system was introduced in 1929. From that time until the middle 1940's, the C, CF and D systems, or basically equivalent systems from manufacturers in the United Kingdom, were used to meet the main development of the long-distance trunk network. During this period provision of telephone circuits by open wire carrier became progressively more economical and the minimum distance between stations at which terminals were installed decreased from about 500 to about 100 miles. Although open wire telephone systems predominated, voice frequency telegraph systems were also introduced in 1935 and programme carrier systems in 1934 (1). Most physical open wire circuits longer than about 100 miles were equipped with two-wire voice frequency repeaters in the early 1930's. A coaxial type submarine cable system with carrier circuits was also provided between Victoria and Tasmania in 1935 (1).

The first 12-channel open wire carrier system, a Western Electric Type J1 system, was installed between Sydney and Melbourne in 1939 (2). Relatively little development with this type of system occurred for some years afterwards because of difficulties in obtaining supplies, but after the end of the Second World War, its use increased rapidly. At first the main application was to long distance circuits between the State capital cities, but the average distance per system has been reduced progressively as trunk traffic to provincial centres has increased. The longest single system (Melbourne to Perth) has a route distance of 2,584 miles. At present this type of system provides the greatest channel-mileage of any type of system in the carrier network, but new systems are being provided mainly to extend channels from broadband systems. With the introduction on a large scale of 12-channel open wire systems, the use of 3-channel systems has been restricted mainly to shorter distances. There has still been an appreciable increase in the use of 3-channel systems, but the rate of growth is decreasing at present, mainly due to the rapid general growth in circuit requirements which favours the use of higher capacity systems, the extended provision of cables, and the advent of rural carrier systems. Transistorised rural systems were introduced first in 1958, and their inbuilt compandors which minimise line re-transposition costs, together with the low capital, maintenance and power supply costs for the equipment itself, have made it possible to use them economically for distances down to about 10 miles.

Cable carrier systems operating on separate "go" and "return" carrier-type quad cables were introduced into Australia in 1942 (3). A number of such cables were installed in the period 1942-1951 from Sydney, Melbourne, Brisbane and Adelaide to provincial centres, and over distances from about 20 to 160 miles. Various types of systems with capacities of from 9 to 48 channels have been operated over these cables (4). During the past twelve years no new routes of this type have been established, and any development has been directed towards obtaining the maximum channel capacity from existing cables. Six-channel cable systems operating on single pair-type cables were introduced in 1947 (5) as an expedient to provide relief on established short-distance cable routes in metropolitan networks. These systems were designed in Australia by Communication Engineering Pty. Ltd. and represented the first major Australian effort in the design of a basically new type of system. In the succeeding years other systems designed overseas for a similar application were introduced in relatively small quantities on specific routes. These systems included the Western Electric Type N1 System (6, 7), the Philips STR 113 System (8) and the German Z12N System (8). As a result of experience, the latter system has proved to have the most general application, and almost all systems installed in the past five years for use on existing or new pair-type cables have been of the Z12N type.

Broadband systems, either of the radio or coaxial cable type, have been introduced relatively recently in Australia, as the traffic demand and economic considerations generally did not justify their use on most routes before about 1958. Their use is increasing very rapidly, both for long distance and short distance applications, and as indicated in another article in this issue (9), they will undoubtedly form the backbone of the Australian trunk network within a few years.

Apart from the trunk line network, a relatively large network of physical and carrier broadcast programme transmission lines (10) has been developed since the early 1930's to serve many commercial and national broadcasting stations located throughout Australia at almost every centre of any significant size. A similar network is being established at a fairly rapid rate for television relay purposes (11, 12). Since about 1955, the provision of voice frequency cables for trunk line purposes has also been increasing significantly and there has been a corresponding increase in the provision of repeater equipment, both of the four-wire and negative impedance types.

Growth in Quantities

The general growth in the use of carrier and physical trunk circuits in the Australian network is shown in Fig. 1. Figs. 2 and 3 illustrate the growth in channels and channel-mileage for each main type of carrier telephone system. The quantities in Figs. 2 and 3 include

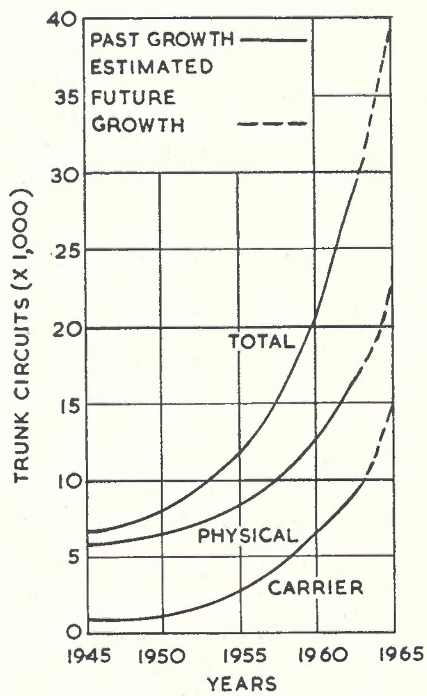


Fig. 1.—Growth of Trunk Telephone Circuits. Includes all inter-exchange circuits over five miles radial distance except those in capital city networks.

* See page 168.

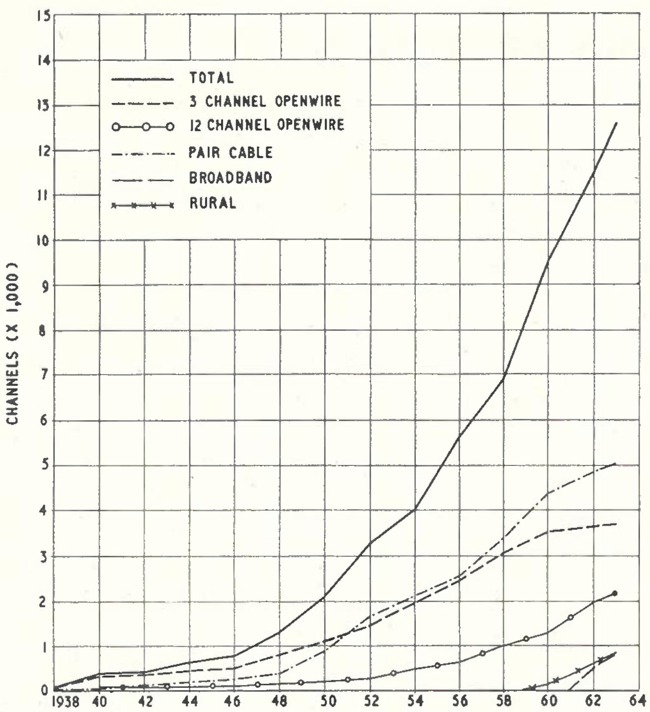


Fig. 2.—Growth of Carrier Telephone Channels.

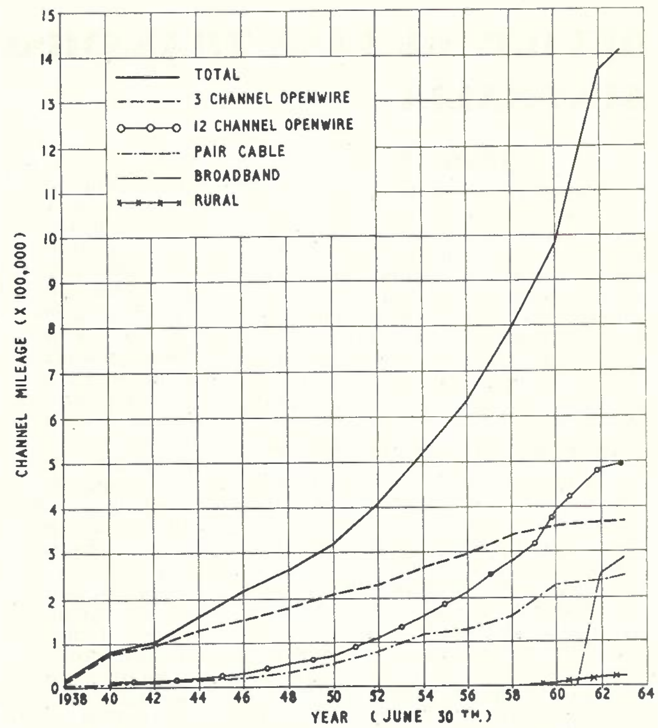


Fig. 3.—Growth of Carrier Telephone Channel-mileage.

systems used in the junction networks as well as the trunk network, and include facilities provided for leased services and voice frequency telegraph bearers, etc. Several carrier channels are also connected together in many instances to form a complete trunk circuit. For these reasons, the total of the carrier channels in Fig. 2 does not coincide with the total carrier trunk circuits shown in Fig. 1.

It may also be of interest to note that the provision of circuits has for many years been well behind the requirement justified by the traffic offering. This is due to difficulties in obtaining adequate capital funds which is a situation which exists in almost every public utility in Australia, and results from the large rate of development in relation to the nation's resources. As far as carrier telephone equipment is concerned, both channel and channel-mileage provision have been doubling at about every 6 to 7 years, but at present only about 65% of the immediate requirements have actually been provided. With the introduction of subscriber dialling, it has already been necessary to overtake arrears on a number of routes and as subscriber dialling extends the grade of service given will improve.

The voice frequency telegraph network has also grown considerably since the early 1930's, and at present 3,400 one-way channels are provided, representing a one-way channel-mileage of about 1,475,000.

EQUIPMENT SUPPLY ARRANGEMENTS

General

Before the Second World War, all line transmission equipment was purchased from abroad, mainly from the U.S.A. and the United Kingdom. During the war it was possible to obtain supplies only from the U.S.A., and the quantities obtainable from that country were restricted. Manufacture in Australia was commenced in 1941/42 by two companies and by a third company in 1945 and the Department also designed and manufactured some systems during the war period. Three other companies have commenced manufacture in the last five years while one of the original companies has ceased operations in the same period. Since the war, approximately 75-80% of all requirements have been produced in Australia, the percentage varying slightly from year to year. The items obtained from overseas have been mainly new types of systems which have been made locally at a later stage after experience has been obtained with their operation in the field.

Local Manufacturers

All local companies have overseas affiliates, and obtain basic design and manufacturing information from them. However a considerable proportion of the design work on some types of systems, particularly open wire systems and systems for the special carrier-type quad cables, has been carried out in Australia. Most companies have commenced by manufacturing almost completely to overseas designs, but have established design organisations shortly afterwards to meet performance and other requirements which are peculiar to Australia.

The local manufacturers tend to specialise in certain types of systems, and no company produces all types of systems used in the Australian network. It is generally arranged, however, that any type of system can be obtained from at least two manufacturers.

Competitive Tender System

The suppliers to the Postmaster-General's Department of any particular type of system are decided from tenders submitted by manufacturers, both in Australia and abroad. All suppliers must agree to meet the conditions of detailed specifications which cover performance requirements, reliability and any other conditions necessary, for example to ensure the proper operation of the equipment over a period of about 25 years. Delivery, general quality, and other factors which cannot be specified exactly are taken into account as well as price in the selection of tenders. Tenders for any particular type of system are invited usually at about 3-yearly intervals, and sufficiently far in advance of requirements to permit contracts to be placed about one to two years before delivery is to commence. Where possible, supplies are obtained in bulk quantities of individual items rather than as complete systems.

To ensure the quality of the equipment, most new types of equipment from any supplier are obtained firstly in small quantities only, and are subjected to laboratory and field investigations before further bulk purchases are made.

Apart from ensuring a minimum cost, the competitive tender system has the general advantage that it enables new developments to be introduced from overseas at a fairly early stage, and generally keeps the Department informed reasonably well on technical progress overseas. This is very important in a country with a relatively small population which cannot produce nor afford the number of engineers necessary to compete with larger countries on development and design work. It also enables the basic new designs which best meet Australian needs to be selected from a number of countries, rather than to rely on a few sources.

GENERAL TECHNICAL STANDARDS

The general technical standards for line transmission equipment used in Australia have evolved gradually since 1925 from the standards used by the suppliers of new types of equipment and from Australian experience with the equipment. Thus the standards originally followed the American Bell System practices very closely. American standards were for example used for broadcast programme transmission, leading among other things to the use of the "volume unit" for the measurement of programme level. American type trunk test boards and test jacks were introduced, American group levels and impedances were adopted as standard with the first 12-channel systems, and battery power plants giving 24 and 130 volt supplies were established at all carrier centres. The technical specifications for most of the earlier carrier systems also leant heavily on the performance obtainable with American equipment, and measuring techniques were dictated by the general availability of American types of testing instruments. As local manufacture was introduced, additional technical requirements found to be desirable from Australian experience were incorporated in the equipment. This type of requirement often arises from the need to co-ordinate with other types of plant, for example exchange or line plant, for which practices may differ in Australia to those of the country of origin of the transmission equipment.

By the early 1950's, a system of technical specifications had been developed which had little relationship to that used in any other country but which nevertheless was practical and ensured reasonably good quality equipment of the types used in Australia. At that time C.C.I.T.T. (then C.C.I.F.) specifications had not been developed to their present stage. Since then the trend has been to change to C.C.I.T.T. standards where these are appropriate and to supplement them by additional requirements where these are shown to be necessary by local experience, or where better performance is desirable and can be obtained at relatively little extra cost. Examples of the types of general performance specifications and the reasons for them are given in Reference 13 which relates to the Sydney-Melbourne coaxial cable equipment. In addition many other detailed standards have developed, mainly as a result of the method by which equipment is purchased. These have evolved largely from the need to have tests which can detect possible design weaknesses after equipment is designed, rather than to take care of weaknesses by the joint design of the equipment with the manufacturers in the first place.

Needless to say, care is taken to ensure that specifications are not unduly restrictive, and that complete freedom is given to manufacturers to design their equipment for minimum cost wherever this is practicable. The whole objective is to obtain systems with adequate performance and reliability and with minimum annual charges.

BASIC EQUIPMENT TYPES USED IN AUSTRALIA

General

Although many types of systems have been developed throughout the years in overseas countries, and each could probably find an economic application on some particular route in Australia with its wide geographic conditions and variations in population density, it is essential to restrict the number of types used to a minimum. This is because each type used requires considerable engineering effort to ensure the suitability of the design and to establish planning, installation and maintenance methods, and this effort is not justified unless the type will be used in sufficient quantities. The problem is aggravated by the general unavailability of engineering staff compared with standards applying in more populous countries, and also by the geographic and population distribution conditions mentioned previously which tend to increase the number of types usable. Before any new basic type is introduced, therefore, there must be a fairly wide economic use for it, and an appreciable saving in money must be possible by its introduction. This type of consideration led to the deferment in the introduction of coaxial cables, and currently is delaying the introduction of small diameter coaxial cable systems. It has resulted in the "standard" types of system being restricted to those described in the following paragraphs.

Open Wire Carrier Telephone Systems

3-Channel: After a period when systems using the Bell System CS and CU frequencies were the Australian standard, a new design was introduced in 1955. The line frequencies used in a typical system are shown in Fig. 4. The frequency spacing between channels in the same direction is 3.6 kc/s, and as outband signalling facilities using a virtual frequency of 3.425 kc/s per channel are incorporated in the systems, the highest channel frequency effectively transmitted is 3.1 kc/s. It was not possible to use the desirable frequency spacing of 4 kc/s between channels as there is an interference problem in Australia between the lowest frequency channel and 5 kc/s voice frequency programme circuits which are often operated on the same routes as 3-channel systems, and as the highest frequencies which can be transmitted are limited to 31 kc/s by the type of line filter which is commonly used for 12-channel open wire systems. The restriction in channel bandwidth is not serious as 3-channel systems are now used mainly in the end links in the trunk network, and connections with more than two channels of this type in tandem are seldom encountered. Outband signalling is the most economical form of line signalling and is a standard facility on all types of carrier systems which are now being provided in Australia. Automatic gain regulating equipment is provided on all systems even though the maximum distances covered by systems are now relatively short and seldom exceed 100 miles.

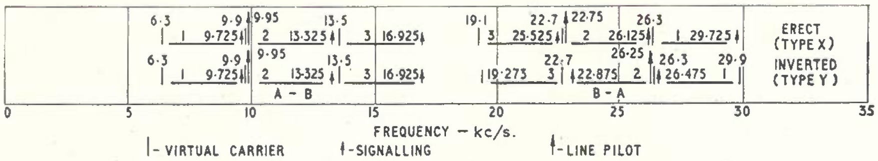


Fig. 4.—Line Frequencies for Typical 3-channel Open Wire Carrier Telephone System.

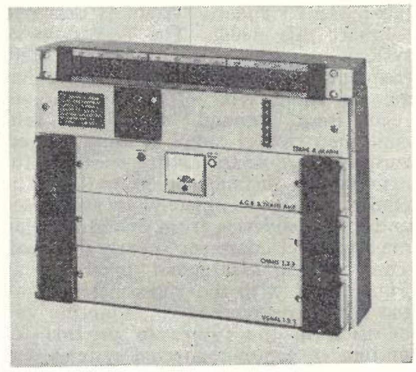


Fig. 5.—3-channel Open Wire Carrier Telephone Terminal.

The systems at present being provided are completely transistorised and supplies are obtained from one United Kingdom and two Australian manufacturers. A typical terminal is shown in Fig. 5. Each terminal is mounted on sub-frames which are attachable to an old-type rack of dimensions 10 ft. 6 ins. by $20\frac{1}{4}$ ins., this arrangement giving the greatest flexibility in established offices. It is expected that further details of the design of a typical system will be given in an article in the next issue of the *Journal*.

12-Channel: Until recently most systems provided in Australia followed the general design of the Bell System J2 system and used line frequencies and electromechanical type automatic gain regulation which were identical to the American system (14). However, with the recent expansion in the use of broadband coaxial cable and radio systems on the longer distance routes and the dismantling of many of the older open wire routes, the earlier type of 12-channel system is being recovered in appreciable quantities, and all expansion on other long-distance routes will be able to be met by the use of recovered systems. At the same time there is a relatively large and continuing requirement for shorter-distance systems, including systems to extend circuits from the broadband routes, and the present standard system is designed to meet this need. The new type of system uses the same line levels and frequencies as the older type, but has an electronic type of automatic gain regulation, outband signalling, self-contained carrier supplies and the performance requirements are specified for a maximum distance of 300 miles. The equipment is completely transistorised and bulk deliveries from one Australian manufacturer commenced early this year. The terminal equipment is shown in Fig. 6. As with the 3-channel systems, the sub-frame method of mounting will be used in the future to provide for options of group-connected systems, etc. It is expected that a more detailed description of the design will also be given in the next issue of this *Journal.*

Rural: A rural carrier system with up to 10 channels and using frequencies of between 4 and 172 kc/s, with either a stackable or grouped line frequency allocation, has been in use in Australia since early in 1958, and has a fairly wide general application on open wire routes over distances of from about 10 to 30 miles. The original system followed closely the design adopted by the South African Post Office (15) which suits Australian conditions very well. Double sideband transmission is used with carriers transmitted and used also for signalling purposes and for individual channel gain regulation. As compandors are an integral part of the design, the use of the system is restricted to the end links of the trunk network (terminal exchanges to higher order switching centres) or for subscribers' lines, although there has been little application so far for the latter purpose. The system is completely transistorised and supplies have been obtained mainly from one Australian manufacturer. A complete redesign of the original system is nearing completion, the objectives being to simplify the circuitry, provide an optional 83 c/s signalling channel and to improve the performance, particularly in respect to the distortion introduced by the compandors. The 83 c/s signalling facility is required in addition to the transmitted carrier to enable multi-metering signals to be transmitted during conversation. The improvement in distortion is necessary as a result of the more severe requirements imposed by the multi-frequency code signalling system which will be used to transmit information between registers in the new crossbar switching system (16). The latest supplies of this equipment are again mounted on sub-frames for flexibility reasons.

Pair-cable Carrier Telephone Systems

As indicated previously, the system standardised for general use is identical in main design features to the German Z12N system, and other types are used only in small quantities for additions to the special carrier type cables installed up to the early 1950's. The standard system has line frequencies of 6-54 and 60-108 kc/s for two directions of transmission on one cable pair, and includes frequency-frogging at repeaters to avoid interaction crosstalk problems when used on cables also carrying voice-frequency circuits. A description of the system is given in Reference 8. Equipment delivered during the past two years has been completely transistorised,

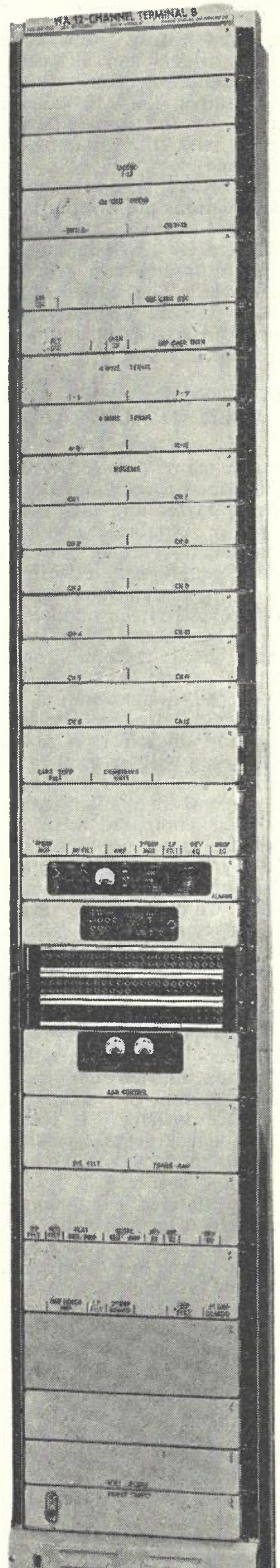


Fig. 6.—Transistorised 12-channel Open Wire Carrier Telephone Terminal.

and low level signalling using a level of −18 dbm0, which is now the general standard level for all types of systems, has also been introduced. Supplies are now being obtained from two Australian manufacturers as well as West German companies. The systems are used mainly over distances of from about 10 miles to about 40 miles. Repeaters buried in cases similar to loading coil cases, and power-fed over the cable pairs, will be installed at trial locations during the next two years.

Broadband Carrier Telephone Systems

The system which has been adopted for general use on coaxial cables is the 6 Mc/s system, providing up to 1,260 channels on one pair of coaxial tubes. This particular type of system was chosen as the line equipment is suitable also for television transmission to the Australian standards, and the telephone channel capacity is adequate for most routes. Further details of the reasons for the choice, together with detailed descriptions of systems from two overseas manufacturers, have been given in recent articles in this *Journal* (13, 17 18). Channel deriving equipment for broadband radio systems uses the appropriate components of coaxial cable terminal equipment, and equipment for both types of broadband bearer is provided in most centres as a common installation.

All channel modulator equipment which has been installed so far is fully transistorised, and after the initial installations on the Sydney-Melbourne and Melbourne-Morwell routes, all such equipment has been supplied by local manufacturers. The manufacture in Australia of other items of broadband carrier equipment is being introduced progressively, but it will be a number of years before the local manufacture of all items will be justified. In the meantime, supplies of line, supergroup, and carrier supply equipment are being obtained from manufacturers in West Germany, the United Kingdom, and Japan. Arrangements are being made at present to improve the stability of supergroup carrier supplies to 1 part in 10^8 to ensure adequate performance with the relatively large numbers of modulations at supergroup frequencies which will be encountered from one end of the Australian network to the other. Future group pilot frequencies are also being changed to 104.08 kc/s to avoid problems which will arise with the extended use of data transmission. Preliminary arrangements are also being made for the introduction of 12 Mc/s operation on the Melbourne-Dandenong section of the Melbourne-Morwell cable as extension to this capacity will be necessary within a few years.

Television Line Transmission Equipment

Vestigial sideband television equipment using a carrier frequency of 1.056 Mc/s has already been provided on the Sydney-Melbourne coaxial cable route (19), and will be provided on the Perth-Bunbury and Wagga-Griffith cables within the next two years. The terminal equipment has been obtained from one manufacturer in the Netherlands. Further major extensions in the use of this equipment may not be likely as the trend is towards the use of radio systems for longer distance routes on which television transmission facilities are required.

For shorter distance routes in metropolitan networks and for extensions between radio link terminal and television transmitter buildings in country areas, direct video transmission on coaxial cables (11) is the standard facility. Equipment for this application is of Japanese design and manufacture.

Voice Frequency Telegraph Systems

Supplies of voice frequency telegraph systems have been obtained mainly from the United Kingdom. The only type of system being installed at present is a 24-channel system using 120 c/s spacing. This system uses frequency modulation and the equipment is completely transistorised.

Voice Frequency Telephone Transmission Equipment

Under this category are included many different items of repeater equipment, channel terminating equipment, test boards, etc. In general such equipment has been designed and manufactured in Australia for many years and the current versions are transistorised. Echo-suppressors have not been used so far in Australia, but they will be required in the future on all circuits from Perth and Darwin to the other State capital cities. Trial installations of two types are in hand for the purpose of determining the standard type of equipment to be used. Special mention may perhaps also be made of negative-impedance repeaters. Requirements for this type of repeater are increasing fairly rapidly but the usage will not even approach the present extent in North America until improvements are required to the local network transmission losses. Following trials of several different types from various countries, the type mainly used during the past few years has been a fixed network type based on a United Kingdom design. There have been some difficulties in meeting return loss requirements with the fixed network type in the case of circuits which will be switched to the trunk network, and consideration is being given to the use in such cases of a variable network type, for example one similar to the Western Electric E6 repeater.

STANDARDISATION OF EQUIPMENT DESIGN

General

In view of the diversity of the basic types of systems used and the options necessary with each type, the numbers of different sources of supply for each type, and the frequency at which re-designs of each type are desirable as a result of technical developments, the question of the degree to which standardisation is desirable is very important and has been kept under review for many years. The degree to which standardisation is possible ranges from complete standardisation in which one design is produced (either by the operating Administration or by a contractor) and all manufacturers are required to produce identical versions, to the opposite extreme where any manufacturer can supply anything he thinks will suit the customer. Intermediate stages include standardising sizes of racks, test jacks, levels, complete mechanical construction, sizes of panels or sub-units, screw threads, control positions, types of components used, individual circuits, the finish of the equipment, types of wire, etc., or various combinations of these.

Factors leading towards a high degree of standardisation are savings in maintenance costs and staff training, some savings in installation costs and in the value of stocks of spare parts held. Also if a perfect design could be produced for an item of equipment, there would be considerable overall savings in design effort if identical items could be produced by all manufacturers. Against standardisation are practical difficulties in the different parties concerned reaching agreement on designs, which would tend to delay their introduction, difficulties in certain manufacturers obtaining supplies of components made by their competitors, the need for some manufacturers to retool while others would not, questions of patent rights and royalties, and perhaps most important, the removal to a large extent of the element of competition and technical responsibility by manufacturers. Needless to say, under any system of manufacture, difficulties in design and production are passed on ultimately as increased costs to the user. The further the degree to which standardisation is taken, the greater the tendency will also be to delay redesigns or introduction of new types of equipment due to the greater inertia in the system, and to stifle initiative by designers. If the original designs are not perfect, the longer will the difficulties persist.

As far as equipment maintenance costs are concerned, they can be subdivided into routine tests and adjustments, preventative maintenance measures such as cleaning and vibration testing, and actual repairs after faults have occurred. Providing systems are reasonably similar in respect of levels and impedances, etc., at test points, and the maintenance staff have a reasonable basic knowledge of their operation, it is only the repair work component which is affected by detailed differences in design and circuitry. The extent to which this affects maintenance costs is also influenced by reliability (it would not be a factor if faults did not occur), by practices in having repairs made to equipment by specialist staff at central depots, and also by the extent to which different types are mixed at individual stations or on individual routes.

In Australia, experience with line transmission equipment has shown that the maintenance difficulties due to lack of complete standardisation are not significant compared with the general advantages of competition, and of speed and flexibility in introducing new designs, all of which are reflected in capital cost savings. Certain restrictive measures of course have to be taken, and the general practice on individual cable or broadband routes is to use systems of only one type and produced by only one manufacturer. In open wire stations and other large stations where a multiplicity of system types and designs is unavoidable, and would exist due to improvements in design over the years in any case, the problems are reduced to a minimum by standardisation of testing procedures, access

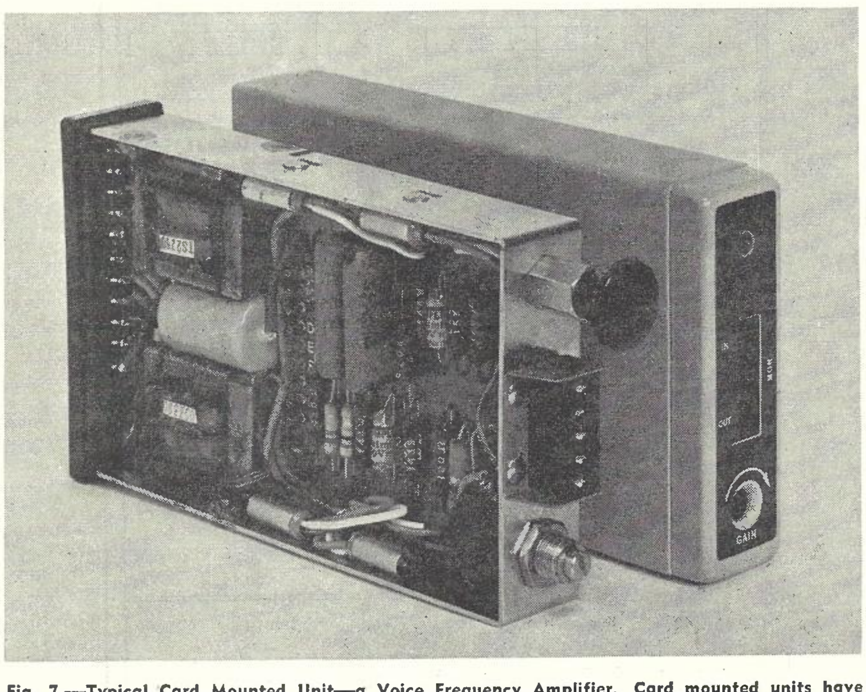


Fig. 7.—Typical Card Mounted Unit—a Voice Frequency Amplifier. Card mounted units have all components mounted on one side of the card, all wiring (either printed, stitched or normal insulated wiring) on the other side, and plug into main sub-units or shelves.

jacks, levels, etc. At open wire stations, also, much of the maintenance effort is devoted to line fault testing, setting up programme transmissions, patching after route failures, etc., and equipment fault repairs play a minor part, particularly with modern reliable equipment.

Mechanical Construction

Until the early 1950's, the mechanical construction of line transmission equipment used by the Department was of a reasonably standard form, almost all equipment being mounted on 10 ft. 6 in. by $20\frac{1}{4}$ or $20\frac{1}{2}$ in. rack frameworks with 3 x $1\frac{1}{2}$ in. channel section vertical members; these were based on the original Bell System designs which had also been adopted by most other countries. Panel dimensions and mounting positions, etc., were similar for most manufacturers and installations presented a reasonably uniform appearance and could be extended readily without rearrangement. There were problems in odd cases, for example due to the wider frameworks introduced with American Type J and K systems, 8 ft. 6 in. racks which were obtained at times when supplies of 10 ft. 6 in. racks were impossible to obtain, and differences in colours.

With the advent of increasing miniaturisation, differences in mechanical designs tended to increase, but fortunately the original rack dimensions were retained in most cases. Nevertheless the designs of panels, sub-units, connectors and test-jacks tended to become more and more diverse between manufacturers in different countries, and even between individual manufacturers in the same country. In Australia, it was not possible to introduce a single standard at that stage, even for equipment manufactured locally, as most manufacturers were dependent on overseas associates for the supply or the detailed design of some components such as filters, and these could not be mounted on panels or sub-units designed by other manufacturers. Most of the new designs were also associated with new types of systems which had to be introduced quickly to meet pressing requirements. A further complication occurred with the introduction of systems of German design which had rack dimensions which were different from those of other designs. This led to the segregation of equipment into different areas, for example on the Sydney-Melbourne route, and further information on this is given in Reference 13. As a result, there are at present two basically different types of installations in Australia, namely offices established with equipment of German origin (Type A) or of other types (Type B).

More recent developments in miniaturisation are tending to reverse this process, as all new designs introduced in the next five years in all countries will almost certainly be mounted on individual cards, the general arrangement being shown in Fig. 7. With this in mind, new general standards of mechanical construction have been introduced recently. Future designs of channel modulator and certain other types of equipment from any manufacturer are required to mount on racksides of either Type A or Type B dimensions (8 ft. 9 in. x 23.8 in. x 8.9 in. and 10 ft. 6 in. x 20.5 in. x 8.9 in. respectively) for extensions as required in existing installations of either type. Most manufacturers will produce a single design of plug-in card units and mounting shelves which can be mounted in either type of rack framework as required. All test jacks have also been standardised. Details and dimensions of component mounting cards and shelves, etc., and the type of plug-in connector to be used, have not been specified completely as it is not considered that standardisation to this degree is justified, but approval by the Department of the types used by any manufacturer will be necessary.

For open wire equipment for which greater flexibility is necessary for additions to established installations, units will be supplied on sub-frames which can be attached to old type racks. This will permit maximum utilisation of rack space in established offices, and the use of racks of reduced height or wall mounting in some very small offices.

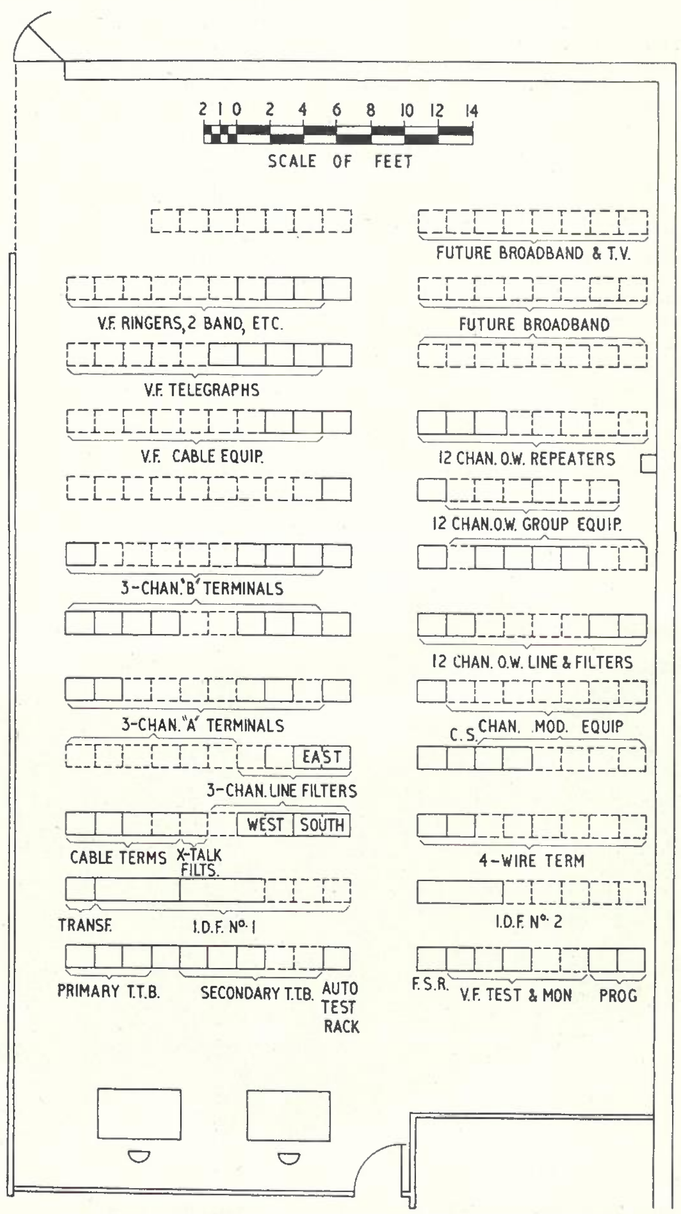


Fig. 8.—Layout of Line Transmission Equipment Installation at Toowoomba, Queensland.

GENERAL OFFICE PRACTICES

The layout of offices for broadband equipment has been described generally in Reference 13, and the layout for a typical open wire office at a country provincial centre can be seen from Figs. 8 and 9. The layouts are arranged for the grouping together of functionally similar equipment for reasons of flexibility to meet growth which cannot be predicted accurately, and to facilitate maintenance operations such as line testing, patching, etc. The standard channel terminating arrangements and levels were also described in Reference 13.

Channel and line testing facilities vary with different types of installations. In open wire offices (except the very smallest), three different types of test boards are used:

(i) Physical line ("primary") test boards on which all lines entering an office are terminated after passing through line filters. These boards are used for line testing and fault location. The appearances of lines on the boards are arranged in the order of pole routes and wires on each pole route.

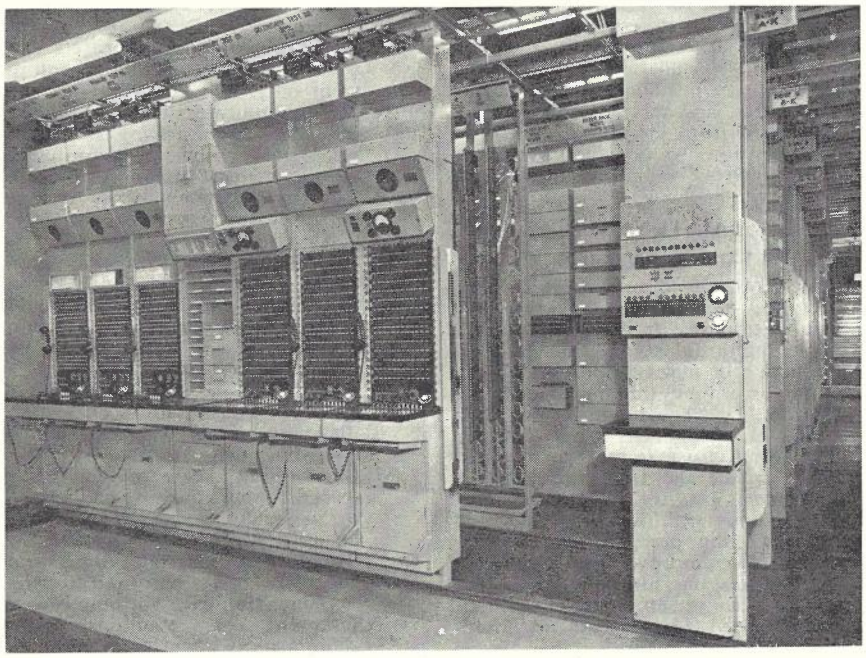
(ii) Derived channel ("secondary") test boards on which all circuits passing to the exchange are terminated. These are used for preliminary testing when faults are reported, and also for routine checks of the performance of channels. Appearances are arranged in the order of termination at the exchange.

(iii) "V.F. test and mon." four-wire test boards on which all modulator input and demodulator output circuits appear at relative levels of −13 and +4 db respectively. These are used for the patching of circuits between systems, patching voice telegraph systems or setting up picturegram and other special services, and the accurate check of channel losses and line-up of systems. Appearances are arranged in system order.

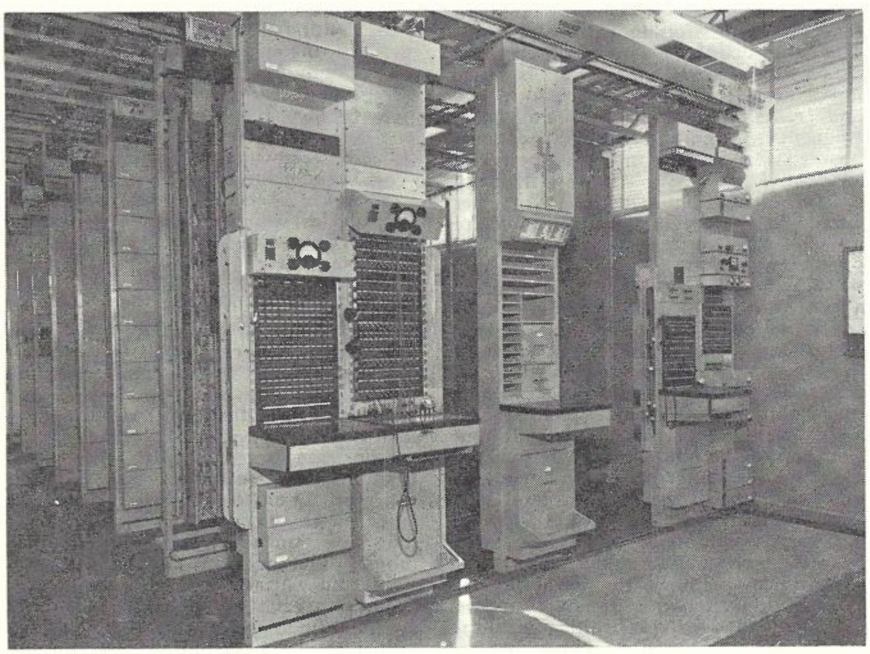
In broadband and shorter distance pair cable offices where there are relatively large concentrations of circuits, and patching of channels between routes is not required, and for other very short distance systems (for example rural carrier), the "V.F. test and mon." boards are not provided. Test access at the four-wire points is obtained by a central test jackfield on the channel modulator racks in the case of broadband systems and a similar jackfield on the cable systems. The general arrangement in this case follows the German practice.

Derived channel test boards are not used on very short distance routes on which subscriber trunk dialling is in operation (and fault dockets are not prepared by telephonists). The access for testing purposes is obtained in these cases from the signalling relay sets. Equipment to provide automatic access for channel testing is being provided at a large semi-automatic trunk exchange in Sydney to replace this type of board. Automatic routiners will also be used for channel testing on major routes associated with A.R.M. crossbar trunk exchanges in the future. Derived channel test boards will not be required in these cases.

The test jacks used in the test boards are a locally made version of the Western Electric type 482A twin contact jack. Ironwork, cabling and other miscellaneous facilities at Type A installations follow German practices very closely and have been described for example in Reference 18. For Type B installations, the ironwork is a modification of the system used for British 2000 type telephone exchanges. Various separate ducts are provided for cabling to minimise noise and crosstalk. Entrance cables of open wire routes are terminated with protection on racks in the main installations. Line filters are concentrated on special racks with central jackfields to facilitate patching of systems. Distributing frames are used at supergroup and group points in broadband systems, and at all points where voice frequency cabling is run between different racks, in order to add flexibility to installations and cater for future rearrangements. 17 db pads required for the permanent extension of channels from one system to another are mounted directly on the appropriate distribution frame.



(a)



(b)

Fig. 9.—Photographs of Toowoomba Installation showing Test Board Row—(a) left-hand side and (b) right-hand side.

POWER PLANT

The first carrier systems required power plants with nominal voltages of 24 and 130 volts. Battery power plants to provide these voltages were installed at many centres, and were developed to a very high degree of reliability. Duplicate batteries were generally provided and floated in parallel from rectifier units. Except in very small stations, standby diesel alternator sets were also provided and the battery reserve reduced to a minimum of three hours. This type of plant has been the standard until the recent introduction of transistorised equipment, and is still available at most centres. At stations without commercial mains supplies, duplicate batteries operated on a manually controlled charge/discharge basis from engine-generator sets were the original means of obtaining power. The Western Electric 420 B power plant, which is an automatically controlled charge/discharge system (20), was introduced in the early 1940's, but since 1955 the British Austinlite double-engine type no-break set, backed by a separate diesel alternator set, has been the plant used. Wind driven generators were installed at a number of stations in remote areas to assist the engine sets, but have not proved to be very effective.

For very small stations with valve type equipment and 48 volt exchange batteries, a special power plant was introduced during the middle 1950's. The transmission equipment would normally be supplied directly from commercial A.C. mains through a regulator and power pack, but on mains failure would change over, with a slight break, to an A.C. supply obtained from the exchange batteries through a dynamotor or a static inverter.

When the introduction of broadband systems first appeared to be necessary, no-break plants of different types were obtained on a trial basis, and used for supplies to A.C. operated pair-cable systems. Experience gained in the middle 1950's with these trial plants led to the adoption as standard for broadband installations of the three-machine battery type no-break set (21). The three machine set is now giving way to the two-machine battery set and trials are also being made of static plants.

For transistorised equipment, the reliable, simple battery type of plant is the standard facility except at the few centres which have no-break supplies of adequate capacity but no battery supplies. Stations already established with 24 volt plants present no difficulties as all transistor equipment is designed basically for operation from 24 volt supplies. At new stations, new 24 volt battery plants will be provided if the load is large, but at smaller stations the equipment will be operated from 48 volt exchange supplies, either through regulated D.C./D.C. converters or through dropping resistors incorporated in the transmission equipment.

INSTALLATION OF EQUIPMENT

The Postmaster-General's Department has always installed its own line transmission equipment, the only notable exception being the Sydney-Melbourne cable which was installed by private contract (22). The practice arose in the first instance as the overseas suppliers of equipment had no installation staffs in Australia and sending staff from overseas was very costly, and the Department was moreover anxious to learn as much as possible about the new equipment. In later years, the practice was supported by the scattered nature of installations throughout Australia and the random intervals at which extensions were made, both of which would make it difficult for individual contractors to organise a planned programme of continuous work. The possibility of contract installation is kept in mind, however, and was the most economical arrangement in the case of the Sydney-Melbourne project where a number of new offices were involved. A review made recently has shown that under present conditions there is little likelihood of contract installation proving economical except for a few special projects.

Installation work is carried out on a State basis, the organisations differing somewhat due to different geographical conditions. In some States the line transmission installation is combined with exchange installation work at the same centres, and this has some attractions as new trunk circuits often require some extensions to exchange plant and the provision of signalling facilities.

MAINTENANCE

General Approach

The problem of maintenance is a world-wide one, and is aggravated by the rapid increase in the quantities of plant being installed and the frequent introduction of new types of equipment. At the same time the introduction of subscriber trunk dialling and the removal of telephonists from the control of connections is making it necessary to reduce the fault incidence on circuits, and also to maintain channel loss variations within closer limits and to improve the performance in other respects. This improvement in performance is necessary not only to ensure satisfactory conversations to subscribers, but to ensure that end-to-end multi-frequency code signalling systems operate satisfactorily over a number of links in tandem; signalling can impose more severe performance conditions than speech transmission in certain respects. The introduction of automatic telex and data transmission facilities is also imposing a need for better performance and reduced interruptions on voice frequency telegraph circuits and their bearer systems. The improved performance must also be obtained with very much reduced maintenance effort per circuit in the future, since circuits are growing at a much faster rate than the population.

With these factors in mind, a general approach to the problem must be established which will ensure that a satisfactory standard of service is given, both in respect to performance and interruption rate, while ensuring that overall costs, of which maintenance costs form a significant component, are a minimum. The service standard adopted and the costs are also interrelated (the standard must not be an extravagant one) and this complicates the problem. The approach which seems to have emerged from these considerations is:

(i) Improvement of the reliability of equipment and components to the maximum extent practicable, duplicating common equipment where circumstances dictate, and relying on simplification, adequate margins and good design in other cases.

(ii) Building into the systems a maximum of automatic equipment to regulate the systems and of supervisory aids to indicate that systems are performing properly and to indicate the cause of troubles as they occur. In this category are included pilots, alarm equipment, etc.

(iii) Readjustment of systems as a routine only when it is known with certainty that the need for such readjustments is inherent in the fundamental design of the systems. Such readjustments should be required only to take care of seasonal variations in bearers and would be restricted to line equipment only.

(iv) Making routine checks (including observation and testing as appropriate) of equipment performance on a systematic sampling basis so that the behaviour of systems is known with reasonable certainty. Such checks would exclude re-adjustments. They would be concentrated on line systems common to a number of channels and would be restricted to the minimum extent at which it is possible to obtain reliable information.

(v) Analysis of statistics of all faults to obtain information on design weaknesses and equipment which is giving undue trouble.

(vi) Overhauling equipment, using specialist staff, only when dictated by an undue incidence of faults or by inadequate performance.

(vii) Using specialist staff in central depots to carry out fault repairs to the maximum extent practicable.

(viii) Scrapping or rebuilding older equipment as dictated by performance and fault statistics. Attention should be concentrated on types of systems in fairly common use and effort should not be wasted on uncommon types.

(ix) Confining the activities of station staffs, as far as equipment maintenance is concerned, to observation of performance, location and replacement of faulty units, and keeping the equipment clean. They would of course have many other duties which would be associated mainly with bearer troubles, power plants, etc.

Procedures

The translation of this approach into practical procedures for all the different types of systems in use in Australia is not simple, nor can it be claimed that progress in this direction has been satisfactory. Many of the older types of systems are not equipped with pilots for automatic regulation or alarm indication, there are transistorised types and valve types using valves of short and long lives, and there are sufficient other minor differences in designs to make significant variations in optimum procedures in each case. Standards of service for open wire equipment are also influenced by interruption rates on the bearers and must be co-ordinated with the bearer fault liability. The problem in any case is of such magnitude that it would not be appropriate to discuss it in detail in a general review article of this type, and it is hoped to give further information on it in a future issue of the *Journal*. In the meantime the following aspects may be of special interest:

Overhauls: The state of line transmission plant in Australia is such that complete overhauls of all equipment in many offices are justified once each year. The overhauls are combined with complete vibration testing (23) of equipment and cabling, etc., which is undertaken 12 months after systems are first installed and then at about four-yearly intervals as dictated by the fault incidence. Significant numbers of dry joints are being found at many overhauls despite the fact that vibration testing has been in use for about seven years. Troubles in soldered joints constitute one of the major problems in the Australian network. In general, the annual overhaul probably pays the greatest dividend of any of the maintenance procedures, and is extremely valuable in many respects other than the correction of soldered joint troubles.

Voice Frequency Telegraph Systems: Attention is being given to improving performance and reducing interruptions in view of the imminent introduction of data transmission facilities and automatic telex. Among recent developments have been the introduction of automatic patching equipment which changes a system to another bearer when an interruption of more than about 0.2 second occurs simultaneously on all channels of a system. Adjustment of receive relays will be carried out in future only by specialist staff at central depots. The provision of special equipment to monitor continuously a spare channel of important systems (this will in effect be a pilot channel) and to record performance is also being examined.

Broadband Systems: Although the fault performance of new broadband systems has been relatively good, some interruptions have occurred and it is of interest that about half have been due to power plant. Some of these have been due to design troubles which are being corrected, but a significant proportion has been caused by "human errors" during maintenance operations. Similar errors have also occurred during patching operations on line transmission equipment. Although maintenance operations which could cause interruptions on these systems are carried out at night, and the position has improved considerably since the systems were first installed, human error troubles are still a potential cause for concern.

Fault Indication: With the operator dialling network, faults are reported by telephonists or disclosed by pilot and other alarms or discovered during maintenance checks. Pilot supervision will play an important part with the subscriber dialling network, and channel routiners will also be installed at offices with large groups of circuits, but indications of troubles on individual channels will be disclosed in most cases for small or large groups by the failure of the line signalling on the channels, which will result in an alarm being given.

As a further check on troubles, the system of analysis of subscriber complaints which is being developed for local networks (24) will also be extended to the trunk network.

Fault Analysis: The analysis of all faults to obtain information usable in the correction of design troubles, or to decide where special attention must be given to maintenance, is a fairly difficult problem when the information originates from many different offices located over a very large area. The future system will use punched cards for the recording and analysis, but it will be some time before this system will be introduced.

PAST DESIGN DEVELOPMENTS IN AUSTRALIA

General

Some mention has been made in previous paragraphs of the influence of overseas developments on Australian plant and of design work undertaken in this country. The first systems of almost all types used have been imported, and compatability considerations which have applied thereafter have had an influence on later designs. Nevertheless after any type of system has been in use for some years, design changes have been made and the systems which have evolved in this way have become basically Australian. Other types of systems have also been developed originally in Australia to meet special needs, although these in general have had a limited application. Such designs have been undertaken mainly by manufacturers, generally at the request of the Postmaster-General's Department, but some have been carried out by the Department itself.

Detailed system design is probably the most difficult and perhaps the most interesting part of the design work in line transmission equipment field, and for that reason most literature published overseas is concerned with the basic design of systems. However many other design problems are encountered in the general application of systems and in their application in particular cases. There are also problems to an operating organisation in specifying its essential needs and in making sure it obtains equipment which meets those needs. As little information on these aspects is published, and as, due to its long distance from other countries, Australia has had relatively little contact with overseas operating organisations in the past where matters of detail have been concerned, design work in its application field has been undertaken exclusively by the Department.

System Design

Of the five main types of telephone system in general use at present, the 3-channel system can be said to be completely of Australian design, the 12-channel open wire system almost completely of Australian design, and the rural system is being redesigned in Australia. For these systems, however, manufacturers have had some design work (certain filters for example) undertaken by overseas associates. Other earlier types of 3-channel and 12-channel open wire systems were also designed largely in Australia. Other locally designed systems used on a more restricted scale at earlier stages included voice frequency telegraph systems, the 6-channel cable system (5), the 34-channel cable system (4), and 12- and 24-channel cable systems including one type with long repeater sections. A special system was also designed by the Department's Research Laboratories for the extension of facilities on the Bass Strait cable (25).

Main System Components

Certain major components of main systems have been designed by the Department from time to time, generally to meet special requirements. Examples are the "pole-mounted" 12-channel open wire repeater for use in remote areas (26, 27), and the high-speed telegraph equipment for the Sydney-Perth route (28). The 12-channel repeater was designed by the Research Laboratories and numbers are in use on the Alice Springs-Darwin route and the North-West route in Western Australia. A pole mounted line filter for 12-channel systems was also designed by the Research Laboratories and is now the standard facility for these systems, simplifying cable entrance arrangements and reducing problems of impedance matching in the offices.

Office and Other Practices

Under the original design work undertaken in connection with the application of systems may be included the very important contribution associated with the reduction of crosstalk and noise in offices (29). This work led to a much better understanding in Australia of earthing and office cabling problems which are now fully under control. Similar work has been undertaken on impedance matching of open wire line entrances, power plants and power distribution, the spacing of open wire carrier repeaters, etc.

Testing and Specification of Equipment

Because of the method under which line transmission equipment is purchased, considerable emphasis has been placed by the Department on testing and specification methods to ensure its proper performance. Among Australian developments in this field may be mentioned the introduction in 1952 of weighted noise for the measurement of crosstalk and intermodulation in small capacity systems (30), and the development of a pulse method of measuring the stability of feedback amplifiers (31, 32). The C.C.I.T.T. is also considering an Australian proposal for a new method of measuring circuit noise.

CURRENT AND FUTURE DEVELOPMENTS

General

The major part of the current development effort by the Department is being directed towards making the trunk network operate in the manner in which it was intended. Apart from the development of more effective maintenance practices, this work includes the design of the plant associated with end circuits which are connected to the trunk network to reduce transmission losses and to achieve the return loss requirements necessary for control of stability and echo in the overall circuits. It also involves work on the optimum design and operation of negative impedance repeaters and the use of echo-suppressors. At the same time an increasing amount of attention is being given to achieving greater reliability of all types of line transmission equipment which will be provided in ever increasing quantities, and greater flexibility of the equipment to cope with problems of providing quickly the unforeseen extensions which will be necessary as the subscriber trunk dialling programme gains momentum.

Reliability

The improvement of equipment reliability is being undertaken as a joint effort by both the Department and the manufacturers. The work includes the investigation of available components to ensure that only high quality long life types are used in future equipment. The design of individual circuits is also being studied with a view to achieving the maximum simplicity, a minimum number of components, and adequate design margins to ensure good performance if components need to be replaced. The Department has been in the position in the past where it has been able to compare designs of units from a number of different manufacturers, and in many instances there has been a surprising difference in the numbers of components in units designed to perform the same function. Almost without exception the units with the fewest components have been the most reliable as well as the easiest and cheapest to manufacture, and have often also given the best performance, so that increased reliability does not necessarily result in greater first cost. With any system of purchasing, it is of course impossible for a user to pass on design information from one manufacturer to another, so that very careful handling of the circuit design problem is necessary. The improvement of the individual components is not such a delicate problem, and is being covered by specifications and individual approval of types used. Another major factor in reliability is the number and type of soldered joints included in the units and the types of plug-in connectors used. Fortunately the use of card mounted equipment is easing the soldered joint problem, particularly when satisfactory dip-soldering techniques are used in manufacturing.

Miniaturisation

The extent of miniaturisation of equipment has been progressing steadily and this trend will continue in the future. As an example, in the case of channel modulator equipment produced in the early 1950's, 12 channel-ends, without signalling, occupied one rack-side. Current equipment has 48 channel-ends together with signalling on one rack-side, and many designs either completed at present or nearing completion will allow 120 channel-ends, with signalling, in the same space. This equipment will generally be available on a production basis in about two years' time or earlier in some cases. Designs which will mount 240 channel-ends per rack-side are also in various stages of completion. All this work is aimed basically at reducing equipment costs, apart from the incidental advantages of reduced accommodation requirements.

New Systems

The present standard types of system will continue in use for an indefinite period into the future, redevelopments occurring from time to time to take account of new components and techniques as they become available, with the objective of reducing costs and improving reliability. New designs of broadband systems are almost certain to be completely transistorised within the next three years. It has been mentioned earlier that the introduction of further new types is being discouraged until such time as there is a reasonably large-scale application for them. Nevertheless, the 12 Mc/s system giving 2,700 channels on a pair of coaxial tubes must be introduced within the next three years, and a further extension of the frequency band is likely after that time to utilise coaxial cables already laid to their maximum channel capacity. Small diameter coaxial systems must also be introduced at a later stage to meet requirements which will arise in increasing quantities on medium distance medium capacity routes in country areas; the deferment of their introduction will permit the use of systems of 960-channel capacity which are being developed overseas at present. It appears that it will be very many years before extremely large capacity systems using waveguides as bearers will be required in Australia, and again Australia will be fortunate that the main engineering problems in the use of such systems will have been solved overseas before the systems are required here. The Department will however keep in touch with overseas developments on basically new systems, and endeavour to an increasing extent to have any special Australian requirements in the basic design taken into account through active participation in the work of the C.C.I.T.T.

The most pressing need in Australia as far as new types of systems are concerned is for a very cheap short distance system for use on existing cables in the large metropolitan networks. Overseas developments of pulse code modulated and other types are being watched closely, and some trials will be made in Australia shortly to obtain information on basic techniques. However the break-through in cost which is necessary for the wide application of such systems does not appear to have occurred yet. Nevertheless with the large amount of work which is being carried out in this field, some interesting results must occur within the next few years, and there will be a considerable increase in the use of carrier equipment when a suitable design is developed.

CONCLUSION

In a short review article of this type, it has been possible only to touch on most of the interesting developments in the field concerned. The main conclusion which can be drawn from a review must be the very rapid rate at which developments have been occurring in line transmission equipment, and at which the quantities of this type of plant have been continuing to grow. Many problems in the design, application and maintenance of the equipment have arisen and will continue to arise in the future. Fortunately many of the problems have been solved, and as far as Australia is concerned, much useful advice has been obtained from overseas countries, and valuable information is being obtained to an increasing extent from the work of the C.C.I.T.T. A country with the population of Australia cannot itself expect to solve all its problems with plant of the complexity of line transmission equipment, and owes a considerable debt of gratitude to these other countries.

REFERENCES

Except where indicated, all References are to the Telecommunication Journal of Australia.

1. N. W. V. Hayes and C. Anquetil, "Mainland-Tasmania Cable Equipment"; Vol. 1, No. 3, page 81.
2. J. T. O'Leary, J. B. Scott and A. M. Thornton, "The Sydney-Melbourne Type J Carrier Telephone System"; Vol. 3, No. 1, page 2.
3. C. J. Griffiths, "The Sydney-Newcastle-Maitland Cable"; Vol. 2, No. 5, page 274.
4. N. M. Macdonald, "Cable Carrier Systems in Australia"; Vol. 7, No. 4, page 217.
5. G. R. Lewis and O. J. Connolly, "Installation of Junction Carrier System (Newtown-Miranda)"; Vol. 7, No. 2, page 65.
6. P. W. Seymour, "The Type N1 Carrier Telephone System"; Vol. 11, No. 1, page 18.
7. M. W. Gunn, "Application of Type N1 Carrier Systems in Australia"; Vol. 11, No. 2, page 43.
8. M. W. Gunn and R. W. E. Harnath, "Short Haul Cable Carrier Systems"; Vol. 11, No. 6, page 197, and Vol. 12, No. 1, page 18.
9. R. W. Turnbull and G. E. Hams, "Australian Telephone and Telegraph Networks"; in this issue.
10. J. G. Bartlett, "Long Distance Programme Transmission"; Vol. 8, No. 3, page 169.
11. R. W. E. Harnath, "Line Transmission and Switching for the Australian Television Network"; Vol. 13, No. 2, page 99.
12. Technical News Item—"Long Distance Television Relay"; Vol. 13, No. 4, page 305.
13. N. M. Macdonald, "The Sydney-Melbourne Coaxial Cable Project: General Features of Telephone Transmission Equipment"; Vol. 13, No. 3, page 227.
14. J. E. Freeman, "The Type J2 Twelve-channel Carrier Telephone System"; Vol. 6, No. 2, page 98.

15. C. F. Boyce, "Open-Wire Carrier Telephone Transmission"; (Book) Macdonald and Evans Ltd., London, 1962.

16. E. R. Banks, "Crossbar Switching Equipment for the Australian Telephone Network"; Vol. 13, No. 2, page 85.

17. J. R. Walklate, "The Sydney-Melbourne Coaxial Cable Project: Design of Transmission Equipment"; Vol. 13, No. 3, page 235.

18. L. A. White, R. K. Edwards, I. L. McMillan and J. R. Walklate, "The Melbourne-Morwell Coaxial Cable System"; Vol. 13, No. 4, page 291, and No. 5, page 405.

19. P. G. Krastev, "Sydney-Melbourne Coaxial Television Transmission"; Vol. 14, No. 1, page 29.

20. W. D. McKenzie, "Type J2 Auxiliary Carrier Repeater Station with 420B Power Plant"; Vol. 9, No. 1, page 8.

21. A. Hannah, "The Sydney-Melbourne Coaxial Cable Project: Power Plant"; Vol. 13, No. 3, page 259.

22. R. A. Peacock, A. M. Boyd and W. G. Beard, "The Sydney-Melbourne Coaxial Cable Project: Installation of Transmission Equipment"; Vol. 13, No. 3, page 250.

23. H. L. C. Read, "Vibration Testing"; Vol. 13, No. 4, page 310.

24. D. J. Omond, "An Introduction to the Analysis of Subscribers' Complaints"; Vol. 13, No. 6, page 446.

25. D. A. Gray and E. Rumpelt, "The Bass Strait Submarine Cable—9 Channel Extension Carrier System"; Vol. 10, No. 6, page 178.

26. J. C. Wilson, "Pole Mounted Repeaters for Carrier Systems"; Vol. 12, No. 5, page 314.

27. A. W. Thies, "A Transistor Amplifier with Heavy Feedback for 12-Channel Open Wire Carrier Systems"; Vol. 12, No. 3, page 187.

28. S. Dossing, "High Speed Voice Frequency Telegraph Operation between Sydney and Perth"; Vol. 9, No. 6, page 273.

29. S. Dossing, "Principles of Cross-talk and Noise Suppression at Open Wire and Balanced Cable Carrier Stations"; Vol. 11, No. 6, page 180.

30. S. Dossing, "Inter-channel Interference in Multi-channel Carrier Telephone Systems"; Vol. 9, No. 2, page 101.

31. E. Rumpelt, "The Stability Margin of Feedback Amplifiers"; P.M.G. Research Laboratory Report No. 4393.

32. E. Rumpelt, "Pulse Testing of Feedback Amplifiers"; P.M.G. Research Laboratory Report No. 5710.

Installing Asbestos Cement Conduit in an Outer Metropolitan Area.

SOME ASPECTS OF THE USE OF RADIO SYSTEMS IN THE AUSTRALIAN INTERNAL NETWORK

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INTRODUCTION

Australia is a large rapidly developing country with a small population scattered over vast distances, so that radio has displayed some unique advantages in the provision of telecommunication circuits. A wide variety of radio equipment is in service to provide facilities ranging from simple message passing under emergency conditions to the relay of large blocks of telephone channels or a television programme. This article gives a general outline of the types of equipment in use in the Postmaster-General's Department's internal telephone, telegraph and television relaying networks. It also refers briefly to the general pattern of development in the use of this equipment, and to plant practices and special problems in Australia.

GENERAL HISTORY

The earliest use of radio in Australia for internal message purposes was probably the H.F. system established by the Australian Inland Mission in 1929. This developed into the fairly extensive Outpost Radio System (1) which is however not part of the Departmental network. No use was made of radio by the Department itself, other than for broadcasting purposes, until 1938 when the first V.H.F. radio system was used between Stanley (Tasmania) and Tanybryn (Victoria) during repairs to the Victoria-Tasmania submarine telephone cable (2). This system was provided only for emergency use in the case of failure of the cable, and was improved gradually as experience was obtained with the new techniques. In 1944, two new V.H.F. systems replaced the original system on this route and have operated continuously, providing six and later twelve telephone channels (3). After 1945, with the conversion of the local radio manufacturing industry from war production to commercial products, a number of V.H.F. single channel and low capacity systems were produced which were rapidly utilised in country areas to provide circuits to locations which were difficult to serve by wire lines. A number of mountain resorts and small coastal islands are served by such equipment. and over 100 systems are at present in service.

The post-war period marked a rapid rise in population, especially in urban areas, and combined with industrial development there was a rapidly increasing demand for trunk channels which the Department attempted to satisfy by major extension of trunk facilities (4). Radio systems appeared capable of providing one solution to the problem when a number of channels were required, and several medium capacity V.H.F. and microwave systems were installed in the period 1947 to 1952, largely on an experimental basis. The availability in the mid-1950's of microwave radio broadband bearer equipment for 600 telephone channels, capable of performance to international standards, resulted in the application of this equipment on major trunk routes or routes requiring television relay facilities. The first radio broadband bearer system was commissioned between Melbourne and Bendigo in Victoria, in December, 1959, and expansion in this field since then has been very rapid. At the present time, approximately 1,000 miles of microwave route are operating for trunk telephone or television relay purposes, and expansion is continuing at an accelerating rate (5).

TYPES OF PLANT USED

High Frequency Links

High frequency circuits provide communication over long distances to remote areas for message passing, to ensure continuity of service in the event of failure of other forms of circuits, or to provide one or two trunk circuits to isolated communities (6, 7). In many cases, the conditions are such that radio provides the only practical method of communication. Thus the sparsely populated and remote areas of Northern, North-Western and Central Australia are served by a number of high frequency zone networks referred to previously. These operate on an individual licensed basis and provide message-passing facilities from homesteads to the zone centres where they are passed on to the normal Departmental network (1).

High frequency circuits have been used in a few instances to provide trunk circuits satisfactorily to remote areas. For example, a multi-channel independent sideband radio-telephone circuit operates between Perth and Derby in far North-Western Australia (8), and the trunk circuits so provided are extended on to other centres past Derby by various means. Medium power transmitters are used with directional aerials, and the operators at Derby dial direct into the Perth telephone network. Similar equipment is used to provide three direct dialling telephones plus three voice frequency telegraph trunk circuits over a 2,000 mile path between Perth and Melbourne. It is used in the event of failure of the regular landline, or to provide additional circuits to overcome periods of traffic congestion. A number of Departmental H.F. circuits have been established also for use in periods of emergency such as floods, cyclones or bushfires in Western Australia, Queensland and Northern New South Wales. The majority of these take the form of zone networks, using low powered SSB transceiver equipment, and generally are restricted to a message handling role.

A variety of H.F. equipment is in service and, for telephony use, originally double sideband emissions were used, with hand speed Morse on-off keying (AI. emission) for telegraph circuits. The earlier equipments, which have now reached the end of their useful life, are being replaced by modern plant and, for some years now, all installations have employed independent sideband or single sideband emissions, with frequency shift keying for telegraph circuits to facilitate the use of machine working (9). Some emergency circuits retain the use of hand-speed Morse working. The transmitter powers range from low power (10-50W) units for the smaller zone networks to 5kW transmitters used on the long distance circuits of 1,500 miles or more. Directional aerials are employed, rhombics for long distance circuits and low aerials with vertically directed radiation for zone network use. In addition to the reduction of interference to other users by these measures, spectrum conservation is practised by the use of common frequency working on zone networks.

V.H.F. and U.H.F. Equipment

V.H.F. and U.H.F. systems are used mainly in the more remote areas. They include small capacity trunk systems to extend facilities from the main trunk network and also subscribers' systems. A further application is the flood relief networks which have been established in several northern areas of New South Wales (10) to provide a skeleton service when the major routes are interrupted. Apart from the early V.H.F. multichannel systems between Victoria and Tasmania which were amplitude modulated, and several 23 channel 2 Gc/s time division multiplex systems (11), all other single channel and low capacity systems are frequency modulated bearers. A variety of different types of aerials are used, and, until the introduction of the high capacity broadband bearers, it was the general practice in the Department to use separate aerials for each system, so that there developed some repeater stations which carried only a modest number of trunk channels over a number of radio systems, but which boasted an impressive array of aerials of various types.

Microwave Equipment

In a later section, it is indicated that the system design is arranged so that equipment which has been developed and proven overseas may be utilised to provide the required standard of performance. At the present time, the Department has in service, or is installing, microwave broadband bearer equipment manufactured by several

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* See pages 168 and 169.

leading international manufacturers, and this is similar to the equipment made by the same manufacturers and in use by Administrations overseas. A map showing the main routes on which systems of this type are in use or will be installed shortly is given on page 104 of this *Journal*. The main line long distance systems installed are all generally similar in design. They are either 4 Gc/s or 6 Gc/s systems, and routes may be developed up to a capacity of six or eight bearers including a protection bearer. In the development of trunk telephony and television relay bearers in parallel on the same route, both are given access to a common protection bearer. The earliest systems had a capacity of up to 600 telephone channels per bearer, but all present and future systems will have a capacity of at least 960 channels per bearer. All systems which have been installed or are currently on order use valves and travelling wave tubes, but consideration is being given to the use of solid state devices in future systems.

In addition to the long haul systems, a number of 7 Gc/s short haul systems are being provided for the relaying of television programmes to regional stations. These systems are generally being restricted to a maximum of two repeater sections.

Ancillary Equipment

Although the radio equipment, including the aerials and connecting waveguides, supervisory bearer and telemetering equipment, is provided with the radio bearers as standard equipment by the manufacturers, the remainder of the installation is arranged by the Department. Aerial support towers are purchased from Australian manufacturers in accordance with site requirements and route development, buildings are usually constructed locally to standard Departmental designs, and power plant is purchased from Australian manufacturers who assemble prime movers and electrical plant to Departmental specifications.

DESIGN

General

In providing radio systems of all types, the Department normally undertakes the design of the system, leaving the design of the equipment to the manufacturers. These two design aspects are co-ordinated in the equipment specification contained in the tender schedule. In some few instances, the quantity of equipment required is sufficient to justify a special design and production run to suit the particular situation. Most often, however, the system design is arranged to accept equipment designs which are known to be already available or which can be readily modified to meet special needs. In this way, the cost of equipment is minimised and the probability of obtaining a good competitive range of tenders is increased. It follows that one of the most important elements in the Department's design function is to maintain up-to-date information on the state of equipment development throughout the world so that the tender specifications are neither excessively optimistic on the one hand nor unnecessarily relaxed on the other.

Wherever they apply, C.C.I.R. and joint C.C.I.R./C.C.I.T.T. Recommendations are taken as the basis for system designs. The growing coverage of these Recommendations is proving to be most satisfactory as a means of rationalising the designs of different manuturers, so allowing a wider choice of suppliers. In those special cases where the specification must be made more rigid in some respects than the C.C.I.R. recommends, it is the practice first to confirm by calculation and research that this may be done with practicable modifications to otherwise standard equipment.

High Frequency Links

Although H.F. circuits are never used in Australia where the facility can be obtained by other means, the great distances in this country make H.F. working mandatory for some applications. Particular care is taken in these cases to use the greatest practicable refinements in the design. The system design aims at minimum transmitter power and optimum aerial directivity in the interests of providing an adequate service with least interference potential to other users of the spectrum. Both for the fixed links and also for broadcasting, the designs from the C.C.I.R. Antenna Handbook are frequently used and other types of directional antenna are continually being investigated.

V.H.F. and U.H.F. Links

As indicated previously, V.H.F. and U.H.F. links are used mainly on the outer fringe of the heavily developed trunk systems to provide a few channels in the more remote country areas. In such locations, low power consumption and minimum maintenance effort become paramount design goals and the Department has encouraged the development by local manufacturers of special equipment to meet these requirements. In the route planning of V.H.F. and U.H.F. systems, propagation tests are carried out to determine system parameters (12, 13). Each State Administration in the Commonwealth is equipped for these measurements. A V.H.F. Public Subscribers' Mobile System is operated by the Department in the main capital cities (14, 15).

Microwave Systems

The last five years have seen an extremely rapid development of the major trunk telephone and television relay routes provided by broadband radio bearers. In this field too, the Department has borne the full responsibility for route and repeater site selection, propagation predictions and path and system engineering, while the equipment has been purchased from several of the major overseas manufacturers. Up to the present time, over 3,500 miles of microwave route have been fully surveyed and engineered for systems which have been or are soon to be installed. Microwave paths are mostly assessed on the basis of accurate physical surveys of the ground contours in critical areas, and propagation testing is applied only to the few special paths for which predictions are judged to be doubtful.

The largest single route yet designed in Australia is for the Brisbane-Cairns bearer which, amongst other things, will carry traffic to the SEACOM cable at Cairns. This route is almost 1,000 miles long and passes through a variety of country including tropical jungle and rain forests. The efforts of seven draughtsmen, surveyors and engineers, together with field support staff, over a period of 15 months have resulted in a very accurate survey of the route,

Fig. 1.—Field Party Surveying on Brisbane-Cairns Route. The party is using an accurate (1 second) theodolite, heliograph, and 80 watt spotlight.

allowing the system to be designed with great precision. Fig. 1 shows a survey party at work on this route. Particular care was needed in this case since the bearer is required to meet unusually stringent performance criteria for the traffic channels feeding the SEACOM cable.

INSTALLATION

The installation of radio relay systems is normally carried out by Departmental staff, and each State administration has a competent radio installation staff to handle all aspects of the work. In the case of broadband radio bearers, the equipment installed to date has been supplied by a number of companies and, in view of the technical differences between these equipments, it has in the past been the general practice to hire the services of company experts to assist in the installation, initial line-up and testing of these systems. This practice ensures that the equipment installed fully meets the manufacturer's specifications and, furthermore, has resulted in rapid specialist training of Departmental installation, operational and maintenance staff. At the present time, a total of approximately 1,000 bearer miles of mainline broadband radio bearer systems have been installed, and a further 4,000 bearer miles are under construction. More than one bearer is being provided on some routes.

For broadband bearer systems, the buildings are normally of brick construction, single storey, and are divided to form standby power plant and main equipment rooms. A typical repeater building layout is shown in Fig. 2.

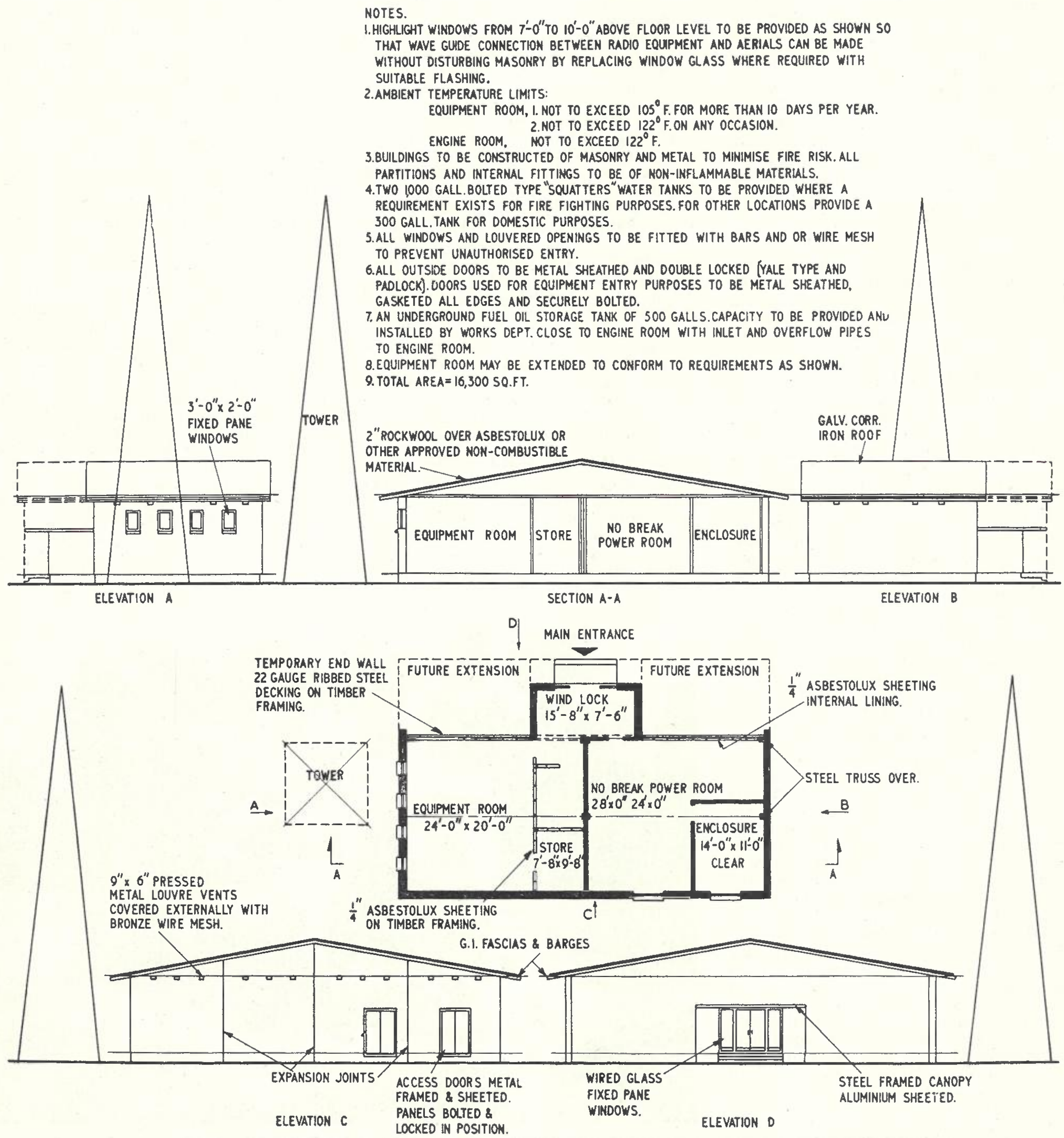


Fig. 2.—Layout of Typical Radio Repeater Building for Unattended Operation. Minor alterations to the site layout are made to cater for special site characteristics.

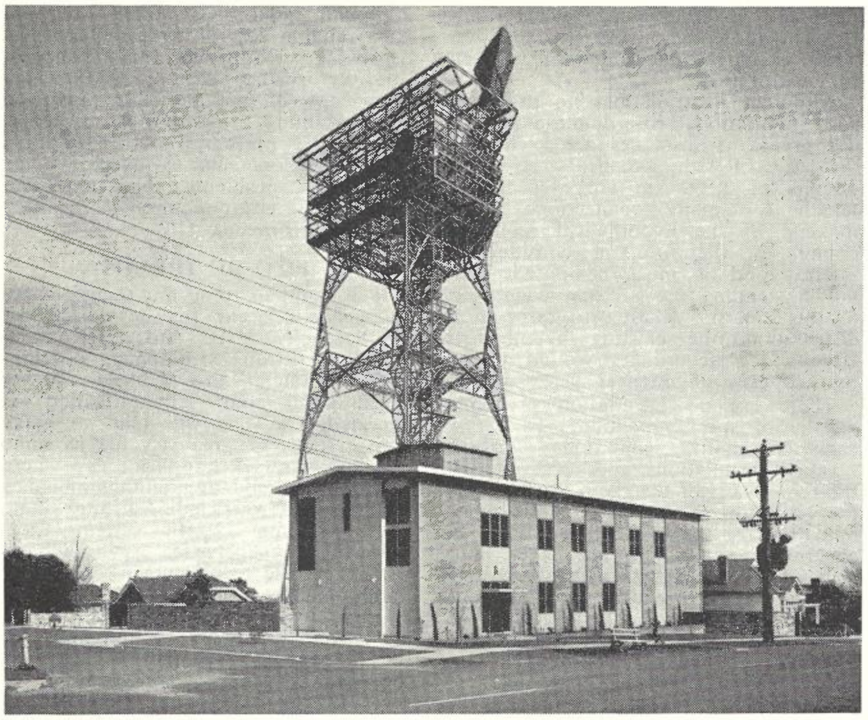


Fig. 3.—A Modern Radio Terminal Established in a Suburban Location in a Capital City. Provision has been made in the building and aerial support structure for future development and expansion.

Radio terminal buildings are similar in form, although longer, and with the requirement for attended operation of the equipment contained therein. In some cases, terminals have been established as part of large metropolitan exchange buildings, but the trend of building development in city areas is such as to necessitate the future separate establishment of radio terminals in an unobstructed location. Fig. 3 is a photograph of the Melbourne radio terminal, established in an elevated suburban location. Adequate provision has been made for aerial mountings on the support structure to cater for future route development and expansion. It is Departmental policy to install no-break power plant, backed with normally stationary diesel alternators, on radio bearers of 24-channel capacity or larger, although, to date, no-break sets have been installed on one main route only. The power plant and internal cabling is generally installed immediately prior to the delivery to site of the radio equipment, thus enabling the radio installation to be carried out quickly.

Aerial towers used to support the microwave antennae are of the self-supporting type and are installed on concrete foundations adjacent to the building. These towers are provided to the Department on supply and erection contracts, or alternatively for erection by the Department.

Single channel radio-telephone systems find their application in the provision of trunk circuits to small communities (16) or telephone services to subscribers in remote areas where the provision of service by wire lines is uneconomical. Generally, no special accommodation is provided for the radio-telephone equipment at the subscriber's premises, the equipment being installed in any location convenient to the subscriber. At the point of connection with the trunk network, the radio terminal equipment may be installed in a Post Office building, an exchange, or separate hut on some convenient high point. In the more remote areas, where this type of service is provided, power supply difficulties invariably arise due to the unavailability of commercial power supplies, and the need to integrate the radio equipment with the home lighting plant normally used by the subscriber for domestic purposes often causes installation difficulties. In this regard, transistor equipped VHF systems, with their inherently low power consumption, have a distinct advantage over their HF counterparts in that trouble-free operation from separate battery supplies with recharging at fairly infrequent intervals is possible.

Single channel HF systems are, in many cases, required to work over distances up to 400 miles and, as the power consumption of these units is necessarily relatively high, it becomes essential to install engine generating equipment to power this equipment.

As the cost of providing radio-telephone circuits to subscribers is borne by the individual subscribers, it is common practice to allow the subscriber or his staff to assist in the installation of the equipment. In this regard, many subscribers have, in the past, fabricated and installed their own HF aerial systems in accordance with standard Departmental designs, thus reducing the cost of the service.

PROCUREMENT

In the procurement of radio bearer equipment, the Postmaster-General's Department has access to supplies, providing a wide choice of equipment from all countries. Procurement is by means of a competitive system, and tenders are normally received from Europe, U.S.A., Canada and Japan.

Mainline broadband bearer equipment has not yet been developed and manufactured in Australia, and all past purchases have been from European sources. A chart showing the recorded expenditure on broadband bearer equipment to date, and the expected expenditure in the next few years, is shown in Fig. 4.

As far as low capacity bearers and towers and power plant are concerned, experience over the years has shown that Australian manufacturers are able to supply equipment of the required standards and performance, with the result that almost all of this equipment is purchased from local sources.

MAINTENANCE

In general, apart from capital city terminals and control stations, all stations are unattended and rely for their routine maintenance and fault finding on visits by district technicians from the nearest telephone exchange or long line station. This staff generally has not been formally trained in radio but has received limited training from

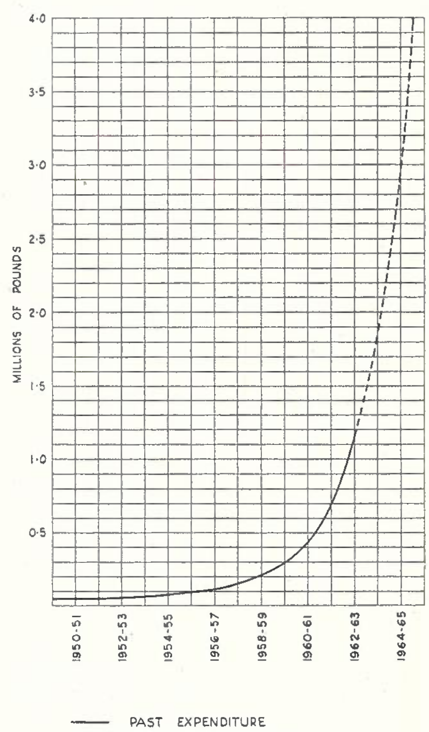


Fig. 4.—Chart showing Recorded and Expected Future Expenditure on Broadband Radio Bearer Equipment. Site and building costs are not included.

conversion courses and instruction from specialist radio staff on particular aspects of the radio-telephone equipment under their care.

Metropolitan terminals and control stations are staffed by a small group of experienced radio technicians to permit constant supervision of the systems during the main periods of peak traffic. They carry out the testing and maintenance of the systems at their stations and give assistance and advice to technical staff at country stations by directing the testing, routine maintenance and fault eradication at other stations on outlying routes.

The country technicians periodically visit the stations in their district to record meter readings on the equipment, carry out periodical maintenance routines and, under the direction and guidance of the metropolitan terminal staff by means of the system order wire, attend to any fault or non-standard condition detected during the visit, which may be within their capabilities. In addition, they may be required to attend the station at any time to clear a fault on the system, again, under the direction of the metropolitan terminal. For the location and correction of the more complex faults, specialised staff is made available to the country stations, with a consequent delay of several hours before the fault is cleared.

An inspection of all stations is carried out at regular intervals by experienced specialist staff to ensure that the equipment is maintained to the required standards, and to carry out any necessary special tests or modifications. During these inspection visits, the district technician attends to carry out his regular work and to assist the specialist officer, so gaining valuable training and experience.

The regular maintenance visits and the inspection visits are made at intervals which are determined by the requirements of the particular equipment and the particular route. The visits to single channel and low capacity systems are relatively infrequent, but, for broadband equipment, routine maintenance visits are generally made at weekly or bi-weekly intervals, and inspection visits at quarterly to six-monthly intervals, depending on station locations.

SPECIAL PROBLEMS IN AUSTRALIA

The magnitude of the Australian continent and its scattered population in the remote, somewhat inhospitable areas, implies a need for small numbers of circuits over long distances. For this reason, there is a basic need for some high frequency channels in cases where wire lines are impracticable. Similarly, in the areas where broadband bearers are warranted, there is a tendency to long routes with low channelling development. Allied with this situation is the need for providing dropout facilities in small blocks along many of the broadband routes, and it is often found that distribution from the radio demodulation points is by existing open wire routes. In some respects, this represents a disadvantage when compared to the common overseas situation where existing trunk cables can be used for distribution.

Although Australia has no problems with international co-ordination in border areas, its distances are such that the C.C.I.R. hypothetical reference circuits of 2,500 km are exceeded in length for many connections. The makeup of the hypothetical reference circuits is, therefore, of considerable interest and it must be noted that, notwithstanding the unusual conditions in this country relating to population distribution, the existing hypothetical circuits are nevertheless found to be representative of practical system design.

There are no installation problems worthy of special mention. In a few cases, climatic conditions disturb planned installations and, occasionally, the remoteness of the radio site involves the provision of special on-site accommodation for the installation party. In general, these factors are taken into account in preparing installation programmes and, provided that the contractor supplies the equipment in accordance with the specified time schedule, planned completion dates are achieved.

The scattered centres of population and the vast areas covered by urban and rural population create some problems in the operation and maintenance of radio-telephone equipment. It is necessary to provide staff to the unattended stations for routine maintenance and fault correction, and, in the case of broadband systems, it is essential to take this action as quickly as possible in order to safeguard the route. The travelling time to some remote repeaters may be several hours, during which time the staff may have to face natural hazards such as flooded rivers, fallen trees across mountainous access roads, torrential rainfall or bushfires. Despite the widespread use of standby systems to ensure circuit protection, the need to have maintenance personnel attend to the equipment remains, and it presents an ever-present challenge to the resources of the Department.

It has been mentioned previously that the district technician is the first line of maintenance attention. Although it would be desirable for this staff to undertake a greater proportion of the system maintenance, the work is limited at present by two factors. It is difficult to provide a sufficient degree of training and knowledge of the art, in general, and the equipment in particular, to field staff whose responsibility is not solely radio. Secondly, it is impracticable to provide sufficient unit spares and expensive and complex test equipment at each station. Much of this equipment has to be sent from the nearest holding depot and it is usually sent in the care of a radio-telephone technician who has the necessary skill and experience to perform the special work.

The techniques employed in modern radio-telephone equipment are necessarily complex, but the application of developments and refinements in equipment design, and monitoring and control, combine to ensure reliable service with a very high degree of performance. Maintenance of this performance requires a thorough knowledge of the principles involved and the ability to apply this knowledge, and every opportunity is taken to apply recent developments to overcome the operational problems associated with reducing the effort required to maintain system performance (17).

FUTURE TRENDS

It is unlikely that any considerable change will occur in the density of low capacity VHF and UHF radio links in Australia. Equipment development leading to reduced power consumption and miniaturization is expected, and this will tend to make such systems of greater value to some of the outback applications where power, accommodation, and maintenance facilities are restricted. Existing single and 4-channel VHF systems will gradually be superseded by broadband systems as the trunk network develops.

Broadband radio bearers now in existence or soon to be installed provide a substantial network, linking most of the more densely populated areas of the country where power facilities or road access are not often a serious problem. With this network developed, the next step will be to extend these routes gradually further into the more remote areas. At that stage, it will be of the greatest importance that the relatively complicated power supply arrangements associated with current broadband systems be replaced by a simple efficient and reliable no-break power source. Such an arrangement, particularly for situations where mains power is not available, would invite a more rapid extension of broadband facilities into remote areas. In association with improvements to the power sources, it might be expected that the equipment will become smaller and, perhaps, more reliable, leading to a valuable reduction in building requirements.

With these developments already appearing on the horizon, it is to be expected that medium and large capacity radio bearers will consolidate their position in the Australian trunk network as major contributors to the trunk telephone and television relay facilities operated by the Department.

REFERENCES

1. L. F. Pearson, "The Australian Outpost Radio Communications System"; Telecommunication Journal of Aust., Vol. 13, No. 6, page 456.

2. D. McDonald, "Ultra High Frequency Experiments between Victoria and Tasmania"; Telecommunication Journal of Aust., Vol 2, No. 1, page 5.

3. N. S. Feltscheer and W. F. Beard, "The Development of Radio-Telephone Facilities Across Bass Strait"; Proceedings of Institution of Radio Engineers (Aust.), Vol. 20, No. 5, page 272.

4. A. H. Freeman, "The Need for Radio in the Australian Front Line Network"; Proceedings of Institution of Radio Engineers (Aust.), Vol. 19, No. 5, page 206.

5. A. H. Little, "Trunk Line Systems of New South Wales"; Proceedings of Institution of Radio Engineers (Aust.), Vol. 22, No. 1, page 15.

6. J. Mead, "The Installation of the Radio-Telegraph Network in North-West Western Australia"; Telecommunication Journal of Aust., Vol. 7, No. 5, page 303.

7. S. J. Ross, "Very High Frequency and Ultra High Frequency Radio Links in the Australian Post Office Communications Network"; Telecommunication Journal of Aust., Vol. 8, No. 5, page 257.

8. J. Metcalfe-Moore, "Perth-Derby Radio Link"; Telecommunication Journal of Aust., Vol. 12, No. 4, page 298.

9. D. A. Brooke, "Frequency Shift Keying Radio Equipment"; Telecommunication Journal of Aust., Vol. 9, No. 1, page 42.

10. J. D. Thompson and B. W. G. Penhall, "The New South Wales North Coast Radio Network"; Telecommunication Journal of Aust., Vol. 12, No. 4, page 287.

11. K. R. Faragher, "23-channel P.T.M. Radio-Telephone Equipment"; Telecommunication Journal of Aust., Vol. 10, No. 5, page 130.

12. O. M. Moriarty, "Projected New Radio-Telephone Link from Mainland to Tasmania—Propagation Measurements"; Telecommunication Journal of Aust., Vol. 7, No. 5, page 281.

13. B. W. G. Penhall, "Planning and Field Surveys for VHF Radio-Telephone Systems"; Proceedings of Institution of Radio Engineers (Aust.), Vol. 20, No. 2, page 87.

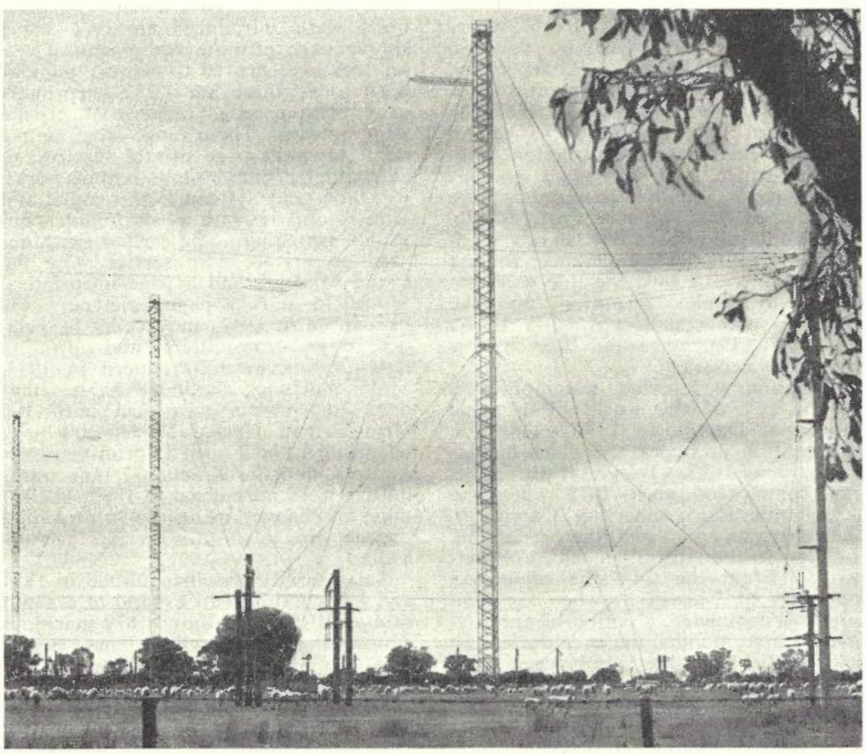
14. N. S. Feltscheer, "Mobile Radio-Telephone Services"; Telecommunication Journal of Aust., Vol. 7, No. 6, page 322.

15. B. W. G. Penhall and J. D. Thompson, "A New Method of Signalling for Single Channel and Mobile Radio-Telephone Systems"; Proceedings of Institution of Radio Engineers (Aust.), Vol. 20, No. 5, page 279.

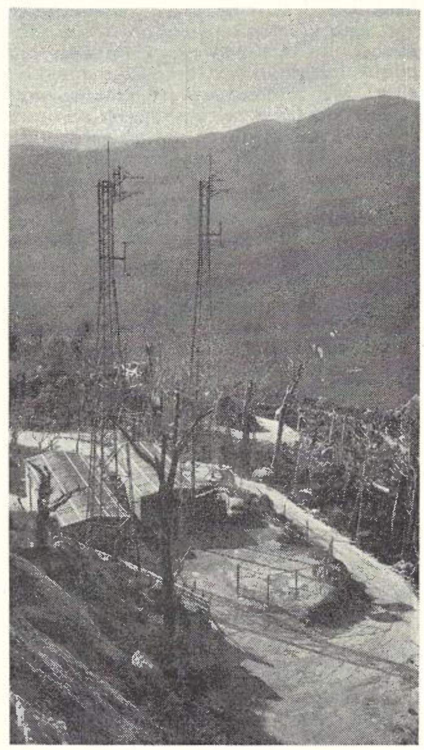
16. C. H. Brown, "Flinders Island-Tasmania Radio Link"; Telecommunication Journal of Aust, Vol. 4, No. 1, page 29.

17. R. J. Boyle, "Maintenance of International Performance Standards in Radio Trunk Line Services"; Proceedings of Institution of Radio Engineers (Aust.), Vol. 20, No. 6, page 331.

18. A. G. Ellis, "Site Noise and its Correlation with Vehicular Traffic Density"; Proceedings of Institution of Radio Engineers (Aust.), Vol. 24, No. 1, page 45.



The aerials at Radio Australia, Shepparton, beam programs to all parts of the world throughout the day in seven languages. The station site occupies 567 acres, and is located about 120 miles north of Melbourne. It is equipped with seven transmitters—four of 100 kW, two of 50 kW and one of 10 kW power output and has 26 directional aerial systems. Incidentally, the flock of sheep seen busily keeping the grass cut have proved a good investment.



Mt. Oberon (Victoria) station of Victoria-Tasmania Radio Telephone circuit. The station is unattended and generates its own power from diesel engines.

AUSTRALIAN TELEGRAPH ENGINEERING PRACTICES

*R. K. McKINNON, B.E., D.P.A., and D. J. RICHARDSON**

INTRODUCTION

Historically there has always existed a considerable community of interest between the widely separate Australian cities and the means for rapid, accurate transmission of information between them has been a pressing need. As a result long distance telegraph communication developed very quickly in this country and the "telegraph habit" became widespread in the community. Thus in the public telegraph field today the total volume of traffic in Australia is greater than in the United Kingdom or in West Germany, even though on a population basis Australia is so much smaller than these countries.

The specialised requirements of such groups as the press, the defence services, the shipping and banking industries, and later the aviation industry also became apparent at an early stage and soon resulted in the establishment of private wire leased networks covering great distances. The development of these subscriber operated services convincingly demonstrated that the telegraph needs of large sections of the community, particularly in the business field, could be met more economically and with greater satisfaction to the subscriber in this way than through the public telegraph network. Consequently, effort was directed toward making subscriber operated telegraph service more readily available, even down to the quite small user, and at first the short period "part-time" leased service and later the telex service were established to meet this need. In recent years, press requirements for the transmission of pictures have led to the establishment of a phototelegram network, and the facsimile transmission technique has also been exploited for the transmission of weather maps, and for business document facsimile service.

In this article a general survey is made of Australian telegraph engineering practices in the four main fields of telegraphy, namely public telegraph, leased private wire, telex, and facsimile service.

HISTORICAL

The first commercial electric telegraph service in Australia was established between Melbourne and Williamstown and opened to public traffic on March 3, 1854. This was just 10 years after the opening of the first electric telegraph service in the world between Washington and Baltimore, U.S.A. Services were opened in the other colonies (now States) in order of South Australia 1856, Tasmania 1857, New South Wales 1858, Queensland 1861 and Western Australia 1862.

The first inter-colonial line was that opened between Melbourne and Adelaide in July, 1858. It was routed from Melbourne to Mount Gambier (338 miles) via Geelong, Ballarat, Beaufort, Warrnambool and Portland. At Mount Gambier, traffic was manually repeated into the section to Adelaide (320 miles) which was routed via Robe and Goolwa. The line was worked on closed circuit morse, and under favourable conditions, the two sections were joined together at Mount Gambier, thereby avoiding the manual repetition of the messages. The second inter-colonial line was that connecting Melbourne with Sydney. This was opened in October, 1858, and the messages were manually repeated at Albury, which is 200 and 400 miles distant from Melbourne and Sydney respectively.

A submarine cable laid in 1858 between Tasmania and the mainland had only a short life of a few months, and it was not until 1869 that a permanent link was established. Brisbane and Sydney were linked in 1861 with manual repetition at Tenterfield. A direct Adelaide-Sydney line was opened in 1867 with manual repetition at Wentworth by separate South Australian and New South Wales staffs.

December, 1877, saw the opening of the Adelaide-Perth line which was 1,986 miles long. Manual repetition of the messages took place at Eucla where separate staffs employed by the two colonies were housed. After initial operation on closed circuit morse, the two sections were operated on the open circuit principle because of its greater stability under poor insulation conditions which were prevalent on this coastal route. Automatic repeaters were operated at Port Augusta, Port Lincoln, Streaky Bay, Fowler's Bay, Eyre's Sandpatch, Israelite Bay, Esperance, Bremer and Albany. In 1894 the line was converted to duplex operation, and the repeater stations at Port Augusta, Eyre's Sandpatch, Esperance and Bremer were no longer necessary.

Australia was joined, telegraphically, to the rest of the world by a cable landed at Darwin in 1871. This was the fruition of hopes and plans laid as far back as 1857. Telegraph traffic was not commenced until 1872 when the 1,975 mile line connecting Darwin to Adelaide was completed, thereby linking London to the Australian telegraph network. From the time the cable was operative at Darwin to when the land line was completed, a period of approximately nine months, the ever decreasing gap in the land line was bridged by a horse express service carrying the messages.

Commencing in 1904, telegraph lines were paired together to provide trunk telephone service to country towns, and telegraph channels were derived on these trunks by such means as cailho and composite sets. Wheatstone machine working was introduced successfully in 1907 on various main routes to replace the manual quadruplex operation which had been first introduced in 1876. Strangely enough the quadruplex had, at that date, replaced the Wheatstone system which had been tried unsuccessfully for the previous two years. Wheatstone operation was improved with the introduction of the Creed morse reperforators and printers in 1912 and continued in limited use for about another 40 years. Morse tape relaying of messages at Adelaide eliminated manual repetition of traffic between Western Australia and the eastern States. 1922 saw the advent of the Murray Multiplex system which carried the bulk of interstate traffic and some country traffic for the following thirty years. At the same time the five unit start stop code Model 12 Teletype was introduced on a number of the heavier country services.

Western Electric Type B carrier telegraph systems were introduced commencing in 1927, and these provided main interstate channels until they were abandoned in the mid 1940's. The first 18-channel voice frequency telegraph system was placed in service between Sydney and Tamworth in 1935. These types of systems have continued to expand until today there are 1,784 channels provided by this means.

Private wire teleprinter services for commercial and government organizations were introduced in 1934 using simple page printing equipment. These services have proved to be very popular until today there are 1,952 teleprinters in operation on all classes of private wire systems. These range from simple point to point page printer services, to manual teleprinter switchboard networks, and tape relay systems both manual and semi-automatic with push button controlled switching. The earliest machines used on private wire service were the Creed Model 7 and 8 page teleprinters. Model 15 and 19 page Teletypes were introduced in 1942, and Model 14 Teletype tape transmitters and printing reperforators were introduced in 1943. These machines continued to be standard for private wire use until the Siemens and Halske Model 100 page teleprinters, the T loch 15 printing reperforators, and the T Send 77 tape transmitters were introduced in 1960. 112,000 miles of channel are in use in providing private wire teleprinter services in Australia.

Telex service was inaugurated in 1954 and has continued to expand at a rapid rate until there are now 1,679 machines connected to the service. These machines are almost entirely Siemens and Halske Model 100 teleprinters.

Picturegram service was made available between Melbourne and Sydney in 1929 using Siemens-Karolus equipment and this continued in operation until 1942. The service was recommenced in 1949 using Muirhead-Jarvis equipment and extended to Brisbane, Adelaide, Perth, Hobart, Canberra and Newcastle.

An extensive network of Muirhead equipment was commenced in 1957 to transmit weather maps to all major aerodromes and weather bureaux. Also using Muirhead equipment, message

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* See page 169.

facsimile service was introduced in 1959 for commercial and government organizations. 8,000 miles of channels are in permanent facsimile service.

GENERAL PROBLEMS

Many of the problems and special features of telegraph practice in Australia arise from the large size of the continent, the small population, and the distribution of population, which have been referred to in other articles in this issue. The area of Australia is about 3,000,000 square miles with a population of only about 11,000,000 persons, and the average population density is very low. However, there are also large cities, in particular Sydney and Melbourne, each of which has a population exceeding 2,000,000 persons. The telegraph engineering problems associated with the large cities are basically the same as those encountered elsewhere in the world under similar conditions, but Australia also has telegraph engineering problems because of transmission over very long distances through very sparsely populated areas. Major cities are being linked by coaxial cable and micro-wave radio systems, but a high proportion of Australian telegraph channels are provided by carrier systems on open wire lines and this will remain the case for a considerable period of years. Natural hazards to which lines are subjected include (depending on the part of the country concerned) floods, bushfires, cyclones and lightning. In particular the northern part of Australia (including Darwin) which being lightly populated and remote from major centres of population depends very largely on communications over open wire lines, has a thunderstorm and lightning activity which is one of the highest in the world.

Beyond the limits to which it is practicable, because of cost, to extend telegraph service by wire line, radio transmission is employed. Some such radio telegraph services are provided and operated by the Postmaster-General's Department but a much greater use of radio in association with the public telegraph system is in the Outpost radio communication system. In this system, base or control stations, which are provided and operated by bodies such as the Royal Flying Doctor Service, work with outpost stations provided and operated by pastoralists, mineral prospectors and others living remote from towns. This system has been referred to briefly in several other articles in this issue. Access to the public telephone network for these groups of outpost stations is available through the appropriate base station and over 300,000 telegrams are handled each year by this means. A detailed discussion of this system is beyond the scope of this article and further information on it is given in Reference 1.

TYPES OF PLANT USED

Public Traffic

The message switching network for public traffic uses as its basic storage and retransmission medium the Siemens and Halske T loch 15a reperforator-retransmitter. This machine, which is illustrated in Fig. 1, operates on the well-known start-stop principle, the start pulse of the signal arriving from the distant end releasing the receiver shaft which is coupled to the drive for a one revolution operation. During this revolution the five intelligence pulses are registered and mechanically stored in five setting members. Just before the end of the revolution the receiver shaft sets the printer in motion and the stored code group is printed and punched into a paper tape. After about a quarter revolution of the printer shaft, a clutch will engage the tape feed shaft which, in the course of one revolution, feeds the tape along by one character space and is subsequently stopped in its rest position.

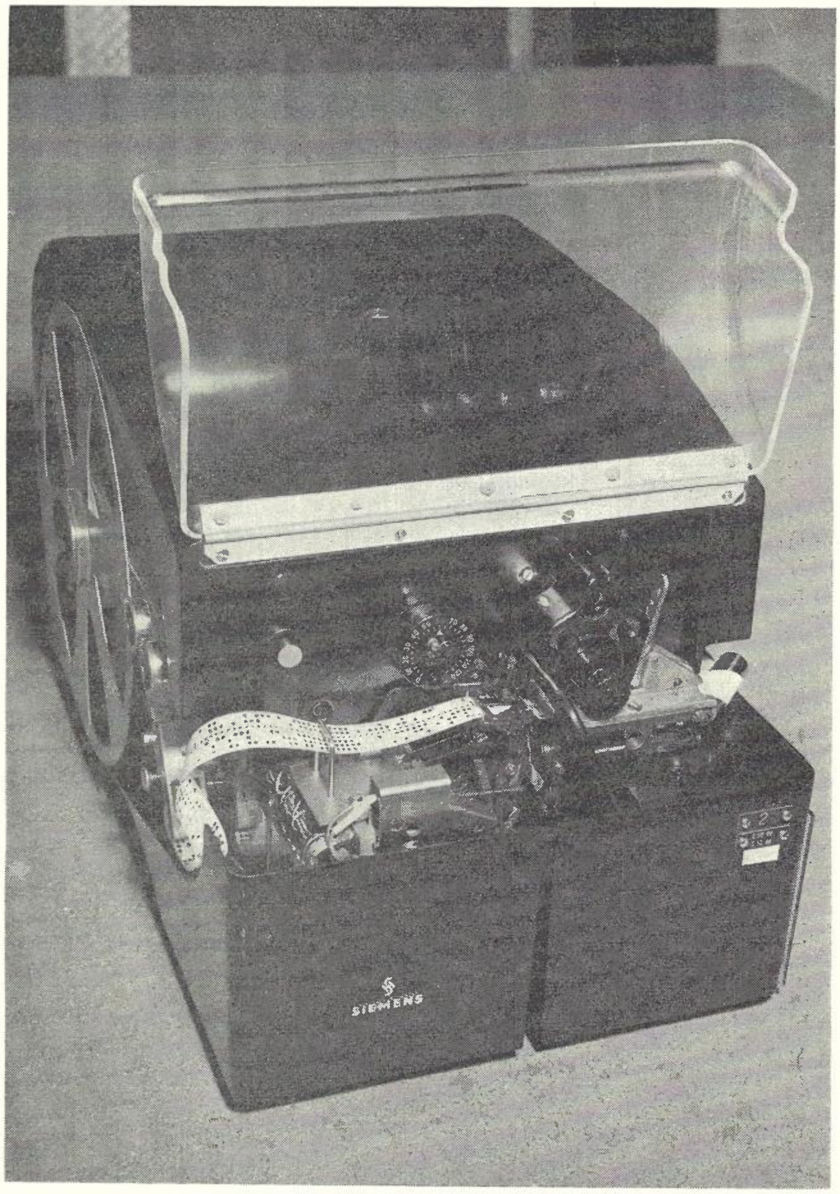


Fig. 1.—Reperforator-retransmitter, Siemens & Halske T loch 15a.

For the retransmission of the message stored in the perforated tape, the latter is introduced into the pivoted sensing unit. An externally supplied tripping pulse causes the transmitter shaft, associated with the sensing unit, to be coupled with the drive shaft for the duration of one revolution. During this cycle the tape is fed along in the sensing unit, the five code elements stored in the tape are sensed simultaneously and the five transfer contacts set accordingly. The latter are connected with the five distributor contacts over five separate wires. Before the transmitter shaft is again arrested, it will operate the clutch of the distributor cam shaft. In the course of the revolution of the distributor shaft, the start pulse (no current pulse), the five intelligence bearing pulses and, finally the stop pulse (current pulse) will be transmitted. Following this the distributor shaft will again be arrested.

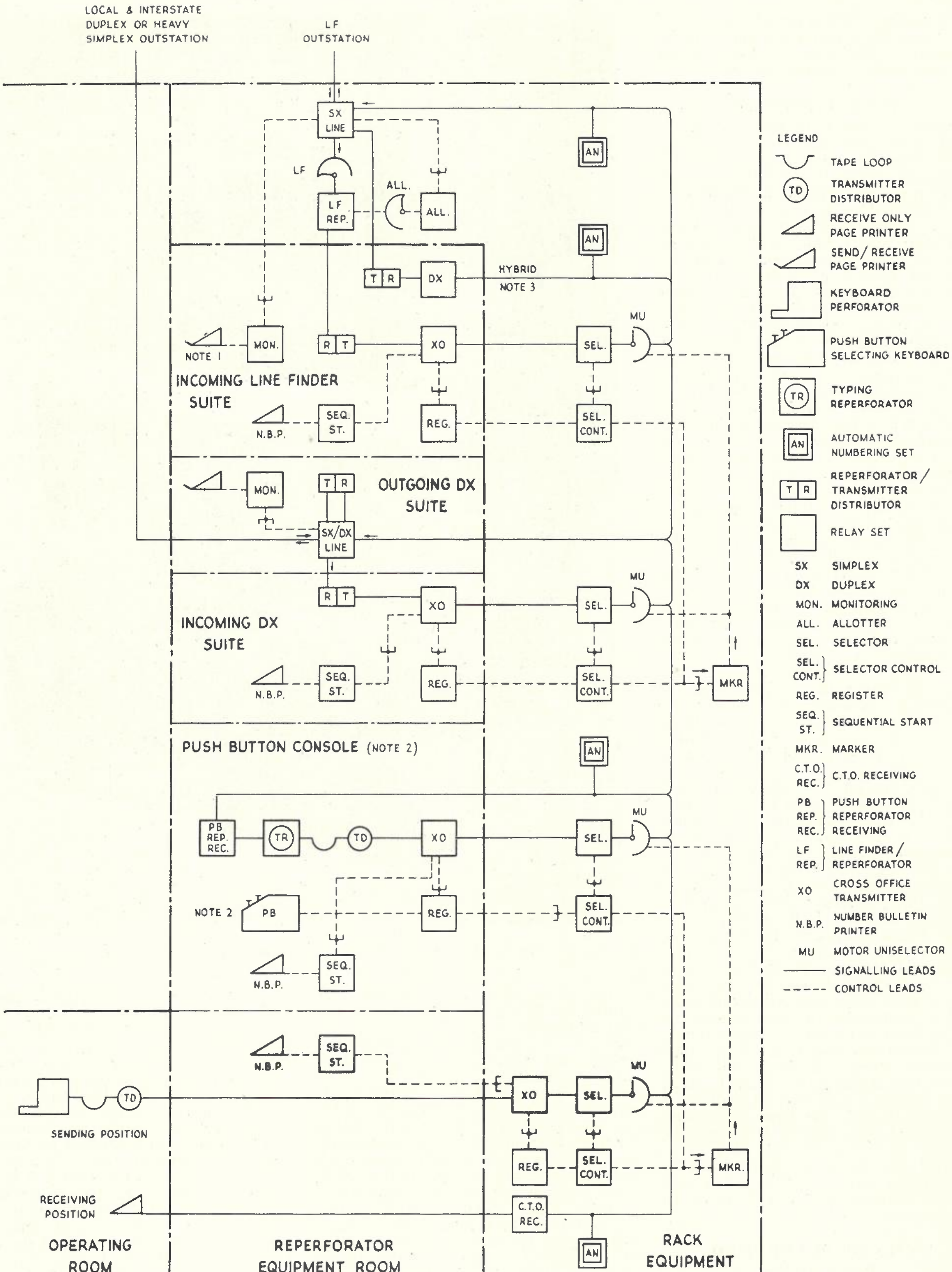


Fig. 2.—Teleprinter Reperforator Switching System—Block Schematic.

Notes: 1. Monitor machine normally consists of keyboard in number bulletin printer together with a tapeprinter or typing reperforator for receiving.
2. Push button console used for emergency storage only.
3. Line finder line with storage on incoming side (hybrid).

The tape transmitting mechanism on this machine is arranged so that the last character reperforated can be transmitted, thus avoiding the necessity for feeding out tape at the end of a message to allow the last characters to reach the transmitter. The T loch 15a reperforator fully perforates the message tape as well as providing a printed record on the tape. It also incorporates a tape winding mechanism which winds up the message tape onto a reel as it passes from the transmitter.

The following facilities are also incorporated in the machine, facilitating switching system design:

(1) Auxiliary contacts on the transmitter and on the reperforator for detecting "end of message" signals.
(2) Alarm contacts to indicate that the tape supply is low, tape is exhausted, or is torn when passing through the transmitter.
(3) A motor control relay to facilitate external control of motor power.
(4) Additional contacts operated from the reperforator, transmitter or distributor shafts to perform switching or control functions.

Fig. 2 illustrates the general principle of operation of the teleprinter reperforator switching system. Referring to this figure it will be noted that there are several different line arrangements, these depending upon the originating point and loading. These may be classified as:

(1) Heavily loaded lines which use simplex/duplex terminations (for offices with busy hour loads exceeding 70 messages or for long country lines with busy hour loadings of 40-70 messages). Each terminal consists of a relay set with which is associated two reperforator retransmitters. The incoming reperforator-retransmitter receives messages from the outstation and retransmits these via a cross office circuit to a selected outgoing line. The outgoing reperforator-retransmitter receives messages via its cross-office circuit and retransmits these to the line.
(2) Lightly loaded lines which handle less than 30 messages per hour; these are connected as simplex lines in groups to a smaller number of reperforator-retransmitters via line finders, normally providing access from 25 lines into 10 reperforator-retransmitters. A Tress line finder suite is shown in Fig. 3, the suite including number bulletin printer and supervisory facilities. Printed service signals are automatically sent indicating that access to a store has been obtained, and at the end of message that the message has been "received O.K."
(3) Local send positions which handle traffic originated at the Central Telegraph Office by perforating tape on a keyboard perforator, the tape passing directly to a tape transmitter. The tape transmitter sends direct into a cross-office circuit. Messages destined for the Central Telegraph Office are received on page printers at receiving positions. No outgoing reperforator-retransmitters are employed, transmission being from cross-office circuits direct into the printers via repeating relays in the receive relay sets.
(4) Interstate lines which are divided into two groups on each route, one group carrying messages destined for Central Telegraph Office delivery and the other group handling messages destined for all other offices. All lines terminate on simplex/duplex terminals but traffic from the first group is received directly on page printers in the Central Telegraph Office receiving section. On the outgoing side each interstate message is reperforated in the reperforator-retransmitter and then retransmitted via the associated outgoing line to the selected interstate switching centre.

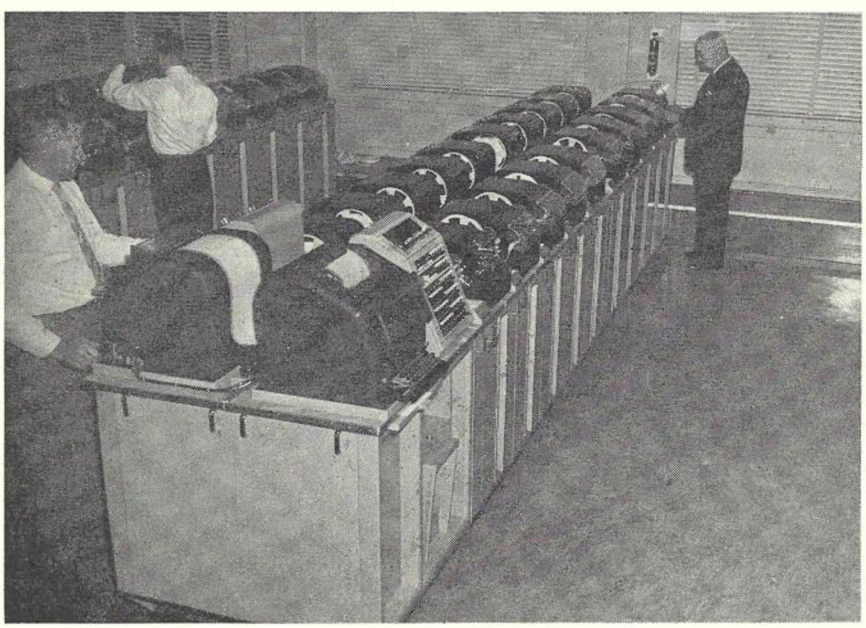


Fig. 3.—Tress Line Finder Suite.

The operating procedure requires that an outstation operator may transmit any number of signals such as "Letters", "Carriage Return", etc., to page-up his printer as required, but that the Tress equipment will not act upon this until a "Space" (3rd marking) is sent as a "beginning of message" signal. This must be followed by three characters, the first character representing the destination state, and the second and third identifying the office of destination and representing 676 possible destinations. An originating message route serial number (including station identifying letters) follows with a succeeding "=" sign [Figs. V (combination 22)]. The message concludes with page-up "line-feed" signals as required and the "+" signal (Figs. Z).

As an example, if the 123rd message from Ballarat (VBA) on a particular day is addressed to Geelong (VGE), the preamble from Ballarat would commence:—

(Space) VGE (Space) VBA (Figs.) 123 =
Ballarat 10.30 a etc.

As a message is reperforated on tape, this tape advances through the associated transmitter until the "beginning of message" signal is read.

The transmitter immediately stops and calls for a register, common to a group of 10 circuits. The register, when free, connects itself to this transmitter and causes it to step until the routing signal is read. The register stores this information and calls for a marker common to a group of registers. When the marker is free, it connects itself to the register, reads the stored switching information and marks the required outlet on the selector switch associated with the calling transmitter. The switch then hunts to the marked outlet and frees the marker and the register from the connection. Automatic message logging is achieved at the Tress centre, each message being numbered by the outstation operator in sending and automatically numbered on the circuit established from the storage machine transmitter to the office of destination, both numbers being recorded on a "number bulletin printer" common to a group of cross-office transmitters.

The basic switch used in the design is the Siemens Henley motor uniselector (2), the switching relays used being of the British Post Office 3,000 type (3). The telegraph signalling relay used is the T.M.C. Carpenter type 4 relay (4), this relay conveniently mounting in the same relay set frame punchings as a 3,000 type relay. Printed service signal generation is achieved via relay type programme trees, utilising the Siemens and Halske T Send 73 for the basic character generation cycle. All switching and signalling equipment is designed to operate from ± 50 Volt D.C. battery supplies.

All the telegraph machine equipment used for switching and reperforating functions was manufactured in Germany by Siemens and Halske A.G. Certain

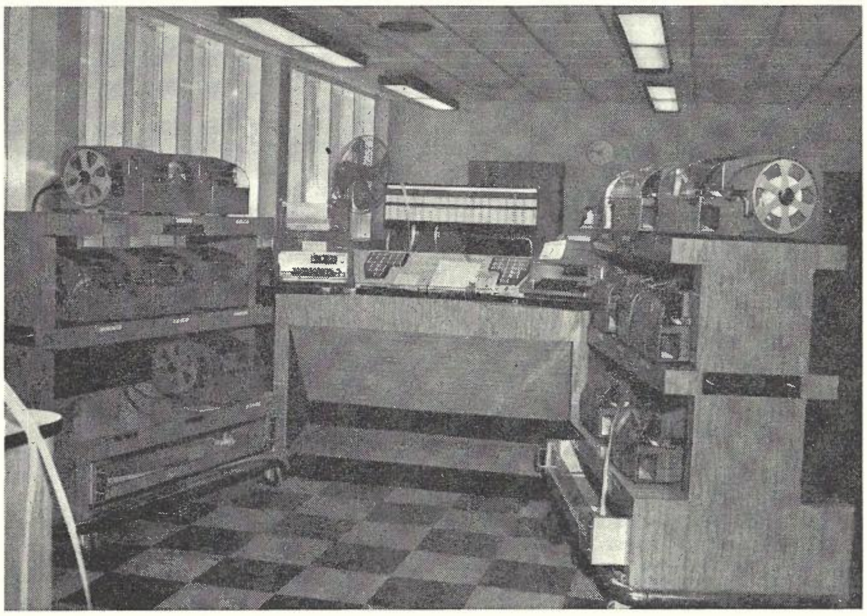


Fig. 4.—Semi-automatic Private Wire Message Relay Office.

of the functions and facilities on these machines were provided to meet the specific conditions of usage in the Tress system. All switching equipment, relay sets and consoles were manufactured in Australia.

Private-Wire Services

The private wire field referred to earlier is a very diverse one, ranging from simple point to point teleprinter services to medium size circuit switching systems, and medium size semi-automatic message relay systems. The private wire direct switching services use manual equipment identical with that in the telex service while the message relay systems operate basically on the "torn-tape" principle with special features for multi-address or broadcast traffic, and automatic numbering facilities. For example, in one design the operator places the messages received in tape form in a transmitter and after key selection of the line, or lines, to which the message is to be sent, operates a common "start" pushbutton. Lamps associated with each line indicate whether the line is busy or out of service, but it is not necessary to wait until lines are free before selection. From this stage the operation is automatic. The lines are checked to determine whether they are free (that is, no other transmitter in the office is connected to any of the lines selected) or in the case of a simplex line that no message is being received from that line. Should more than one broadcast transmitter be calling the same line or lines, the lines are tested sequentially from each transmitter to ensure that only one transmitter can be connected to any line at any one time. When all selected lines are free, transmission of the message commences and continues until the end of tape passes through the transmitter. A range of additional facilities is available, including page or tape monitoring of the broadcast or monitoring on each outstation line, automatic sequential numbering of individual messages on each outgoing line, automatic time of day insertion on each message, automatic check message operation to idle lines at predetermined intervals, line operating options such as simplex, duplex or omnibus working, and "flip-flop" operation of message centre tape transmitters with facilities for batch sending, or alternatively for access by other transmitters to a particular line at the end of the message from the working transmitter of the "flip-flop" connected transmitters. A semi-automatic relay centre with some of these facilities is illustrated in Fig. 4.

Telex Service

In the telex field, although cutover to automatic operation is planned for 1965, the existing network of approximately 1,600 subscribers is entirely manually switched. Previous articles in this *Journal* (5, 6) have outlined the development of the manual telex system. In 1960 a new terminal machine, basically chosen for use in the automatised telex service, was introduced into the telex network, and subscribers' terminal units were designed for compatible manual or automatic operation. Fig. 5 illustrates the machine, the Siemens and Halske Teleprinter Model 100. The entire network is now equipped with Model 100 teleprinters with the exception of a few machines used in special defence applications. Fig. 5 also shows the control unit fitted to the machine via a connector at the rear of the machine, "call" and "clear" keys being an integral part of the machine itself. This machine, of modern low maintenance design and of pleasing appearance, is particularly suited to telex operation. It has the following important optional features which are additional or alternative to those of the basic page machine:

(a) Tape reperforation.
(b) Tape transmission.
(c) Paper supervision.
(d) Repeat space tabulation.
(e) Sprocket feed paper feeding.
(f) Code selection contact operation.

The first two attachments are of particular importance to business organisations with a large volume of teleprinter traffic since they permit operation with perforated tape, which allows transmission at maximum speed with an appreciable reduction in message charges due to the shorter transmission time. In addition, incoming messages may be not only printed but also perforated for subsequent retransmission or for off-line processing, in the latter case the

Fig. 5.—Siemens & Halske Teleprinter Model 100 with Terminal Control Unit.

telex link often being used for data interchange. It is interesting to note that more than 50% of all subscribers are equipped with tape reperforation and tape transmission attachments. This subscriber preference, which compares with a figure of 10-15% in well developed European telex networks, is thought to reflect the predominance of long distance, high rate traffic in the Australian system. A recent survey, which for comparison purposes, also lists telephone traffic, is summarised in Table 1.

TABLE 1: DISTRIBUTION OF NATIONAL TELEX TRAFFIC WITH DISTANCE

Mileage Categories	Telephone Traffic	Telex Traffic	Telex Revenue
0-50	97.5%	7.5%	0.5%
50-100	1.25%	5.0%	1.5%
100-200	0.70%	5.0%	2.5%
200-400	0.30%	6.5%	5.5%
Over 400	0.25%	76.0%	90.0%

International traffic, which in Australia's case is of course entirely high rate intercontinental traffic, is another influence. More than 10% of all telex traffic originated by Australian subscribers is international traffic, mainly to Japan, the United Kingdom and the United States of America.

Facsimile Service

Exploitation of the facsimile field falls into three distinct fields. The first of these, phototelegraphy for the high quality transmission of pictorial information, is well developed with an integrated network of Departmentally-operated and privately-operated transmitters and receivers. An article in an earlier issue of this *Journal* (7) has described the Muirhead-Jarvis equipment in public service in Sydney, Melbourne, Brisbane, Adelaide, Perth, Hobart, Canberra and Newcastle. Supplementing this equipment is a group of Muirhead D-601-A type portable transmitters, these being used flexibly to establish phototelegraph service at points of immediate newspaper interest. Most of the newspaper groups also own equipment, all units being to C.C.I.T.T. recommendations, and connected to permit complete freedom of interconnection. International phototelegram service is provided through the Overseas Telecommunications Commission (Australia), a feature of this traffic inward to Australia being the high percentage of multi-address traffic. For this traffic the international channel at the gateway point feeds interstate channels, enabling simultaneous reception at all points.

The second field which is also well developed is the weather facsimile services. In association with the Commonwealth Bureau of Meteorology the Department provides weather facsimile service to some 30 locations, covering all Australian States and feeding radio transmitters broadcasting weather facsimile signals. All of the terminal equipment was purchased from Muirheads Ltd., England, and has provided highly reliable service since commencement more than five years ago.

The third field in which there has been small development so far is the business message facsimile service. This is established in a small way in the leased private wire field, the largest network being that provided for local distribution and collection of information by the Australian international airline Qantas, the service centring on the Mascot, Sydney, aerodrome. Internal airlines have small leased services in several States. All of the equipment used was again supplied by Muirheads Ltd.

Field trials in the public telegram field of lower quality equipment from various manufacturers, specially designed for cheap telegram pick-up and delivery, have proved this type of service to be uneconomic. Although the quality obtained was equivalent to that obtained in working services in some countries, the service did not gain acceptance from operating staff. In this country all Post Offices provide telegraph facilities and the widespread availability of these collection points reduces the economic incentive toward telegram facsimile service that exists in some other countries. In these countries the telegraph service is separated from the postal service or is a privately-owned utility, and the cost of establishing collection points is high. In such countries the provision of facsimile service operated by the subscriber in hotels, banks and other business offices tends to defer the need for establishment of telegraph offices.

DESIGN AND PROCUREMENT

The existing telegraph services in Australia have been entirely designed by the Postmaster-General's Depart-

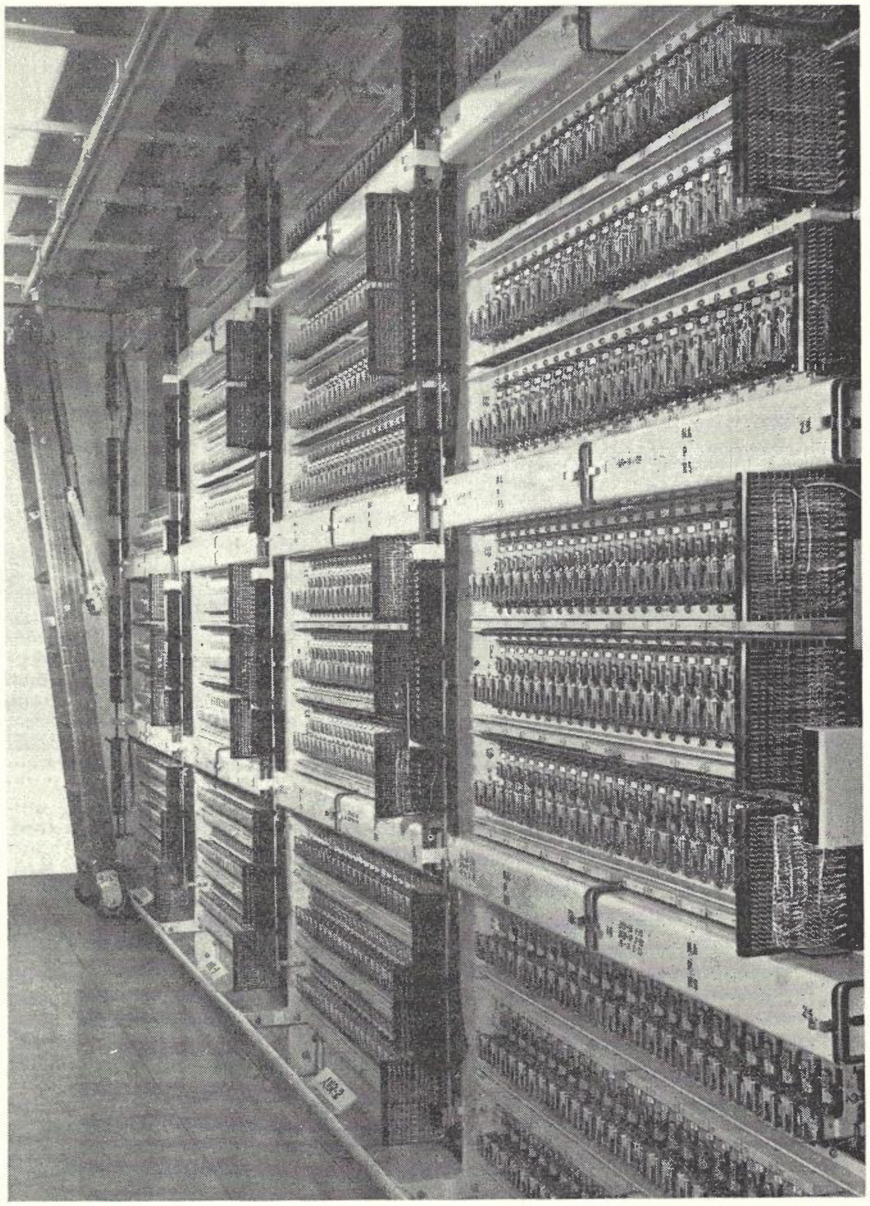


Fig. 6.—Typical Recent Telegraph Switching Equipment Installation.

ment, although Australian thinking has of course been coloured by practice in other countries. The major components such as teleprinters, switches, signalling relays, switching relays and other items are purchased on a world market. The Tress system owes much to the Western Union message switching system, and the manual telex system follows manual switching practice drawn from telephony and adapted to the different subscriber and operator instrument (the teleprinter) and the limitation to two condition signalling on trunk telegraph channels. In planning the automatisation of the telex network, however, it was decided to explore the possibility of purchasing a complete system from an equipment supplier and tenders were sought for a system closely specified as to facilities. Telegraph machines have been purchased from established machine manufacturers against specifications which are largely based upon best current practice, and which do not attempt to control the direction of machine design, although preference for particular arrangements of facilities is usually stated.

A strong effort has been made in recent years to reduce Australian dependence upon imported components, and recent contracts incorporate agreements for progressively increasing percentages of Australian production. Under these agreements manufacturers have been induced to set up factories to manufacture or part manufacture in Australia. As an example Siemens and Halske has estabilshed a factory at Richmond, Victoria, which, among other things, part manufactures the basic telex teleprinter, the Model 100. L M Ericsson is establishing a factory at Broadmeadows, Victoria, which will part manufacture automatic telex equipment as well as other similar equipment for trunk telephone switching.

Rack equipment and relay sets designed by the Postmaster-General's Department are purchased on an open tender basis from the well established Australian telecommunication manufacturing industry and from the Department's workshops.

INSTALLATION

Installation has in general always been carried out by Departmental staff, although the automatic telex equipment now under contract with L M Ericsson will be installed by that firm. Installation practices in the telegraph field have closely followed those in the telephone field and in recent years have been the well known British Post Office 2,000 type equipment installation practice. For example Fig. 6 shows part of a recent telegraph switching equipment installation. The automatic telex installation will of course follow normal L M Ericsson crossbar installation practice, as used in telephone crossbar installations.

FUTURE TRENDS

At present total traffic handled by the public system (Tress) is stable at approximately 21.6 million messages per annum and is expected to tend to decline rather than increase. Automatisation in the public traffic field is virtually complete and within the Commonwealth little change is anticipated in traffic handling methods. There are several fringe problems affecting particular classes of traffic which are being examined. These are:

(a) Transfer of traffic from the national message switching public telegraph system to an international system through the Australian international operator, the Overseas Telecommunications Commission (Australia). In the 1961-62 financial year 1.43 million messages which originated from the Department's Telegraph Offices were for destinations outside Australia, and 1.41 million telegrams were received from overseas originators. Problems of automatic format conversion, and operating procedure problems affecting special classes of international traffic are important aspects of this problem. C.C.I.T.T. study of the conditions to be recommended for message relay in the international field is not yet complete, and Australian efforts so far have been directed toward reaching agreement at the C.C.I.T.T. meetings.

(b) Transfer of traffic from the message switching public telegraph system to the telex system, and vice versa. Contrary to European experience this class of traffic, referred to as printergram traffic, is an important component of both telex and public traffic. In the last financial year almost three million telegrams were transferred between systems. At present this traffic is handled substantially by manual relay methods. As an example of the volume of this traffic, there are 37 page printers operating on printergram reception or delivery in Sydney. Automatic transfer methods are being examined to reduce the cost of transfer.

(c) Transfer of traffic from the message switching public telegraph system to the leased meteorological network. Post Offices throughout Australia are used as weather recording points, reporting by telegram over the public traffic system, while the leased network disseminates this and other information coming in from meteorological forecasting points to forecasting centres all over the Commonwealth. The present manual transfer is being replaced by automatic transfer, with the intention eventually of automatically switching from the public message network to and through a meteorological leased message switching network.

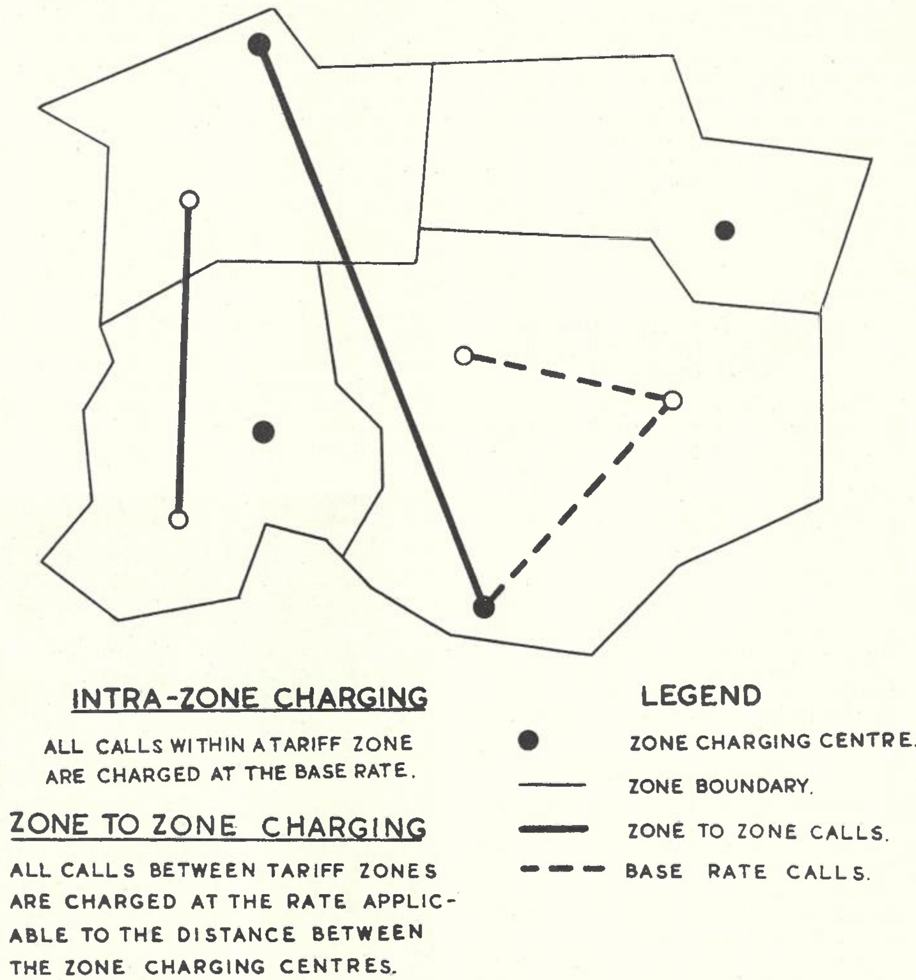


Fig. 7.—Automatic Telex Charging Principle.

In the private wire field the future seems to point toward more advanced message switching systems for large users, notably the various airlines. The present semi-automatic basically "torn-tape" systems are flexible and well adapted to the present traffic loads but in this field traffic loads are rising sharply. Airline traffic often has special problems such as fixed format requirements on one or more routes to accord with an international message switching centre requirement, a high degree of multi-address traffic, very pronounced peaks of traffic coupled with stringent message delay limits, a large number of separate traffic priorities, and high security requirements. The development of computer oriented message switching systems is interesting in this respect, and the advent of magnetic reusable storage methods in this type of system and other more conventional systems offers great operating advantages. At present paper tape storage systems are considerably cheaper but this advantage may not be maintained to the same extent in future years.

A new class of traffic, data traffic, is of course exciting attention in the private wire field all over the world, and one large data network for defence purposes is already in the advanced planning stage and will be introduced within a few months. Development is also expected in a special data field, that of airline reservation systems, requirements in this respect possibly being linked with the more advanced message relay possibilities referred to previously.

In the telex field the immediate objective is to automatise the existing manual network, and contracts have been placed with L M Ericsson for more than 3,000 lines of subscriber switching equipment. The system will use C.C.I.T.T. type B trunk signalling with keyboard selection and will use common control switching methods using the L M Ericsson crossbar switch for switching purposes. Printed service signals will be an integral part of the system and provision is made for remote tariffing of long distance connected subscribers and for subscriber classification. The system of numbering decided upon is a Commonwealth-wide five digit closed numbering scheme, and route selection in a transit exchange may use up to the fourth or D digit. The method of call charging on all calls will be multi-metering by the Karlsson method, that is, by the use of randomly phased time pulses. The Commonwealth will be divided into 44 tariff zones, each of these being allotted up to two digits, that is the A, B digits. All calls within a tariff zone are charged at the base rate, all calls between tariff zones being charged at the rate applicable to the distance between the zone charging centres. Fig. 7 illustrates the principle of charging. Four charging rates will be used in distance categories of less than 100 miles, 100 to 200 miles, 200 to 400 miles, and greater than 400 miles.

It is proposed to describe the system in more detail in a later issue of this *Journal,* but it is appropriate here to point out that the telex service is expanding at a very rapid rate even though still a manual network, and a development to 11,000 subscribers by 1980 is predicted. In the last financial year for which records are available the number of subscribers rose by 24.5%, while the number of calls rose by 43% and paid call minutes by 44%. The average number of calls originated per subscriber rose by 21% from 580 to 702. International telex calls rose by 31.3%. Subscriber operated service, such as the telex service offers, appears to be the most profitable way of meeting telegraph transmission and data transmission needs for the many moderate to small users in this country, and much of the telegraph engineering effort in Australia during the next five years will be devoted toward Commonwealth-wide establishment of a modern, efficient, automatic network.

MAINTENANCE

With the exception of equipment terminating international circuits in the offices of the Overseas Telecommunication Commission, and equipment in some defence establishments, all telegraph equipment on line service in Australia is maintained by the technical staff of the Postmaster-General's Department. Traditionally, this activity involved a high proportion of precision manufacture and fitting of parts, and regular inspection, lubrication and overhaul routines based on fixed time schedules irrespective of the amount of use of the equipment. However, sensing the potential demand for telegraph services and the difficulties and expense of recruiting staff with these traditional skills at a commensurate rate to the development, together with the fact that modern, precision telegraph machines could be maintained on a direct parts replacement basis, the Administration decided on a change in the maintenance processes in 1954. Routine inspections and lubrication are now based on variable time schedules related to the use of the machines. Overhauls are rarely performed even on the oldest equipment.

This change in practice has had two striking effects; firstly, the rate of fault occurrence has been reduced to 60% of that obtaining previously, and secondly, staff of the same numerical strength are now installing and maintaining nearly four times as much plant as they were a decade previously. This is shown in Fig. 8. It is a tribute to the integrity and skill of our technical staff that they have accepted these changes willingly.

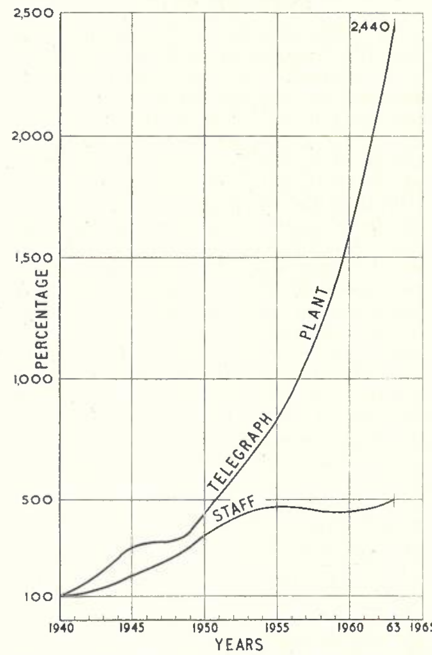


Fig. 8.—Telegraph Plant and Staff Development.

REFERENCES

1. L. F. Pearson, "The Australian Outpost Radio Communication System"; Telecommunication Journal of Aust., Vol. 13, No. 6, page 456.

2. C. L. Hosking, "The Melbourne Trunk Exchange"; Telecommunication Journal of Aust., Vol. 3, No. 5, page 280.

3. H. M. Aitchison, "Design Features of the 3,000 Type Relay"; Telecommunication Journal of Aust., Vol. 9, No. 3, page 166.

4. H. A. Turner and B. Scott, "A Polarised Relay of Improved Performance"; Post Office Electrical Engineers' Journal, Vol. 43, Pt. II, page 85.

5. R. D. Kerr, "Some Aspects of Teleprinter Switching"; Telecommunication Journal of Aust., Vol. 9, No. 3, page 129.

6. R. K. McKinnon and D. Y. McFadden, "The Development of Teleprinter Exchange Service in Australia"; Telecommunication Journal of Aust., Vol. 11, No. 4, page 108.

7. R. D. Kerr, "Picture Telegraphy"; Telecommunication Journal of Aust., Vol. 8, No. 1, page 2.

THE RESEARCH LABORATORIES OF THE POSTMASTER-GENERAL'S DEPARTMENT

*L. M. HARRIS, B.Sc.**

INTRODUCTION

In spite of the large resources of scientific manpower and facilities that are devoted to telecommunications research in overseas countries, the Postmaster-General's Department has found it advantageous to maintain its own independent research and development group so that it is in a position to contribute to its own technical advancement in those areas where overseas research and development or local industrial development does not adequately meet the needs of the Administration. The Laboratories must of course be geared to the resources available on the one hand, and to the unsatisfied needs of the Department on the other. This means that the Laboratories do not attempt to carry out research that can be done more effectively elsewhere, nor attempt to develop systems or apparatus if suitable items are available for purchase from commercial sources at economic rates. It does mean however, as experience has shown, that there are many areas where research and development effort is necessary by the Department, and its Research Laboratories have the responsibility to provide this effort.

* See page 169.

GENERAL RESPONSIBILITIES

Briefly the functions of the Laboratories are as follows:

(i) To conduct research and development work with the aim of developing telecommunications theory and practice, as applying in particular to Australian conditions.

(ii) To develop and design forms of telecommunication or mail-handling plant suitable for use in Australia, in collaboration with user groups.

(iii) To collaborate with planning and design groups in Engineering and other Divisions in appraising world-wide developments, and in keeping abreast of prospective developments; adaptation and introduction of Laboratories developments into service, including field trials.

(iv) To provide other groups with services calling for a scientific approach or laboratory back-up or specialised testing facilities; to provide the Departmental reference standards, and a scientific and engineering consultative service, including patent, information and library services.

(v) To participate in the work of national or international organisations or committees associated with telecommunications research.

Broadly speaking these functions have not been changed in principle since the Laboratories were founded in 1923 as part of the Headquarters Engineering Division, and mean that the Laboratories have the responsibility to maintain a position at the forefront of knowledge in communication techniques and, from this position, to advise and assist the Department on advances in communications technology. Naturally, over the years, there have been radical changes in emphasis of their activities; for example, two of the early responsibilities of the Laboratories were to provide the scientific and engineering background necessary for the successful introduction of voice frequency

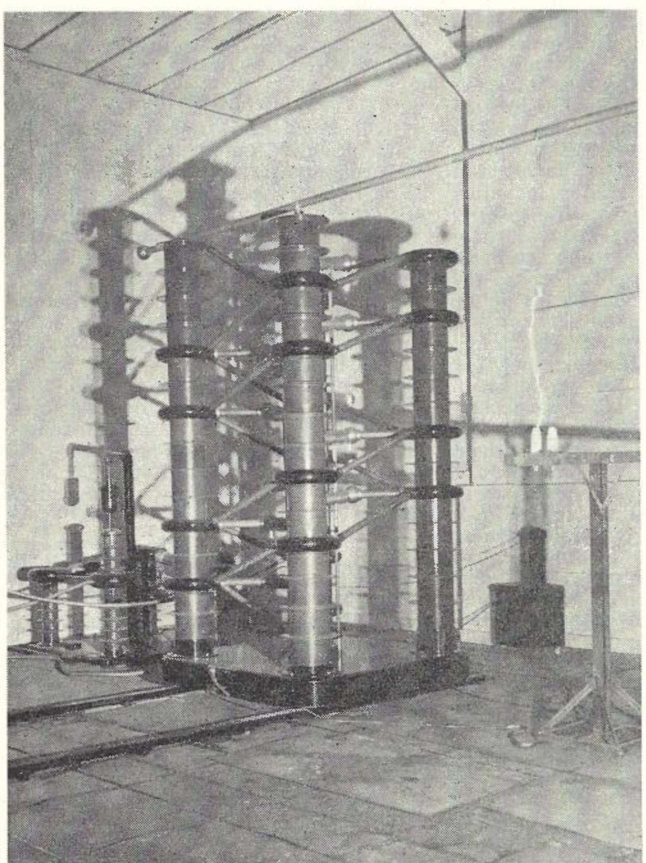


Fig. 1.—1 M.V. Impulse Generator used in Studies of Lightning Protection.

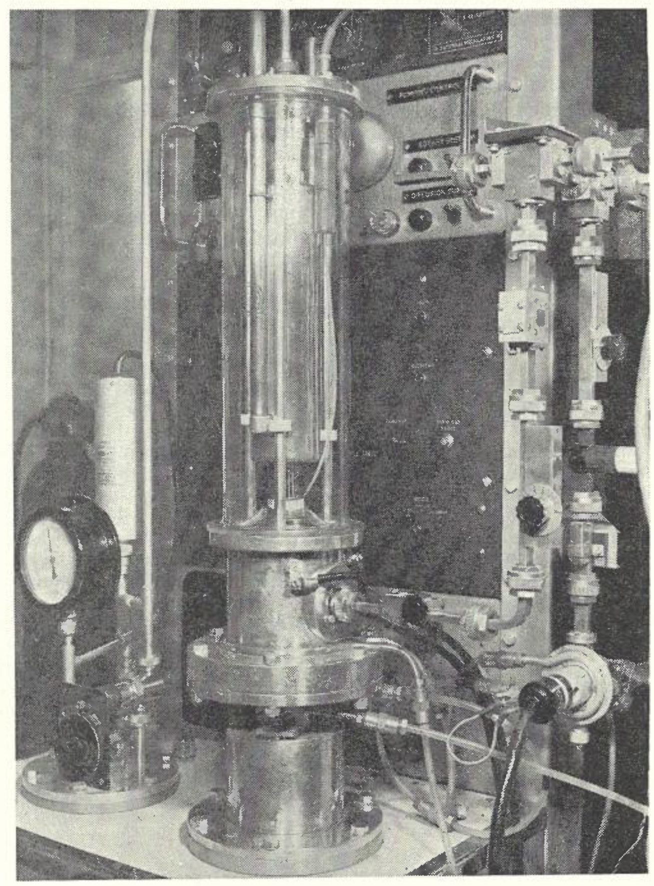


Fig. 2.—Ammonia Gas Maser. A precision oscillator with high order of short-term stability used with the primary frequency standard at the Postmaster-General's Department Research Laboratories. Frequency—23,870 Mc/s approximately.

repeaters and carrier telephony. These were followed by responsibilities in the field of radio broadcasting and radio communications, and during the war years a major interest in Radar for the armed services. At the present time satellite communications and electronic switching are among the activities occupying the attention of the Laboratories.

ORGANISATION OF LABORATORIES

In recent years it has become increasingly evident that the old break-up of activities into separate areas of Radio and Line Communications was outmoded by modern developments which cut across the distinctions between these areas. Furthermore the increasing complexity of the science of telecommunications increased the demands being made on the Laboratories, particularly in regard to the level and range of talents necessary in the staff, and necessitated conditions that would attract outstanding young research workers to the Laboratories and would provide them with satisfaction and adequate reward in their activities. During 1961-62 a thorough examination was made of the Laboratories' organisation and activities in relation to other Departmental activities and requirements and, as a result of this examination, a new organisation has been adopted.

The basic objectives in planning this organisation were:

(1) To raise the level of attention that can be given to projects by providing an environment which will attract and retain men with the necessary intellectual attainments and abilities. More levels were introduced into the organisation, so that a total of four levels of professional staff now actively participate in research work, with two further levels for supervision and direction.

(2) To provide a classification structure within the Laboratories that will offer adequate advancement opportunities for men with the necessary talent, and will provide positions to which outstanding specialists from outside the Laboratories can be attracted if no suitable men are available from within.

(3) To provide for adequate attention being given at an appropriate level to matters of research policy, and its development and implementation within the framework of the Department.

(4) To provide a flexible organisation that can be modified to take account of the experience and specialist ability of individuals.

(5) To provide a grouping of activities and functions that will facilitate specialist knowledge in one area being made available in another area. With the old type organisation it was not unknown for two groups concerned with development for two different applications to spend a good deal of effort independently on technical problems common to both projects.

(6) To retain sufficient flexibility in the control of projects to facilitate collaboration between various groups at the specialist level without the necessity to observe the formality of a rigid pyramidal structure.

The activities of the Laboratories are divided into 22 Divisions with functions ranging from the theoretical and mathematical concepts that form the basis of telecommunications, to intensely practical matters of design and application.

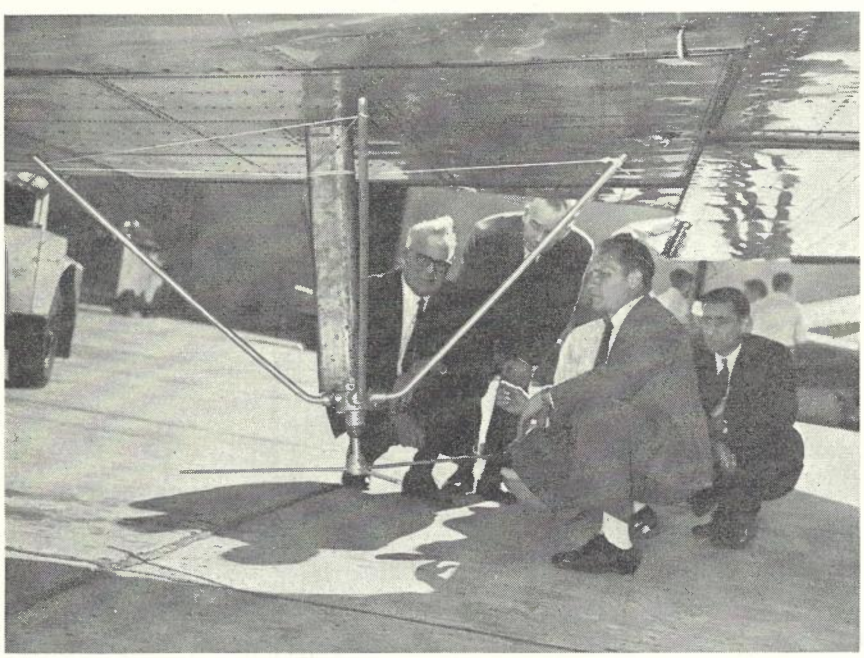


Fig. 3.—Transmitting Aerial for TV Relay Project. An airborne repeater was used circling at 10,000 to 14,000 feet to relay TV over a distance of 500 miles. The aerial is shown in the retracted position under the belly of the DC3 aircraft.

The titles of these Divisions are Circuit Theory, Probability, Telephone Standards, Frequency Standards, Electrical Standards, Radio Systems, Pulse Systems, Multi-Channel Systems, Electronic Switching, Physics, Chemistry, Metallurgy, Mechanical and Electrical Design, Radio Equipment, Telephonometry, General Laboratory Services, Laboratory Equipment, Information, Microwave Techniques, Pulse Techniques, Radio Propagation, and Transmission Lines.

Further expansion of activities in the near future is contemplated, Divisions working on Field Physics, Semi-conductor Circuitry, Materials Evaluation, Mail Handling, and Polymer Applications being possible additions. The existing Divisions are organised in seven groups, and these in turn are arranged in three Sections, namely the Systems Principles and Standards Section, Apparatus and Services Section, and Advanced Techniques Section.

As in most other research establishments, it is realised in the Research Laboratories that their greatest asset is in the special abilities and personal talents of the research workers. For this reason the theoretical organisation of activities can be departed from if by doing so better use can be made of the specialists actually occupying the various key positions.

ACTIVITIES

Systems Principles and Standards

The Principles and Standards Group has the responsibility to ensure that its communications research and development is based on sound mathematical and theoretical concepts, and that it is supported by adequate standards of measurement. The Circuit Theory Division and the Probability Division are located in this group, as will be the Field Physics Division when created. By its very nature this group is very much of a specialist nature and here is found one of the classical problems of industrial research laboratory organisations, namely to provide adequate opportunities for growth, recognition and advancement by specialist mathematicians. Telephone traffic engineering positions in the State and Headquarters organisations provide possible areas where men with mathematical ability can obtain wider experience of the Department's activities before coming to the Research Laboratories, and also offer avenues of advancement.

Standards activity covers electrical measurements from DC up to UHF frequencies, as well as transmission standards for telephone instruments and networks. In addition, the Departmental Primary Frequency Standard is maintained by the Research Laboratories as an essential Post Office standard.

Advances in engineering technology necessitate advances in standardisation techniques and methods. This group is working to extend the Laboratories' standards of measurement into the higher radio frequency regions, to supplement the frequency standards by molecular and atomic oscillator techniques, and to extend telephone and network standards to take account of the modern under-

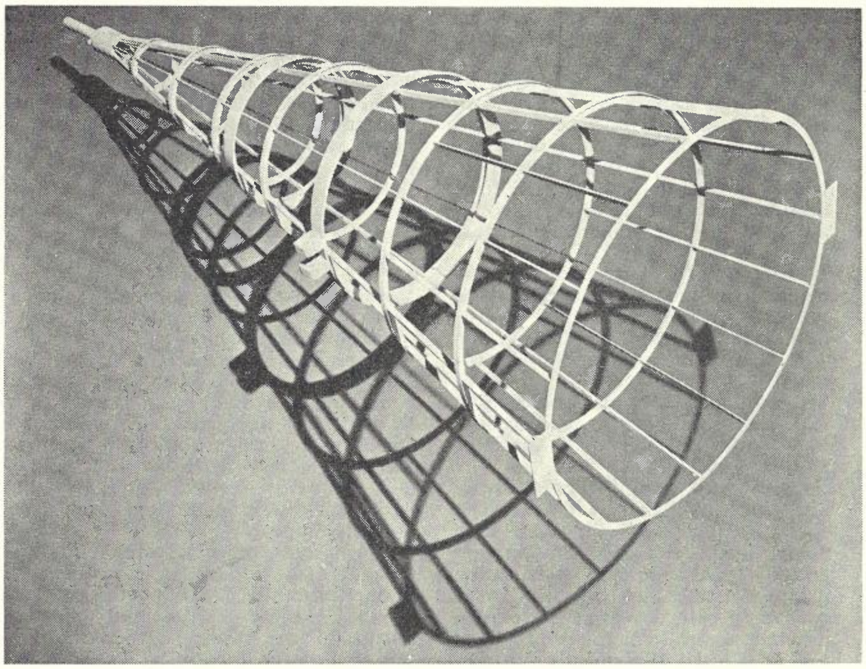


Fig. 4.—Launching Horn used in Experiments with Surface Wave Transmission Line. Length is approximately seven feet, for broadband operation centred on 300 Mc/s.

standing of speech and intelligibility.

Systems Development occupies a very important place in the programme of the Laboratories. Communications from one point in the network to another is by means of a system or combination of systems, and in this Group the objective is to keep abreast of modern developments in systems and, in special cases, to develop systems that are found desirable in the Australian network but which have not been developed commercially. A typical project is to improve the service offered to subscribers living in sparsely populated inland areas. In some instances these subscribers are connected by earth return circuits one hundred miles or more in length, and very poor performance is obtained from conventional equipment. The Laboratories have developed a transistorised voice frequency amplifier for use on these circuits. Another example of application in outback areas is the development of a special repeater for use with a 12-channel open wire carrier system between Alice Springs and Darwin. This route traverses 1,000 miles of sparsely populated territory and because of the high cost of providing buildings, power supplies and adequately trained staff, it was decided to reduce the number of conventional repeater stations by developing a pole mounted transistorised repeater. Every third repeater is a conventional 12-channel repeater station and power is supplied over the lines to the two adjacent pole mounted repeaters. Replaceable "plug-in" units keep on-site maintenance to a minimum.

Many new advances in devices, apparatus and systems are taking place overseas and the Department has found it necessary to conduct its own research into modern system developments in order to acquire technical competence so that it is continually in a position to evaluate and if necessary to engineer the introduction of new types of systems into Australia. For example, it is probable that solid state electronic exchanges will be available in the future. If the Department is to take advantage of such an advance it must have staff with experience in the concepts involved. It must have engineers who know the problems and are able to set the standards to be observed and see the pitfalls to be avoided. In the Research Laboratories, research is being conducted on transistorised switching systems and on semiconductor circuitry, not because the Department expects to manufacture solid state telephone exchanges but to gain experience, so that when such exchanges are available the Laboratories will be in a position to assess them and give advice that is based on practical experience and knowledge. Digital methods of communication is another area of work of this Group.

Apparatus and Services

Even in the largest of research organisations major advances in communications are comparatively rare. Many advances are of a marginal nature—an improved material, a faster assembly technique, or a modified design. Although small in themselves, in the aggregate substantial advantages accrue from these improvements, and there is a great deal to be gained by ensuring that the best materials and the latest techniques are incorporated into equipment, and the resources of modern scientific or engineering knowledge are brought to bear on existing equipment problems as well as on future developments. This is an important function of the Section of the Laboratories which deals with Apparatus and Services.

The Physical Sciences Group is staffed with physicists, chemists and metallurgists whose responsibility is to bring the knowledge of their respective disciplines to bear on the material and equipment problems of the Department. The Materials Evaluation Division and the Polymer Applications Division, when created, will be located in this group. These scientists cannot operate without the tools of their profession and

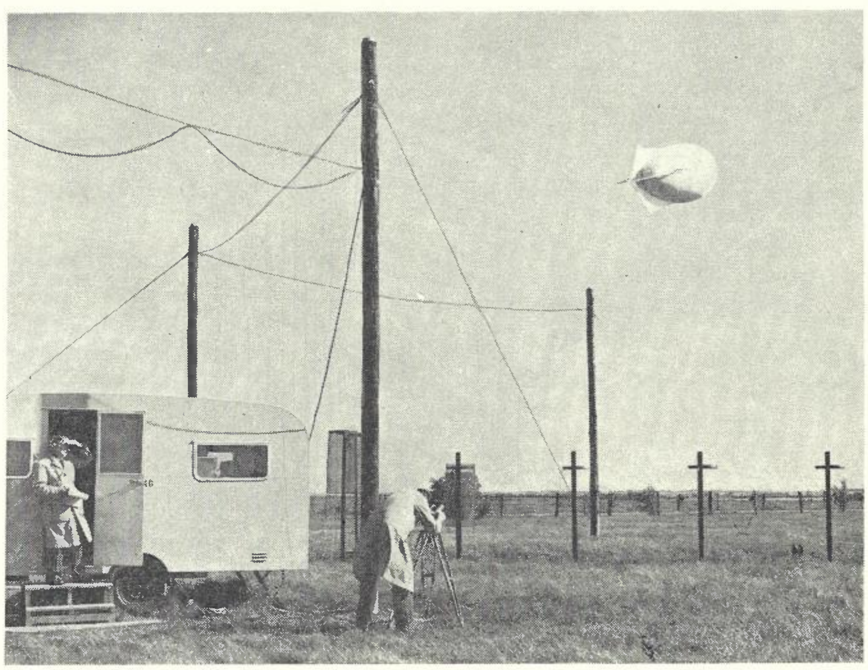


Fig. 5.—Polar Diagrams of Aerials being Measured at a Field Site using a Kytoon to Position a Signal Source in the Vertical Plane.

the Sub-Section is equipped with a wide range of physical, chemical and metallurgical equipment including facilities for Gas Chromatography, Infra-Red Spectrography, and X-ray Fluorescence Analysis. Whilst not always spectacular, the efforts of this group have made a big contribution in identifying points of weakness in materials and equipment and in the application of physical and chemical methods to plant problems. The introduction of epoxy resins for component encapsulation and for cable jointing techniques, as covered in more detail in another article in this issue, is a typical project by this group, and has been of considerable importance to the work of the Engineering Division.

The Equipment Development Group has responsibility for mechanical and electrical design, for radio equipment development and for development and assessment of subscribers' apparatus. In this group the emphasis is on items of equipment and apparatus rather than on integrated systems. In conjunction with the Physical Sciences Group these Divisions are responsible to see that the very latest advances in material and techniques are incorporated in the items of equipment which go to make up the communications systems. A further aspect of this responsibility is the very practical task of assisting local manufacturers with problems arising in the manufacture of equipment in Australia. A typical project is the development, in association with Broken Hill Pty. Ltd., of a grade of soft magnetic iron that will be a suitable substitute for iron that is otherwise only available from Sweden. Another is the development of an Australian design of telephone dial for local manufacture.

Although the interest of the Engineering Division is primarily in telecommunications, the Laboratories are mindful that the Department has a huge responsibility for mails and that mechanisation and automation, although of long standing in Australia, are being introduced in this area to an increasing extent. Considerable advances in mechanisation have already been made by the Postal Services Division and the Laboratories have assisted in several of these projects. In future developments it can be expected that there will be an increasingly complex component concerned with address coding, reading devices and memory techniques, and the projected Mail Handling Division will deal with these problems in collaboration with the Postal Services Division.

Essential requirements in any laboratory are well organised Library and Information Services, efficient equipment control and maintenance, and a competent Model Shop. These functions are the responsibilities of the Laboratories Services Group and the Library. In recognition of the increasing importance of library services the Library has been completely re-organised and the staff strengthened. The Library works in close association with the Information and Patents Service to provide the latest technical information when and where it is needed. The Model Shop is equipped to carry out precision machine work as well as the more routine fabrication tasks. It is expected also to be up to date with the latest of manufacturing and assembly techniques and to carry out experimentation and trials in this area. Printed circuits, solderless wrapped connections, and epoxy encapsulation are typical projects appropriate to the Model Shop and its controlling engineers.

The whole Laboratories depend on an efficient system of equipment maintenance and calibration and, this together with a specialist instrumentation service, is provided by the Laboratory Equipment Division which also has overall responsibility for the purchase and control of equipment.

Advanced Techniques

The activities dealt with so far in this paper have been activities that can be defined, for the most part, as applied research and development or the application of effort to achieve practical goals that can be fairly precisely defined. There is also an area of activity in the Laboratories which can be described as objective basic research as defined in the Zuckerman Report*, that is, research in a field of recognised potential but where the final application is a little less clear. Activities of this type are found in the Advanced Techniques Section, intermingled with activities of a more practical nature.

Thin film and laser phenomena receive attention in this Section together with microwave and pulse techniques. Bandwidth compression for TV signals is the basis of a fundamental study of the psycho-physics of human perception. Satellite communication systems and surface wave transmission lines are other projects in this Section, as well as more practical investigations concerning radio propagation, lightning protection, and microwave switching.

The Laboratories C.D.C. 160A Computer is under the control of this Section and is available on the "open shop" principle to other engineers of the Laboratories, many of whom are being trained in programming techniques.

CONCLUSION

The Research Laboratories are not restricted to research and development only, but are also called on to fulfil pressing needs of a working Department. Included in their activities are functions covering almost the full spectrum of research and investigation, from objective basic research through applied research to development, design and testing and, in some special instances, to maintenance trouble shooting. They are responsible also to use influence to foster the study of telecommunications problems in Universities and Colleges, and to collaborate with other government and industrial research and development laboratories working in similar fields.

The normal method of publication of the results of work is through Australian Post Office Research Laboratory Reports, which in many cases are circulated to interested bodies throughout Australia and overseas. It is recognised however that such publication reaches only a limited audience, and staff are encouraged to publish their work through papers delivered to the appropriate learned societies and published in the technical press.

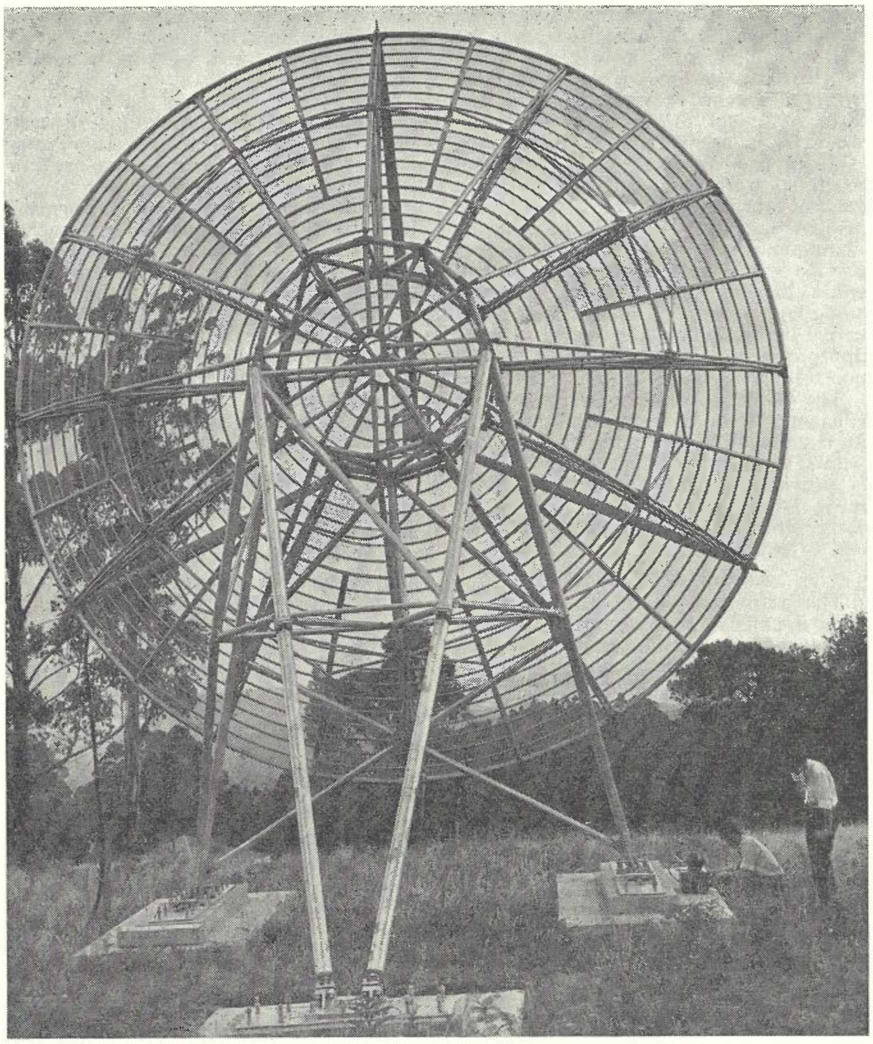
As examples, the following references illustrate types of papers by staff of the Research Laboratories which have been published in this *Journal* during the past few years.

*Report to Minister for Science by Committee on the Management and Control of Research and Development—Her Majesty's Stationery Office, 1961.

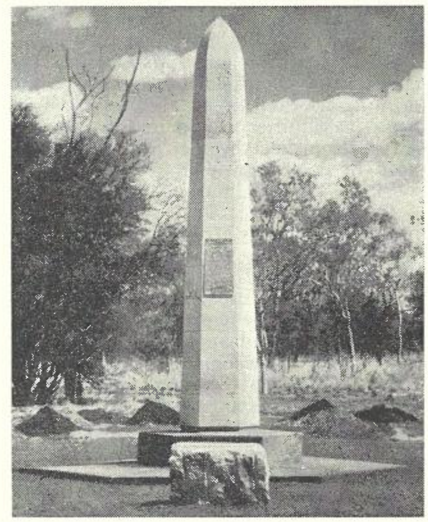
REFERENCES

All References are articles in the Telecommunication Journal of Australia.

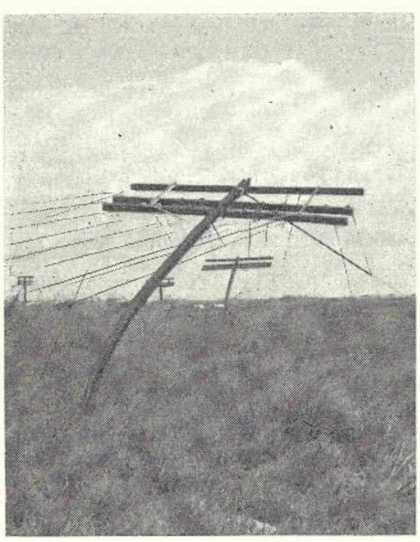
1. F. W. Arter, "Design Aspects of Transistor and Diode Switching Circuits"; Vol. 13, No. 4, page 330, No. 5, page 423, and No. 6, page 492.
2. E. R. Craig and F. P. O'Grady, "Radio Communication by Artificial Satellites"; Vol. 13, No. 1, page 2.
3. R. Smith, "An Automatic Traffic Recorder"; Vol. 13, No. 4, page 306.
4. F. W. Wion, "Generation of Exchange Service Tones and Bell Ringing Current"; Vol. 13, No. 6, page 490.
5. R. E. Bogner, "Telephone Numbers and the User"; Vol. 12, No. 5, page 318.
6. J. N. Bridgford, "A Transistorised Hearing-Aid Telephone"; Vol. 12, No. 1, page 31.
7. J. F. M. Bryant, "Electrical Noise in Automatic Telephone Exchanges"; Vol. 12, No. 3, page 173.
8. M. W. Farmer and N. A. Cameron, "Switchboard Attachments for Blind Telephonists"; Vol. 12, No. 3, page 205.
9. E. Rumpelt, "Methods of Numerical Filter Design"; Vol. 12, No. 1, page 28, No. 2, page 133, No. 3, page 185, No. 4, page 271, No. 5, page 360, and No. 6, page 440; Vol. 13, No. 1, page 69, No. 2, page 140, and No. 3, page 317.
10. R. W. Kett, "Acoustic Shock Absorbers"; Vol. 12, No. 5, page 353.
11. J. F. M. Bryant, "Reduction of Engine Noise"; Vol. 12, No. 2, page 114, and No. 3, page 211.
12. E. F. Sandbach, "Time Signals in Australia"; Vol. 12, No. 4, page 280.
13. A. V. Seyler, "Portable Video Test Set"; Vol. 12, No. 2, page 89.
14. A. W. Thies, "Transistor Amplifier with Heavy Feedback for 12-channel Open-wire Carrier System"; Vol. 12, No. 3, page 187.
15. J. C. Wilson, "Pole-mounted Repeaters for Carrier Systems"; Vol. 12, No. 5, page 314.
16. H. S. Wragge, "Design of Transistor Circuits"; Vol. 12, No. 3, page 151.
17. H. S. Wragge, "Electronic Telephone Exchanges"; Vol. 13, No. 1, page 14.



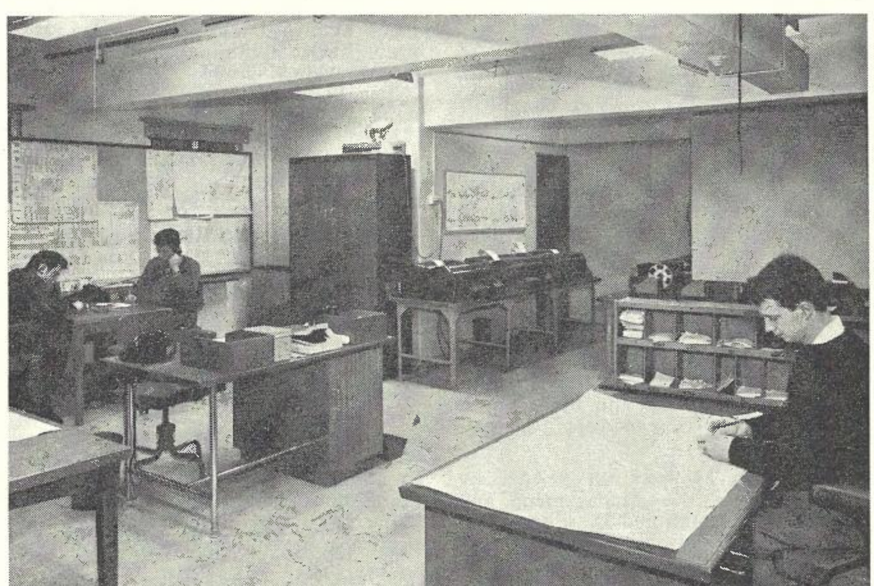
Parabolic aerial, diameter 28 feet, used in tropospheric scatter experiments conducted by the Research Laboratories.



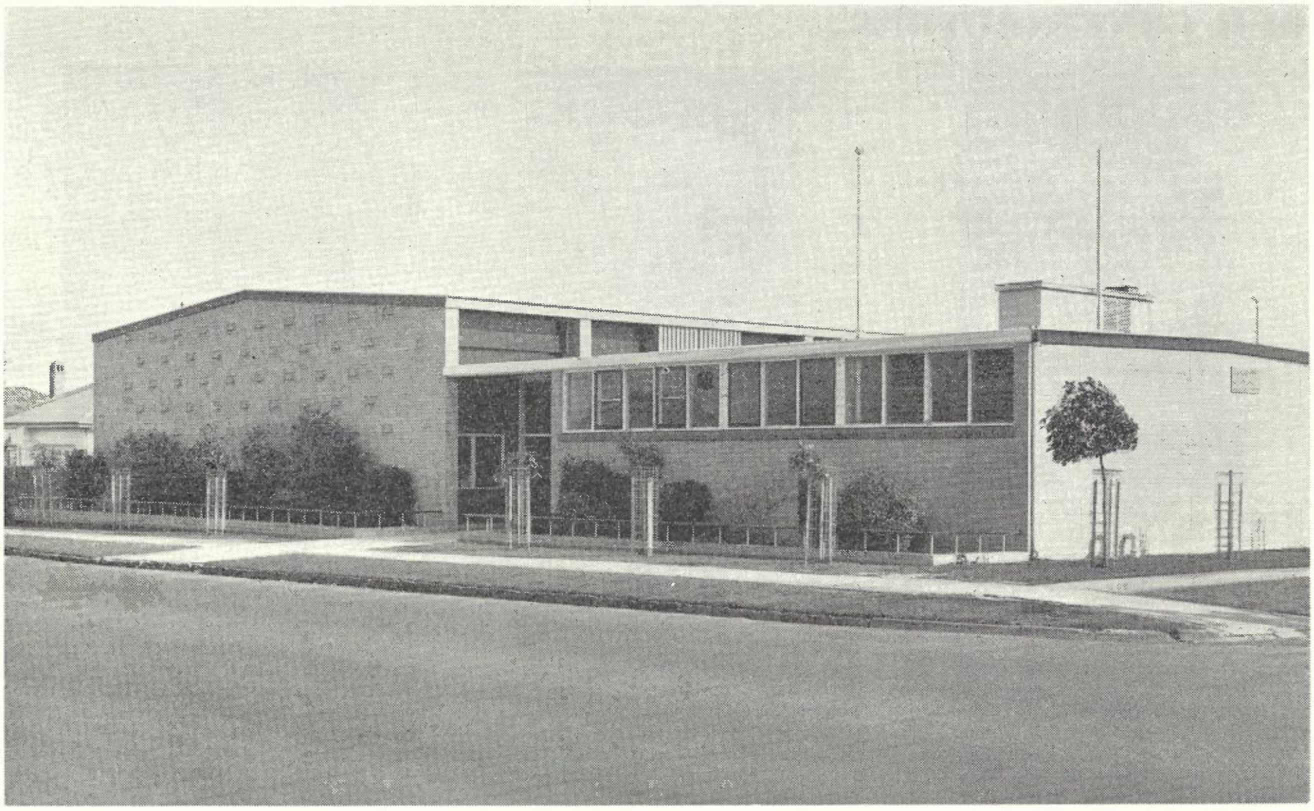
The Todd memorial, erected at Frew's Ironstone Ponds, 32 miles north of Newcastle Waters in the Northern Territory. This is where the final joint was made on the 2,000 mile overland telegraph route between Adelaide and Darwin in 1872. Completion of this route by a line party under Sir Charles Todd was a fine feat of pioneer engineering and brought the first instantaneous telegraphic communication between the capitals of Australia and Great Britain. The original monument was made and erected by Departmental Lines Staff in 1954.



The North West and North Eastern coastal sections of Australia are in cyclone belts. This steel rail pole route near Onslow, Western Australia, was flattened by winds up to 165 m.p.h. during February this year.



The Melbourne Complaints Analysis Recording and Graphing Organization (CARGO) Room.



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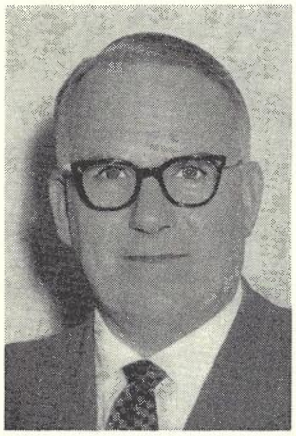
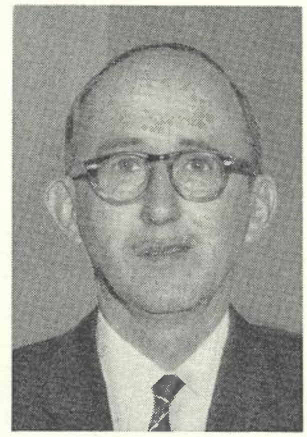


E. SAWKINS

E. R. BANKS



C. J. GRIFFITHS

E. SAWKINS, co-author of the article, "C.C.I.T.T. Study Group Meetings in Melbourne, October, 1963", is Assistant Director-General (Engineering) and Engineer-in-Chief of the Postmaster-General's Department. After joining the Department in New South Wales as a Cadet Engineer in 1928, he was awarded a Commonwealth Government Free Place in Science at Sydney University and graduated with the degree of Bachelor of Science. As an Engineer he served mainly on exchange installation work, and during the second World War organised street lighting control for air raid purposes and worked on the production of signal and radar supplies for the Allied Services in Australia. In 1945 he was selected to establish the first Telephone Planning Division in the Department and in 1946 prepared a Rehabilitation Plan for Telecommunication Services in New South Wales, which later formed the basis for securing greatly increased funds for the expansion of engineering services. In this year also he prepared an interim plan for the development of the Sydney Metropolitan unit fee network. He was successively promoted as Supervising Engineer, Telephone Planning, Assistant Superintending Engineer, Internal Plant, and in 1955 Assistant Director (Engineering), New South Wales. In September, 1956, he was transferred to Headquarters in Melbourne and was promoted as Deputy Engineer-in-Chief. He was appointed Engineer-in-Chief in February, 1957.

In the period that Mr. Sawkins has been at Head Office, policy objectives have been set for the National Telephone Service, new standards for telephone exchange switching equipment have been adopted, wide band transmission equipment has been introduced and expanded on a large scale and a national plan for automatic service throughout Australia has been introduced. Mr. Sawkins represented Australia at the Administrative Council meetings of the International Telecommunications Union in Geneva in 1961 and 1962. He is an Associate Member of the Institution of Engineers, Australia.

E. R. BANKS, co-author of the article "C.C.I.T.T. Study Group Meetings in Melbourne, October, 1963", joined the Postmaster General's Department in 1948 as a Cadet Engineer and completed his training and the degree of Bachelor of Electrical Engineering at Melbourne University in 1952. In this year, Mr. Banks shared the Dixson Scholarship in Electrical Engineering and won Monash, Newbigin, and Oral Presentation prizes of the Institution of Engineers, Australia. After nine months on country installation work in Victoria, Mr. Banks joined the Long Line Equipment Section at Central Office. He spent 1955 and 1956 in England and Europe as the holder of a scholarship from the Federation of British Industries. On his return from England Mr. Banks took up duty as Divisional Engineer, Traffic, in the Telephone Equipment Section and later as Sectional Engineer, Network Planning. He was associated with revision of traffic engineering instructions and with the studies and work leading to the recommendation that the Department adopt crossbar as the new standard switching system. Mr. Banks was appointed Supervising Engineer, Switching and Facilities Section, Planning Branch, in May 1962. He was a member of the Departmental delegation to the New Delhi Plenary Assembly in November, 1960, and is currently Chairman of the C.C.I.T.T. Study Group XI Working Party on National Automatic Telephone Networks. Mr. Banks is an Associate Member of the Institution of Engineers, Australia, and an Editor of this *Journal*.

★

C. J. GRIFFITHS, author of the article "Australian Telecommunication Authorities," is Deputy Engineer-in-Chief, Postmaster-General's Department. He joined the Department as an Engineer in the Victorian Administration in 1927 and was employed first in the Telephone Equipment Section. After a total of eight years in the Telegraphs, Lines, and Transmission Sections, he transferred as Engineer to the Lines Section in Central Office. He was promoted as Divisional Engineer in 1939, became an Assistant Supervising Engineer (Sectional Engineer) in 1947 and was promoted as Supervising Engineer, Lines, in 1955. In 1957, he commenced acting as Assistant-Engineer-in-Chief and was promoted Assistant-Engineer-in-Chief (Services) in February, 1959, and Deputy Engineer-in-Chief in May, 1959. These moves brought to an end a period of 22 years in the Headquarters Lines Section where he had played a vital role in the shaping of external plant policies and in the planning and execution of many nationally important projects such as the Sydney-Maitland, Melbourne-Ballarat and Adelaide-Nuriootpa Trunk Cables; the Adelaide-Perth, Adelaide-Darwin and Townsville-Cape York Trunk Routes; the Bass Strait Submarine Cable; and the Woomera and Maralinga Rocket Range telecommunication facilities. Mr. Griffiths has been closely associated with the COMPAC and SEACOM projects and has been active in the international sphere. He led the Australian delegation to the 2nd Plenary Assembly of the C.C.I.T.T. at New Delhi in November, 1960, and headed the Post Office Section of the Australian Delegation to the South-East Asia Cable Conference at Kuala Lumpur, Malaya, in June, 1961. In March this year he attended the 18th Session of the Administration Council meeting of the International Telecommunications Union at Geneva. Mr. Griffiths has been prominent in Postal Electrical Society affairs. He was an Editor of the *Journal* for 12 years from 1944, has written several articles and was elected a Life Member of the Society in 1953. Mr. Griffiths holds the Degree of Master of Electrical Engineering, Melbourne University, and is a Member both of the Institution of Electrical Engineers and the Institution of Engineers, Australia.

T. J. PETRY

R. W. TURNBULL

G. E. HAMS

W. H. WALKER

T. J. PETRY, author of the article "Australia's Overseas Telecommunications Network", is Sectional Engineer, Construction, in the Overseas Telecommunications Commission (Australia).

After serving some years at sea with the Royal Navy during the war, he spent one year in the South Rhodesian Post Office, thence three years with the New Zealand Post Office. He qualified as a Graduate Member of the Institution of Electrical Engineers (London) in 1950, and came to Australia in 1951. He then worked on telecommunications systems with the Snowy Mountains Authority, and the Electricity Commission of New South Wales until 1959, when he joined O.T.C. (A.).

Mr. Petry has since been engaged on the installation and commissioning of new equipment at the International Radio stations, and in Papua/New Guinea. More recently he has been associated with the installation and commissioning of the COMPAC project. He is an Associate Member of the Institution of Electrical Engineers (London).

★

R. W. TURNBULL, co-author of the article "Australian Telephone and Telegraph Networks", is Assistant Engineer-in-Chief (Planning). He joined the Postmaster-General's Department as a Cadet Engineer in Sydney, and was promoted as Engineer in 1937. He holds the Diploma in Electrical Engineering of the Sydney Technicial College. In 1945 he was transferred to the Headquarters Administration, Melbourne, where for ten years he participated in developmental activities in the Telephone Equipment Section, and was closely associated with the industry established for the manufacture of automatic switching equipment in Australia. After initial investigations in 1955 of problems in the development of the telephone network, and a period of overseas study, he was appointed, in 1956, Chairman of a special Post Office planning group, the Automatic Network and Switching Objectives (A.N.S.O.) Committee, with the status of Superintending Engineer. The work of this group led to the formulation of the National Telephone Plan for Australia which provides for progressive implementation of Government policy for a completely automatic nationwide subscriber dialled telephone service Mr. Turnbull shared the 1960 Professional Officers' Association Award of Merit in recognition of the importance and excellence of this work. He was appointed Assistant Engineer-in-Chief (Planning) in May, 1962 and led the Australian Post Office delegation to the 10th Plenary Assembly of the C.C.I.R. in Geneva in January, 1963. Mr. Turnbull is a former Editor of this *Journal,* and is a Member of the Institution of Engineers, Australia.

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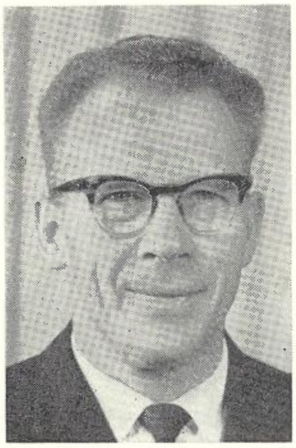
G. E. HAMS, co-author of the article "Australian Telephone and Telegraph Networks," commenced with the Postmaster-General's Department as a Cadet Engineer in 1947 and subsequently graduated as Bachelor of Science from the University of Melbourne. His early work as an Engineer was in the Telephone Planning and Trunk Service Divisions, Victoria. In 1955 he was promoted to the Central Administration as Divisional Engineer in the Systems Planning Section, and in 1958 became a member of the ANSO Committee where he played a prominent part in the preparation of the National Telephone Plan for Australia. Mr. Hams was promoted Sectional Engineer, National Planning, Planning Branch, in May, 1963. In February this year he attended a Geneva meeting of the C.C.I.T.T. Plan Sub-Committee for Asia and later visited Sweden, the United Kingdom and the U.S.A. to review aspects of Systems Planning. Mr. Hams is an Associate Member of the Institution of Engineers, Australia.

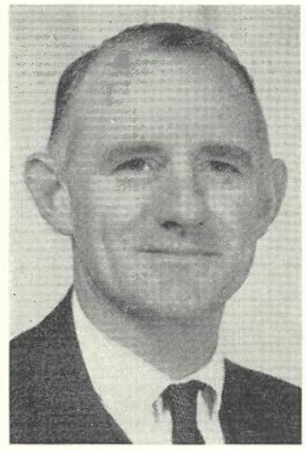
W. H. WALKER, author of the article "Some Aspects of External Telephone Plant in Australia", has been Supervising Engineer, Lines Section, Engineering Division, Headquarters, for the past four years. He graduated as Bachelor of Engineering from the Brisbane University in 1925 and was appointed Assistant Engineer with the Brisbane Tramways Trust, a position he held for three years. In 1929 he joined the Postmaster - General's Department, Queensland, as an Engineer and gained wide field experience in the Metropolitan Lines District Works, Transmission Planning and Country District Works Divisions. Transferred to Headquarters in 1940, he became the expert on transposition design and trunk design generally, and prepared many designs for new trunk lines and carrier bearers to provide additional carrier channels to the North of Australia during the second World War. During this period at Headquarters Mr. Walker was appointed Divisional Engineer, Trunk Aerial Planning and Design. Between 1949 and 1953 he was Divisional Engineer, Trunk Planning, Victoria, and during this time prepared plans and designs to increase considerably the channel capacity of the existing routes. Mr. Walker returned to Headquarters Lines Section as Sectional Engineer, Service and Maintenance, in 1953, and in this position was largely responsible for the creation of the Joint Power Co-ordination Committees, and the preparation of Codes of Practice which have been very successful in meeting the problems in the power co-ordination field. In this position Mr. Walker was also technical adviser to the Public Service Board and Departmental witness in union hearings before the Public Service Arbitrator.

Mr. Walker was elected Honorary Secretary to the Postal Electrical Society of Victoria (forerunner to the Telecommunication Society of Australia) in 1942, and when he resigned in 1951 was unaminously elected a Life Member. He is an Associate Member of the Institution of Engineers, Australia.

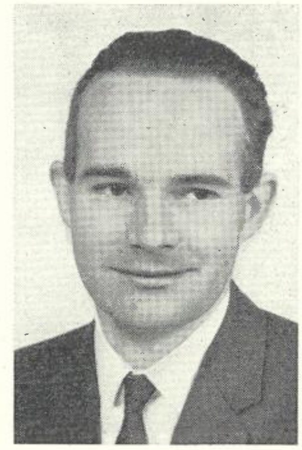


K. B. SMITH

N. M. MACDONALD



D. A. BROOKE



E. L. BROOKER

K. B. SMITH, author of the article "Telephone Equipment Plant Practices in Australia", joined the Postmaster-General's Department from the Western Australian Government Railways in 1936 and was appointed Cadet Engineer in 1937. After graduating as Bachelor of Science from the University of Western Australia and completing the cadetship he commenced duty in Perth, early in 1941. Later the same year, following initial service in a country division, he transferred to Headquarters Telephone Equipment Section. First as Engineer and later as Divisional Engineer, he was engaged on the design and procurement of subscribers' and automatic exchange equipment. Mr. Smith was transferred to London early in 1950 as Engineering Representative at the Department's newly established office in Australia House. He was the Australian Post Office Representative on the British Telephone Technical Development Committee and Alternate Australian Member of the Commonwealth Telecommunications Board.

He returned to Headquarters Telephone Equipment Section late in 1953, re-entered the equipment design field and in 1960, as Assistant Supervising Engineer, took over control of four equipment design sub-sections. Mr. Smith is an Associate Member of the Institution of Engineers, Australia.

★

N. M. MACDONALD, author of the article "Review of Line Transmission Equipment in Australia", joined the Postmaster-General's Department in Melbourne in 1938 as a Cadet Engineer. He graduated Bachelor of Science at the University of Melbourne in 1941 and qualified as Engineer in 1942. After experience in the Victorian Transmission, Country and Lines Sections, he was transferred in 1947 as Divisional Engineer, Cable Carrier and Special Projects in the Long Line Equipment Section, Central Office. From 1952 to 1960 he was Sectional Engineer in charge of the design, procurement and installation of all types of long line equipment. He was Supervising Engineer in charge of the Long Line Equipment Section from late in 1960 until recently, and is now occupying the position of Assistant Engineer-in-Chief (Services).

In his early career, Mr. Macdonald was responsible for the introduction of integrated regional planning of telephone services in the Gippsland area of Victoria. During his period in the Long Line Equipment Section at Central Office he was closely associated with the design of most of the major carrier projects undertaken in Australia, including the Sydney-Melbourne coaxial cable system, and with the development of all new types of carrier systems. He was also associated with the standardisation of equipment installation practices, the rationalisation of carrier manufacturing programs for the local companies, and with the introduction of new transmission standards for the Commonwealth trunk network.

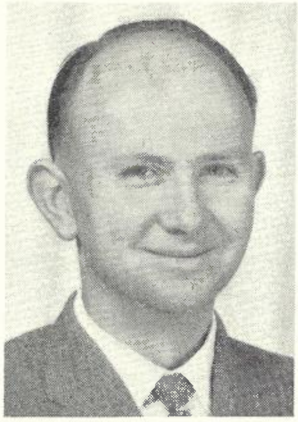
Mr. Macdonald has played an active part in the affairs of the Telecommunication Society of Australia, mainly through his long association with this *Journal*. He was appointed an Editor in 1950, is currently Editor-in-Chief, and has contributed several previous articles to the *Journal*. He is a Member of the Institution of Engineers, Australia.

★

D. A. BROOKE, co-author of the article "Some Aspects of the Use of Radio Systems in the Australian Internal Network", joined the Postmaster-General's Department in 1943 as a Cadet Engineer whilst on war service. He commenced training in 1946 when released from service with the R.A.A.F., and graduated Bachelor of Science from the University of Melbourne in 1949. During several years of field experience as a Group Engineer in the Radio Section, Victorian Administration, he was associated with broadcasting—chiefly the operations and maintenance of the Radio Australia transmitting installation at Shepparton. In 1953, he was promoted as Divisional Engineer, Plant Applications, in the Headquarters Research Laboratories and was engaged on the co-ordination of the introduction of the VHF radiotelephone system between Mt. Oberon (Victoria) and Launceston (Tasmania). Mr. Brooke joined the Headquarters Radio Section in 1954 and has been associated with broadcasting and radiocommunications plant. At present he is appointed as Sectional Engineer, Service, responsible for the operational and service aspects of the Departmental broadcasting and radio-communications plant, including broadband radio bearers for telephony and television relay purposes.

★

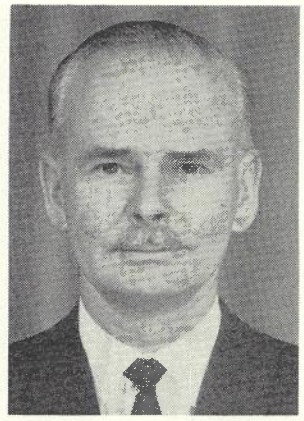
E. L. BROOKER, co-author of the article "Some Aspects of the Use of Radio Systems in the Australian Internal Network," began an engineering Cadetship in Perth in 1947, after four years as a Technician-in-Training. After graduating with a degree of Bachelor of Science from the University of Western Australia, Mr. Brooker completed his cadetship in Melbourne and joined the Design and Development Division of the Headquarters Radio Section. In 1953 he was awarded a Federation of British Industries post-graduate scholarship, and was in the United Kingdom for a period of two years studying, primarily, the design of broadband radio bearer systems. He returned to the Headquarters Radio Section and continued in the Design Division, including in his work design and measurements on audio and acoustic equipment. Mr. Brooker was a member of the Australian Post Office delegation to the 10th Plenary Assembly of the C.C.I.R. in Geneva in January of this year. He is at present occupying a position of Engineer Class 4 in the Design Sub-Section and is an Associate Member of the Institution of Radio Engineers, Australia.



D. J. RICHARDSON

R. K. McKINNON,

L. D. SEBIRE



L. M. HARRIS

D. J. RICHARDSON co-author of the article "Australian Telegraph Engineering Practices", is a Sectional Engineer in the Telegraph and Power Section at Headquarters. He entered the Postmaster-General's Department in Victoria in 1940 as a Junior Mechanic and subsequently qualified as Technician (Telegraphs) and Senior Technician (Telephones). He qualified as Engineer in 1947 and after two years' experience in the Bendigo Country Division, transferred to Central Office as acting Divisional Engineer in the Telegraphs Section. He was promoted Divisional Engineer in 1952 and Sectional Engineer, Telegraph Service and Sub-Station Provision in 1956. At Headquarters, Mr. Richardson is concerned with the development of policy and formulation of general principles and standards for the maintenance of telegraph equipment and services and for the provision of telegraph subscribers' facilities.

★

R. K. McKINNON, co-author of the article "Australian Telegraph Engineering Practices", joined the Postmaster-General's Department in Adelaide in 1949 as an Engineer. Following experience in the South Australian Telegraph Section he transferred to the Central Office Telegraph Section in 1952 and after acting as Divisional Engineer (Telegraphs Services) from 1954 was promoted to that position in 1956. This year he was nominated to the position of Sectional Engineer. Telegraph Design and Provision (Exchange Equipment). Mr. McKinnon has been closely associated with the development of the telex service in Australia and is the co-author of a previous article on the subject. In connection with the automatisation of the telex network, he visited telegraph administrations and leading telegraph equipment manufacturers in the United States and Europe during 1962. Mr. McKinnon holds the degree of Bachelor of Engineering (Adelaide) and the Diploma of Public Administration (Melbourne).

★

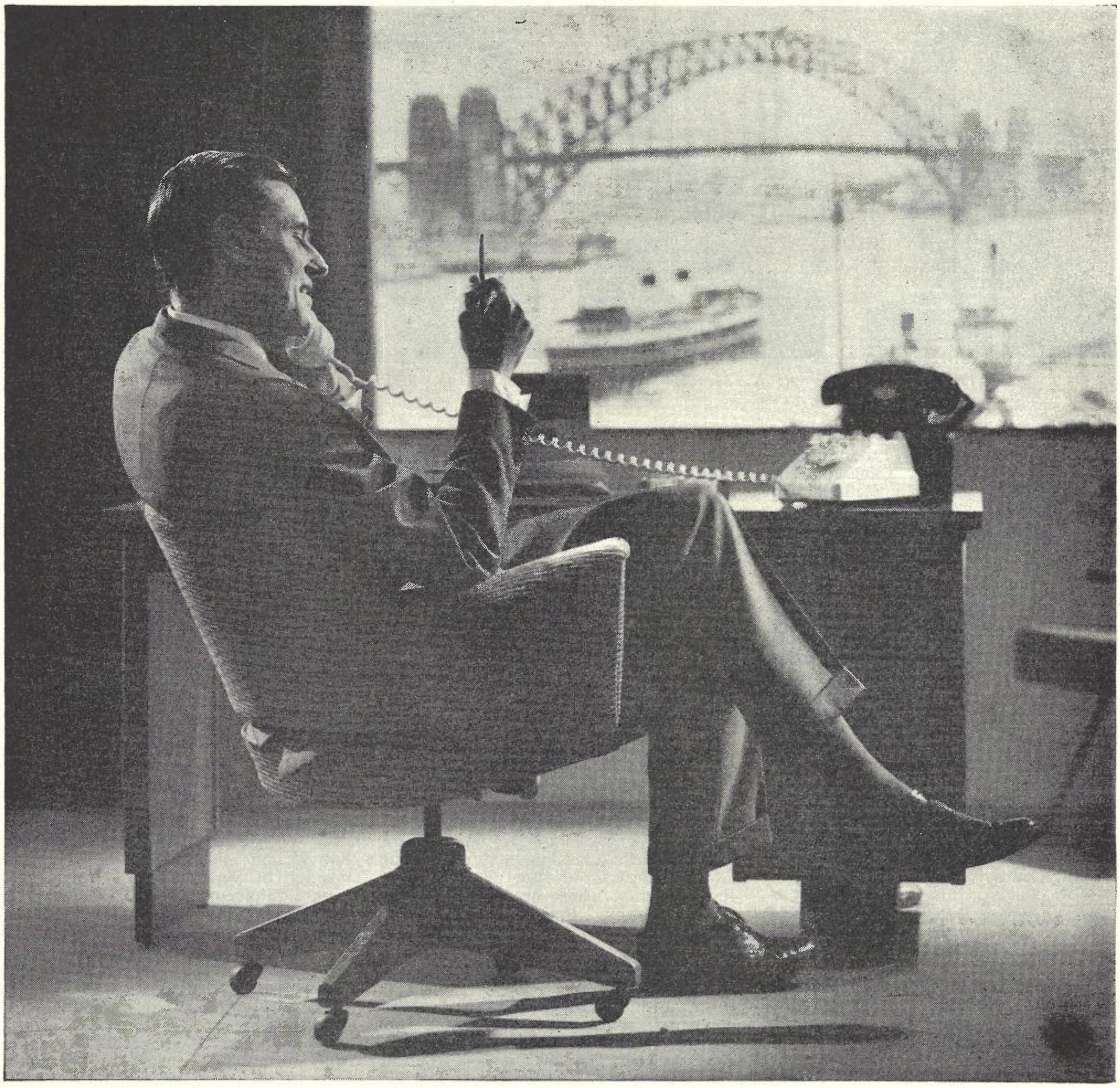
L. D. SEBIRE, co-author of the article "Some Aspects of the Use of Radio Systems in the Australian Internal Network," is Divisional Engineer, Plant Provision No. 2 Sub-Section in the Headquarters Radio Section. In 1956, after working for a number of years in private industry, Mr. Sebire joined the Broadcasting Stations Installation Division of the Headquarters Radio Section where he remained until 1962. During that time, he was responsible for the implementation of the Joint Australian Broadcasting Control Board/P.M.G. Developmental Plan for the improvement of the National Broadcasting Service, the major projects being the establishment of medium frequency stations at Armidale, Wollongong, Mt. Isa, Tennant Creek, Katherine and Rabaul, and the increase in power of 12 existing national stations to 50 kilowatts.

Since 1962, Mr. Sebire has been responsible for the provision of small capacity radio-telephone bearers in all States of the Commonwealth, and, more recently, for the equipment provision and installation planning of broadband microwave systems in New South Wales and Queensland, including the 961-mile Brisbane-Cairns radio relay being provided as part of a system to link the COMPAC and SEACOM cables.

He is an Associate Member of the Institution of Engineers, Australia, an Associate Member of the Institution of Radio Engineers, Australia, and an Affiliate of the Australian Institute of Management.

★

L. M. HARRIS, author of the article "The Research Laboratories of the Postmaster - General's Department", joined the Postmaster-General's Department as a Cadet Engineer in June, 1926. After qualifying as an engineer and obtaining the degree of Bachelor of Science in Physics at the University of Melbourne, he joined the staff of the Research Laboratories to work in Line Communications. He rose to the position of Sectional Engineer in this Sub-Section and was promoted to the position of Supervising Engineer, Long Line Equipment, in 1955, returning to the Laboratories as Supervising Engineer early in 1961. Upon re-organisation of the Laboratories later that year, he was promoted to the position of Assistant Engineer-in-Chief (Research). In 1951, Mr. Harris went to Florence as official delegate to the C.C.I.F., and since then has made several contributions to C.C.I.T.T. work as an official delegate of the Department including attendance as deputy leader of the delegation to the 2nd Plenary Assembly of the C.C.I.T.T. in New Delhi, November-December, 1960. He was a member of the official delegation to the Commonwealth Conference on Satellite Communications held in London in April, 1962, and is to lead the delegation to the Extraordinary Administrative Radio Conference on Frequency Allocation for Space Systems and Radio Astronomy to be held in Geneva in October, 1963.



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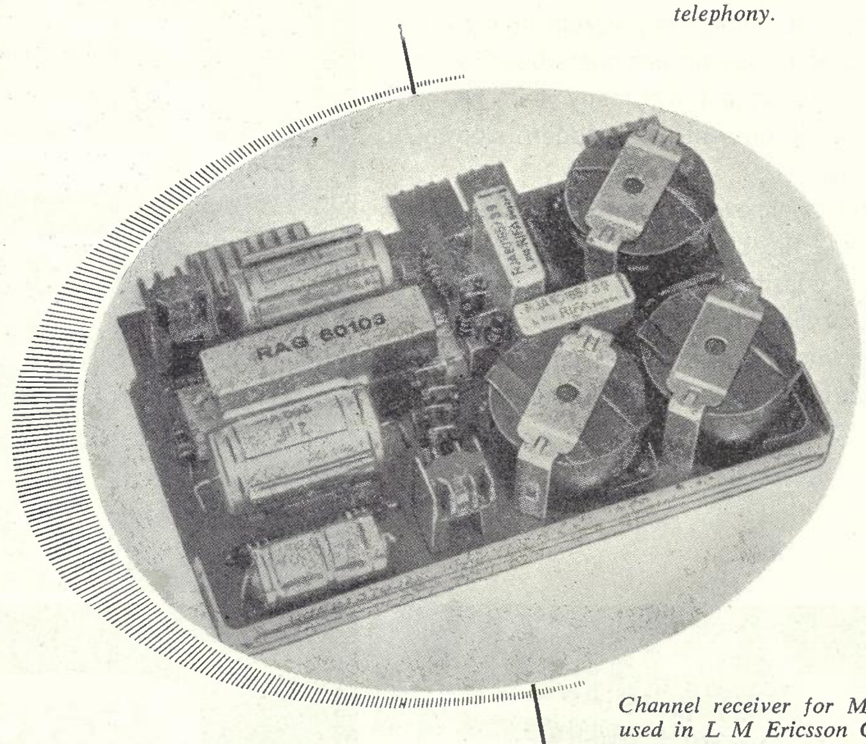

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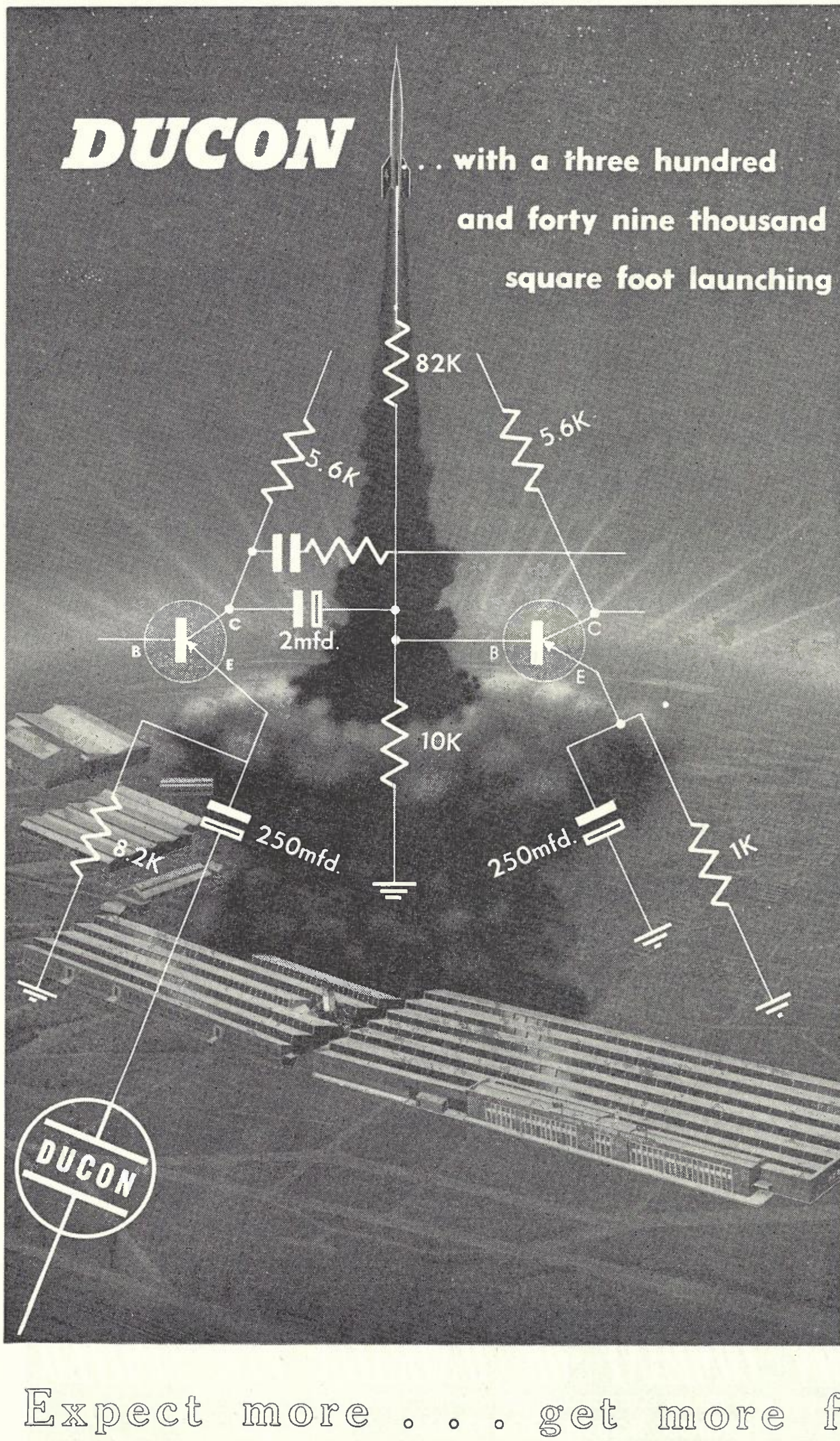

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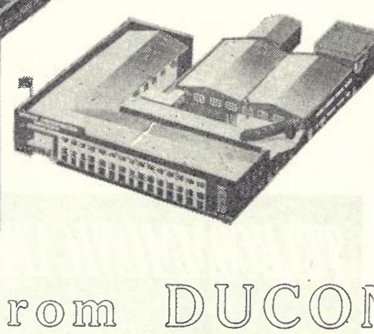

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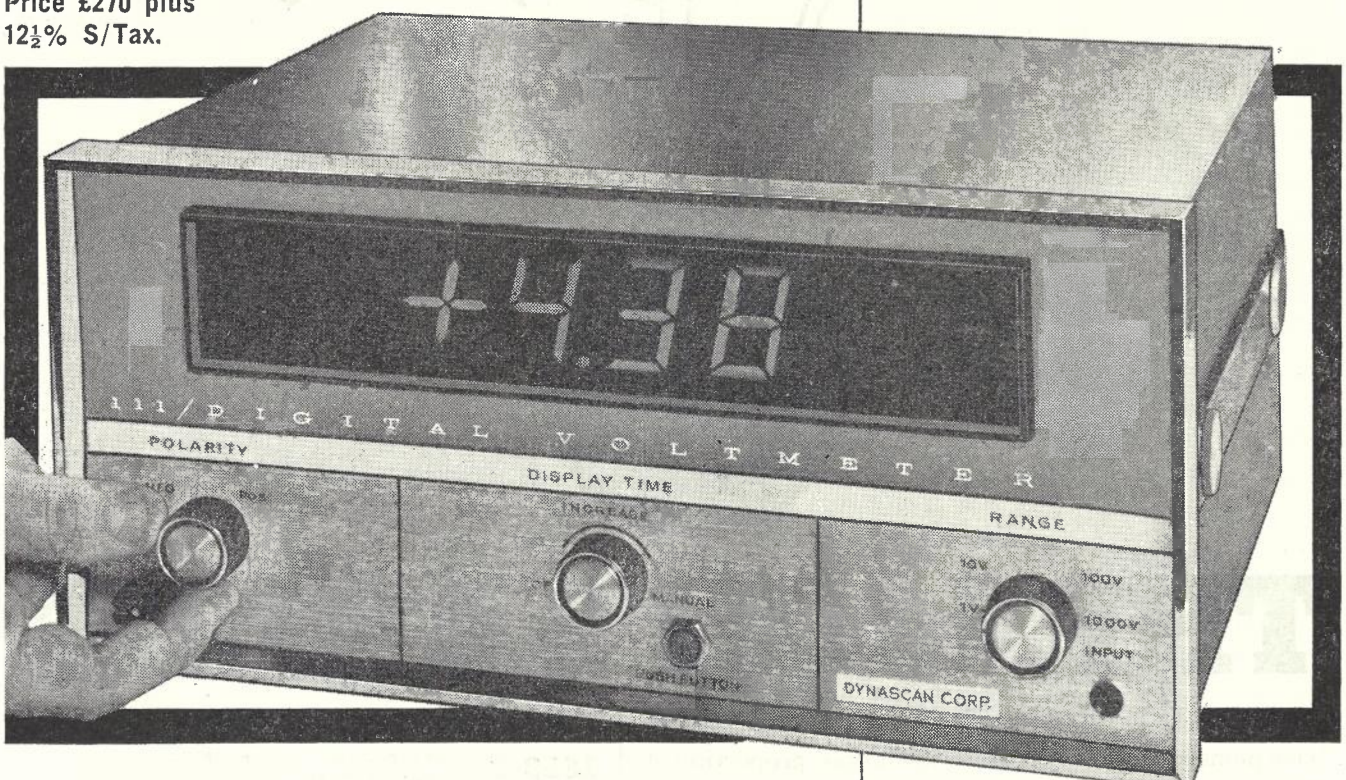

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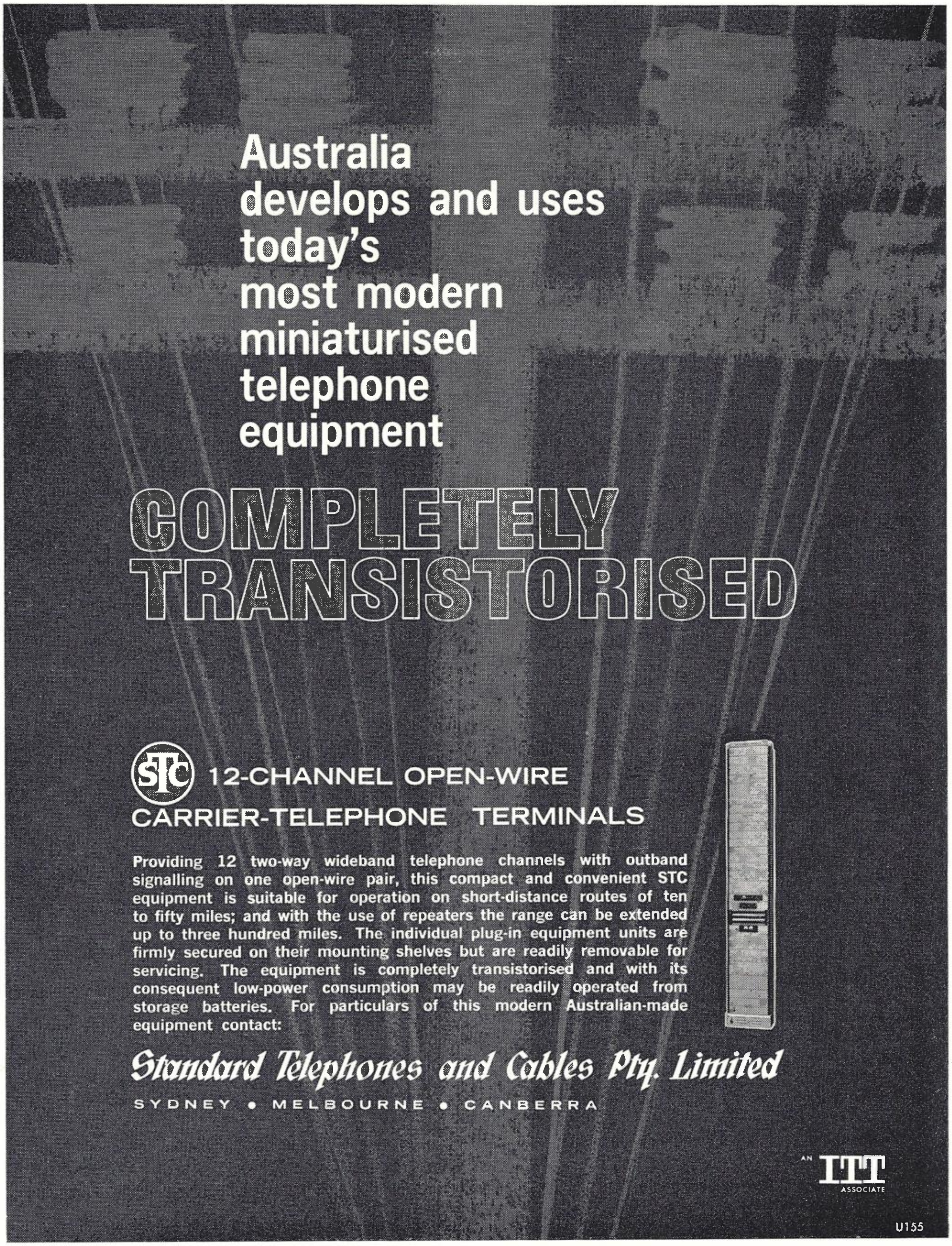
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Providing 12 two-way wideband telephone channels with outband signalling on one open-wire pair, this compact and convenient STC equipment is suitable for operation on short-distance routes of ten to fifty miles; and with the use of repeaters the range can be extended up to three hundred miles. The individual plug-in equipment units are firmly secured on their mounting shelves but are readily removable for servicing. The equipment is completely transistorised and with its consequent low-power consumption may be readily operated from storage batteries. For particulars of this modern Australian-made equipment contact:
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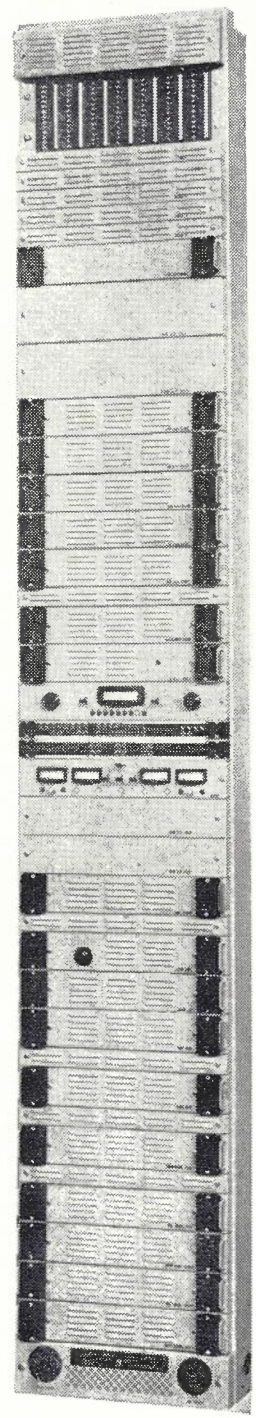

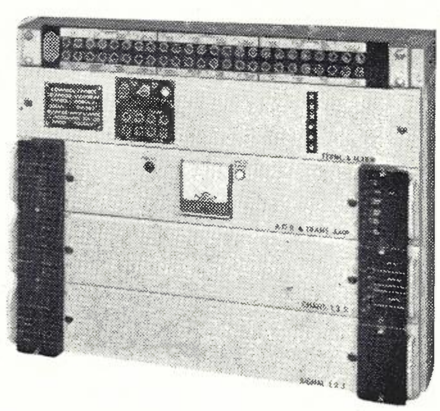

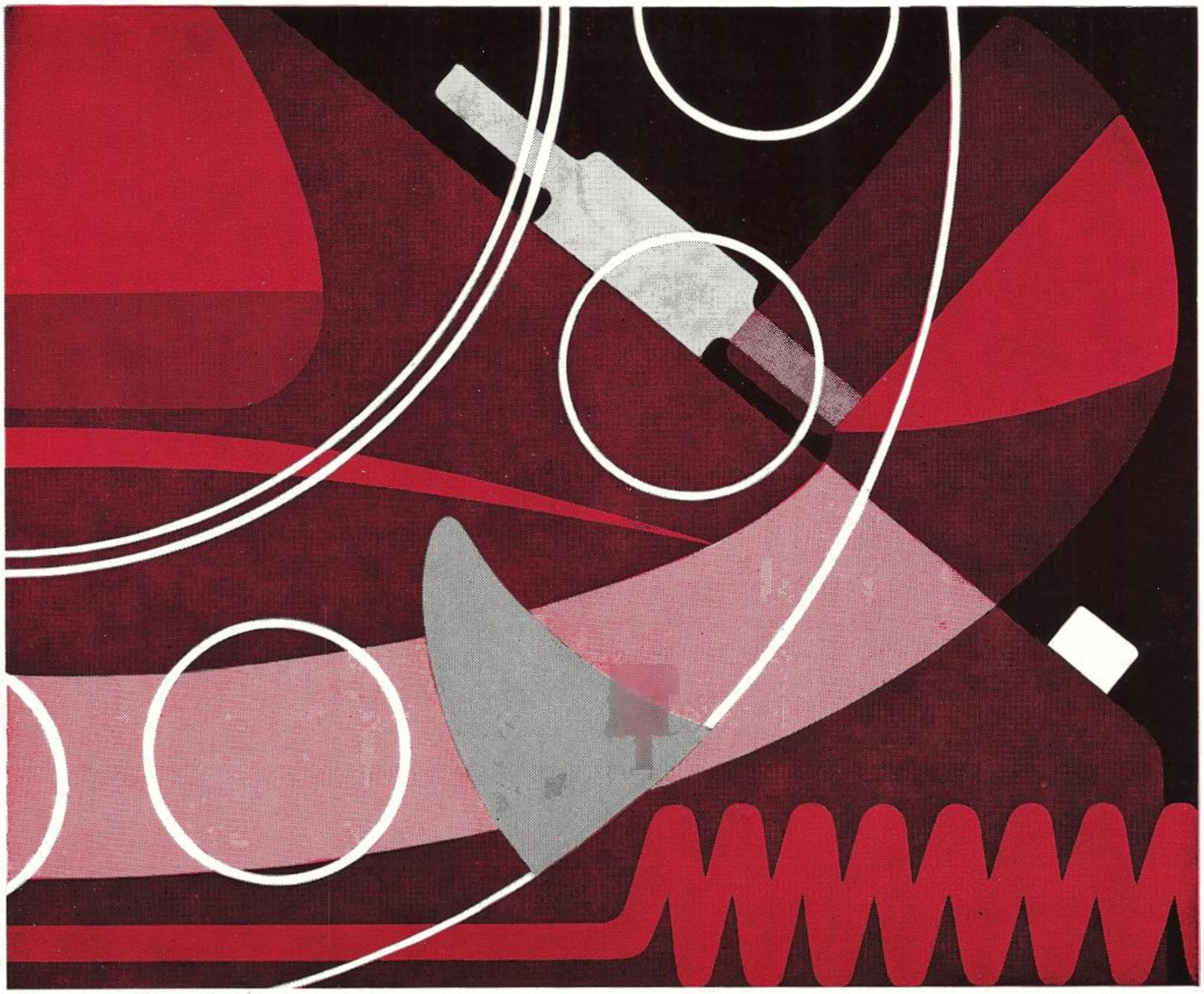

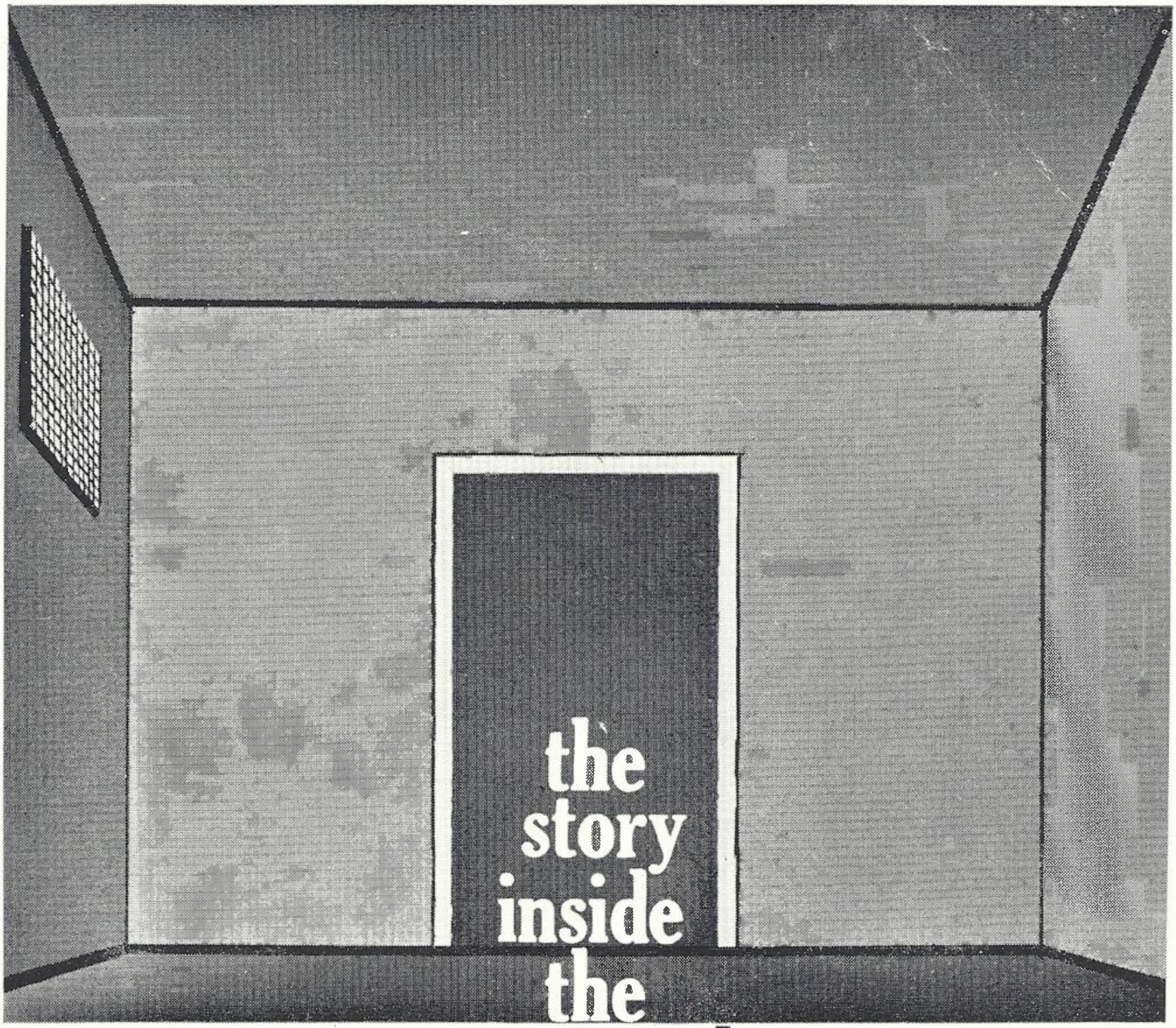

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CONTROLLED RECTIFIERS

Now available in a wide range . . . and in

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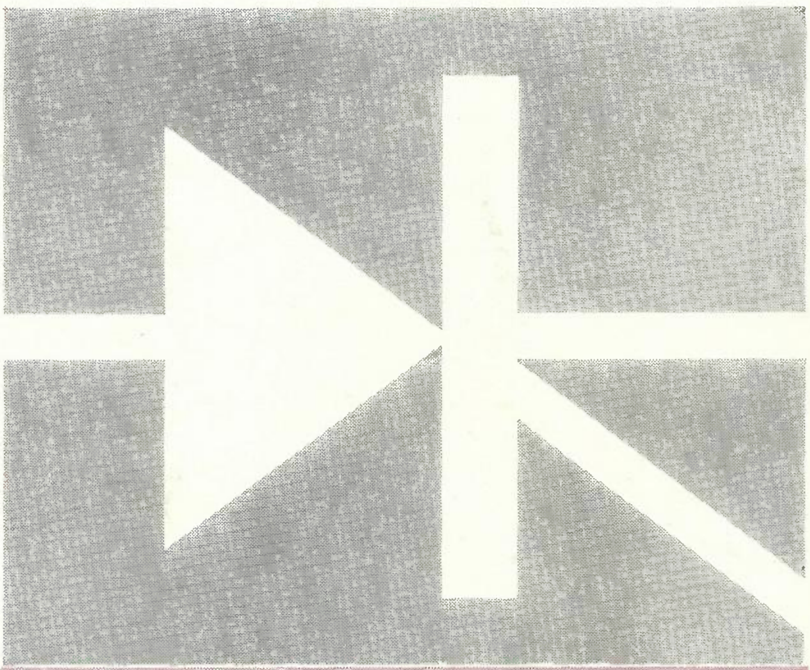

Solid state control at low cost.

No maintenance an important feature

STC's range of "2SF" codings are pnpn-type silicon controlled rectifiers for use in power control or switching applications. The reverse characteristic is similar to a pn silicon rectifier, and the forward characteristic is such that it will block below the peak forward voltage if no gate signal is applied. When a gate signal is applied, it switches to the conducting state and presents a very low forward voltage drop similar to a silicon rectifier.

Silicon Controlled Rectifiers are available in the following ranges and voltages identified by each coding.

Rating	P.I.V. Coding	25	50	100	150	200	250	300	400
300 m.a.		—	2SF101	2SF102	2SF103	2SF104	2SF105	2SF106	2SF108
6.5 A.		2SF20	2SF11	2SF12	2SF13	2SF14	2SF15	2SF16	2SF18
11 A.		2SF30	2SF21	2SF22	2SF23	2SF24	2SF25	2SF26	2SF28
19 A.		2SF40	2SF31	2SF32	2SF33	2SF34	2SF35	2SF36	2SF38
55 A.		—	2SF111	2SF112	2SF113	2SF114	2SF115	2SF116	2SF118
80 A.		—	2SF120	2SF122	2SF123	2SF124	2SF125	2SF126	2SF128
300 A. Available shortly									

The Industrial Products Division of STC can supply either the device or the complete equipment incorporating Silicon Controlled Rectifiers. In addition, engineering advice is available to assist in applying the wide range of S.C.R.'s offering. Its research facilities are at present engaged in the development of a complete range of equipment using Silicon Controlled Rectifiers for inverter/converter equipment up to 25 kVA, both 3 phase and single phase.

FEATURES OF STC SILICON CONTROLLED RECTIFIERS

- ★ **Low forward voltage drop during conducting state.**
- ★ **Low leakage current in both forward and reverse directions at high temperature.**
- ★ **Large power control with small gate power.**
- ★ **Wide range of allowable operating temperatures.**
- ★ **Quick response.**
- ★ **Stable operation and long life.**
- ★ **Compact, light weight.**

For further information on STC Silicon Controlled Rectifiers contact Industrial Products Division

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S162