THE

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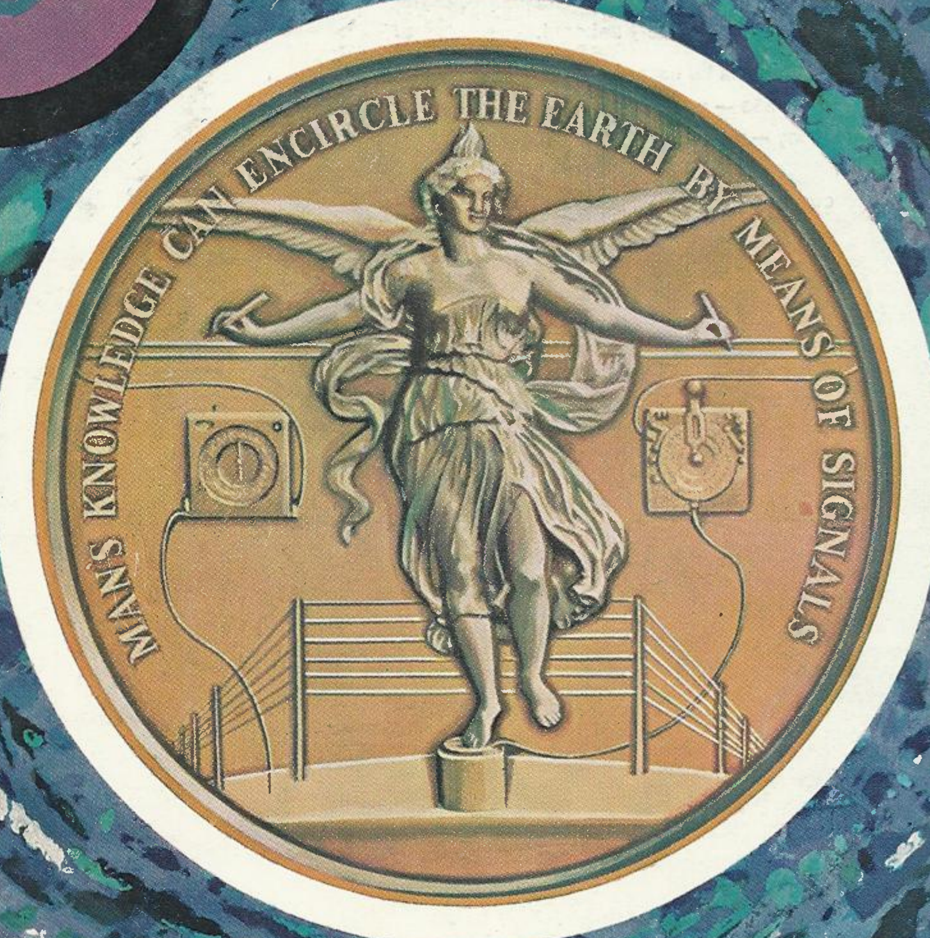

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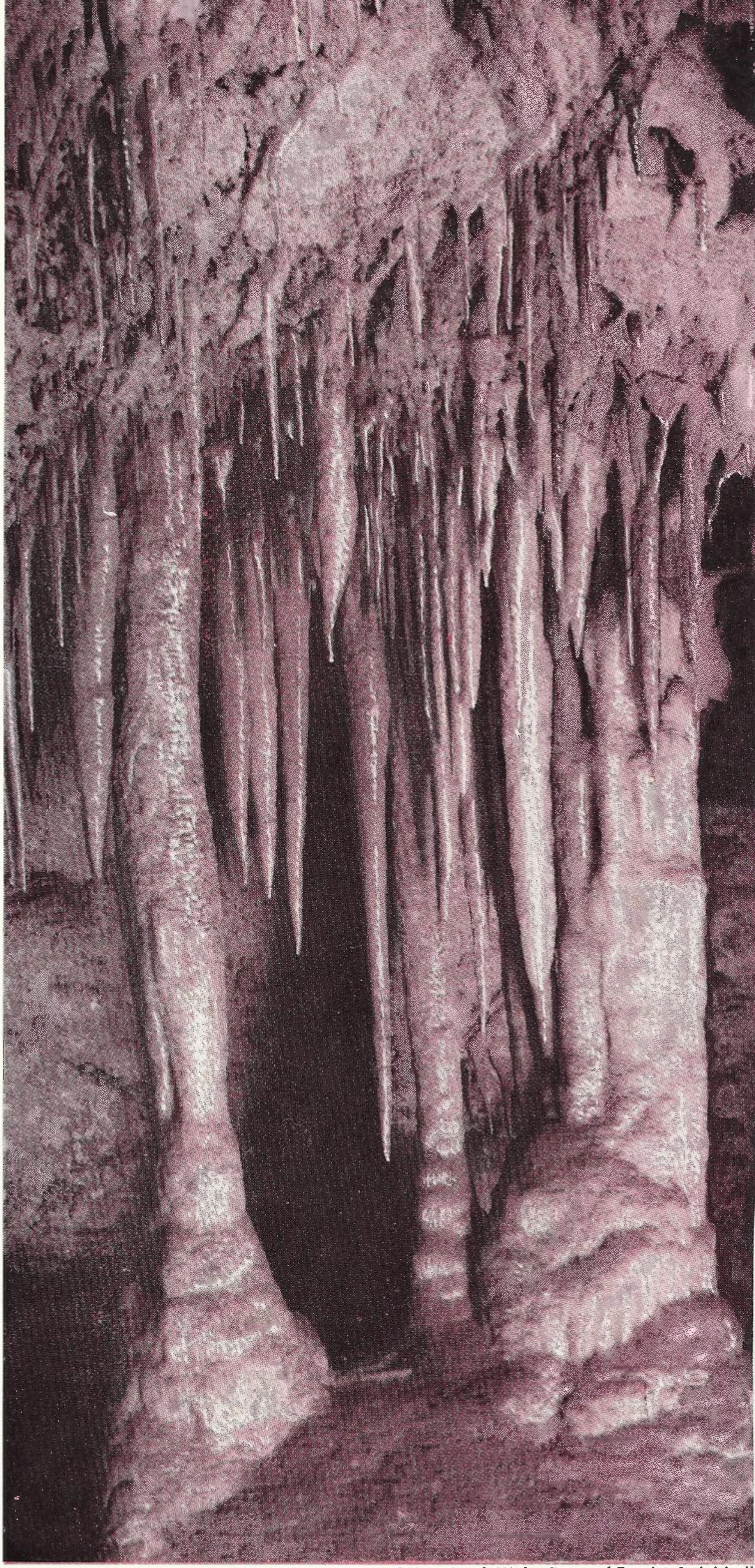
CENTENARY YEAR 1965



"Photo by courtesy of New South Wales Dept. of Tourist Activities"

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ERRATUM

Our contributors, page 246, lines 14 and 15 should read:

"presenting Council's Report after the formal opening of the Conference in this, etc."

The TELECOMMUNICATION JOURNAL *of Australia*

VOL. 15, No. 3 — *Registered at the General Post Office, Melbourne for transmission by post as a periodical.* — OCTOBER, 1965

CONTENTS

FRONT COVER

The cover features the medal struck in 1866 to commemorate the first Conference of the International Telegraph Union, in Paris, 1865.

The Journal is issued three times a year (in February, June and October) by the Telecommunication Society of Australia. Commencing with Volume 15, each volume comprises three numbers issued in one calendar year.

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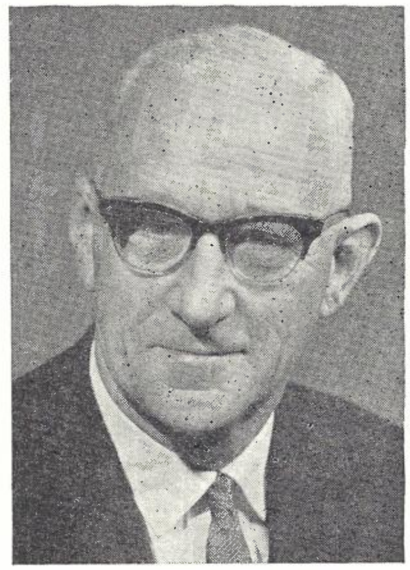
* For addresses see page 254.

FOREWORD

"MAN'S knowledge can encircle the earth by means of signals." So read the inscription on the medal struck by the Paris Mint to commemorate the first conference of the International Telegraph Union held in Paris in 1865.



Mr. F. P. O'Grady, C.B.E.

One hundred years ago this quotation adequately described the introduction of electrical telegraphy. The transmission of speech by telephone, radio techniques, coaxial and submarine cables, videophones and teleconference facilities had not been developed. Telegraphy had advanced as the conventional form of telecommunication with the conversion of written telegraph messages into coded signals as a logical follow-on from the use of semaphore.

Today, a century later, much more ambitious uses have been found or are predicted for telecommunications, which has a host of purposes other than the relay of Government and public communication services. We have the continuing fascination of man's quest in outer space, adding constantly to our knowledge of the universe and relying heavily on telecommunications for its success. The diversity of its uses is also highlighted in the daily activities of air and surface transportation, astronomy, health and meteorology.

Looking to the future, prospects are developing for more important break-throughs in the extension of communication via earth satellites and submarine cables, in the use of lasers and even in the development of microwave transmission of power by radio.

The I.T.U. deserves full recognition for the part that it has played in fostering a century of international co-operation, and in the orderly development of standards, and the adaptation of new techniques for the benefit of telecommunications generally. Without the Union there would be chaos where there is now order.

Australia has been a member of the Union since South Australia joined in 1878. The other five States followed South Australia into the Union and membership by agreement passed to the Commonwealth at Federation in 1901. We are pleased to have been associated with such a long history of international co-operation.

At the commencement of the second century of service, we cannot overlook the new problems facing the Union in a period of rapid changes, and thus it is appropriate that the Plenipotentiary Conference should be called together this year to review Union policy and to establish a new Convention to meet the demands that lie ahead.

F. P. O'Grady

Director-General,
Postmaster-General's Department.

THE INTERNATIONAL TELECOMMUNICATION UNION IN 1965

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

INTRODUCTION

Under Article 4 of the International Telecommunication Convention, Geneva, 1959 — the basic document of the International Telecommunication Union — the purposes of the Union are:—

(a) to maintain and extend international co-operation for the improvement and rational use of telecommunication of all kinds;

(b) to promote the development of technical facilities and their most efficient operation with a view to improving the efficiency of telecommunication services, increasing their usefulness and making them, so far as possible, generally available to the public;

(c) to harmonise the actions of nations in the attainment of those common ends.

For the International Telecommunication Union 1965 has special significance; it is the year of the centenary and for nine weeks in September, October and November the Plenipotentiary Conference, its supreme controlling authority, meets and shapes the destinies of the Union for the first six years of the second century of its existence.

The last such Conference was held in Geneva in 1959. It is therefore appropriate, in this October issue of the *Journal*, to set down the way in which the I.T.U. operates and refer to some of the matters which are of concern to Member countries in this important year.

ORGANISATION

In its simplest form, the organisation of the I.T.U. is shown in Fig. 1. The Plenipotentiary Conference, which is representative of all Members of the Union, determines the policy and guiding principles which are set down in a Convention and associated general Regulations. For the period between Plenipotentiary Conferences the responsibility for the control of the Union's activities on behalf of the Member nations rests with the Administrative Council.

Four permanent organs of the Union, located at Geneva under the direction of the Secretary-General, implement the policies and decisions of the Plenipotentiary Conference and the Administrative Council. In addition, there are Study Groups, Plan Committees and various other Conferences representative of the Members, which play an important part in developing the needs of the Member countries in establishing satisfactory bases for the operation of national and international communication networks. (Ref. 1).

ADMINISTRATIVE COUNCIL

The Council, which meets in annual session, supervises the administrative functions and co-ordinates the activities of the General Secretariat, the International Frequency Registration Board (I.F.R.B.), the International Consultative Committee on Radio (C.C.I.R.) and the International Consultative Committee on Telegraph and Telephone (C.C.I.T.T.) at Headquarters. It consists of 25 members representative of the five main regions of the world. These are Africa (4), Asia and Oceania (6), Eastern Europe (3), North and South America (6), Western Europe (6). The countries represented are:—

Africa —
- Egypt
- Ethiopia
- Morocco
- Tunisia

Asia and Oceania —
- Australia
- China
- India
- Iran
- Japan
- Philippines

Eastern Europe —
- Czechoslovakia
- Russia
- Yugoslavia

North and South America —
- Argentine
- Brazil
- Canada
- Colombia
- Mexico
- U.S.A.

Western Europe —
- Britain
- France
- Germany
- Italy
- Spâin
- Switzerland

The Council meets for a period of five weeks, usually in April and May, and deals with its work through seven Committees. These are:—

Committee 1 — Finance.

Committee 2 — Staffing.

* Mr. Griffiths is First Assistant Director-General, Engineering Works Headquarters, and is the 1965 Chairman of the Administrative Council of the I.T.U. See Page 243.

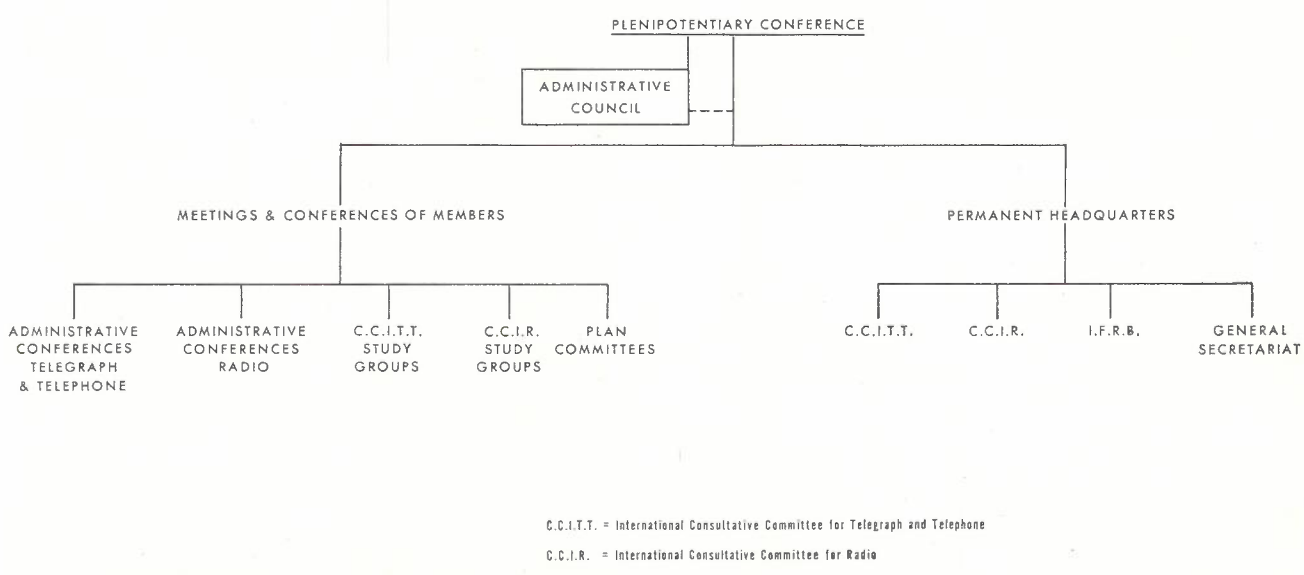


Fig. 1 — Organisation of the I.T.U.

Committee 3 — Technical Assistance and Relations with the United Nations.
Committee 4 — Audit of Accounts.
Committee 5 — Radio Conferences and Space Considerations.
Committee 6 — Resolutions and Reports.
Committee 7 — Drafting.

The Plenary meetings of Council deal with the reports of the Committees and with major matters of policy and procedure. All members of Council attend meetings of Committees, which are not held concurrently, as well as the Plenary, so that matters decided in Committees seldom require extensive further discussion in Plenary.

Ad hoc working parties are set up to deal with particular aspects of problems arising during Committee discussions.

The basis of discussions are documents issued by the General Secretariat and during a normal session the number approximates 190. These range from one page to as many as 167 in the document setting out the budget of the Union. Formal minutes of all Committees and the Plenary are recorded and issued to all Members of the Union. An Annual Report and a Financial Report for each year's activities are prepared by the Council and these also are distributed to all Members. In addition, since 1962 a special Annual Report has been prepared for the United Nations dealing with Telecommunications and the Peaceful Uses of Outer Space and the I.T.U. contributions in this field.

In 1965 a special task of the Council was the preparation of the Council report to the Plenipotentiary Conference, a task allotted primarily to Committee 6 (Resolutions and Reports). This report of 265 pages records the work of the Council and the activities of the I.T.U. since the last Plenipotentiary Conference in Geneva in 1959. In addition, it presents a review of problems which have developed since 1959 and which require consideration by the Plenipotentiary Conference.

Some of the more important matters which were dealt with at this year's Administrative Council are discussed hereunder.

Accommodation: Arising from the need to cope with additional staff accommodation at Headquarters and the difficulty in obtaining adequate facilities in Geneva for the large number of Conferences held by the I.T.U., a proposal has been recommended to the Plenipotentiary Conference to arrange for extensions to the existing building to cater for 100 additional staff and Conference facilities for up to 400, readily divisible into two conference rooms accommodating 150 to 200. Some idea of the Conference requirements of the I.T.U. is demonstrated by the following figures:—

Average period of meetings per year for various attendances:—

	Weeks
Large Conferences held at intervals of from three to six years — 400-800 delegates	10
Smaller Conferences held at one or two year intervals — 200-400 delegates	10
Study Groups and similar meetings held throughout each year — 50-200 delegates	50

In addition, the purchase of the existing I.T.U. building, see Fig. 2 has been recommended. This building was financ-

Fig. 2 — Headquarters Building of the I.T.U. in Geneva.

ed by the Canton of Geneva on a rental basis with an option to purchase under favourable terms by 31st December, 1965.

Broadcasting: Considerable discussion took place on the break down of the African LF/MF Broadcasting Conference held in Geneva in October 1964. This followed difficulties between South African and Portuguese delegations and delegations of other African nations. Complex procedural and political factors were involved and the aim of the Council was to resolve these in the best manner possible and in the interests of the I.T.U. as a whole.

Technical Assistance: As at previous sessions in recent years, much discussion took place on the question of technical assistance to new and developing countries and the best means by which such assistance should be given. A special Technical Co-operation Department at Headquarters exists to manage the expenditure of the United Nations Technical Assistance Funds made available for telecommunication purposes. Again, in such a complex matter, there are necessarily differing views as to the best and quickest way of providing technical assistance.

Budget: The budget of the Union, which was approved at 20,261,000 Swiss francs (£A2,110,530) also involved considerable discussion and in many areas was subject to pruning by Council from the figures presented in the first place by the Secretary-General.

Staffing: Staffing matters, because of the major impact they have on the budget, also come in for close scrutiny by the Council.

PLENIPOTENTIARY CONFERENCE

As mentioned earlier, this conference is the supreme authority of the Union and is ultimately responsible for all policy. The duties of the Plenipotentiary Conference are to:—

(a) determine the general policies for fulfilling the purposes of the Union prescribed in Article 4 of the Convention;
(b) consider the report by the Administrative Council on its activities and those of the Union since the last Plenipotentiary Conference;
(c) establish the basis for the budget of the Union and determine a fiscal limit for the expenditure of the Union until the next Plenipotentiary Conference;
(d) fix the basic salaries, the salary scales and the system of allowances and pensions for all the officials of the Union;
(e) finally approve the accounts of the Union;
(f) elect the Members of the Union which are to serve on the Administrative Council;
(g) elect the Secretary-General and the Deputy Secretary-General and fix dates of their taking office;
(h) revise the Convention if it considers this necessary;
(i) conclude or revise, if necessary, agreements between the Union and other international organisations, examine any provisional agreements with such organisations concluded, on behalf of the Union, by the Administrative Council, and take such measures in connection therewith as it deems appropriate;
(j) deal with such other telecommunication questions as may be necessary.

There are 127 full Members of the Union and one Associate Member (Zambia) and most of these are expected to send delegates to the Plenipotentiary Conference to be held in Montreux, Switzerland, from the 14th September to the 12th November this year.

In dealing with its work the Conference adopts broadly the same practice as the Administrative Council in setting up a series of Committees headed by a Plenary; one essential difference is that some Committee meetings will be held simultaneously and this can lead to more extensive discussions of Committee reports in the Plenary. The time factor, however, makes this practice essential. The Committee structure for the Conference will probably be along the following lines:—

Committee 1	— Steering.
Committee 2	— Credentials.
Committee 3	— Finance Control.
Committee 4	— Organisation of the Union.
Committee 5	— Personnel Questions.
Committee 6	— Finances of the Union.
Committee 7	— Relations with the United Nations, the Specialised Agencies and other International Organisations.
Committee 8	— Technical Co-operation.
Committee 9	— Convention and General Regulations.
Committee 10	— Editorial.

Some of the more important matters to be considered by the Conference are discussed briefly in the following.

Organisation of the I.T.U.: Improvements in procedure and changes in responsibility have pointed to the need to change certain aspects of the organisation of the Headquarters permanent organs. For instance, there have been suggestions that some alteration to the structure of the I.F.R.B. would be of benefit, because of the changed requirements since the Board's formation by the Plenipotentiary Conference at Atlantic City in 1947.

Structure and Representation of the Administrative Council: A number of proposals have been presented for changing the method of representation on the Administrative Council. For example, since 1959 the number of African Members of the Union has increased from 16 to 39 and operations of the Council need review to streamline its proceedings.

Revision of the Convention and Associated General Regulations: Apart from probable amendments arising from changes in organisation and procedure, there is a need for simplification in the layout and improvement in definition, again based on experience during the last six years.

Policy on the Holding of Conferences: The tremendous expansion of international communications during the last few years has emphasised the world wide nature of I.T.U. activities and the need to hold Plan Committee and other meetings at locations in the various regions of the world. This does involve some additional expenditure in the budget of the Union, compared with the holding of such meetings closer to or at the Headquarters of the Union in Geneva, which has to be balanced against the important advantages of regional meetings.

CENTENARY YEAR

The original agreement which was the beginning of the I.T.U. was signed on the 17th May, 1865, in the Salon de L'Horloge at the Quai d'Orsay in Paris by representatives of 20 countries, as follows:—

Austria, Hungary and Bohemia
Baden
Bavaria
Belgium
Denmark
France
Greece
Hamburg
Hanover
Italy
Netherlands
Portugal
Prussia
Russia
Saxony
Spain
Sweden and Norway
Switzerland
Turkey
Wurtemberg

The highlights of the history of the I.T.U. since that date and set against some of the significant dates in the development of telecommunications, are as follows:—

1837 First electric telegraph.

1849 The telegraph first used internationally.

1865 Paris, 17th May. Foundation of the International Telegraph Union by 20 States with the adoption of the first Convention. First Telegraph Regulations.

1868 Vienna Conference. Bureau of the Union set up in Berne.

1871/2 Rome Conference.

1875 Saint Petersburg Conference. New Convention which lasted until 1932.

1876 Invention of the telephone by Alexander Graham Bell.

1885 Berlin Administrative Conference makes first I.T.U. provisions for international telephony.

1895/6 First wireless transmissions.

1903 Berlin. Preliminary Radio Conference of nine States.

1906 Berlin. First international Radio Conference with 27 States. Convention and Radio Regulations drawn up. Adoption of SOS signal.
1912 "Titanic" disaster. London Radio Conference. Improved Radio Regulations.
1924 Paris. Creation of C.C.I.F. (International Telephone Consultative Committee).
1925 Paris. Creation of C.C.I.T. (International Telegraph Consultative Committee).
1927 Washington Radio Conference with 80 States. Establishment of C.C.I.R. (International Radio Consultative Committee). First allocation of radio frequencies to the various radio services.
1932 Madrid Conferences. Organisation's title changed to International Telecommunication Union. First single International Telecommunication Convention. New Radio, Telegraph and Telephone Regulations.
1938 Cairo Administrative Radio and Telegraph and Telephone Conferences.
1947 Atlantic City Plenipotentiary and Radio Conferences. Creation of International Frequency Registration Board (I.F.R.B.). New International Frequency List. Creation of the Administrative Council. Agreement with the United Nations approved.
1948 Seat of the Union transferred to Geneva.
1952 Buenos Aires Plenipotentiary Conference.
1956 Geneva. C.C.I.F and C.C.I.T. merged into new C.C.I.T.T. (International Telegraph and Telephone Consultative Committee).
1958 Geneva Telegraph and Telephone Conference.
1959 Geneva Plenipotentiary and Radio Conferences.
1962 New headquarters building opened in Geneva.
1963 Geneva Space Radiocommunication Conference.
1965 Centenary year and Montreux Plenipotentiary Conference.

The Union has organised a number of functions and special commemorative activities to celebrate the Centenary and in doing this, part of the objective has been to publicise the work of the I.T.U., and the importance of telecommunications in world affairs. These are set out hereunder:—

Special Commemorative Celebrations in Paris, 16th, 17th and 18th May: On the 17th May a special meeting, attended by the French Minister for Foreign Affairs (Mr. Maurice Couve de Murville) and the French Minister of Posts and Telecommunications (Mr. Jaques Marette), was held in the Salon de L'Horloge where the first meeting was held in 1865. A special message was conveyed to the meeting by the Secretary-General of the United Nations (U Thant) televised by the Early Bird satellite. Representatives of the original 20 countries signing the first agreement were present, as well as members of Council and special guests. On that day also the final session of the 1965 Administrative Council meeting was held at the Conference Hall at the Headquarters of the French Department of Posts and Telecommunications.

Apart from these two formal sessions, the Council was entertained with true French hospitality at an official dinner, the Paris Opera, and a visit to the Cathedral city of Rheims.

Issue of Commemorative Stamps by Member Countries: About 100 Members have made such issues. A special album containing these stamps is being prepared for limited issue to Member countries.

Commemorative Sculptured Plaque: A commemorative sculptured plaque is to be installed close to the I.T.U. building facing the Place des Nations. An international competition is being held and many sculptors from some 33 nations have entered the competition.

Issue by the I.T.U. of a History of the Union and of Telecommunications: Entitled "From Semaphore to Satellite" and published in three separate editions in English, French and Spanish, it covers 343 pages, including 365 illustrations, and sets out in light and entertaining form the main landmarks in telecommunications during the last 100 years. (Ref. 3). Twenty thousand copies have been printed and it is expected to generate wide interest, both within and outside the I.T.U. Fig. 3 shows from this book a landmark in early communications, the semaphore invented by Chappe in France in 1794, and Fig. 4 illustrates the Early Bird satellite launched in 1965, and the first communications satellite in commercial operation.

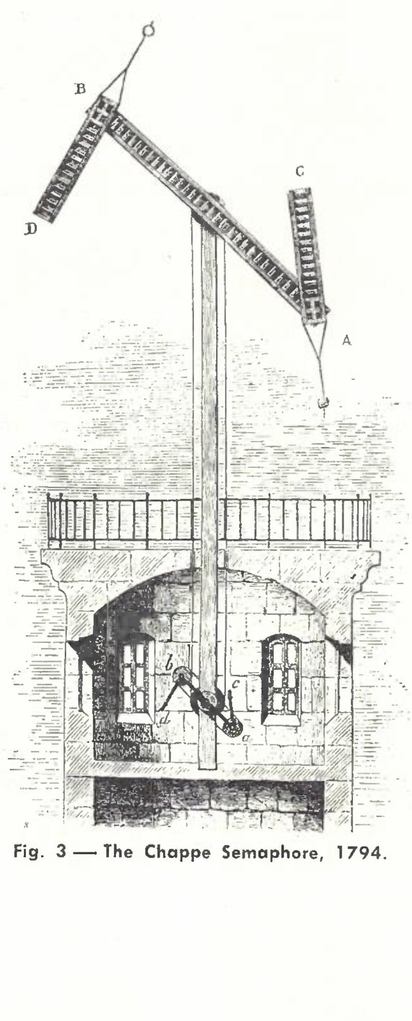


Fig. 3 — The Chappe Semaphore, 1794.

Other Activities: Publication of special articles in the official journal of the I.T.U. — "Telecommunication Journal" — and distribution of special written and illustrative material to press agencies, information centres, reviews and newspapers.

A commemoration to be held on the 8th October at Berne, the seat of the I.T.U. Headquarters for many years.

A special public celebration at the I.T.U. Headquarters at Geneva on the 6th November.

Distribution by Member countries of appropriate publicity in their countries.

Publicity in journals of other United Nations agencies.

Production by the United Nations and France of special film "Commemoration of the Centenary of the Signature in Paris of the first International Telegraph Convention (May 1865)."

CONCLUSION

There is little doubt that the I.T.U. has played a vital but generally little known part in the orderly advancement of the telecommunication art throughout the world. 1965, the Centenary year, has produced the opportunity to draw attention to its activities and the increasing role it must play if the rapid advances in technology are to be properly applied to the world network of communications.

The Union is not just a body of people at Headquarters in Geneva, it is a composite of this group and a very large number of expert representatives from Member countries applying, through an ordered system of Radio Conferences, Telephone and Telegraph Conferences, Study Groups, Plan Committees and Special Committees, the knowledge to ensure understanding and acceptance between all countries of recommended procedures and standards.

Everyone concerned looks forward to the second Centenary of the Union with optimism and enthusiasm for the advancement of its objectives.

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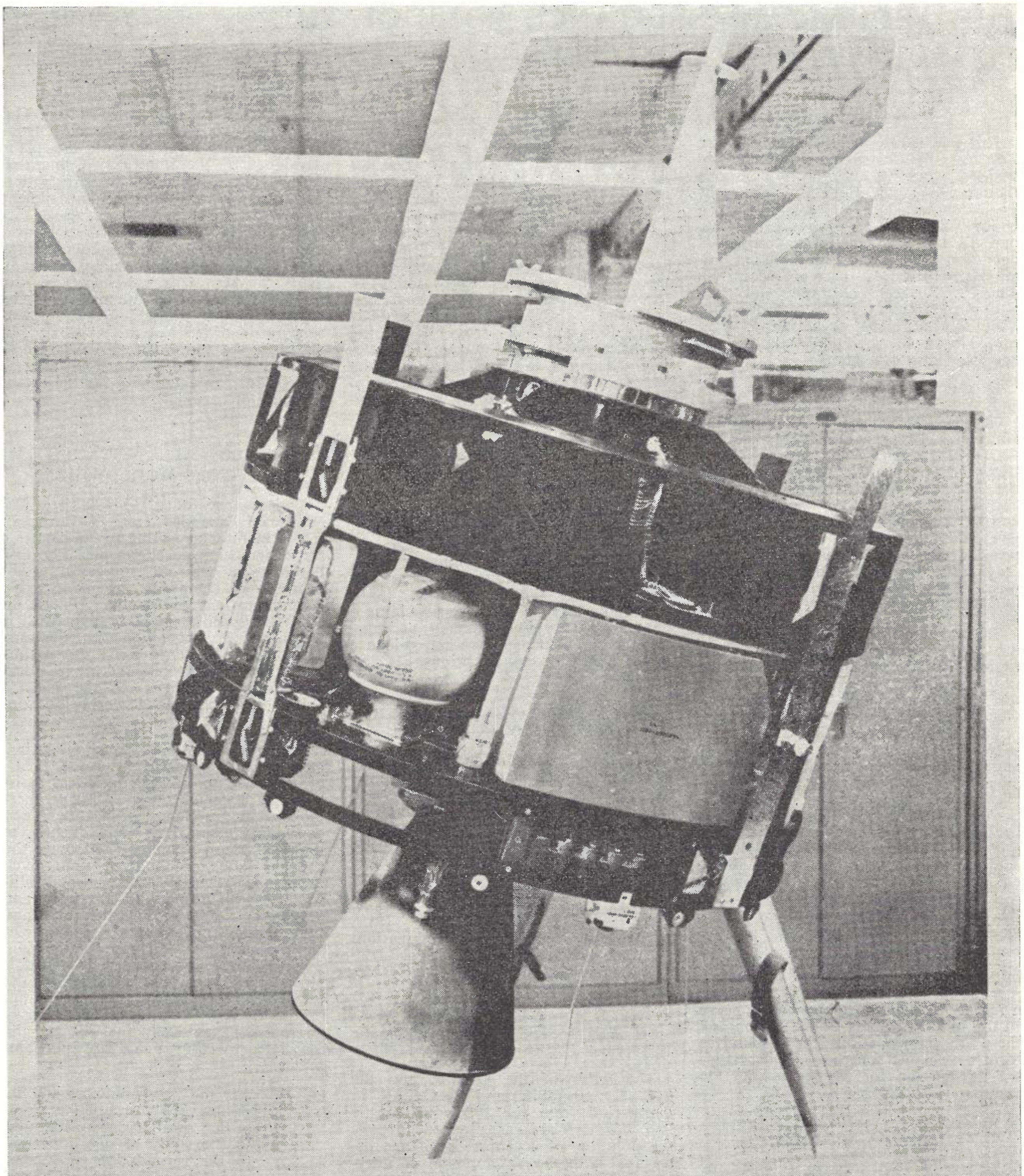

THE MECHANISM shown in Early Bird, the world's first commercial communications satellite, without solar cell panels which will absorb the sun's rays and provide power to operate the satellite after it is launched into space. This internal view displays the electronics and fuel containers that will operate Early Bird when it has achieved synchronous orbit 22,300 miles above the Atlantic Ocean at the equator. The satellite, designed and built for the Communications Satellite Corporation, is the first expressly built to enable the average person to place telephone calls or watch TV between the United States and Europe.

Fig. 4 — The Early Bird Communications Satellite, 1965.

THE TECHNICAL ASSISTANCE ROLE OF THE CONSULTATIVE COMMITTEES

*E. R. BANKS, B.E.E., A.M.I.E. Aust.**

INTRODUCTION

This year is International Co-operation Year for the United Nations Organisation and it is very appropriate that it should also be the 100th anniversary of the International Telecommunication Union. The I.T.U. is a pioneer organisation in the field of international co-operation and the two Consultative Committees, which form part of the I.T.U., the C.C.I.T.T. for Telegraphy and Telephony and the C.C.I.R. for Radio, are essentially technical organisations concerned with international technical co-operation and assistance.

At the first conference of Telegraph and Telephone Engineers in September, 1908, the Technical Director of the Hungarian Administration, Mr. Kolossvary said, "Telegraphy and telephony know no political or national frontiers but serve the interests of all mankind, and we must concentrate our efforts to ensure that scientific progress is put to good use everywhere and, as far as possible, in the same way and at the same time". (Ref. 1). This undoubtedly was a charter for technical assistance in its broadest sense.

Since 1959 the I.T.U. has actively directed its technical assistance efforts towards meeting the specific needs of the new and developing countries. Between the Plenipotentiary Conference at Geneva in 1959 and the Montreux Conference in 1965 the number of countries in Africa alone has risen from 16 to 39 and many of these have not had the advantage of the more developed countries of long association with the activities of the I.T.U. For this reason it has been necessary for the Consultative Committees to undertake special studies in addition to their traditional work, directed specifically to answering problems in the development of communications in the new and developing areas of the world.

This work by the Consultative Committees is complementary to the recommendations that they have prepared, as a result of studying problems of concern to the older members of the Union and these recommendations in themselves form a valuable source of basic technical information for use throughout the communications world.

UNITED NATIONS

A consideration of the role of the Consultative Committees in the field of technical assistance can only be undertaken in the full context of the technical assistance activity of the I.T.U. Since 1952 and especially since 1959 the I.T.U. has been responsible for administering the expenditure of funds for "technical assistance in kind" and for the provision of experts in the field of communications. This activity has been carried out by the Technical Assistance Department of the I.T.U. as part of the United Nations expanded programme of technical assistance. This programme has included the provision of I.T.U. selected experts to advise Administrations on all aspects of communications network development and administration, the provision of fellowships and scholarships for nationals from developing countries to undergo training in telecommunications in all its facets, and the provision of a limited quantity of equipment for training, teaching and demonstration purposes. A very important part of this programme has been the supervision of the establishment and the staffing of training schools in various areas of the world.

However, in addition to this responsibility for administering United Nations funds for technical assistance and the selection of experts in communications, the I.T.U. through its technical organs, the C.C.I.T.T. and the C.C.I.R., has a continuing responsibility for providing a foundation of internationally accepted technical recommendations and guidance in the field of communications.

EARLY TECHNICAL CO-OPERATION ESSENTIALLY EUROPEAN

Very early in the history of the I.T.U. it was recognised that there were fundamental technical problems on which international co-operation was essential and it was as a result of this recognition that the C.C.I.F. on telephony was formed in 1923 at the stage when two basic questions were of concern to the European Telephone Administrations. These questions were:

1. Are overhead wire combinations alone sufficient for long-distance telephony, or should long-distance cables be constructed?
2. Which is preferable for telephony — a manual service or an automatic service?

The work of the C.C.I.F. and the C.C.I.T. (telegraphy) and the C.C.I.R. in the period from the 1920's up to the 2nd World War was directed towards the solution of technical problems associated with the development of international communications within Europe. This was certainly technical co-operation.

Immediately after the war another major requirement of a technical co-operation nature existed with the need to plan the reconstruction of the European communications network. This challenge was met by the formation of a Joint Plan Committee between the C.C.I.'s and this committee opened a new field of technical co-operation. The results of the studies undertaken from 1923 onwards together with the plans developed by the Joint Plan Committee formed a valuable mine of information and advice applicable to the development of international telecommunications services and much of this advice is also applicable to national communications services. To cite one example, for many years the standards established by the C.C.I.'s have formed the basis for the specification of transmission equipment used in many parts of the world and, in addition, the transmission plans recommended by the C.C.I. have been used as a basis in many countries for the establishment of national systems.

TECHNICAL ASSISTANCE BECOMES WORLDWIDE

The role of the C.C.I.'s in technical assistance expanded from a European into a world-wide setting as the result of three significant developments. The first development was the successful establishment of submarine telephone cable communications across the Atlantic in 1956. This achievement brought with it the possibility of automatic telephone operation on a world basis and it thus became necessary to expand the technical co-operation activities of the C.C.I.'s from a European to a worldwide context.

This new possibility came at a time of increasing awareness by the I.T.U. of the need to provide technical assistance of a documentary nature to meet the specific problems of the new and developing countries. Consequently at the 1959 Plenipotentiary Conference the C.C.I.'s were for the first time given explicit technical assistance responsibilities — with respect to the new and developing world — in articles 178 and 179 of the Convention. These articles and the associated Recommendation No. 2 which are reproduced below had a vital influence on the activities of the C.C.I.'s and especially on the proceedings of the C.C.I.T.T. at its second plenary assembly in New Delhi in 1960, and the associated meeting of a Plan Sub-Committee.

(178) (3) In the performance of its duties each Consultative Committee shall pay due attention to the study of questions and to the formulation of recommendations directly connected with the establishment, development and improvement of telecommunication in new or developing countries in both the regional and international fields.

(179) (4) At the request of the countries concerned each Consultative Committee may also study and

* Mr. Banks in Assistant Director-General, Switching and Facilities Planning, Headquarters. See Page 246.

offer advice concerning their national telecommunication problems.

A recommendation of the conference called on the C.C.I.'s to consider the establishment of special working parties and study groups with the specific responsibility for studying problems of interest to new and developing countries and of extracting from the existing library of recommendations those which would be of particular interest to these countries.

C.C.I.T.T. ACTIVITY

In New Delhi in 1960 moves were initiated to widen the scope of the technical assistance activities of the C.C.I.T.T. in the following ways:—

1. Plan Sub-Committees for three regional areas were set up, one for Africa, one for Latin America and one for Asia (Administrative Council Resolution No. 383) and it was agreed that at the meetings of these Plan Sub-Committees new questions of a technical assistance nature and of interest to Administrations in the region concerned, could be raised and either dealt with during the meeting of the Sub-Committee or forwarded to the appropriate C.C.I. study group for an answer. The study groups concerned were enabled to set up special working parties if necessary to consider these technical assistance questions.
2. A Working Party was established under the guidance of Study Group XI to prepare an answer to a technical assistance question on the specification of switching equipment for national automatic networks.

This work initiated in 1960 was reviewed in 1964 (Ref. 2) and the C.C.I.T.T. at its third Plenary Assembly in Geneva took note of considerable progress in this new field of technical assistance. The study of the question on national automatic switching systems and networks had yielded a successful result in the form of a manual of guidance (Ref. 3) of which the first two parts were approved by the Plenary Assembly. The interest shown in the manual by Administrations throughout the world, as evidenced by its reception at the Plenary Assembly, was confirmed later when up to 6,000 copies of the first edition in three languages were ordered from the I.T.U. and moves were made to translate the manual into Chinese, German and Polish in addition to the three languages English, French and Spanish.

In fact, this work proved sufficiently successful to cause the C.C.I.T.T. to set up five Special Autonomous Groups (G.A.S.) responsible directly to the plenary assembly each of which will prepare a manual of guidance on a particular aspect of national communications. The five groups will cover the following subjects:

G.A.S. 1. National automatic networks.

G.A.S. 2. Local networks.

G.A.S. 3. Technical and economic studies of transmission systems. (This is a joint Working Party with the C.C.I.R.).

G.A.S. 4. Primary sources of power.

G.A.S. 5. Economic conditions in the development of national communications systems.

In addition to the establishment of these autonomous working parties, a large number of technical assistance questions were listed for study by the specialised study groups of the C.C.I.T.T. and, in addition, action was initiated to make available standard specifications for particular types of equipment especially in the transmission field.

C.C.I.R. ACTIVITY

The C.C.I.R. has also made a considerable contribution in the field of technical assistance, partly as a by-product of its normal deliberations and partly in response to specific needs of the developing countries.

Until the advent of submarine telephone cables, high-frequency radio was the classical means of overseas communications and is still very important to many of the developing countries. These countries are also faced with the need for rapid development of domestic broadcasting facilities in order to keep their populations informed of current affairs. The basic C.C.I.R. recommendations and reports, developed over the years, provide a course of essential reading to the engineers of the developing countries and supplement the assistance given by I.T.U. experts. In recent years, certain specific problems have also been referred to the C.C.I.R. In response to a request from the Administrative Council, for example, the C.C.I.R. has formulated specifications for low cost broadcast receivers in the expectation that such a receiver would be used in quantities measured in millions in the developing countries.

A series of questions in somewhat similar vein but relating to simple radio communication systems has also been put to the C.C.I.R. by the Plan Sub-Committee for Asia. Other examples of the application of C.C.I.R. work to the field of technical assistance can be seen throughout the C.C.I.R. Green Books (typically, the gathering of propagation data as a basis for the frequency planning of the African Broadcasting Conference, 1964). The international technical forum which the C.C.I.R. represents and the recommendations and reports which it issues are clearly of direct value as media of technical assistance to the developing countries.

TECHNICAL ASSISTANCE WORK BY THE SECRETARIAT

In addition to the above activities in the field of technical assistance the Secretariat of both the C.C.I.T.T. and C.C.I.R. have been playing an increasingly active role in this field of work. In addition to their work for the various study groups and working parties of the C.C.I.'s they provide technical advice to the I.T.U. experts who are selected for work in various Administrations under the control of the Technical Assistance Department in the general Secretariat. In the 1964 period the Secretariat of the C.C.I.T.T. produced a draft condensation of the transmission recommendations in a form more readily usable by national Administrations and this was considered at the third plenary assembly. Also the Secretariat have been responsible for organising seminars and discussions in association with the meetings of the Plan Sub-Committee so as to provide delegates to these plan meetings, with the opportunity to discuss basic development problems in the field of national communications.

SUMMARY

It can surely be said that the origin of the C.C.I.F. and the other Consultative Committees arose from a need for co-operation and mutual assistance at a technical level between Administrations who had the possibility of establishing communications with one another.

This technical co-operation activity has increased in volume and diversified in subject matter as the total demands of the system and the technology have developed. These activities have been progressively broadened in their scope and coverage with the 1945 European reconstruction plan, the 1956 Trans-Atlantic cable and the 1960 establishment of Plan Sub-Committees for Africa, Latin America and Asia. The 1959 Plenipotentiary Conference recognised this broader responsibility of the C.C.I.'s and since that time the development of technical assistance work specifically for new and developing countries has been a feature of C.C.I. activity. In 1923 the C.C.I. was formed as a technical co-operation body for the then communications world of Europe. In 1965 the C.C.I.T.T. and C.C.I.R., together embark on the same basic mission of providing a forum for technical cooperation and technical assistance but now world communications are the challenge and technical assistance on a world basis for new and developing countries as well as for the older networks is the requirement.

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AUSTRALIAN INTERESTS IN THE INTERNATIONAL TELECOMMUNICATION UNION

*R. E. Butler, A.R.M.T.C., A.A.S.A.**

During the past 100 years or so the world has seen some astonishing scientific achievements. But probably none has been more remarkable, nor had so profound an effect upon the affairs of man, than the improvement that has taken place in the means for people to communicate over long distances. The historic "break through", with the introduction of the electric telegraph in the 1830's, has been followed no less dramatically by the development of the telephone, radio, television, the submarine telephone cable and, in more recent times, the use of the space satellite.

One hundred years ago few communities were more interested than Australia in the development of the means for speedy and reliable long-distance communication. The slow exchange of news and information with the old countries was a constant reminder of Australia's immense distance from the cultural sources of its settlers and the markets that sustained them. Even within its own boundaries, communication between the widely separated settlements was hazardous and uncertain.

Thus, the introduction of the electric telegraph into Europe, about the time the first tents appeared on the banks of the Yarra River, was viewed in Australia with understandable interest.

The expansion of the European network within national boundaries was very fast. It was favoured by the social, political and commercial challenge of the times. The first submarine cable was laid between France and England in 1851 and, with the obstacle of the sea breached, slender links began to creep outwards from the old world to the new. During the 1850's and 1860's several plans were put forward with the objective of bringing a submarine cable to the Australian shore. Similar conditions stimulated the installation of international communications.

Eventually, in 1870, the Government of South Australia entered into an agreement with the British/Australian Telegraph Company to lay a cable from Java, already linked with Europe, to Port Darwin. Fig. 1 shows the cable being hauled ashore at Darwin in 1871. Here it joined the historic overland telegraph line to Adelaide constructed with infinite labour and resource by Sir Charles Todd and his men along a difficult and inhospitable route explored some ten years earlier by McDouall Stuart. Fig. 2 shows a group of overland telegraph officers at Roper River in 1872. The first "through" message reached Adelaide from London on 22nd October, 1872 and 12,000 miles were bridged in an instant.

With the establishment of telecommunication with the outside world the individual Australian States, led by South Australia in 1878, progressively joined the relatively young International Telegraph Union, which had been founded in 1865.

Now, 100 years later, the Union is widely regarded as an impressive and long-standing example of world-wide

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Fig. 1 — The Landing of the Telegraph Cable at Darwin in 1871.

Fig. 2 — A Group of Overland Telegraph Officers at Roper River in 1872. From left to right: J. A. Little, R. C. Paterson, C. (later Sir Charles) Todd, and J. Mitchell.

international co-operation. It is the oldest of the inter-governmental organisations which form the specialised agencies of the United Nations. Its work is largely of a standard-setting and regulatory nature. It provides the forum for the telecommunication authorities of the world to discuss the removal of inconsistencies in the arrangement and conduct of their services so that the amazing advances that have been achieved in telecommunications will be employed to the full.

The Union's role is to encourage and assist the effective and efficient utilisation and extension of the world networks by providing opportunity for the exchange of information, advice and assistance in the solution of telecommunication problems.

Australia today is no less interested in current telecommunications advances than it was 100 years ago. Certainly the speed, variety and range of our facilities have increased enormously in that time. However these have been paralleled by a vigorous national growth with all of the familiar and complex demands for service which the modern world generates. Telecommunications are now the life blood of a modern society and of virile and successful government, trade, industry and commerce.

Although the physical reality of distance no longer constitutes in itself the problem that it presented to our forebears, other barriers have been exaggerated or imposed which, if left unsolved, would detract no less from the effectiveness of our services.

The first of these is that the other end of any international communication system is owned and operated by another administration or operating agency. Frequently a third or even fourth party is involved at intermediate transit or switching points. The most immediate effect of this situation is that the quality of an overseas call originated by an Australian subscriber is affected by the standards of one or all of the networks through which at some time it passes and over which the Australian administration may exercise no direct control.

In other words the efficiency of any one national network, for international purposes, is no greater than the weakest network in the chain.

The elimination of conflicting operating standards therefore becomes a prime objective of the Union and forms a major part of the activities of the Consultative Committees.

Australia's circumstances, from the telecommunication viewpoint, are such that they require her to take perhaps more than usual interest in the work of the Union.

Our geographical position, comparatively remote from our communities of interest in the northern hemisphere and, to a lesser extent, in the south-east Asian and Pacific regions, has led to a proportionately high investment in submarine cable networks and international telecommunication installations. In addition to the long established Commonwealth telegraph and radio telephone networks, we have in recent years become substantial partners in the submarine telephone cables COMPAC and SEACOM and in a proposed global communication satellite system.

The development of common standards of equipment, techniques and procedures and the task of persuading the various nations to introduce them into their individual networks therefore are of vital consequence to the effective conduct of our own telecommunication operations and the full economic employment of our capital investments.

Inadequacies in areas of the world networks can even be carried into our national system. The adoption of subscriber trunk dialling, for instance, and the provision of automatic telex in our internal system introduces into the network problems arising from inefficiencies or shortcomings in foreign cables or networks.

A further factor affecting Australia more than most major telecommunication Administrations, and also arising from our geographical position, is the problem of differing world time regions. For example, there is no overlap of business hours between Europe and Australia. When we are at work London is sleeping. Most of Sunday in America is Monday in Australia. This in turn affects traffic volume on a particular route at a particular time. It imposes problems for Australian operators not shared to the same degree by northern hemisphere operators. In a modern world requiring large scale capacity circuits and imposing ever increasing demands for new facilities, the time differential must also be recognised in planning facilities to achieve maximum utilization of plant.

The word "persuasion" has been used in this Article when referring to the decisions of the Union. This has been deliberate in order to emphasise that the Union has no powers of compulsion. It can only *recommend* that a course of action is followed by members.

The extent to which members will put this advice into effect is of course subject to a number of factors, mainly financial, i.e. the substitution of equipment, etc. However acceptance of the principles expressed in the Recommendations is strongly assisted by the fact that the people to whom they are directed have themselves contributed to their formulation.

The opportunity that the Union provides for joint and voluntary consultation in the widest sense is the corner stone in its continued success. At the same time this continued consultation presents a strong reason why Australian participation in I.T.U. activities should not diminish in the future.

Australian conditions have provided us with unusual opportunity to subscribe to the technical studies of the Union. The magnitude of the areas covered by our domestic networks has produced telecommunication problems in our national services that are repeated within the boundaries of very few countries. For example, circuits equivalent in length to those between Cairns and Perth would stretch from London to Karachi. The experience gained in the solution of these problems has earned for Australia considerable recognition as a long distance telecommunication authority.

However it should not be forgotten that, despite our experience in the telecommunication field, Australia must still be regarded as a young and developing country. The expansion of our networks, involving continued substantial investment and technical commitment, is therefore inevitable. The advantages of avoiding decisions, in respect of world standards, which could be prejudicial to the continued compatibility of our telecommunication networks with the world systems are obvious. This can best be achieved by maintaining the closest possible association with the forums at which these decisions are reached.

Just as most organisations have need to review their responsibilities and management, to analyse requirements and to re-organise their methods and structure where necessary, it is also desirable that the members' collective responsibilities as a Union should be regularly examined and appraised to ensure that they still are being properly discharged. This need is accentuated in an era of rapid changes.

The most appropriate forum for such a review is the supreme body of the Union, i.e. the Conference of Plenipotentiaries, which is presently convened at Montreux. The Conference has the opportunity to decide the fundamental aspects of the Union's working methods, Headquarters Secretariat requirements and general policies, and to provide further avenues for international co-operation, improved telecommunication understandings and services generally to the benefit of the various communities.

Australia is equally interested in contributing to the improved effectiveness of the Union and like many other countries has submitted proposals for Conference consideration.

There are few of man's activities with a history of peaceful international co-operation as impressive as that pertaining to telecommunications. But it is only fair to say that the remarkable progress that has been made in this field would not have been possible without the realistic attitude with which telecommunication authorities have approached the development of their own national networks, those in other countries and the international cables and facilities which lace them into a world wide network.

The growing needs of the modern world demand more comprehensive, more rapid, more efficient means to communicate. The Union is making its contribution by encouraging the study of mutual problems in joint consultation, the sharing of telecommunication knowledge and the fruits of research, and by arranging the provision of materials, equipment and assistance, where needed, for the improvement of the world telecommunication network.

Australia, along with the other Members of the Union, has much to gain by continuing to play a full and vigorous role in these activities.

TECHNICAL NEWS ITEM

RECENT ADVANCES IN PUBLIC MOBILE TELEPHONE SYSTEMS

Radical changes have recently been introduced in the equipment and operational features of mobile telephone systems produced for use by the public. These changes have been dictated mainly by:—

(a) the need to make more efficient use of the limited radio channels available, and
(b) a policy of upgrading the available facilities and operational procedures to those available to fixed subscribers, such as full-duplex working (replacing the "press-to-talk" action previously required), privacy of conversation and subscriber dialling (trunk and local).

The changes involved have been made possible largely by the growth of semiconductor techniques where the inherent advantages of low power consumption, robustness and compactness have direct application to the problems of vehicle-borne equipment. With the replacement of relays by solid state units it has been possible, within the space, reliability and power consumption limitations, to introduce sophisticated logic control circuitry into a vehicle installation, thus furnishing the means of full automatic working.

Probably the most advanced equipment presently available is the I.M.T.S. (Idle Mark Telephone System) which first went into service in March this year in Salt Lake City, U.S.A. I.M.T.S. was developed by various American companies to meet specifications set by Bell Laboratories who had carried out a comprehensive study of existing mobile systems. I.M.T.S. uses up to 11 two-way radio channels and in a given system any mobile subscriber may be connected via any of the available radio channels. This provides a full trunking advantage compared to existing systems where a subscriber has access to only one radio channel, or can be called on only one pre-arranged channel. The method used in I.M.T.S. to achieve this multi-channel operation is based on marking a particular idle channel for use (hence the name "Idle Mark Telephone System"). The base station logic selects a free radio channel and automatically marks it for use by modulating it with an "idle" tone. All idle mobile equipments automatically search through the available channels and park on the channel carrying the idle tone. Thus all free mobiles may be signalled on the marked channel, or any mobile originating a call will signal out over the channel. Various built-in delays minimise the possibility of simultaneous seizure, either by mobiles, or by base and mobile. Directly the "idle" channel is taken for use, the base station logic transfers idle tone to the next free channel. This idle tone technique also leads to a ready method of providing conversation privacy, accomplished by incorporating additional features to inhibit call-action at any mobile and disconnect its handset, when idle tone is not received.

In addition to the above, two-way, subscriber-to-subscriber dialling is made possible by providing an individual exchange line for each mobile subscriber, with the radio system and control circuitry functioning as a line concentrator. On originating a call the mobile equipment automatically sends an identification code for examination by the base control circuitry which connects the radio channel to that mobile subscribers exchange line. On hearing exchange dial tone the mobile subscriber dials the required number. When a fixed subscriber dials the listed number of the mobile subscriber, the base control circuitry detects ringing tone on the mobile subscriber's line from the exchange, selects the particular subscriber's code address and transmits it to all idle mobiles parked on the idle channel. The mobile equipment concerned, sensing its code, stays on that radio channel while all other mobiles, sensing a code mismatch, search for the new idle marked channel. The base then sends ringing tone for 45 seconds, or until the mobile subscriber lifts his handset where upon the talking circuit is established.

Over the radio channel, all identity and selection codes are carried in sequential, pulsed digit form with a frequency shift between two tones registering as a pulse. Frequency shift pulsing is also used to relay ringing signals and dialling pulses. The use of guard tones, parity checks and long time-constant sensing circuits afford protection against spurious operation due to noise or speech.—R.K.

ARTIFICIAL SATELLITES FOR TELECOMMUNICATION

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INTRODUCTION

General

Population growth and social and economic development throughout the world demand the provision of ever larger and more sophisticated communication systems. The operators of national telecommunication systems engage in a continuous process of forward planning and research, examining and selecting new technological advances for combination with established techniques so that their systems may be expanded to meet these demands economically. This paper reviews current developments in a new technology — the technology of satellite communications — and the investigations which the Post Office is making to establish its potential for furthering the communication service offered to the Australian public.

The growth in telecommunications in this country and in the world at large has been spectacular both in its magnitude and in the facilities provided, and shows no signs of abating. Its magnitude can be seen from Figs. 1 and 2, which in addition to showing the growth in telephone service predict the size of the task ahead. It will be seen that at June, 1964, Australia had 2,670,000 telephones in a world telephone population of 169,000,000 and that with continuance of the historical growth rates of approximately 6% per annum these totals will double over the next 12 years. The growth of intercontinental traffic is exemplified in Fig. 2 by the doubling every four years of calls involving the United States, and highlights the reason for world interest in large-scale intercontinental circuit provision via satellites. Subscribers have experienced improved facilities such as the conversion of local networks to automatic and the great improvement in the trunk system, where rapid service and good quality connections are now accepted as normal. The recent availability of top quality international circuits with the completion of the COMPAC submarine cable system now provides virtually "on demand" connections from Australia to the North American continent and the United Kingdom.

The growth is to an extent self-sustaining since improved communication facilities are productive of economic and social advancement which in turn generates further demands. This interplay of demand, technical progress and service has brought us to the stage in telephony where nation-wide subscriber dialling is being introduced, and world-wide subscriber dialling is being planned under the auspices of the International Telecommunication Union, the United Nations' specialised agency for telecommunications. (Refs. 1 and 2).

Potential of Satellite Communication

The extension of the range of telecommunications services, the increase in the speed of connection and the improvement in the quality of service have always been dependent on the ability to provide interconnecting circuits of adequate quality and in sufficient numbers. It is because of their potential for providing large numbers of high quality circuits over intercontinental distances that satellites hold such interest for telecommunication system operators. Their successful application would speed the implementation of plans for world-wide automatic service and would have special implications for Australia because of its geographical isolation from the American and European continents. They could also assist in the solution of some of the problems of long distance internal circuit provision, imposed by the vast unpopulated expanses separating centres of population in this country.

Communication by satellites offers the potential of large bandwidth and global coverage with theoretical capacity for providing telephone, telegraph, data and television channels in very large quantities. Satellites will introduce a new dim-

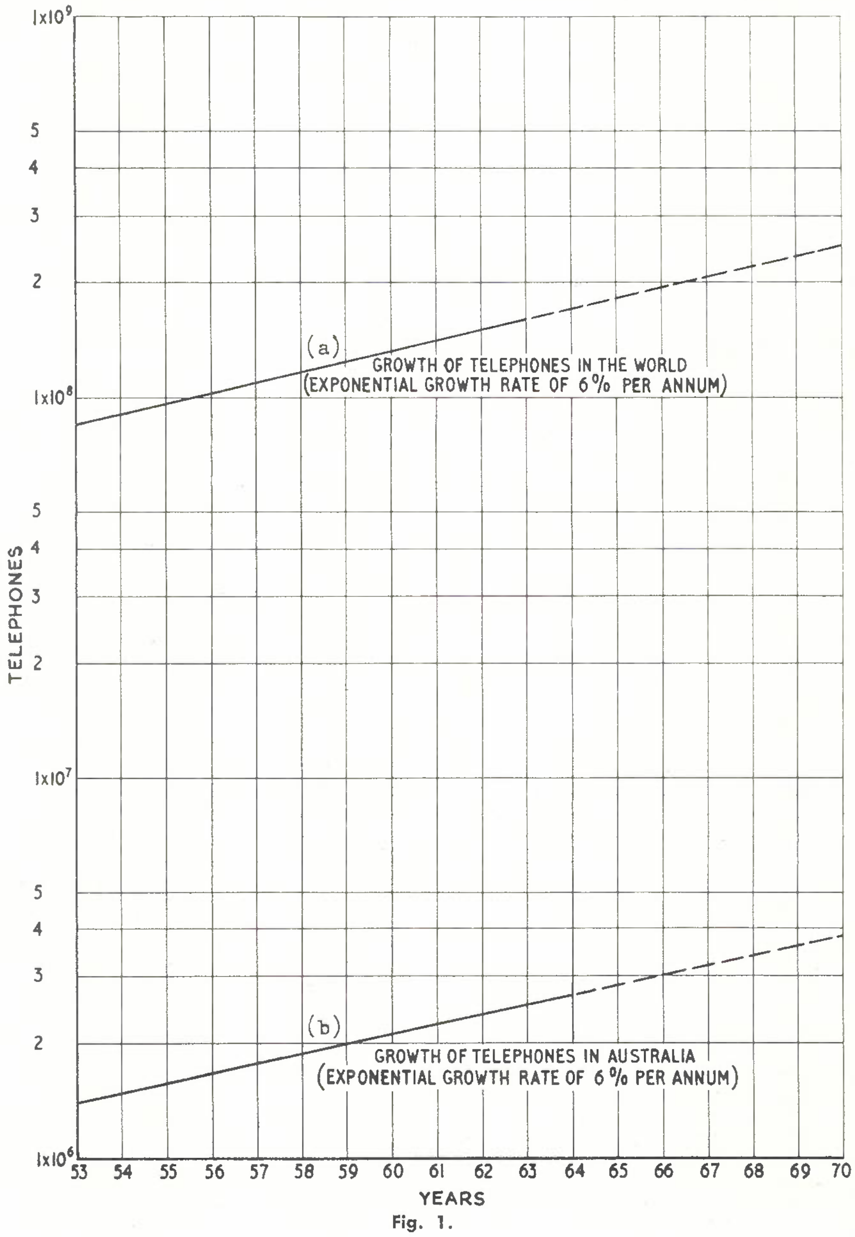


Fig. 1.

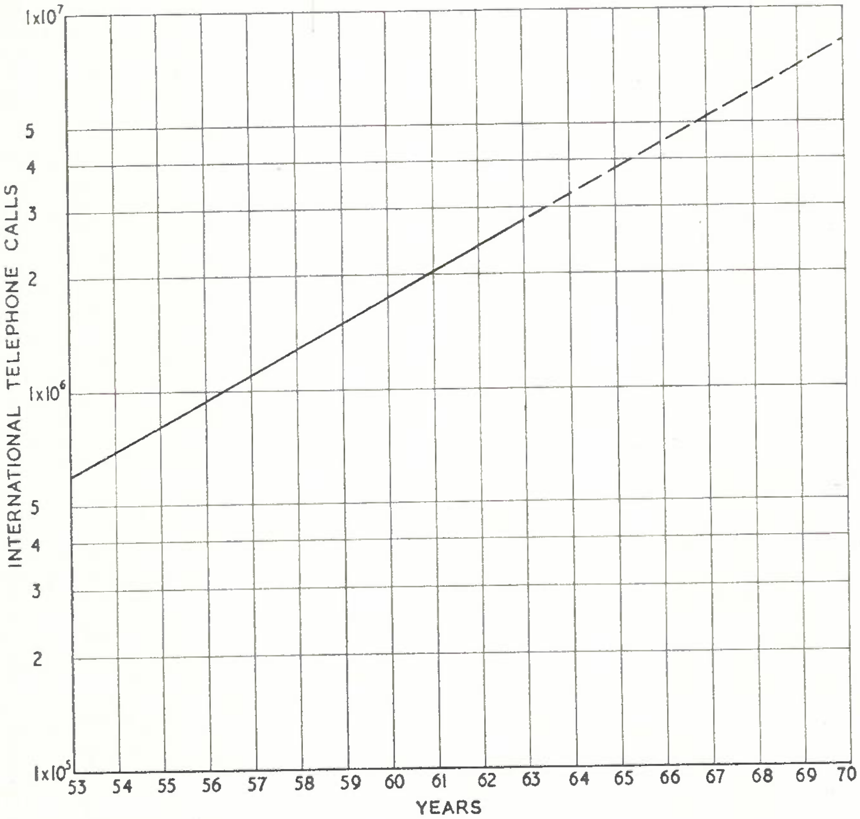


Fig. 2.

ension into intercontinental circuit provision since access to the system will, in principle, be possible from any location by the construction of a suitable ground station. Because of the wide accessibility of satellite systems, it may also be possible to exploit the time differences in major streams of intercontinental traffic to increase the amount of traffic carried by each circuit, to a far greater extent than is practicable with submarine cable systems with their fixed entry and exit points.

MILESTONES TOWARD A COMMERCIAL SYSTEM

Satellite communication experiments first began in 1956 when James Trexler transmitted and received voice signals via our natural satellite, the Moon, using a large but relatively cheap parabolic reflector dug into the side of a hill. The first public demonstration with an artificial satellite was "Score", which in 1958 transmitted a tape recording of President Eisenhower's Christmas message. Other experimental satellites followed, using both active (amplification) and passive (reflection) re-transmission principles, culminating in the launching on the 10th July, 1962, of Telstar, the 5Mc/s bandwidth active television relay satellite developed by the American Telephone and Telegraph Company working in co-operation with the National Aeronautics and Space Administration (N.A.S.A.); Telestar continued to operate until February, 1963. Subsequently, Telstar 2, Relay 1 and 2, and Syncom 1, 2 and 3 communications satellites were launched and operated successfully, and a series of experiments conducted by the U.S.A. with the collaboration of other nations demonstrated the technical feasibility of providing communication circuits via earth satellites.

Early Bird, the first satellite for regular traffic between North America and Europe was launched on 6th April 1965. (Ref. 3). Developed for the Communication Satellite (ComSat) Corporation (see below), by the Hughes Aircraft Company from the successful Syncom design, this project followed protracted negotiations both within the U.S.A. and internationally between the Americans and many other countries, including Australia.

The performance of Early Bird in traffic will be watched with great interest, particularly to assess the subscribers' reaction to the one-way propagation time of 250 milliseconds, which is associated with its synchronous orbit altitude. Success of the Early Bird proposals, which the ComSat Corporation has decribed as a "quasi-operational" system, will no doubt confirm plans to launch one over the Pacific some time in 1966.

The Soviet Union's communication satellite Molnya 1 was launched on 23rd April 1965. (Ref. 3). It is designed to relay television programmes and provide two-way multi-channel radio telephone and telegraph links over long distances.

The development work in satellite communications and its implications for all nations were recognised by the United Nations General Assembly, which in December, 1961, passed a resolution that "communication by satellites should be available to the nations of the world as soon as practicable on a global and non-discriminatory basis" and took special administrative action through the International Telecommunication Union to assist in the achievement of this objective.

The use of satellite systems in the world telecommunication networks is only part of the I.T.U's. interest in the conquest of outer space, since telecommunications by radio are involved in practically all space projects. Its International Consultative Committee on Radio, the C.C.I.R., had commenced studies soon after the launching of the first artificial satellite. After establishing the formal organisation of the work in 1959, the C.C.I.R. in 1963 was able to secure important technical agreements which paved the way for an Extraordinary Administrative Radio Conference to allocate frequency bands for space communications purposes later in that year. Other groups have been studying time delay and echo effects associated with very long transmission circuits, which are of particular importance in assessing the potential of satellite systems for long distance telephony.

In 1962, the Government of the United States of America announced plans for an attempt to implement the United Nations resolution in the context of their private enterprise ideology. The Communication Satellite Corporation was established and was fully subscribed on the American Stock Market to the nominal 200 million dollars. In addition, the American Administration was active in enlisting the support of other nations for a world-wide commercial satellite system in which ComSat Corp. would participate. After protracted negotiation, an interim agreement was signed in July, 1964, by 19 participating countries. Australia is a signatory to this agreement and, with a shareholding of £2.5 million, is a member of the Interim Committee which, in effect, is the Board of Management which will determine the technical, financial and operational conditions of the first commercial system projected for initial introduction in 1965/66. In view of its responsibilities in regard to Australia's international communications, The Overseas Telecommunications Commission is the nominated communications entity for the purposes of the agreement and represents Australia at meetings of the Interim Committee.

ECONOMIC, SERVICE AND COMPATIBILITY ASPECTS

There is therefore no doubt that a commercial satellite system will be established, but to retain a place as a regular means of international circuit provision, satellite systems must compete with other forms of circuit provision on the grounds of both economics and service standards. They must also be examined to see, not only whether their adoption as part of the telephone service is feasible, but what adjustments will be necessary and under what circumstances they should be incorporated into the existing service and existing network.

Not all new developments withstand such close scrutiny, and others, because of inherent limitations, find only a temporary period of usefulness. Moreover, technical, geographic and traffic considerations vary significantly between countries, so that a development with useful application in one may be rejected in another. For example, in the 1920s the 2-wire voice frequency repeater was extensively employed in the European trunk network, whereas in Australia, with the longer trunk distances involved, it found relatively little application.

As a result, when carrier working was subsequently developed, the Australian trunk network moved directly from physical circuits to 4-wire carrier circuits avoiding the problems which the legacy of the 2-wire V.F. repeatered systems continued to pose in Europe for many years. Similarly, in the post-war years, coaxial cable and line-of-sight microwave radio developments have dominated long distance circuit provision in national systems, whereas systems using tropospheric scatter or surface-wave transmission lines, although technically feasible, have failed to find a place in the Australian network.

One of the considerations which the Australian Post Office naturally gives to any major development is to its effect on the existing plant, which represents an asset in which the national investment is very great. There are the various physical factors such as technical compatibility with the new development and the extent to which streams of traffic in the network might be altered, as well as the effect of the new development on the policies and objectives of the telephone service. In the Australian telephone system which provides service to two million subscribers, fixed assets in the form of 6,888 telephone exchanges, line plant involving 13 million miles of copper wire, and extensive line carrier and radio equipment have been accumulated to an assessed value of £579 million. With nation-wide automatic service proposed, all plant items must be developed as part of an integrated system.

Satellite systems must compete with submarine cable for intercontinental circuit provision and with line-of-sight microwave radio and coaxial cable systems for national long distance circuit provision. These will present impressive opposition on economic grounds. The successful operation of a number of intercontinental submarine cables and the rapid increase in the available bandwidth and reduction in cost per circuit mile of successively provided cables have shown spectacular progress in this arm of technology. The first Trans-Atlantic submarine cable (TAT) which was installed in 1956, provided for thirty-six 4kc/s speech circuits at a cost of approximately £208 sterling per circuit mile; COMPAC in 1962 provided sixty 4kc/s circuits at approximately £45 sterling. Today the cost of a 160 circuit system is about £20 sterling per circuit mile, and future 640 and 1,200 circuit trans-ocean systems would cost, respectively, about £10 sterling and £5 sterling per circuit mile. Costs per circuit mile on large capacity national systems are below these figures.

The economic justification of satellite systems will depend on a number of factors including the build-up of international traffic to permit effective exploitation of the wide bandwidth available, solution of the problems of multiple access, and other technical developments leading to increased satellite reliability and life, and to reductions in the cost of rocket launchings and ground stations.

Some idea of the current level of these costs can be gained from the ComSat estimate of $200 million to provide the space segment of the first commercial world system. About $60 million is expected to go on system development and $75-90 million on manufacture and placing of satellites in orbit (launching costs are of the order of $3 million each), $10 million on a command and control centre, $20 million on research, administration, etc.

A high capacity station of the type Australia would need to build, which would be capable of handling TV relaying and several hundred telephone channels, would be equipped with, say, an 85 foot steerable antenna and would cost £2 million or more. The cost could be reduced if a stationary satellite system were used, making it possible to use a fixed antenna.

If the satellite system is appropriately designed, lower capacity stations for use where traffic requirements are small could be provided for a much lower figure. It might be as low as £250,000. These stations, however, would not have the capacity to handle TV relays.

If ComSat achieves its aim of providing a world-wide coverage by 1967 within its expected expenditure, and the bandwidth provided allows for 240 channels or more, it will be achieving comparable first cost per circuit mile with that achieved with recently laid submarine cables. Operating costs would be a good deal higher due to the comparatively short life of satellites.

SOME TECHNICAL ASPECTS

The many technical aspects of satellite communication have been adequately covered in the literature (Refs. 4, 5, 6, 7 and 8). Two problems of special significance are the effect of delay and delayed echos and the problem of optimising the multiple access facility.

Delay and Delayed Echoes

Typical time delays which occur when a satellite system is used for a long connection are:—

Satellite at 14,000 kilometres (8,700 miles) altitude — 110mS.

Satellite at 36,000 kilometres (22,500 miles) altitude — 260mS.

If the propagation time is sufficiently long a telephone conversation is in danger of breaking down. For example, a speaker expecting a reply, tends to interpret a long period of silence after he stops speaking, as a sign that the listener has not heard and he begins to speak again, before he hears the answer.

Recent studies by several groups throughout the world of the effects of long propagation time on telephone circuits have led to some revision of C.C.I.T.T. limits on this factor. The present Recommendation (G. 114 (p. 14) Geneva 1964) states that satisfactory conversation is possible when the one way propagation time is in the range 0 to 150 milliseconds. For the range 150 to 400 milliseconds it is considered that conversation will probably be satisfactory, but if the propagation time is greater than 400 milliseconds, the circuits would probably be unacceptable.

D. L. Richards (Ref. 9) has estimated that the number of unsatisfactory conversations per minute is roughly proportional to the propagation time. On average, a conversation was judged unsatisfactory when more than two confused situations occurred in the first minute and at 600 milliseconds one-way propagation time, 16% of conversations fell in this category. Furthermore, it was considered that about 10% of the subject pairs were particularly prone to suffer confusion and for them some 44% of conversations would be unsatisfactory. It was concluded that the maximum practicable limit on one-way propagation time would be 350 milliseconds, which is close to the maximum thought to be feasible by C.C.I.T.T.

In the case of the telephone system it is necessary to take account of delayed echoes which also operate to the detriment of natural conversation. At least 40db return loss is required to ensure substantially complete separation of the two directions of transmission and at present this is not practicable. In fact, any substantial improvement awaits a technical break-through to provide balance of very complex networks at an acceptable cost. It should be remembered that each channel must be balanced separately which means that thousands of units are involved. A complicated solution is thus not practicable.

If the propagation time is short enough, say less than 15 milliseconds or so, the echo will appear as sidetone to the subscriber and no distinct echo will be perceived. At longer propagation times the subscriber will be aware of the echo of his own voice and the disturbing effect produced becomes progressively more serious as the delay time and the echo level increase. At the worst, a high level echo with a long delay will so disturb the subscriber that coherent speech is virtually impossible.

For many years, voice-operated switching devices have been used to suppress the echoed signal, but it can be appreciated that a reasonably simple device cannot cope with all possible situations. As an instance, if the speech level produced by a particular subscriber is in the lower range and he happens to be at the end of a longer than average local line, it is quite possible for the unwanted echo level associated with a high level subscriber at the far end to exceed the wanted speech level. Furthermore, in the presence of long propagation times the conversation confusions are applied as signals to the echo suppressors with the result that it is possible for devices at both ends to operate so that both talkers can be disconnected simultaneously for a time.

Multiple Access

The modulation system and orbits used for a satellite system may be chosen with a view to providing for a facility known as multiple access. Other methods of communications such as submarine cable systems are essentially trunk connections between two terminating stations. A satellite repeater on the other hand is visible at any one time from points within a large area of the earth's surface so that by suitable design it may be worked from a number of terminal points simultaneously. This multiple access facility allows increased flexibility for traffic routing.

At the present state of the art, multiple access working leads to a substantial loss in the total number of telephone channels available in a given satellite compared with its use as a simple point-to-point repeater. Future developments may be expected to overcome the problem. For the time being and so long as we are tied to F.M. as the only practicable modulation system, we are faced with an engineering dilemma which has not yet been resolved in a really satisfactory manner.

On the one hand, reasonably efficient utilisation of the total repeater capacity is possible by a demodulating process in the satellite. This method would allow up to a dozen or so ground stations to work to the satellite but at the expense of a very complex demodulating repeater which could be difficult to make sufficiently reliable. On the other hand, the alternative approach is to pass the several signals through a simple non-demodulating satellite repeater separated in frequency by generous guard bands. This method eases the problem of satellite reliability but it is severely limited in the subdivision possible. If the capacity in point-to-point working is taken as 100%, a typical result of frequency subdivision to allow two pairs of stations to work on a multiple access basis is a reduction in total capacity to 75%. Further subdivision is even more inefficient, the reduction in the case of four pairs of stations, for instance, being to a figure as low as 35%. The reductions are necessary to ensure that the intermodulation produced by several R.F. signals passing through a common amplifier does not degrade the derived telephone channels to a performance worse than that specified in C.C.I.R. recommendations.

A desirable objective for a multiple access facility is that the total channel capacity should not be reduced by subdivision between many co-operating stations and in fact should be independent of the number of participating terminals. Such an ideal is theoretically possible using single sideband (S.S.B.) methods in the ground to satellite direction and experiments along these lines were proposed in the Advanced Syncom programme. However, at present these methods have not yet been proved in practice and it is likely that the first commercial systems will not employ the most efficient of the F.M. methods. This can only be considered an interim compromise, justified on the grounds of urgency rather than engineering requirements.

IMPACT OF SATELLITES ON PLANNING OF NETWORKS

Assuming that the economic and technical problems are solved satisfactorily, let us examine the impact which satellite communications will be likely to have on the Australian system and the world network.

National Network

The world telecommunication system is an aggregation of the individual national systems, and therefore the planning and setting of standards for the international interconnecting system is of vital interest to the operators of national systems. Subscribers of the national system are of course the users of the world system and the national operator has a responsibility to them to ensure that the procedures for making world-wide calls are straightforward and that the quality of connections is satisfactory. This latter requirement means that national systems must be planned with the capability for any one of their telephones to take part satisfactorily in international connections, as a boundary condition. It also means that the transmission degradations or switching losses in the international interconnecting system must be kept within prescribed bounds; it is undesirable that the properties of the international system should require compensating adjustments in the national systems. Such compensation throughout a national system could result in considerable expenditure for the relatively very small segment of the total traffic which is destined for other countries. At present, less than .02% of the 2,100 million telephone calls made annually by Australian subscribers are international calls. The Australian Post Office as the national operator has a great interest in the transmission characteristics of circuits provided via earth satellites, and in other aspects of satellite communications affecting the national network, such as frequency spectrum management, the optimum location of ground stations, provision of connecting circuits to the national network, the solution of interface switching and signalling problems and the possible use of satellite circuits for trans-Australian communication.

Depending on the satellite system finally adopted, there could well be advantages in having ground stations on both western and eastern seaboards of Australia to serve separate sources of international traffic. This immediately raises the possibility of deriving internal circuits linking Perth with the eastern capitals, particularly as the traffic streams between these centres will have peak hours at times when international traffic to America and Europe is slight.

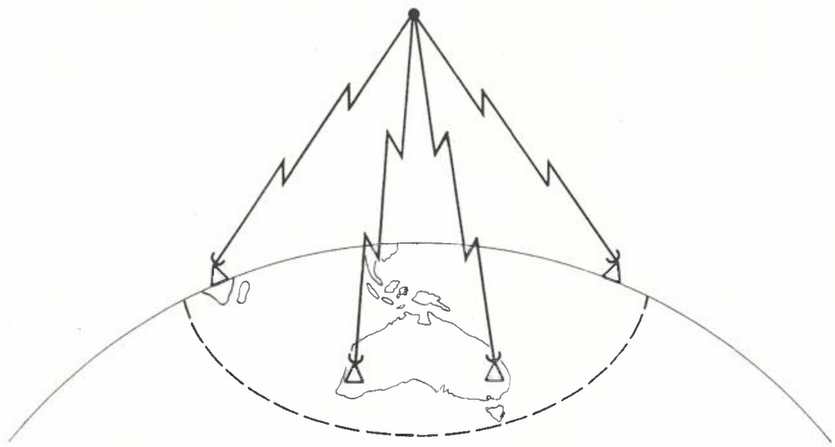
It could also be that small capacity ground stations become economically attractive for the provision of circuits to northern Australia, particularly if northern development schemes result in substantial traffic growth over the next decade.

The decision as to whether a satellite system which was accepted as satisfactory for international working, would be utilised for national traffic would not depend simply on the cost of circuits provided in this way. Other costs would be incurred in the national system itself. Special signalling means would be required and interfaces would have to be established between these circuits and the standard compelled sequence information signalling system of the new national automatic trunk system. Also, special measures would have to be taken to automatically bar these circuits from participation in overseas connections since the propagation delay of a satellite circuit far exceeds the prescribed limit of 50 milliseconds for the national system contribution to group delay on international connections. Further, there are subjective factors to be assessed. Whilst subscribers will be tolerant of unusual conditions such as long propagation delays and post dialling delays on special calls such as international calls, they could be critical of like performance in the national system where standards are well established and accepted. The differences would be obvious under the more or less direct comparison on successive calls to certain destinations which would result from the random selection between conventional and satellite system circuits.

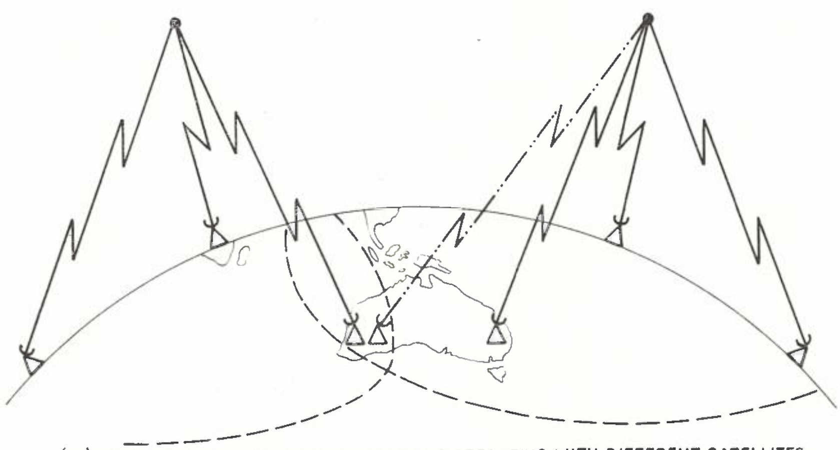
The amount of extra equipment required to utilise ground stations established for international traffic handling would depend on the type of satellite system and the coverage planned with the antennas provided. The minimum additional cost would occur with a stationary satellite system which embraced both ground stations in its coverage. Here only channelling equipment would be required to exploit spare bandwidth. For other types of satellite systems, additional sets of antennas would be required at either one or both of the established ground stations, depending on the relative locations of the ground stations and the ground stations in other countries with which they are working. This is illustrated in Fig. 3. Availability of the additional national antennas in Case (c) would open the way for further international connections within their coverage area.

International Networks

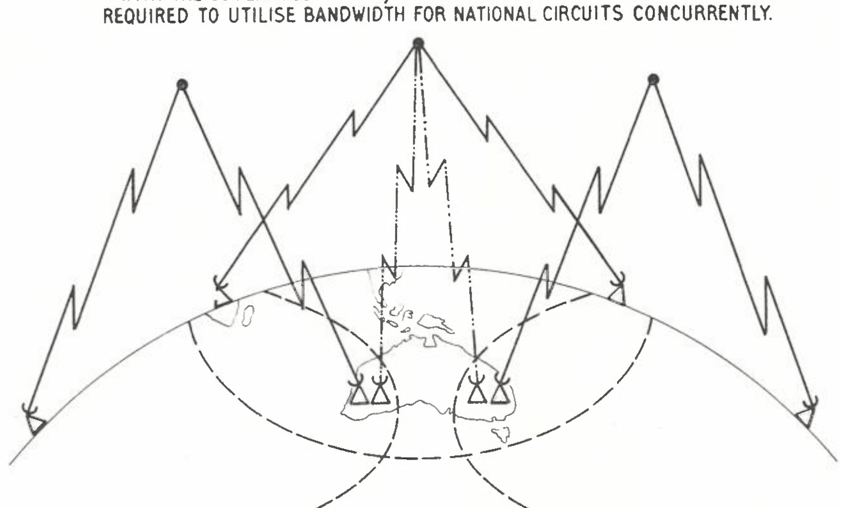
With the build-up of multiple entry points, which satellite communications facilitate, earlier concepts of a national communication "gateway" as a centre which provides the interface between all international and national traffic will tend to disappear. The international network has operated on a gateway basis since its inception, so far as Australia is concerned, in 1930, when the first radio telephone channels were installed. Currently, Australia gains access to the



(a) TWO INTERNATIONAL GROUND STATIONS OPERATING TO ONE STATIONARY SATELLITE – NO ADDITIONAL ANTENNAE REQUIRED TO UTILISE BANDWIDTHS FOR NATIONAL CIRCUIT PROVISION CONCURRENTLY.



(b) TWO INTERNATIONAL GROUND STATIONS OPERATING WITH DIFFERENT SATELLITES – WITH THE COVERAGES SHOWN, AN ADDITIONAL ANTENNA WOULD BE REQUIRED TO UTILISE BANDWIDTH FOR NATIONAL CIRCUITS CONCURRENTLY.



(c) TWO INTERNATIONAL GROUND STATIONS OPERATING WITH DIFFERENT SATELLITES – WITH THE COVERAGES SHOWN, ADDITIONAL ANTENNAE & EQUIPMENT WOULD BE REQUIRED AT BOTH GROUND STATIONS TO OPERATE WITH A THIRD SATELLITE FOR NATIONAL CIRCUIT PROVISION.

Fig. 3.

world system via a gateway exchange in Sydney. However, as the world network evolution proceeds, more extensive inter-access will become economical as the differences diminish between the technologies of the networks being connected.

This changed character of international operations is consistent with the experience of network development within national systems, where networks now tend to interleave rather than interconnect through defined gateways. Within local networks in Australia, such as our capital city networks, we have reached this stage of sophistication and the national system as a whole is headed in this direction under a plan for full mechanisation. Sources and destinations of trunk traffic will be directly connected wherever it is economic to do so, while at the same time full access throughout the national system will be achieved through a "backbone" network of trunk switching centres. These national switching centres will be capable of handling international traffic directly with little adaption.

It is clear that satellite communications will cause radical changes in the traffic-routing concepts incorporated in current plans of the I.T.U. for the world-wide automatic system. (See Ref. 1 and 2). These plans were framed principally in terms of the conventional circuit techniques and include a hierarchical routing pattern whereby traffic is offered to a small group of direct high-usage circuits, with the overflow traffic components being amalgamated on larger backbone routes and switched through higher order centres at maximum efficiency. The provision of large blocks of satellite channels available on a point-to-point basis between ground stations will greatly increase the extent of direct routing in the world switching plan. There will be a corresponding reduction in the extent of overflow and transit routed traffic, which will reduce to some extent the significance of the higher order switching centres.

Integration of satellite and submarine cable channels will be necessary for maximum efficiency, the latter being employed to switch traffic for centres without ground stations and to serve as feeder routes to amalgamate smaller blocks of traffic into sufficiently large entities to utilise efficiently the capacity of ground stations. With the diversity of switching points available in a satellite system it will be possible, when justified under conditions of heavy load, to exploit the changing traffic patterns which occur with changing coincidence of daylight hours. This could be achieved in two ways:—

(i) By time sharing of the satellite's frequency bandwidth. For example, at a time of low traffic interest between Japan and North America, and between Australia and North America, bandwidth of a Pacific areas stationary satellite allotted to carry the peak volumes of trans-Pacific traffic could be diverted to cater for peak traffic between Australia and Japan. In a more sophisticated proposal the reallocation of bandwidth with time would be made automatically in accordance with the changing volume of offered traffic under the control of ground computer stations.

(ii) By appropriate changes in the world network switching pattern to permit interconnection of idle circuits. In the case quoted in (i), Australia to Japan traffic could be switched via North America during appropriate times. This too could be done on a time scheduled basis or else continuously under the control of centralised computing centres which analysed the traffic flow and directed changes in the routing pattern to be made automatically at international switching centres.

This flexibility of routing which is made possible through the diversity of access points will bring more efficient utilisation of international circuits but will call for close co-ordination in world system planning and new concepts in circuit switching and control.

IMPACT ON COST OF CALLS

No discussion of satellite systems can avoid the recurring question, "Does this mean overseas calls for 6d or at least for much less than we pay at present?" The plain, honest answer is that no one yet knows. It is impossible to foretell the exact final cost of any new scientific and engineering development. Anyone who doubts this should reflect on the various amounts of money spent on such items as supersonic aircraft and guided missiles. An engineering estimate is necessarily based on known costs of somewhat similar jobs done before, with allowances for differences between the new job and the old. Every launching furnishes further data on real costs and makes it possible for the new estimate to have a higher degree of probability of accuracy. No one can do more than assess the probable order of cost of satellite communication systems at this stage. There is little enough to go on, even in the actual satellite link itself. All that can be said is that the best available data shows that satellite systems *ought* to be competitive with cables and/or microwave systems if all goes well.

There are two other aspects, however. First, cable and microwave systems are not standing still but are undergoing phenomenal technological development and the cost per channel mile is dropping rapidly. Second, the whole population does not live in, say London or Sydney, so that a satellite link between those cities is only part of the story. Certainly a large proportion of traffic happens, in our case, to come from the large aggregations of population close to these particular cities, but a new system to be attractive financially must fit in with the idea of a large network at each end. In Australia, a large number of calls come from Melbourne and Canberra, as well as from the other main centres in the network. At the European end, for example, the calls are distributed over a very wide number of cities. If, therefore, the satellite section of the call between London and Sydney incurred no charge, it would not mean a 6d. call from any subscriber, even in Sydney. The call has to be carried on local plant to the particular city or outer suburban area concerned. This cost of local plant has to be paid for. It is not reasonable that other people who never make overseas calls should necessarily bear this component of cost. It follows, therefore, that to the actual cost of the satellite link itself must be added the cost of "hauling" the overseas call to its actual terminal subscriber. Therefore, in the case of real subscribers at various locations in such a large country as Australia, a very real charge must be included in the total overseas call — what is called the terminal charge — which covers the cost of the local plant between the overseas point of entry and the actual location of the subscriber.

The foregoing assumes no special and additional operating costs but, in fact, at least at present, very real additional operating costs are involved in overseas calls. The prospects of dramatic reductions in overseas call charges are therefore not very great. It is simply too early to assess this feature. All that can be said is that there is every reason to believe that satellite systems are likely to be competitive with other systems. Consequently we may some day succeed in reducing the real *overall* costs of connecting one subscriber to another one overseas, but no one can safely go beyond this on available evidence.

CONCLUSION

Experimental satellite programmes, particularly the Telstar, Relay and Syncom series, have demonstrated the practicability of satellite communication and the Early Bird project has brought it close to the fully operational stage. In conclusion let us consider a few of the technical developments that might be possible or desirable in the future.

First comes a requirement for enhanced reliability from the satellite; lifetimes of one or two years such as we have seen to date appear to leave little economic margin. Improvement by a factor of 10 times, although difficult, would be highly desirable.

Substantial savings could be made in ground stations if it were possible to increase satellite power output considerably. This is technically feasible by the use of nuclear power sources and would also give a greater margin of performance in hand. The main difficulty is the increased possibility of interference being caused to services sharing frequency bands with satellite systems, but further study and measurement of the interference question may overcome this hurdle.

Multiple launching techniques offer another avenue by which costs may be reduced. By this means, more than one satellite is launched from a single vehicle. The cost per pound of satellite launched does tend to reduce as the total payload is increased and for random systems particularly this technique is promising.

Mention was made of the flexible traffic routing possible if multiple access to a satellite is not to be restricted to only a small number of stations. The most promising line of development appears at present to be the use of S.S.B. for at least the "up" path. For this a linear transmitter capable of high capacity operation is required for ground operation at power levels of several kilowatts. Successful development of this item would enlarge the system designer's scope greatly.

The problem of delayed echoes in telephone circuits still awaits an elegant solution. Perhaps better echo suppressors are the answer but at best they appear to be only a palliative.

A self-adapting hybrid, which might reduce the impedance mismatch causing the effect, to tolerable proportions, is one approach although it is hard to see it paying off in economic terms.

It is obvious that satellite communication is still in its infancy. The first traffic system has yet to be proved in service and no doubt great developments will take place in the future. Perhaps some developments will be revolutionary but even in the absence of dramatic breakthroughs it can be confidently expected that continuous improvements will take place to ensure a place for satellite communications as an important part of the world network.

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SEACOM: DESIGN AND PROVISION OF EQUIPMENT FOR THE BRISBANE-CAIRNS MICROWAVE SYSTEM

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INTRODUCTION

Previous articles in this series have covered the overall planning aspects of the land section of the SEACOM cable system (Ref. 1) and also transmission performance assessments (Ref. 2) and route survey methods (Ref. 3) for the Brisbane-Cairns microwave radio section of the route.

This paper covers the plant provision aspect of the Brisbane-Cairns microwave system and outlines the system arrangements evolved to meet the requirements mentioned in previous articles. The salient features of the various items of equipment are also mentioned.

PROVISION OF EQUIPMENT

After completion of the field survey and selection of sites, a schedule was drawn up providing sufficient information for the preparation of tenders. It was decided that the provision of roads, buildings and public power supplies should be the responsibility of the Postmaster-General's Department. All radio equipment, towers and power plant would be supplied by the selected contractor. At this stage, it was undecided how the installation of equipment would be handled. Tenders were to be submitted to cover complete installation by the contractor or alternatively, by the Department.

Few restrictions were imposed on equipment design so as to invite the widest possible range of offers. However, the unusual noise performance and the high degree of reliability required were stressed, and tenders were expected to give firm guarantees in these respects. Estimated tower heights were included in the schedule as a basis for tendering. However, path profile and site information obtained from the field survey was provided also and tenderers were required to comment on any adverse effect of the proposals on overall performance.

Tenders were called for the end of April 1963 and it was anticipated that installation and commissioning would be completed in the first half of 1966. There was considerable interest in the project and the offers received included radio equipment from major manufacturers in seven countries.

An offer by Standard Telephones and Cables Pty. Ltd. of Sydney, incorporating transistorised radio equipment designed by the Nippon Electric Company of Japan was selected. The equipment was in an advanced stage of development by this company, who had already an impressive record of achievement in the microwave field. The choice was made after inspection of prototype equipment and an appraisal of the company's capabilities during a visit to Japan by the Director-General and Departmental engineers.

The contract was let in September 1963 and the completion date for the whole system was set for the end of February 1966. It was decided that the contractor should be responsible for the installation and testing of all equipment, including towers and power plant. The five separate sections of the route would be accepted as they were completed and target dates were set for each. The first section, Brisbane - Maryborough was scheduled for completion by the end of September, 1965.

EARLY STAGES OF THE PROJECT

Although the basic system and equipment requirements were firmly established before the contract was awarded, many points of detail remained to be settled. These were the subject of discussion with the contractor and subcontractors in Japan as well as in Australia. During subsequent visits to Japan by Departmental engineers, further progress towards the final designs for the radio and supervisory equipment was demonstrated. Prototype units were subjected to rigorous tests, including environmental changes, with encouraging results.

An important decision reached during this period was to inspect and test the equipment being manufactured by N.E.C. at the factory before shipment. The Nippon Telephone and Telegraph Public Corporation (NTTPC), counterpart of the Department in Japan, undertook to carry out both mechanical and electrical inspection to a mutually agreed specification. This arrangement will undoubtedly prove to have been a sound policy in ensuring a minimum of difficulties during the installation and testing phase of the project.

Work began at an early stage on the construction of the new access roads and the 30 new buildings required. By September 1964, nine buildings were

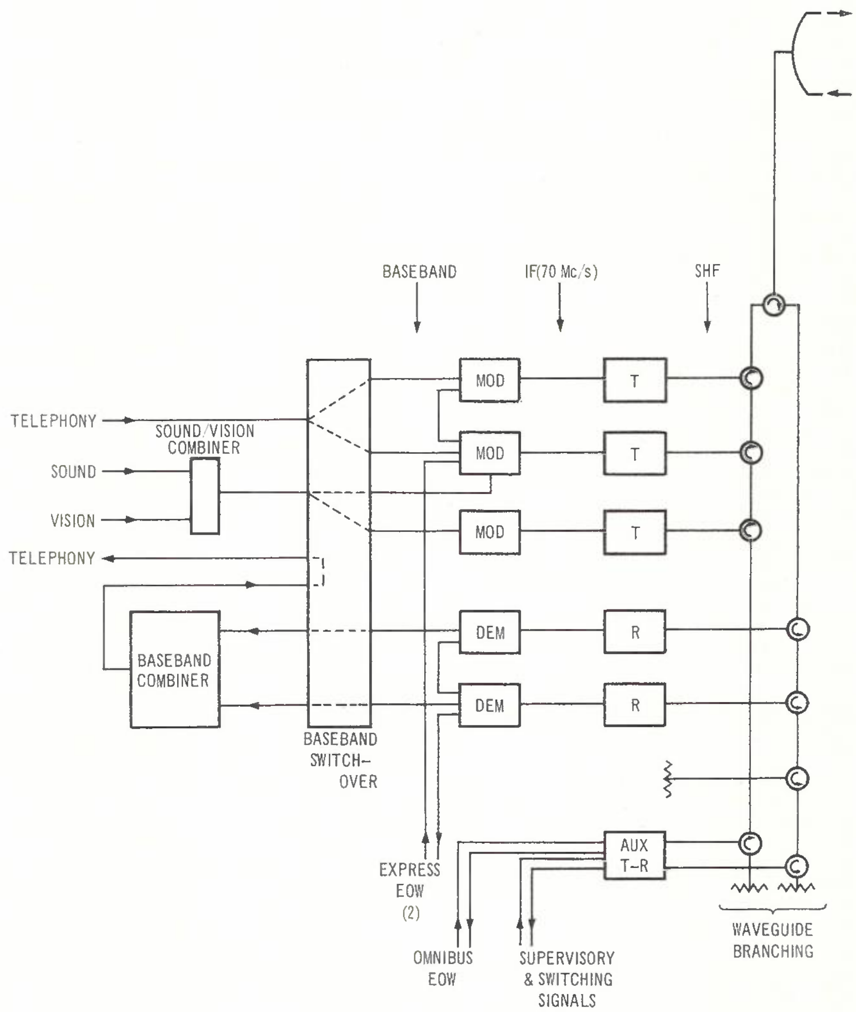

Fig. 1 — Schematic Diagram of Terminal Station (Brisbane).

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ready and roads were available to all but two sites. Despite difficult weather conditions over the northern part of the route, a further 11 buildings were available by March 1965. During the second half of 1964, the preparation of tower foundations was started and tower erection teams moved into the southern end of the route. A start was made also on the installation of power plant. As mentioned in a previous article (Ref. 1.), commercial AC mains power was made available to every station in the system, thus eliminating the need for continuously running generating plant.

The installation and testing of the equipment will be the subject of a further article in this series.

GENERAL SYSTEM ARRANGEMENTS

The main system between Brisbane and Cairns includes two terminals, (Brisbane, Cairns) four back-to-back terminals (Maryborough, Rockhampton, Mackay, Townsville) and 25 repeaters. The initial installation will provide one telephony bearer in each direction, one television bearer northgoing only, and a protection channel, for telephony or television, each way. An auxiliary bearer is also provided to carry switching and supervisory signals, and engineers order wire facilities. Future expansion is allowed for up to a maximum of five working and one protection channels in each direction.

For control and supervision purposes, the system is divided into five sections with the intermediate control stations at Maryborough, Rockhampton, Mackay and Townsville. To meet local traffic requirements at these points, the telephone bearer is demodulated to baseband frequencies. For television, however, video frequencies are required only at Rockhampton and Townsville. The interconnections between sections for television are therefore made at intermediate frequency (IF) in the case of Maryborough and Mackay.

An unusual feature of the Brisbane-Cairns system is that the protection channel normally carries the same traffic as the main telephony channel. The baseband outputs of the two channels are combined at the end of each section. This arrangement is expected to give a small improvement in noise performance, which will provide a useful additional margin in view of the stringent specification of 1pW/km for the route.

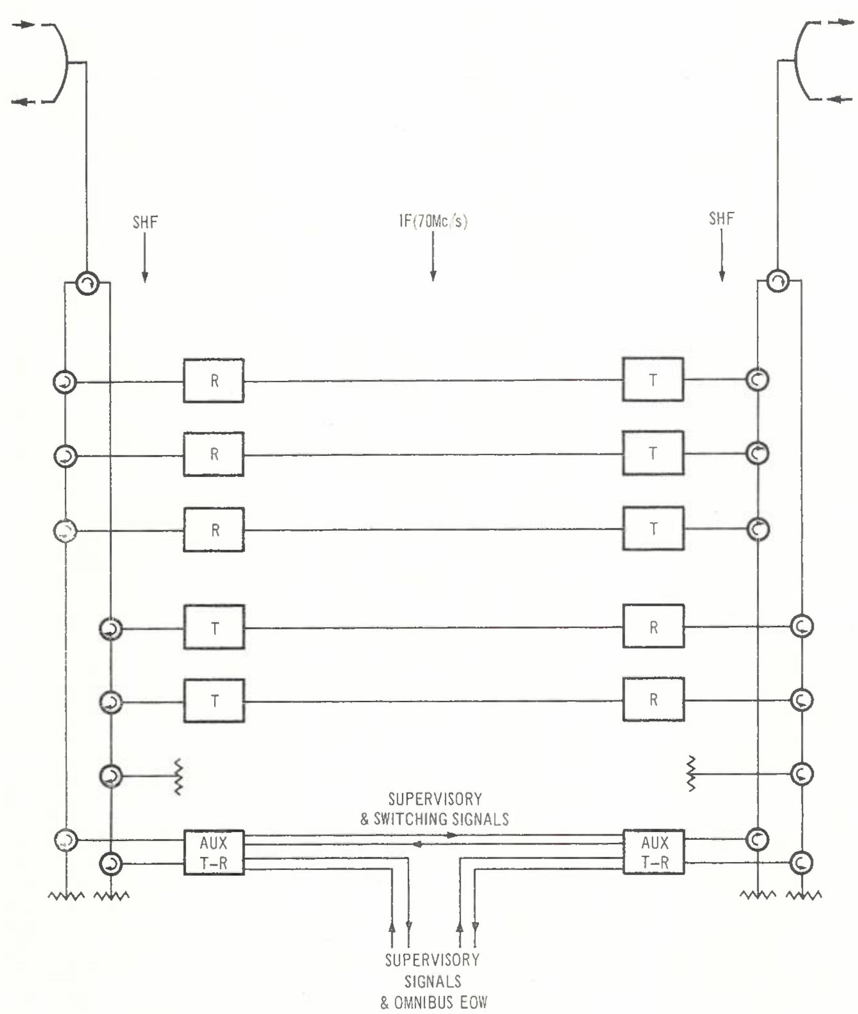

Fig. 2 — Schematic Diagram of Repeater Station without Diversity.

Switchover equipment is located at each end of a control section so that a changeover to the protection channel affects one section only. At Maryborough and Mackay, the switching arrangement automatically provides baseband connections for telephony or IF connections for television.

Typical terminal, repeater and back-to-back terminal arrangements in block schematic form are shown in Figs. 1, 2 and 3.

RADIO EQUIPMENT FEATURES

The N.E.C. equipment chosen for this project uses semi-conductor techniques throughout except for the output stage of each transmitter. This results in greatly reduced power consumption and makes possible the use of float-charged batteries instead of the continuously running no-break power plant required for valve type equipment. Also, a substantial reduction in floor-space requirements results from the compact construction which is possible when using semi-conductors. A considerable improvement in reliability is expected also, the life of transistors probably being comparable to that of "passive" components such as capacitors and resistors.

The travelling-wave tube (TWT) amplifiers are necessary in the transmitters to obtain the required output power of 4-5 watts. This cannot be achieved with solid-state devices at present, but the travelling-wave tube is a stable device with an expected life of 10,000-20,000 hours.

All equipment is designed to operate from a nominal 48 volt DC supply and variations of +20% −10% from this voltage are permissible without affecting performance. The primary power arrangements are discussed later in this article. This supply is used directly only for relay circuits and lamps. Within each item of equipment, the various voltages required by the transistor circuits are derived via electronic regulators from the 48V primary supply. In some cases, both positive and negative voltages are required and it is convenient to use a static inverter to supply 1000 c/s AC to multiple rectifier circuits.

To take advantage of the reduction in size made possible by the use of transistors. N.E.C. have adopted a novel form of construction. The principle units of equipment are housed in bays which are half the height and half the width of a normal 19 in. bay. Thus, four of these units, stacked in pairs, occupy the same space as a standard bay, with overall dimensions of approximately: 7 ft. 0 in. x 20 in. x 9 in. Each of the principal items of equipment, which make up a complete terminal or repeater station, is self-contained in one unit, or two stacked units, and can be set up and tested on its own. Plug-in type circuit modules are used in all units, and, by varying the complement of these, different system requirements can be readily accommodated. The small size and compactness of the equipment may be

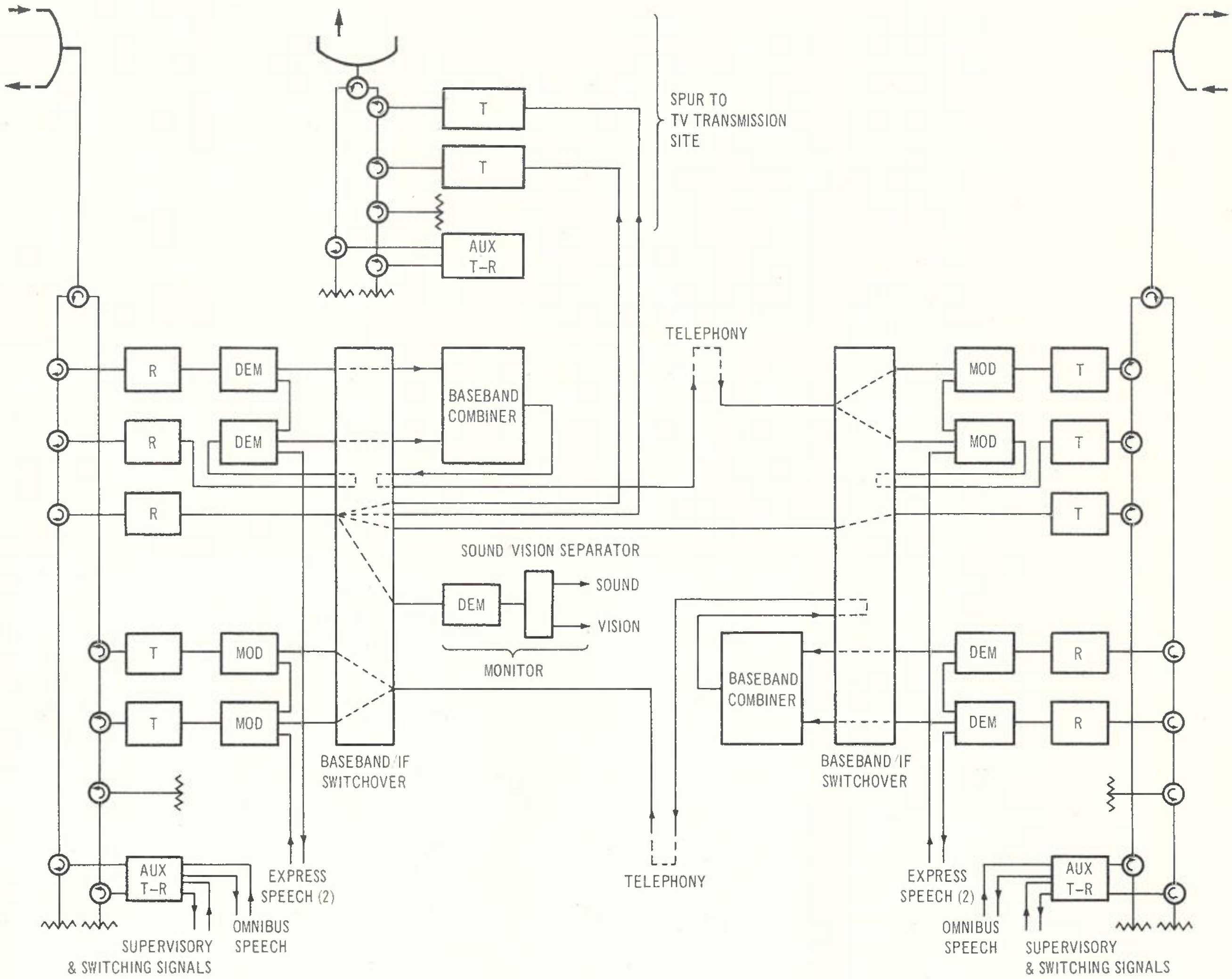

Fig. 3 — Schematic Diagram of Back-to-Back Terminal Station (Maryborough, Mackay).

seen from Fig. 4 which shows a typical unattended repeater station equipment.

The principal items are:—

- Transmitter/Receiver (2 units) (main bearer)
- Modulator/Demodulator
- Switchover Equipment (2 units)
- Baseband Combiner
- Sound/Vision Combiner/Separator
- Diversity Control (2 units)
- Auxiliary Transmitter/Receiver (2 units) (auxiliary Bearer)

Transmitter/Receiver

The Supervisory and Switchover Control equipment, which includes lamp-display panels, are housed in full height bays of normal width.

The transmitter accepts a frequency-modulated 70 Mc/s signal from the Modulator and converts this to the 4000 Mc/s region by combining with the output of a crystal oscillator/frequency multiplier chain. The crystal frequency is in the region of 50 Mc/s and multiplication by 72 is achieved in four cascaded multiplier stages, using varactor diodes. The travelling-wave tube amplifier raises the level of the 4000 Mc/s signal from the transmit mixer to 4.5 watts nominal. The receiver, which uses

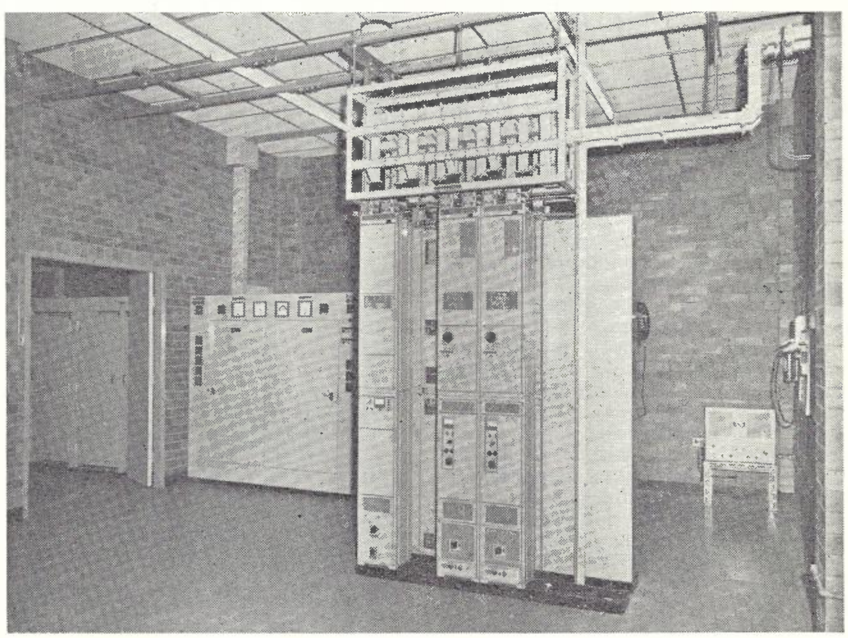

Fig. 4. — Interior View of Typical Repeater Station Showing Transmitter/Receiver bays, Power Rectifier and Battery Cubicles.

70 Mc/s IF amplifiers, derives its local oscillator signal from the same source as the transmitters via a shift oscillator-mixer arrangement. This provides the difference between transmit and receive frequencies which, for this system is 213 Mc/s, 198.5 Mc/s, or 227.5 Mc/s depending on the particular station involved. At a repeater, the IF output of the receiver is connected to the IF input of the transmitter.

Modulator/Demodulator

This unit is used only at terminal stations where telephone traffic or television signals are to be dropped and inserted. In the modulator, a 70 Mc/s oscillator, stabilised by an AFC circuit, is frequency modulated by the baseband signals. The demodulator is conventional in principle, accepting the IF output of the receiver and providing baseband telephony or television outputs. This unit is capable of handling a traffic capacity of 960 telephone channels, but, for this project, a limit of 600 channels is imposed by certain measures taken to improve performance for the SEACOM channels. Pre-emphasis of the baseband signals is not used as it would degrade the noise performance in the 564-1052 kc/s segment of the baseband where the SEACOM super group is located. The baseband combiner described below also restricts the frequency band to 600 channel capacity.

Switchover Equipment

These units contain the circuits necessary to switch telephone traffic or television signals from the normal working bearers to the protection bearer. They include pilot oscillators and pilot/noise detector circuits which provide continuous monitoring of continuity and noise level on each bearer and initiate the necessary switching action when predetermined limits are exceeded. Bearers must be switched at both ends and, in fact, although switching action is controlled by the monitoring and logic circuits at the receiving end, the transmit end of the bearer is always switched first. The necessary commands are transmitted via the switchover control equipment and the auxiliary radio bearer.

The switchover equipment being supplied will cope with two working channels plus one protection channel northbound and one working plus one protection southbound. By adding a few plug-in units, a further southbound channel can be accommodated. However, the switching arrangement has been designed so that future expansion to a 5 + 1 system in both directions is possible and provision is being made in the equipment suites for the additional units.

Switching is effected in most cases at baseband frequencies using mercury-wetted reed relays having a "break" time of less than 2 milliseconds. At Maryborough and Mackay, however, television signals are not demodulated, as the spur routes to the television transmitters are fed at IF. It is arranged, therefore, that the television bearer, and the protection bearer when used for television relays, are switched at IF, using semi-conductor switches. The telephony bearer, and the protection bearer when used for telephony, are switched at baseband.

Telephone traffic is normally carried by both working and protection bearers on this system in order to derive further advantages in terms of performance by using baseband combiners. In the event of a fault on the television bearer, however, the telephone traffic is removed from the protection channel. In the event of a subsequent fault on the telephony bearer, the television signal is removed automatically from the protection bearer, and telephony, which has overall priority, is substituted.

Baseband Combiner

The baseband outputs of the telephony and protection bearers are applied to a ratio-squared combiner, which compares the noise levels of the two channels and derives its output largely from the quieter of the two.

As the frequency separation of the two bearers is 116 Mc/s, it is expected that some measure of improvement from frequency diversity will be obtained under certain propagation conditions.

Sound/Vision Combiner/Separator

The sound signals accompanying a television programme are carried on the bearers as a frequency modulated subcarrier at 7.5 Mc/s i.e. above the video spectrum. This unit contains the necessary FM modulator/demodulator circuits and the sound/vision combining and separating filters. The active circuits are provided in duplicate with manual changeover.

Diversity Equipment

On certain paths, in particular those where strong reflections from water or flat land may be encountered, space diversity is being provided. Altogether 11 of the 30 paths of this route are being so equipped. Each station involved requires an additional antenna above or below the main antenna, and a separate waveguide feeder. Fig. 5 shows a typical

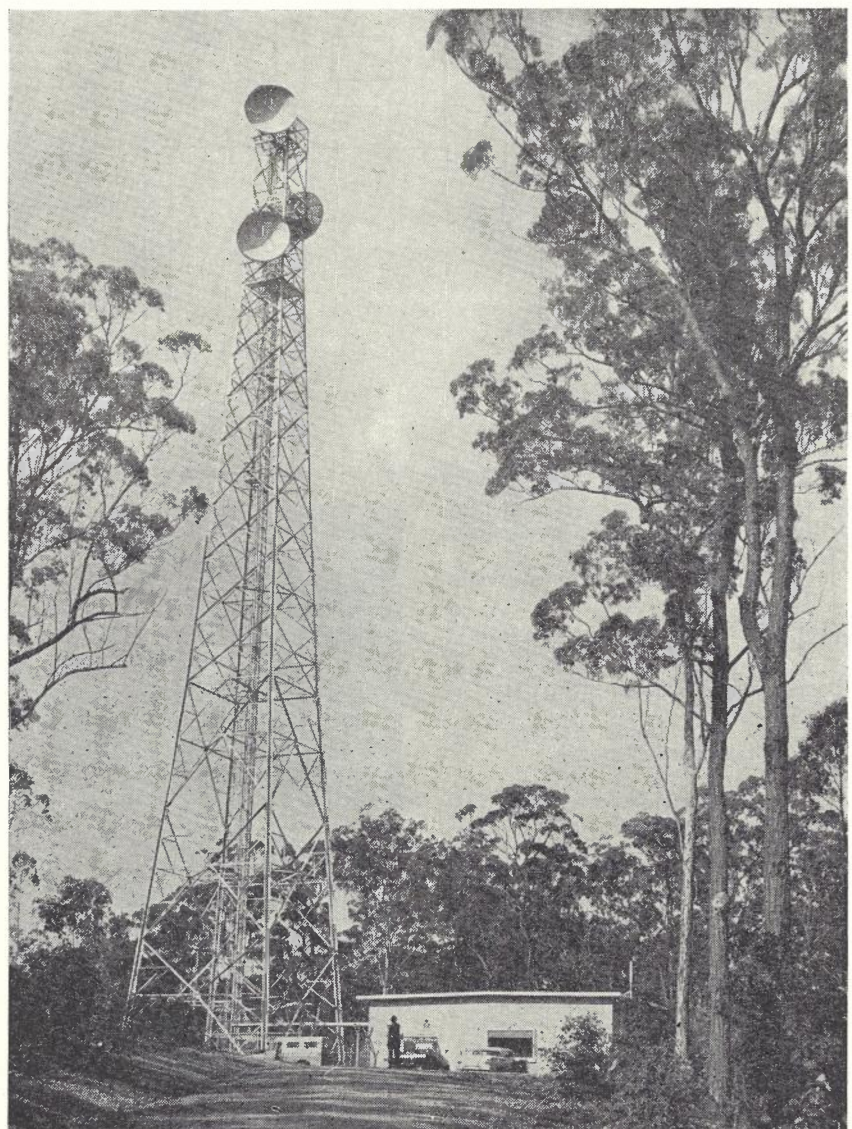

Fig. 5 — Typical Repeater Station Showing Main and Diversity Antennas on 200 ft. Tower.

station with diversity facilities. The spacing between antennas is dependent upon the propagation characteristics of the path concerned, but is usually between 20 ft. and 60 ft. The signals from the two antennas are combined in a RF phase-combiner before being applied to the receiver. The diversity control equipment, using a servo-loop action, ensures that the maximum signal is delivered from the phase-combiner to the receiver at all times. It is essential that the time delays in the two waveguide feeders should be matched fairly closely, and, to achieve this, the feeder from the diversity antenna is folded in a "trombone arrangement" so that it has the same electrical length as the main feeder.

Auxiliary Transmitter/Receiver

The auxiliary bearers, one in each direction, also operate in the 4 Gc/s band using the same antennas and feeders as the main bearers. The transmitter uses direct phase modulation of a crystal oscillator source with varactor diode multipliers to achieve the final frequency. The output of 200 milliwatts achieved is sufficient so that a TWT amplifier is not necessary. The auxiliary bearers, therefore, are fully solid state. Repeaters are of the baseband type, this being necessary in order to extract and insert the speech and supervisory signals which this equipment carries. The maximum baseband frequency for this bearer is 60 Kc/s.

Supervisory and Switchover Control

The supervisory bays at terminal and control stations provide a lamp display of the state of intermediate unattended repeater stations, 11 indications being available from each site. It is also possible to start and stop the stand-by diesel-alternator set at each remote station in a section from either terminal. In addition, an overall supervisory display is provided at Brisbane giving an indication in condensed form of circuit conditions on all sections of the route. Information is transmitted as audio-frequency tones in standard telephone carrier channels on the auxiliary bearers.

The switchover control equipment transmits and receives the command signals initiated by the switchover equipment described above. Again a series of tones in a carrier channel on the auxiliary bearer are used.

Engineers' Order Wire Circuits

Three telephone communication circuits are provided. An omnibus circuit within each of the five sections of the system, provides speech communication between control terminals and repeaters for maintenance purposes. This is carried by the auxiliary bearers. There is also an express speech circuit linking only the six control stations and a second one linking Brisbane with the five television transmitting stations along the route. These two circuits are carried sub-baseband by the main bearers to obtain improved performance. All of these speech circuits have selective calling facilities.

WAVEGUIDE BRANCHING

All transmitters and receivers for one direction of transmission, including those for the auxiliary bearer, are connected to a common waveguide feeder and antenna. This is effected by an arrangement of circulators and waveguide filters mounted in a framework above the equipment suites. Where space diversity is used, the phase combiners are also included in the assembly as are also the necessary filters for an additional southbound television bearer which may be installed in the future. To reduce space requirements a "thin" type rectangular waveguide having external dimensions of approximately $2\frac{3}{8}$ in. x $\frac{5}{8}$ in. is used for the branching network, and also inside the transmitter/receiver bays.

ANTENNAS AND FEEDERS

The 10 ft. paraboloid antennas used throughout the route have single-polarised horn feeds, vertical and horizontal polarisation being used on alternate paths. A novel feature is a 12 in. deep annular skirt, around the periphery of the dish, which substantially reduces minor lobe radiation. This is necessary to reduce interference effects which result from operating alternate paths on the same frequency plan. The antenna gain is 39.5 db and the main lobe has a beam width of 1.7° in both planes. Fig. 6 shows a typical arrangement of the aerials on the top of a 100 ft. tower.

Standard rectangular waveguide type WR229/R40 having external dimensions of approximately $2\frac{3}{8}$ in. x $1\frac{1}{4}$ in. is used for the external feeders. The transition to the "thin" waveguide is effected by a taper section. For tower heights of 100 ft. and above, it was considered worthwhile to use circular waveguide for the vertical section of the feeder. This has a loss of 0.5 db/100 ft. as compared to 1.0 db/100 ft. for straight sections of rectangular waveguide. Taper sections are fitted at each end of the vertical circular waveguide to convert to rectangular waveguide.

The external waveguide and the horn feeds of the antennas are pressurized with dry air to about two lb/sq. in. Motor-driven pump units with dehydrators are connected to a gas inlet/barrier section of waveguide in each feeder inside the buildings.

TOWERS

Self-supporting tapered type towers are being provided at all sites except Mt. Gravatt (Brisbane) which has a suitable existing structure. Their heights range from 75 ft. to 200 ft. and, in each case, allowance has been made in the design for supporting additional antennas. Expansion of the system beyond 2 + 1 bearers in each direction will necessitate a second antenna in each case and provision is required also for a number of short-haul systems along the same route. The structures are designed to have the required degree of stability in twist and deflection for wind velocities of up to 100 m.p.h. Higher wind velocities are sometimes experienced along the part of the route north of Rockhampton, and in this area the towers are designed to withstand winds of up to 140 m.p.h.

At two sites, Halifax and Cairns, it was found that soil conditions would not permit the use of conventional concrete block foundations for the towers. At considerable cost, special pile foundations have been provided with 5 or 6 piles for each leg driven to a depth of 50-60 ft. to obtain sufficient soil resistance. The high cost was considered well worthwhile as the alternative would have been to use other sites involving much higher costs for road construction.

Fig. 6 — 10 ft. Diameter Paraboloidal Antennas.

POWER PLANT

It was found possible to supply all stations with commercial mains power, new lines of considerable length being constructed in some cases.

The radio equipment, however, requires a nominal 48 volt DC supply and this will be provided by two batteries, each of 23 lead-acid cells, float-charged by silicon rectifier units from the AC supply. The two batteries will be connected in parallel normally but each may be isolated for maintenance purposes. Transistorised regulators in the rectifier units maintain the float voltage at 50.6 volts ± 0.5V.

In the event of an AC supply failure, a normally-stationary diesel-alternator set takes over the load. However, as an added precaution in view of the importance of this route and the isolation of some of the sites, the total capacity of 1000 ampere-hours for the two batteries is sufficient to run the equipment for almost 24 hours. This is a valuable feature covering possible failure to start of the stand-by set. As a further safeguard, each station has an external waterproof power connector to accept an AC supply from a mobile power plant which can be taken to the site to feed essential loads.

EMERGENCY TRANSPORTABLE EQUIPMENT

The route of the system passes through areas occasionally affected by cyclones and suitable precautions have been taken in the design of buildings, towers and antenna systems. However it was felt desirable to have a further safeguard against complete failure at any one site from this or any other cause. This has taken the form of complete repeater station packages which can be transported to any site by road. The radio equipment, similar to that used for the main system, provides two bearers, working and protection, plus auxiliary bearer in each direction. This is accommodated in a transportable shelter, approximately 9 ft. x 7 ft. 6 in. x 8 ft., which can be carried on a flat-top vehicle.

Power is obtained from a trailer-mounted power plant which includes a diesel-alternator set, rectifier unit and 50V battery. A 150 ft. guyed tower of a type designed for quick erection is also provided to support two 4 ft. diameter paraboloid antennas. These are connected to the radio equipment shelters via flexible waveguide of elliptical section which can be reeled on a drum for storage.

The emergency equipment will be kept at a central location ready for despatch to any site at very short notice.

MAINTENANCE FACILITIES

From the description above it will be seen that precautions have been taken to ensure continuity of service under all conditions. This is to be backed up by a strong maintenance organisation. Stocks of spare units, which can be plugged in to replace faulty units, are to be held at each of the 2 terminal and 4 control stations. In addition, repair centres will be set up at Brisbane, Rockhampton and Townsville, equipped with test benches and a comprehensive range of test instruments, to effect repairs to faulty units. Spare transmitter/receiver and modem bays will be available at all six terminals for checking of spare units.

Along the route, district technicians will carry out routine inspections at repeater stations and be responsible for the location of faults and replacement of faulty plug-in units. At terminal stations, specially trained staff will be in attendance during normal office hours and on call at other times for route supervision, fault location guidance and the repair and testing of faulty plug-in units of equipment.

Nevertheless, a high standard of reliability is expected and as a result of experience, it may well be found that some modification of these extensive maintenance facilities may be possible.

CONCLUSION

Some account has been given of the system and equipment design features which have been adopted to meet the stringent overall specification for the Brisbane-Cairns microwave radio system carrying SEACOM traffic.

The radio equipment being installed is the first of its kind to be purchased by the Department incorporating transistorisation and requiring a DC supply. Substantial savings have been effected in building costs and it is expected that reliability will exceed that already achieved with other microwave broadband bearer systems.

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MR. E. J. BULTE, B.Sc.

Mr. E. J. BULTE, B.Sc.

Mr. E. J. BULTE has this year been elected a Life Member of the Telecommunication Society of Australia by the Victorian Division in recognition of outstanding service to the Society. He has also been created a Life Subscriber to the Society by the Council of Control.

Mr. Bulte was President of the Postal Electrical Society of Victoria in 1958/59 and was Chairman of the Victorian Division of the reconstituted Australian Society in 1961/62. He was an Editor of the Journal from June 1956 to June 1959 and has been a sub-editor for Victoria since June 1959. In addition, Mr. Bulte has contributed many articles to the Journal; his first article appeared in the October 1938 issue and his twelfth in the October 1964 issue.

The Board of Editors wish to make a special tribute to Mr. Bulte's services to the Journal. As Editor he played an important role in revitalising the Journal after a difficult period; his enthusiasm and energy were strong factors in the development of an improved and expanded issue. His transfer to Victoria in 1959 ended his work as Editor but did not end his active editorial participation. As a Sub-Editor in Victoria he has, since June 1959, continued to stimulate interest and support for the Journal and the Society. The Board of Editors, therefore, has great pleasure in congratulating Mr. Bulte on the distinctions now conferred on him by the Society.

CROSSBAR TANDEM SWITCHING IN THE MELBOURNE METROPOLITAN NETWORK

*R. W. CUPIT, A.M.I.E. Aust.**

INTRODUCTION

The introduction of L. M. Ericsson crossbar equipment with its increased alternate routing capabilities, into the large capital city networks of Australia has caused much attention to be paid to the network switching design aspects of the changeover of equipment types.

* Mr. Cupit is Engineer Class 2 Metropolitan Service Station, Victoria. See Page 247.

The Pre-Crossbar Network

The position in the Melbourne network just prior to the changeover to crossbar equipment was briefly as follows:

The Melbourne uniform numbering scheme covered an area forming approximately three quarters of a circle of 15 miles radius with approximately 100 exchanges and a total of approximately 300,000 subscribers. This part circle was subdivided into seven sections, each of which was allocated an individual first digit, see Fig. 1. The main or tandem exchanges for each section had first and second selectors to handle the local traffic. All traffic not carried on direct routes between other exchanges in the group was handled by the 1st and 2nd selectors at the main exchanges. These other exchanges were of two types:—

(i) **Trombone** trunked — where all

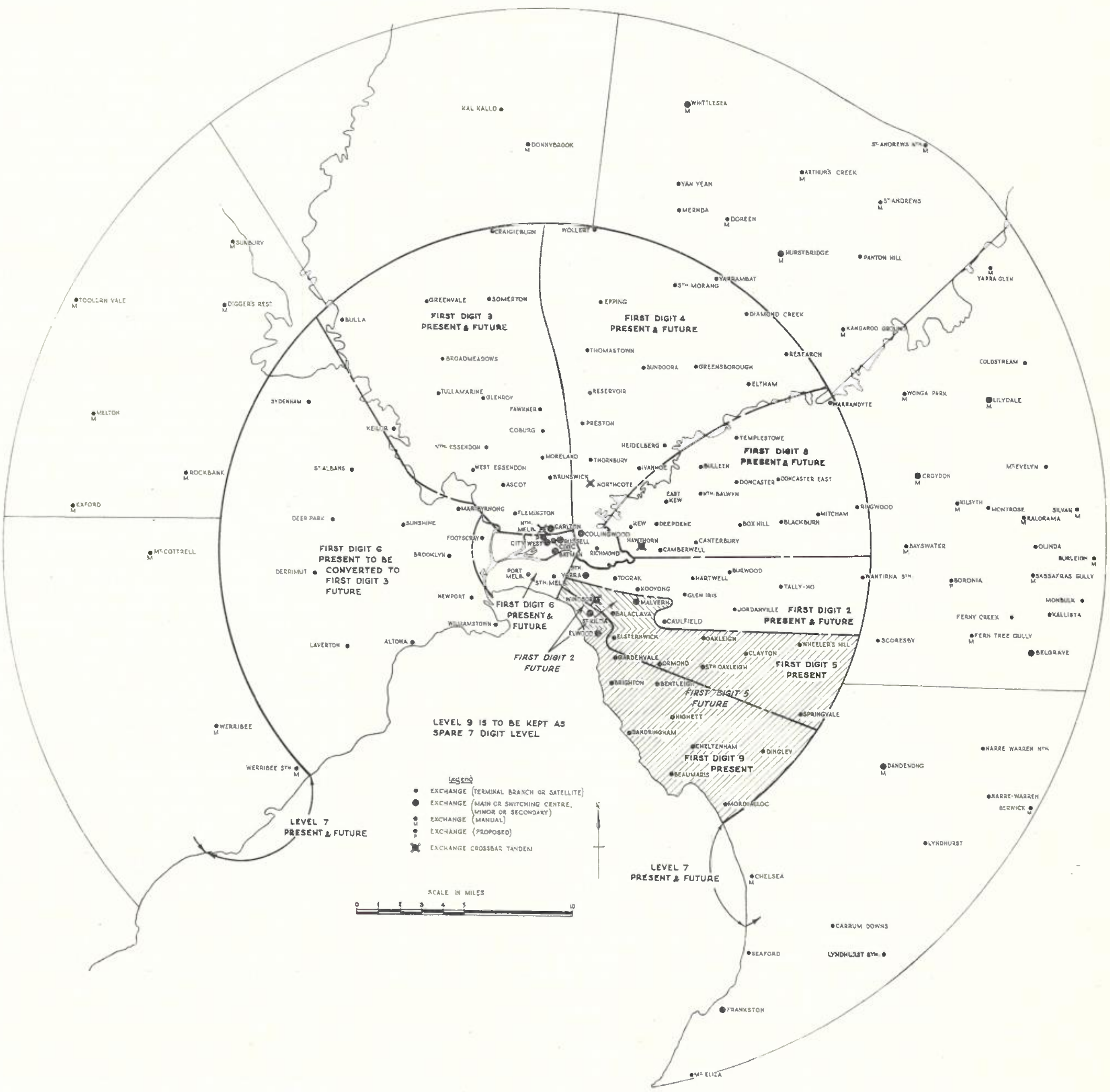


Fig. 1 — Present and Proposed Number Allocation Plan.

originated traffic is passed directly to first selectors at the main or tandem exchange.

(ii) **D.S.R. trunked** — in which local exchange traffic is switched locally. Direct routes can be provided to exchanges in the same first digit group, with overflow to first selectors at the Main or Tandem exchange and all other traffic is switched via the first selectors at the Main. Discrimination is on the second digit, with direct routes terminating on third selectors at other Exchanges.

The network was very largely six digit with a small but rapidly increasing seven digit component. This seven digit component would have required an additional rank of selectors for all terminating traffic under the step by step switching scheme employed.

The 15-25 mile annulus surrounding the metropolitan area which comprised the Melbourne Extended Local Service Area (E.L.S.A.) (Ref. 1) contained approximately 50 exchanges with a total of approximately 20,000 subscribers and had a number of local switching schemes. Level 7 was used for access from the inner metropolitan area to these local switching areas. Access to the Melbourne metropolitan area from these local switching areas was by the use of an access code. Special access codes were also used for routes between these areas if available, otherwise access was via the same path as the Melbourne subscribers with the addition of the Melbourne access code. The number length in these areas was very variable and a number of manual exchanges existed.

Development of Numbering Plan

In a fully register controlled network, numbering and routing are not intimately tied as they are in a step by step network which employs relatively simple D.S.R.'s for discrimination. In a mixed network however, unless register control is added to existing step by step exchanges, full flexibility of trunking can be maintained only when a number allocation based on step by step principles is used.

The cost of fully registerising the existing step equipment in a large network such as Melbourne if done at all, must be spread over a considerable period; therefore, a seven figure numbering pattern based on the existing step allocation has been used. The existing and proposed numbering plans are shown in Fig. 1.

Crossbar Equipment Features

The features of crossbar equipment which are of interest from a network design viewpoint are:—

(i) Increased capability for alternate routing together with the necessary high speed junction signalling.

(ii) Larger availability of the basic first switching stage which replaces the D.S.R. making practicable the introduction of alternate routing on a larger scale.

(iii) Together with these features we have the development of traffic measuring and design techniques which make it possible to produce effective designs under the much more complex conditions which exist when alternate routing is employed on a large scale.

The equipment features enable almost complete flexibility in routing traffic originating on crossbar primary equipment. Saving in switching equipment is possible by employing alternate routing techniques to by-pass tandem switching stages. External plant savings are more difficult to achieve but should come as a result of the possibility of introducing shorter cross country cable routes and by permitting provision of segregated groups of junctions requiring large and small gauge cable to meet transmission requirements.

The interworking of the crossbar and step systems contains two basic restrictions:—

(i) All traffic entering a crossbar stage from a preceding step by step stage must pass via a signalling conversion register at significant cost.

(ii) Traffic from crossbar terminal exchanges to step by step tandems must use decadic pulsing and cannot revert to high speed m.f.c. signalling should subsequent routing lead to a crossbar terminal.

These restrictions lead to a desire to introduce crossbar tandem stages as soon as possible to avoid, as far as possible, the cost associated with (i) and the post dialling delays associated with (ii).

DESIGN ASPECTS

General

The problem of determining the functions and locations of tandem switching equipment is basically simple. The following questions are considered:—

(i) Where does the traffic flow?

(ii) What is the cheapest way of providing plant to carry the traffic?

(iii) Can improvements in plant be incorporated into the proposed solution at some time in the future?

Two different lines of approach are possible:—

(i) To use a computer of sufficient size to enable the complete design and costing of networks to be carried out for different switching assumptions.

(ii) To analyse the major influencing factors so that the final step becomes self evident.

At a very early stage in the investigation it was decided that with the available computers too much simplification into model networks would have been necessary. This would have resulted in many simplifying assumptions and would have tended to invalidate the results. Furthermore and possibly of more importance, solutions to the immediate problems of planning for the introduction of crossbar equipment were required and these individual investigations formed the stepping stones to the final tandem switching scheme for Melbourne.

Traffic Flow

In order to determine the location of tandem exchanges, the basic question "Where does the traffic flow?" must be broken into a number of specialised studies.

Traffic Flow under Full Mesh Conditions: The first of these studies was to determine where the traffic would flow in a fully mesh trunked network that is with NO restriction imposed by the switching equipment.

The starting point for this investigation was an estimate of the traffic between all exchanges at the 20 year date which was in turn based on a carefully prepared estimate of subscriber development to that date.

Assuming a full mesh network and a junction cable route for each parcel of traffic of 50 erl or more, the traffic grid was turned into a hypothetical 20 year cable network. The result is shown in Fig. 2 on which the estimated 20 year junction cable is shown, with the major routes not in existence at the time the study was done, clearly marked.

It can be seen that the existing, mainly radial junction cable routes will continue to carry by far the heaviest concentrations of traffic and the possible new routes between the radials will be of secondary significance even in the long term. It should be remembered that the study assumed full mesh trunking i.e. all traffic being handled direct. Thus although possibly a fully crossbar network could develop a junction network similar to that shown, the existing step network certainly could not.

The introduction of new cross country cable routes will be evolutionary in nature and will be dependent on the rate of provision of crossbar equipment and the consequent build up of direct routed traffic.

Availability: With the pattern of future junction network development reasonably settled, it was then necessary to investigate in more detail the degree to which alternate routing could be employed economically using the equipment available.

Detailed analysis of network costs involved in designs for originating exchanges, based on various assumptions as to the availability to be provided, showed that using the standard 80 inlet 400 outlet ARF 102 crossbar group selector stage, the additional cost of equipment to provide availability above 400 outlets more than outweighed the savings to be gained by extending the degree of direct routing. This conclusion has been confirmed using the actual tandem configuration. Thus the basic 400 outlet group selector stage only, will be provided at originating exchanges in Melbourne, unless special circumstances indicate the desirability of providing additional availability by the use of group selector stages in series.

This does not of course preclude the provision of more availability should design changes in the future alter the cost basis of the comparisons made so far and this is a field for future development. With the tandem configuration chosen in Melbourne the need for additional availability may come as the size of crossbar exchanges increases above 8-10,000 lines.

The basic reason for the present lack of justification for the provision of greater availability is that with the traffic distribution pattern normally en-

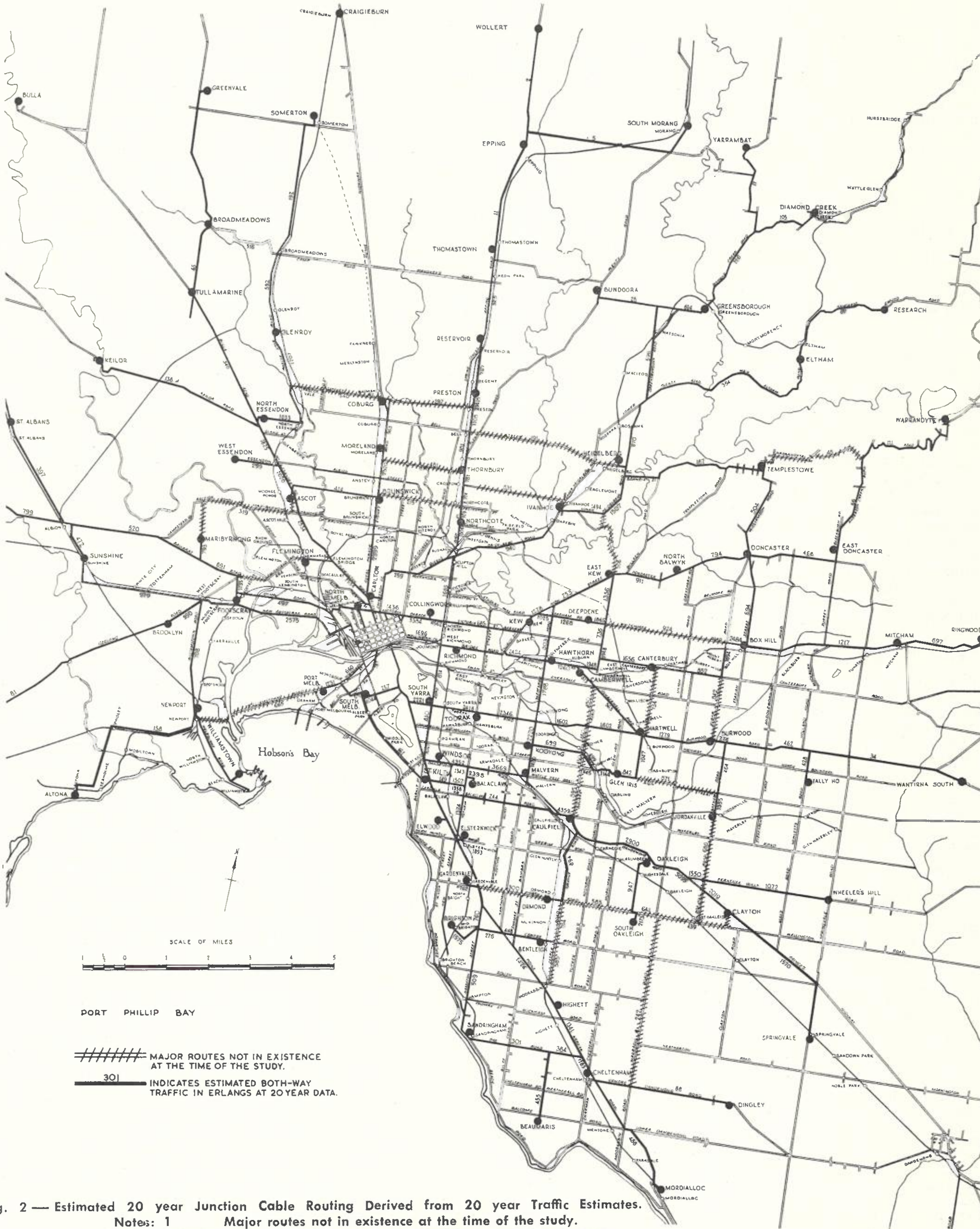


Fig. 2 — Estimated 20 year Junction Cable Routing Derived from 20 year Traffic Estimates.
Notes: 1 Major routes not in existence at the time of the study.
2 301 indicates estimated both way traffic in erlangs at 20 year date.

countered in Melbourne, once the direct routes to reasonably close exchanges have been provided, the marginal savings by providing the longer direct routes, can in general be achieved by the provision of tandem stages strategically placed with respect to the junction cable network, such that "back tracking" is minimised, whilst at the same time traffic is concentrated into larger, more efficient parcels.

Traffic Dispersion

The traffic distribution of typical branch exchanges in the metropolitan area follows a reasonably consistent pattern viz:—

(i) 15% local
(ii) 25% to adjacent areas
(iii) 20% to the central city area
(iv) 20-25% to an inner area within approximately 5 miles of the city but outside the central city or the same 1st digit group.
(v) 5% to trunks and the E.L.S.A. area
(vi) 10-15% to outer non-adjacent areas.

Except for exchanges on the fringe of the 15 mile radius all exchanges can reach all other exchanges in the first four categories above, using 10 lb. junction cable for a transmission loss of not more than 12 db. Thus if no restriction is placed on the provision of junction circuits by the switching scheme, some 80-85% of traffic originated at exchanges within the metropolitan area would not utilize any 20 lb. cable.

Traffic from the metropolitan area which is destined for trunks and the E.L.S.A. area, has a stringent requirement of 7.5 db access to the trunk switching centre and will need some 20 lb. cable if the distance is more than 9 or 10 miles.

Similarly the 10-15% of traffic destined for outer areas in the metropolitan network will need varying proportions of 20 lb. cable depending on location of the originating exchange.

Under step network conditions the 15-20% of originating traffic destined for outer areas or to trunks and E.L.S.A. exerts a controlling influence on the need for 20lb. cable. This arises because of the limited ability of the equipment to segregate traffic having varying requirements into different groups. Crossbar equipment on the other hand has the capability of achieving almost unlimited segregation. The optimum solution lies between these extremes.

A prime factor in the choice of location and trunking of a tandem switching exchange is to ensure that traffic through it does not have to use a heavier gauge junction than it would use if considered alone.

Transmission Criteria

The design of transmission loss allocations for the backbone or last choice links in any proposed switching scheme under crossbar conditions have not been finally settled. However direct routes and the major second choice routes within the metropolitan network are to have a junction cable loss not greater than 12 db, with subsequent choices being tolerable at a total loss up to 15 db. Access to the trunk centre must be gained on a total loss of not more than 7.5 db in order to fit into the overall national plan.

The introduction of alternate routing could result in the overall transmission performance of any network being significantly degraded if each link is built out by the use of lighter gauge junction cable so as to use up the transmission allowance. The choice lies between maximum savings by the use of light gauge junction cable or retention of the existing transmission performance by continuing to provide junction cable to the existing standards. Basically this infers not using cable of lighter gauge than 10 lb. for junctions.

The major savings to be made in the external plant field due to the introduction of alternate routing is in reducing the quantity of 20 lb. cable required, by segregating out all traffic which does not require it in order to meet the standards. The savings due to the provision of shorter junction routes will be relatively small and will be of an evolutionary nature as the volume of crossbar switched traffic increases. This segregation of 20 lb. cable requirements is of course much more important in exchanges towards the edge of the metropolitan area.

Sub-Metropolitan Area Tandem Switching

The sub-metropolitan area is divided into a number of local switching areas at the present time and these will continue with minor changes in the future, the centres being self selecting by the nature of the development which is concentrated round the main centres. Centres which have tandem switching facilities at present are:

Frankston
Dandenong
Belgrave
Croydon
Lilydale
Hurstbridge

The western zones of the E.L.S.A. area contain small terminal exchanges only at the present time, and development is very slow and unpredictable.

Traffic to all the E.L.S.A. area is fed from the metropolitan area almost exclusively on carrier channels from the central trunk terminal. It is anticipated that with minor exceptions this will continue and thus traffic from the metropolitan area will continue to trunk in the same way as at present even when crossbar stages are installed to replace the existing step switching equipment. Originating traffic from crossbar exchanges in the E.L.S.A. area can use the routing flexibility of crossbar equipment so as to permit circuits to be provided into any tandem switching system proposed for the metropolitan area. (Similarly, any metropolitan crossbar exchange can route direct into an adjacent sub-metropolitan exchange if such a course is justified by the traffic volume.)

The traffic to and from this outer area is of secondary importance as compared with the traffic volume within the metropolitan area.

Theoretical Basis for Tandem Design

The basis on which the initial tandem installations were designed is now clear:—

(i) The long term junction routing will follow the traffic distribution closely because of the increasing influence which will be exerted by the need for the provision of direct or first choice circuits.
(ii) The locations chosen for the installation of crossbar tandem equipment must take advantage of the intersections of major cable routes to avoid "back tracking".
(iii) Suburban originating exchanges will normally use only the standard 400 outlet first group selector stage.
(iv) The 80-85% of originated traffic which could utilize 10 lb. junction cable under full mesh conditions must not be forced to use 20 lb. junction cable because of the switching pattern.
(v) There must be sufficient flexibility in the switching scheme to permit easy expansion and the incorporation of future developments in both internal and external plant.

Evolutionary Nature of Network Development

The provision of tandem switching centres, and the new cross-country cable routes which will become necessary, with the increasing volume of traffic which originates on equipment capable of alternate routing, will be evolutionary in nature much as is the provision of subscriber exchanges.

It would be normal therefore to expect that in a simple very small network there would be only one tandem exchange. In a medium size network this central tandem would normally be retained for trunk traffic but traffic within the network would have a number of tandem exchanges away from the centre.

In a very large complex network, at the same time as the tandem centres for metropolitan traffic become more numerous, the trunk centre itself could well become decentralised due to the physical size required and from the need to increase security.

It would be extremely dangerous in a rapidly expanding network to attempt to accurately predict the nature of this evolution over a period longer than say 10 years due to the many intagibles both as to the rate and pattern of development and the methods of meeting it in both the internal and external plant fields.

For the above reasons the Melbourne tandem switching scheme was based on the predicted 20 year junction cable pattern as far as the initial locations are concerned. No attempt has been made to predict future switching developments accurately beyond the ten year period, except for ensuring that the arrangements proposed are flexible enough to permit a wide variety of possible changes in switching equipment and junction circuit provision.

Location of Major Proportion of Crossbar Equipment

The major proportion of crossbar equipment will be installed in exchanges serving the rapidly expanding outer suburbs and an investigation has shown that concentration of crossbar equipment in these areas is desirable, in order to maintain orderly and economic development. The distribution of crossbar equipment is an important feature of any tandem switching scheme since many of the advantages gained by the use of common control switching systems can only be fully achieved from large installations.

Tandem switching centres must of course be a compromise between the location of the originating and terminating exchanges.

LOCATION AND FUNCTIONS OF TANDEM SWITCHING EQUIPMENT

General

The direct routing capability of crossbar equipment is such that direct routes are provided to most exchanges in the same first digit group and close exchanges in adjacent first digit groups. A tandem switching centre would only carry overflow traffic from these routes and thus it becomes of great significance that the tandem centres be located in such a way as to handle the inner area traffic which does not justify direct routes.

Examination of the present and predicted junction cable pattern and assessment of likely traffic volumes and hence size of building space required, led to the selection of four initial tandem locations —

Windsor
Hawthorn
Northcote
North Melbourne

As discussed above, crossbar tandem centres will also be established at the E.L.S.A. switching centres of

Frankston
Dandenong
Ferntree Gully (in lieu of Belgrave)
Croydon (takes the function of Lilydale also)
Hurstbridge

together with others which may become apparent as development proceeds.

The trunk switching centre will be contained in the proposed Lonsdale Building which is an extension of the present trunk switching centre. This location will also contain a further city tandem centre and the main switching equipment for traffic to the E.L.S.A. area. Partial decentralization of the trunk centre is under active consideration at the present time. The trunk centre will use 4 wire switching A.R.M. equipment. (See Ref. 2.)

The tandem centres located in the E.L.S.A. area will consist of 80 inlet 400 outlet first selector switching stages. These centres will enable the achievement of a uniform 7 digit numbering scheme throughout Melbourne Metropolitan and E.L.S.A. areas.

The problem of major significance in the first instance was the method by which the existing two-wire switching, ARF 102 crossbar equipment could be employed, to handle the metropolitan tandem traffic which will of course build up at a considerable rate. Crossbar primary equipment is being installed to meet growth at a rate of 30-35,000 lines each year in the Melbourne network.

Switching Functions for Metropolitan Traffic

In the study of the Melbourne metropolitan tandem scheme it was found that the traffic could be subdivided into five basic classes. The switching scheme has been designed to cater for these different classes.

(i) Traffic to exchanges in the same tandem area which overflows from direct routes or for which a direct route is not provided.
(ii) Traffic from exchanges in one tandem area to exchanges in the inner area of other tandem groups, which can utilize largely 10 lb. junctions and which overflows from direct routes or for which a direct route is not provided.
(iii) Traffic to the outer area of other tandem groups which requires some 20 lb. junctions.
(iv) Traffic to trunks and the E.L.S.A. area.
(v) Traffic overflowing from second choice routes.

The optimum location for type (i) switching is somewhere in the traffic centre of the tandem area. For type (ii) traffic the optimum location is a compromise depending on the originating and terminating exchange locations. The optimum location for one switching centre for both functions depends on the relative traffics. Since the first two classes of traffic are of overwhelming importance compared to the other three the initial locations were chosen with little concern for the latter.

Type (iii) traffic can either be trunked into the switching centre closest to the originating or the terminating exchange depending on the particular economics. Type (iv) traffic may need special treatment because of the trunk access transmission loss requirements. Type (v) traffic will need to pass through at least two tandem stages.

Proposed Switching Scheme

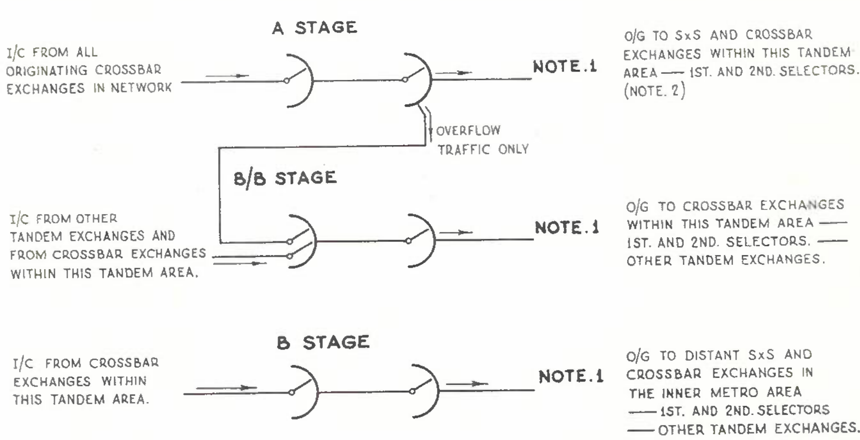
The switching centre to handle type (i) and (ii) traffics will have routes to approximately 50 exchanges of which approximately 25 are located within the tandem area and 25 in the central area. Availability requirements at the initial tandem exchanges are such that one 400 outlet stage is sufficient and at least two stages are necessary. The cheapest way to provide these two stages and one in which the traffic of type (iii) can be readily incorporated in the design is to have one stage hereafter called the A stage to handle all traffic destined for exchanges in the tandem area. A second stage hereafter called the B stage will handle traffic originated in a tandem area and destined for the inner area of other tandems.

The A stage will therefore handle overflow traffic from direct routes within a tandem area, as well as traffic within the tandem area for which no direct route is provided. The B stage will handle traffic to the central area which overflows from direct routes together with traffic destined for the central area which has no direct route.

The B stages at all four initial tandems will handle traffic destined for approximately the same area and can be considered as a distributed tandem for traffic terminating in the inner area. This has advantages over a central tandem in that shorter overall route distances are achieved.

Terminal exchanges which are accessible via the B stage are those which in general can be reached via 10 lb. junctions with a transmission loss of not more than 6 db. The loss from originating exchanges to the B stage will also be 6 db. Thus second choice traffic through the B stage will have a cable loss of not more than 12 db. Use of 6 db loss on both sides of a tandem in most cases permitted standard types of relays to be used for signalling.

The loss from the A stage to terminal exchanges is to be 6 db also, as is the loss from originating exchanges to the A stage serving the tandem area in which the exchange is located; thus traffic to exchanges in the same tandem area which



NOTE.1: ON SOME ROUTES (e.g. ROUTES TO 1ST. AND 2ND. SELECTORS) THE TRUNKS ARE COMMON TO MORE THAN ONE STAGE.
NOTE.2: IN ADDITION, SOME TERMINAL EXCHANGES IN OTHER TANDEM AREAS MAY ALSO TRUNK FROM THE A STAGE, IN SPECIAL CASES WHERE AVAILABILITY IS SPARE.

Fig. 3 — Tandem Exchange Outline Trunking Diagram.

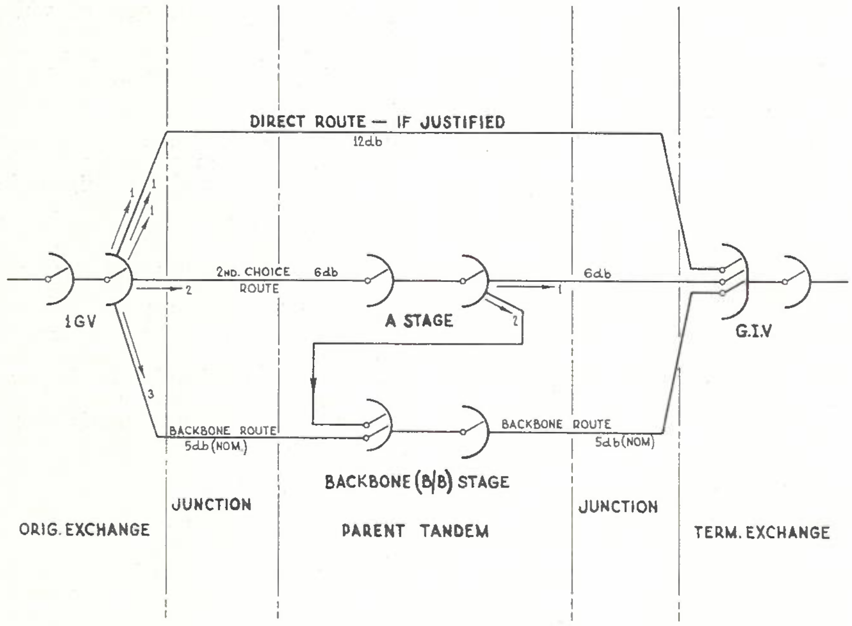


Fig. 4 — Switching of Calls to a Crossbar or Hybrid Terminal Exchange with Same Parent Tandem.

is switched via the A stage will suffer a cable loss of not more than 12 db.

Traffic destined for a terminal exchange in another tandem area which cannot be reached via the B stage of the local tandem will be handled via the A stage located in the tandem area of the terminal exchange. Routes of this latter type will be permitted a cable loss of 8 db; thus traffic on these routes will suffer an overall cable loss of up to 14 db. These routes handle only 10-15% of originated traffic, however.

The overflow from second choice tandem routes at originating exchanges will be carried on the final choice route. The switching stage to handle this traffic will be located with the A and B stages serving each tandem area and will be called BB. Traffic to trunks and the E.L.S.A. area will be included with the final choice traffic. The majority of originating exchanges will of course have direct routes to the appropriate central switching stages which handle trunk and E.L.S.A. traffic.

A key factor in the economics of alternate routed systems is that the number of final choice routes should be minimised. All last choice traffic destined for crossbar terminal exchanges or terminal exchanges with mixed equipment types is routed via the crossbar backbone BB stage throughout. Traffic overflowing from routes to step by step exchanges off the tandems will first be offered to a route to the appropriate step by step second selectors and traffic overflowing from these routes will be carried by a last choice route to step by step first selectors in the tandem exchange.

Trunking Details

The trunking diagram for all tandems will be similar and will be as shown in Fig. 3. Figs. 4 to 10 show how the different classes of traffic will be handled from originating to terminating exchanges.

It will be noted in Figs. 5, 6 and 7 that traffic overflowing from both the A or B and the BB stages is offered to a route common to both stages. Should availability restriction become a problem in the future, the traffic overflowing from the A or B stage onto numerous routes could be combined and passed via the BB stage. These routes would then only appear on the BB stage thus making available additional outlets on the A or B stages. In Figs. 5, 6 and 7 it will be noted that the apparent loss on overflow traffic from the tandem can exceed 15 db i.e. 15 db cable loss plus 1 db switching loss. This cannot occur in practice, however, since the exchanges trunked off the B stage are within 6 db of the B stage and this will generally still be true even if switched via the distant tandem or the appropriate second selectors. Figs. 4, 5 and 8 show that the last choice routes to crossbar or mixed terminal exchanges pass via the crossbar tandem BB stages and never enter the step network.

Fig. 11 illustrates geographically, the tandem stage to which traffic originating in the Windsor backbone area is directed

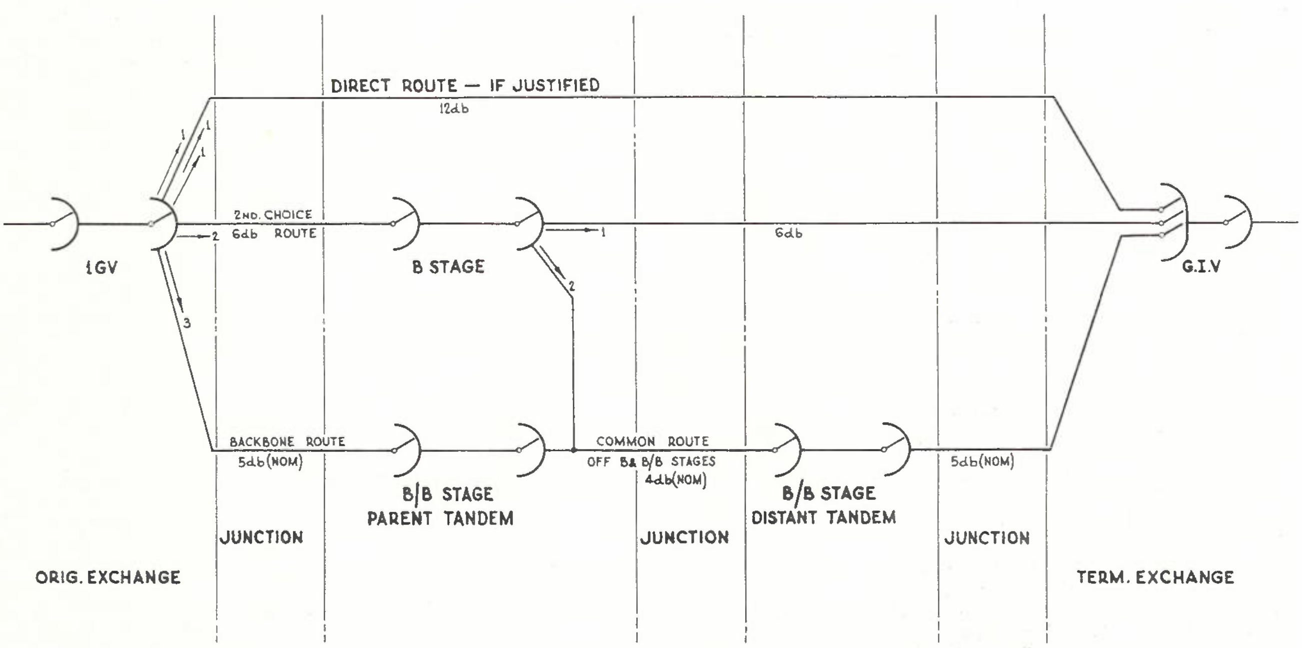


Fig. 5 — Switching of Calls to a Crossbar or Hybrid Terminal Exchange within Approximately Five Miles of the City Centre but in a Different Tandem Area.

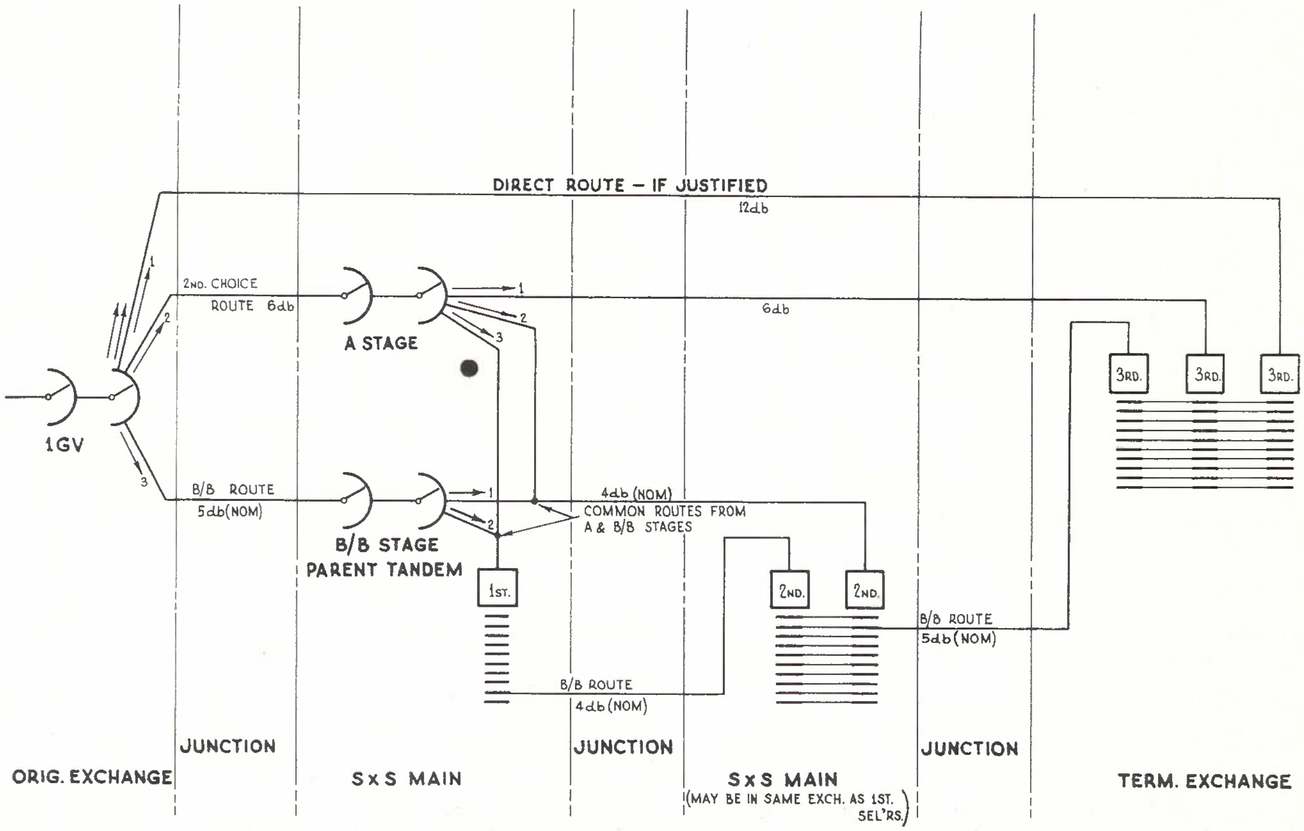


Fig. 6 — Switching of Calls to a Step by Step Terminal Exchange in the Same Tandem Area.

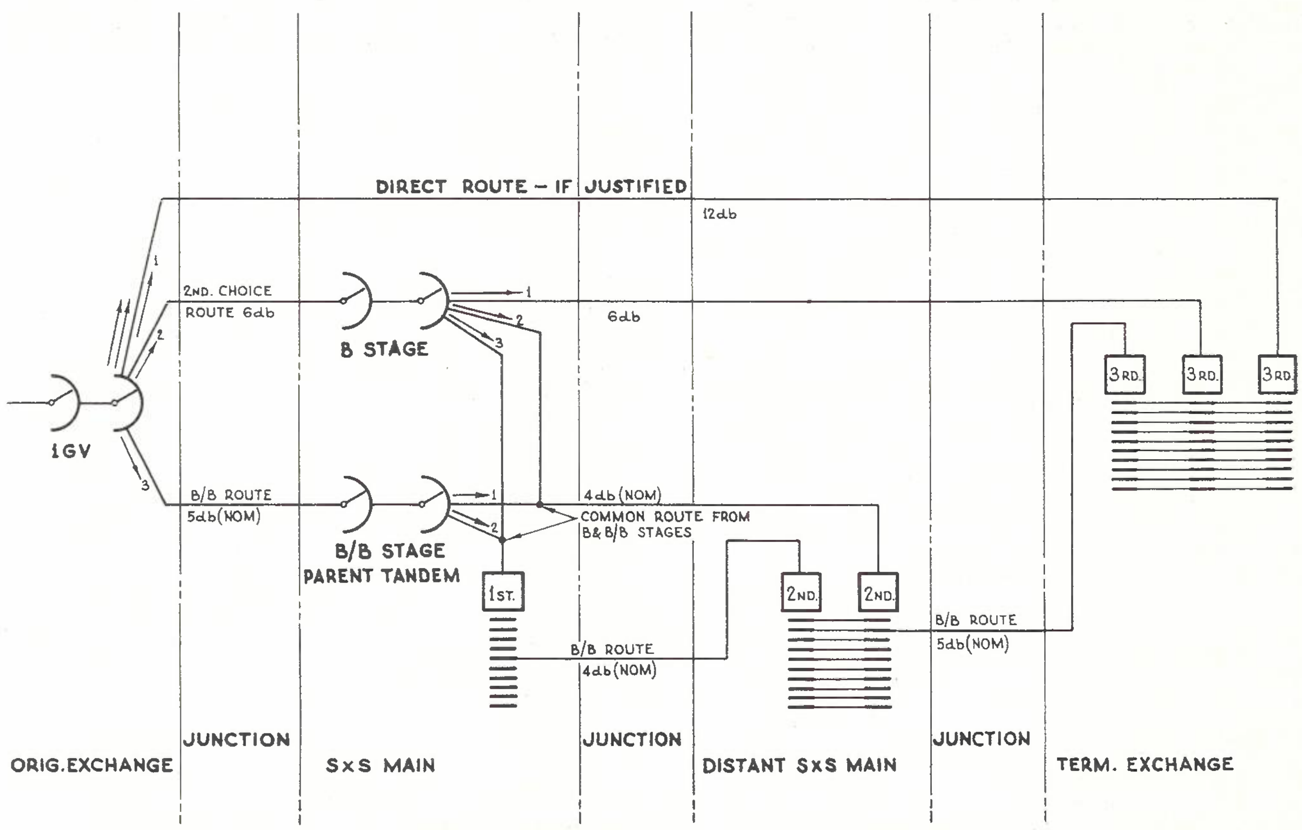


Fig. 7 — Switching of Calls to a Step by Step Terminal Exchange within Approximately Five Miles of the City Centre but in a Different Tandem Area.

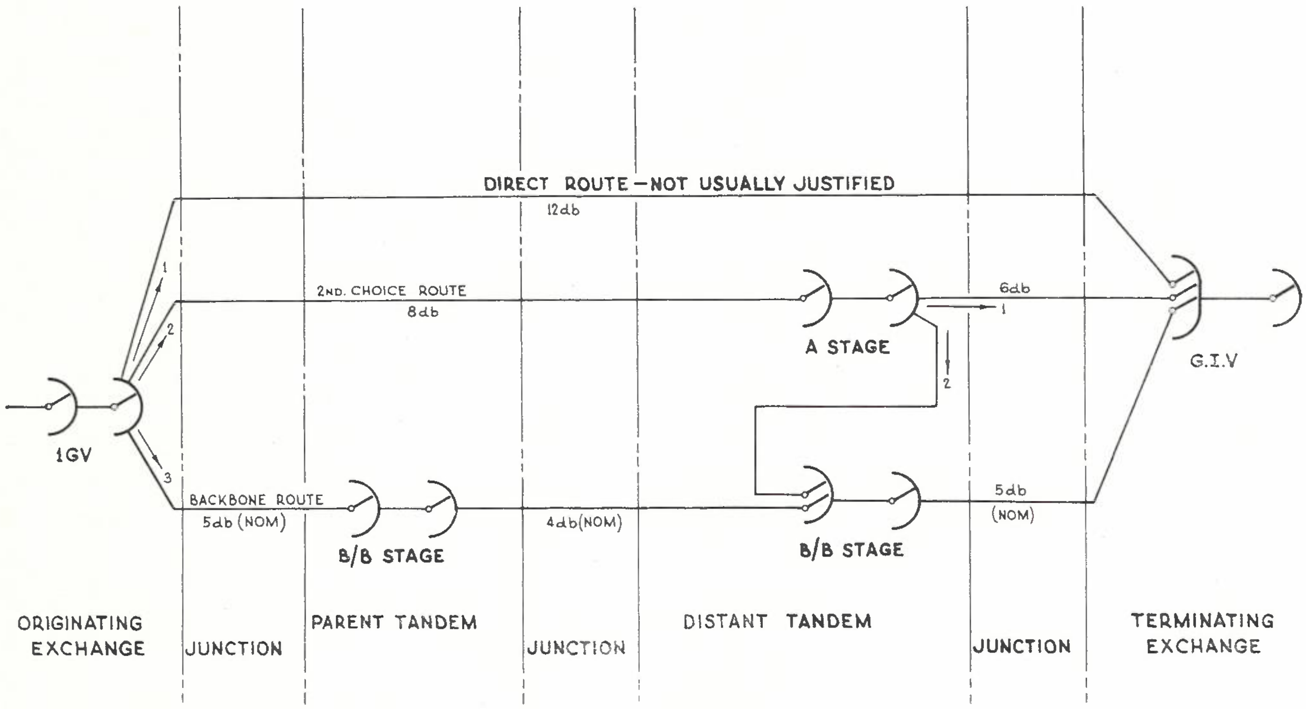


Fig. 8 — Switching of Calls to a Crossbar or Hybrid Terminal Exchange More than Five Miles from the City Centre but in Other Tandem Areas.

on second choice routes. All other tandem areas have a similar routing pattern.

The availability required at the BB stage in order to achieve the method of trunking described above will in the near future become greater than one stage can provide and it will then be necessary to subdivide the BB stage into originating and terminating sections with interconnection for traffic terminating in the same tandem area.

The development of the tandem system will be by the provision of stages similar to the currently proposed A stage which will be located further from the centre of the network. The precise location and the exchanges to be served off these stages will depend on the develop-

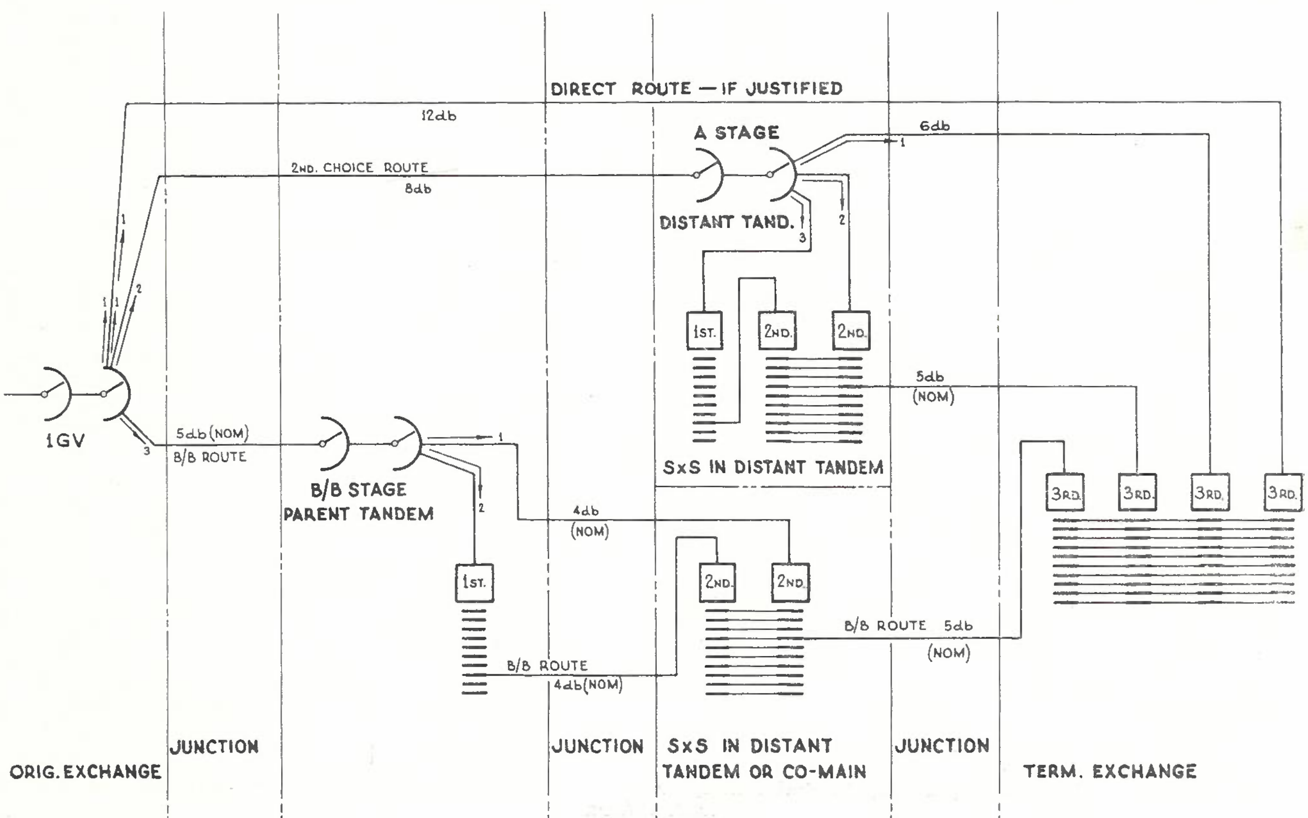


Fig. 9 — Switching of Calls to a Step by Step Terminal Exchange More than Five Miles from the City Centre but in Other Tandem Areas.

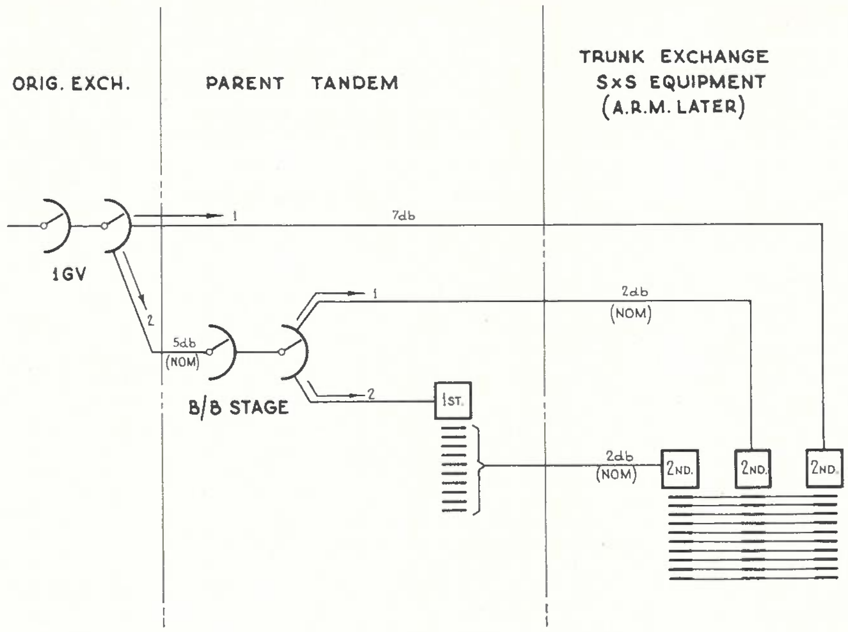


Fig. 10 — Switching of Calls to Trunks and the E.L.S.A. Area.

ment of new cable routes as the volume of crossbar originated traffic increases.

CONCLUSION

The Melbourne crossbar tandem switching system was cut-over on May, 17th, 1964, and its subsequent performance has been in accordance with the design criteria established. The additional complexity of the system has been readily absorbed by the staff involved. The fact that the basic network switching pattern has been set for the introduction of crossbar primary equipment in the Melbourne Network has been of assistance to all sections involved in the continuing work necessary for the introduction of further facilities such as S.T.D.

REFERENCES

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2. L. M. Wright, "Crossbar Trunk Exchanges for the Australian Network"; Telecommunication Journal of Aust., Part 1. Vol. 14, No. 5/6, P. 356. Part 2. Vol. 15, No. 1, P36.

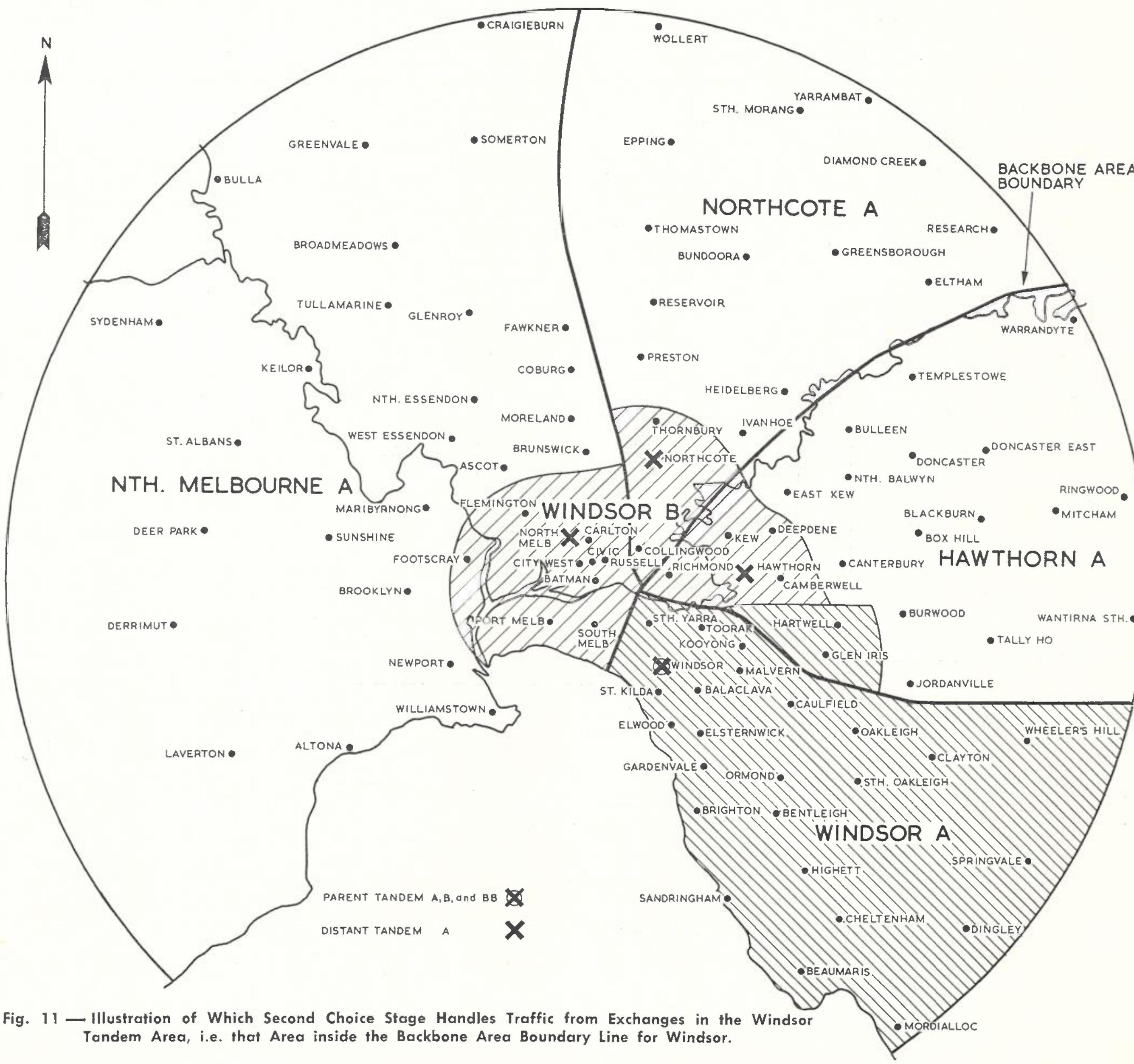

Fig. 11 — Illustration of Which Second Choice Stage Handles Traffic from Exchanges in the Windsor Tandem Area, i.e. that Area inside the Backbone Area Boundary Line for Windsor.

REMOTE TESTING OF SUBSCRIBER SERVICES USING TELEMETRY

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INTRODUCTION

With the rapid expansion of metropolitan exchange networks, the introduction of qualitative maintenance procedures and the difficulty and cost of continuous staffing of automatic exchanges, came the need for more comprehensive centralised fault testing services from test desks situated at strategic points in large metropolitan areas The provision of testing junctions multipled to reduce overall resistance is costly, both in terms of initial provision and the loss of revenue earning capacity of the routes concerned. Further, the greatly increased capacitance mitigates against successful testing of subscribers' lines in the most distant exchange areas where the effect of long multipled junction arrangements is most pronounced. The increasing use of light gauge junctions and subscribers' cables further accentuates the problem.

Substantial economies can be effected by the establishment of Maintenance Control Centres at selected locations in large metropolitan networks from which all subscribers' maintenance activities may be directed and co-ordinated.

Maximum use is made of the field staff and greater effectiveness of vehicle usage is possible. Maintenance Control Centres of this type are staffed with highly skilled staff who, if provided with adequate diagnostic testing facilities, are able to minimise the time spent in fault clearance and also to reduce the average elapsed time from the initial report to the final clearance with consequent improvement in efficiency of the network (Ref. 1).

A method of performing remotely the whole range of subscribers' line and equipment tests as though at the local exchange to which the subscriber concerned is connected, has been evolved and is described in this article.

* Mr. J. L. Harwood is Manager of Research, Electric Control and Engineering Limited, N.S.W. See Page 246.

GENERAL DESCRIPTION

Fig. 1 shows the general trunking arrangements employed. By utilising data transmission techniques between the control centre and the distant exchange via the testing junctions, the testing circuits at the remote exchange concerned may be set-up directly by relay circuits equivalent to the normal key circuitry in the standard test desk. The data transmission system employed may use either frequency division or time division multiplexing, but in the system described, time division multiplexing is employed due to the relative simplicity of the voice frequency signalling arrangements and the absence of interference with other voice frequency tones and supervisory signals now in common use in modern switching systems. A small additional delay of approximately one second is involved in the transmission of each block of data from the instant the key at the control centre is operated to the time the test relay operates at the distant exchange. This delay is occasioned by the validity checking system applied to each block of data before it is accepted at the remote exchange, but the Testing Officer soon becomes accustomed to this short delay and manipulates the testing keys in such a way as to minimise its effect.

Telemetry of the voltmeter readings is achieved by D.C. "constant current" methods, the response time of which is negligible. It is also possible to use variable frequency telemetry whereby the distant voltmeter reading is changed into a variable frequency between 800 and 1600 c.p.s., but the equipment described in the following caters only for D.C. telemetry at this stage.

Data Transmission

The time division multiplexing system employed in this application is the straightforward relay type TELSCAN* system capable of data transmission at 10 to 20 bauds and having a word length of 16 binary digits (see Figs. 2 and 3). Five binary digits are normally required for address coding, although only a small number of addresses are employed in this system. If a tandem connection to a satellite exchange is involved and TELSCAN systems are connected at both the intermediate and terminating exchange, the address coding will ensure that only the selected exchange testing circuitry responds to the key manipulation by the Testing Officer.

Eight information binary digits are provided in each of the two message trains to control the operation of testing relays at the distant exchange. Fifteen test relays, plus one spare function, are normally provided. During data transmissions, which take place immediately a key is operated or released, a flashing lamp on the testing position panel will assist the operator in gauging the response time of the equipment at the distant exchange.

Relay TELSCAN System

TELSCAN is a data transfer system for communicating information in binary coded digital form between one central controlling station (e.g., the Maintenance Control Centre) and several remote outstations (e.g., distant exchanges). The advantages of digital transfer (few lines, add-on capacity, error rejection, interference-free and accuracy) will be well

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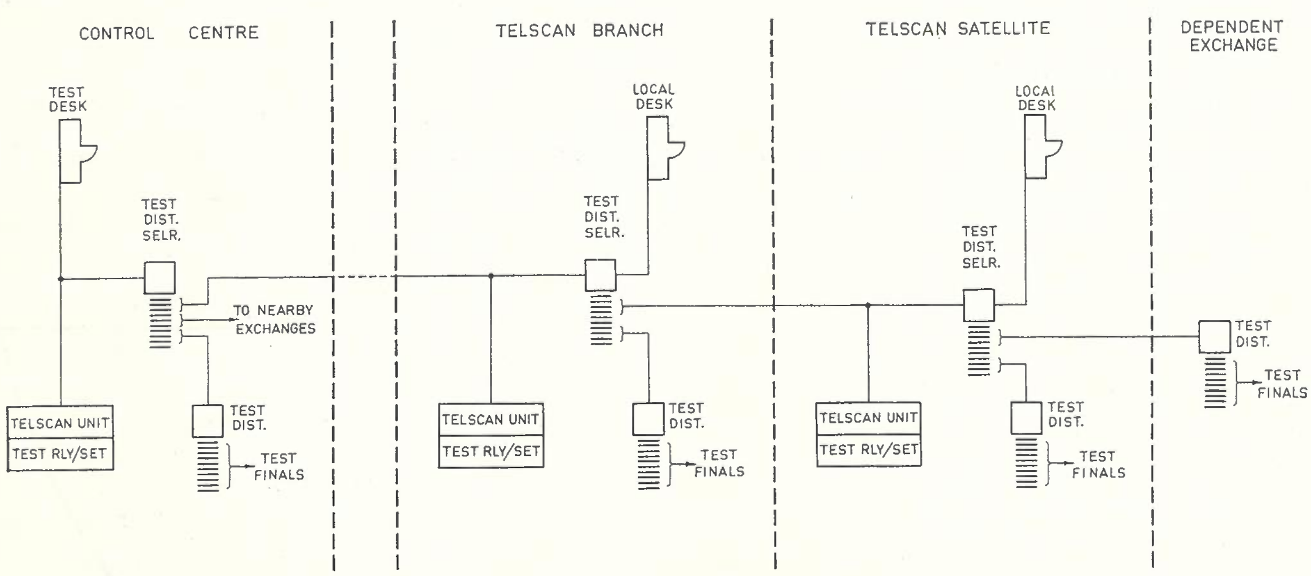

Fig. 1 — Trunking Diagram for Remote Exchange Testing Scheme.

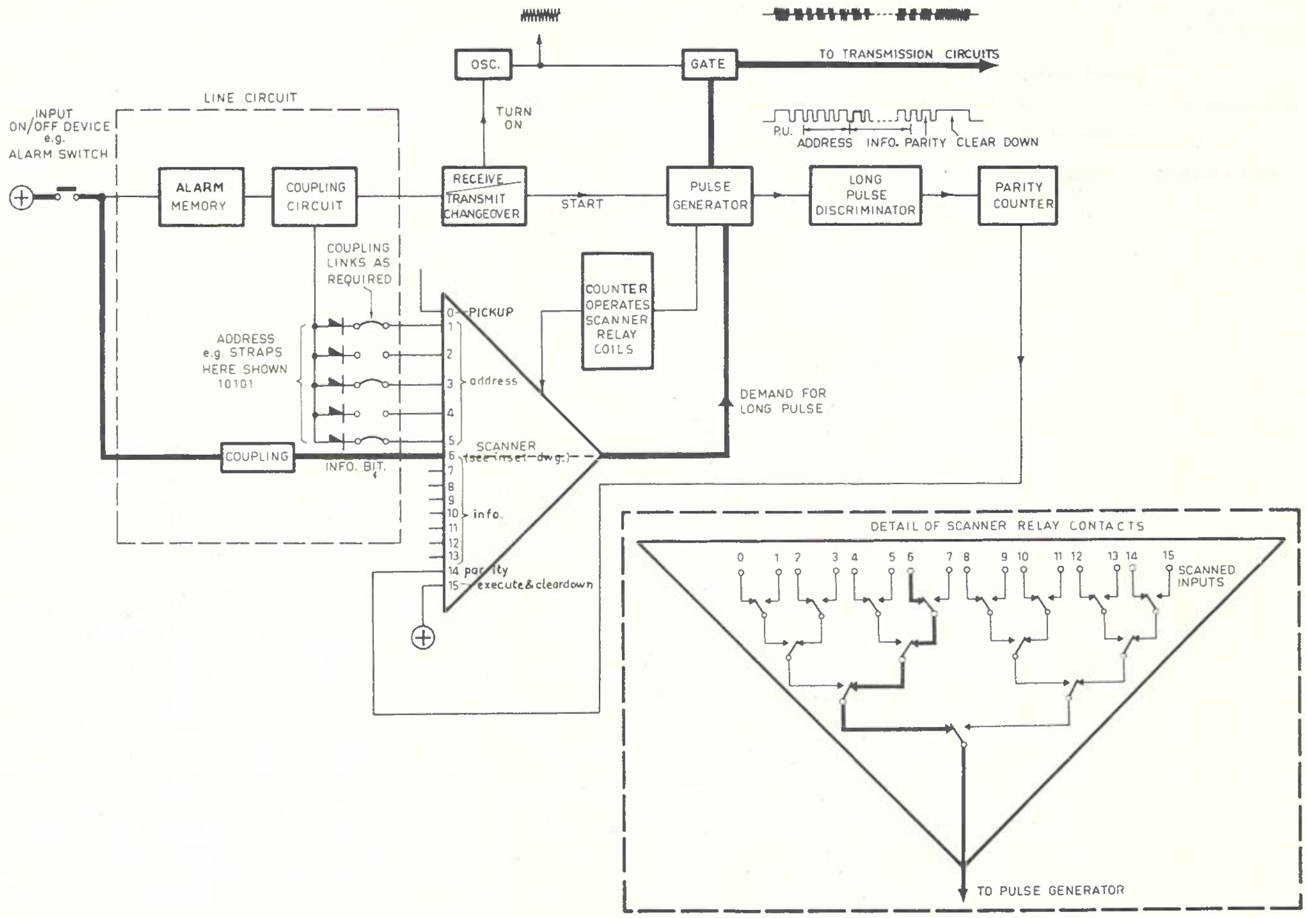

Fig. 2 — Data Transfer System — Transmitting mode.

known to telecommunication engineers familiar with telegraphy and teleprinter systems. The relay version described here uses wire-spring relays originally designed for telephone exchange use (see Fig. 4). Relay equipments have already proved satisfactory in the field and are providing remote supervisory control and telemetry facilities in the operation of several Australian utilities, in addition to remote exchange testing.

Communication

Communication can be carried over any voice-frequency channel, telephone or telegraph lines, radio communication system, power line carrier equipment, etc. Only one such channel is required to carry all information between the control centre and a group of outstations. The use of time division multiplexing requires only a fraction of the total band width to be occupied by data transmissions, leaving the remainder of the voice frequency channel available for an independent speech communication facility.

For remote exchange testing, the V.F. signals are passed over the "operate" pair of the testing junction.

Messages

Data is translated into discrete messages, each composed of a block or train of 16 pulses of tone. The modulating envelope is in pulse-coded form in which there are two pulse durations (long and short) which can be used to correspond to the two bits 1 and 0 where quantitative data has to be transferred. In each message the pulses are arranged in consecutive groups to conform to the code format of that particular equipment. After an initiating pulse comes an address group in simple binary form; then the various coded information groups; next is the penultimate pulse for the parity error-check; and finally a long execute and clear-down pulse (see Fig. 5).

System Operation

The TELSCAN system can provide three facilities for remote operation:

1. Control of outstation equipment by control commands from the central desk.
2. Supervisory functions in which the outstation reports back to the central control any significant changes in the state of external devices. These reports include alarm signals and confirmation that a command has been executed. Censors monitor the external equipment.
3. Telemetry facilities in which the outstation reports back to the central control precise numerical values of measurements. It should be noted, however, that D.C. telemetry is used in lieu of digital telemetry in this application.

TELSCAN transmitting receiving equipment is provided at the Control Centre and at each controlled remote exchange. At the Control Centre, the operation of keys on the test desk initiates transmissions, while at the distant exchange concerned, all functions corresponding to the operated keys are performed by relays.

At both the central control and each outstation, the devices (switches, relays, etc.) which feed information into the TELSCAN transmitters and also those which deliver it out from the receivers, have a hold-on property enabling them to be used as storage or "permanent" memory devices. There are two reasons for this:—

1. These devices can maintain local control of external equipment, even after the transmission and line circuits have been disconnected from them. Thus only one communication channel can serve several outstations.
2. The storage property enables the actual operation of external equipment to be compared with control commands given previously. In the case of remote exchange testing, the test function "memory" relays will be released when the test distributor train is released.

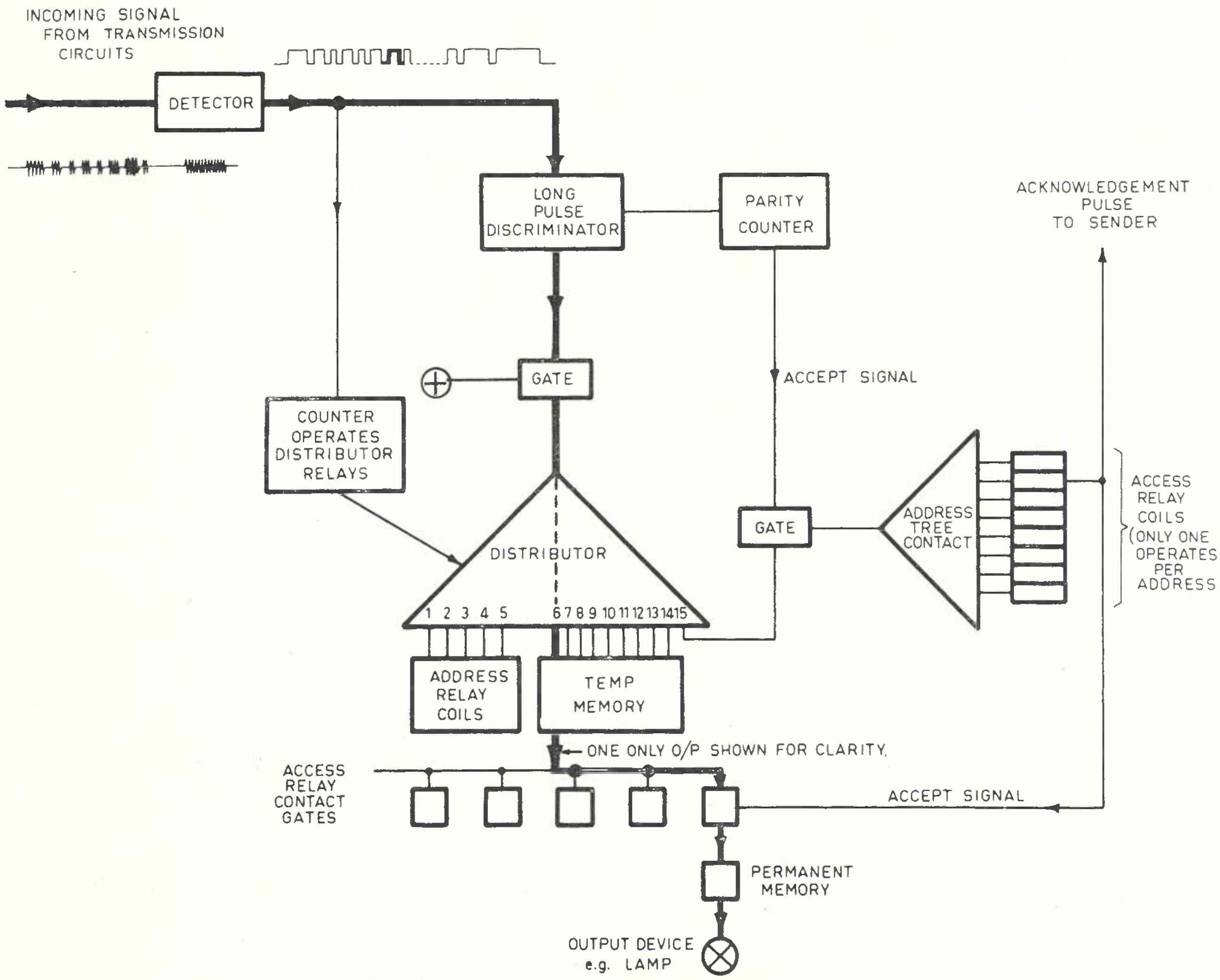

Fig. 3 — Data Transfer System — Receiving mode.

DEPENDABILITY AND RELIABILITY

The possibility of false operation has been reduced to the point where it can be ignored for all practical purposes. This degree of dependability has been achieved by making the system fail-safe. Some of the methods are:—

1. In TELSCAN receivers, all incoming message data is withheld from reaching the permanent memories unless three error-check conditions are simultaneously true. These are:—
   (i) The total number of long (1) pulses in the message is odd (parity check).
   (ii) The total number of pulses in the message is 16.
   (iii) The final execute and clear-down pulse must exceed a specified length.
2. More information pulses are allocated to pulse groups which control major functions, so that the more complex code greatly reduces the possibility of error. Moreover, for a change from a passive to an active state (e.g., initiation of a starting signal) the data bit is changed from an "0" to a "1" since "0" always corresponds to the passive or "fail" state of the input device.

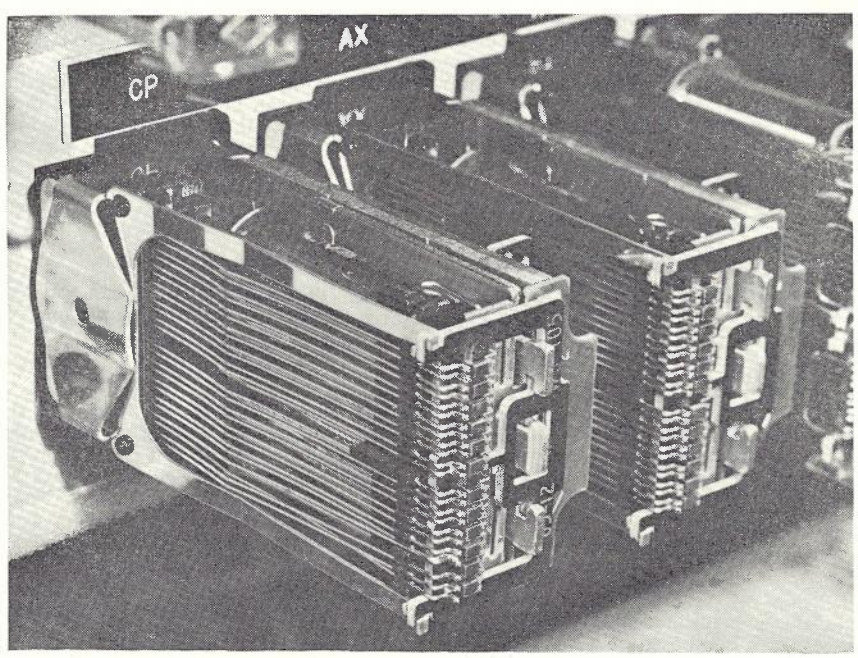

Fig. 4 — Wire-spring Relay.

3. In normal industrial or public utility applications, cross-reference relay circuits at both the control central and outstations prevent the discrepancy lights from ceasing to flash until correct operation at the outstation is confirmed by a 'supervisory' transmission back to the control centre.
4. External equipment faults automatically send alarm signals to central control.

Dependability is achieved by the use of high-quality components and careful design. Checking systems are incorporated in the equipment and the construction is in functional module form. Power supply is obtained from the exchange batteries held on floating charge from 240V A.C. mains.

TRUNKING ARRANGEMENTS FOR REMOTE TESTING

From Fig. 1 it will be seen that normal inter-exchange and intra-exchange trunking arrangements may be employed due to the greatly increased sensitivity of the D.C. dialling path via the "operate" pair. Thus it is unnecessary to provide intermediate dialling repeaters at any of the exchanges en route. If, however, repeaters are provided for other reasons or are required to work in with existing testing facilities, no difficulty will be experienced due to the presence of the D.C. amplifier at the terminating exchange. A general schematic of this system is shown in Fig. 6.

In cases where tandem operation is involved and test distributor selectors are provided at intermediate exchanges in the testing network, impulse repetition may be provided as a normal function by the addition of repeaters. However, each TELSCAN system installed at a remote exchange will include a D.C. amplifier on the "operate" pair of the local test distributor and dialling over loops up to 3000 ohms will be accepted.

The data transfer equipment, together with the test relay set, is associated with the incoming junction at the intermediate and terminating exchanges. By this means, it will be possible to have two TELSCAN systems attached to a particular testing train. The operator selects the required one by manipulation of the branch/satellite key which affects the address code associated with each outgoing transmission. Data transmissions not intended for a particular station are ignored.

In order to cater for ultimate voice frequency dialling, and also to dispense with the supervisory relay circuit at the control exchange, the "Sub or Selector Busy" signal is transmitted via a TELSCAN message. On long junctions with relatively low dialling currents, the reversal supervisory relay (relay D) at the control exchange may not be able to operate, thus making the provision of a TELSCAN supervisory signal essential. Notwithstanding this, an additional relay at the remote exchange is provided for the purpose of sending a polarity reversal via the "operate" pair in addition to the TELSCAN signal. This relay (BZ) is connected in parallel with the G relay of the standard test distributor circuit or from a contact of the reversal relay where applicable and applies the current reversal before the D.C. amplifier circuit. This is shown in Fig. 6.

CONTROL CENTRE TO REMOTE EXCHANGE

Initiated Function	Key/Relay		Group	Function No.		Receiving Relay		Resulting Function
Line Reverse	KLR/LR		1	1		LR		Line Reverse
Earth	KE/E		1	2		E		Earth
Loop	KLP/LP		1	3		LP		Loop
Foreign Battery	KFB/FB		1	4	Address	FB	Via AXA	Foreign Battery
VM Reverse	KVR/VR	Via RTA/ CPA	1	5	BR=10000	VR		VM Reverse
Res.Test	KRT/TR		1	6	SAT=10001	TR		Res.Test
Low Scale	KLS/LS		1	7		LS		Low Scale
Insulation Res.	KIR/IR		1	8		IR		Insulation Res.
Dial Test	KDT/DT		2	1		DT		Dial Test
Selector Release	KSR/SR		2	2		SR		Selector Release
Ring	KR/R		2	3		R		Ring
Howler	KH/H	Via RTB/ CPB	2	4	Address	H		Howler
Battery & Buzz	KB/B		2	5	BR=01000	B		Battery & Buzz
Private Control	KPC/PC		2	6	SAT=01001	PC		Private Control
Res. X10	KX10/MX		2	7		MX		Res. X10
Spare	KSP/X		2	8		X		Spare
Interrogate	K.INT/RTA & CPA		3	-	Address BR=00000 SAT= 00001	RTA/RTB Via - AXC		Report of status of alarm etc.

REMOTE EXCHANGE TO CONTROL CENTRE

Initiated Function		Group	Function No.		Receiving Relay		Resulting Function
Ring Pilot	Via RTA/CPA	4	1	Address	LR	Via AXA	Ring Pilot Lamp
Selector or Sub-busy	(& AXC under	4	3	BR=00000	LP		Selector or Sub-busy Lamp
Battery & Buzz	interrogation)	4	5	SAT=00001	VR		Battery & Buzz Signal

Miscellaneous Alarms		Group	Function No.		Receiving Relay		Resulting Function
1		5	1		MA		
2		5	2		MB		
3		5	3		MC		To Miscellaneous
4	Via RTB/CPB	5	4	Address	MD	Via AX	exchange alarm lamps
5	(& AXC under	5	5	BR=11000	ME	(8 bit	and bell (on MAR.)
6	interrogation)	5	6	SAT=11001	MF	Line	
7		5	7		MG	circuit)	
8		5	8		MH		

ADDRESS CODING

CONTROL CENTRE TO REMOTE EXCHANGE

	To Branch	To Satellite
Group 1	10 000	10 001
Group 2	01 000	01 001
Group 3	00 000	00 001

REMOTE EXCHANGE TO CONTROL CENTRE

	From Branch	From Satellite
Group 4	00 000	00 001
Group 5	01 000	01 001

TYPICAL CODE FORMAT OF 16 - PULSE MESSAGE

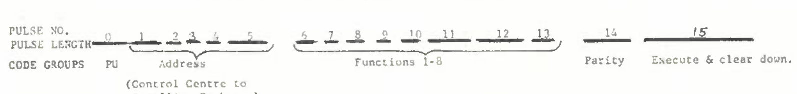

Fig. 5 — Table of Functions.

DETAILED DESCRIPTION

Testing Facilities

The following test key operations are required to be signalled to the distant exchange from the Control Centre:

Group 1.
- Line reverse
- Earth
- Loop
- Foreign battery
- Voltmeter reverse
- Resistance test (80V)
- Low scale (0-800 ohms)
- Insulation resistance (250V)

Group 2.
- Dial test (pulse length monitor)
- selector release
- Ring (continuous)
- Howler
- Battery and buzz
- Private control
- Resistance x 10 (0 to 8000 ohms)

Examination of Table 1 (Fig. 5) will illustrate the grouping within each sub-address and also the test relays and resulting functions involved. A schematic diagram of the test desk facilities is shown in Fig. 7. The complete testing circuit is shown in Fig. 8.

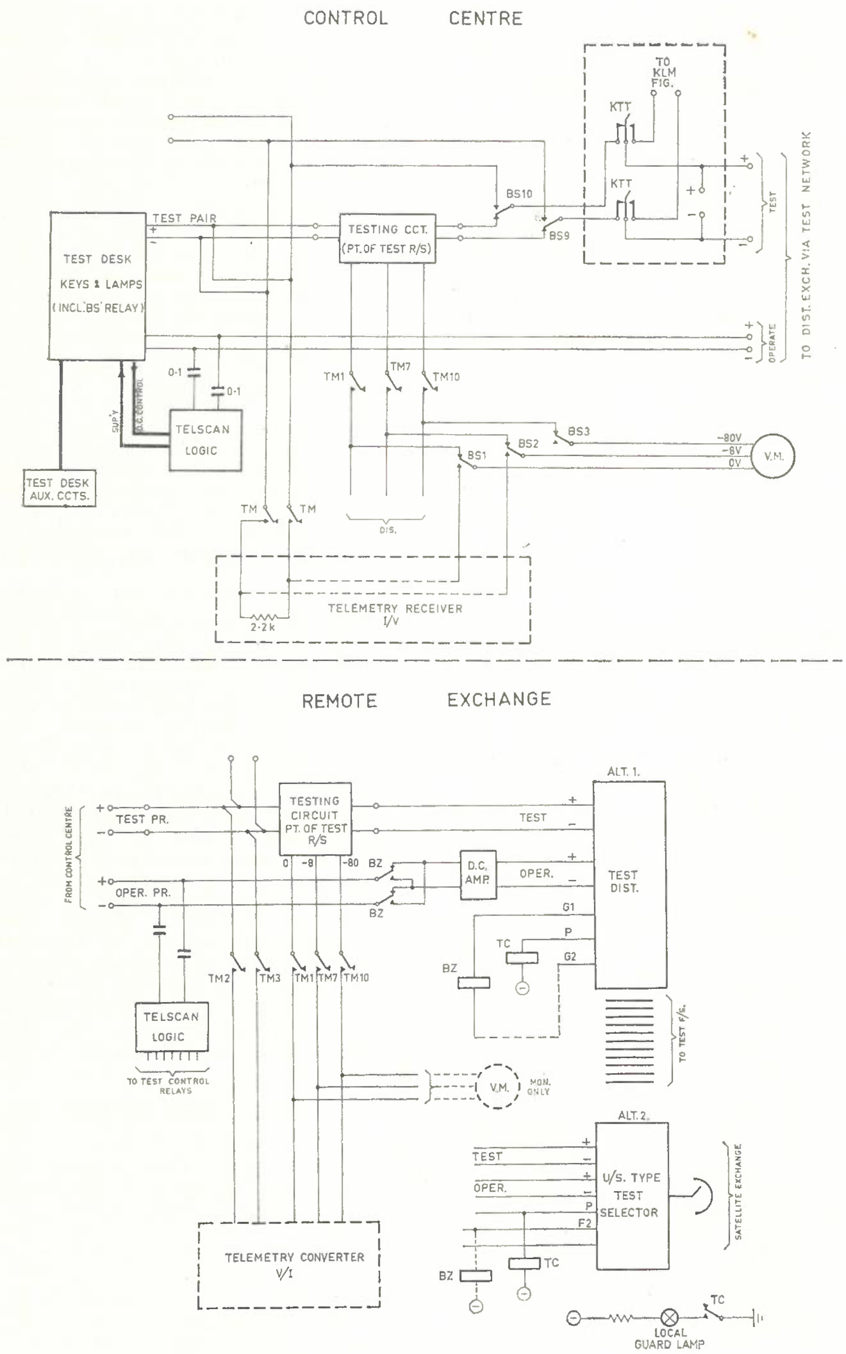

Fig. 6 — System Schematic.

Operation or release of any key will initiate a data transmission sequence which will be immediately acknowledged: otherwise the transmission concerned will be repeated. Interference penetration by noise has no practical effect on the correct transmission of signals.

By providing identical testing relay sets by both the control centre and each distant exchange, local tests at the control exchange and nearby exchanges may be carried out in the conventional manner. Manipulation of the testing keys will operate local relays directly and the necessary testing circuit end configuration will be established accordingly.

The operation of the branch/satellite control key will introduce the TELSCAN equipment at the control exchange and all key manipulations thereafter will result in data transmissions to the distant exchange. The local test relay set remains inert at the control exchange under this condition.

Certain tests have been modified to take advantage of recent developments in semiconductor circuitry. These are:—

1. Low scale resistance tests are performed by a special ohmmeter circuit configuration by which the Test Desk voltmeter reads 0-800 ohms on the normal 0-8 volt scale, e.g., a reading of 1V would indicate a resistance of 100 ohms. Operation of the "Resistance x 10" key will change the scale factor to read 0 to 8000 ohms. This feature eliminates the need to refer to separate non-linear scales usually located on the Test Desk writing space. High resistance tests via the 80 volt scale and insulation resistance tests via the 250 volt D.C. supply (625,000 ohms at mid-scale) are still retained in their present form. Capacitance tests are usually made on the 80 volt scale.
2. Dial pulse length monitoring (Ref. 2) in lieu of the conventional impulse speed, weight and count tests is provided for. The supervisory tone heard at the conclusion of the impulse train will indicate the condition of the dial in the telephone under test. Each separate impulse will be gauged in respect of both the make and break portions of each impulse, and the failure of any single impulse will result in a rejection of the dial.

With regard to the use of the ohmmeter-type low scale resistance test, it is pointed out that a low voltage is applied to the subscriber's line in lieu of the relatively high voltage applied by the conventional low scale testing circuit. Further, the maximum current in the line is limited to 10 milliamps which is unlikely to break down intermittent dry joint faults which are often the cause of noisy lines. Elusive faults of this type are often temporarily cleared by the relatively high test voltages and currents employed on the conventional low resistance testing circuit. One disadvantage, however, with the low current type of circuit is the inability to hold series supervisory relays in substation equipment on the testing current. Duplex services are therefore more difficult to test in some cases.

In addition to the transmission of the various test control signals listed above, transmissions in the reverse direction are employed for the following supervisory purposes:—

(a) Ring Pilot
(b) Subscriber or Selector Busy
(c) Battery feed (Subscriber answer)

Test Train "Operate" Circuits

In order to cater for the dialling of the test selectors over junctions of up to 3000 ohms resistance, a D.C. amplifier consisting of an emitter follower type circuit on each leg is provided at the terminating exchange (see Fig. 9). Current and voltage limiting is provided to prevent excessive power dissipation in the transistors and to enable local dialling to be achieved also. By-pass capacitors are included for transmission of the supervisory tones where required although the speech transmission efficiency of this circuit is relatively low.

The private control function, normally effected via the "operate" circuit, is catered for in the usual manner by applying earth potential to one side of the "operate" loop at the control exchange, but this signal is also duplicated by a TELSCAN message to cater for full V.F. working if required.

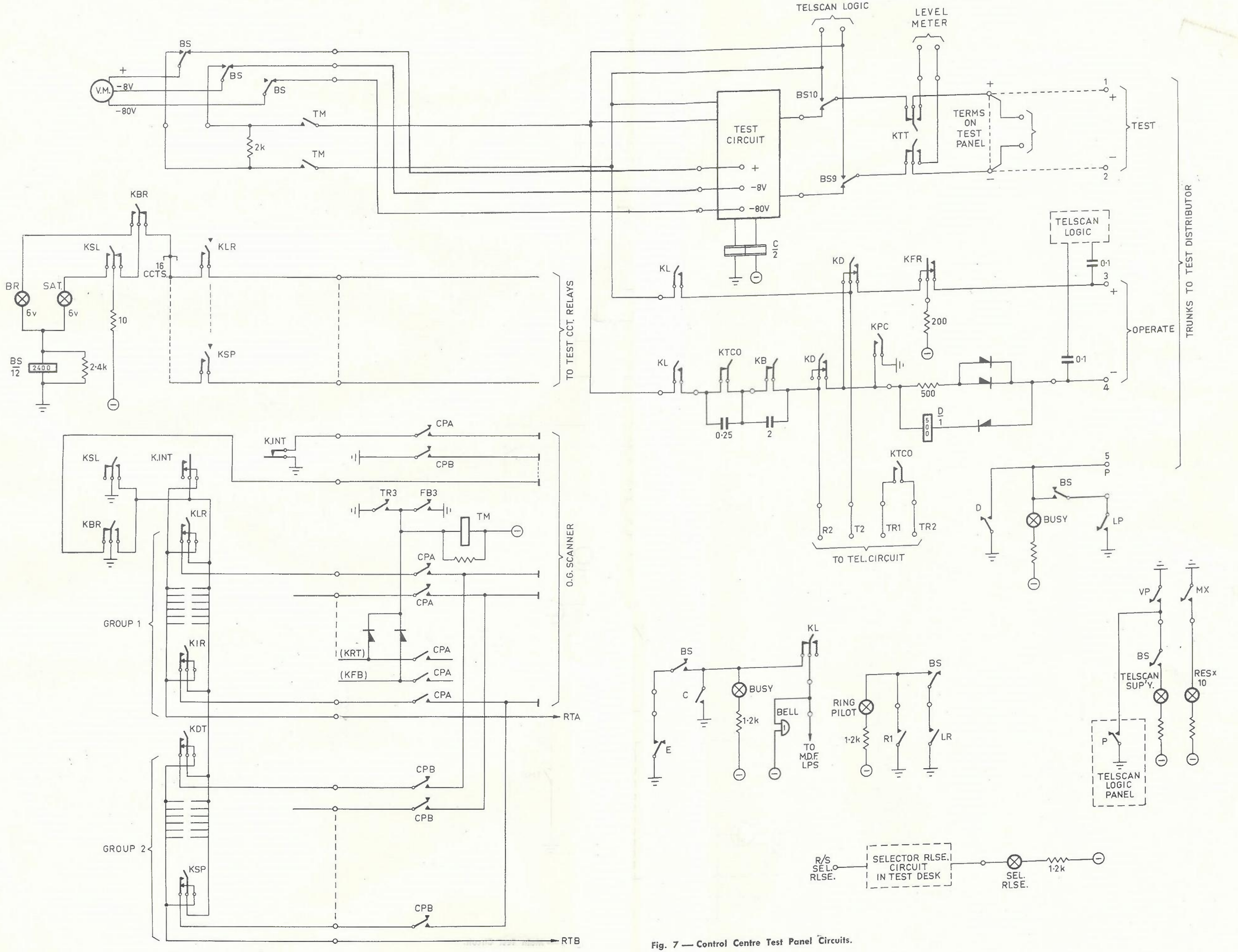

Fig. 7 — Control Centre Test Panel Circuits.

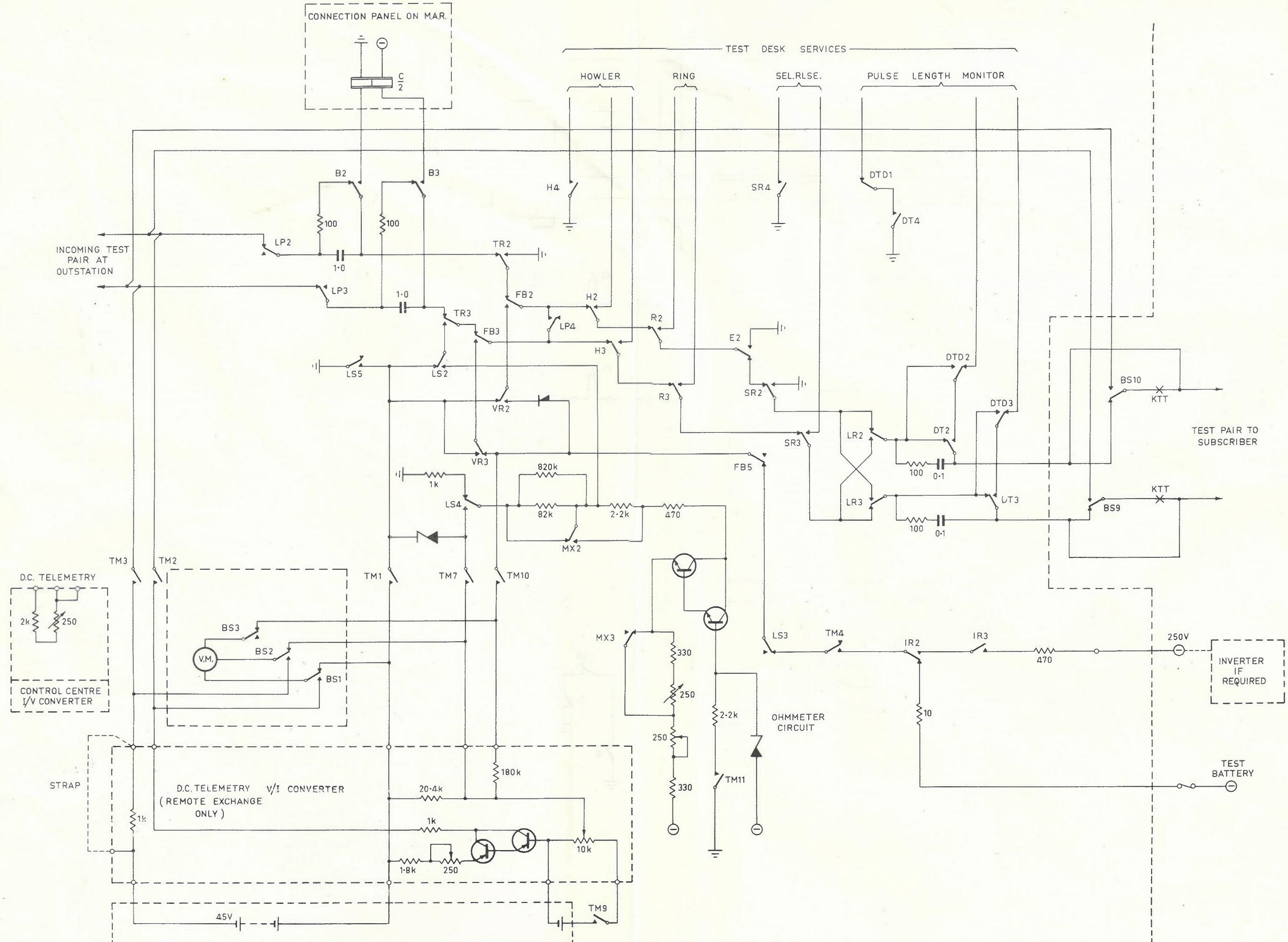

Fig. 8 — Main Test Circuit.

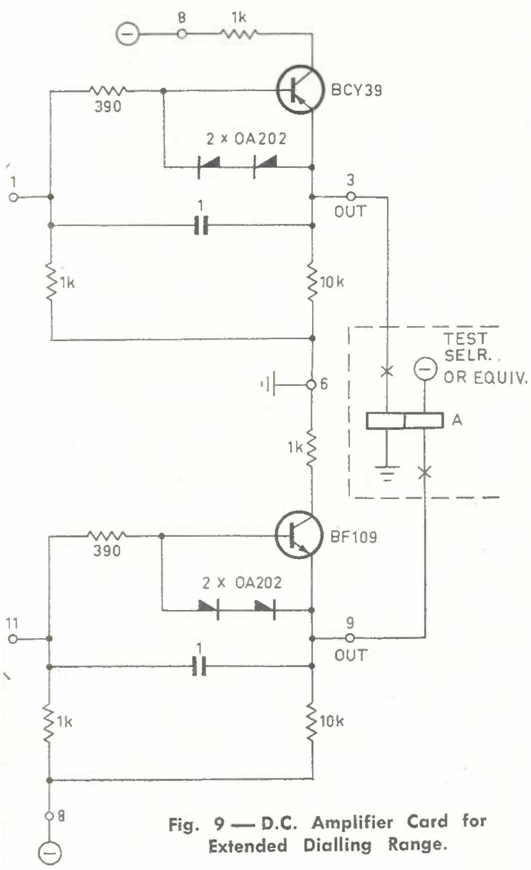

Fig. 9 — D.C. Amplifier Card for Extended Dialling Range.

No provision is made for the final selector releasing feature as this is normally required only for routine tests on individual subscriber's lines at relatively infrequent intervals.

The reversal detection relay in the "operate" circuit at the control exchange has been increased in sensitivity by the substitution of a high resistance winding with a greatly increased number of turns. Signalling to nearby exchanges will be unaffected by this modification.

Ringing Circuits

Continuous ringing under the control of the test panel ring key is provided so that the minimum period of continuous ringing which can be applied to a subscriber's line will be approximately one second under TELSCAN working. Interrupted ringing may be applied only from the Control Centre by the manipulation of the ringing key associated with the test distributor trunk circuit.

A supervisory signal is fed to the Testing Officer via the TELSCAN system when continuous ringing current is applied to a subscriber's line. In many cases it will be possible to send ringing current from the Control Centre via the testing junction with the aid of TELSCAN relaying system and experience will guide the Testing Officer in this regard.

Selector Releasing

It is not possible to apply a selector release circuit to a subscriber's line at a distant exchange without relaying equipment. The TELSCAN equipment includes a selector release control relay which utilises the local circuit, and the booster battery supply already available at the distant exchange.

Howler Circuit

The howler equipment at the distant exchange is similarly shared with the TELSCAN equipment.

Ohmmeter Circuit

Fig. 10 shows the method of applying a constant current to a subscriber's line in order to read the voltage drop across the unknown resistance. A linear resistance scale reading is obtained. Unlike the conventional ohmmeter circuit configuration, no scale crowding will occur, but on high resistance lines the voltmeter pointer will slightly overshoot the full scale reading.

A zener diode protection circuit guards the movement, but the telemeter circuit indicates to the Testing Officer the need for the operation of the "Resistance x 10" key to expand the scale to 8000 ohms. Under this condition, the line current is reduced from 10 to 5 milliamps and the maximum subscriber's line voltage is limited to 40 volts.

The Telemeter Circuit

The equivalent voltmeter circuit at the distant exchange is connected to an emitter follower type constant current generator input. Voltages over the range of 0 to 8 volts are translated into line current variations of 0 to 4 milliamps, irrespective of the length of the line to the control exchange (up to 3000 ohms). At the control exchange a 2000 ohm resistor in series with the line will reproduce the 0 to 8 volt potential indications on the local test desk voltmeter. No delay between the application of the voltage at the distant exchange and its appearance on the control centre test desk voltmeter is apparent. Fig. 11 shows the circuit arrangement involved.

Testing Services in Outer Metropolitan Exchanges

Outer metropolitan exchanges which are served by a branch or satellite exchange equipped with TELSCAN equipment may be tested from the control exchange via the Data Transfer System so that the tests are applied as closely as possible to the subscribers' lines concerned. These tests will be performed from the relay circuits situated at the nearest exchange so equipped. If the outer exchange is equipped for Selector release and/or pulse length monitor facilities, a sixth junction wire may be provided to relay the signals in order to apply these tests at the outer exchange and so eliminate the effects of any junction resistance.

Test Desk Equipment

The operating panel of the test desk has been redesigned to incorporate the new style of lever key. An attractive wood grain finish in "Laminex", or equivalent material, has been employed in preference to the matt-black finish conventionally used. The operating panel is so arranged that the voltmeter section may be re-located in certain cantilever type positions if so desired. Test trunk access keys and lamps are located on adjacent operating panels.

The layout of the operating keys is similar to the standard APO test desk arrangement, but several additional

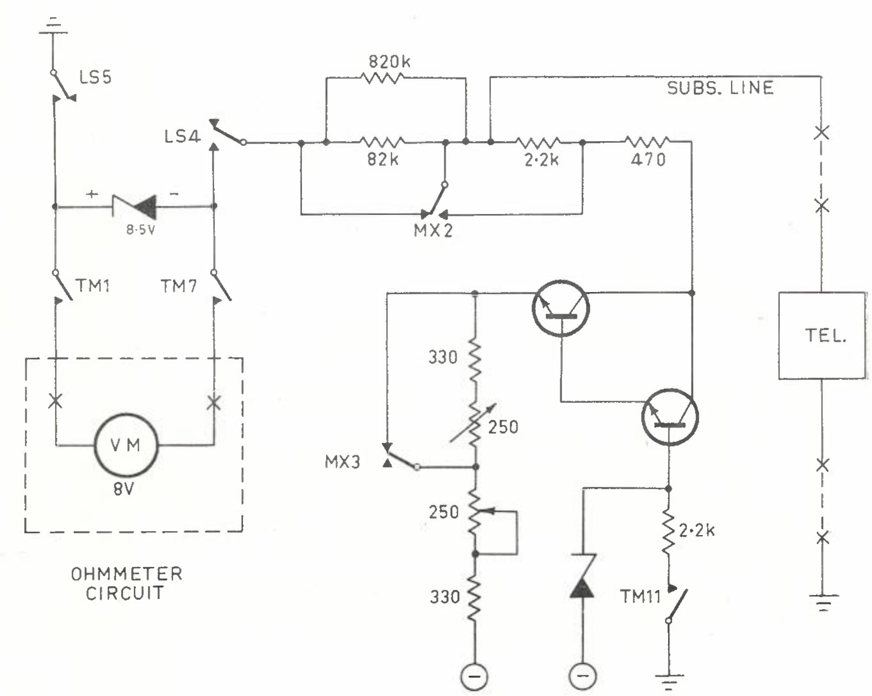

Fig. 10 — Ohmmeter Circuit.

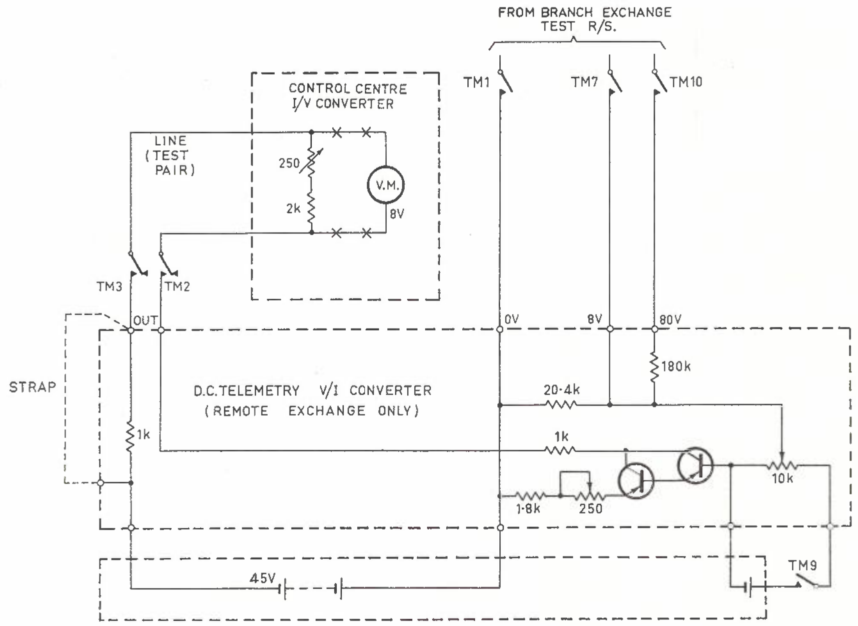

Fig. 11 — D.C. Telemetry Circuit.

functional keys have been added. Fig. 12 shows the arrangement employed.

Miscellaneous Apparatus Rack

A sub-frame is mounted on the M.A.R. and is arranged to contain the following:—

(a) TELSCAN Logic Panel (Data Transfer Control Relay Set).
(b) TELSCAN Routine Test Panel.
(c) The Test Relay Set.
(d) The Alarm Identification Relay Set (at Control Centre only).
(e) Interconnecting wiring column.

Fig. 13 shows the M.A.R. equipment at the Homebush Exchange, N.S.W., where the first installation has been completed.

OPTIONAL FACILITIES

Alarm Identification at Remote Exchanges

An important additional feature which may be derived from this method of remote exchange testing is the complete identification of alarms at any of the exchanges equipped with the TELSCAN System.

A common alarm pilot is all that is necessary to advise the control exchange that an alarm condition exists at any one of the group of exchanges served by a particular branch exchange. The Testing Officer then sets up a test train connection to the test selector at that exchange and after operating the branch/satellite key to introduce TELSCAN working, he then operates the interrogate key and observes on a row of lamps below the test keys the further identity of the alarm. If the alarm is local to the branch exchange, the appropriate lamp indication will be given, but if the alarm had originated from a TELSCAN equipped satellite exchange, the exchange identity would be indicated The Testing Officer has simply to dial the code of the satellite concerned and re-interrogate with the branch/satellite key now operated to the "Satellite" position. The ability to identify alarms by this means should prove a valuable adjunct to the operation of centralised testing services.

Voice Frequency Telemetry and A.C. Dialling

By providing variable frequency VF telemetry (800 to 1600 c.p.s.) together with a simple form of VF dialling (2200 c.p.s.), a comprehensive remote exchange testing system could be installed to work over carrier or radio junction circuits, and if required in the future, could be arranged to operate on trunk circuits. By choosing carefully designed filters and employing hybrid transformers, only one voice channel would be necessary for the entire operation of the Remote Exchange Testing System.

Solid-State System

The System described in the foregoing involves small delays in the overall operation of the test desk due to the time taken for the transfer and check-out of each set of information to and from a distant exchange. Data Transfer Systems employing solid-state circuits and operating at speeds of several hundred bauds have been fully developed and could be applied to remote exchange testing if the increased cost warranted the additional expenditure. The slight delay now experienced by the Testing Officer would, for practical purposes, be eliminated.

Miscellaneous Applications of TELSCAN Equipment

A number of other applications of data transfer equipment of the type described in the foregoing are possible. These include:—

(a) The remote control, supervision, alarm indication and telemetry (by digital coding methods) of all types of power plant at unattended exchanges, repeater stations, carrier terminals, etc.
(b) Route switching together with alarm identification at remotely controlled switching stations forming part of a carrier network.
(c) Remotely operated routine test sequences together with relevant alarm indications and identifications for a remote exchange or repeater station.
(d) Remote reading of traffic data from all sources.
(e) Remote reporting of meteorological data.
(f) Comprehensive operation of public utilities e.g., electric power generation and/or distribution, gas, water, fire alarm systems, sewerage, pumping stations, etc.

CONCLUSION

The application of the TELSCAN data transfer system to remote exchange testing has enabled the efficiency of centralised testing networks to be further increased. Junction resistance limitations no longer exist for practical purposes. Future scope exists in the employment

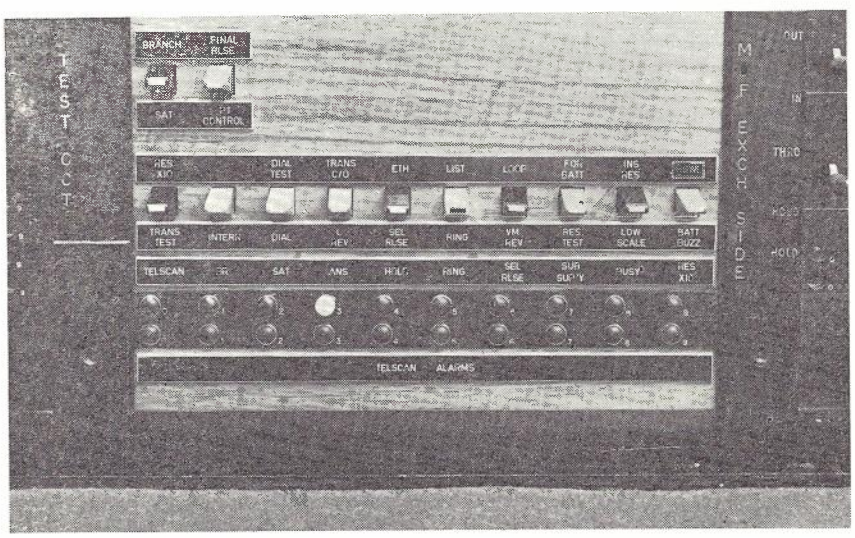

Fig. 12 — Test Desk Position, (Homebush Exchange, N.S.W.).

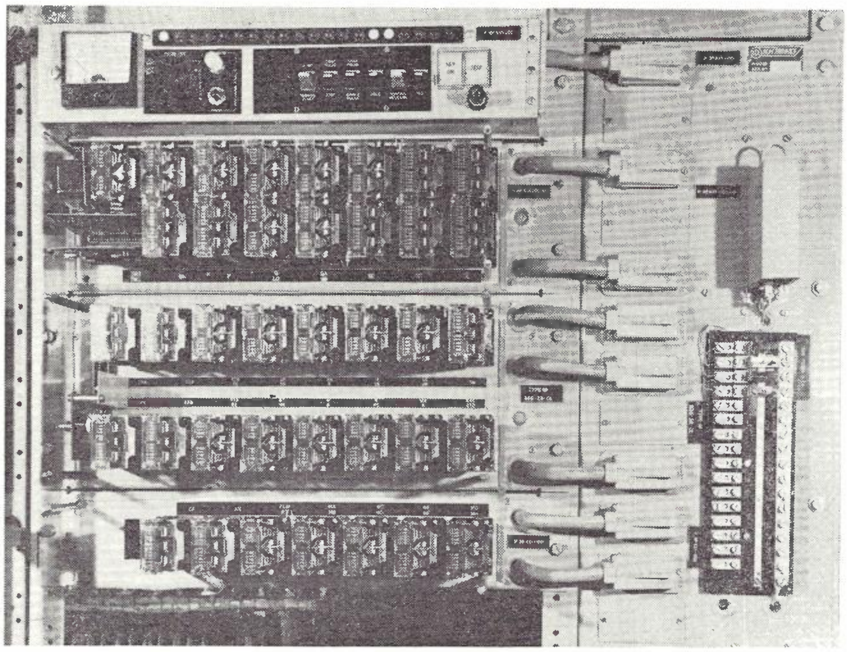

Fig. 13 — M.A.R. Equipment, (Homebush Exchange, N.S.W.).

of V.F. dialling, V.F. telemetry and fully electronic data transfer all of which will ultimately enable testing to be performed over long distance carrier circuits.

While the installation described in the foregoing is being used in step-by-step exchange networks, the concept is equally applicable to crossbar systems.

ACKNOWLEDGMENTS

The assistance of the author's colleague, Mr. D. Jeffs, in the development of the remote exchange testing system and the preparation of this article, is gratefully acknowledged. The permission of the Managing Director, Electric Control and Engineering Limited, N.S.W., for publication of this paper is also gratefully acknowledged.

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TECHNICAL NEWS ITEM

TELECOMMUNICATIONS SYMPOSIUM AT 38th ANZAAS CONGRESS AT HOBART IN AUGUST, 1965

A two-day Symposium on Telecommunications convened by Mr. P. R. Brett, Senior Assistant Director-General in charge of the P.M.G. Research Laboratories, formed part of the programme of the ANZAAS Congress in Hobart in August, 1965. Scientists and engineers from four Universities and the Weapons Research Establishment of the Department of Supply and from the P.M.G. Department presented and discussed papers on the two themes:

Antennas and Propagation, and
Communication Systems Engineering.

The Australian and New Zealand Association for the Advancement of Science (formerly the Australasian Association for the Advancement of Science) held its first meeting in Sydney in 1888, the objects of the Association being:

"To give a stronger and more systematic direction to scientific enquiry, to promote the intercourse of those who cultivate Science in different parts of the British Empire with one another and with foreign philosophers; to obtain a more general attention to the objects of Science and a removal of any disadvantages of a public kind which may impede its progress."

Over the years this objective has been modified and now is:

"The advancement of knowledge and the promotion of a spirit of co-operation between scientific workers and scholars and those in sympathy with science and scholarship generally, especially in Australia and New Zealand".

Meetings are now held at approximately 18 months intervals and provide a meeting ground for scientists and engineers from all over Australia and New Zealand to discuss their work. Activities are divided into 16 Sections each dealing with a separate discipline or group of closely related disciplines. Because of its scientific as well as its engineering implications, the Telecommunications Symposium was classified as of joint interest to Section A, Mathematics, Physics and Astronomy, and Section H, Engineering and Architecture.

The Symposium comprised 15 papers. The opening paper was by Professor A. E. Karbowiak, Professor of Communications at the University of New South Wales who gave a comprehensive discussion of the possibilities and limitations of lasers and optical communication systems — topics on which he is a world authority. Another paper of considerable local interest was contributed by Mr. G. Larsson, Assistant Director, Engineering, P.M.G. Department, Tasmania, whose topic was The Development of the Telecommunications System in Tasmania. Four papers dealt with antennas, six were on propagation topics and three on Departmental communication system engineering. Seven of the papers were contributed by the Department and ranged from work done on antenna development and propagation research to developments in miniaturized 12-channel multiplexing equipment, message switching systems and equipment maintenance techniques.

One of the major advantages of an occasion of this type is that it brings together workers with similar interests from all over Australia; the resulting exchange of ideas and discussion of papers enable them to see their work in perspective alongside related work in other organisations.

All of the papers were of a high standard. The good attendances at all sessions and the calibre of the discussion on each of the papers showed that there is a wide interest in Telecommunications in University and other research circles. It is proposed to organise another similar symposium for the 39th ANZAAS Congress which is to be held at Melbourne University in January, 1967.

AUTOMATISATION OF THE AUSTRALIAN TELEX NETWORK — PART II

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SIGNALLING IN THE NATIONAL SYSTEM

Fig. 10 shows the signalling system used in connecting a calling subscriber (or "A" subscriber) to the required called subscriber (or "B" subscriber), the connection being through two transit exchanges. At the top of the figure the type of connection is drawn and each section lettered, these corresponding to the lettered sections of the signalling system drawn immediately below. A typical call of this type would be a call from a Hobart local subscriber to a Newcastle local subscriber (see Fig. 3). Both the A and the B subscriber connections have been drawn as single current loop signalling circuits, but polar signalling terminals are also available.

The A subscriber calling causes his loop current to rise from 5 mA to 35 mA. The ARB marker group switches the calling line through to a free repeater which calls forward with stop polarity to the distant incoming ARM trunk repeater as shown in Section B. The normal C.C.I.T.T. type "B" trunk signalling sequence, as described in Part 1 of this article, follows. On receipt of the proceed to select signal, the ARB equipment forwards over the trunk to the first ARM, the start/stop code corresponding to the A subscriber's tariff zone (the T character) and the start/stop code corresponding to the A subscriber's classification (K character). Immediately following this, the ARB equipment signals into the A subscriber's loop (section A of signalling diagram) the printed service code "GA" as an indication to the subscriber that he should send the selection information from his keyboard.

The subscriber then sends the selection information from his keyboard preceding this information with the register opening code combination "Figures Shift". All national subscriber numbers are five digit so that no end of selection signal is needed or used. (Service positions, printergram, test positions have three digit numbers but in all cases the first digit is 0 so that the register is able to recognise whether selection finishes at the third or fifth digit). This information is received in the parent ARM exchange and, together with the T and K characters forwarded earlier, is used to determine the appropriate rate for the particular call. As the rate information is returned from the parent ARM to the ARB exchange in start/stop five unit code, a telegraph code receiver (KMT) is first called in by a 25 mS KMT seizure pulse on the backward path. The connection of the KMT at the ARB exchange is acknowledged on the forward path by a 40 mS start polarity pulse, following which the start/stop code (Z character) indicating the tariff to be set up is signalled on the backward path preceded by a short interval of steady stop polarity. Although the rate to be set up is now known in the ARB exchange, the rate lead is not yet connected through to the subscriber's metering wire.

From the selection information sent into it, the parent ARM recognises that the required route is to a second ARM exchange and calls forward (on the C section) in the normal type "B" mode. The complete selection information as well as the classification information is then sent forward to the second ARM exchange. This exchange recognises from the incoming trunk that the call is from a transit exchange, not from one of its own ARB terminals and that the tariff function is therefore not appropriate. It also recognises from the selection information that the call is to an ARB exchange trunked off it and this exchange therefore requires only the last three digits of the B subscriber's number and the originating subscriber's K character.

The second ARM therefore calls the terminating ARB in the usual way (Section D), the "proceed to select" signal from this ARB indicating that a telegraph code receiver KMT is connected in order to receive digits in start/stop five unit code. This information, together with the classification character, is then sent and the terminating ARB marker tests the called subscriber's line and switches through if the line is free. The calling condition on the subscriber's line (Section E) causes the subscriber's machine to be switched on with an approximate ½ second delay while the motor runs up to speed, when a loop current of 40 mA is established. This current condition is recognised in the ARB exchange which now reverts stop polarity on the backward path. This stop polarity condition, the call connected signal, is repeated section by section back to the originating ARB exchange.

Since in a telex call the receiving or B subscriber's machine operates unattended (its motor being started automatically when line connection is established) C.C.I.T.T. recommends a verification signalling procedure. For this reason, each machine is fitted with a special signal sending device known as an "answer-back" unit. The 20 character signal sequence sent under the control of the answer-back unit may be tripped from the distant end of the circuit upon transmission of the code combinations "Figures Shift D". Receipt of the "call-connected" signal at the originating ARB exchange is used to initiate a "Figure Shift D" signal forward. Upon receipt of this signal the B subscriber's "answer-back" is reverted and is transmitted through the repeater at the originating ARB exchange to the calling subscriber's line circuit. Thus the calling subscriber receives the answer-back of the B subscriber immediately below the printing of his selection information. In the Australian system the 20 characters are arranged to include the called subscriber's number, e.g., a typical answer-back would print as follows, BRITUBE AA82214.

The call connected signal is also used to control the commencement of metering. However, through connection of the chosen rate lead to the subscriber metering wire is delayed for a period which may vary between 5 and 10 seconds. This "free" period is given so that the A subscriber may check the answer-back received and clear if the connected subscriber is not the wanted subscriber.

Clearing may be initiated by either party but in Fig. 10 the usual case is shown in which the A subscriber initiates the clearing action. In the Australian system the clear condition of start polarity is acted upon after it persists for 800 mS.

In a complete system description there are a number of signalling conditions other than the one considered. These may be categorised as:—

(a) Subscriber calls which encounter a congestion or fault condition.
(b) Subscriber calls which encounter a transit or terminating classification restriction.
(c) Calls to and from service positions. This general title covers manual assistance, enquiry, directory information, printergram and test equipment ARM connections of various kinds.
(d) Originating and terminating international calls. Because these calls are an important proportion of total calls some details are given below.

Inter-Operation with the International System

The Australian national network connects to the international system via a single international gateway, the international telex centre operated by the Overseas Telecommunications Commission (Australia) at Sydney. The main features of this exchange may be described in a later article but the interconnection conditions are of immediate interest. Australian subscriber making an outward call semi-automatically (or eventually fully automatically) will make the connection in two stages. The first stage will be similar to a national subscriber-to-subscriber call except that a three figure number commencing with 0 will be sent, e.g., 022. In this stage con-

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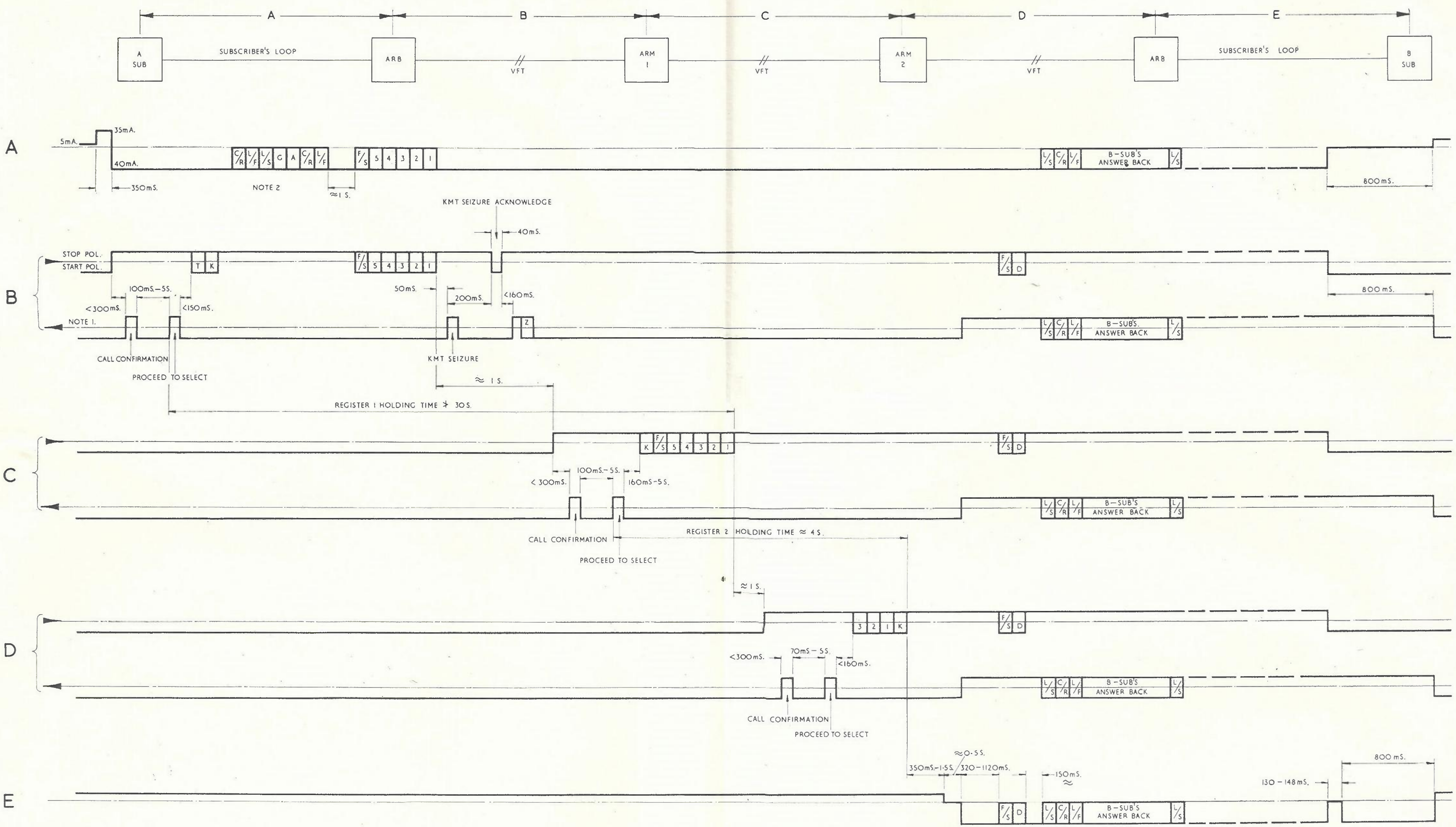
* Mr. McKinnon is Engineer Class 4, Telegraphs, Headquarters. See Vol. 14, No. 11, Page 169.

** Mr. Crane is Engineer Class 3, Telegraphs, Headquarters. See Page 247.

*** Mr. Krol is Engineer Class 2, Telegraphs, Headquarters. See Page 247.



NOTES:- 1. THE WAITING TIME FOR CALL CONFIRMATION ALLOWS FOR MAXIMUM LOOP DELAY TIME, NOT INCLUDED IN OTHER FIGURES.

2. | G | A | GO AHEAD SERVICE SIGNAL.

| T | SIGNAL CODE CORRESPONDING TO A SUBS. ORIGIN TARIFF ZONE.

| K | SIGNAL CODE CORRESPONDING TO A SUBS. CATEGORY.

| Z | SIGNAL CODE FOR DETERMINATION OF RATE, IF Z– CODE MEANS NO RATE THIS ALSO PREVENTS F/S D-SIGNAL BEING SENT FORWARD.
T, K, & THEN GA SIGNALS ARE SENT FROM SPECIAL RELAY SET ZR.

ESTABLISHMENT OF EFFECTIVE CALL OVER 2 TRANSIT EXCHANGES

Fig. 10.

nection is made to the international exchange, which either under manual control or automatically, depending upon the route, will return a printing service code identification followed by a "Figures Shift D" signal to trip the calling subscriber's answer-back for ticketing identification purposes.

Following receipt of the calling subscriber's answer-back, the GA service code will be sent backward from the international exchange as an indication to the subscriber that he may now key the international selection information. Answer-back is obtained automatically from the B subscriber either from the distant international system or by "Figures Shift D" being forwarded from the Sydney international exchange, depending upon the characteristics of the distant national system. From the selection information the Australian national system is able to recognise that no meter rate should be set up for the call and that "Figures Shift D" should not be forwarded when the "call connected" signal is received. For charging purposes all outward international calls are toll-ticketed at the international exchange.

For international inward calls, the international exchange is treated as though it is a service position connection and 5 digit selection information preceded by "Figures Shift" is fed into the national exchange register to set up the call in the usual way.

SUBSCRIBERS TERMINAL EQUIPMENT

Two basic types of subscriber terminal unit are used with the Siemens and Halske T typ 100 telex page printer. The most commonly used is that based on single current loop signalling conditions. The essential features of the circuit are shown in Fig. 11.

In the idle circuit condition a 5 mA current keeps the B relay operated, and the motor therefore switched off. The subscriber calls by operating his call key (part of the M.100 machine) allowing the A relay in his terminal unit to operate and hold. The exchange switching process, having recognised the call by operation of LR, switches through to a free repeater. This reverses the polarity conditions to the subscriber's loop thereby allowing terminal unit B relay to release and the motor to start. A relay continues to hold until the motor runs up to speed when its centrifugally operated contacts OS close and short circuit relay A. (BR relay in the exchange termination operates when the call is switched through removing LR from the line circuit. The switching process is described in a later section).

When a terminating call is switched through, BR relay is operated and the reverse polarity sense as compared with the idle loop condition is connected from the terminating repeater. The B relay releases and the motor starts so that via OS a 40 mA loop is established.

The second basic type of termination uses two path polar signalling and approximately 20% of terminations are of this type. These are used where subscribers are located some distance from the exchange and a 40 mA loop condition cannot be obtained with the cable circuits available. These terminals are also used in country areas where there is no exchange and subscribers are directly connected over a voice frequency telegraph link to a metropolitan exchange.

Both basic types of terminal unit have versions which allow "local run" operation for the off-line preparation of perforated tape for subsequent line transmission through an automatic tape transmitter. The T typ 100 page printer design makes provision for convenient reperforator and automatic tape transmitter attachments and these facilities are more freely used in the Australian telex network than in European networks. Should an incoming call occur during "local run" tape preparation, in accordance with a C.C.I.T.T. recommendation, the machine is automatically brought on line within three seconds during which time an audible and visual alarm is given to the operator to enable partly prepared tapes to be cleared.

The terminal unit for single current

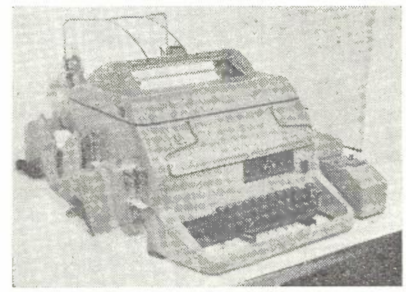


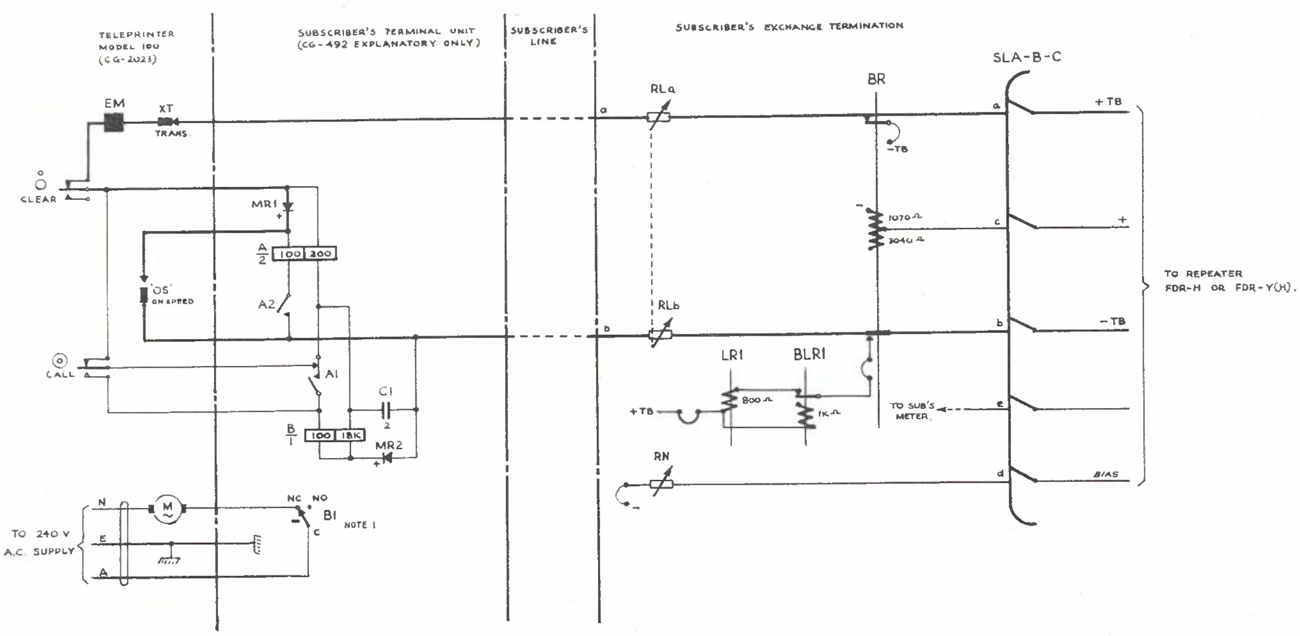
Fig. 12 — Model 100 with Terminal Unit.

working without "local run" fits under the teleprinter cover ("Call" and "Clear" Keys are part of the teleprinter itself). The versions with "local run" tape preparation facilities are an external attachment to the rear of the machine. Fig. 12 illustrates a typical subscriber's terminal of this type.

THE ARB111 TELEX TERMINAL EXCHANGE

Fig. 13 is a block schematic of the 400 line ARB111 telex terminal exchange. (For the basic trunking see Fig. 7).

The SLA-LR equipment provides connection capacity for 400 subscribers in five BDH type racks each mounting 8 SLA-LR relay sets, each relay set mounting one SLA switch and LR/BR/BLR relays for 10 circuits. Two MIR-A relay



NOTES: 1. 'B1' SHOWN RELEASED — NORMALLY OPERATED IN THE 'IDLE-CLEAR' CONDITION.

Fig. 11 — Single Current Subscriber Line Circuit.

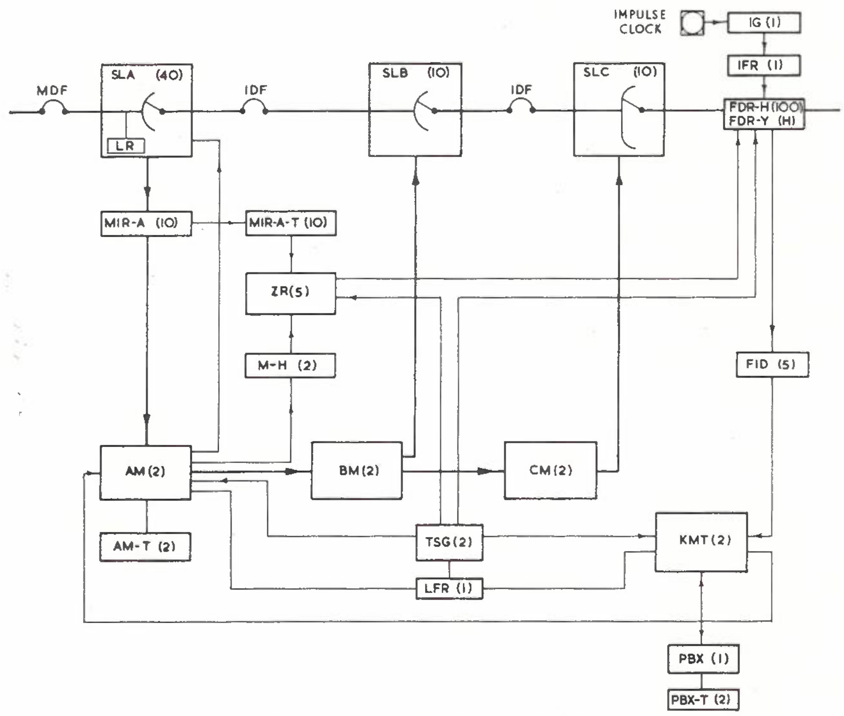


Fig. 13 — Block Schematic ARB 111.

sets mount on the SLA rack, each MIR-A handling 40 subscriber lines and extending calls from subscribers to the A-marker. The A marker calls for one of five free code sending relay set, ZR, via an associated marker auxiliary relay set, M-H. When an outgoing repeater has been selected through the marker group and a "proceed to select" signal has been received (as described earlier) the connected ZR relay set sends the appropriate T and K start stop characters forward and the GA signal backward to the calling subscriber, obtaining its basic timing from a TSG.

The A markers, telegraph code receivers, KMT, and telegraph signalling generators, TSG, alarm relay set, LFR, and PBX relay sets mount on a single BDH rack. As well as mounting 10 switches each the SLB and SLC racks also mount their associated markers. Thus for each 400 line ARB group there are 7 switching racks, (5 SLA, 1 SLB, 1 SLC) and 2 common equipment racks. An alternative grouping arrangement not used in the Australian Post Office system allows an additional SLB and SLC rack, catering for heavier traffic conditions.

Terminating calls via repeaters FDR-H seize one of the two KMT's provided via connecting relay set FID mounted on the FDR rack. Provision is made in these relay sets for up to 5 KMT's but only two are provided per 400 line block in the Australian system. Some exchanges, such as Newcastle, are connected to their parent ARM over voice frequency telegraph trunks and in this case the terminating repeater is coded FDR-Y(H). The code receiver in the KMT circuit receives and stores the selection information transferring this information, (or modified information as a result of PBX interrogation) to the marker group which proceeds to switch the call. A PBX relay set provides for six groups, each having up to six lines and, via each of the two PBX-T relay sets, for a further 12 groups of up to six lines. Thus a total PBX capacity of 30 groups with a maximum of 180 lines is provided.

Outgoing Call from ARB111 type Telex Terminal Exchange

A telex call is originated when a subscriber operates a push-button key on his teleprinter thus increasing the loop current from 5 mA to 35 mA. A simplified survey diagram, Fig. 14, shows the main circuit elements of the ARB type exchange and Fig. 15 shows the sequence of circuit operation.

When the loop current increases to 35 mA the line relay, LR, operates. Relay LR closes the operating path to one of the AN relays in AM which identifies the 40 line group in which the calling subscriber is located. Supposing this is the first 40 line group, then relay AN1 operates from negative over a break of AV, make LR, break MA to earth behind AN1. Group relay ANA operates and extends earth from the AN call distributor to relay MA in the MIR-A for the 40 line group of the calling subscriber. Relay MA operates and extends the operating condition for the B and A relays in the 4 x 10 identifier in the A-marker. Supposing that the tens digit belongs to group one then relay B1 operates and supposing that the units digit is also one then relay A1 operates.

When relays A1 and B1 in AM have operated the identification of the calling subscriber is completed and the number is then transferred to the connected MIR-A and its associated MIR-A-T, where corresponding relays D1 and U1 operate. Horizontals HA and H1 in SLA stage now operate secondarily to relays D1 and U1 in MIR-A. Over a contact combination of the D and U relays and a rectifier connection in MIR-A, the calling subscriber's category, K, is transferred to the ZR relay set where it is stored on X and Y relays. Similarly over the contact combination of the D and U relays and a rectifier connection in MIR-A-T the calling subscriber's tariff zone, T, is transferred to the ZR relay set where it is stored on relays S and B.

While the calling subscriber's number is being identified by the marker, AM, earth is extended by ANA to operate relay WH in the C-marker. Relay WH extends connections from idle repeaters to operate ZQ relays in BM. Operated ZQ relays provide paths for by-path testing through the switching stages SLA, SLB and SLC. By-path testing starts with relays F1-20 in AM being operated via idle vertical contacts in SLA, ZQ contacts, idle vertical contacts in SLB to earth. Each operated F relay represents one idle path. However only one idle path and its corresponding F relay are selected and the other F relay released.

Following the operation of the F relay a vertical in SLA operates and relay M1 in SLB also operates and as a result H1 (corresponding to F1) operates. At the same time HA in SLB also operates. Relays Q1-10 in BM which mark idle verticals in SLB operate secondarily to M1 from earth extended over idle vertical contacts, break VK, make M1 to negative behind Q. Only one Q relay is selected, the other Q relays being released. Relay VK in SLB operates secondarily to the selection of Q and closes the operating path for the vertical V1 in SLB from negative over make HV in BM, make Q, make M1, make VK to earth behind vertical magnet V1.

In SLC relay M1 operates after the selection of a relay Q in BM and extends the operating paths to horizontals in SLC and to relays Q1-20 in CM which correspond to idle repeaters. Horizontal HA operates from negative over make of Q in BM and M1 in SLC. Horizontal H1 operates from negative over a make of F1 in AM and M1 in SLC. Relays Q1-Q20 in CM operate from earth on the idle repeaters, idle vertical contacts V in SLC, break VK, make M1 to negative behind Q. Only one Q relay is selected. Relay VK in SLC operates and extends the operating path to the selected vertical magnet which operates in parallel with the occupation relay BL of the repeater.

ZQ and Q relays in ZR are controlled by the selected Q relays in the BM and CM so that ZQ and Q form an identifying grid for the selected repeater.

Relay BL in FDR connects relay R1 to the c-wire which is connected to relay BR in SLA and both relays operate in series. The c-wire now provides a holding circuit for verticals in SLA and SLB, the vertical in SLC obtaining a hold direct from the repeater. Earth on the c-wire also initiates release of the markers. The subscriber's line wires are

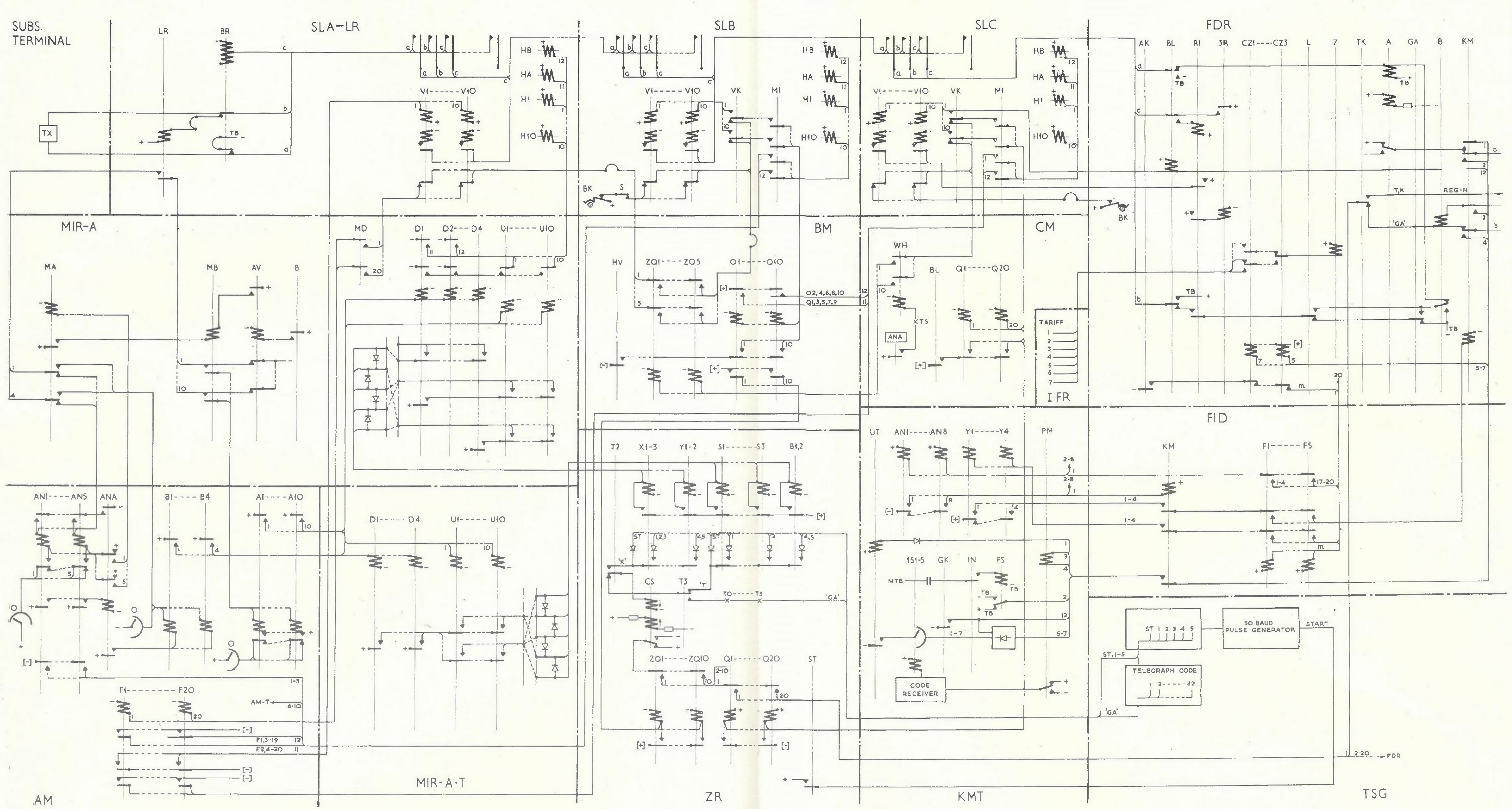


Fig. 14 — Simplified Survey Diagram ARB 111.

now through connected via the a and b wires of SLA, SLB and SLC stages to the repeater where negative is connected to wire a and positive to wire b via contacts of the BL relay. The repeater becomes connected to a free register. The register sends a "proceed to select" signal to the repeater on the b-wire of RS. The B relay responds to this signal and, as a result relay TK in the FDR and relay ST in ZR operate. The TSG generates the signal elements which allow ZR to transmit the T character (via the S1-3, B1-2 contact) and then the K character (via the X1-3, Y1-2 contacts) to the register.

The release of the C marker had released relay BL in the repeater and the condition in the subscriber's loop was reversed. On reversal of the loop current the teleprinter motor runs up to speed and under the control of signals from ZR the machine prints the service signal, "GA" and the subscriber now sends the required number to the register.

When the register has received all the routing information it calls the route marker for determination of route and tariff. When the route marker has advised the register of the tariff character to be sent, the register calls KMT with a 25 mS stop polarity pulse on the b-wire. The B relay in FDR receives this signal and AK relay operates. In this way negative is extended on the m-wire to FID where one of the F relays operates. Now negative on m is extended via an F contact to operate one of the AN1-8 relays which identifies the calling FID. AN relay operates the KM relay in FID and relay KM connects the m-wire to one of the Y1-4 relays in KMT which now completes identification of the calling repeater. When the repeater has been identified relay KM in the repeater is operated and the repeater is through-connected to KMT. The KMT transmits start-stop code combination 22 (start polarity of 40 mS) to the register as an acknowledgement signal and the register then returns the tariff character which is received by the telegraph start-stop code receiver via PM relay and is stored on 1S1-5 relays. Over a combination of 1S1-5 contacts negative from UT contact is connected via the rectifier field to operate one or more CZ1-3 relays in FDR. The CZ relays connect the required tariff lead to relay Z which drives the subscribers meter. In operating, relays CZ break the connection to the m-wire and KMT releases.

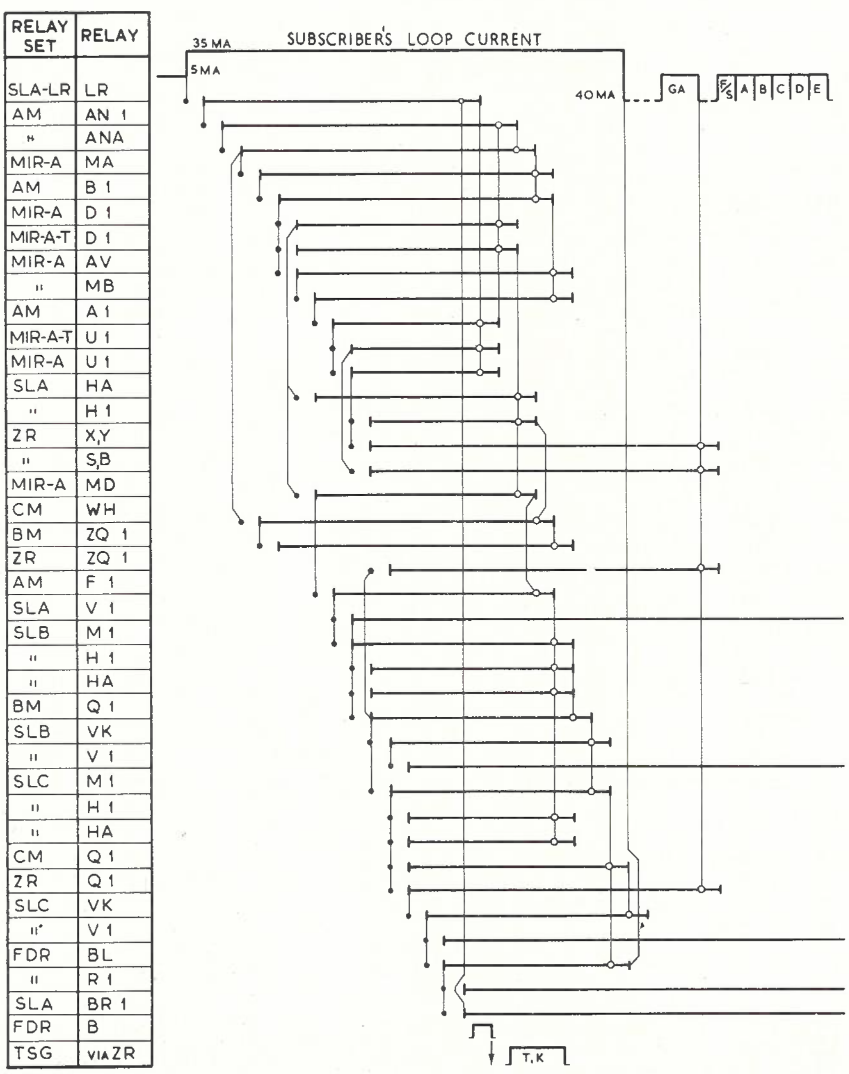


Fig. 15 — Operational Sequence Diagram.

Incoming Call to ARB 111 Exchange

When the FDR (repeater) has been seized from the ARM transit exchange steady stop is received by polar relay B. This results in negative being connected to wire-m and the FID relay set is seized. Relay F in FID operates and extends negative on wire-m to KMT which is seized and connected to the FDR in the same manner as described for an outgoing call.

In KMT relay IN operates and connects a capacitor to a coil of the sending relay, PS and while the capacitor is being charged PS transmits stop polarity (and thus a "proceed to select" pulse) to the register over the a-wire. The register then sends the last three digits of the called subscriber's number and the originating subscriber's K character to KMT where they are received by the code receiver as described later in dealing with the principle of the start stop telegraph code receiver.

The digit information is translated in KMT and the A marker is informed in which 40 line group the called subscriber is located. Identification of the 40 line group allows seizure of the corresponding 40 line MIR-A group. The tens and units digits stored in KMT control the B, A identifier in the A marker and subsequently the corresponding D and U relays in MIR-A operate.

The by-path testing and operation of horizontals and verticals in SLA and SLB stages takes place in the same manner as for the outgoing call.

When relays D and U in MIR-A operate the called subscriber's category is transferred to KMT for comparison with the calling subscriber's category. If the categories are compatible the connection proceeds, but is prevented if incompatible. At this time a test is being carried out by the marker on the c-wire to check whether the called subscriber is free. In this test the polar relay, PL, in the marker is connected to the c-wire after relay TF2 operates (at the beginning of the by-path testing), as shown in Fig. 17. When the subscriber is free, there is –50 volts potential on the c-wire and relay PL does not operate. Relay TK1 then releases and connects the c-wire to relay WRU. Relay WRU operates and extends negative from a TF2 contact to relay GK in KMT over break TK2, make WRU, break ABS, make M in KMT. Relay GK operates and connects negative to wire 12, thus operating relay BL in FDR in parallel with the vertical V in SLC. Relay GK also provides for the operation of relay CZ2 in the FDR. Relay CZ2 operates and initiates the release of KMT, and the marker group.

When vertical V in SLC operates the c-wire is extended from the relay BR in SLA to relay R1 in the FDR. Relays BR and R1 operate in series. The subscriber's line is now through connected to the FDR but as for an outgoing call the loop is not reversed until BL releases after the release of the markers. Supervision circuits in the repeater wait for the subscriber's machine to come on line and run up to speed. When this has been achieved relay A is driven to the stop polarity condition. Communication may now proceed.

Principle of the Start-Stop Telegraph Code Receiver

In the Australian telex system information transfer is by start-stop telegraph signals. Certain relay sets must therefore be able to receive and send start-stop telegraph signals as for example the register and relay set KMT. A simplified circuit of the start-stop telegraph code receiver used in the KMT is shown in Fig. 16.

The code receiver used consists of a pulse generator, a bi-stable polarised relay CB3, connecting relays CS1-5, receiving relays CP1-5 and the storing relays 1S1-5 for the hundreds digit, 2S1-5 for the tens digit and 3S1-5 for the units digit. As a start-stop telegraph device, the code receiver is started when the start element of the five unit code signal arrives and triggers the pulse generator. Of the pulses generated only the short negative pulses at 20mS intervals are used, the first of these being arranged to occur 10mS after the commencement of the start element. The first pulse drives the tongue of the polarised relay CB3 to contact 5 where it remains until the next pulse. Relay CS1 which is a normal speed relay operates from negative battery connected over make H, CB3 and break contacts CS4 and CS2. The second pulse is applied to relay CP1 which is an extremely fast reed relay via make CS1 while the first element of the incoming signal is being applied to the CP1 relay over the receive lead. If the element is of start polarity relay CP1 will operate and will lock itself. If the element is stop polarity relay CP1 will not operate. The second pulse also drives relay CB3 to contact 1 thus causing relay CS2 to operate from negative connected over make H, CB3, break CS3 and make CS1. The third pulse is applied to relay CP2 via make CS2 and tests whether the second signal element is stop or start polarity. This process continues until all five signal elements are tested. When the stop element arrives the pulse generator is stopped.

The received digit is stored on 1S1-5 relays which operate secondarily to the corresponding CP1-5 relays via RV2 contacts. The 1S1-5 contacts provide a path which connects earth from PA to the required digit lead. The other two digits are received in the same manner and stored on 2S1-5 relays via RV2 operated and 3S1-5 relays via RV3 operated.

Printed Service Code Supervision

One of the features of the Australian telex system is the use of printing service code supervision to inform the subscriber of the progress of his call or request the subscriber to proceed with the next setting up action such as keyboard selection. It is not possible to fully describe all service code injection processes and three have therefore been chosen for description below. The first describes special marking of a subscriber line, the second the automatic advice to a subscriber of a fault condition, the third the frequently met "called subscriber busy" condition.

ABS Facility: The ABS facility is provided for subscribers who temporarily close down their offices over holiday breaks, etc. In such cases a strapping is provided between A contacts in the marker and D contacts in MIR-A, to operate relay ABS which controls the transmission of a service code ABS.

When a call is received for a subscriber who is "absent' the last three digits of the number are received by the KMT which transfers them to the marker in the usual manner. The marker now identifies the MIR-A group and transfers the tens and units digits to the D and U relays of that MIR-A. As shown in Fig. 17 a path from earth over make TF2, make 1MD1, make D, the strap, make A, make TF2, break TK1 operates the ABS relay.

When the digits were transferred to the marker relay AB operated and connected earth to relay TF2 which operated. Relay ABS operates secondarily to the TF2 relay which breaks the operating circuit to relay TK1. When relay TK1 releases, a circuit is closed for relay WRU from negative battery on c-wire over make TF2 break TK1 and break DER to earth behind WRU.

With relay WRU and ABS operated a circuit is obtained to relays CZ in the repeater from negative battery over make TF2, break TK2, make WRU, make ABS, make M in KMT, the rectifier connection, make KM in FID to earth behind the CZ relays. The CZ relays provide a connection between the ABS lead in TSG and the C signalling relay which transmits the ABS signal on the a-wire to the calling subscriber.

DER Facility: When a call is received for a subscriber whose line is blocked a service code DER is sent back to the calling subscriber. The last three digits of the called number are received in KMT and transferred to the marker. Relay TF2 operates and connects the testing polar relay PL to the c-wire via make TK1. Because the blocking relay BLR is now operated the potential on the c-wire is not –50 volts but –37 volts. Relay PL operates causing relay DER to operate.

When relay TK1 releases the PL relay also releases, but relay DER locks itself in. An operating path is now established to relays CZ in FDR from negative behind TF2 through a DER contact operated to earth behind the CZ relays. A service code DER is transmitted from the TSG over CZ contact path to the C signalling relay which repeats it to the distant subscriber on the a-wire.

There are other possible "DER" signalling conditions in repeaters, and the condition here described is only one of the "DER" injection circuits.

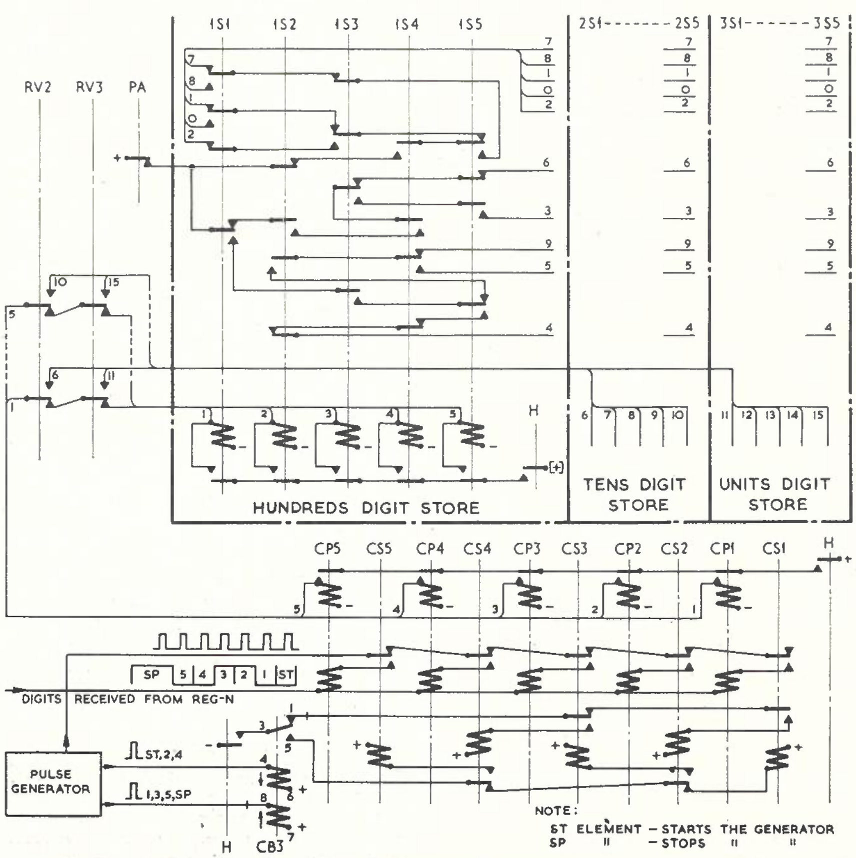


Fig. 16 — Code Receiver Principle.

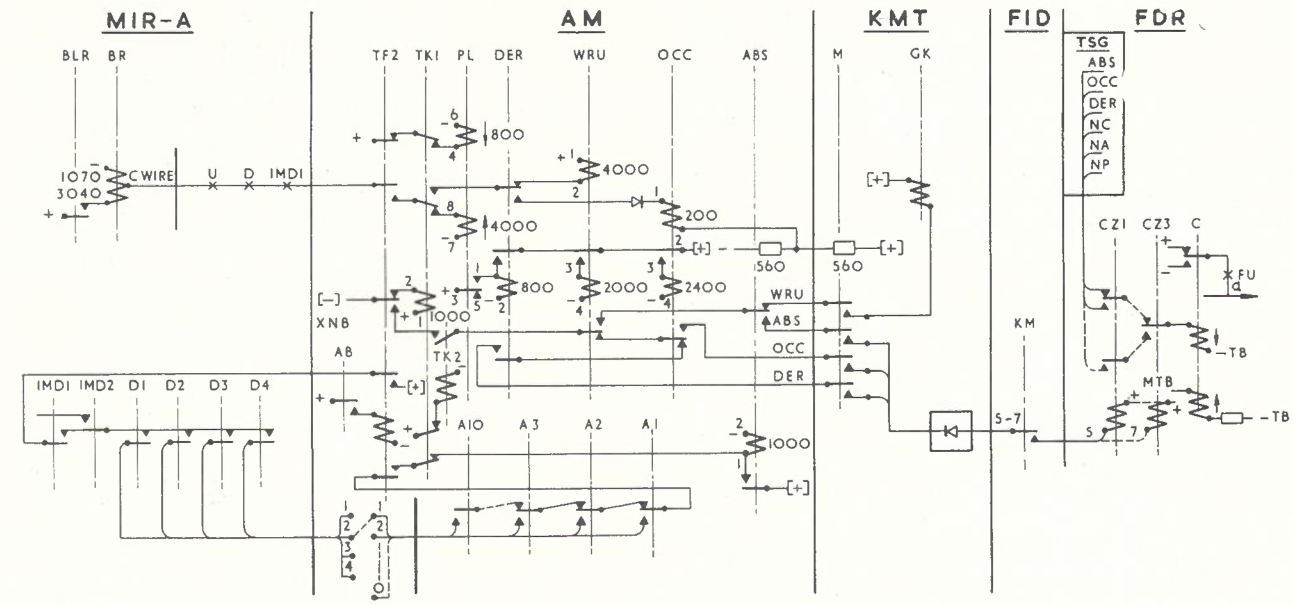


Fig. 17 — Printed Service Code Operation.

OCC Facility: When a called subscriber is busy a service code OCC is sent back to the calling subscriber. As before the last three digits are received in KMT and transferred to the marker.

Relay TF2 operates and connects the testing polar relay **PL** to the c-wire via make TK1. A busy line has earth potential on the c-wire. Relay PL operates causing relay DER to operate. Relay DER connects relay OCC to wire c via break TK1 and make TF2. Relay OCC now operates from earth on the c-wire via rectifier to –25 volts behind OCC from the voltage divider. A circuit to operate relays CZ in FDR is obtained from negative extended over make TF2 and make OCC. A service code OCC is fed from TSG via contacts CZ to the signalling relay C which transmits it to the calling subscriber on the a-wire.

ARM 20 TRANSIT EXCHANGES

General Principles

System ARM 201 consists of group selector stages. Crossbar switches set up the connections which may be through a single or two group selector stages. The system employs the bypath principle and switches are operated under the control of markers (11).

In system ARM 201 each group selector stage consists of two partial stages, GDA and GDB, which are interconnected by means of links (Fig. 18). The

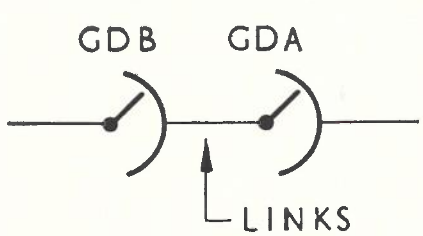


Fig. 18 — Group Selector Stage ARM 201 Consisting of Two Partial Stages GDA and GDB.

lines terminate on the GDA multiple, and the GDB verticals in the various group selector stages are interconnected by links. Thus a connection between two lines terminating on the GDA multiples pass through four partial stages GDA — GDB — GDB — GDA, as shown in Fig. 19.

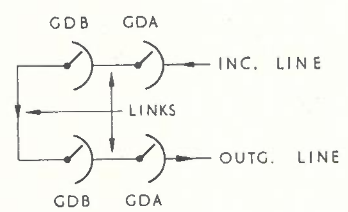


Fig. 19 — Connection through Four Partial Stages.

The group selector stage is made up of units, which may have 200 GDA verticals and 300 GDB verticals (Fig. 20) when installed to full capacity. The two partial stages GDA and GDB can be built up in steps of 100 verticals and

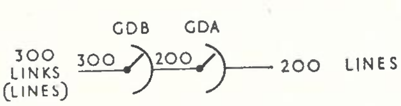


Fig. 20 — Group Selector Stage Unit ARM 201 for 200 lines.

the GDA — GDB arrangement of verticals may be 100-100, 100-200, 200-200 or 200-300. The unit is called a 100-group or 200-group according to the number of GDA verticals and will correspondingly have 100 or 200 lines connected to its GDA multiple.

If the lines are to be used for two-way traffic, the group selector stage must be designed for switching in both directions and is then called GD. A GD unit can therefore accommodate incoming, outgoing and two-way circuits. A selector stage for incoming traffic alone is called GI (partial stages GIA and GIB), and for outgoing traffic alone GU (partial stages GUA and GUB). Two way selector stages are used in A.P.O. telex exchanges.

Lines to and from other transit exchanges, lines to and from dependent terminal telex exchanges and from the telex service centre are terminated on the GDA multiple. GDB is used for links to GDB in all other groups; these links carry the inter-group traffic. A number of GDB verticals are connected to other GDB verticals in the same unit for switching traffic between lines terminating on the GDA multiple of that unit. GDB verticals may also be used to terminate outgoing lines to a local exchange but this is not used in telex because of other limitations (Fig. 21).

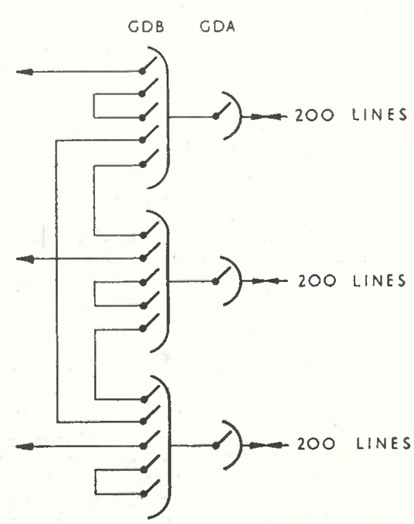


Fig. 21 — Three Group Selector Stage Units for Two-Way Traffic.

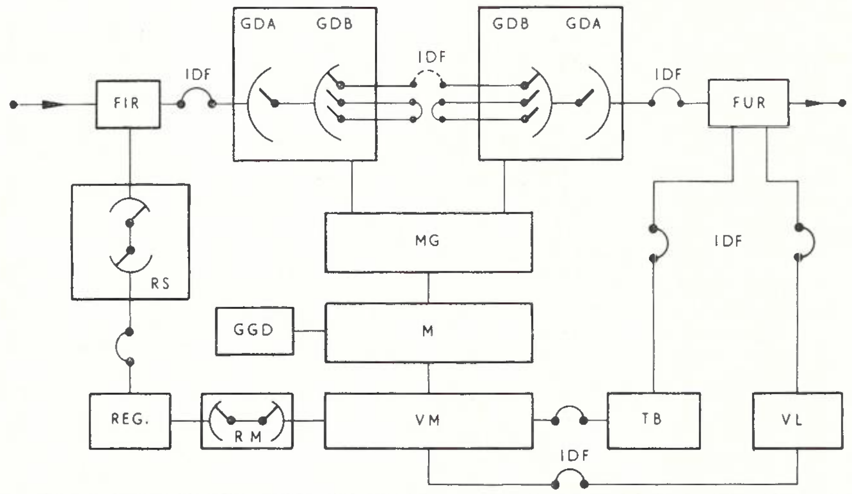


Fig. 22 — Block Schematic of Telex Transit Exchange with Group Selector Stage ARM 201.

Switching Procedure

The block schematic in Fig. 22 shows in a simplified form the equipment employed in setting up a connection through the selector stage. On a call incoming from a line (assumed to be from a terminal exchange) the associated repeater, FDR (acting as FIR) is connected to a free register, REG, via a register finder, RS. An indication of the origin of the line is sent from FDR to REG and stored there.

The register will subsequently receive the calling subscriber's T and K characters and these will be followed by the numerical information transmitted from the subscriber's keyboard. Upon receipt of the routing digits, REG calls and seizes a free route marker, VM, via connecting relays, RM. The VM identifies the number of the group selector unit accommodating the line connected to the register.

The T and K characters and the routing digits are transferred from REG to VM. A maximum of four routing digits may be transferred from REG. The numerical information generated by a subscriber may consist of a maximum of five digits referred to as the A, B, C, D, and E digits, and of these A, B, C, and D may affect routing.

The route and tariff are determined by contacts on the associated reception relays in VM. The tariff is determined by analysis of T, K, A and B and is stored in VM. The route is determined by A, B, C and D although T and K may, as discussed later, be used to impose certain limitations of choice. The tariff information is returned to the calling repeater and a circuit is then closed for the route relay corresponding to the routing information received.

The outgoing repeaters, FDR (acting as FUR), associated with the line in the required route, are connected to test blocks, TB. The lines in a route may be divided between three test blocks at most. For the lines in a route part connected to a particular test block there is a route-free indicating relay, VL, which is operated if any line in that particular group of lines is free.

The route relay in VM connects the marking wires from the corresponding operated VL's so that VM receives an indication of test blocks in which there exist free lines in the required route. VM now selects one of the free test blocks timing out if none becomes available within a preset period. Information about the route is passed to TB which now examines the lines in the route and selects a free line. VM is then informed of the group selector unit to which the selected outgoing line is connected.

VM now selects a free marker, M, and passes to it information of the group selector units in which the incoming and outgoing lines are situated. Before the switching path can be determined, the marker must check whether any other marker is engaged in either of the two selector units. This check is made by GGD. Having established that no switching is in progress in either unit, the marker obtains access to the units via MG, which connects test and control wires between the marker and selector units.

In the incoming selector unit the horizontal magnet for the incoming line is operated. With the aid of test chains the marker selects a free path from the incoming to the outgoing line and the corresponding horizontal and vertical magnets operate. The connection is now established through four partial stages and a circuit is closed from the outgoing line relay set through the selectors to the incoming line relay set. The marker and route marker release and are free to handle fresh calls. The register remains in circuit if it is to control the subsequent switching process. Only the incoming FDR, the outgoing FDR and verticals in the four partial stages GDA—GDB—GDB—GDA remain occupied during the call.

Capacity of Exchange

Fig. 23 shows the inter-working possibilities of ARM 201 equipment being installed although the maximum figures shown will not, of course, be provided initially. Fig. 23 is capable of further extension so that 20 GD stages are provided for rather than 5. This means that the fully extended exchange has a limitation of 4,000 lines which adequately provides for a predicted maximum 1980 requirement for the largest telex centre of a little over 2,000 lines.

Arrangement and Function of Equipment

Fig. 24 shows a detailed block diagram of a telex transit exchange. The arrangement and function of various units of equipment are described in the following sections.

Line Repeaters, FDR: The lines connected to the transit exchange are of different types, and each has its own repeater. The various types of repeater and their application are as follows:—

- FDR-Y terminate inter-transit exchange trunks and also terminate trunks between a parent transit exchange and a remote telex terminal exchange.
- FDR-H terminate the junction between a parent transit exchange and an adjacent terminal telex exchange.
- FDR-S terminate circuits to telex printergram positions.
- FDR-M terminate circuits to the Telex Service Centre.

Register Finders, RS: A register finder is used to provide access between re-

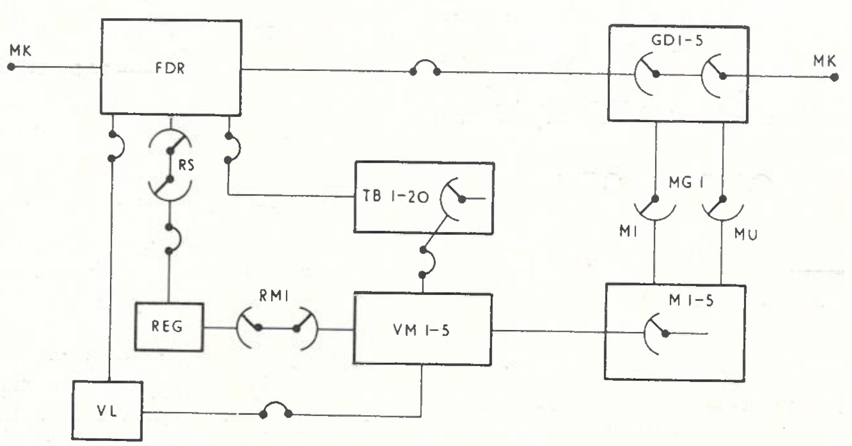


Fig. 23 — Automatic Telex Transit Exchange Block Diagram.

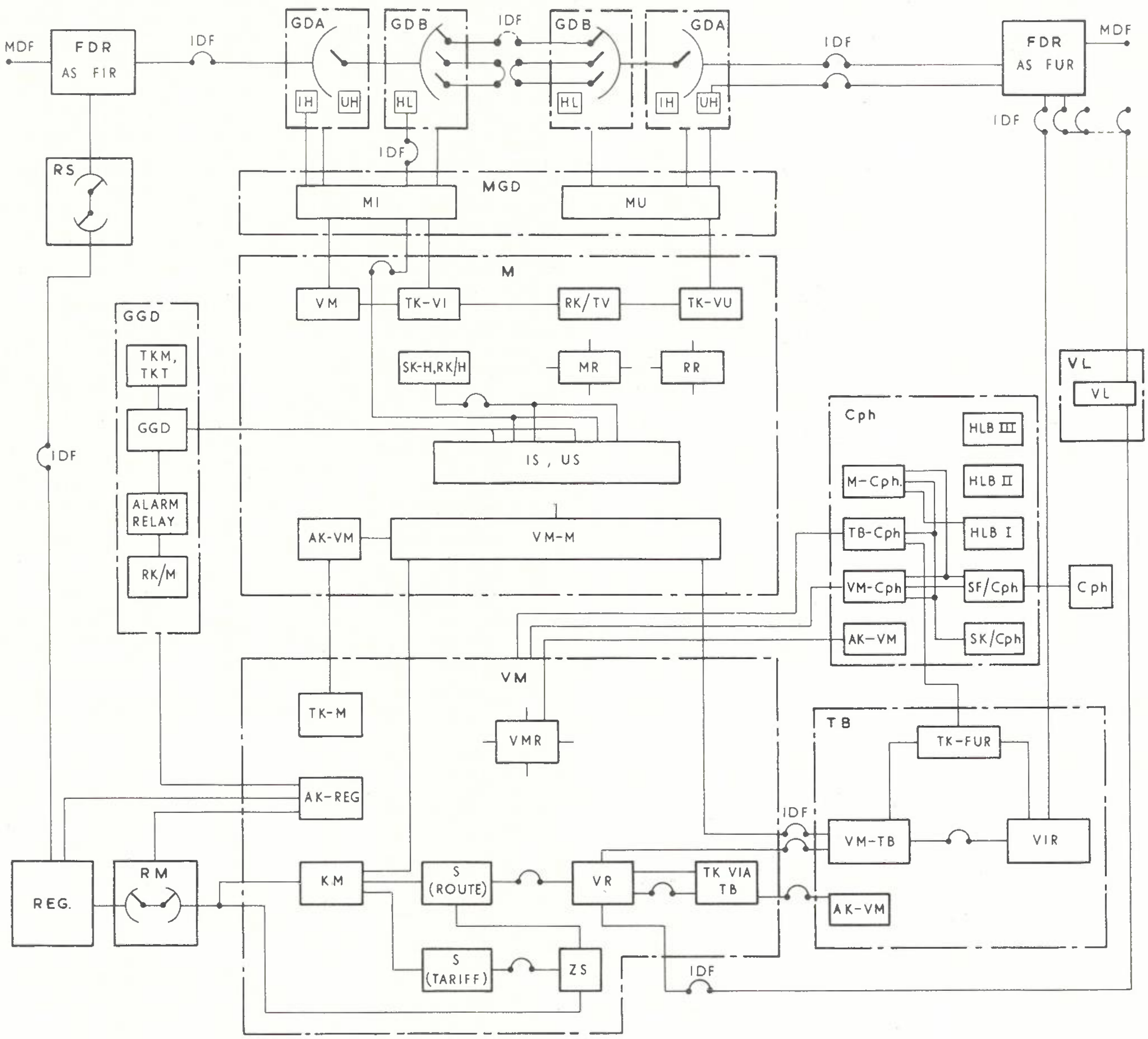


Fig. 24 — Telex Transit Exchange System ARM 20 Block Diagram.

peaters and registers. The telex register finder provides for 64 repeaters to be connected over ten signalling wires to 20 registers.

Register REG: A register directs and controls the connection to the called subscriber. It receives information from the line and passes this to the route marker when connected. When the marker has been released, the connection is held under the supervision of the register which transmits the required signals forward over the outgoing line so that a connection to the called subscriber may be obtained. The register is released when the connection is completed or when the connection has been taken over by another register in a subsequent transit exchange or taken over by a code receiver (KMT) in a telex terminal exchange.

Connection of Registers to Code Receivers, RM: The connection between register and route marker comprises 48 wires which are interconnected by means of multi-coil relays. An RM unit comprises one rack and serves 5 route markers and 50 registers. All registers can reach all route markers. The registers are divided into ten groups of five and only one register out of a group can be served at a time.

Route Markers VM and Markers M: The marker functions of the system have been divided between two units, route marker, VM, and marker M. The connection, route marker to marker is 74 wire via multi-coil relays in relay set VM-M of the marker.

Included in the functions of the route marker are tariff determinations, route determination, interaction with test blocks, time supervision, statistical metering and registration of possible faults by means of Centralograph. A route marker occupies one rack and can recognise up to 160 routes. If additional routes are required, an extra rack may be installed to accommodate route relays only. In VM the following circuit blocks are included:—

AK-REG a call chain for registers and interoperates with RK/M of GGD and RM to identify and select a calling register.

KM receives the T and K characters and the A, B digits multiwire from the register as well as information regarding the number of the 200 group in which the incoming repeater is located.

ZS receives the C and D digits stores the tariff character as determined by the S (tariff) relays. It also returns the tariff character multiwire to REG.

S (route) analyses the A, B, C

and D digits to allow operation of a route relay, VR.

S (tariff) analyses the T and K characters and A, B digits to allow operation of a particular Z relay in ZS.

VR a route relay operated for a particular combination of routing digits and provides for examination of a maximum of 3 test blocks.

TK-via, TB selects one of the test blocks which have lines in the required route. It also controls the progress of alternate routing.

VMR contains control relays for various purposes.

In M the following circuit blocks are included:

AK-VM a call chain for route markers; it inter-operates with TK-M in the route marker so that one and only one marker is selected to operate with the calling route marker.

VM-M provides the interconnection necessary between marker and route marker.

MR contains control relays for various purposes.

RR miscellaneous alarm relays.

IS,US marks the number of the 200 group in which the calling line is located as well as the number of the 200 group in which the selected outgoing line is located.

SK-H,RK/H provides for a systematic examination of the links available between the calling and called 200 groups until a link is selected by other circuit elements.

VM Identifies idle verticals in row of verticals having access to the calling line.

TK-VI tests the incoming GDB verticals and selects a free one.

TK-VU tests the outgoing GDA verticals which have access to the selected line and selects a free vertical.

Test Blocks for Route Connection and Line Selection, TB: The lines belonging to a route may be in different 200 groups but connect to the same test block or blocks. Each test block has space for 150 lines but these are limited to a maximum of 30 routes. Further, in a test block there may be no more than 30 lines per route and the lines cannot be distributed among more than 10 different 200 groups. One route should be distributed over more than one test block but not more than three, a limitation imposed by the system. Because of this limit a route cannot normally contain more than 90 lines. If a route requires more than 90 lines, the maximum of 90 can be multiplied by the use of up to five choices. In the telex exchange a test block can serve 10 route markers.

In TB the following circuit blocks are included:

AK-VM a call chain for route markers and provides for route markers to bid for TB.

VM-TB provides for connection between a test block and the route marker which has successfully bid for the TB.

VIR multicoil relays one or more of which are operated via control wires from the route marker so that lines in the test block may be examined and a selection made.

TK-FUR tests the lines extended from VIR and selects a free line. Only 30 lines may be tested.

Route-Free Indicating Relays, VL: An outgoing route can be divided into three route parts, each part being confined to one test block so that all lines in the group are spread over three test blocks. Each such part is provided with a route-free indicating relay. These relays are connected to group-free marking wires from the corresponding both way repeaters. The VL relays operate as soon as a line on the route part becomes free and this condition is marked on the route relays in all route markers.

Common Group, GGD: This common group consists of two parts. One is an allotter (RK/M) which directs the calls from the registers so that the route markers are called in turn. The other consists of lockout chains (GGD) to control markers calling selector units. Each selector unit has its own lockout chain in which the individual relays represent markers. When a marker has recorded the condition of incoming and outgoing group selector units, it attempts to call the corresponding GGD. As soon as the two relay chains are free, the marker can seize the selector units and set up the connection.

MGD Connection of Selector Stage to Marker: A number of wires are connected between the marker and selector unit for testing and control functions. The connection to the incoming selector unit is on 168 wires and to the outgoing on 96 wires. The MGD rack contains equipment for connection of five selector units to five markers.

ESTABLISHING A CALL THROUGH ARM 201

Referring again to Fig. 24, when an incoming call is being handled by a particular FDR a REG is first called in and stores the information received from the line and then a VM is connected to the REG and the necessary information transferred to it. The subsequent circuit action may be divided into two general phases, (a) for the particular route, selection in the route of a line to be the outgoing line for this connection and (b) having selected the outgoing line, determination of the particular link path from calling inlet to selected outlet.

Selection of Outgoing Line (See Fig. 25)

The lines in a route may be spread over three test blocks and each such group (route part) then has its own VL relay. In Fig. 25 connection 1 in each test block arranges to operate a VL relay if any FDR in a particular route part is free. The lines in a route part are connected by means of path 8 to VIR relays of the test block.

When a particular route relay, VR, has been operated the condition of the route part VL relays associated with the three test blocks is extended on paths 2 through VR to TK via-TB on path 3. Selection of one test block is made by TK via-TB and by means of paths 4 and 5 the selected test block is seized by the route marker. Connection 6 between AK-VM and VM-TB in the test block through connects leads 7 and 9 from the test block to the particular route marker.

The operated route relay, VR, in the route marker will now operate the connected VIR relays in the test block over path 7. Lead 8 in the test block provides for an examination of lines in the route part by TK-FUR. One free line is selected and an indication of which line has been selected is returned to the route marker by path 9. In particular path 9 contains information regarding the 200 group in which the selected line is located.

Determining the Link Path to Connect Calling Inlet and Selected Outlet (See Fig. 26)

After a test block has been connected to a route marker, the route marker calls for and seizes a free marker. After line selection has been achieved IS, US of the marker has stored in it the number of the 200 group in which the calling line is located and the number of the 200 group in which the selected (outgoing) line is located. GGD is called and when both 200 groups (incoming assumed to be 1 and outgoing assumed to be 3) are free, GGD arranges that MGD connect GD1 and GD3 to the marker.

The number of interstage GDB links which can be simultaneously examined is limited to 20. The maximum number of interstage links is 80 and the minimum is 5. Interaction between IS-US and SK-H of the marker determines the number of links which may be examined for a particular combination of incoming and outgoing stages; SK-H also determines the order in which examination is to be made. SK-H operates particular HL relays associated with incoming GDB switches and hence links are through connected for examination. If none of the first twenty links examined are satisfactory to interconnect calling inlet and selected outlet, a relay chain operates within SK-H and the previously operated HL relays are released and new ones operated. One HL relay controls 5 links and only 4HL relays may be operated simultaneously. The interstage links connect a vertical in a switch of the incoming stage to the corresponding vertical in a switch of the outgoing stage. To improve the traffic handling capacity of the links and obviate against certain fault conditions, transpositions

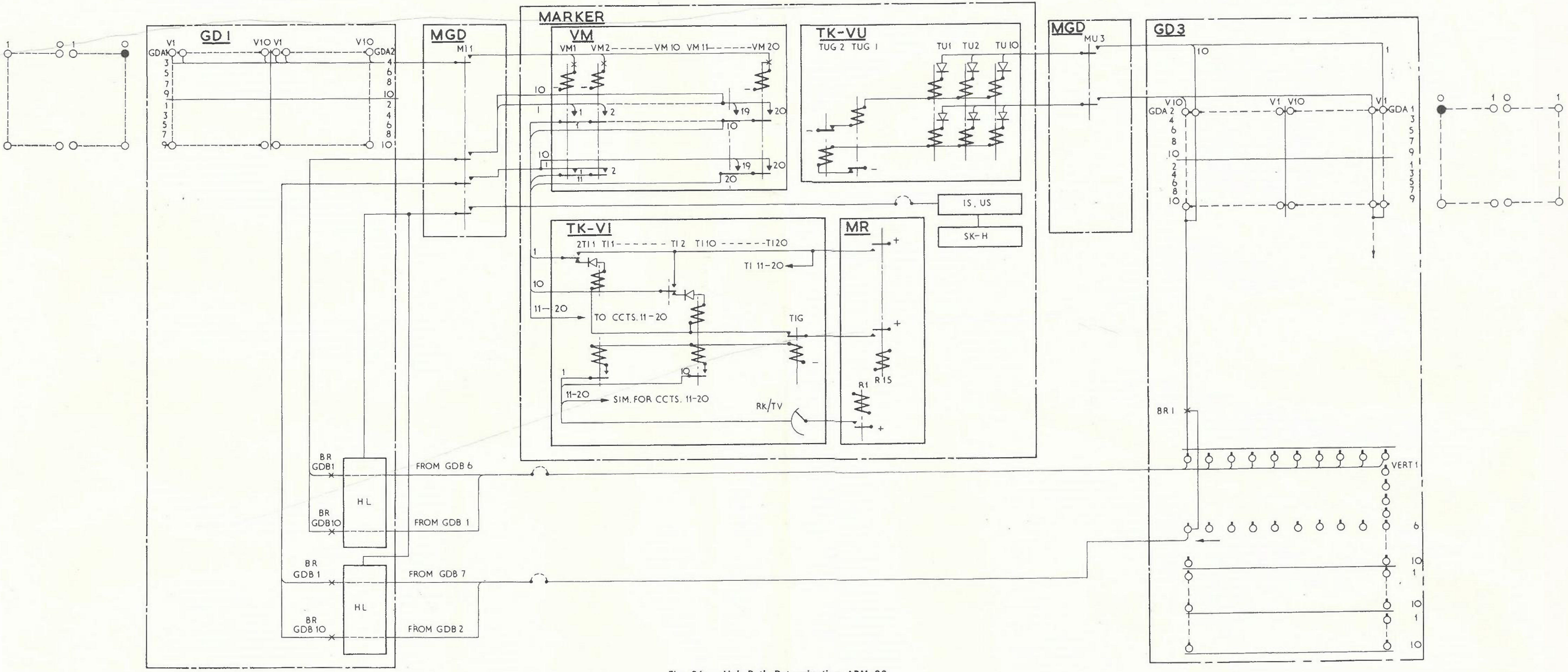


Fig. 26 — Link Path Determination ARM 20.

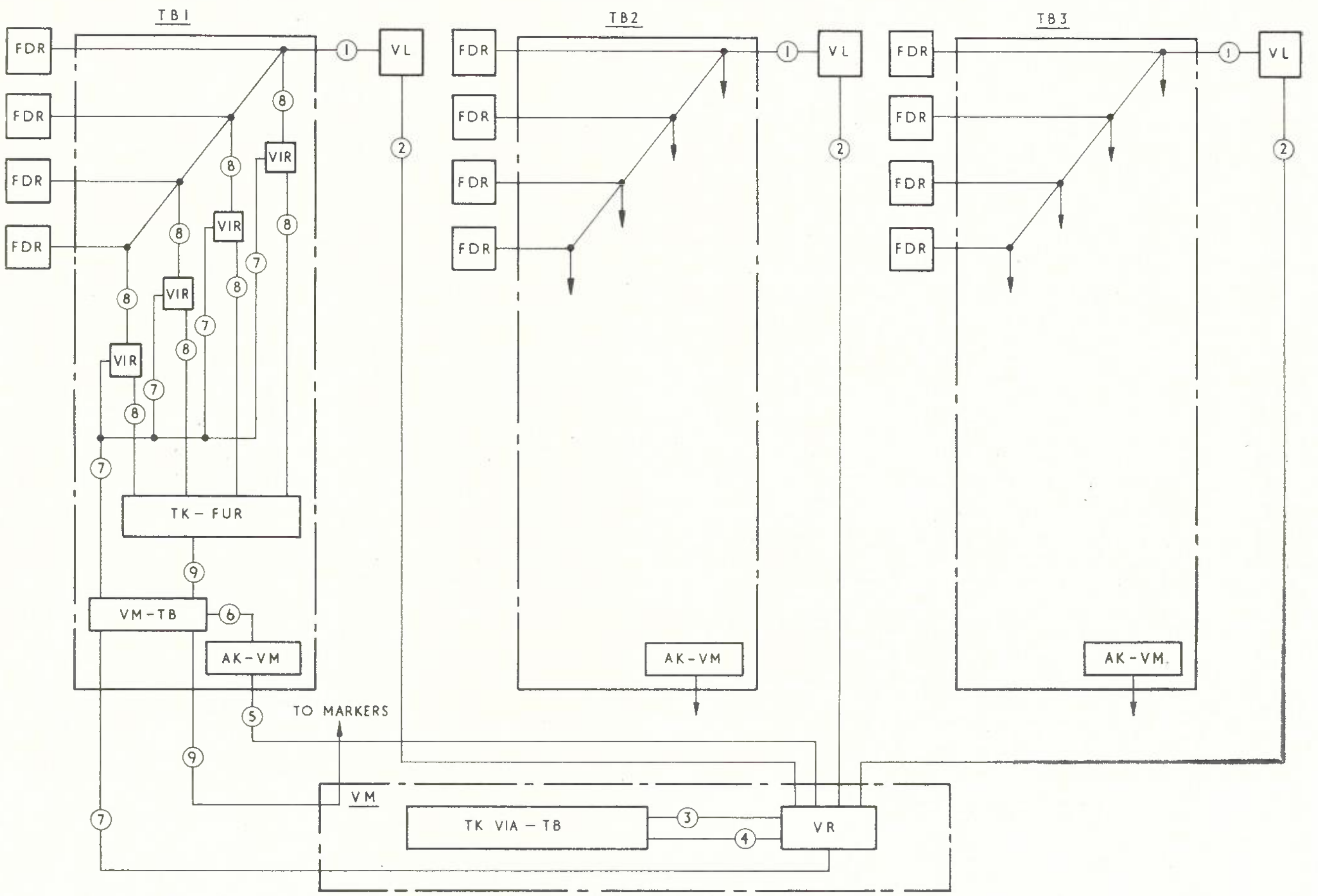


Fig. 25 — Interaction between Test Block and Route Marker to Effect Line Selection in Required Route.

are made in the selectors of the second stage which are connected to selectors in the first stage e.g.

20 links required between stages GD1 and GD3.

A restriction exists on the selection of verticals but vertical 1 may be chosen for links 1-10 and 6 may be chosen for links 11-20. The arrangement would be as follows:

Selectors in GD1	1	2	3	4	5	6	7	8	9	10
Selectors in GD3 links 1-10 (vertical 1, say)	6	7	8	9	10	1	2	3	4	5
Links 11-20 (vertical 6 say)	8	9	10	6	7	3	4	5	1	2

The situation reached now is that the calling outlet is known, the selected outlet is known and the links which may interconnect the two GD stages concerned are known. Determination of the actual link path proceeds.

A particular calling inlet confines attention to a particular group of incoming GDA verticals. A particular selected outlet confines attention to a particular group of outgoing GDA verticals as indicated in Fig. 26. Relays VM1-20 in the marker operate if an incoming GDA vertical is free and extend link test paths to TK-VI where the paths traverse the corresponding relay coils TI1-TI20, terminating on positive supplied by a contact of R15 relay in MR of the marker. From TK-VU, coils of relays TUI-TU10 and TUG1 are extended to the odd numbered verticals in the outgoing GDA and the coils of relays TU1-10 and TUG2 are extended to the even numbered verticals in the outgoing GDA. Leads from pairs of verticals in the outgoing GDA are extended to vertical 1 of the GDB switches and also in parallel to vertical 6 of the outgoing GDB switches. The leads from the outgoing GDB verticals are transferred to the incoming HL relays according to the logic of the linking pattern. Relays R1 and R15 in MR of the marker are both operated and the link paths are examined. Positive to operate TI relays is provided by R15 and the negative is supplied by either TUG1 or TUG2. TI relays with complete paths may operate but TU relays will not operate in series. Only one TI relay may lock as determined by RK/TV. When a TI relay locks a secondary TI (i.e. 2TI1 etc.) operates as well as the group relay TIG.

The locking of a TI relay selects a particular interstage link for use so that the incoming and outgoing GDB verticals are now determined. A particular TI relay together with one or the other or both associated operated VM relays determine which incoming GDA vertical will be used.

When a secondary TI relay has operated positive is extended to operate a TU relay and either TUG1 or TUG2, the combination of which determines the outgoing GDA vertical to be used.

The path has been fully determined and the horizontals and verticals may be operated. The route marker and marker remain on circuit until the selected path has been successfully tested at which time they release and the register takes over its function of calling forward on the selected outlet.

Reselection Possibilities

ARM201 is described as a system with one reselection. A route marker may seize a test block in which only one line is available in the required route and this line may be taken into use from the distant end before it has been selected by the test block. In this case the test block indicates to the route marker that it no longer is available and the route marker selects another test block. Reselection executed at this time is theoretically possible a number of times but the likelihood of encountering the situation described above in two

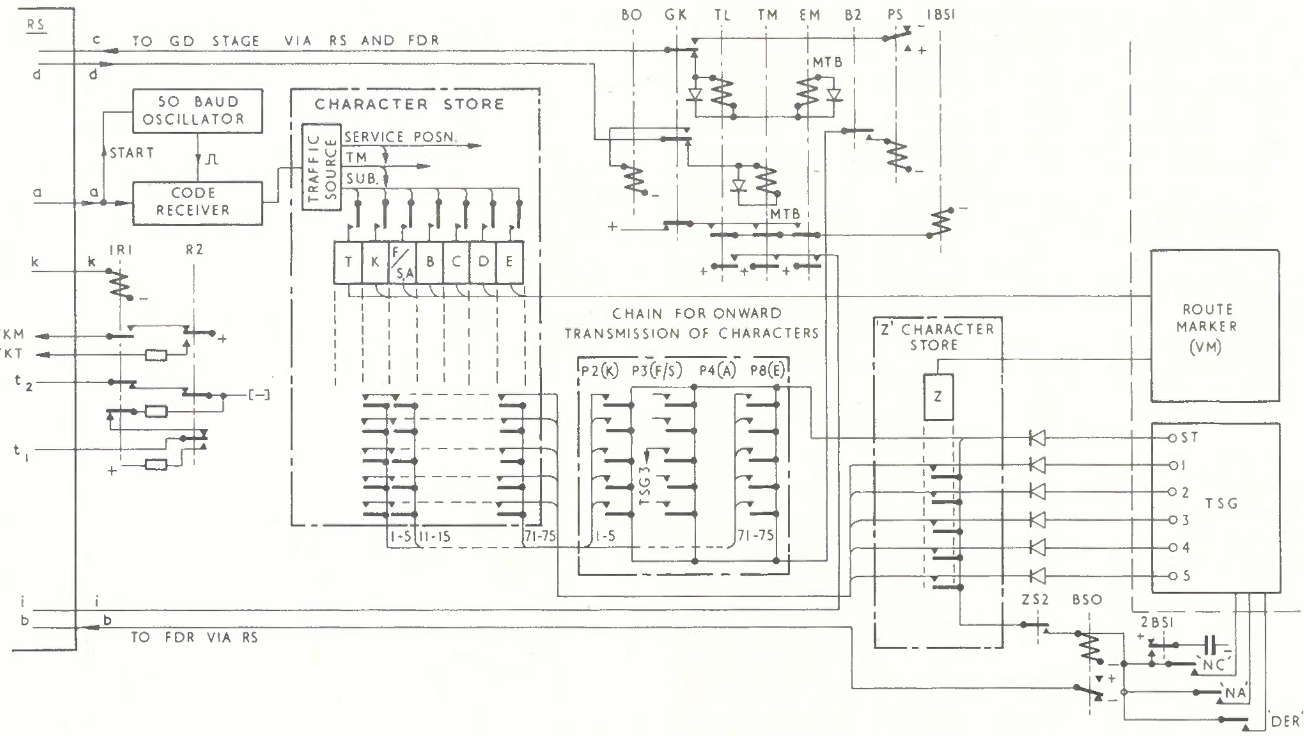


Fig. 27 — Elements of Telex Register.

successive seizures of test blocks is exceedingly small.

Another class of reselection is possible after a line has been selected by a test block. Should the selected line be seized from the opposite end of a trunk while a link path is being determined, or should no link path be available to connect the calling inlet and selected outlet then reselection occurs. It is this class of reselection which is limited to one occurrence. When conditions arise for reselection, the route marker is informed and takes the necessary action to arrange a reselection; it also remembers that one reselection has occurred and should a similar situation be encountered on the next attempt to through-connect the incoming line to a selected outgoing line a busy indication is reverted to REG.

Register Operation (See Fig. 27)

When a repeater is connected to a register the condition on the c and d wires determine whether relays TL, EM or TM operate. TL operates if the call is from a service position (manual assistance or printergram), TM operates if the call is a transit call (i.e. coming from another transit exchange) and EM operates if the call is from a subscriber connected to a terminal exchange. The characters received by the code receiver are stored in the character store, the point of entry to the store being controlled by the type of traffic source.

For an EM call, the characters received into the store are firstly the T and K characters for the particular calling subscriber. The character store expect the next character to be "figures" and will take no action until it is received. Once "figures" has been received the called subscriber's number (A, B, C, D and E digits) is stored.

When a route marker is connected to the register, the T and K characters and the A, B, C, D information are transferred. By analysing T, K, A and B the route marker determines the tariff to be applied on this call and corresponding relays are operated in the 'Z' character store. After the 'Z' character has been stored and all digits from the line have been received in the REG character store, a seizure signal is sent from REG on the b-wire of RS to call in a KMT in the telex terminal exchange. When the KMT has connected to the calling repeater in the terminal exchange, a confirmation signal is sent from KMT to REG. Relay ZS2 in REG now operates and a TSG provides the signals to drive BSO relay via the 'Z' character store. The 'Z' character corresponding to the determined tariff is now returned to the distant KMT. When transmission of the 'Z' character has finished REG informs the route marker that route and line selection may proceed.

After a path has been established between calling ARM inlet and selected ARM outlet and testing of the path is completed satisfactorily, relay GK is operated in REG. The contacts of relay PS are now connected to the c-wire of RS. The REG now transmits the seizure signal (stop polarity) forward on the selected outlet. The "call confirmation" and "proceed to select" signals are received in REG on the d-wire and key relay BO. Following the receipt of these signals, relay B2 is operated and controls the operation of relay PS by information contained in the character store. The "chain for onward transmission of characters" determines which characters will be forwarded, e.g. for a call to another transit exchange the chain arranges that K, F/S A, B, C, D, and E are sent in that order; for a call to a telex terminal exchange it arranges that C, D, E and K are sent in that order.

When all characters have been sent forward, an end of chain relay initiates release of the register from this call and the register becomes free to handle another call.

ROUTE AND TARIFF DETERMINATION

(See Fig. 28)

The REG transfers its stored information regarding T, K, A, B, C and D into the route marker VM. T, K, A and B are stored in the KM relay set and C and D are stored in the ZS relay set.

Tariff Determination

T, K, A and B are extended to operate S relays in the S (tariff) relay set. The various combinations of the corresponding S relay contacts are jumpered to operate the required Z relay in ZS. Initially only five different tariffs will be used in the system.

Route Determination

The K character and A, B, C and D digits are extended to operate S relays in the S (route) set. When the register extends a "proceed to connect" signal to VM so that relay KF is operated in ZS, a negative is applied to the particular path through the S (route) relay set and a first choice route relay, 1VR operates. If there are other choices allowed for this particular route then other VR relays may also operate, e.g. if two choices are allowed then 1VR will operate a 2VR relay; if three choices, 1VR will operate 2VR, 2VR will operate 3VR etc. but the maximum possible choices are five.

The operation of route relay 1VR provides for the route marker to examine the lines connected to a maximum of three test blocks. The corresponding VL relays for these test blocks operate TV1 relays in TK-via, TB if there are free lines in the required route. This provides for an examination of a maximum of 90 lines.

If a second choice route is allowed, then a 2VR relay has been operated. This provides for the route marker to examine the lines in the second choice route if there are no test blocks with free lines in the first choice route. The corresponding VL relays for these test blocks operate TV2 relays. This provides for an examination of a further 90 lines.

The operate path for TV relays traverse a break contact of a blocking relay, ST. Control of relays, ST, can therefore prevent examination of the lines in alternative choices although corresponding VR relays (2VR, 3VR etc.) may be operated.

Some inter-transit exchange trunks may develop to the point where it will be necessary to extend them to, say, three choices, i.e. a first choice and two alternative choices, so that 270 lines may be examined. There may subsequently be a further two alternative choices if these 270 lines are busy so that lines to another intermediate transit exchange may be examined.

Now in this particular arrangement, because alternate routing must be avoided on transit calls (see Part I) the analysis of the lines to another transit exchange (not the one indicated by 1VR operation) must be prevented if the call is already a transit call. Relay TM in ZS has been operated if the call is a transit call and by means of a 1VR relay contact a strapping may be made to

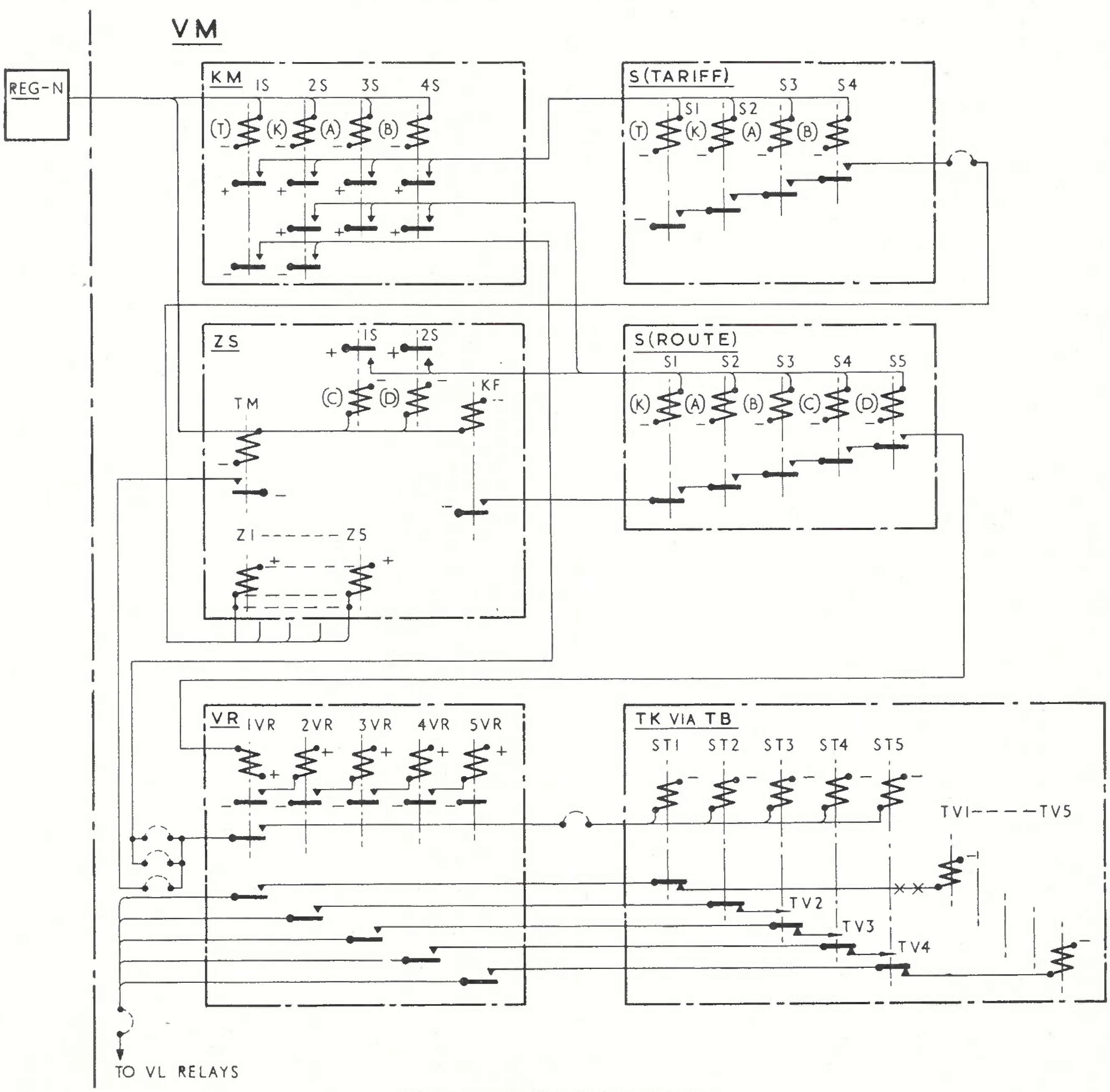


Fig. 28 — Route and Tariff Determination.

operate ST4 and ST5 relays so that only the first 270 (max.) lines of the direct route may be examined.

A similar situation may arise for subscribers with a particular K character. It may be desirable (or necessary) to ensure that calls from these subscribers are connected only to the direct inter-transit exchange trunks and not via an intermediate transit. This may be arranged by providing that the K character operate the necessary ST relays.

Subscribers in a particular tariff zone have a particular T character. For telegraph transmission reasons, it may be necessary to prevent these subscribers from having access to the required transit exchange via an intermediate transit. This may be arranged by providing that the T character operate the necessary ST relays.

ARM50 TRANSIT EXCHANGES

For small transit exchange requirements a more economical design known as ARM50 is available and was selected for use in Canberra. The system used, ARM503, is a group selector stage made up of two selector stages GVA and GVB which are interconnected by means of links. Telex traffic considerations limit the use of a transit stage of this type in Australia to less than 200 lines capacity because of call handling capacity of the common control equipment. Reference (11) gives further information on this system.

SUPERVISORY, TESTING AND TRAFFIC METERING EQUIPMENT

In designing the automatic telex system care has been taken to integrate supervisory, testing and traffic metering equipment requirements with the basic exchange design, rather than add these at a later stage. Testing has been automatised to a high degree enabling trunks and repeaters to be automatically routined in the low traffic periods with automatic print out of results. Furthermore, testing into exchanges by service technicians has been automatised to a degree to avoid using exchange maintenance staff on the more usual subscriber loop transmission tests. It is intended to describe in more detail the equipment designed for these purposes at a later date and a general outline only is given below.

Service Alarm and Service Control

Service alarm and service control equipment is similar in kind but more advanced in circuit technique and mechanical detail than that currently used in ARF 102 crossbar telephone exchanges (Ref. 12). This equipment continuously monitors the performance of the common control equipment and operates an alarm if performance deteriorates beyond a preset limit. As an aid to fault localisation more detailed supervision of particular common control items by key switching from the test desk is available. This detailed examination would normally be taken following the operation of a service alarm indicating that there is some common control element malfunctioning.

Fig. 29 is a block schematic of the service alarm equipment provided for each 400-line ARB telex terminal exchange.

The "occupation counter" is operated from one of the two A markers when

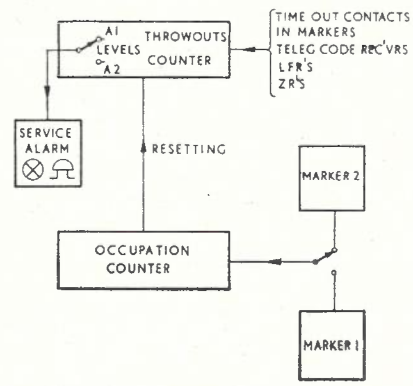


Fig. 29 — "Percentage" Type Service Alarm.

occupied either for an incoming or an outgoing call. Since these markers are brought into use alternately the indication on this counter is representative of the total traffic through the exchange. The "time-outs" counter is a 64 position relay counting chain operated from time out contacts in the various common control items. The occupation counter is a pre-determining electromagnetic unit made in West Germany by J. Hengstler K.G. which operates a set of contacts in the unit when the count has reached a preset figure.

The circuit arrangement is such that these contacts on the occupation counter reset the time out count chain to zero each time the total occupation reaches the preset figure. However, should the time out counter have reached a certain figure before resetting occurs a service alarm is operated. The system as a

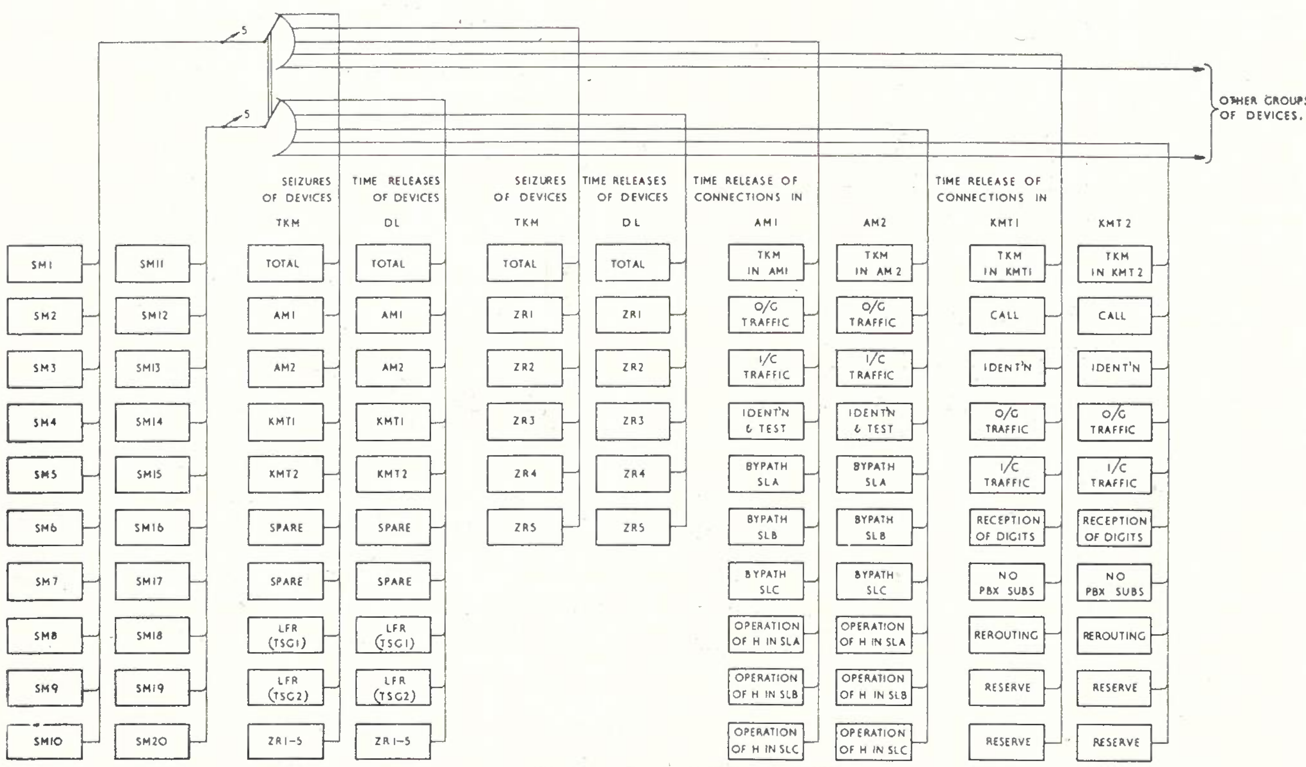


Fig. 30 — Service Control ARB 111.

whole thus gives a "percentage" type service alarm over the integrating period set on the pre-determining "occupation" electromagnetic counter. Two selectable alarm levels are provided, one for night operations, the other for operation during normal working hours. These are tied into the normal exchange alarm system, the night alarm level, A1, being a service alarm level indicating trouble which should be corrected immediately.

For service control purposes ARB exchanges have 20 counters provided on a service control rack which is mounted in the same form of construction with test desk facilities in the test and control area. Fig. 30 shows the principle of connection of these devices. It will be noted that one set of 20 resettable meters is arranged through key switching on the service control rack so that it can be used on up to five ARB blocks of 400 lines and within each ARB exchange can perform five separate groups of measurement. The purpose of each of these is shown in the figure. The actual connection of the counters is performed by multi-coil relays which are controlled from keys.

Similar service alarm and service control equipment is being installed for the ARM 201/4 equipment, service alarm being then by route marker group, by marker group, and by register group. One group of 20 resettable meters is provided for service control statistical metering and these can be switched as a group to a maximum of 40 devices (VM, M's, Reg. etc.) via multi-coil relay connecting circuits. Permanently connected non-resettable meters located in the subscribers meter room are also available for long term service control and traffic counting purposes. Analysis of alarm conditions is greatly simplified for ARM201/4 equipment by the centralograph which via a control rack supervises the operation of route markers, markers and test blocks. Similar equipment is not immediately available for ARM 50 exchanges but common control relay sets are prepared for centralograph connection via control relay sets yet to be designed.

For route markers and markers an observation lamp display is also provided on the service alarm and control rack in the test and control area. This display indicates which route markers are free. which route marker will next be seized, seizure of a test block from a route marker, seizure of a marker from the route marker, which markers are in operation and a lamp indication for each marker on connection of the GD stage.

Traffic Metering

L. M. Ericsson traffic metering equipment is provided at each capital city exchange installation permitting simultaneous metering of the traffic in exchanges in 60 groups of up to 20 connections. The traffic meter counts the number of occupied "devices" in a given metering group on the basis of the current in a metering conductor belonging to the group, this conductor being connected in each busy device to the exchange battery via a traffic metering resistance. For metering the meter compares the current in the metering conductor with the current in an internal comparison circuit. This internal circuit is progressively built up in the meter by parallel-connected comparison resistances with exactly the same resistance values as the traffic metering resistances in the connecting devices. The traffic counter of the traffic meter is stepped forward one step for each comparison resistance connected to the circuit. The process is interrupted when the current in the comparison circuit has attained the same value as that in the metering conductor. The process is interrupted when the current in the comparison circuit has attained the same value as that in the metering conductor. The traffic counter therefore is stepped forward a number of steps equivalent to the number of devices occupied in the group metered. In the course of metering, normally one hour, each metering conductor will be checked 100 times. The mean traffic is thus available directly from the group meters in hundredths.

Line Testing

Test access to subscribers lines is available in two ways:—

(i) Automatically from the test desk by keying selection information into KMT through a special, SLC connected input relay set, known as FIR-P. These relay sets must of course be particular to each 400 line ARB exchange. Fig. 31 shows the general arrangement which permits the usual range of subscriber line tests to be made. In addition functional tests can be made towards the subscriber's terminal unit.

(ii) The subscriber's line may be patched to the test desk from the SLA rack. The test desk can then control testing such that line tests clear of the exchange equipment can be performed as well as functional and machine tests toward either the subscriber or the exchange or in leak with the subscriber's line circuit.

Automatic Exchange and Tariff Testing

The automatic exchange tester is a mobile apparatus associated with a teleprinter enabling a variety of tests to be carried out. For example this tester can be connected via break jacks on subscriber rack (SLA) as a subscriber to the line relay equipment. In this condition it also connects to the special individual access testing marker (ITM) enabling the subscriber tariff zone to be varied by carrying this marking through ITM from the tester to the ZR relay set which will be used on the call. From SLA a programmed series of calls can be made to any B subscriber and an automatic print out of faulty tests obtained on an associated page printer. By utilising the individual access testing marker (ITM), the exchange tester can make an individual choice of a repeater, test its distortion and, in association with a tariff test trolley, test all charging functions of the outgoing repeater. These tariff tests may be tape programmed and automatic print out of faults obtained.

An 80 point test connection jack is provided in each repeater rack enabling tests of each local repeater from the ARB side clear of the switching stage and with automatic backward busying to the ARM system. Tests may also be conducted from the line side of local repeaters in order to carry out incoming ARB link tests. The tester may also test the trunk signalling function of individual trunk repeaters FDR-Y and from the line side of these repeaters carry out incoming link tests of the common equipment and switching path of the ARM exchange as well as test the charge determining function of the ARM.

Automatic Transmission Measuring Equipment

Automatic tape programmed transmission measurements may be performed on all inter-transit exchange trunks via equipment associated with the test desk. Under tape control a connection may be set up to a particular repeater through individual ARM selection via Individual

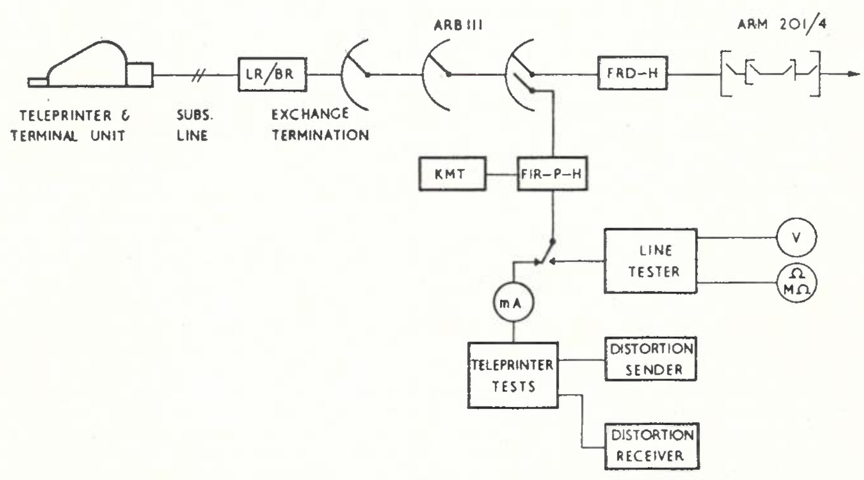


Fig. 31 — Subscriber Line Testing ARB 111.

Test Block (I.T.B.) control and a connection set up through the equipment under test from transmission sending equipment to distortion receiving equipment in a number of different test configurations. An associated page printer prints out the results of the test programme. This equipment makes use of modern distortion sending and receiving equipment connected to ARM test outlets.

Distortion Testing

Each transit exchange is equipped with a Siemens and Halske electronic central test transmitter with a number of outlets associated with a particular ARM routing code allotted for testing purposes. One code allows connection to outlets providing continuous test text with zero distortion and another allows access to outlets providing this text with progressive, defined values of distortion. At each transit exchange a Siemens and Halske central test receiver has been provided and is associated with a particular ARM routing code. This device measures start-stop distortion, and automatically returns information about the magnitude of maximum early and late distortion to the sending device under control from the sending end. Reference (13) describes the principles of these testers.

Apart from the use of these testing equipments in routining large groups of trunks or repeaters, they are also available for subscribers loop tests enabling technical staff at the subscriber's premises to check the subscriber loop in both directions of transmission without requiring the assistance of exchange staff.

CONCLUSION

The technical and operating features of the automatic telex national network currently being installed in Australia have been outlined. It is expected that the entire network will cutover simultaneously in mid-1966, thus completing the second major step in the automatisation of telegraph services in this country, the first being the mechanisation of the public traffic service (TRESS) in 1959. The high development rates, both in subscribers and traffic, show that customer operated telex service will play a very important part in the development of telegraphy. New needs in the data field have become evident in this field recently and are currently being handled in somewhat cumbersome ways. Following the introduction of the automatic network, the development of special facilities for these users employing the very flexible origin marking and classification features of the network will be undertaken. At the same time it is proposed to begin the third major step in the automatisation of telegraph service, the rationalising of the great variety of leased private wire services having some degree of message or circuit switching. These networks increasingly transfer traffic to and from the telex network and the special features of the automatic telex system again offer new design possibilities in this field.

ACKNOWLEDGMENTS

The authors would like to acknowledge that many people within the Australian Post Office, Telefonaktiebolaget L. M. Ericsson, Sweden, and Siemens and Halske A.G., West Germany have contributed to the development of the Australian automatic telex system. In particular the authors wish to acknowledge the work done on this project by Mr. P. S. Bethell both in this country and as Liaison Engineer with the London office.

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TECHNICAL NEWS ITEM

AN INVERTED VEE ANTENNA FOR SHORT-RANGE HF COMMUNICATIONS

With the increasing use of the HF spectrum for communications within Australia, and in addition its long standing use in long-distance international communications, a need has arisen for antennae with improved directional properties to reduce the likelihood of interference between systems operating in the same frequency band. Such antennae include rhombics, curtain arrays and flat-top arrays. A project has been undertaken by the P.M.G. Research Laboratories to develop a more economical type of antenna employing the Inverted Vee configuration. The basic idea was initially suggested by Dr. J. F. Ward of the RAAF Academy, University of Melbourne, in an antenna designed for use in the Royal Flying Doctor Service.

The basic structure studied, consists of an Inverted Vee with the wire inclined at a low angle of 10°-20° to the ground. With an antenna having a length of wire equal to one wavelength and an angle of wire to the ground of 10°, fed from one end at ground level and terminated at the other, a front-to-back ratio of greater than 10db, a vertical beam width of about 30° and an angle of maximum radiation of 45° to the horizontal was obtained. This simple structure has two basic disadvantages in that high level, low angle side lobes are present at an angle of about 45° to either side of the vertical plane containing the antenna, and also, by using a resistive termination to obtain a uni-directional vertical radiation pattern, the efficiency falls to an inordinately low value, rendering the antenna unsuitable for transmitting applications.

The low angle side radiation can be suppressed by using a broadside array of two structures with a spacing of approximately three-quarters of a wavelength. This arraying technique places nulls at about 45° to either side of the antenna, which suppresses the side radiation by as much as 8 db. The low efficiency is overcome by using open-ciruited structures, but this produces an additional disadvantage in making the antenna bi-directional. To restore the required uni-directional property, an end-fire array is composed of two identical structures with a separation of the order of one-third of the wavelength in the direction of propagation, each structure being fed in a suitable phase relationship (the front structure is fed approximately 90° lagging with respect to the rear structure). A front-to-back ratio of more than 10 db is obtained using this technique. A combination of both arraying techniques gives the best overall characteristics for a point-to-point HF antenna of this type, with a gain of approximately 12 db with respect to an isotropic antenna. A choice of antenna design is available ranging from a single structure to the end-fire/broadside array of four open circuited structures, depending on the requirements of a particular system design.

The chief advantage of this new antenna design over that of existing antenna types already available is the reduction in the height requirement and the number of supporting masts required for an equivalent electrical performance. The antenna may require a larger site; however, this may not be important in the remote areas of Australia where HF radio systems are normally operated. This latest development adds to the number of antenna designs available from which a selection can be made, depending on the requirements and economics involved in a particular case.—D.C.

AUTOMATIC PRINTOUT OF CONTROL INFORMATION

*A. DOMJAN, Grad. I. E.Aust.**

INTRODUCTION

It is often desirable to translate information gained by measurements into a form that can be easily transmitted and either printed out or punched into paper tape. The information can thus be accumulated for analysis. When a fast sampling rate is required a parallel type readout is the obvious choice. However, on many occasions a high sampling rate is not needed and in these cases a series type readout using the Australian Post Office standard telegraph speed of 50 bauds is sufficient as this permits up to 400 characters per minute to be either page printed or punched as required. Also, if the parallel readout (which can produce 6000 characters per minute with parallel punches in paper tape) is then page printed, the overall rate of providing information is less than direct page printing.

This article describes equipment that can accept measured information in several forms, e.g. as a pulse length, and convert it into appropriate series 5-unit code trains that will print or punch the information on standard telegraph equipment. In the applications described the information is page printed for maintenance technical staff, but it would also be possible to analyse the results on punched paper tape with a digital computer.

The equipment, which is known as Series Type Automatic Readout (STAR) usually consists of three operational parts. There is the measuring equipment which converts the measured information into a digital form, the programming stage that translates the output of the measuring equipment into suitable readout characters, and a telegraph signal synthesiser that provides standard groups of pulses for the programming stage to turn into appropriate character codes.

THE TELEGRAPH SIGNAL SYNTHESISER

General

The telegraph signal to be produced should be in accordance with the A.P.O. standards, i.e. pulse trains of ± 25mA amplitude, speed of 50 bauds, and in accordance with the International Alphabet No. 2. It is conventional to call the positive going pulse a "Space" and the negative going pulse a "Mark" when considering double current telegraph transmission. (In the case of the single current transmission a current represents "Mark" and no current "Space". Also in voice frequency transmission (A.M.) a tone is "Mark" and no tone is "Space," and in FM transmission, lower frequency "Mark" and higher frequency "Space.") According to the abovementioned terminology the basic unit of intelligence, the "Character" which could be a letter, a number, or a symbol, consists of a start signal (always "Space"), a 5 unit pulse code carrying the information and finally the stop signal which is a "Mark" of at least 1.5 times the unit signal length. For STAR operation, this latter has been chosen to be 2X20ms = 40ms duration, during continuous transmission. A complete signal for the letter "Y" could be represented graphically as shown in Fig. 1.

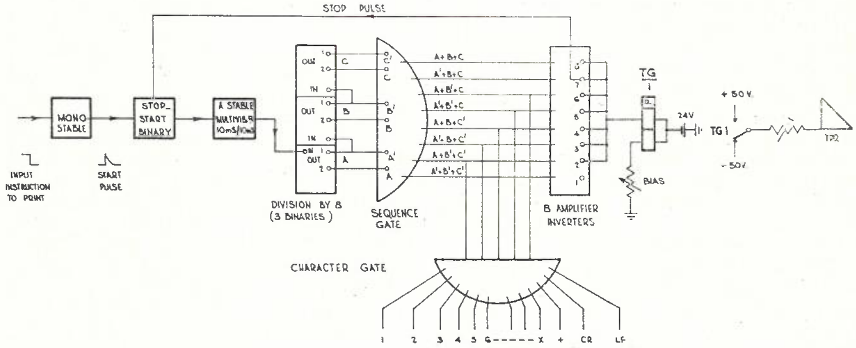


Fig. 2 — The Telegraph Signal Synthesiser Produces Eight 20 ms Duration Pulses in Sequence, from Which the Character Gate Forms the Required Telegraph Signal Code (according to International Alphabet No. 2).

The mechanism used to produce the telegraph signal itself consists of:

(a) Start signal from outside source (Monostable)
(b) Start-stop binary.
(c) Multivibrator.
(d) Division by 8 (3 Binaries) and sequence gating.
(e) Character gating.
(f) Signal commoning.
(g) Telegraph relay.

The block schematic diagram (Fig. 2) shows the operation of the equipment.

A start signal is required from an outside source, indicating that there is something to be printed. The start-stop binary which normally holds the multivibrator in the idle condition will change its state allowing the multivibrator to oscillate freely.

During the operation of the multivibrator a chain of three binary stages divides the original pulses, and the sequence gating of the three binaries produces 8 pulses of 20 ms duration, at 8 separate outputs, appearing in sequence one after another. The sequence gating also counts the number of pulses produced by the multivibrator. When it recognises the required number of pulses it will feedback a stop signal to the start-stop binary, which in turn will prevent the multivibrator from producing any further pulses. (It should be noted here that the multivibrator output is not a proper square voltage waveform and it is not used for gating purposes. Only outputs of the binary stages are used for this purpose, hence the multivibrator is operated at twice the required unit pulse frequency).

The first pulse (i.e. the output of the first sequence gate) is suppressed constantly to produce the start pulse. The outputs of the 2-6 gates are let through or are suppressed according to the character to be printed. This is the function of the character gate. All gates are extended separately to eight single stage transistor amplifiers which have separate base connections but are commoned on their collectors to the signal

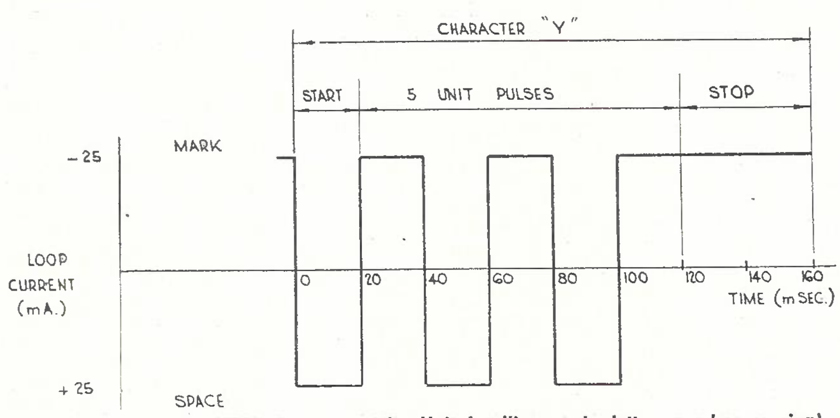


Fig. 1 — A "CHARACTER" Represents the Unit Intelligence (a letter, number or sign).

* Mr. Domjan is Engineer Class 2, Research Laboratories, Headquarters. See Page 247.

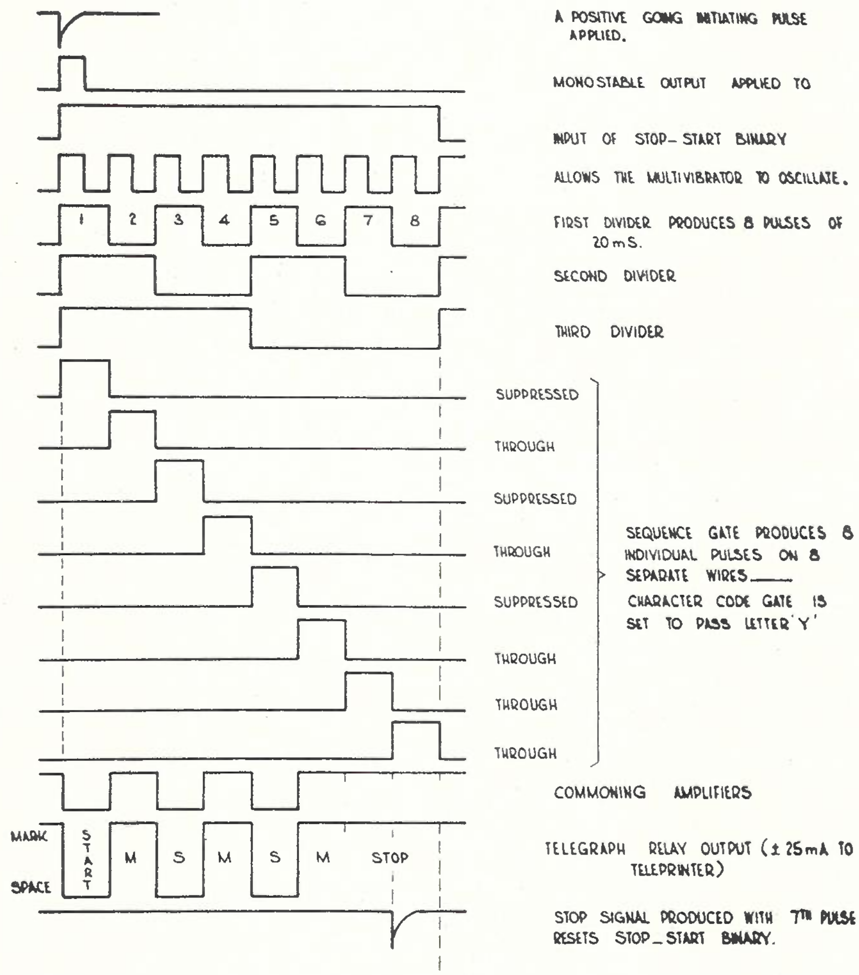


Fig. 3 — Sequence Diagram of the Telegraph Signal Synthesiser Showing the Composition of a Character (letter "Y").

winding of a telegraph relay which is the common load resistance. The telegraph relay when its signal winding is not energised, is held in the space condition by its bias winding. When there is an input signal from the sequence gate and it is not suppressed by the character gate the pulse will reach the relay winding changing the relay from space to mark. The leading edge of the 7th pulse is used to stop the start-stop binary which in turn stops the multivibrator. A common reset, operated from the start-stop binary, will ensure this rest position when all the equipment is back to normal and it is ready to print another character.

An earth potential applied to one of the inputs of the character gate causes a combination of earth potentials on the five outputs which provides the corresponding 5 unit telegraph code. A positive going pulse applied to the input of the monostable stage will start the equipment operating. The result is a printed character on a page printer (or reperforator as required).

The sequence of operation is shown on Fig. 3.

PROGRAMMING

Electronic Key Board

The equipment described is ready to print out any character represented on a teleprinter. The simplest application is an Electronic Key Board. The operation of any of the keys will provide the earth connection to the character gate and the readout start pulse.

From Fig. 4 it can be seen that when button "A" is pressed one contact provides earth to the character gate "A" input and the other contact a start signal. The operation is identical with that of the mechanical key board, except that the key should be held down until the character is printed out. The printing here is the result of the operator's hand movement directed by his sight, hearing or memory devices. What the operator does is called programming. His two main functions are:

(a) Make the printer work in an orderly fashion (i.e. to keep spaces between words, not to print one line on the top of another etc.).

(b) To receive the information with his sensing equipment (e.g. visually by copying from a preprinted form, aurally by hearing, etc.) and to compose a text from this information collected and stored in the brain.

(A third function, the decision making device is not used in connection with STAR as this is only "Slave" equipment. "Master" equipment with more sophisticated memory devices could provide this function also).

In the human operator the functions (a) and (b) are closely associated. Similarly, in STAR these functions are only partly distinct. The division is such that there will always be a measuring device which provides the primary information and gives an order signal to initiate the operation of STAR, but in other cases STAR has to search for any other available information. In general the measuring equipment will change from case to case and the

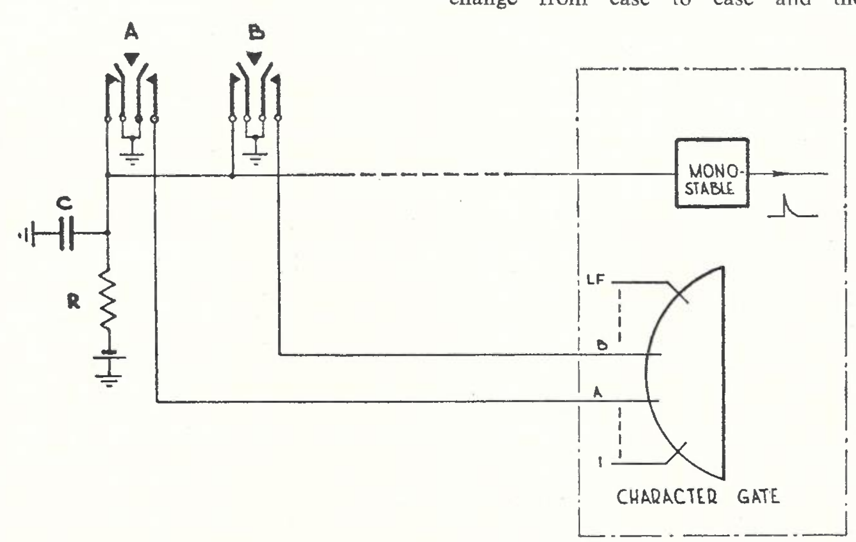


Fig. 4 — The Electronic Keyboard. A, B etc. are Pressbutton Keys on the Board. Each provides an earth potential to the character gate and also a positive going pulse to start the synthesiser, when operated.

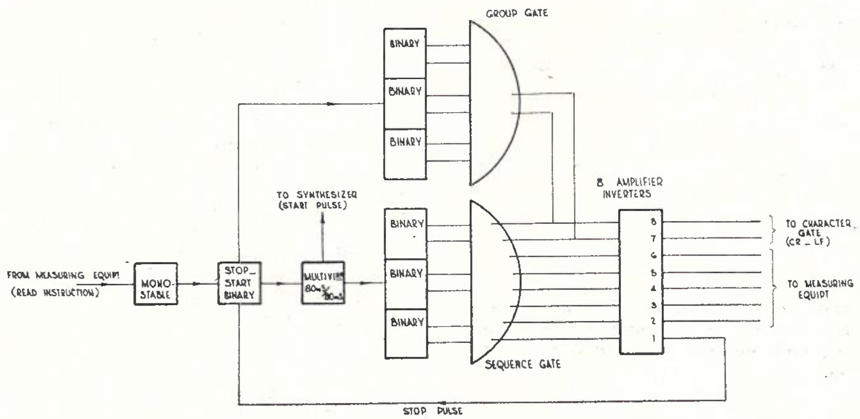


Fig. 5 — Programming Equipment Controls the Printing Arrangement. Each operation of the Start - Stop binary produces a "WORD" printed. Group gate controls the number of words in a line.

arrangement of printing is preset in a definite fashion.

The Functions of Programming

To print words and groups is the function of the programming. As shown in Fig. 5 it is built up in a similar way to that of the signal synthesiser. Its signal input comes from measuring equipment and will provide a start signal through the monostable stage to the start-stop binary, which normally holds the multivibrator in the "Stop" and releases it in the "Start" condition. The timing of the multivibrator is such that a complete cycle will correspond with the time required to print a character (i.e. 80mS on — 80mS off).

Three binaries prepare the signals from the multivibrator for sequence gates to produce individual pulses on 8 separate wires. The gate outputs are amplified with single stage d.c. amplifiers, and used as command pulses to readout from the measuring equipment.

The first pulse leading edge from output 1 is used to reset the start-stop binary. The five outputs numbered 2 to 6 are 160 ms duration "command instruction" pulses for the measuring equipment. Each of these triggers the printing of a character so that a maximum of five characters is possible in a group, e.g. for a 3 character group outputs 2 - 4 are connected and outputs 5, 6 are not used. Hence every operation of the programming start-stop binary will cause a "word" to be printed. Each word or group steps the group gate which can be preset to permit the printing of one, two, four, or eight words. The group gate inhibits the generation of pulses on outputs 7 and 8 until the completion of the preset train of words and then carriage return and line feed occurs.

Pulses from outputs 2 to 6 energise that part of the measuring instrument from which information is required and this information is fed to the character gate. The front edge of each 160 ms pulse serves as an input signal to the telegraph signal synthesiser.

THE MEASURING EQUIPMENT

The measuring equipment should provide the information in digital form. An indication that there is information available to be printed, also is needed in certain cases. If this is not provided, then the programming apparatus should provide the initiation signal in a predetermined scanning period. Suitable commercially available measuring equipment includes the E-put meter (to measure frequency or time), digital ammeters or voltmeters, optical scanning devices to readout pen recorded or written statements, etc.

The problem associated with coupling the measuring equipment to STAR is twofold. The measuring equipment is usually an electron tube device with high impedance output, and the code provided may not be in the form of a proper binary code. The first will need emitter follower stages to transform the impedance. The second will need an additional translator stage to provide the binary code required.

PRACTICAL APPLICATIONS

Quality Control of Voice Frequency Telegraph Systems

In one method used previously to establish the reliability of a telegraph system a reversal signal is sent continuously on one channel and looped back on the far-end. The returning signals can be recorded at the main station with a penrecorder, which will act as a centre scale zero meter and will indicate the loss of a mark bit by a deviation in one direction and a space bit by a deviation in the opposite direction from the zero point. On AM systems a mark loss could indicate a break on the transmission path, and a space loss could be an indication of foreign signal interference. From the recorder chart then the "Probability of nil errors in a ¼-hour message" may be calculated. The first step is to ascertain from the chart whether there has been any loss of space or mark signal during the ¼-hour under observation, and if so then this particular ¼-hour is lost. By recording the fault free time intervals a table is set up from which the percentage of "fault free intervals" to "total recorded time" is calculated. The cumulative percentage so produced is characteristic of the quality of the telegraph system. The same quantity recorded as a function of a week or a month could be the basis of Qualitative Maintenance. The provision of such a recording system at a medium sized station approximately 20 Voice Frequency Telegraph Systems) would take 20 penrecorders, recording paper ink, maintenance and floor space, and economically is not particularly attractive. However, the application of STAR, as shown in Fig. 6 will eliminate most of the disadvantages detailed above. A simple detecting system provides a positive or negative pulse to the measuring equipment when there is a discrepancy in the telegraph transmission. A single transistor (PNPN) memory device will hold this information until it is read out by STAR at which time the programming device of STAR will reset the memory device as required. The encoding gate operated by the scanning uniselector will indicate whether or not there has been a fault and whether the fault was marking or spacing or both. The scanning time is set to 15 minutes and the device will give complete information on the performance of 20 VFT systems.

Voice Frequency Telegraph Routiner

Distortion Alarm Measuring Equipment (DAME) is equipment which scans all the telegraph channels at the local centre and stops, for 15 seconds, on the channels which are operating.

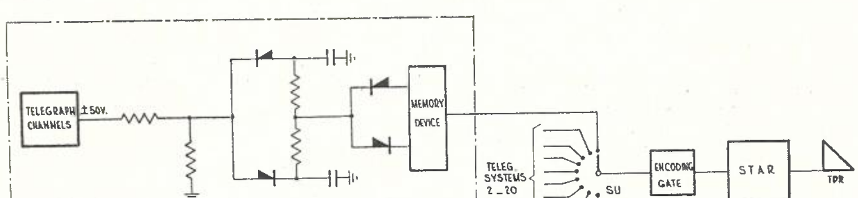


Fig. 6 — Quality Control of VFT's. One channel of each VFT system receives continuous reversals from distant terminal. Fault conditions register in memory devices, which are scanned and printed out every quarter hour.

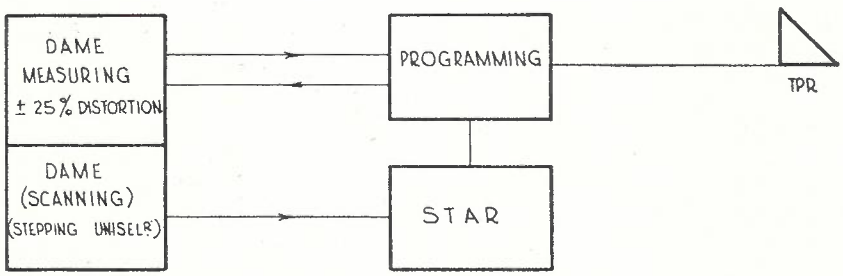


Fig. 7 — Distortion Alarm Measuring Equipment (DAME) Scans All the VFT Channels at One Station. Stops on working channels for 15 secs. Programming equipment commands STAR to print out System and channel number and also records the distortion if this is in or outside of the present limits.

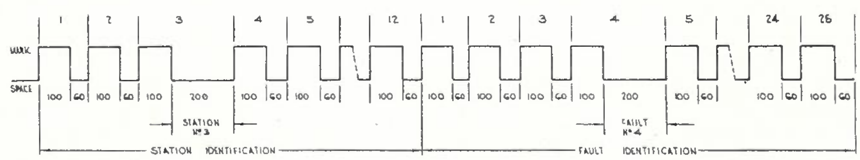


Fig. 8 — Input Pulse Train for ASTRA from the Coaxial Carrier System Control Bay. An increase in length of the space pulse and its order number in the train, carries the required information.

During this time it measures every space signal and determines whether or not they are within the permissible limits of distortion. If any of the telegraph channels are indicating more than say ± 25% distortion, it brings up an alarm to indicate that a faulty channel or sending device needs attention. The technician can determine whether the distortion is recurrent or not by resetting the alarm. If it is recurrent a fault docket is prepared and the usual maintenance procedures followed. Staff non-availability to attend promptly to a fault alarm causes loss of time not only for the technical staff but also for the DAME scanning time. The application of STAR solves these problems by automatically printing out the system and channel numbers (in code form) and scanning the alarm indicator continuously for 15 seconds (See Fig. 7.).

With the arrangement of STAR and DAME currently in use in Adelaide, the first three numbers represent the system and channel number, and the next 15 the condition of the alarm indicator scanned once in each second. For example:—

179 000000+00000000 (Sydney ch 23 fortuitous dist.)

180 0++000+++0+0+++ etc. (Sydney ch 24 faulty needs maint.)

Printout for Coaxial Cable Carrier Fault Indicator

When fault information is fed into a control station in pulse width modulation form, as is the case from unattended repeater stations on the Siemens Halske Coaxial Cable Carrier Systems, the display for the fault condition and also the location is given on a control panel by a number of rows of drop indicators. The row order number represents the station and the column order number the nature of the fault being reported.

However, if there is a fleeting fault at a repeater station the maximum display time of the fault condition is 6 or 7 seconds. This time is insufficient to read out the fault unless a technician is near the display panel. In addition to providing a proper statistical distribution of the different faults, a written report using STAR equipment is more reliable than the subjective report of the human element.

With the Siemens and Halske equipment the fault report is produced by the faulty station with a series of 50 c/s signals. Thirty-five pulses are produced per station report of 100 ms tone and 60 ms no tone (or 100 ms mark 60 ms space) duration. When the 60 ms space increases to 200 ms space during the train of pulses, this increased space and its position in the train is used to give the information required. The first 12 pulses are station identifications and the following 25 are fault type identification pulses. A typical message would be received as shown in Fig. 8.

It can be seen that the time required to print a character is 150 ms and the time available to measure and print is 160 ms Referring to Fig. 9, with the application of STAR equipment, a chopper multivibrator driven by a start-stop binary is used. The latter is operated by the incoming signal train. When a space is received at the input of the start-stop binary, it will free the multivibrator which will produce a number of pulses which are proportional to the length of the space incoming. The following mark will stop the start-stop binary which will then hold the multivibrator in a non-operated condition. The timing of the multivibrator is such that it will produce one pulse during the "no information" period (60ms), four pulses during the "information" period and five or more at the end of the signal train. A counter will count the pulses and will give a coding of "0" if the count is between two and four and finally a "Carriage return" and "Line feed" signal if it is more than five.

Only when the subsequent "mark" has been produced can a decision be

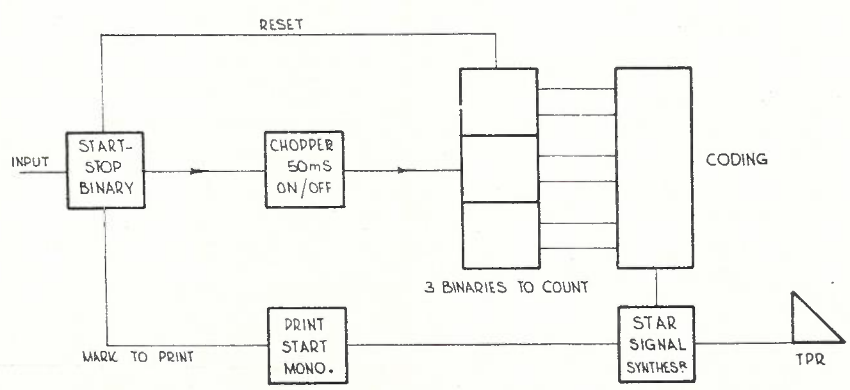


Fig. 9 — ASTRA's Start - Stop Binary Lets the Chopper Multivibrator Operate for the Duration of the Space Input Signal. Count binaries measure the length of the space signal.

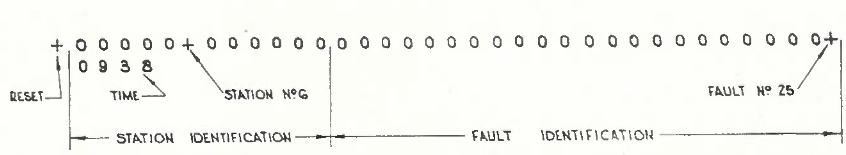


Fig. 10 — STAR Prints the Code 0 for 60 ms Space, a "+" if the Space is between 100 and 200 ms., and a CR and LF if the Space is Longer Than 200 ms.

made as to the length of the previous "space". The leading edge of the mark pulse therefore triggers the "Start to print" monostable and also resets the three binaries (count) to normal, to enable the next pulse length to be measured. A typical printed form of a pulse train is shown in Fig. 10. An automatic time signal can be readily provided if required. The equipment itself is called Automatic Series Type Teleprinter Readout Apparatus (ASTRA). See Fig. 11.

E-put Meter Readout

Method: An E-put meter (Beckman type 1760H) is used to determine the frequency (i.e. events/sec.) of an oscillator or pulse generator, or to measure time to the order of micro-second accuracy. The display is normally visual, but simultaneous with the visual indication a four wire binary code is also provided. "Count" and "Ready to read" signals are provided on a separate output. The general arrangements whereby STAR may be used in conjunction with the E-put meter are shown on Fig. 12.

The output of each E-put meter column is represented by four wires carrying plus or minus 30 volts and approximately 1 megohm source impedance. These are transformed into OV-12V output of impedance 10K ohms by 4 emitter followers per column and are energised by the programming equipment only when readout is in progress (E4-E5-E6). Also the four outputs of the emitter followers are connected to common equipment, which consists of four Schmitt trigger stages and does the translation between the E-put code and the binary code required by STAR. To provide the right amplitude pulses to the STAR, ten additional amplifier-inverters are used. The interconnection can be seen in the block schematic diagram (Fig. 13).

The operation starts when the E-put meter counts the events, and after one second operation it displays the result. At this moment the negative pulse provided on the "Ready to read" lead initiates the STAR operation. The programming equipment provides the first 160 ms duration pulse, which energises the sequence switched input stage and connects the output of the first column on the E-put meter to the translator which instantaneously selects the corresponding number to be printed out. At the same time the leading edge of the same 160 ms pulse starts the synthesiser and produces the correct telegraph signal character, which is accepted automatically by the Teleprinter. The second 160 ms duration pulse will energise the second column of the input stage and so on. Five columns can be printed in this way as the 6th and 7th pulse are reserved for carriage return (CR) and line feed (LF) signals and the 8th for the reset condition.

If the group count in the programming is set to produce one group per printed line, then the CR and LF signals are produced after each group is read, or they are produced on the end of the group where they are required. The group count steps once whenever the "Ready to read" signal is applied. When all the columns are read out, the visual display returns to 0 on all columns and the E-put meter starts again to count for the next one second duration.

It is obvious that whatever possible application the E-put meter has, STAR can provide a printed record of the measurement. The display time adjustment determines the sampling rate and the time required to print out the columns sets the minimum repetition time.

Examples:

(a) *Oscillator Stability Measurement.* An oscillator which is to be checked for frequency stability can be recorded with the E-put meter. The display adjustment is set to sample the frequency once every 15 seconds. Group reading is set to four group so that every row printed represents one minute. The E-put meter can then measure the frequency of the oscillator, indicating the changes in the function of time (1 row printed = 1 minute) automatically for as long as desired.

(b) *Crystal Oscillator Oven Regulation Check.*

When the oscillator is fairly stable (e.g. a crystal oscillator with oven control) then the E-put

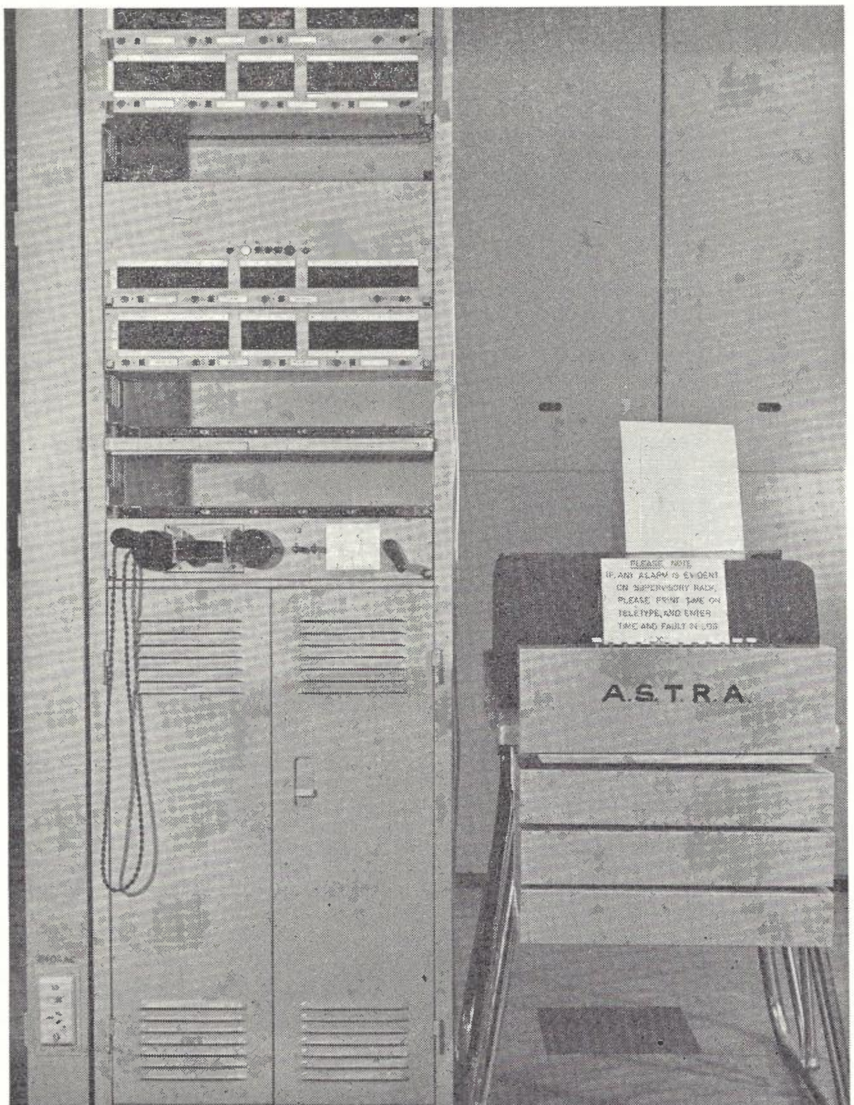


Fig. 11 — Coaxial Cable Carrier System Control Bay (on left) Showing Indicator Panel. ASTRA is mounted on the Teleprinter. On the vertical panel is the Electronic Keyboard. The horizontal panels contain the measuring equipment and programming, the signal synthesiser, power supply and electronic telegraph relay.

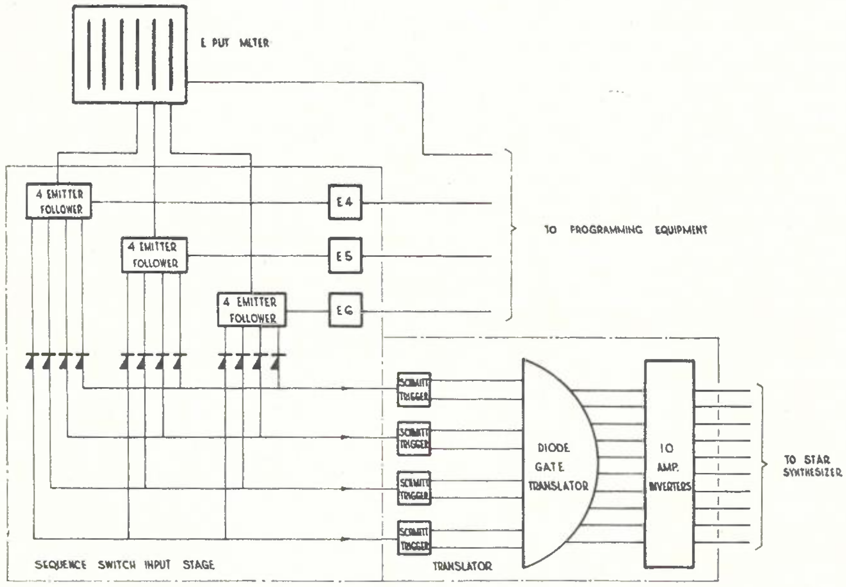


Fig 12 — E-put Meter Reads Out for Three Columns. Emitter followers impedance match the E-put meter to the transistorised device. They are energised by the command pulses from the programming equipment. The translator produces binary to decimal conversion for the character gate of the Synthesiser.

meter readings will not give sufficient information as the accuracy is ± 1 cycle/second. In this case the reading time can be extended to say 10 or 100 seconds per reading. The fractional cycle change per second then shows up clearly. For example if a 4000 c/s oscillator under test shows 4001-4000-3999 then it is probable that its frequency is 4000 and some decimals. Counting it for 10 seconds it may read 40002/10 = 4000.2 c/s or for 100 seconds 400028/100 = 4000.28 c/s. This is a measurement which can be done with the E-put meter only for the time involved. An operator should check on a stopwatch the approximate seconds and switch the meter from "E-put" to "Scan" and read out the results. This can be done automatically with STAR for any length of time without attendance. The programming unit has to be extended with an adjustable time delay circuit to replace the manual operation of the operator. Here again if the rate of reading is chosen to be say one reading/100 seconds then 8 groups in three rows will set up a 40 minute time scale and the effectiveness of the oven control can be easily measured.

(c) *The Statistical Distribution of the Isochronous Distortion.*
On a telegraph channel the statistical distribution of the distortion is usually measured with a "Distortion Analyser." The E-put meter is used as the basic measuring equipment (in "PER" condition). The sampling time is set with the display switch. On a continuous transmission the measuring equipment selects randomly a bit of the character and displays its duration. This should be a full number times the 20 ms unit signal when measuring only the space elements. A measurement of 22 ms or 18 ms therefore represents 10% isochronous distortion. Also 42 or 62 or 102 readings represent the same 10% distortion and so the first digit is not important. When STAR is used, the measured distortions are printed out one by one and a complete analysis is possible. On the conventional analyser the read out is provided with the use of subscriber meters and to enable distortion between 25% short or long pulses to be read, grouped into 2% distortion groups (0-2%, 2-4% etc.), 25 meters are required. The first conventional type analyser was produced by the British Post Office with 40 counters followed by the French PTT using 0.5% increments over a range of 25% distortion using 100 counters. With STAR operation no counter is used, and if a perforated tape is produced and fed into a digital computer, it could give the proper statistical distribution of the distortions in a minimum time.

(d) *Fault Location Using Propagation Time Difference Measurement.*
To locate interruptions on a long transmission path a narrow recording window can be produced in the middle of a speech channel with band pass-band stop filters. Two such recording paths on two different systems, operating on two different physical lines, cross-coupled at the far end terminal compose the measuring path for the fault locator. The observing station sends a continuous frequency (corresponding to the mid-band frequency of the window) into both paths and it will receive the same frequency back via the far end cross-coupling. The continuous signal so received is rectified and used as a holding current for a Schmitt trigger. If there is an interruption on the transmission path the loss of signal (or the signal fault) travelling in the direction of the observing station will arrive first. The "go" signal fault should go to the far end terminal and come back on the second system and arrive much later. The time difference between the front of these fault signals indicates the location of the interruption (See Fig. 14). It is clear that if the fault is near to the observing station, the incoming signal will present itself instantaneously and the go signal has to travel up to the terminal and back. Therefore this will give the maximum time difference. If the far end terminal produces a fault the go and return paths will be nearly equal and the measured time difference a minimum. All the other repeater stations will have a time difference, characteristic of their location. (The distance in this domain is a function of the L and C constants of the electrical circuit and not only the geographical distance). The time difference measured with E-put

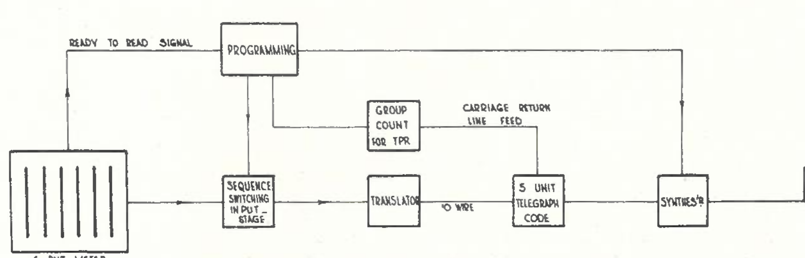


Fig. 13 — Block Schematic Diagram of the E-put Printout.

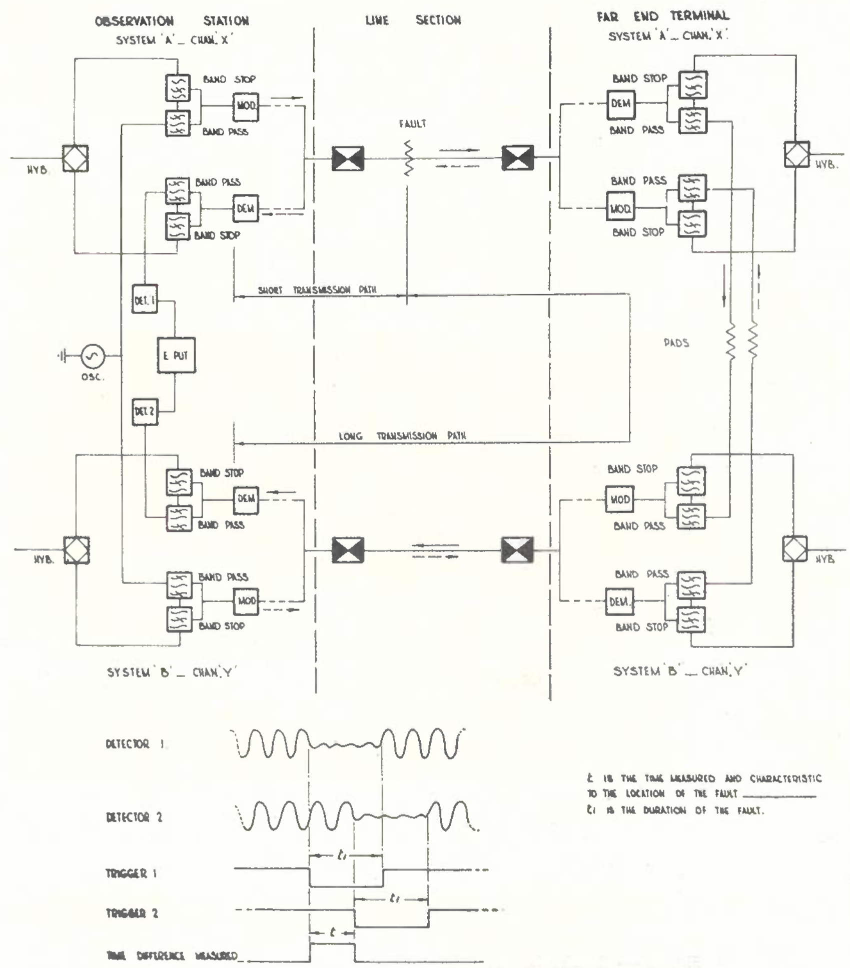


Fig. 14 — Voice Frequency Fault Location with Propagation Time Difference Measurement. Time difference measured with the E-put meter and printed out with STAR is characteristic to the locality of the interruption.

meter and written out with STAR will indicate the distribution of the interruptions according to their locations. The operation is completely automatic and continuous. Two systems are checked continuously and simultaneously.

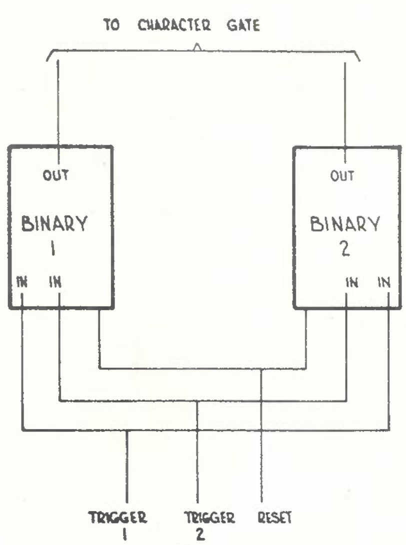
An added feature is the identification of the faults (i.e. if they are produced by the transmission paths of the first or second system) which is done with two binary stages. Both binaries have split inputs which are connected as shown in Fig. 15. If the fault comes initially from the first system it will switch the first binary only. The second signal coming from the second system will switch both binaries. Therefore the first binary will be back to the reset state and the second will be in a switched condition. When the fault signal comes initially from the second system, the second binary will switch and then the signal arriving later from the first system will switch the first binary on and second binary off. Therefore the equipment can differentiate between a line fault originating on the first system or on the second system. When a fault signal originates from a place where the transmission path is divided (i.e. repeaters or terminals) a so called "single path" fault exists. The E-put meter has a start pulse but no subsequent stop pulse is produced. In these conditions the E-put would count continuously and another subsequent fault signal only could stop it. To prevent this possibility an artificial stop signal is produced with a monostable so that it could not correspond to a measured location (say 90 ms if the maximum valid measurement is 50 ms). If now the counting period of the E-put meter is longer than 90 ms the artificially injected pulse of 90 ms will indicate that the fault is a "Single sided" fault and it should be located in a different way.

CONCLUSION

In maintenance work the trend is away from indicators that require individual attention as soon as possible (with the exception of urgent alarms) and towards indicators that provide a printed or marked record for analysis. The equipment described in this article provides considerable flexibility in giving an automatic record of measurements and it opens up many possibilities of maintenance control that are at present economically prohibitive.

ACKNOWLEDGMENTS

Special thanks are due mainly to Mr. R. D. Ellis, Divisional Engineer Trunk Service for his encouragement and assistance, also to Mr. K. R. Goode, who was responsible for mechanical construction of the equipment.



IN	B1	B2	PRINT
RESET	1	1	
TRIGGER 1	O	1	
TRIGGER 2	1	O	X −
RESET	1	1	
TRIGGER 2	1	O	
TRIGGER 1	O	1	−+
RESET	1	1	
E PUT TRIGGERS	1	1	X 1
FROM A.C. CHARGE	1	1	
RESET	1	1	

Fig. 15 — Truth Table Showing the Method of Discriminating which Trigger Stage Produced the First Input Signal and Hence Determining from which Carrier System the Interruption Originated.

A STUDY OF VIBRATION DAMAGE OF LEAD CABLE SHEATHING DURING TRANSPORT

*H. YANAGIUCHI and A. SHIMADA**

Editorial Note: This paper was first published in the "Dainichi-Nippon Cables Review", No. 27, August 1964. The problem of fatigue during transport of plain lead cable sheaths has been concerning the Australian Post Office for some time, and whilst the use of an alloy lead sheath would overcome the problem in most cases this solution is costly. Besides, it has not been possible to set other than arbitrary maximum limits on the distances over which plain lead sheaths can be transported by different means, and still arrive at their destination with predictably sound sheaths and future life expectancies under service conditions. There is virtually no published information on transport fatigue under actual transport conditions, nor simulated laboratory work under conditions which incorporate the ranges of variables experienced in practice. Interest in this problem led to a translation being made by Mr. L. R. Oates, of the Headquarters Translation Staff, and with the kind permission of Dainichi-Nippon Cables Ltd., and the authors, this translation is now published.

The study makes a valuable contribution to the known data on transport fatigue of lead, particularly in the field of factors affecting fatigue, the degree of contribution of these factors and the range of their variation and mean level. Of revealing importance is the delineation of expected strains, cycle frequency and the effect of winding tension. In Australia, communication cables are transported under gas pressure, very often at a high ambient temperature and over long distances and for this reason it is necessary to examine the effects of these factors before the work published in this article can be applied to local conditions. Work along these lines is now being planned and it is hoped to publish the results in a future article in this Journal.

INTRODUCTION

The effect of vibration on the sheathing of lead-sheathed cables becomes an important problem during transport over long distances. Cracks may then appear in the sheath as shown in Fig. 1. Since these cracks are produced along the circumference of the sheath, symmetrically on both sides, they are considered to be caused by fatigue due to repeated bending strain in the sheath. Thus a study of vibration during transport depends first on determining the magnitude and distribution of the strain produced in the sheath and the frequency, so as to appreciate the extent of fatigue in the sheath; after which a method of reducing this fatigue can be sought.

This Company has performed continued studies on this problem over the past two years, carrying out transport tests totalling 5,000 km, which are summarised in this report. During the experiments, the strain due to vibration and the winding slack developed were measured in relation to various methods of securing the cable during transport by road or rail of cables wound on drums. The method of road transport is shown in Fig. 2 and of rail transport in Fig. 3.

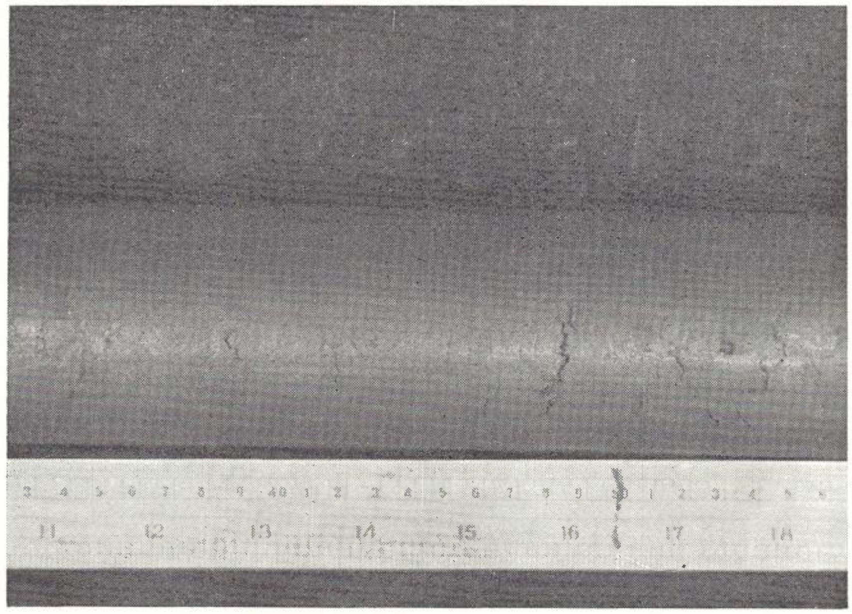


Fig. 1 — Cracks in Lead Sheath Due to Transport Vibration.

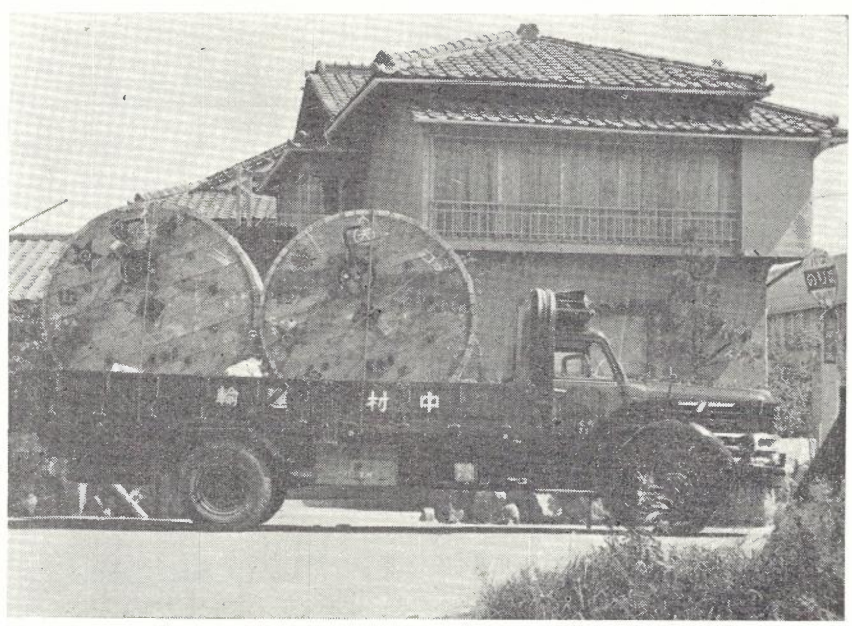


Fig. 2 — Cable Transport by Motor Truck.

* Messrs. Yanagiuchi and Shimada are with Dainichi-Nippon Cables Ltd.

TABLE 1: TABLE OF EXPERIMENTS

Test No.	Objects of Tests						Method of Transport			Transport Route
	Cable		Method of Securing				Road or Rail	Method of Loading		
	Size	Length (m)	Drum* dimensions DxdxW (m)	Winding Tension	Cross-Supports	Anchoring (one or both flanges)		Direction	Position	
1 — 1	3 x 250mm²	100	2.6x2.0x1.1	weak	without	one	road	lengthwise	centre	Hamakoshien
1 — 2								crosswise	centre	
2 — 1	3 x 80mm²	100	2.1x1.4x1.0	weak	without	one	road	lengthwise	front	Hamakoshien
3 — 1	3 x 250mm²	100	2.6x2.0x1.1	weak	without	both	road	lengthwise	centre	Amagasaki Kochi
4 — 1	1 x 600mm²	100	2.3x1.6x1.2	medium	without	both	road	lengthwise	front	Hamakoshien
4 — 2									back	Hamakoshien
4 — 3	1 x 600mm²	100	2.3x1.6x1.2	medium	without	both	road	lengthwise	front	Hamakoshien
4 — 4									back	Hamakoshien
5 — 1	1 x 600mm²	100	2.3x1.6x1.2	weak	without	both	road	lengthwise	centre	Hamakoshien
5 — 2									front	Hamakoshien
5 — 3									back	Hamakoshien
5 — 4					with	both	road	lengthwise	centre	Hamakoshien
5 — 5	1 x 600mm²	100	2.3x1.6x1.2	strong	without	both	road	lengthwise	centre	Hamakoshien
5 — 6									front	Hamakoshien
5 — 7									back	Hamakoshien
6 — 1	1 x 600mm²	100	2.3x1.6x1.2	weak	without	both	rail	crosswise	centre	Sanda Nagaoka
6 — 2	1 x 600mm²	100	2.3x1.6x1.2	strong	without	both	rail	crosswise	centre	Sanda Nagaoka
6 — 3	1 x 600mm²	200	2.3x1.6x1.2	strong	without	both	rail	crosswise	end	Sanda Nagaoka
6 — 4	1 x 800mm²	100	2.6x1.6x1.2	weak	without	both	rail	crosswise	end	Sanda Nagaoka
6 — 5	3 x 80mm²	100	2.3x1.6x1.2	weak	without	both	rail	crosswise	end	Sanda Nagaoka
6 — 6	3 x 325mm²	100	2.8x1.6x1.2	strong	without	both	rail	crosswise	end	Sanda Nagaoka
7 — 1	3 x 80mm²	170 ~250	(2.4~2.5)x1.6 x(1.2~1.25)	strong	with	—	rail	—	—	Umeda Niigata
8 — 1	3 x 325mm²	100	3.0x2.0x1.3	strong	without	both	road	lengthwise	centre	Amagasaki Shimonoseki
9 — 1	3 x 325mm²	170 ~290	3.0x2.0x (1.3~1.8)	strong	with	—	rail	—	—	Umeda Hakata Port

* D diameter of flange, d diameter of barrel, W width between flanges.

DETAILS OF TESTS

Items and Methods Used

Cables: Those used were 60-70 kV single-core and three-core lead-sheathed oil filled cables. Sizes and lengths are shown in Table 1.

Drums: These were wooden, with dimensions as shown in Table 1.

Winding on Drums: Winding on drums was divided into strong or weak winding tension as shown in Fig. 4.

Anchoring of Cable Ends: This was performed, according to the position of the cable end, either to one or both flanges, as shown in Figs. 5 and 6.

Cross-supports: Cases where cross-supports were fitted are shown in Table 1 and the method of fitting is shown in Fig. 7.

Methods and Distances of Transport: Transport was carried out both by road and by rail. Methods of loading and transport routes are shown in Table 1, and details of road surfaces, speeds, and distances in Table 2.

Items Measured:

(a) *Vibration Strain:*
Oscillograph recordings were made of stretching and compressing strain in the axial direction generated in the lead sheath. The measuring equipment used is shown in Table 3.
The fitting of resistance wire strain gauges is shown in Figs. 8 and 9. V-direction strain means that generated by motion in the drum's radial direction and H-direction strain means that generated by motion in the drum's axial direction.

(b) *Winding Slack:*
For this purpose, measurements were made of the cable sag and the cable end tension before and after transport.

EXPERIMENTAL RESULTS AND ASSESSMENT

Results: An outline of the results of tests is as shown in Table 4. The fundamental frequency of vibration strain is within the range of 3-6c/s, the average being 5c/s. The size of vibration strain is always expressed in whole amplitude. An example of vibration strain waveforms is shown in Fig. 10.

Distribution of Vibration Strain and Nature of Cable Vibration: The vibration strain in the cable is greater in the drum axial direction than in the radial direction, being particularly large in the lower half where the winding ends. The cable vibration mainly consists of a lateral deflection in the lower half of the drum, though this is found to be not simple but complex.

Size of Vibration Strain and Influencing Factors: Table 5 summarizes the results of studies on a number of factors thought to influence vibration strain. Vibration strain is considerably influenced by winding tension and the method of transport, these being shown

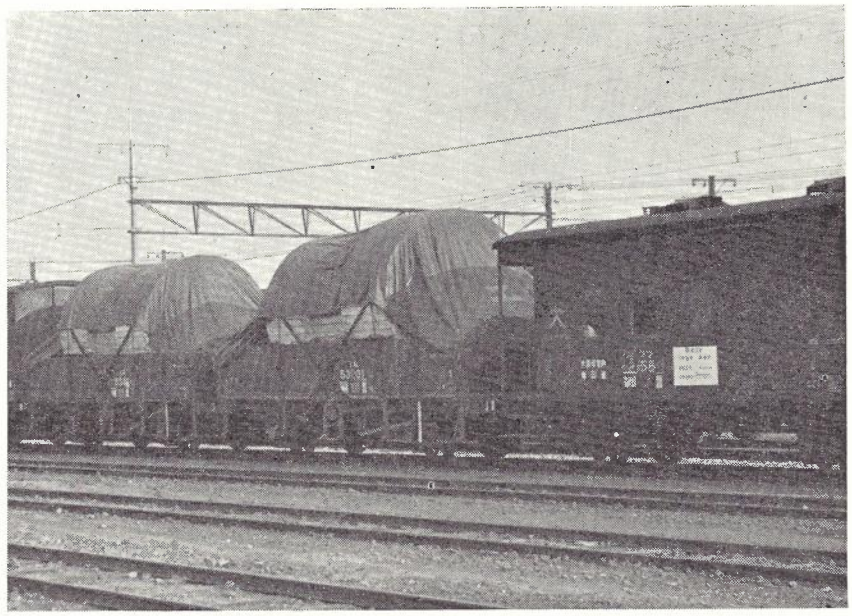


Fig. 3 — Cable Transport by Rail Truck.

TABLE 2: DETAILS OF COURSES RUN

Vehicle	Route	Surfaces	Standard speed (km/h)	Distance (km)	Test No.
Motor Truck (7.5 ton capacity)	Hamakoshien	dirt road paved road	35 40	4 4	1, 3, 4, 5,
	Amagasaki Kochi	dirt road paved road ferry boat	30 45 —	530 580 70	2
	Amagasaki Shimonoseki	paved road	45	1,100	8
Rail truck (4 wheel 15 ton capacity)	Sanda Nagaoka			1,480	6
Rail truck (bogie 35 ton capacity)	Umeda Niigata			590	7
Rail truck (bogie, 30 ton capacity)	Umeda Hakata Port			620	9

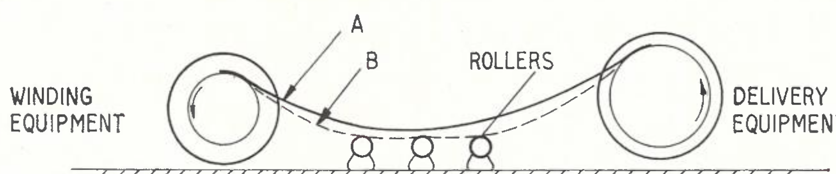


Fig. 4 — Drum Winding of Cable.

TABLE 3: VIBRATION STRAIN MEASURING EQUIPMENT

Instrument	Manufacturer	Model
Resistance wire strain gauge.	Shinko Tsushin	Type S21
Dynamic strain-meter	Shinko Tsushin	Type DS6MT
Electromagnetic oscillograph	San'ei-Sokki	Type 100-A

in graph form in Figs. 11 and 12. As is found from these figures, vibration strain is given approximately by the following formula which expresses the mean values of measurements having a large scatter:

$$k = 3ab\sqrt{v} \qquad (1)$$

where k : mean vibration strain of lead sheath (X10⁻⁶)

v : speed of transport (km/h)

a : coefficient determined by winding tension —
winding tension "strong" 1
winding tension "weak" 1.5

b : coefficient determined by method of transport—
motor truck : dirt road 5
paved road 2
rail truck : second class trunk 3
main trunk 2

The relationship between vibration strain and the distance of transport is as shown in Fig. 13, the strain showing a tendency to increase gradually with longer distances.

Permissible Vibration Strain in Transport and Distance Limitations: The permissible limit to repeated bending strain in lead sheaths is indicated in Fig. 4, page 97, No. 24 of the "Dainichi Cables Review."* Of the permissible limit, 10% is assumed to be expended in transport vibration and 90% to correspond to movement by heat cycles and vibration after laying, the transport vibration frequency, as previously stated, being on an average 5 c/s, assuming a running distance of 2,000 km and a speed of 30 km/h.

Thus the permissible vibration strain during transport of lead-sheathed cable is approximately 100×10^{-6}. Next, although the mean vibration strain in the lead sheath can be determined by equation (1) taking winding tension and the method of transport as factors, the relationship between the mean value given by equation (1) and the actual scatter, as shown in Figs. 11 and 12, is such that the maximum is approximately twice the mean. Thus, if the transport

*Reproduced here as Fig. 14.

TABLE 4: EXPERIMENTAL RESULTS

Test No.	Winding tension	Cross supports	Road or Rail	Frequently occurring large strain ($x10^{-6}$): Dirt Road speed 30km/h	Paved Road speed 45km/h	Second-class Trunks, speed 40km/h	Main Trunks, speed 60km/h	Cable end tension (kg): Before Transport	After Transport	Sag in relation to drum flange (mm)
1—1 1—2	weak	without	road	185 210	170 200					
2—1	weak	without	road	100	90					
3—1	weak	without	road	150	100					
4—1 4—2	medium	without	road	70 90	40 45			74	69	
4—3 4—4	medium	without	road	70 95	40 40			55	51	
5—1 5—2 5—3 5—4	weak	without	road	200 — 120	90 — 45			75	70	
		with	road	180	85			70	67	
5—5 5—6 5—7	strong	without	road	106 80 80	35 45 50			74	68	
6—1	weak	without	rail			115	90	68	31	
6—2	strong	without	rail			55	40	68	65	
6—3	strong	without	rail			65	45	120	48	
6—4	weak	without	rail			90	75	91	55	
6—5	weak	without	rail			85	85	95	35	
6—6	strong	without	rail			90	85	130	—	
7—1	strong	with	rail					90∼67	49∼37	0.4∼1.0
8—1	strong	without	road		40			120	110	2.8
9—1	strong	with	rail					160∼120	110∼57	0.5∼7.0

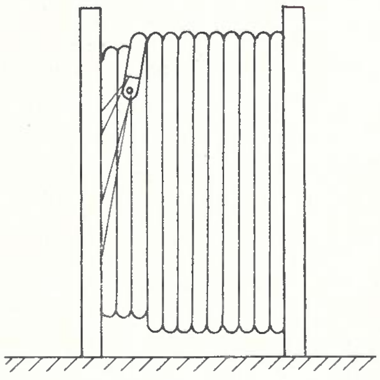


Fig. 5 — Cable End Anchored to One Flange.

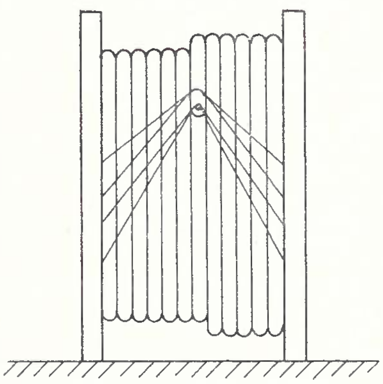


Fig. 6 — Cable End Anchored to Both Flanges.

vibration frequency, as mentioned above, is assumed to be 5 c/s the transport distance limitation, taking winding tension and the method of transport as factors, is as shown in Table 6.

Method of Securing: According to the results of tests, the following are the methods of securing for the prevention of fatigue in the lead sheath due to transport vibration.

(1) It is extremely important both to wind the cable tightly with a strong winding tension, so as to leave no gap underneath, and to avoid any slack in anchoring both ends of the cable.

(2) In anchoring the cable ends, there is no difference between the cases of anchoring to one or both flanges and so long as the anchoring rope is tight, there is no effect from its tension.

(3) There is a tendency for the wound cable as a whole to sag downwards, this appearing to be caused by deformation in the cable due to weight and to structural deformation and water content changes arising from

TABLE 5: FACTORS INFLUENCING VIBRATION STRAIN

Items Examined		Results	
Cable	Size	*	No data for decision because of masking by the influence of winding tension.
	Length	* *	200 m shows approximately 20% larger vibration strain than 100 m.
Method of Securing	Winding Tension	* * *	"weak" winding tension shows approximately 1.5 times the vibration strain of "strong".
	Anchoring	X	No difference as between one-and-both-flange anchoring. So long as the anchoring rope is tight, no difference is produced by its tension.
	Drum	*	A firm one is considered superior but there is no data for decision because of masking by the influence of winding tension.
	Cross-supports	* *	Approximately 10% less vibration strain for one example of "weak" winding tension.
Method of Transport	Means of Transport	* * *	Decided by the type of vehicle, road surface or line condition, the ratios of vibration strain are as follows:— Motor trucks: dirt road 5 paved road 2 Rail trucks: second class trunks 3 main trunks 2
	Speed	* * *	Vibration strain proportional to the square root of speed.
	Direction of loading	X	No relationship.
	Loading Position	*	Amount of vibration considered to have an influence according to position but no data for decision because of masking by the influence of winding tension.
Transport Route	Transport distance	* *	Cable sag produced by long distance transport while cable end tension also drops. Vibration strain increases approx. 30% by 1000 km transport.

* * * : an important factor.
* * : a factor.
* : considered to be a factor but could not be confirmed.
X : not a factor.

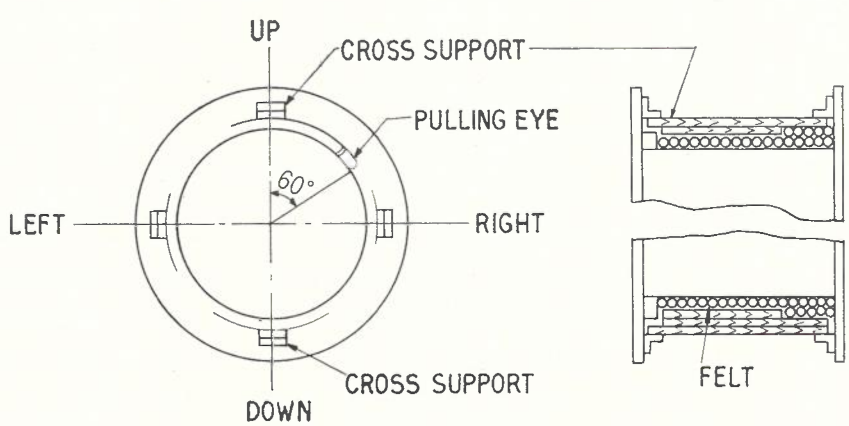


Fig. 7 — Cross-supports in Cable Drum.

the wooden material of the drum.

Method of Transport: According to the results of tests, the following are the methods of transport for the prevention of fatigue in the lead sheath due to transport vibration.

(1) Road transport on well-paved roads has roughly the same effect as rail transport on main trunk lines but, in the case of long roads of poor quality, road transport must be avoided in favour of rail transport.

(2) Among the rail trucks, bogie trucks are better than four-wheeled trucks.

(3) It is necessary to keep speed down on poor roads.

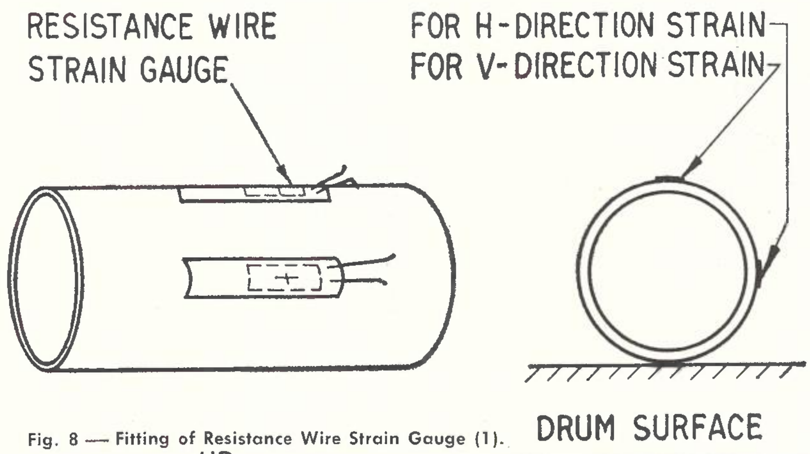


Fig. 8 — Fitting of Resistance Wire Strain Gauge (1).

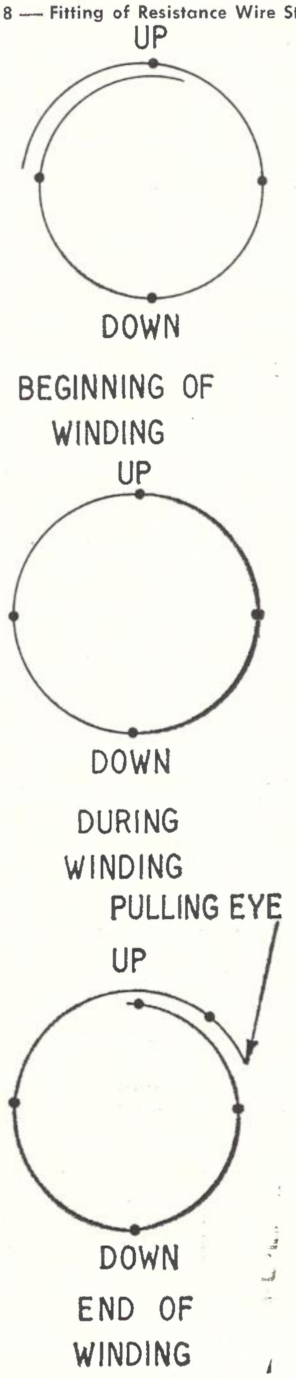


Fig. 9 — Fitting of Resistance Wire Strain Gauge (2).

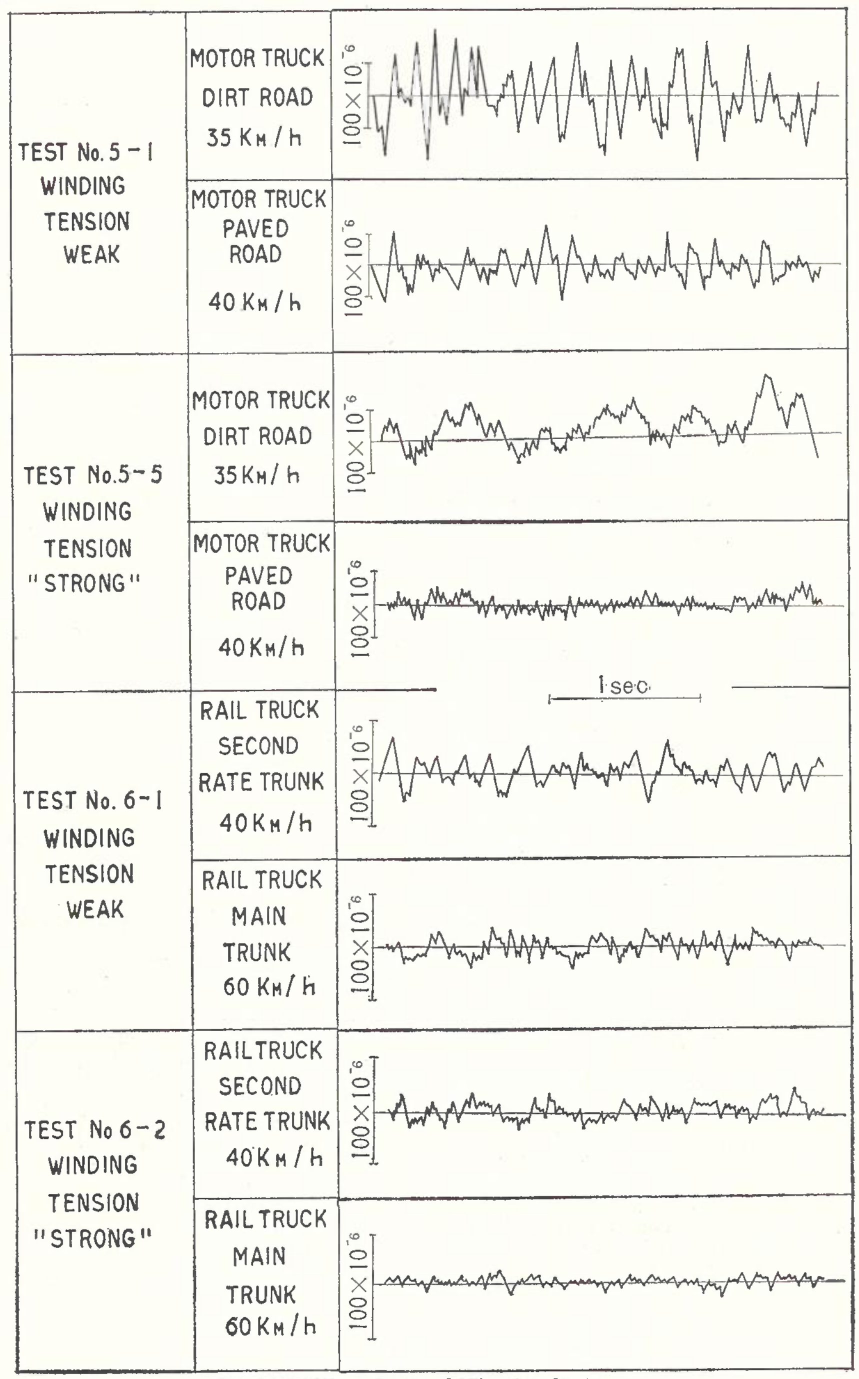


Fig. 10 — Wave Forms of Vibration Strain.

CONCLUSION

By conducting a series of studies on the transport of lead-sheathed cables, it has been possible to elucidate the general problems involved in transport. In the main, the starting-point was the susceptibility of lead-sheathed cable to fatigue due to vibration and, in this respect also, the superiority of aluminium-sheathed cable to lead-sheathed cable was again brought home.

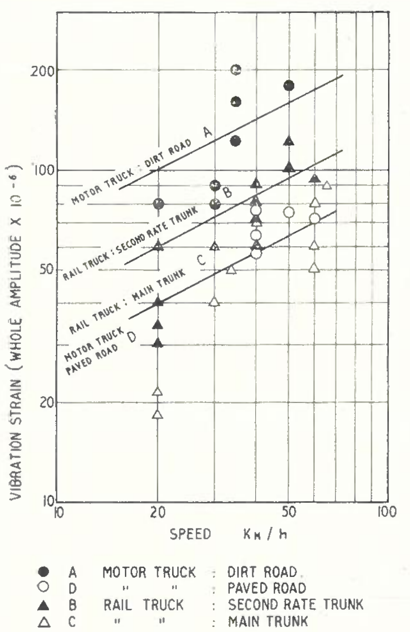


Fig. 11 — Relationship Between Vibration Strain and Transport Speed (1 : winding tension "weak").

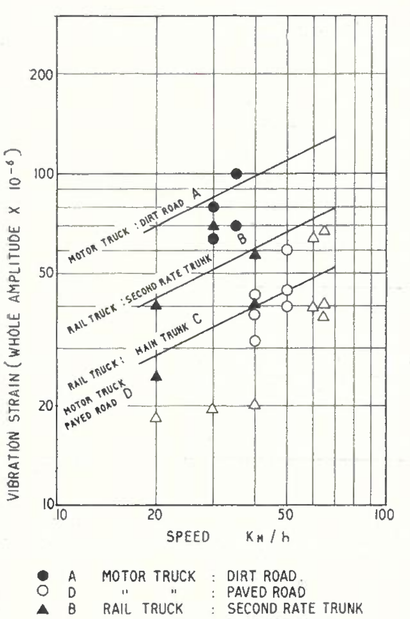


Fig. 12 — Relationship Between Vibration Strain and Transport Speed (2 : winding tension "strong").

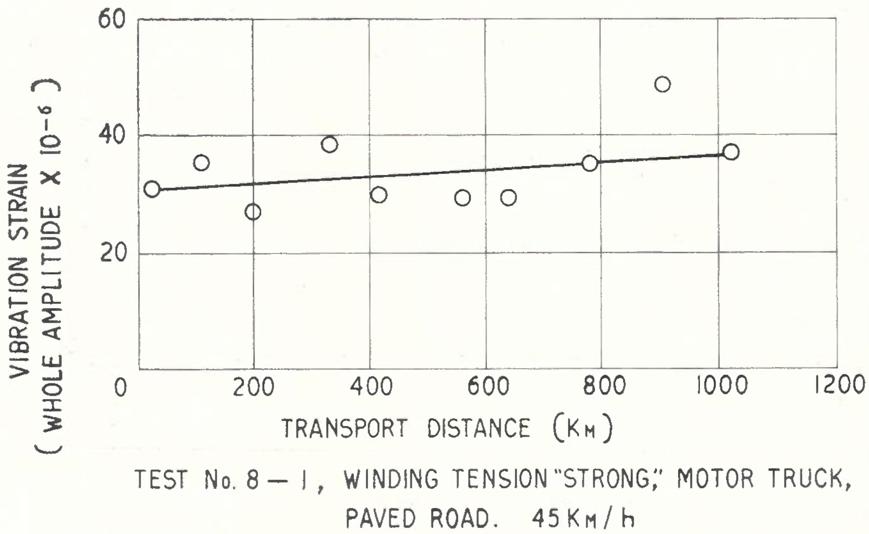


Fig. 13 — Relationship Between Vibration Strain and Transport Distance.

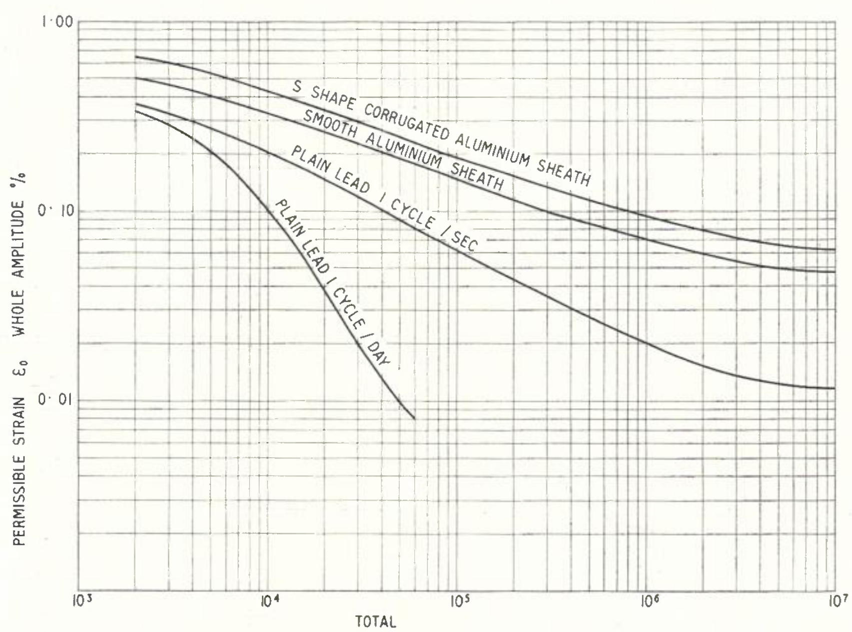


Fig. 14 — Graph of Permissible Strain.

TABLE 6: TRANSPORT DISTANCE LIMITATIONS

Method of transport		Winding tension	Strong		Weak	
Type of Vehicle	Road Surface or line condition	Speed (km/h)	Mean vibration strain (x10-6)	Transport distance limit (km)	Mean vibration strain (x10-6)	Transport Distance limit (km)
Motor truck	Dirt road	30	82	330	132	100
	Paved road	45	41	15,000	61	1,500
Rail truck	Second class trunk	40	57	1,800	86	330
	Main Line	60	47	10,000	70	1,000

A SUCTION DUCT RODDER

*J. GOODFELLOW, A.M.I.E.E., A.M.I.E. Aust.**

INTRODUCTION

The time and effort involved in rodding conduits preparatory to drawing in cables is long and tedious depending as it does on the laborious practice of screwing flexible lengths of rod end to end and manually pushing through the ducts. Mechanisation of this process with the development of rodding machines has been an improvement but the results have not been sufficiently effective to justify full scale application of the machines and inventive search for other means has continued. A new approach to mechanised duct-rodding has recently been made by using air in the manner of the conventional pneumatic tube suction conveying system. The efficient performance of a prototype machine has proved the design to be suitable as a functional rodding unit and twelve production models have been operating satisfactorily for over a year. Performance results have been excellent and even spectacular by comparison with previous rodding techniques; for example, conduits can be cleared of water, swabbed and a draw-wire installed in a matter of minutes.

Practical application has been made of the principle that a suction force at the entrance to a duct must increase along the duct to a maximum at the source of the suction; consequently, if a close fitting "dolly" within the entrance to a conduit is attracted by an induced flow of air, it will proceed along the conduit at increasing speed under the influence of the suction force. This feature demonstrates the advantage of a suction force by comparison with compressed air or systems of forced draught where the maximum force acts at the start of the run. With a blowing system the pressure along the conduit behind the "Dolly" reduces with distance travelled by the "Dolly" because of the friction losses involved in forcing the air through the small diameter duct and also because of the pressure losses resulting from air leakage at the duct joints. This latter effect is accentuated by the need for the "Dolly" to be a good closing fit within the conduit in order to obtain the maximum designed output pressure rating from the fan.

Fig. 1 — The Suction Unit

DESCRIPTION OF THE SUCTION RODDING UNIT

A centrifugal fan was chosen as the means of generating the induced draught using the inlet side of the fan connected by a flexible 4 in. diameter tube to a nozzle inserted into the conduit to perform as an exhauster unit. (Fig. 1). The nozzle serves the dual purpose of sealing the conduit opening and is designed to trap the "Dolly" on arrival under the force of suction. Where the presence of small stones or water is anticipated a 10 gallon polythene drum is fitted between the nozzle and the fan as shown in Fig. 2. The "Dolly" (Fig. 3) comprises two 4 in. diameter flexible suction cups held on the ends of ½ in. diameter aluminium tube by bolts screwed into the tapped inner diameter of the tube; a key ring is fitted at each end. To the rear end of this assembly a 50 lbs. breaking strain nylon fishing line is clipped by a heavy duty fishing type swivel. The line is stored on a 10 inch diameter reel adjustable for height on a vertical pipe fitted into a flat base on which the operator can stand to steady the reel against the pull of the line. This arrangement is shown in Fig. 4 and the convenience to the operator in being able to control the reel from the foot-path level will be appreciated. The photograph also shows the simple brake made up from thin steel to which has been rivetted a small pad of brake facing; this is essential to prevent over-running of the reel, and to control the speed of rotation which increases with the acceleration of the "Dolly" under the influence of the suction stream. To complete the accessories a line guide, (Fig. 5), is inserted into the conduit entry to protect the line from abrasive contact with the rough edges of the asbestos concrete pipes.

Simplicity is the main feature of the unit which was designed to be within the limits of portability. Accordingly,

* Mr. Goodfellow is Engineer Class 2, Automotive Plant, N.S.W. See Page 247.

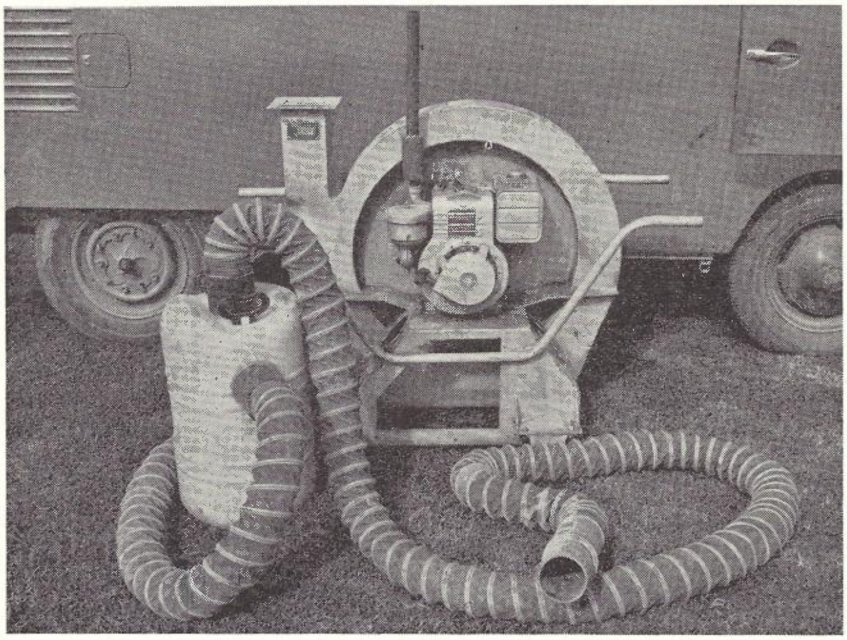


Fig. 2 — Rear View of Unit with Debris Trap

speed and then, taking the nozzle into the manhole, he can insert it into the selected conduits as required. To the operator at the other end of these conduits, the sound and feel of the suction force identifies the ducts into which the "Dolly" with the nylon line attached is to be inserted. The "Dolly" is pushed into the duct with the convex faces of the discs facing the suction force and released to the pull of suction which conveys the "Dolly" the entire length of the conduit to be collected in the trap of the nozzle. The "Dolly" is then unclipped from the line and re-clipped in the reverse position with the convex faces of the rubber cups facing the direction of the manual rewind and the draw wire or rope is attached to the free key ring; reversal of the "Dolly" is necessary to facilitate its passage back through the conduit. The draw-wire is then pulled through on recovery of the "Dolly" to the end into which it was inserted making it available again for the next conduit to be wired from the same manhole. Return of the "Dolly" in this way is only necessary where more than one conduit is to be wired.

the fan impeller was mounted directly on the motor spindle to save weight. This arrangement of close-coupling was made possible by the commercial availability of a 4 stroke petrol motor equipped with a roller bearing having a load rating of adequate capacity to handle the shaft loading of the impeller running at the designed engine speed. Direct mounting of the impeller on the motor shaft overcomes the need of a coupling, pedestal bearings and a clutch.

OPERATIONAL TECHNIQUE

The motor is started by pull cord and the flywheel action of the impeller allows the 4 stroke motor to pick up speed gradually and control of the speed responds readily to the hand throttle setting between idling and maximum revolutions of 3,200 r.p.m. As the suction force generated is greater than normally required it is seldom that the motor need be run at maximum revolutions; one operator can adjust the

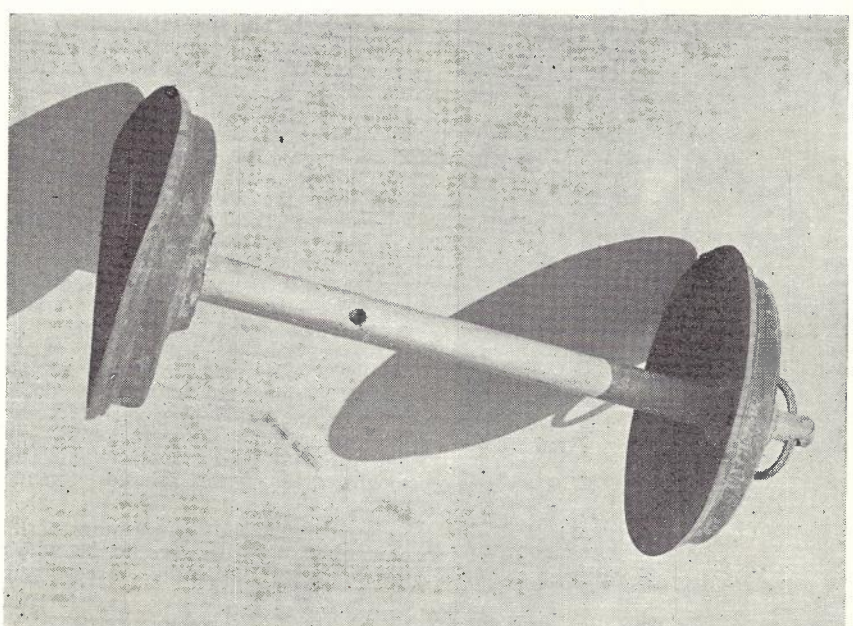


Fig. 3 — The Duct "Dolly"

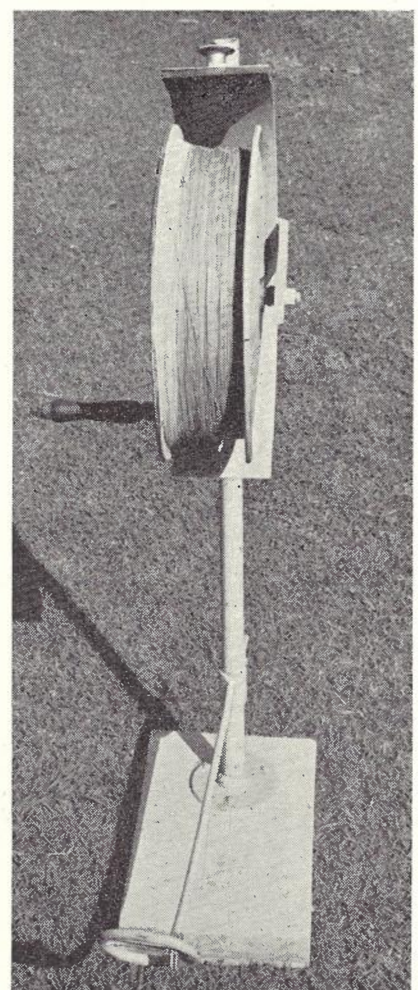


Fig. 4 — Line Reel and Stand

To stop the motor, the spark plug is shorted to frame and the machine takes a little time running down to rest. This inconvenience must be tolerated with close-coupling where the impeller is dynamically and statically balanced and the resultant kinetic energy of the fly-wheel effect drives the motor as a compressor when the ignition circuit is disconnected. To prevent cylinder wear likely to result from wash-away of the oil film by petrol vapour, the petrol is turned off in conjunction with shorting the spark plug.

Small portable radio transmitter/receivers have proved a most useful aid in this operation especially where partly blocked conduits are met with.

PERFORMANCE

Some measure of the effectiveness of the complete unit can be judged from a few field performance figures quoted as follows:

Time taken by "Dolly" to traverse between manholes.

- 4 inch earthenware pipes — 213 ft. — 30 seconds.
- 4 inch Asbestos Cement pipes — 145 ft. — 20 seconds.
- 4 inch Asbestos Cement pipes — 157 ft. — 22 seconds
- 4 inch Asbestos Cement pipes — 181 ft. — 67 seconds maximum, 21 seconds minimum.
- 4 inch Asbestos Cement pipes — 453 ft. — 3 minutes maximum, 32 seconds minimum.
- 4 inch Asbestos Cement pipes — 729 ft. — 44 seconds maximum, 38 seconds minimum.
- 4 inch Asbestos Cement pipes — 996 ft. — 45 seconds.

The times quoted as maximum occurred where blockages had to be removed by the "Dolly" and the minimum times refer to the second pass through the cleared conduits. The 3 minutes taken in one of the examples was due to removal of a substantial blockage of fibrous tree roots. Removal of blockages which halt the "Dolly" can usually be accomplished by pulling it back about two feet by the nylon line against the suction and letting it go again with the air stream for the number of times sufficient to dislodge the obstruction.

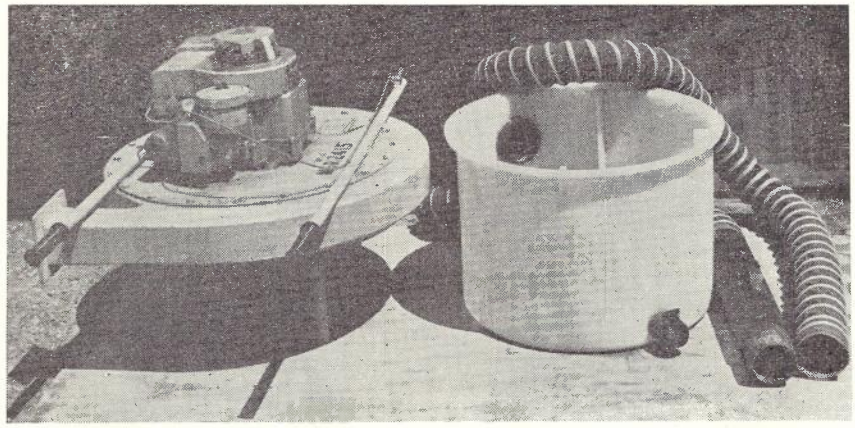


Fig. 6 — Modified Model

FURTHER DEVELOPMENTS

The effectiveness of the prototype model has justified the manufacture of a number of units to the same design to meet the outstanding needs for a machine of this type. However, development of the design has been continued to further simplify the unit and a Mark 2 model has given equal performance on field trials. This latest model is shown in Fig. 6 the improvements consist of eliminating one flexible tube and reduction in the weight of the fan unit. The fan impeller is arranged to run in the horizontal plane and is driven by a vertical assembly motor mounted directly on the fan casing to overcome the need of a mounting pedestal and wheels which are essential to the first prototype model with the fan running in the vertical plane. Lifting handles make the unit conveniently portable for two men to lift it on to the open top of a commercially available 15 in. high by 30 in. diameter polythene drum, the fan inlet being inside the drum and a good air seal obtained by soft rubber where the fan casing rests on the drums. The single spiratube with nozzle fits over a 4 in. diameter inlet located in the side and close to the top of the drum. Near the bottom of the drum a simple self-drainage flap valve is installed which remains closed under the influence of the suction force within the drum and opens when the level of water covers the flap or the speed of the engine is reduced.

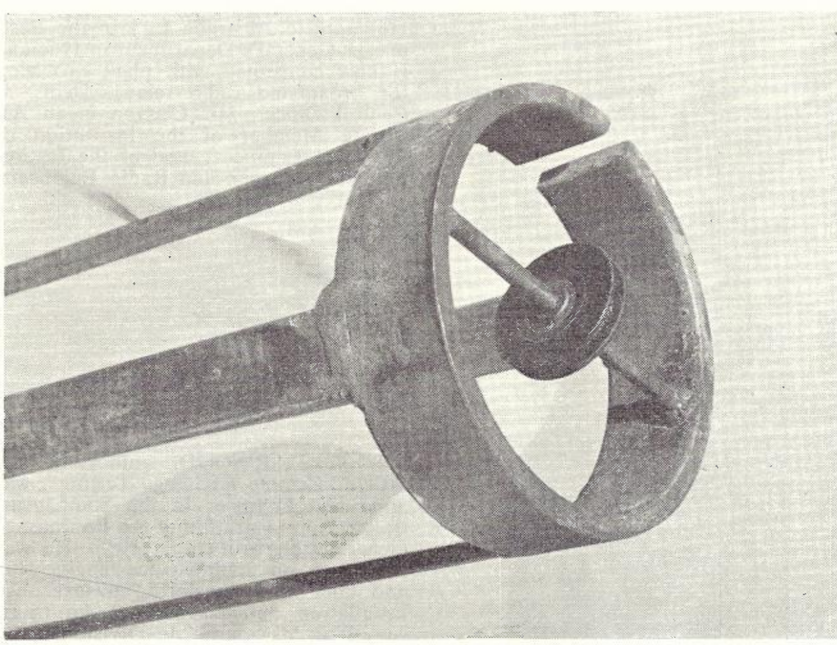


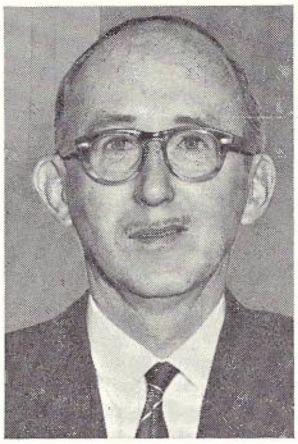
Fig. 5 — Line Guide

CONCLUSION

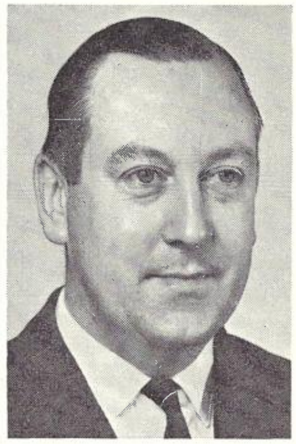
The unit as designed has demonstrated remarkable performance and if the need arises, it would be a simple matter to design a two-stage machine with a suction force capable of clearing ducts of all but the most permanent of obstructions. Accordingly it seems logical to assume that mechanical rodding machines will become obsolete for the installation of cable ropes in empty ducts and it is possible that the nozzle can be redesigned and the "Dolly" modified for traversing conduits where an additional cable is to be pulled in over existing cables.

Improvement in design of the unit would appear to be limited to points of detail and the simplicity of principle and arrangement makes it all the more remarkable that the practical application had not been developed years ago.

OUR CONTRIBUTORS



C. J. GRIFFITHS



E. R. BANKS

L. CLAYTON

C. J. GRIFFITHS, author of the article, "The International Telecommunication Union in 1965" is well known both within the Postmaster-General's Department, where he is First Assistant Director-General, Engineering Works, and on the international communications scene, where he is the 1965 Chairman of the Administrative Council of the International Telecommunication Union. Mr. Griffiths is leader of the Australian Delegation to the Montreux Plenipotentiary Conference and has had the honour of formally opening the Conference proceedings in this, the I.T.U. Centenary Year. (Details of Mr. Griffiths' career are to be found on page 166, Vol. 14. No. 2, October 1963 issue of this *Journal*).

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E. R. BANKS, author of the article, "The Technical Assistance Role of the Consultative Committees", is Assistant Director-General, Switching and Facilities Postmaster-General's Department. He is Chairman of the Special Autonomous Working Party on National Networks (G.A.S.I.) and Vice Chairman of Special Committee B in the C.C.I.T.T. (Further details of Mr. Banks' career are to be found on page 166, Vol. 14., No. 2. October 1963 issue of this *Journal*).

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R. E. BUTLER, author of the article "Australian Interests in the International Telecommunication Union", joined the Department as a Junior Mechanic. After various appointments as Clerk and Senior Industrial Officer he became, in 1960, Executive Officer to the Director-General with particular responsibilities for Legislative, Ministerial, Parliamentary and International Relations, including major external communication partnership matters. Mr. Butler qualified at the Royal Melbourne Technical College with an Associate Diploma of Public Administration, and is a qualified Accountant (Australian Society of Accountants). He has attended various sessions of the Administrative Council of the International Telecommunication Union and was a member of delegations which negotiated agreements for a global satellite communication system in partnership with the U.S.A. and other countries. He is a member of the Australian Delegation to the 1965 Centenary Plenipotentiary Conference of the I.T.U.

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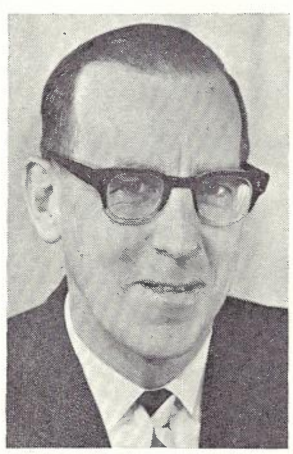


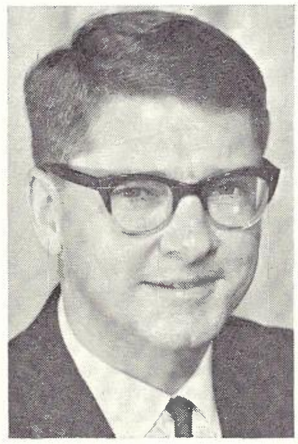
R. E. BUTLER

L. CLAYTON, author of the article "SEACOM: Design and Provision of Equipment for the Brisbane-Cairns Microwave System", was initially employed in England on the development side of the radio industry. After six years in technical branches of the Army, he went to East Africa in 1947 and during the next 12 years he served in various technical capacities with the Post Office, Police and Broadcasting Service. His work there covered a wide field including HF/VHF communications and MF/HF broadcasting, but he was particularly concerned with the development of an extensive police VHF system during and after the Kenya emergency. On returning to England in 1959, he went back to the radio industry to become a microwave systems planning engineer. He came to Australia to join the Postmaster-General's Department in 1964 and is now concerned with plant provision for broadband radio relay systems, at Central Office. Mr. Clayton is an Associate Member of the Institution of Electrical Engineers, and of the Institution of Electronic and Radio Engineers.

★

J. L. HARWOOD, author of the article "Remote Exchange Testing", was appointed Engineer in the South Australian Administration of the Postmaster-General's Department in 1945. He was employed on maintenance engineering and later was transferred to exchange installation duties. In 1949, he transferred to Melbourne as Divisional Engineer, Circuit Laboratory and later assumed control of circuit design services

J. L. HARWOOD



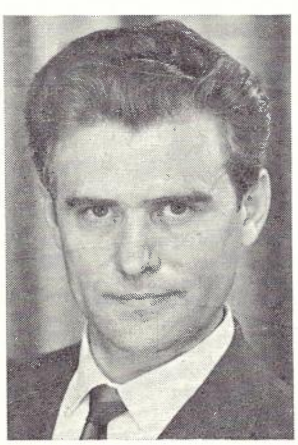
N. R. CRANE

A. DOMJAN

covering the main areas of telephone equipment. In 1956 Mr. Harwood was appointed to the Department of Supply, Weapons Research Establishment, where he was later placed in charge of the Electronic and Electrical Design Group in the Engineering Wing. In 1961 Mr. Harwood joined Electric Control and Engineering Limited, Sydney, as Manager of Research and Development. He is currently engaged in the development of new industrial electronic systems and their application in the various public utilities and major industries in Australia. Mr. Harwood is a Member of the Institution of Radio and Electronic Engineers, Australia and an Associate Member of the Institution of Engineers, Australia.

★

N. R. CRANE, co-author of the article "Automatisation of the Australian Telex Network, Part II", joined the Postmaster-General's Department in Adelaide as a Cadet Engineer in 1950. He completed the degree of Bachelor of Science at the University of Adelaide in 1953 and qualified as an engineer in 1955. During the years 1956 to 1960 he worked in the Telegraph Division Adelaide, firstly as an Engineer Grade I and later as a Group Engineer. These years saw many changes in telegraph activity, the most notable being a revised approach to maintenance practices and the mechanization of the public traffic network by the installation of TRESS; Mr. Crane was involved in both projects. In 1960 he was promoted as Divisional Engineer, Telegraphs, in Central Office. Until 1963 he worked in the subscriber and exchange service field and since 1963 he has worked on the Automatic Telex Project. In this latter capacity Mr. Crane recently visited L. M. Ericsson, Stockholm, for discussion of the design of switching, signalling and testing equipment to be provided in telex exchanges in Australia.



J. R. KROL

★

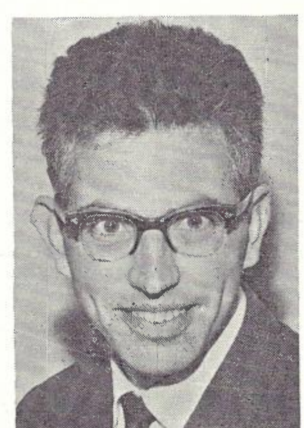
J. R. KROL, co-author of the article, "Automatisation of the Australian Telex Network, Part II", joined the Postmaster-General's Department in 1955 after having completed his Higher National Diploma in Electrical Engineering at The Polytechnic, London. From 1956 to 1957 he was with the Victorian Radio Section as Engineer Grade I, and subsequently transferred to the Sub-station Division in the Victorian Installation Section where he was promoted as Group Engineer. In October 1961 he transferred to Headquarters and is now attached to the Telegraphs Design and Installation Section.

★

A. DOMJAN, author of the article "Automatic Print out of Control Information", completed a Diploma of Electrical Engineering Course at the Budapest University of Technical and Economical Sciences, Hungary, in 1942. He migrated to Australia in 1951 and joined the P.M.G. Department as a Technical Assistant in 1956. In the following years he passed the open Technician Examination and became a Technician, Senior Technician and Acting Engineer on the staff of Long Line and Country Installation Division in Adelaide. In 1961, he passed the examination of the Institution of Engineers Australia and became a Graduate Member. In 1962 he was appointed Engineer Class 1, and later in the same year, transferred to Trunk Service Sub-Section in Adelaide, where he has been associated with Long Line Equipment Maintenance.

★

R. W. CUPIT, author of the article "Crossbar Tandem Switching in the Melbourne Metropolitan Network", qualified as an Engineer in the United Kingdom and is an Associate Member of the Institution of Engineers, Australia, and a Graduate Member of the Institution of Electrical Engineers. He joined the Postmaster-General's Department in 1957 as Engineer Grade I in the Internal Planning Section Victoria. He worked on the problems associated with development of numbering plans, and the introduction of crossbar equipment throughout the period from August 1957, to January 1964. He began acting as Group Engineer in April 1958. Since February 1964, he has been in charge of the Metro. Service Laboratory as Engineer Class 2, Metro. Network Investigations



R. W. CUPIT

ANSWERS TO EXAMINATION QUESTIONS

Examination No. 5364 etc.—3rd July 1965 and subsequent dates to gain part of the qualifications for promotion or transfer as Senior Technician (Telecommunications), Postmaster-General's Department.

TELECOMMUNICATION PRINCIPLES

QUESTION 1

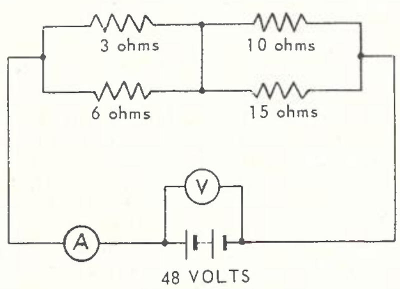
(a) Calculate the value of the single resistor that is equivalent to the four resistors shown below —

(b) The resistors are connected to a battery and meters as shown below—

(i) Calculate the current supplied by the battery.

(ii) Calculate the current flowing in each resistor.

(iii) The voltmeter reads 48 volts, but the ammeter is found to read 4 amperes instead of the calculated value. Give one possible reason for this.



ANSWER 1

(a) The resistors are arranged in two parallel arms joined in series.

The total resistance is —

$$R = \frac{3 \times 6}{3 + 6} + \frac{10 \times 15}{10 + 15}$$

$$= \frac{18}{9} + \frac{150}{25}$$

$$= 2 + 6$$

$$= 8 \text{ ohms}$$

(b) Assume that the battery has no internal resistance, that the ammeter has negligible resistance and that the voltmeter has infinite resistance.

(i) The current I supplied by the battery is —

$$I = \frac{48}{8} \text{ amp}$$

$$= 6 \text{ amp}$$

(ii) The p.d. across the 3 ohm and 6 ohm resistors in parallel —

= 6 x 2 volts

= 12 volts

∴ the p.d. across the 10 ohm and 15 ohm resistors is —

48 − 12 = 36 volts

The current in the 3 ohm resistor

$$\frac{12}{3} = 4 \text{ amp}$$

The current in the 6 ohm resistor

$$\frac{12}{6} = 2 \text{ amp}$$

The current in the 10 ohm resistor

$$\frac{36}{10} = 3.6 \text{ amp}$$

The current in the 15 ohm resistor

$$\frac{36}{15} = 2.4 \text{ amp}$$

(iii) Some reasons why the observed value of current is 4 amp, instead of 6 amp as calculated, are as follows —

(a) 3 ohm resistor disconnected. The parallel 10 ohm and 15 ohm resistors in series with the 6 ohm resistor would give a total circuit resistance of 12 ohms and a current of 4 amp.

(b) 15 ohm resistor disconnected. This would also give a total resistance of 12 ohms and a current of 4 amp.

(c) The use of an ammeter having a resistance of 4 ohm instead of one of negligible resistance as assumed.

Examiner's note on (iii): In all cases the reason given in the above answer are based on the total circuit resistance being 12 ohms instead of the calculated 8 ohms. While it may be possible for an ammeter to be wrongly calibrated, to have an incorrect shunt or to be "sticking" these reasons are not wholly acceptable. However, in the few cases where such reasons were given the examiner gave some credit. The majority of answers gave high internal battery resistance as the reason for the 4 amp reading. This cannot be accepted as the voltmeter reading is stated as being 48 volts. If the internal resistance of the battery was 4 ohms then the voltmeter would read 32 volts. Three marks were lost for an incorrect answer to this part of the question.

QUESTION 2

(a) When a piece of iron is subjected to a varying magnetic force the magnetism produced lags behind the magnetising force. This effect is termed Hysteresis. The figure below shows graphically the magnetic effects (typical hysteresis loop) produced in a piece of iron when it is subjected to a complete magnetisation cycle.

Describe briefly the REASONS for the pattern of variation in the state of magnetisation of the piece of iron as indicated in the two stages A—C—D—E and E—F—G—A of the hysteresis loop.

(b) Complete the diagrams below to illustrate the typical difference in the hysteresis loops for hard steel and soft iron.

ANSWER 2

The diagrams referred to in the question are to be found in the Course of Technical Instruction, Applied Electricity 1, paper 7, page 17, figures 27 and 28.

In this reference (para. 11.4) a complete answer to the question is given.

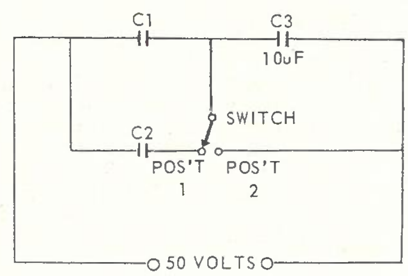
Examiner's note:

Many candidates lost marks in part (b) from careless sketching of the curve and not clearly indicating the **difference** in the hysteresis loops.

QUESTION 3

(a) List three main factors which vary the capacity of a capacitor.

(b) In the circuit below, when the switch is connected into position 2 the charge in C1 is 25 micro-coulombs. When the switch is connected into position 1 the charge in C3 is 100 micro-coulombs. Calculate the capacity of C2.



ANSWER 3

(a) Refer to the Course of Technical Instruction, Applied Electricity 1, paper 10, para. 5.1, page 6.

(b) IN POSITION 2. —

only C_1 is in circuit, therefore —

$$C_1 = \frac{Q}{E} = \frac{25}{50} \text{ micro-farads}$$

$$= 0.5 \text{ micro-farads}$$

IN POSITION 1 —

$$E \text{ across } C_3 = \frac{Q}{C_3} = \frac{100 \times 10^{-6}}{10 \times 10^{-6}}$$

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

E across C_1 = 50 − 10 = 40 volts

∴ Q (charge) in C_1 = E x C_1

= 40 x 0.5

= 20 micro-coulombs

But the total charge in C_1 in parallel with C_2

equals the total charge in C_3 (100 micro-coulombs)

∴ the charge in C_2 = 100 — 20 micro-coulombs

= 80 micro - coulombs

$$C_2 = \frac{Q}{E} = \frac{80}{40} = 2 \text{ micro-farads}$$

Answer — C_2 is 2 micro-farads

Examiner's note: Part (b) of the question was poorly handled by most candidates. The answers showed a lack of understanding of the division of voltages across a series/parallel arrangement of capacitors, and the relationship of the charge held by each.

QUESTION 4

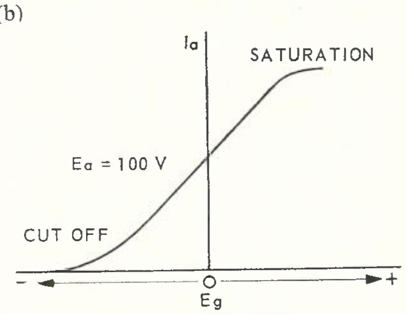
(a) Draw a circuit which can be used to plot the Characteristic Curve of a thermionic diode valve, and briefly describe how the circuit is used to obtain the readings necessary to plot the operating characteristics of the valve.

(b) Complete the sketch below to show a typical characteristic curve of a triode valve.

ANSWER 4

(a) For a complete answer to this part refer to the Course of Technical Instruction, Applied Electricity 1, paper 12, para. 3.5, page 6.

(b)



Examiner's note: Marks were lost in part (a) because of the following —

(i) variable heater volts were used to vary the anode current.

(ii) a circuit was given using an A.C. source of anode potential.

(iii) the question was mis-read and a circuit for a triode given.

The reference given above indicates the answer that should be given to this question.

In part (b) marks were lost because —

(i) the graph was not marked with Ia and Eg.

(ii) no value of Ea given.

QUESTION 5

(a) The vector diagram of a SERIES A.C. Circuit is shown below —

Calculate the following —

(i) The approximate voltage of the applied A.C. supply.

(ii) The resistance in the circuit.

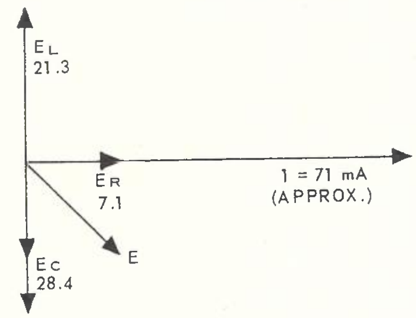
(iii) The inductive reactance in the circuit.

(iv) The capacitive reactance in the circuit.

(v) The Power Factor of the circuit.

(vi) The impedance of the circuit.

(b) List four of the principal factors which are characteristic of series resonant circuits in telecommunications.



ANSWER 5

(a) (i) $E = \sqrt{E_R^2 + (E_C - E_L)^2}$

$= \sqrt{7.1^2 + 7.1^2}$

$= \sqrt{50 + 50}$ approx.

$= 10$ volts approx.

(ii) $R = \frac{E_R}{I} = \frac{7.1 \times 1000}{71}$

$= 100$ ohms

(iii) $X_L = \frac{E_L}{I} = \frac{21.3 \times 1000}{71}$

$= 300$ ohms

(iv) $X_C = \frac{E_C}{I} = \frac{28.4 \times 1000}{71}$

$= 400$ ohms

(v) $\cos\theta = \frac{E_R}{E} = \frac{7.1}{10} = 0.71$

(vi) $Z = \sqrt{R^2 + (X_L - X_C)^2}$

$= \sqrt{100^2 + 100^2}$

$= \sqrt{2 \times 10^4}$

$= 100 \times 1.414$

$= 141.4$ ohms

(b) A complete answer to this part of the question will be found in the Course of Technical Instruction, Applied Electricity 2, paper 2, para. 7.13, page 18.

QUESTION 6

(a) List three items which are often included with a rectifier unit in addition to the essential components of a rectifying device.

(b) Complete the circuit shown below, which is part of a simplified circuit of an Auto Control Rectifier with D.C. Amplifier. Label parts where necessary.

ANSWER 6

(a) The additional items are listed in the Course of Technical Instruction, Telephony 5, paper 1, para. 3.2, page 3.

(b) The complete circuit referred to in the question is shown in Telephony 5, paper 1, figure 15 on page 11.

Examiner's note: Part (b) of this question was poorly answered. The question required the completion of the circuit by adding rectifiers, smoothing chokes and capacitors, and the D.C. amplifier and voltage reference. The main errors were —

(a) rectifiers shown incorrectly connected.

(b) no filter included.

(c) incorrect connection of the voltage reference.

2 marks were lost for each of the above errors.

QUESTION 7

(a) Briefly explain the purpose and operation of the circuit below, as it affects the standard relay —

(b) Illustrate the principle of the Long Shunt and Short Shunt type of Self Excited D.C. Generators by drawing a circuit sketch of each showing the armature, field rheostat and field winding arrangements.

ANSWER 7

(a) A typical answer to this question can be found in the Course of Technical Instruction, Telephony 2, paper 1, para. 9.2. The circuit referred to is shown in Figure 9.

(b) A typical answer to this question can be found in the Course of Technical Instruction, Applied Electricity 1, paper 8, para. 3.9.

Examiner's note: In part (b) marks were lost because of failure by some candidates to label the fields.

QUESTION 8

(a) Use is made of the Wheatstone Bridge principle in locating faults in telephone lines using the Varley Loop Test circuit. Draw the Varley Test circuit and briefly explain what tests and precautions are necessary in making a fault location for a short circuit or loop on a line. Assume that the degree of unbalance in the line is small enough to be neglected.

(b) A Transformer is used to step down the 240 volt A.C. supply to 6.3 volts for the operation of the heaters of five electron tubes which are connected in parallel, and each of which requires a current of 0.3 amps. Neglecting the effects of losses and the magnetising current calculate the following —

(i) the approximate turns ratio of the transformer.

(ii) the secondary current.

(iii) the primary current.

ANSWER 8

(a) A complete answer to this question will be found in the Course of Technical Instruction, Long Line Equipment 3, paper 2, pages 17 and 18. The main points are —

(i) to measure the loop resistance through the fault by the Wheatstone Bridge arrangement.

(ii) then to earth one side of the circuit beyond the fault and take a Varley measurement. If this reading is not zero it indicates the resistance of the fault.

The difference between the two readings gives the true loop resistance to the fault. From this the distance can be calculated.

(b) (i) $T = \frac{E_s}{E_p} = \frac{6.3}{240} = \frac{1}{38}$ approx.

(ii) $I_{sec} = 0.3 \times 5 = 1.5$ amp.

(iii) $I_{prim.} = T \times I_{sec} = \frac{1}{38} \times 1.5$

$= 0.04$ amp approx.

Examiner's note: Most marks were lost in part (a) due to candidates failing to realise that the loop on the line may be high resistance. If allowance is not made for this, serious error can result in calculating the distance to the fault.

QUESTION 9

(a) List four characteristics of semi-conductors which distinguish them from conductors and insulators.

(b) Draw a schematic diagram of a P-N junction crystal (semi-conductor) diode showing the donor and acceptor atoms, electrons, holes, regions with free current carriers and the depletion layer.

ANSWER 9

(a) The characteristics are listed in the Course of Technical Instruction, Applied Electricity 2, paper 12, para. 2.1, page 2.

(b) The schematic diagram is given fully in the same paper, referred to above, in para. 3.1 on page 6. This diagram is in greater detail than that expected in an examination.

Examiner's note: Very few candidates attempted this question. The answers received to part (a) scored poorly as the tendency was to describe the use of a semi-conductor as a rectifier.

QUESTION 10

(a) A parallel combination of pure inductance and pure capacitance is connected to an alternating voltage, the frequency of which is varied from zero to a frequency above resonance. On the diagrams below, sketch the graphs of the following —

(i) variations in the current in each of the inductive and the capacitive branches.

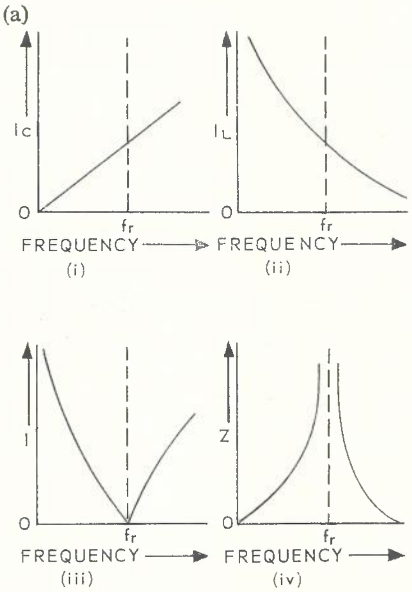
(ii) variations in circuit current.

(iii) impedance variations.

(b) Calculate the value of capacitor which must be connected in parallel with an inductor of 160 mH, so that the circuit is resonant at 4 Kc/s.

ANSWER 10

(a)



(b) $f_r = \frac{1}{2\pi\sqrt{LC}}$

$2\pi f_r = \frac{1}{\sqrt{LC}}$

$2\pi f_r = 2 \times 3.14 \times 4000 = 25000$ approx.

$25000 = \frac{1}{\sqrt{LC}}$

$C = \frac{10^6}{25000^2 \times L}$ micro-farads

$= \frac{10^6}{10^6 \times 25 \times 25 \times 0.16}$

$= \frac{10^6}{10^8} = 0.01$ micro-farads

Answer — 0.01 micro-farads.

Examiner's note: In part (a) the sketches were poorly handled, particularly for the variation in Z. The impedance is theoretically infinite at resonance. In part (b) many candidates lost marks because of careless working (arithmetic or logarithms) which could not be deciphered. Credit is given for correct method although the final answer may be wrong.

QUESTION 11

A battery of e.m.f. 6 volts and internal resistance 2.5 ohms, and adjustable resistor and an ammeter are connected in series. When the resistor is adjusted to 45 ohms, the meter reads 100mA.

(i) Calculate the resistance of the ammeter.

(ii) What value of shunt must be added across this ammeter in order that it still reads 100mA when 0.5 amp flows in the external circuit?

(iii) With the shunt removed, how could the ammeter be converted into a voltmeter to measure 100 volts for an indication of 100mA on the scale?

ANSWER 11

(i) Total circuit resistance $= R_t$

Ammeter resistance $= R_a$

$R_t = 45 + 2.5 + R_a = 47.5 + R_a$

$I = 100$ mA

$E = 6$ volts

$I \times R_t = E$

$\frac{100}{1000} \times (47.5 + R_a) = 6$

$R_a = \frac{6 \times 1000}{100} - 47.5$ ohms

$= 12.5$ ohms

(ii) The voltage across the meter is — 0.1 x 12.5 = 1.25 volts.

When 0.5 amp flows in the circuit then the voltage across the meter and shunt must still be 1.25 volts.

∴ Shunt resistor must carry 400 mA and have 1.25 volts drop across it.

$R_s = \frac{1.25}{0.4} = 3.125$ ohms.

(iii) The ammeter can be converted to a voltmeter by addition of a series resistor to restrict the current to 100mA.

Let R_v be the extra resistance to be added

$I = \frac{E}{R_v + R_a}$

$0.1 = \frac{100}{R_v + 12.5}$

$R_v = 1000 - 12.5 = 987.5$ ohms

Examiner's note: Most marks were lost in part (iii) because the 45 ohms of the variable resistor was deducted from the correctly calculated value of 987.5 ohms for the series resistor required.

QUESTION 12

(a) Draw the basic schematic circuit of a full-wave rectifier milliammeter.

(b) Rectifier milliammeters can be used without modification to measure currents up to full scale deflection value of the meter movement. State briefly what main principles must be considered in the following uses of this meter.

(i) measurement of currents with sharply peaked wave forms.

(ii) measurement of D.C. currents.

(iii) conversion for use as an ammeter.

ANSWER 12

(a) Refer to the Course of Technical Instruction, Applied Electricity 2, paper 6, para. 3.2.

(b) (i) The meter reads the average value of the rectified A.C., but the scale is calibrated to give EFFECTIVE value readings. The meter is only correct for sine waves and there will be an appreciable error when sharply peaked wave forms are measured.

(ii) When the meter is used to measure D.C. the readings will be 11% high. The reason for this is that the meter is reading average value of the current and this is the same as the effective value in the D.C. case.

(iii) Shunts are not used because the non-linear resistance characteristics of the rectifiers makes it difficult to maintain a constant relationship between the resistance of the shunt and the resistance of the meter-rectifier combination over the operating current range of the meter movement. A current transformer must be used.

Examiner's note: Part (a) was answered well, although some candidates lost 1 mark because the polarity of the meter was not marked. Part (b) was not handled well, particularly in section (iii). The majority of answers gave an explanation of the shunt. The answer above gives the reason why shunts are not used.

QUESTION 13

(a) With the aid of a series of graphical sketches, show how a square wave can be approximated by adding to a sine wave of fundamental frequency a number of odd harmonics (the amplitude of each component wave should be clearly indicated).

(b) State what waveform would be approximated if both odd and even harmonics are added to the fundamental frequency sine wave.

ANSWER 13

A complete answer to this question will be found in the Course of Technical Instruction, Applied Electricity 2, paper 4, paras. 1.4 and 1.5.

Examiner's note: The question gave an excellent lead to the answer required, however a number of candidates included even harmonics in their answer. Sketches were poorly executed and made it impossible for the examiner to give adequate credit.

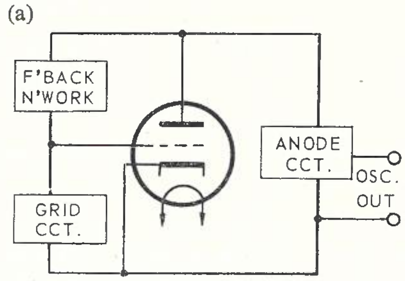
QUESTION 14

(a) Draw a simple BLOCK DIAGRAM of an oscillator circuit which shows the FUNDAMENTAL characteristics which are common to all types of electron tube or transistor oscillator circuits.

(b) Describe briefly the purpose of each of the component items of the block diagram given in answer to 14 (a).

ANSWER 14

(a)



(b) **FEEDBACK NETWORK**

Positive feedback or regeneration of sufficient energy to promote or sustain oscillation.

GRID AND ANODE CIRCUITS

A suitable arrangement of the circuit constants (L & C, R & C, or an electro-mechanical equivalent such as a tuning fork or crystal) to confine oscillations to the required frequency and to produce the desired waveform.

AMPLIFIER

Sufficient amplification (by electron tube or transistor arrangement) to meet the energy loss in the circuit and to provide energy to a load.

Examiner's note: This question was handled well by most candidates. A few marks were lost by some because a schematic diagram instead of a BLOCK DIAGRAM was given in answer to part (a).

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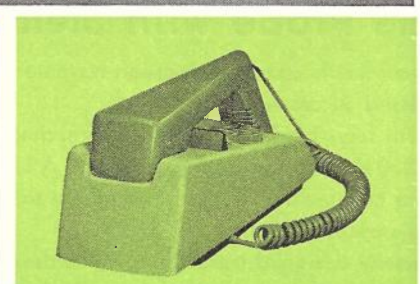

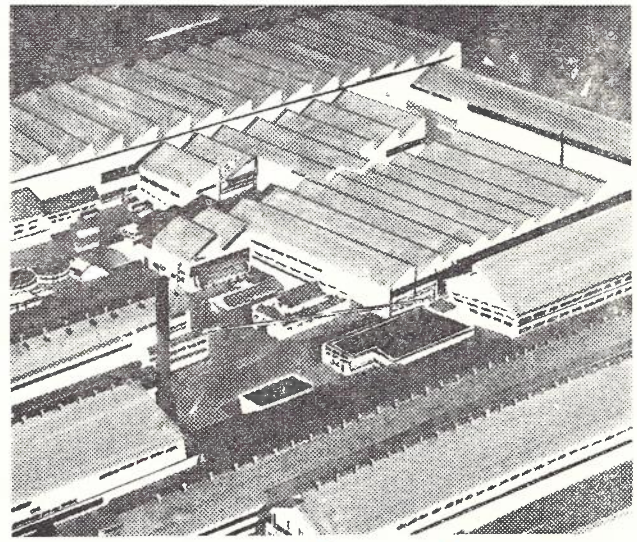

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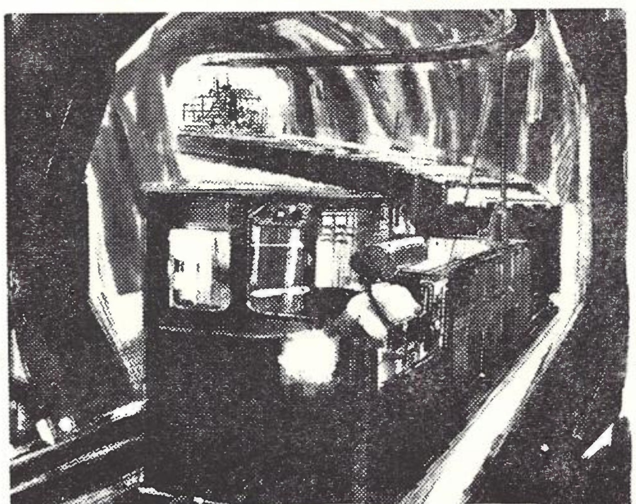

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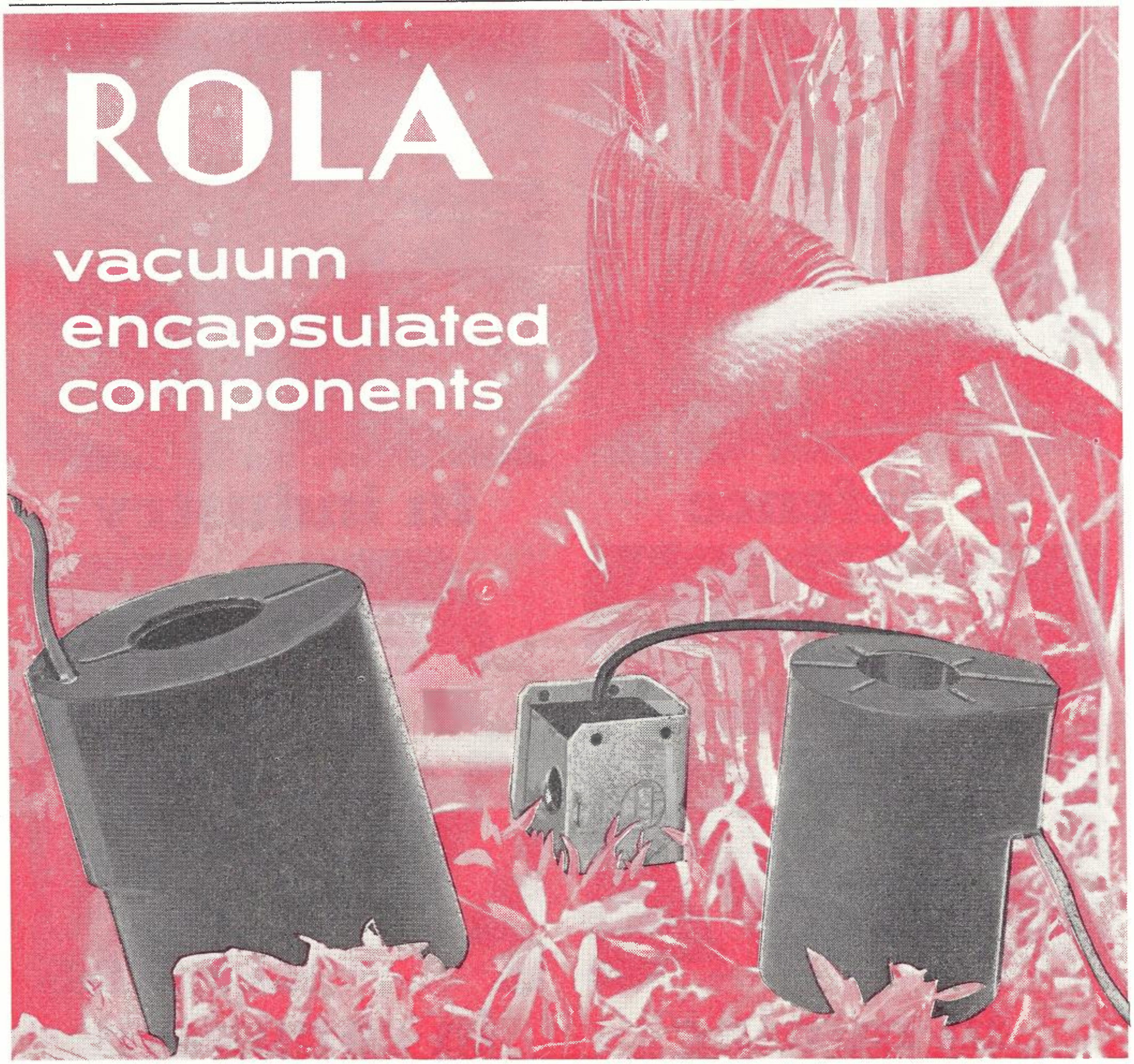
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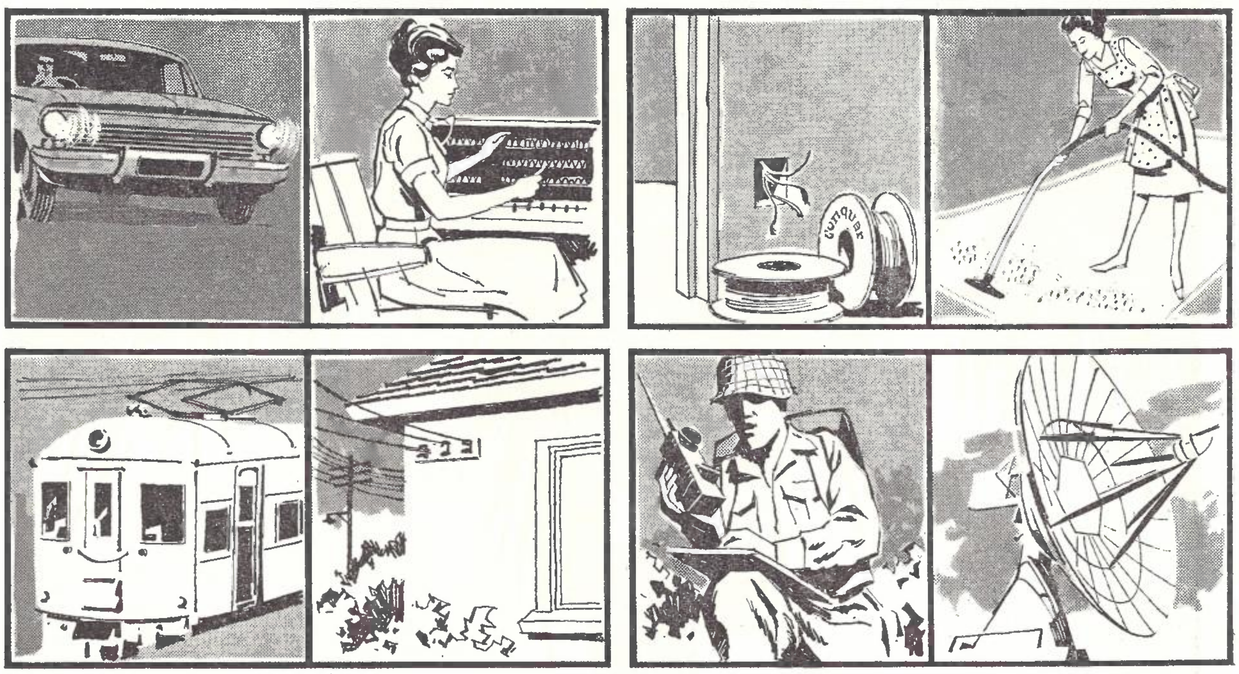

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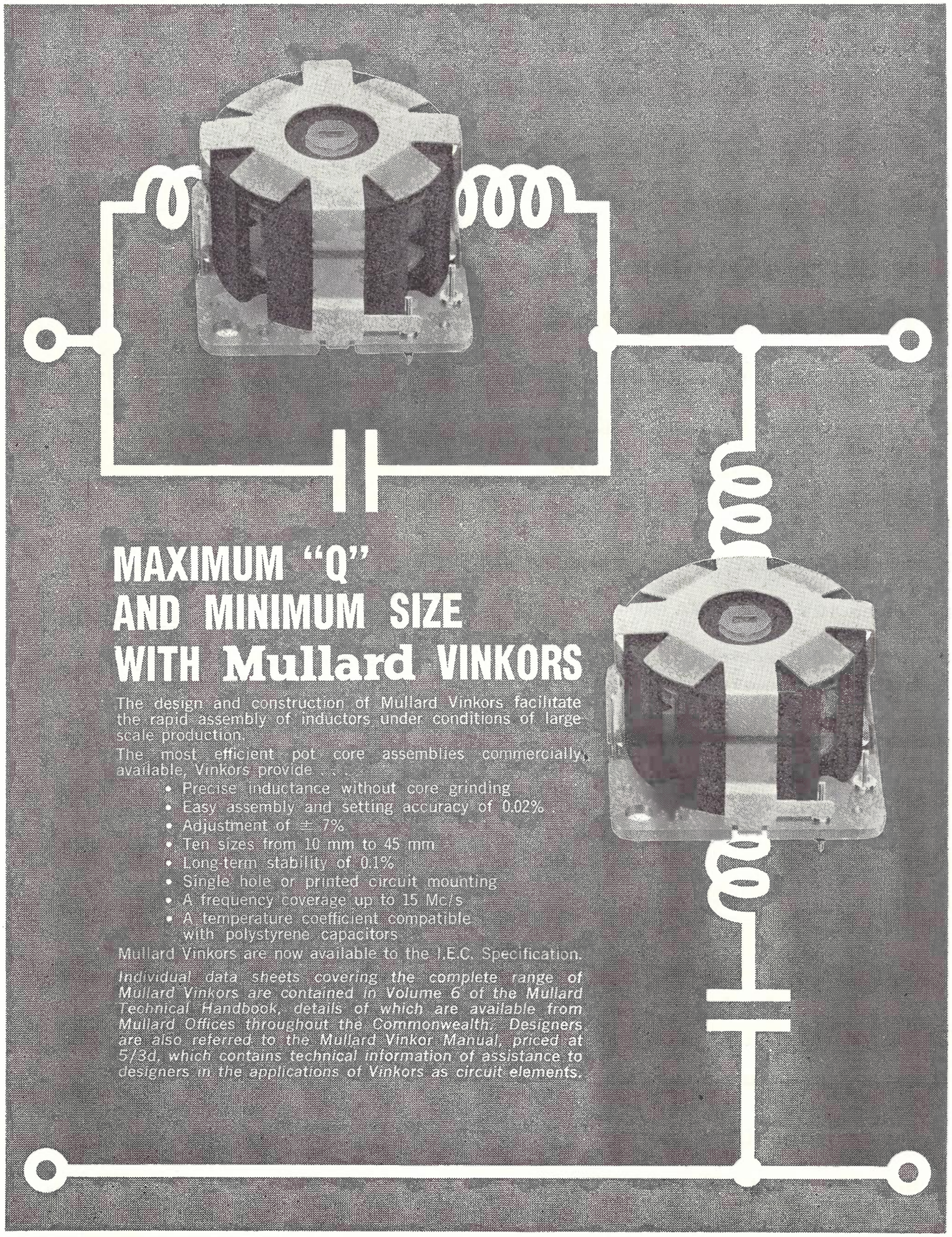

Mullard

Mullard-Australia Pty. Ltd.

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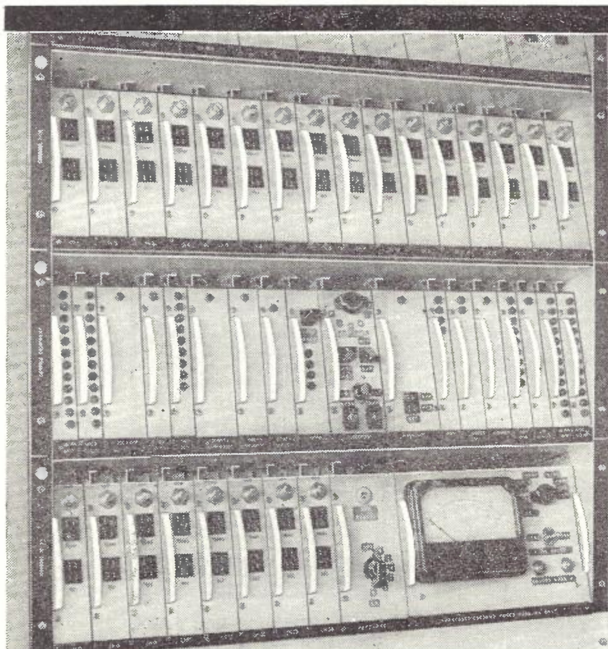
M166

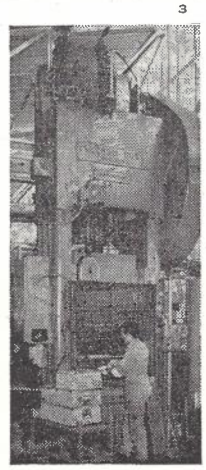


A 24-circuit P.C.M. terminal equipment

2

1

1. Aerial view of factory.
2. A section of the Relay Set wiring line.
3. In the press shop—Relay Set base manufacture.
4. A corner of the Line Transmission laboratory.



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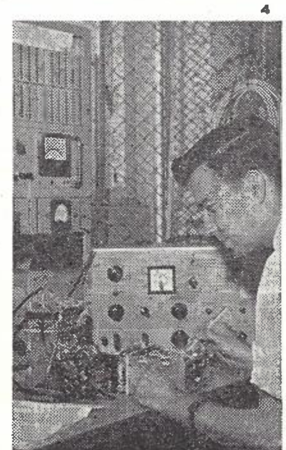

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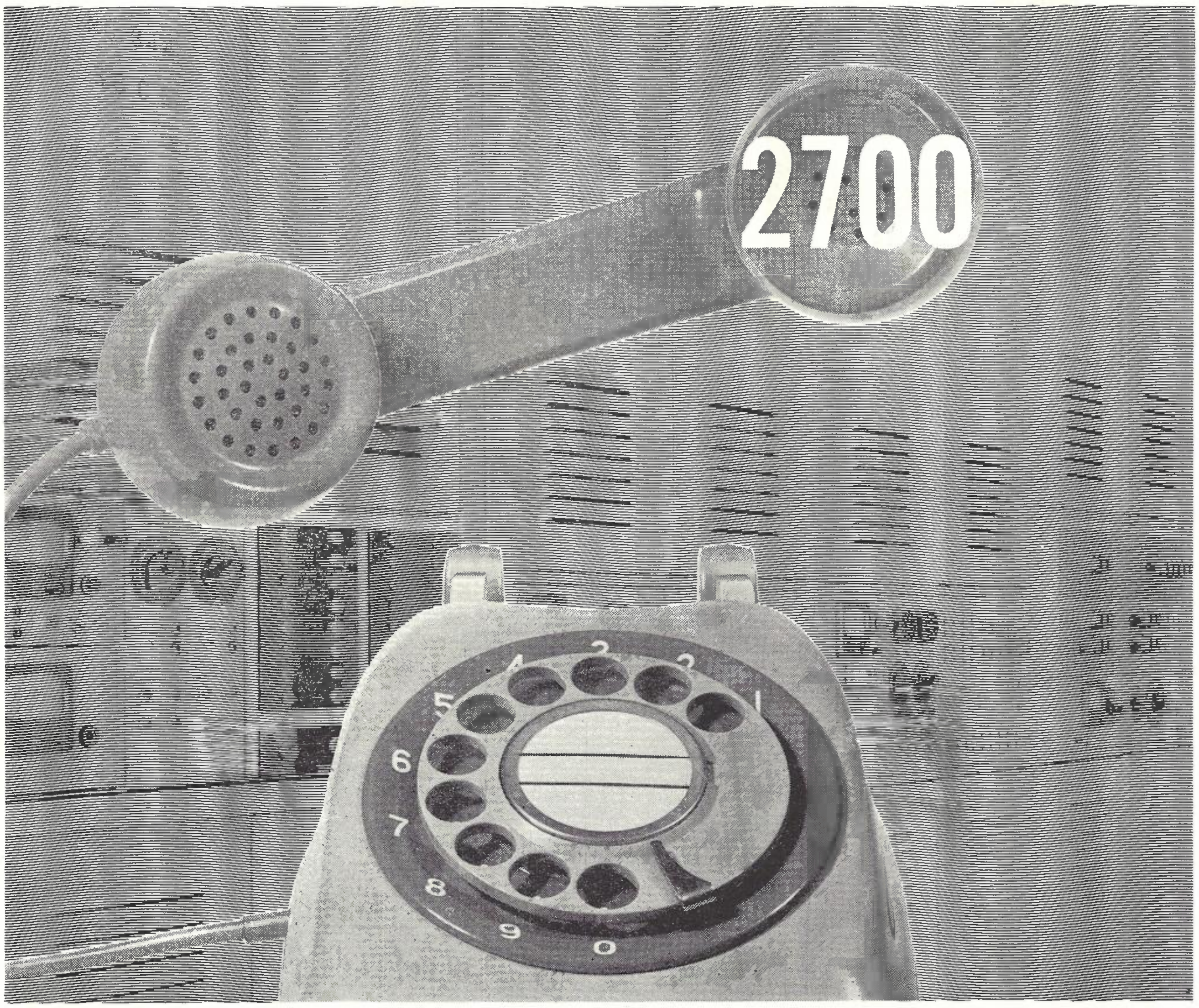
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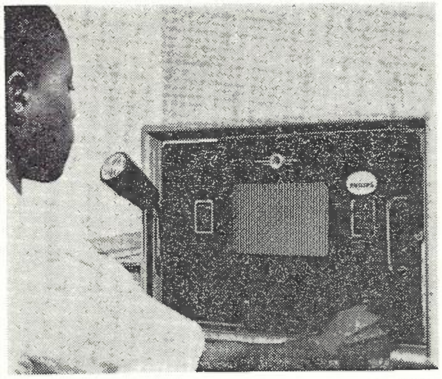
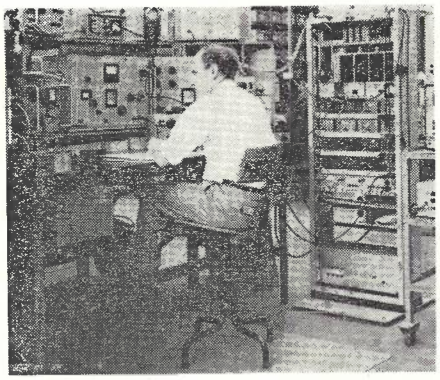
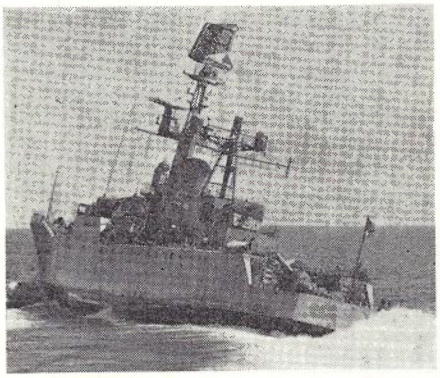
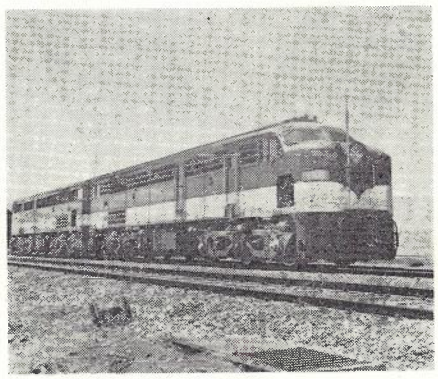
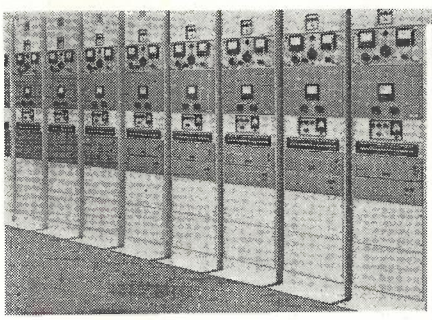



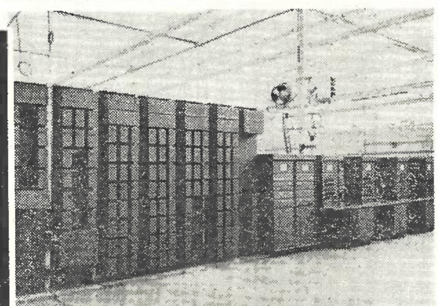
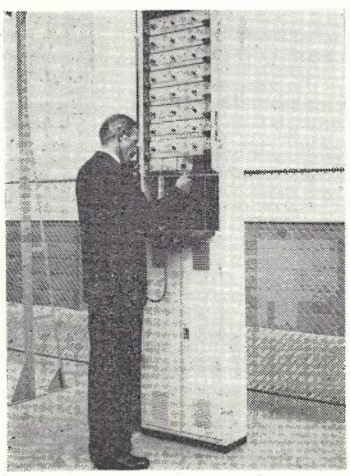
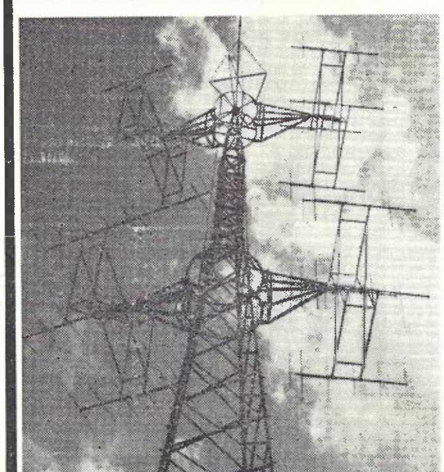


T C A

LEADERS IN THE COMMUNICATIONS FIELD

The wide range of Communications equipment designed and manufactured by T.C.A. caters for the individual needs of:

- **Radio Broadcasting**
- **Radio Communications**
- **Mobile Radio**
- **Radio Relay**
- **Radar**
- **Military Radio**
- **Telemetry & Remote Supervision**
- **Infra-red Detection**
- **Telephone Transmission**
- **Telegraph Switching**
- **Data Transmission**
- **Telephone Switching**
- **Electromagnetic Storage**
- **Weapon Systems**
- **Space Communication**

PHILIPS

TELECOMMUNICATION COMPANY OF AUSTRALIA PTY. LIMITED

A DIVISION OF PHILIPS INDUSTRIES PTY. LIMITED

BRISBANE 4 2471 **ADELAIDE** 51 6337 **SYDNEY** 2 0223 **PERTH** 21 7574 **MELBOURNE** 41 5368 **CANBERRA** 9 0321 **HOBART** 3 3088

ECE REMOTE TESTING SYSTEMS
Automatically Reduce Maintenance Costs

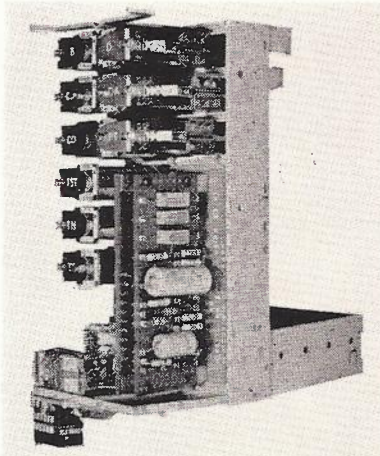
All standard line and equipment tests can now be carried out remotely by systems developed by E.C.E. for the Postmaster-General's Department.

For Metropolitan Exchange networks there is a centralised data transmission system which automatically operates testing circuits at distant Exchanges. For Rural Automatic Exchanges there is an automatic diagnostic tester which can be connected from the Exchange to the required line by dialling.

Both systems greatly reduce the problems of cost and availability of maintenance staff by making testing as fully automatic as practicable. The systems soon pay for themselves in reduced costs and, in addition, they improve efficiency and reliability of the telephone system.

The advanced design concepts used in the Metropolitan Exchange system have been partly derived from the Company's related activities in the design and manufacture of other TELSCAN systems. These are sophisticated digital systems for remote supervisory control and telemetry of utilities and industrial plant as well as remote exchange testing.

The latest techniques have been applied by engineering staff widely experienced in telephone systems, and this has made available modern and comprehensive test systems and equipment.



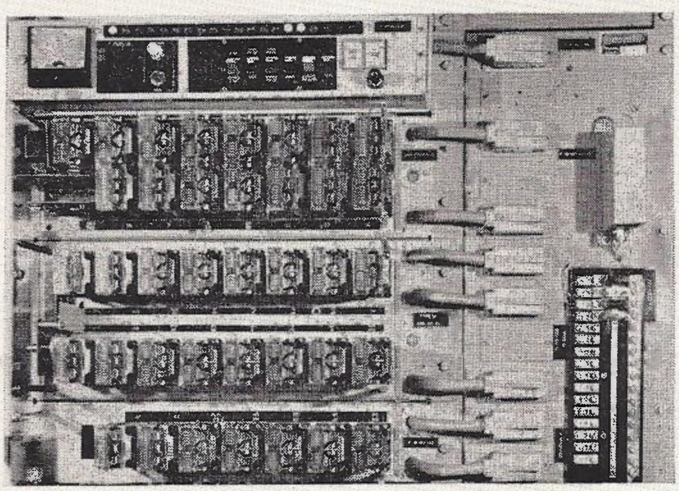
E.C.E. RAX Test Set

Remote Exchange Testing System

The E.C.E. system of Remote Exchange testing for Metropolitan areas enables comprehensive substation and subscribers' line tests to be carried out throughout each Automatic Exchange area from a Test Desk normally situated at a large Exchange in the area.

The efficiency of this centralised test scheme is achieved by the use of E.C.E.'s versatile TELSCAN digital data transfer system.

Completely centralised Metropolitan remote testing systems are now possible in rapidly expanding Metropolitan Exchange networks.



Remote Exchange Testing Equipment showing **TELSCAN** Relay Sets

Rural Exchange Test Set

This automatic test set for RAX use has been designed and produced by E.C.E. to enable Engineering staff to remotely test RAX exclusive and two-party subscribers' lines in rural automatic exchanges. It may also be used in conventional automatic exchanges where special access is available to the final selector.

An automatic test cycle is initiated when the Testing Officer dials the test level followed by the subscriber's number. Then test pulses of 1500 c.p.s. tone will be heard at three-second intervals, allowing time for identification and recording on a check list.

Pulse Length Monitor

The E.C.E. Pulse Length Monitor uses solid-state electronic timing circuits to check the length of make and break pulses on subscriber telephone dials more accurately than the conventional impulse speed, weight and counts tests.

The Pulse Length Monitor is incorporated in the E.C.E. Remote Exchange Testing equipment and is also available as a separate item for local exchange use.

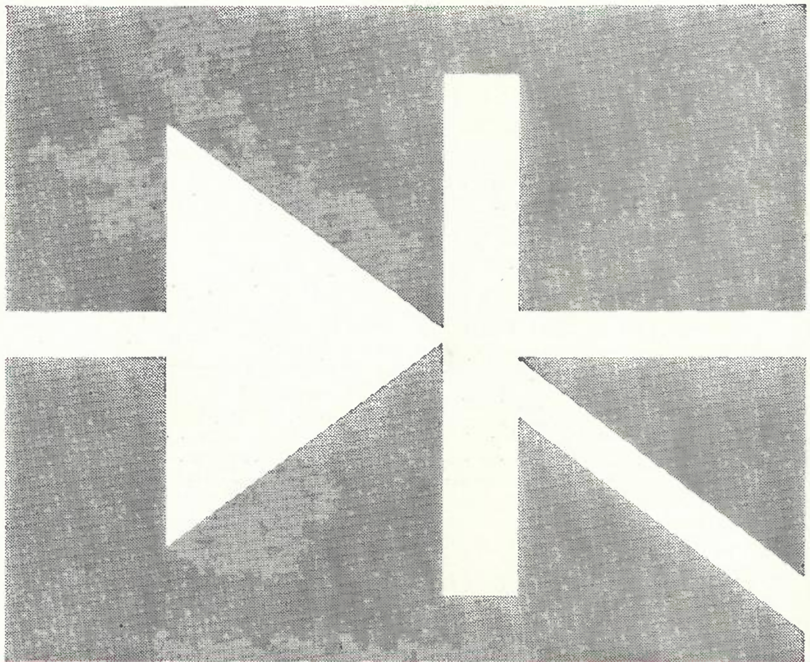
ELECTRIC CONTROL & ENGINEERING LTD.
SYDNEY AUSTRALIA

SILICON

CONTROLLED RECTIFIERS

Now available in a wide range . . . and in

PRODUCTION QUANTITIES



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.

The 2SF series silicon controlled rectifiers are available in extended voltage range and are identified by the following coding:

P.I.V.	300 mA	6.5A	11A	22A	55A	80A	200A
50	2SF101	2SF11	2SF21	2SF31A	2SF111	2SF121	2SF310
100	2SF102	2SF12	2SF22	2SF32A	2SF112	2SF122	2SF311
150	2SF103	2SF13	2SF23	2SF33A	2SF113	2SF123	2SF312
200	2SF104	2SF14	2SF24	2SF34A	2SF114	2SF124	—
250	2SF105	2SF15	2SF25	2SF35A	2SF115	2SF125	—
300	2SF106	2SF16	2SF26	2SF36A	2SF116	2SF126	2SF313
400	2SF108	2SF18	2SF28	2SF38A	2SF118	2SF128	2SF314
500	—	2SF200	2SF205	2SF210A	2SF120	2SF130	2SF315
600	—	2SF201	2SF206	2SF211A	—	—	—
700	—	2SF202	2SF207	2SF212A	—	—	—

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.**

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.

For further information on STC Silicon Controlled Rectifiers contact Industrial Products Division . . .

Standard Telephones and Cables Pty Limited AN ITT ASSOCIATE

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