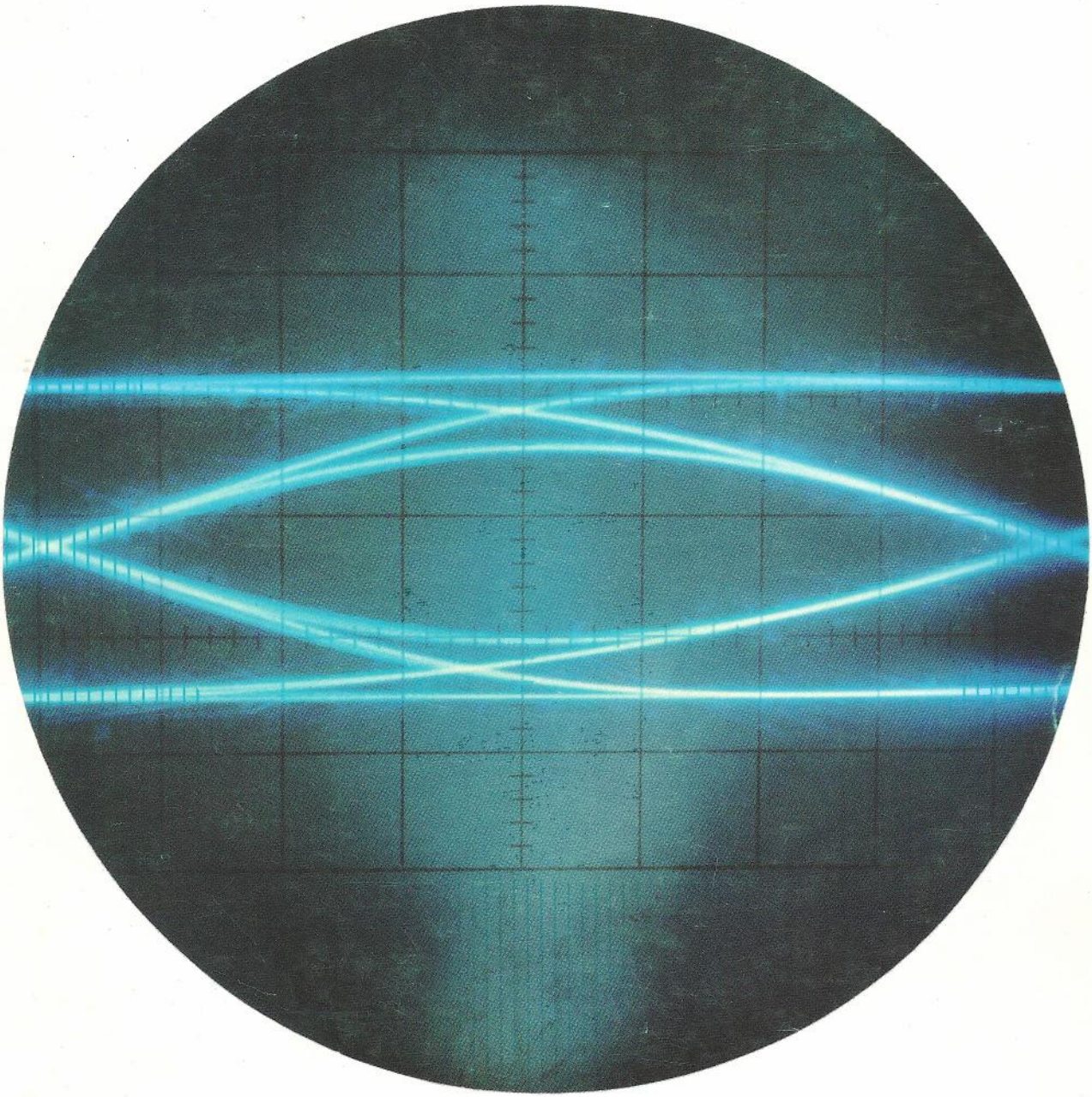
AUSTRALIAN POST OFFICE RESEARCH LABORATORIES



REVIEW OF ACTIVITIES 1970-71

AUSTRALIAN POST OFFICE RESEARCH LABORATORIES 59 LITTLE COLLINS STREET MELBOURNE 3000 AUSTRALIA

Foreword

The explosive growth of scientific and technical knowledge and the associated advance in telecommunications technology present unprecedented opportunities and challenges to the Post Office. If we are to take advantage of these opportunities and make an adequate and timely response to public demands for new and improved types of service, the Post Office must have advanced knowledge and expertise to understand the implications of relevant new discoveries and inventions and to apply them in the Australian situation.

The Research Laboratories have a major role in the provision of advanced knowledge and skill and maintain a position at the forefront of the science and technology of telecommunications by the conduct of research and development on problems and applications of special interest in Australia.

This Review of Activities presents an outline of some of the more important projects and activities by the Laboratories during 1970/71. The range and depth of these illustrate well, not only the calibre and performance of the staff of the Research Laboratories, but also the wide range of the scientific and technical matters that must be encompassed by the Australian Post Office as it meets the demands that are made on it.

I commend this Review of Activities to you.

J. L. Knott
Director-General

Contents

4 FUNCTIONS OF THE LABORATORIES

5 BRIEF HISTORY OF THE LABORATORIES

7 SOME HIGHLIGHTS OF THE YEAR

VISIT BY THE GOVERNOR OF VICTORIA

BUILDING PROJECT

RURAL TELEPHONE SERVICE BY SATELLITE

NEW TIME AND FREQUENCY SERVICE

13 SELECTED LABORATORY PROJECTS AND SERVICES

INTRODUCTION

14 SWITCHING AND SIGNALLING

- I.S.T. (Integrated Switching and Transmission)
- Applications of Microelectronics
- Common Channel Signalling — Trial of the C.C.I.T.T. Signalling System No. 6

20 DIGITAL TRANSMISSION

- General Features and Characteristics
- Pulse Code Modulation
- Digital Modulation of Radio Frequency Bearers
- A Pseudo Random Binary Signal Generator, Error Detector and Counter

27 VISUAL COMMUNICATIONS

- Transmission Aspects of the Television Telephone
- Digital Coding and Transmission Study for Monochrome T.V. Phone Signals

31 SPACE COMMUNICATIONS

- General Activities
- Rural Telephone Service by Satellite
  - Small Station Concept
  - Programme of Experiment
  - Subscriber Station Antenna Design

40 DATA TRANSMISSION

42 ECHO CONTROL
- Echo Suppressors
- Echo Cancellers

44 WIDEBAND TRANSMISSION MEDIA
- Coaxial Cable
- Waveguides

48 TELEPHONE INSTRUMENT DEVELOPMENT
- Alternative to Carbon Transmitter
- Development of a Long Line Telephone

52 MICROWAVE PROPAGATION STUDIES

54 PHYSICS, CHEMISTRY AND METALLURGY
- Metal Failure
- Fatigue Failure of Lead Sheathed Cable
- Corrosion
- Jointing of Large-Size Polythene-Sheathed Cables

59 MAIL HANDLING

60 LIBRARY ACTIVITIES

61 MISCELLANEOUS OTHER PROJECTS
- Tip Welding of Cable Conductors
- The PETRA Call Analyser
- Channel Doubling Equipment

65 **THE LABORATORIES AND STAFF**

ORGANISATION

PROFESSIONAL AND SENIOR STAFF

PAPERS, LECTURES, TALKS AND REPORTS BY MEMBERS OF THE STAFF

STAFF AFFILIATIONS WITH EXTERNAL BODIES

PATENTS

PRESENT AND FUTURE ACCOMMODATION

VISITORS TO THE LABORATORIES

OVERSEAS VISITS BY LABORATORY STAFF

ASSISTANCE WITH STUDIES

SPONSORED EXTERNAL RESEARCH AND DEVELOPMENT

FUNCTIONS OF THE LABORATORIES

The Research Laboratories of the Australian Post Office are a Branch of the Planning and Research Division of the Headquarters organisation. They are responsible for providing expert advice on trends in science and engineering relevant to the Post Office. They are responsible also for conducting applied research, development and design to assist in meeting requirements arising from the growth and diversification of the demand for Post Office facilities, and for investigating problems arising from the provision of those facilities.

In specific terms the responsibilities of the Research Laboratories are to:

1. Conduct basic and applied research in both natural and social sciences and engineering aimed at discovering new knowledge of telecommunications and postal services on topics relevant to operations in Australia and having regard to research known to be in hand overseas or in other Australian laboratories.
2. Conduct development and design of telecommunications and postal equipment and systems to meet Australian requirements, having regard to what is available from overseas and to the resources of local industry, and with a view to making Australia independent of overseas supply for major items.
3. Advise the Department and the Minister on trends in science and technology of relevance to the Department and participate in the formulation of appropriate policies and programmes.
4. Conduct investigations in areas of developing technology to provide the necessary expertise to assist in the definition of Departmental requirements in adequate terms, and in the appraisal of newly developed equipment offered by manufacturers.
5. Create and maintain the specialist staff and facilities necessary to ensure that investigations and developments are conducted at an appropriate level of scientific and technical competence, and to provide and maintain, as necessary, standards of adequate accuracy for weights and measures.
6. Encourage and in appropriate cases arrange research and development on telecommunications and postal topics by industry in Australia.
7. Encourage and support basic research on telecommunications and postal topics in universities and other centres of higher learning, and to encourage and support postgraduate training of engineers, scientists and others in these fields.
8. Provide a focus for research on telecommunications and postal topics in Australia and, by its own efforts, ensure that research in these fields enjoys a standing that will attract and retain a proportionate share of the research talents in Australia.
9. Encourage and develop liaison channels between the research establishments in Australia and overseas to ensure adequate co-ordination of policies and projects, and economy in the use of professional resources.

The research activities of the Postmaster-General's Department began in 1923 with a staff of one, a little equipment and an area of some 300 square feet. This was extended to a staff of two occupying 1,600 square feet the following year when the P.M.G. Research Laboratories were formally established as a separate section of the Department's Central Administration. The Laboratories now employ nearly 400 people, including 90 professionally qualified engineers, 25 physicists, chemists and metallurgists, 140 sub-professional technical staff. The remainder of the staff is employed on non-technical duties. The value of equipment has grown from about $6,000 in 1925 to a nominal replacement value today in excess of $6,000,000.

The Laboratories were established initially to assist the Department with the introduction of the new techniques of amplification, carrier transmission and radio that were becoming practicable as a result of the development of the electron tube, and one of the first functions was the investigation of the transmission aspects of trunk line communications and voice frequency repeaters. This transmission work soon developed and changed emphasis as the Department turned to three and later twelve channel carrier equipment as being more suitable for the provision of trunk telephone circuits in Australia. Tasmania was linked to the mainland in 1935 by means of a coaxial submarine cable, Victoria-King Island-Tasmania; each cable section being just under 100 miles long. This cable was the first of its kind in the world, and operated up to 40 kHz. In 1954 the bandwidth was increased to 108 kHz by the installation of special 100 W amplifiers, and other equipment designed and constructed in the Laboratories, enabling the cable to carry 15 VF Channels.

In 1928, the Laboratories extended their activities into the problems facing the establishment and operation of the National Broadcasting Service, and were concerned with these problems up to the late 1930's. At the end of 1936, eight stations were operational and new aerial designs and fabrication techniques had been developed in the Laboratories. Also in 1928, they had constructed the first experimental short wave station at Lyndhurst, and in the late 1930's were instrumental in the provision of design assistance for the setting-up of the international short wave broadcasting station at Shepparton (Radio Australia).

Just prior to the 1939-1945 War, the Laboratories expanded their activities into the physical sciences to provide support to engineering groups on such questions as corrosion, equipment deterioration, materials selection and analysis. During the war, the staff were concerned also with a number of defence problems, particularly with the development of radar techniques, with the development of materials capable of withstanding military environmental requirements in the tropics, and with the investigation of substitutes for materials which were in short supply from overseas.

During the post-war years, improvements in electronic techniques resulted in the frequency spectrum available for telecommunications being increased by a fac-

MR. S. WITT (RIGHT), THE FOUNDER, AND MR. P. R. BRETT (LEFT) PRESENT HEAD OF THE LABORATORIES, LISTEN TO AN EARLY MODEL RADIO FROM THE LABORATORIES' MUSEUM

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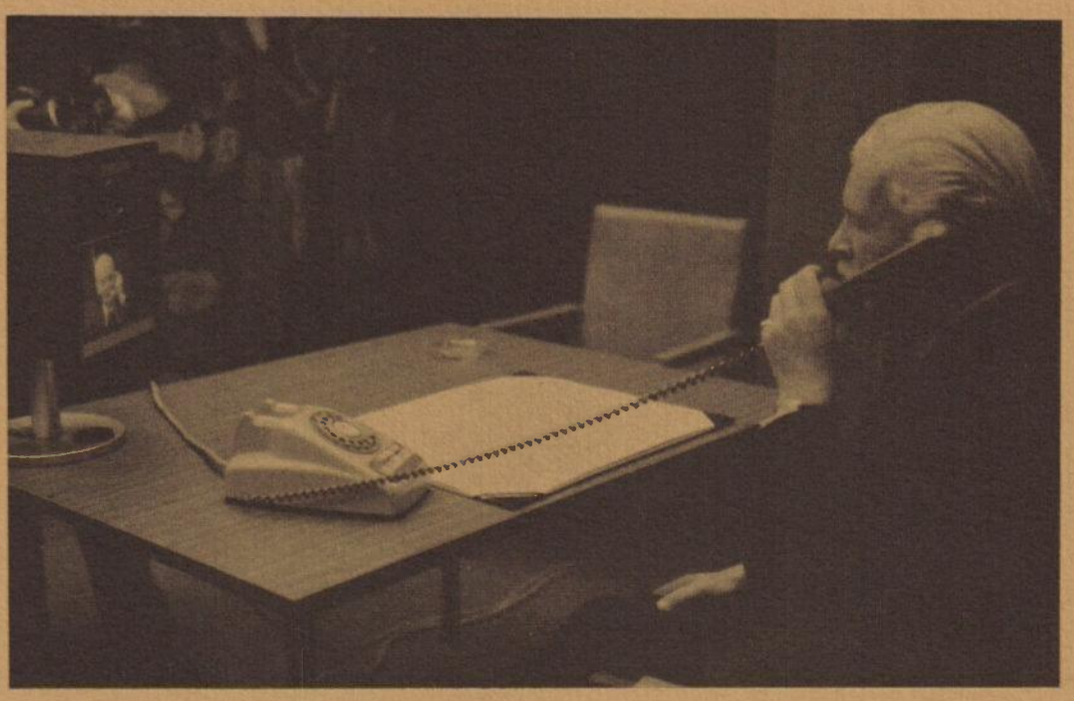
tor of 300 or so. Furthermore, Australian industry increased greatly in versatility partly as a result of Departmental endeavours to encourage the manufacture of equipment within Australia.

The introduction of broadland radio links for telecommunication purposes demanded an increase in the Laboratories activities in the radio field, and the investigation of propagation characteristics of radio paths, and research into radio-meteorological phenomena has remained an important area of work up to the present day. One of the projects in this area has been the investigations of propagation conditions at microwave frequencies on the Nullarbor Desert Plains to provide the basic information for the engineering of the 1,500 mile microwave radio link from Adelaide to Perth, commissioned in 1970. Similar investigations are at present being carried out in north-west Queensland in preparation for a microwave link between Townsville and Mt. Isa.

The early 1950's saw a good deal of work on techniques for transmitting television signals and on coaxial cable transmission systems. Because of this work, the Laboratories were in a sound position to guide the Department on techniques for evaluating television transmissions when television was introduced to Australia in 1956, and for specifying and supervising the performance of coaxial cables when they began to be installed in Australia in the early 1960's.

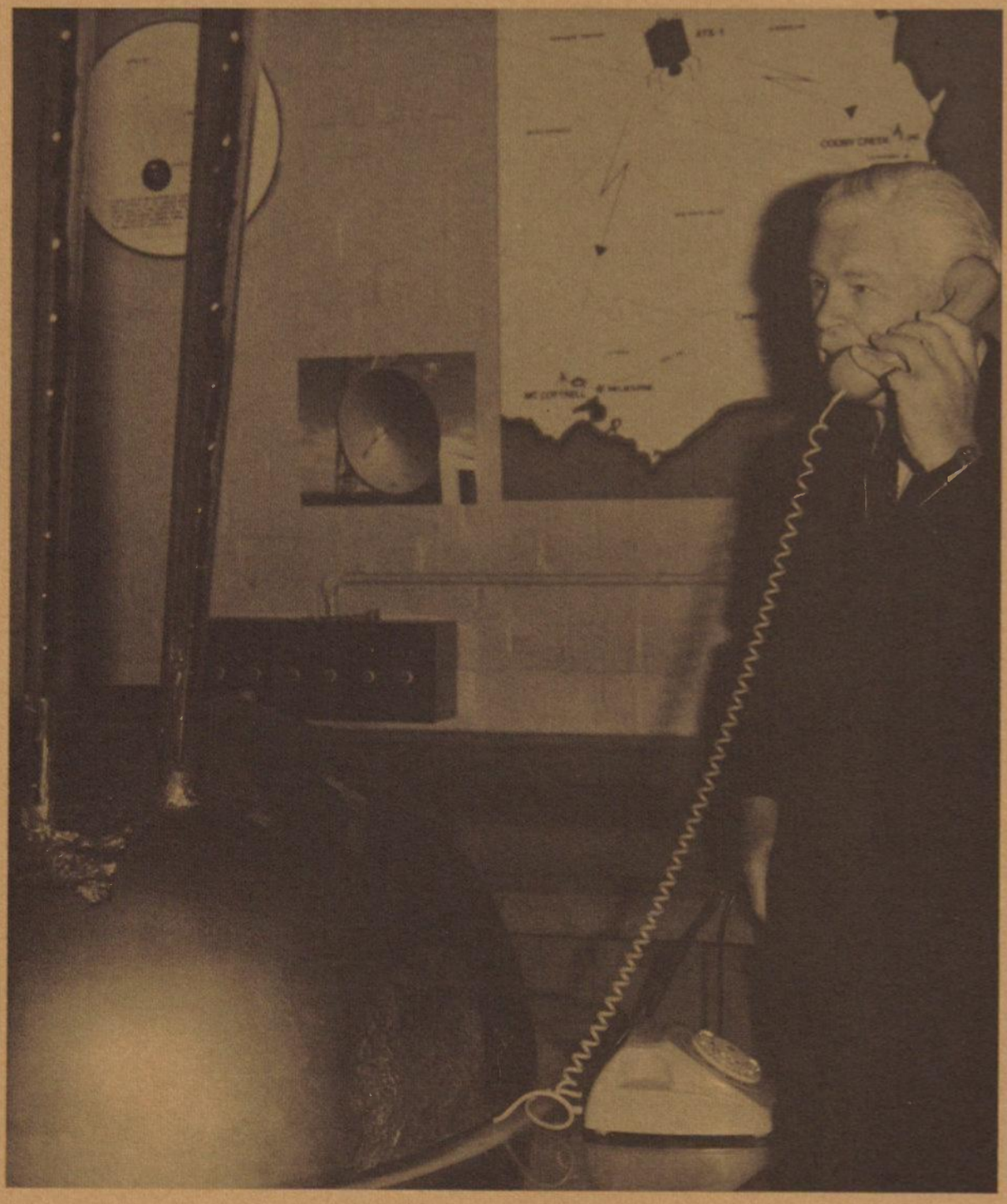
The introduction of new materials and new types of equipment has posed continual problems for engineers and scientists of the Research Laboratories, and their work has given rise to new products and new techniques suited to Australian conditions and to Australian raw materials, and which provide quality and reliability of service which would otherwise be unobtainable.



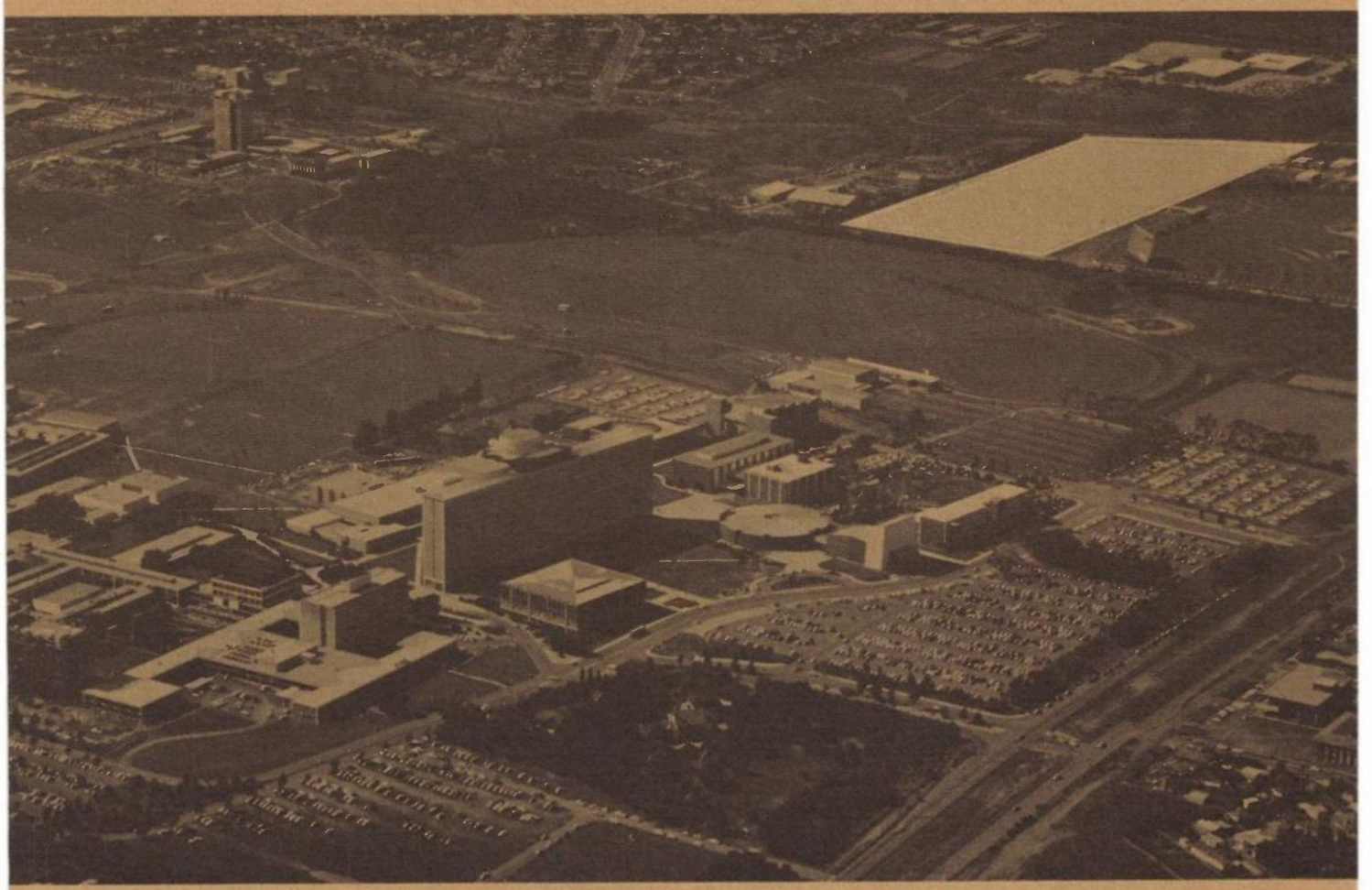
VISIT BY THE GOVERNOR OF VICTORIA

The Governor of Victoria, Major-General Sir Rohan Delacombe, K.C.M.G., K.C.V.O., K.B.E., C.B., D.S.O., K.St.J. visited the Laboratories in August, 1970, when he inspected a number of exhibits. He showed great interest in the computer controlled electronic telephone exchange which will be used in the field trial of the C.C.I.T.T. No. 6 Signalling System, and also in the investigation of a satellite communications link for subscribers in remote areas of Australia.
Sir Rohan also took considerable interest in:

- A demonstration of microwave fading.
- An examination of a special long line telephone, and a special telephone for the hard-of-hearing.
- A TV-Phone demonstration.
- A demonstration of an experimental TV-Conference facility.



SITE FOR APO RESEARCH LABORATORIES

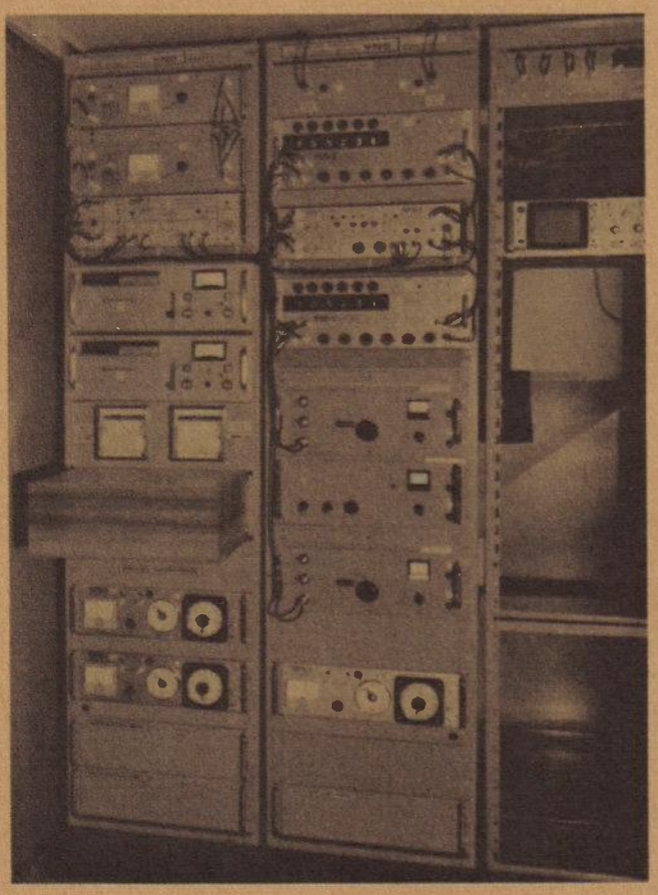


At the beginning of 1970, work was commenced on planning the long-term future accommodation of the A.P.O. Laboratories. Two sites have been obtained for the purpose – one of 2¾ acres at South Melbourne, and another of 171½ acres near the Monash University. Preliminary planning envisages the location of the development activities of the Laboratories at the South Melbourne site, where they will be able to liaise closely with other Headquarters staff. It is proposed to locate the more academic and fundamental research activities at the Monash site, where there will be mutual benefits to the A.P.O. and to the University in the juxtaposition of these activities. The preparation of briefing information for the development of the sites has been conducted, from its beginning, as a joint co-operative project between the staff of the Laboratories, the Engineering Works Division and the Head Office of the Department of Works. Feasibility studies have been undertaken to ascertain whether preliminary plans to erect new specially designed laboratory buildings in a programme of staged development of the two sites over the next two decades can be achieved.

The Research Laboratories have carried out a study of the possibility of using communication satellites for the provision of telecommunication services to subscribers in the outback areas of Australia. The study was validated by experiments using the NASA tracking station at Cooby Creek (Queensland), the ATS-1 satellite in orbit over the Pacific Ocean and a model of a proposed outback station established at Mt. Cottrell, the site of the Laboratories' field test station.

A public demonstration of telephone communication using these facilities was given during February and March, 1970. During this period, Study Groups XII and XVI of the C.C.I.T.T., which deal with telephone transmission quality and telephone transmission circuit planning, respectively, were meeting in Melbourne. Many of the C.C.I.T.T. delegates were actively involved in telecommunication satellite matters and visited Mt. Cottrell to inspect the demonstration. The studies and experiments are described in more detail later in this "Review".

NEW TIME AND FREQUENCY SERVICE



THE A.P.O. FREQUENCY AND TIME STANDARD EQUIPMENT AT STATION VNG, LYNDHURST, VICTORIA

New equipment for the A.P.O. Standard Frequency and Time Signal Broadcast Service from VNG, Lyndhurst, Victoria has been installed to replace older and less accurate equipment.

The new service has been accepted as a subsidiary standard of measurement of time interval and frequency under the Commonwealth Weights and Measures Act, 1960-1966, and its promulgation as such awaits the issue of documentation by the National Standards Commission. It conforms to the C.C.I.R. recommendations for such services and the carrier frequencies are held within one part in 10^{10} of their nominal value. The time signals as radiated are held within 100 microseconds of Universal Time which is maintained at the Laboratories. These accuracies are assured by means of precise control signals from the Laboratories.

VNG provides precise time signals for use by surveyors, seismic and geophysical exploration teams and observatories, academic groups, private industry and Government Departments in Australia and its Territories.

SELECTED LABORATORY

Projects and Services

INTRODUCTION

As a result of the Laboratories' charter to carry out research and development on all aspects of telecommunications and postal services, the work of the Laboratories covers a wide range of activities ranging from scientific to applications oriented projects, and embracing a number of disciplines, such as electronics, human factors and psychology, chemistry, physics, mathematics, etc.

In the limited space available, it is not possible to give anything like an exhaustive coverage of the work carried out during the year. As a consequence, the presentation to be found below covers a fairly limited number of projects only, selected in such a manner as to give a reasonably balanced view of the Laboratories' activities. To achieve this balance, it has been necessary also to cover to some extent work carried out in the period preceding the current 'Review of Activities'. A comprehensive list of projects in hand is issued quarterly (''Quarterly Progress Report''), and is made available to selected bodies with a special interest in the work of the Laboratories.

By virtue of the specialised knowledge and talents available in the Laboratories, a considerable amount of time is expended on informal consultancy within and without the Department. Such consultancy work is considered a normal part of the duties of the staff, as is liaison and participation in the activities of Universities, learned institutions, lecturing and other akin activities.

I·S·T (INTEGRATED SWITCHING AND TRANSMISSION)

The technology of telephone communication is currently passing through an interesting and important phase of development characterised by very rapid changes, both in the technical and the philosophical aspects of telephone systems. The two outstanding aspects are the application of computer techniques to the control of telephone exchanges, and the rapid advances in the semiconductor industry. These offer the prospect of a wide range of new facilities, both for the subscriber in his utilisation of the telephone network, and for the telephone administrations in their operation of the network.

The use of time division multiplex (T.D.M.) and digital (pulse code) modulation techniques have recently been combined to produce a new form of transmission medium which is now winning acceptance in a number of countries. These same techniques can also be applied to switching systems, and the development of T.D.M. digital exchanges is now well advanced. These exchanges utilise T.D.M. digital techniques for transmission between exchanges and switch the speech signals while in the digitally modulated form. This avoids the need for modulation and demodulation equipment on speech channels entering and leaving an exchange. A network consisting of exchanges and transmission links which both use the same type of digital modulation is known as an integrated switching and transmission (I.S.T.) system.

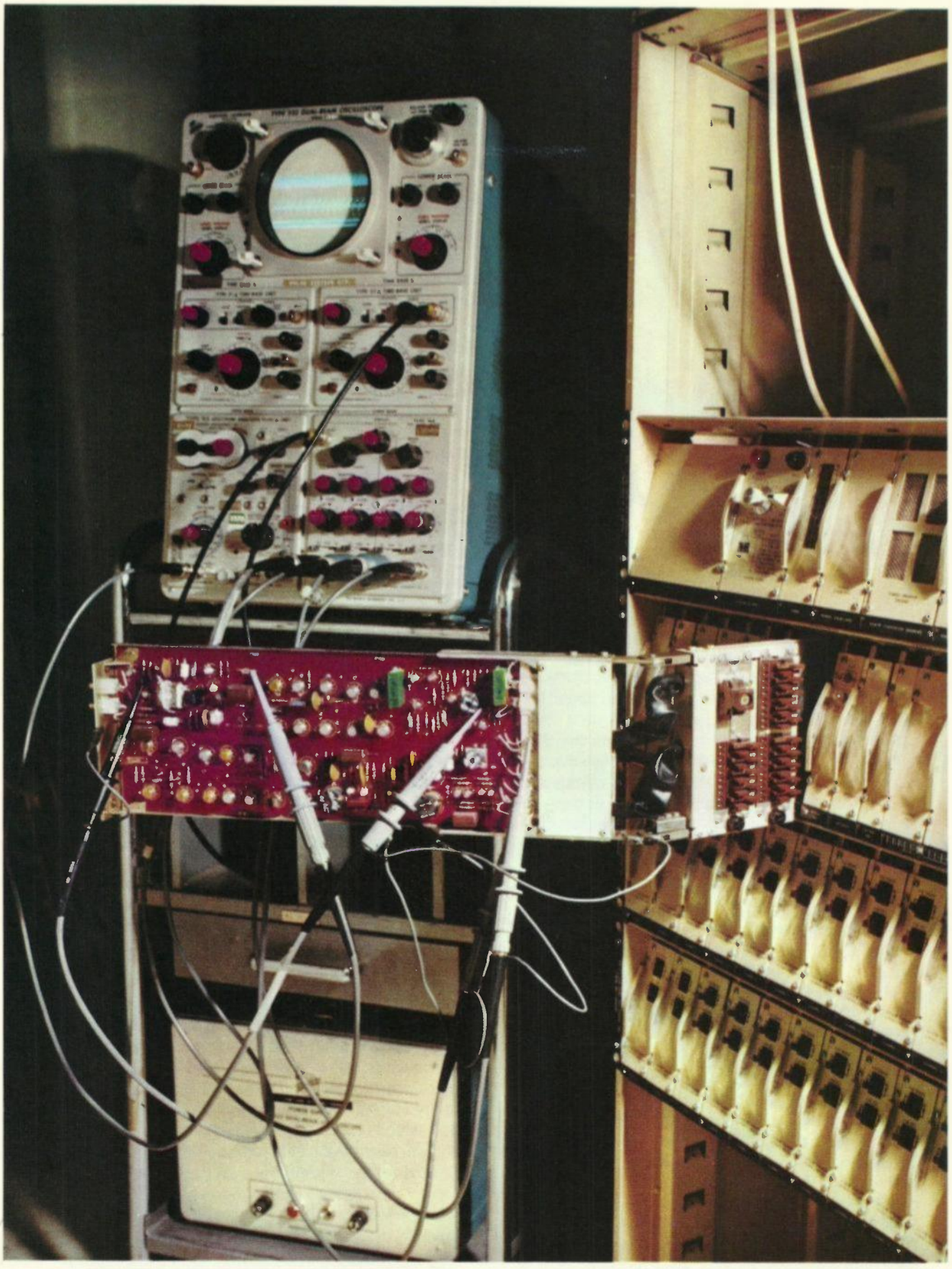
In order to examine the I.S.T. concept in depth, and to obtain some practical experience in the possible benefits to be obtained from its use, a model T.D.M. exchange is being developed in the Research Laboratories. This is capable of switching channels carrying information which has been digitally encoded using pulse code modulation (P.C.M.).

This model exchange will be controlled by two processors (real-time on-line control computers) which will share the control load. In the event of failure of one processor, the other will carry the full load.

The model exchange will be installed for trial purposes in the Melbourne network during 1971, and will carry live traffic between four exchanges. The field experience arising from this trial will enable the possible benefits and methods of introduction and integration of such a system to be examined in detail.

The major technical advances being studied in the I.S.T. project are:

(a) Stored Programme Control, where the telephone exchange is controlled by the programme stored in a computer-like device called a processor.
(b) Digital transmission of the speech in the form of P.C.M. (Pulse Code Modulation).
(c) Digital transmission, where the conversations are switched through the exchange in the same digital form as they are transmitted.
(d) Advanced semi-conductor technology in the form of custom-built integrated circuits.
(e) Remote control of subscribers switching stages, so that subscribers can be supplied with advanced facilities in an economical way.



INTEGRATED SWITCHING AND TRANSMISSION;
PART OF THE MODEL T.D.M. SWITCHING EQUIPMENT AT WINDSOR EXCHANGE

APPLICATIONS OF MICROELECTRONICS

The microelectronics technology is one of the most important technological developments of the last decade. Since the appearance of the first transistor in 1948, the last twenty years have brought such a wide increased acceptance of microelectronics, that there is hardly any field in science or technology which has not benefited from it. Two industries, the computer and the telecommunication industries, have probably received greater benefits than any other from this technology. This was most noticeable when the technology reached its second stage of development with the introduction of the Integrated Circuit (1958), which is eminently suitable for "logic" applications. Its relatively small dimensions and high speed capabilities provide a new scope for the telephone exchange designer and have made new concepts possible such as Integrated Switching and Transmission (I.S.T.) and the new C.C.I.T.T. Signalling System No. 6. Both of these concepts are being actively explored and equipment has been developed for field testing which relies heavily on the use of integrated circuits.

Integrated circuits of many types are available commercially, including various types of logic families, each having a considerable number of members. These products will meet most needs, but occasions often arise in which a custom-built design provides better performance and cost benefits.

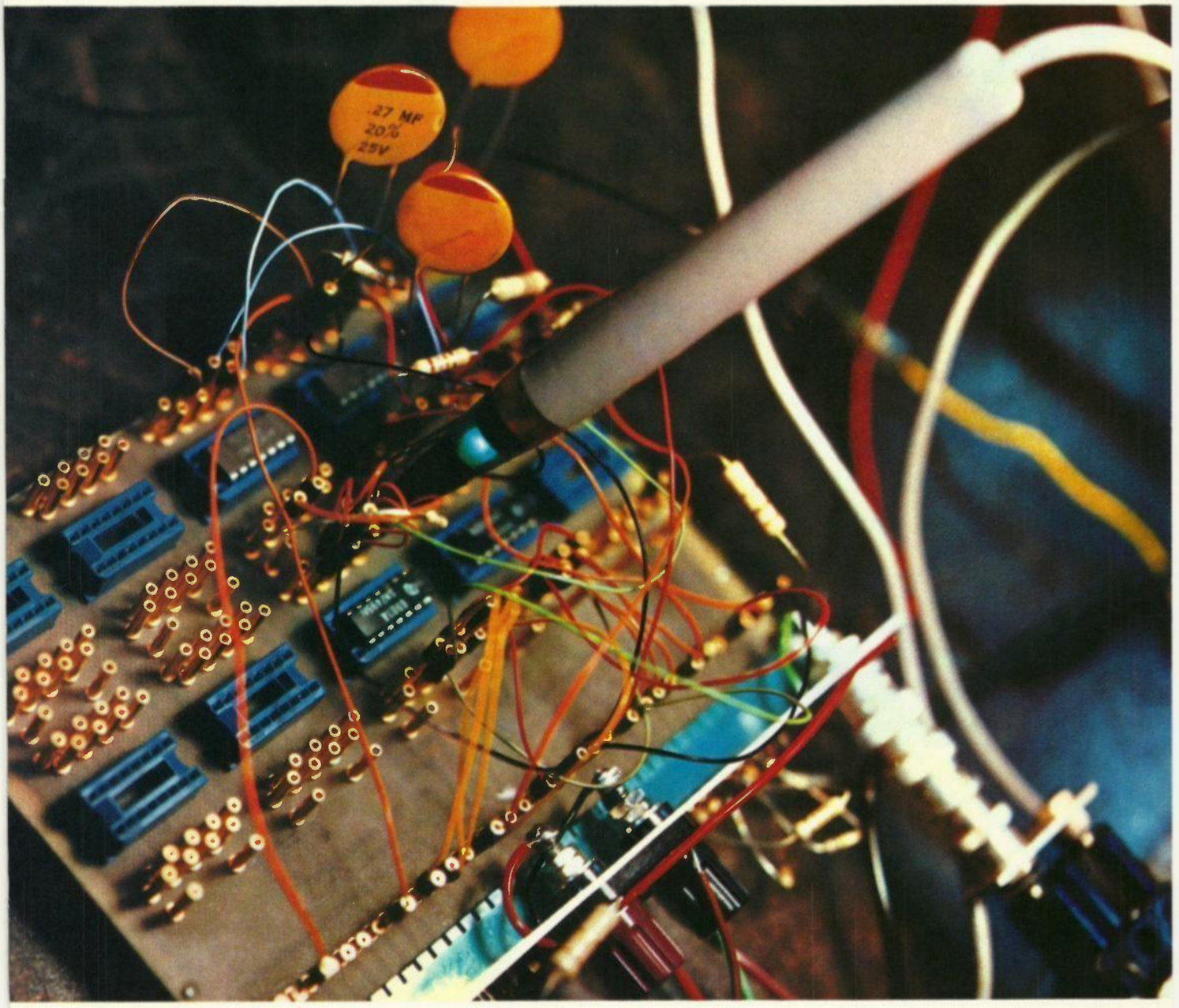
The I.S.T. equipment which has been developed in the Research Laboratories is constructed almost exclusively from integrated circuits. Approximately 75% of these are from a family of four integrated circuits developed by the Laboratories in co-operation with industry. These provide information storage elements with independent reading and addressing facilities.

The trial exchange for the C.C.I.T.T. Signalling System No. 6 also relies heavily on the use of integrated circuits. The signalling terminal has been constructed almost entirely from commercially available integrated circuits. Information transfers between the crossbar switching equipment and the processor are carried by a data highway requiring high noise immunity in an environment of heavy electrical interference, and custom-built integrated circuits are used as line drivers and receivers at the ends of the highway. A custom-built integrated circuit is also used where 50 V relays are to be directly controlled by low voltage (5 V) integrated circuits. These custom-built integrated circuits have also been developed in co-operation with industry.

A total of seven designs has now been successfully completed, and approximately 4,000 integrated circuits have been purchased. These have enabled superior performance to be obtained, combined with a reduction in number of packages, space and power consumption from that required if commercial integrated circuits had been used. If commercial integrated circuits had been used exclusively, approximately 12,500 packages would have been required. The use of custom-built integrated circuits enabled the number to be reduced to approximately one-third, with a corresponding reduction in space and power requirements.

The development of the custom-built integrated circuits has added to the pool of expertise available in the Research Laboratories, and also has been of considerable assistance in providing a firm basis for the microelectronics industry in Australia.

A LOGIC TEST PROBE INDICATES, BY MEANS OF A LIGHTED RED OR GREEN BAND AT ITS TIP, THE HIGH OR LOW STATE OF A GATE IN A LOGIC CIRCUIT

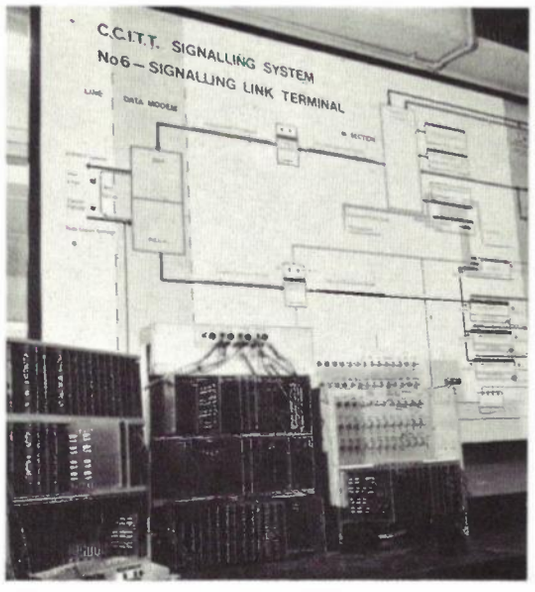


COMMON CHANNEL SIGNALLING —

TRIAL OF THE

C·C·I·T·T

SIGNALLING SYSTEM No. 6



C.C.I.T.T. SIGNALLING SYSTEM No. 6; EXPERIMENTAL SIGNALLING TERMINAL EQUIPMENT

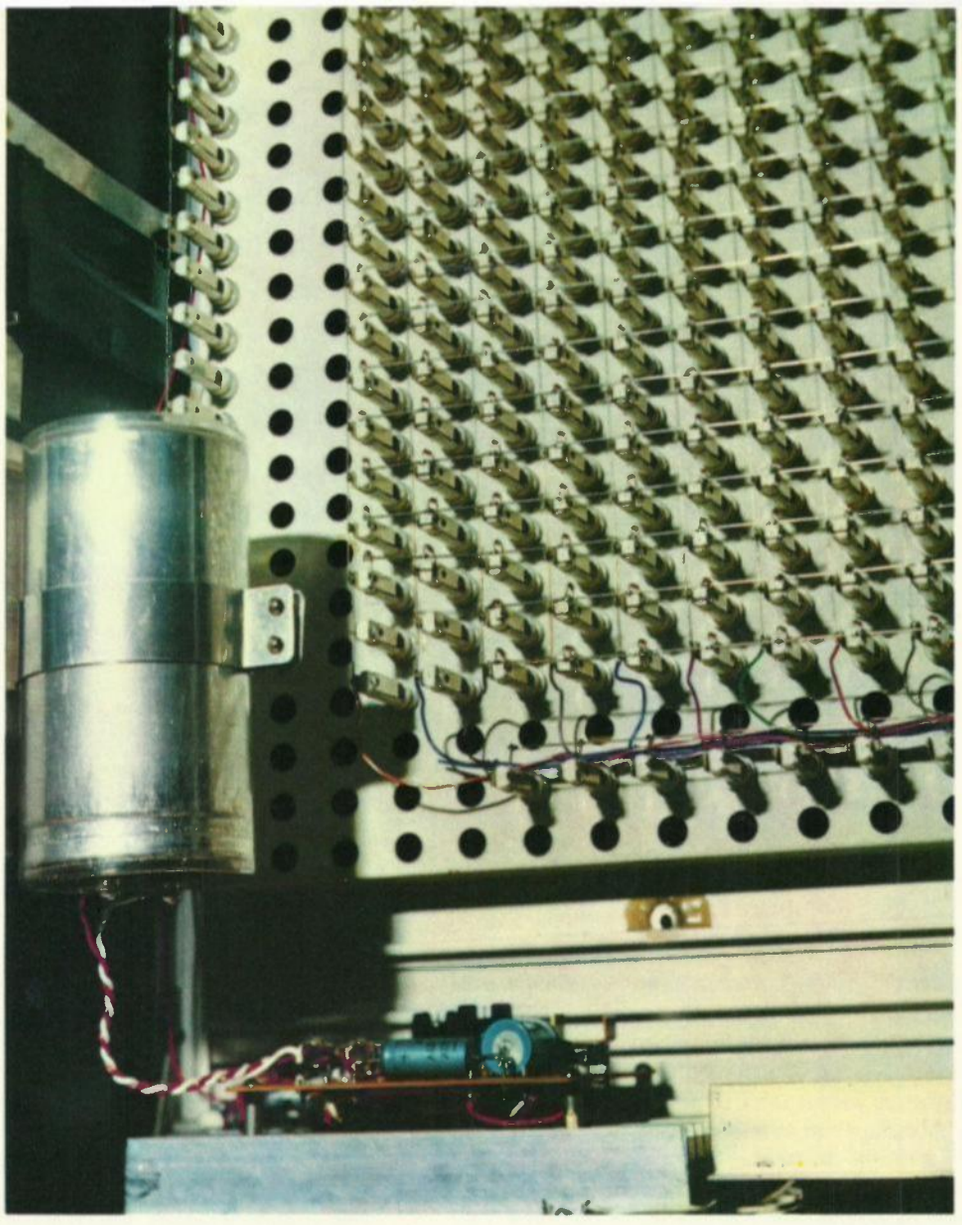
During 1967 and 1968, the International Telegraph and Telephone Consultative Committee (C.C.I.T.T.) specified a new international telephone signalling system known as Signalling System No. 6. This system will provide high speed, high capacity signalling between telephone exchanges employing computer based, stored programme control techniques. The Research Laboratories played a significant role in the design and specification of the system. The system is based on the use of a single data channel to carry all signalling between a pair of exchanges rather than transmitting the signalling information over the individual speech circuits as is the case in existing signalling systems.

Although System No. 6 may not be employed directly in the Australian networks, it is clear that, as larger and larger groups of trunk channels and exchange junctions are introduced, and as stored programme controlled exchanges take on a significant role in the network, common channel signalling, of which System No. 6 is representative, will become an important factor in increasing the efficiency of the network and at the same time reducing its capital cost.

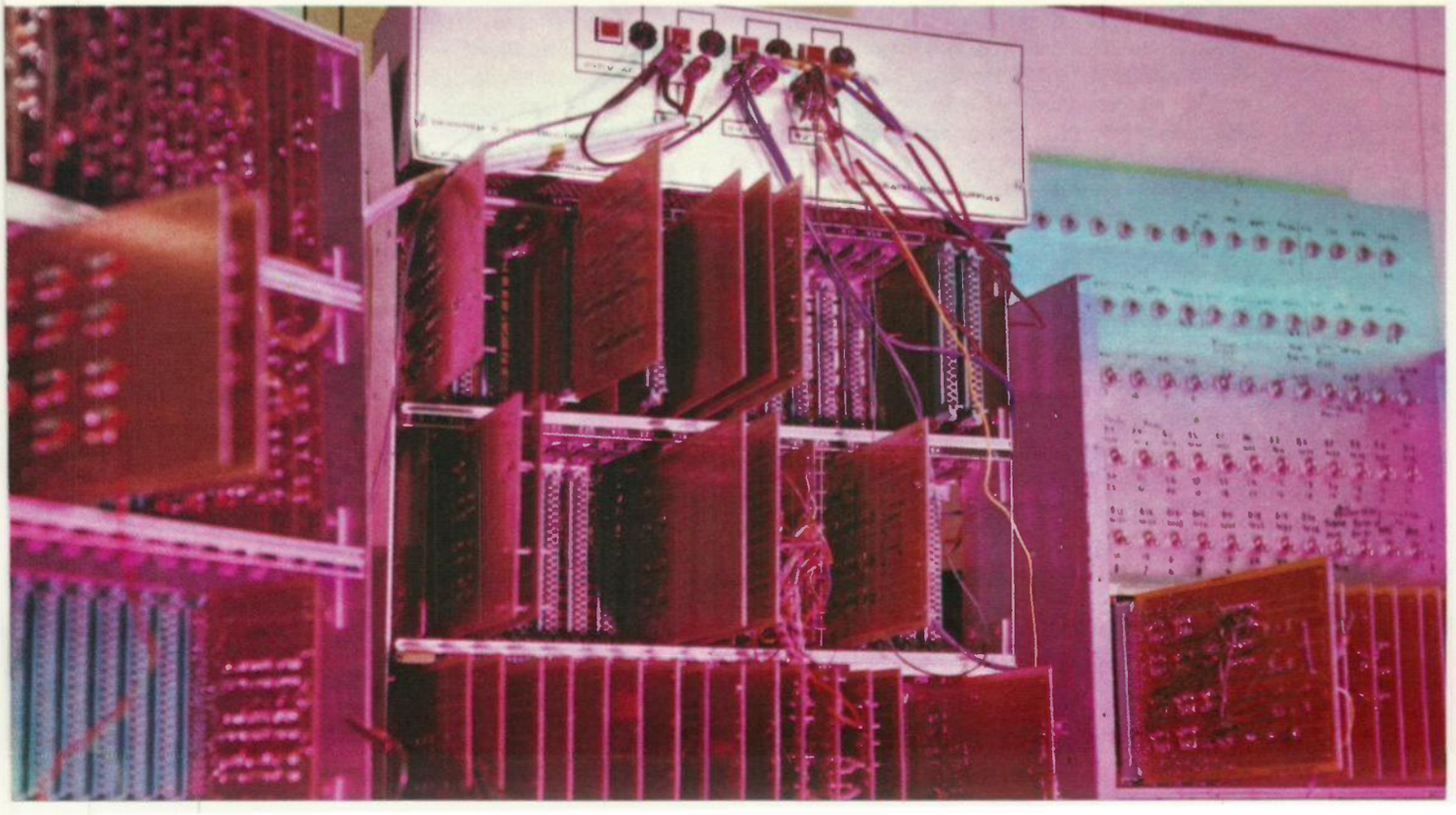
The C.C.I.T.T., during the Plenary period 1969/1972, will conduct a field trial of the System No. 6 which will test the international aspects of its operation. The Laboratories in conjunction with O.T.C. (Aust.) are preparing to conduct national field trials of the System No. 6 by establishing a suitable stored programme control exchange in Melbourne coupled by a group of trunk channels and an appropriate signalling link to a similar exchange being established by O.T.C. in Sydney. The trial will help to evaluate the usefulness of System No. 6 to Australia, it will provide an insight into many aspects of common channel signalling, and will be of great assistance in the future as this form of signalling is introduced.

The Melbourne No. 6 exchange is being assembled in the Research Laboratories for the initial phases of testing. The exchange consists of a standard ARM crossbar switching matrix together with specially designed electronic trunk and junction relay sets. The signalling link terminal to control the transmission and reception of signals on the common channel has been designed, tested and is being built-up in its final form. The programmes for the processor which will control the exchange have all been specified and are well on their way to being coded.

The initial phases of testing have been carried out, and the live traffic part of the trial will commence at Windsor Exchange (Melbourne) during 1971.



PROCESSOR SIMULATOR; IN THE C.C.I.T.T. No. 6 SYSTEM, A MANUAL OPERATOR MAY USE THE SIMULATOR IN PLACE OF THE PROCESSOR. THE DISPLAY PANEL (REAR VIEW SHOWN) WILL SHOW IN WORD FORM THE CODED INSTRUCTIONS SENT TO AND RECEIVED FROM THE EXCHANGE.



GENERAL FEATURES AND CHARACTERISTICS

Modern electrical communication systems are used to transfer information of many kinds from one location to another. The information to be transferred must be converted into an electrical signal for transmission, thus, for instance, a microphone converts sound pressure waves into "equivalent" electric waves; a television camera divides an optical picture into a large number of lines and converts varying light intensity along the lines into correspondingly varying electrical signals. At the receiving end these electrical signals are converted back into a replica of the original sound or picture. The communication systems commonly used in the past, and at present, are thus transmitting an electrical analogue of the original sound or picture, and they are described as **analogue** transmission systems.

The performance of analogue transmission systems is usually limited by the noise and distortion which is invariably added to the transmitted signal. Any transmission link has a certain basic noise level, and this determines how often the signal must be amplified to maintain the required signal to noise performance. Distortion is produced in terminal and repeating amplifiers and, although it can be made low, it is never zero. Noise and distortion are additive and, once introduced into an analogue signal, cannot be removed.

Another type of electrical transmission system which will form an increasing part of the telecommunication network of the future is the **digital** transmission system. In digital systems the electrical signal, representing for example the speech wave form, is not transmitted continuously, as it is for the analogue system, but is sampled regularly at a rate sufficient to ensure that the samples carry enough information to enable the signal to be reconstituted. The samples are coded into digital form, and the stream of pulses which result from the coding process are then transmitted over the appropriate transmission bearer to the remote receiving point. At this point, the digital stream is decoded and the appropriate electrical signal, of say, the speech wave form, is reconstructed from the received samples.

This stream of pulses, which in the simpler cases have fixed amplitudes, have greater immunity to noise and interfering signals than the analogue signals. This is because the noise and interfering signals must rise to a comparatively high level before they cause significant pattern changes (errors) in the digital signal. Also the stream of pulses can be regenerated at intervals along the transmission link avoiding additive noise almost entirely, provided the intervals are not too far apart.

The bandwidth used to transmit information over a digital transmission system is usually significantly higher than that required for an equivalent analogue system. However, digital systems are capable of operating over links with considerably higher noise levels. These points must be taken into account when a transmission system is designed. Further constraints can be placed on the system designer such as the difficulty of installing more telephone cables in a crowded city, or the desirability of using digital modulation on millimetric microwave sources for waveguide transmission. The overall solution will, in general, be the one that is economically attractive. In practice analogue systems or digital systems, or a combination of both may be chosen.

A particular form of digital coding currently receiving

PSEUDO-RANDOM BINARY SIGNAL GENERATOR (FRONT VIEW)

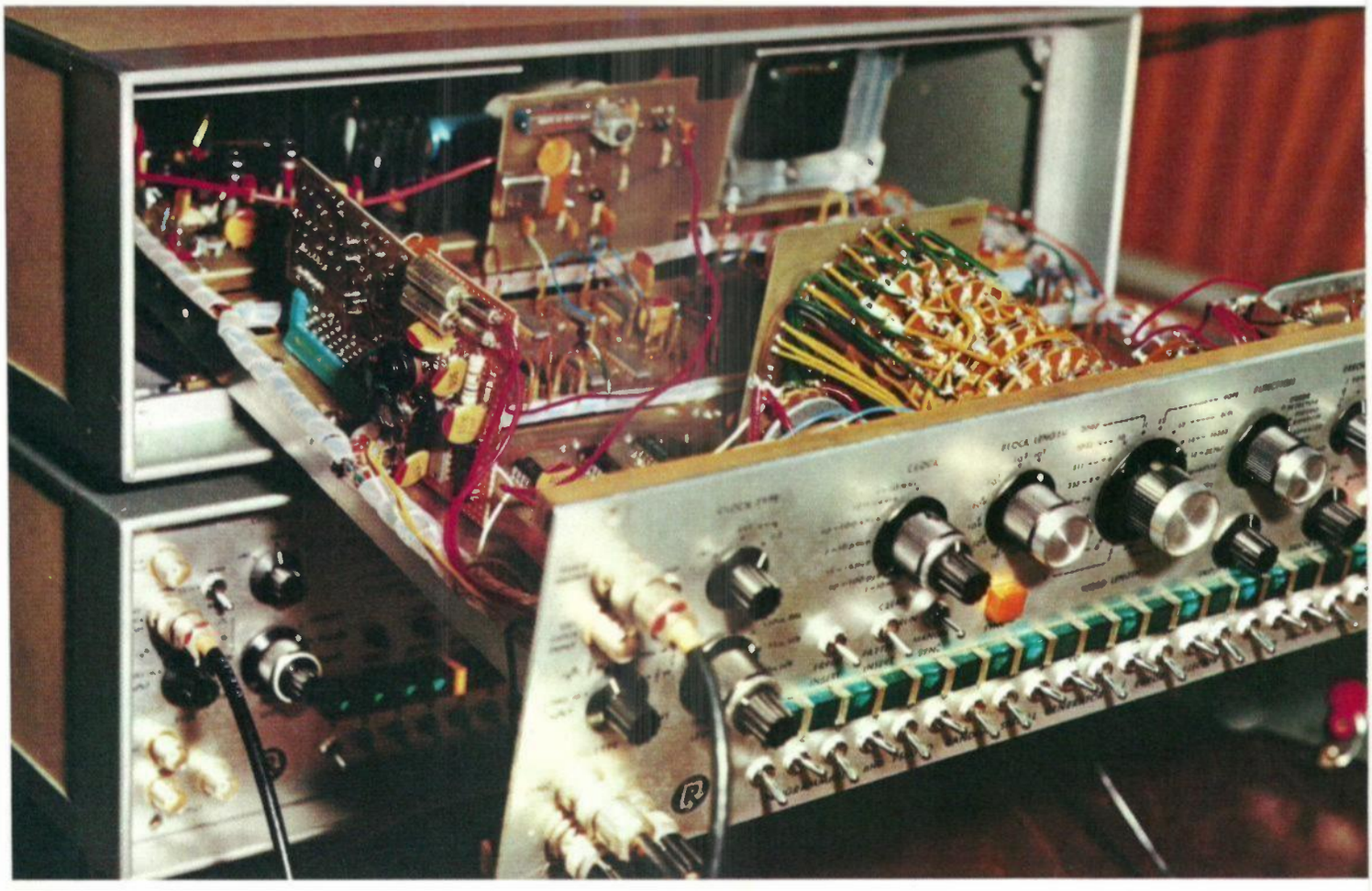
much attention throughout the world is pulse code modulation or P.C.M. In this system an analogue signal such as speech is first sampled, usually at 8,000 samples a second. The amplitudes of the samples are then measured, and these amplitudes are converted into a series of pulses, this process being referred to as coding. In general, digital coding refers to the representation of a number or the value of some quantity by a series of pulses. Examples of this are the address of a particular location in a computer memory, or the well-known telegraph code. After transmission of these pulses to the receiving end they are decoded to give the original samples, from which the speech signal can be reconstructed.

By superimposing samples from several signals, for instance by time division, a multichannel system can be created. A typical P.C.M. system provides 24 channels over two unloaded pairs of wires in ordinary telephone cables, one pair for each direction of transmission. Though not all pairs in a telephone cable can be used for P.C.M. transmission the circuit carrying capacity of the cable can often be increased five-fold with P.C.M. transmission.

Another form of digital transmission system of interest is the delta modulation system. In this system, information in digital form is transmitted as to whether the electrical signal being sampled is increasing or decreasing. This means that information is transmitted on the change in the signal rather than on its absolute value.

Every country finds that its telecommunication network is unique in so far as it differs from that of other

PSEUDO-RANDOM BINARY SIGNAL GENERATOR (INSIDE VIEW)



countries. This occurs because of the varying geographies of different countries, and their differing telephone traffic requirements, both in quantity and type of traffic as well as depending on community habits and traditions, and on the previous history of the networks. Australia is a good example of this uniqueness with its remote subscribers and vast distances between major centres. The introduction of any new development into the telecommunications network must therefore be considered in relation to the nature of the network. In order to evaluate the use of P.C.M. in Australia, and to study the technical features of the various types of P.C.M. systems available, arrangements have been made to install a numer of different systems on an experimental basis in a variety of locations. This experiment will demonstrate the feasibility of incorporating P.C.M. into the existing network, and the economics pertaining thereto.

Also being considered in the A.P.O. Research Laboratories is the introduction of digital transmission over radio bearers. Once again this type of system has both advantages and disadvantages when compared with an equivalent analogue system, and the feasibility and economic aspects of integrating this type of system into the existing network are being studied.

Concurrent with the introduction of digital transmission systems into the telecommunication network, there is a need for instrumentation to test the digital systems. There are instances when the required instruments are not available commercially, and it is then necessary to design and develop the required instrumentation. A typical example of such an instrument is the Pseudo Random Binary Signal Generator developed in the Laboratories and described later.

PULSE CODE MODULATION (P.C.M.)

The A.P.O. Research Laboratories are actively involved in a study of the application and characteristics of P.C.M. systems at this time. Two of the routes involved in the experiments have been selected so that on the completion of the experiment they will be available to form part of the Integrated Switching and Transmission network described earlier.

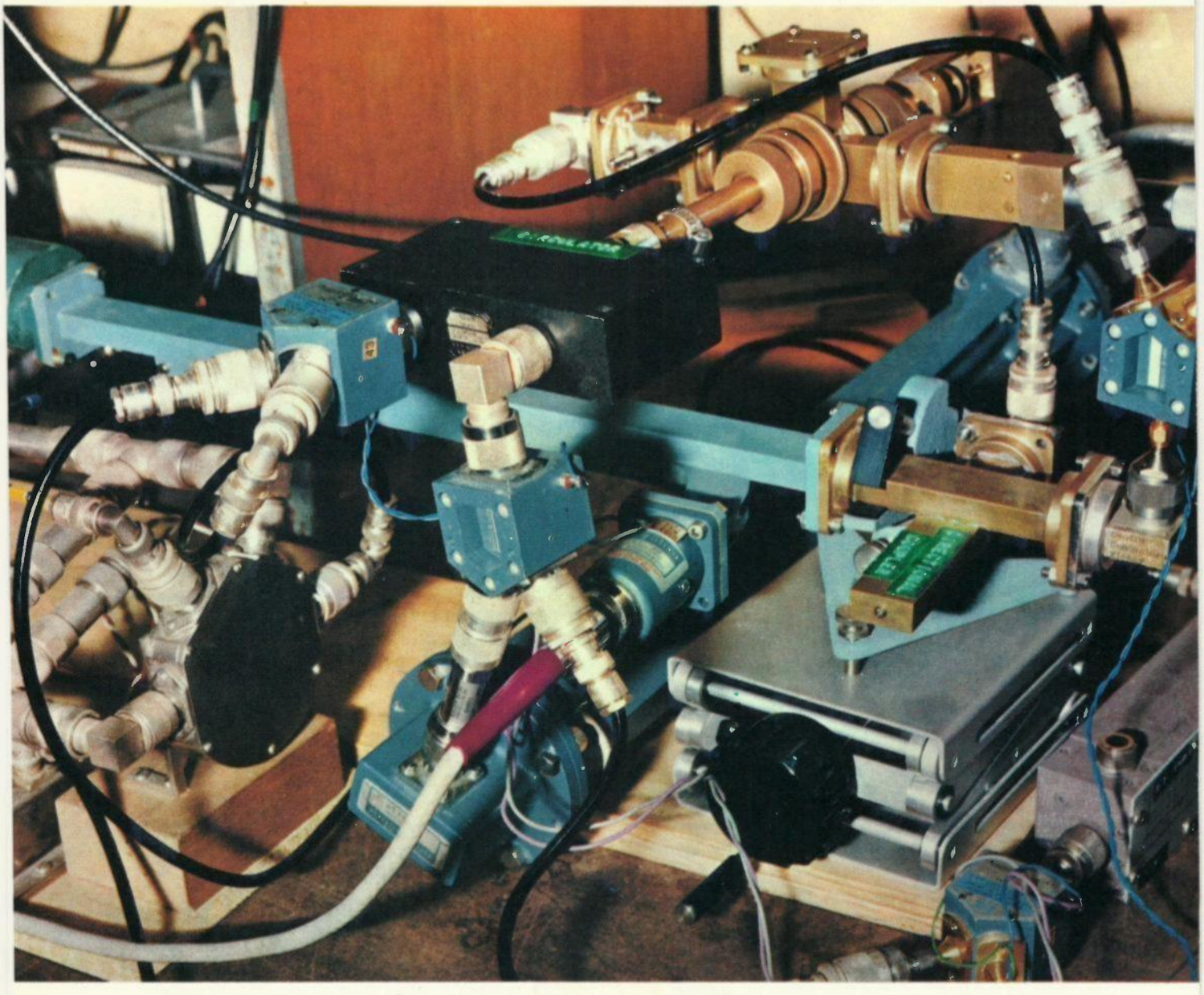
The Research Laboratories are particularly concerned with the more complex technical aspects and principles of P.C.M. An extensive series of tests has been conducted on various P.C.M. terminal equipments to evaluate the relative merits of various methods used for companding, sampling, signalling, etc. In common with other transmission systems, P.C.M. introduces a small amount of distortion into the signals transmitted. Tests have been carried out in the Laboratories to assess the subjective effect of the accumulation of this distortion. Also the transmission medium introduces noise into the P.C.M. channels, and this noise can cause changes in the groups of pulses being transmitted if of sufficient magnitude. Since these noise pulses degrade the transmission channel, tests have been carried out to determine their effect on speech, high speed data and V.F. telegraphy.

A study is being made to see what other advantages might result from the introduction of P.C.M. systems into the network apart from the obvious ones, such as increasing the capacity of telephone cables on crowded routes. This could include the possibility of using one P.C.M. channel to transmit data directly, at a rate of typically 56 kilobits per second.

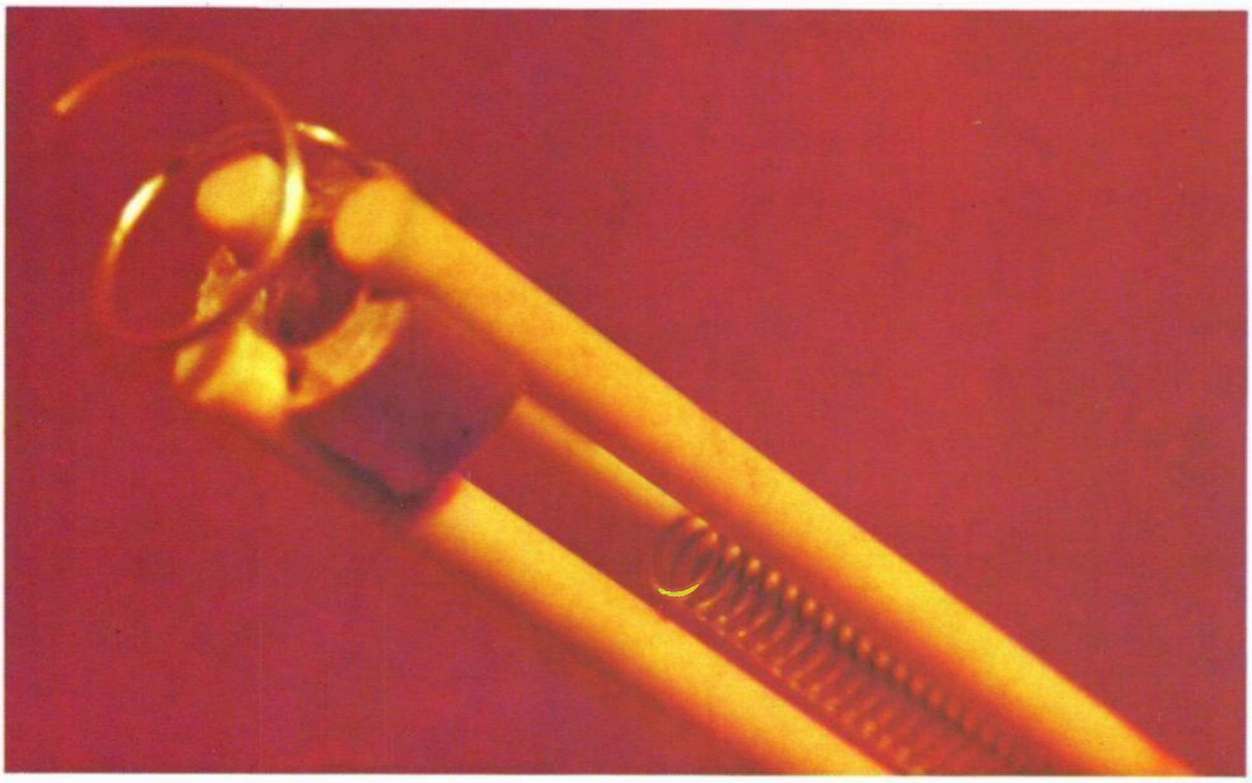
Extensive cable measurements have been made on selected routes to determine those cable characteristics which are important to P.C.M. transmission. Since interaction occurs between the P.C.M. signals on the pairs used as P.C.M. bearers in a voice frequency cable, part of the investigations is aimed at determining a technique for selecting suitable cable pairs for P.C.M. bearer circuits.

A new signalling system (designated T 5) was designed in the Laboratories to optimise signalling over P.C.M. systems. Two separate signalling channels (E-M leads) can be readily provided for each speech channel in a P.C.M. system. This results in simpler relay set design, and the cost of the T5 relay sets is approximately half that for the relay sets required when only one E-M signalling channel is available for each speech channel. This new signalling system therefore assists materially in reducing the cost of providing telephone circuits by means of P.C.M. systems.

WIRE HELIX FROM A TRAVELLING WAVE TUBE



WAVEGUIDES, COAXIAL CONNECTORS AND DIRECTIONAL COUPLERS USED IN UHF RADIO TRANSMISSION



DIGITAL MODULATION OF RADIO FREQUENCY BEARERS

Compared with existing analogue radio systems digital radio systems of the same channel capacity offer comparable performance at lower transmitter power levels. This may make it possible to eliminate the need to use a travelling-wave-tube (T.W.T.), and its associated apparatus which is expensive, bulky and a maintenance liability. Thus, the elimination of the T.W.T. could lead to a substantial reduction in the cost and maintenance of radio systems.

Digital systems are resistant to interference, and it is therefore possible to transmit two independent signals on the same carrier frequency over the same path by using cross polarisation, for instance vertical polarisation for one signal and horizontal for the other. This technique, together with "multi-level" digital modulation can be used to restrict the required radio frequency bandwidth. With four-level modulation, and cross polarised antennas the efficiency of use of the radio frequency spectrum is similar to that obtained with currently used FM systems. These properties make digital modulation attractive for use in trunk radio networks.

Although multi-level modulation is useful in conserving bandwidth, two-level (or binary) modulation is more resistant to noise and interference than modulation techniques using a higher number of levels. For this reason, two-level modulation has been employed in the satellite subscribers system described in another section, and in a rural (terrestrial) radio telephone system currently being studied. This rural radio system is intended to provide fully automatic telephone services in remote areas having low population density, and where the conservation of bandwidth is not as critical as in the more populated areas, and where a low power consumption is advantageous.

The system under study employs delta coding and two-level modulation resulting in relatively simple and inexpensive equipment. Present studies indicate that although the radio frequency bandwidth requirement is greater than that for the analogue systems now used, it can be reduced to an acceptable figure by careful design. The transmitter power requirement of the digitally modulated system should be approximately one-tenth of that required in a conventional FM system for the same quality of service.

A PSEUDO RANDOM BINARY SIGNAL GENERATOR, ERROR DETECTOR AND COUNTER

A pseudo random binary sequence is a particularly suitable signal for testing digital transmission systems. Though the sequence is repeated, it may be made long enough to appear quite random to the system under test and yet its generation by defined rules offers several advantages over testing with a purely random signal.

The first advantage is in the measurement of bit error rate. Error rate is an important measure of system performance, and is simply the ratio of bits received in error to the total number of transmitted bits. With a purely random test signal, errors in transmission are difficult to detect. However, with the pseudo random sequence, the bit pattern is governed solely by the choice of circuit configuration. Therefore a replica of the transmitted signal can be produced locally in an error detector simply by using the same configuration. After synchronising this signal with the signal received from the transmission system, errors can be detected by a bit by bit comparison.

The second advantage of a pseudo random sequence over a purely random signal is that each repetition of the sequence has the same effect on the system under test. For this reason, pseudo random signals cause no statistical variance in test results. Furthermore, direct comparison of results for various systems is meaningful because the test signal in each case is known to be exactly the same.

The techniques of using pseudo random sequences were developed for the testing of data transmission systems, but are useful over a wide range of speeds, from telephone dialling to P.C.M. signals, and above. The equipment has been designed for use as either a pseudo random sequence generator or as an error detector and counter. This allows bothway testing of circuits without having to interchange the instruments. The basis of operation of both the generator and error detector is a feedback shift register of variable length, operating in either the pseudo random or repetitive mode. In the repetitive mode, an n-bit pattern is circulated around a shift register. In the pseudo random mode, with sequence length 2^n-1, feedback is taken from the n^{th} stage and certain others. These feedback signals are combined in a modulo-2 adder and fed back to the first stage.

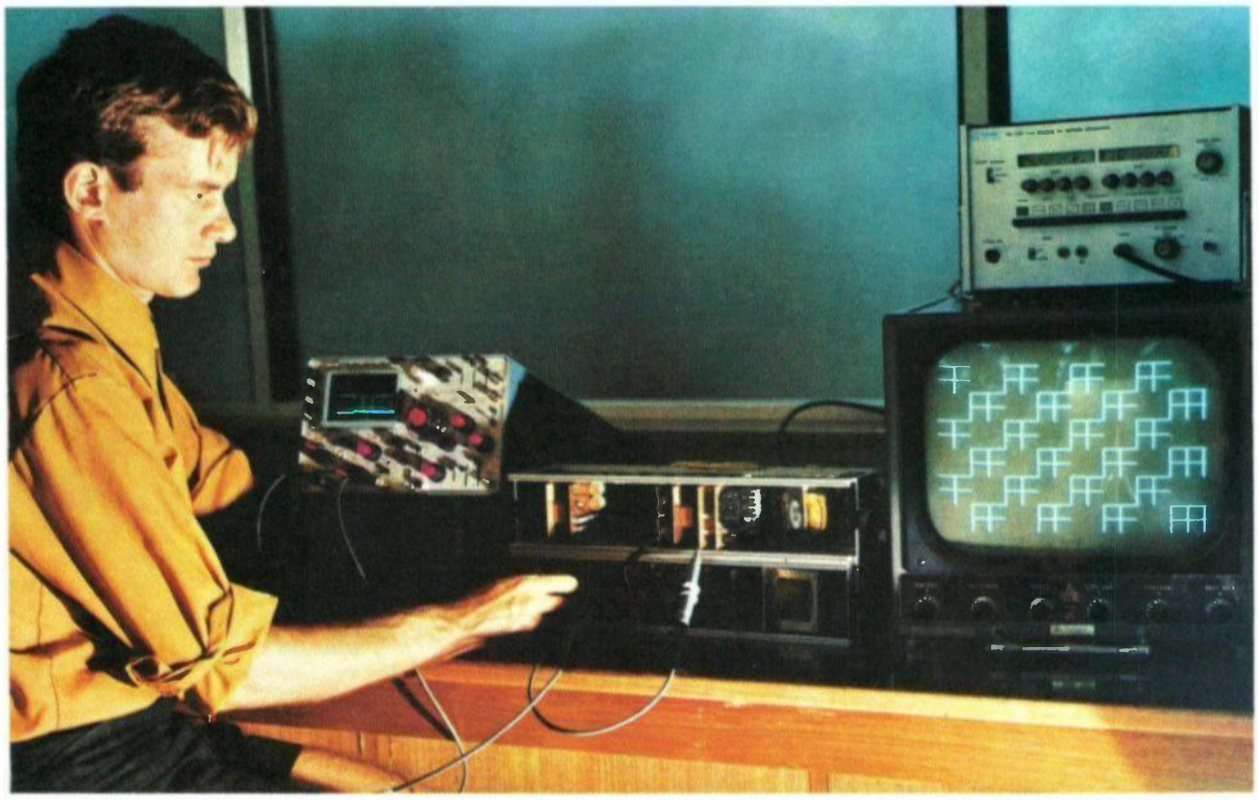
The error detector produces an identical sequence to the generator and after synchronisation compares this bit with the incoming bit. A single output pulse is produced for each error detected. Bit synchronisation is obtained by providing an external clock to the error detector, derived either from the incoming bit stream itself or from the clock driving the generator. Sequence synchronisation is then achieved by recognising a particular n-bit code in the incoming bit stream.

The instrument operates at clock frequencies from 1 Hz to 10 MHz (either internally generated or supplied from an external source), and has either unipolar or bipolar pulse outputs. Error count is 0-999. The instrument is useful for testing a wide range of digital systems, typical examples being P.C.M. links and data transmission systems.

TRANSMISSION ASPECTS OF THE TELEVISION TELEPHONE

In common with other administrations, the Australian Post Office is interested in the eventual introduction of a switched television telephone system for public use. As one of the steps in this direction, a decision has been made to experiment with a small switched T.V. telephone network serving a number of staff of the A.P.O. Headquarters in Melbourne. Later, experimental transmission between capital cities may also be carried-out to gain information on the problems of long distance working. The main objectives of these experiments are to gain an insight into customer reaction and preferences, to assist in the international standardisation of the essential T.V. telephone characteristics by the C.C.I.T.T., and to prepare for the eventual introduction of a switched, public T.V. telephone network on a national basis and capable of interworking with similar networks in other countries. Consideration is being given to two different approaches to a T.V. telephone facility. The first has a nominal 1 MHz bandwidth, while the second has a nominal 5 MHz bandwidth capability, and would have similar characteristics to those of entertainment television. A large part of our attention is focussed on the problem of obtaining successful transmission of video signals over existing distribution cables provided for the present telephone network. In their present use these cables are largely being used for voice frequency transmission only, but they are capable of being used over a much wider frequency range if suitable equalisation and noise reduction techniques are employed. The Research Laboratories are currently paying special attention to the 1MHz system, and this will be used in the initial experimental installation. An experimental cable-pair equaliser using only a single adjustment for line length when used with an appropriate cable type has been developed. Using this

VIDEO TEST PATTERN RECEIVED OVER EQUALISED PAIR-CABLE

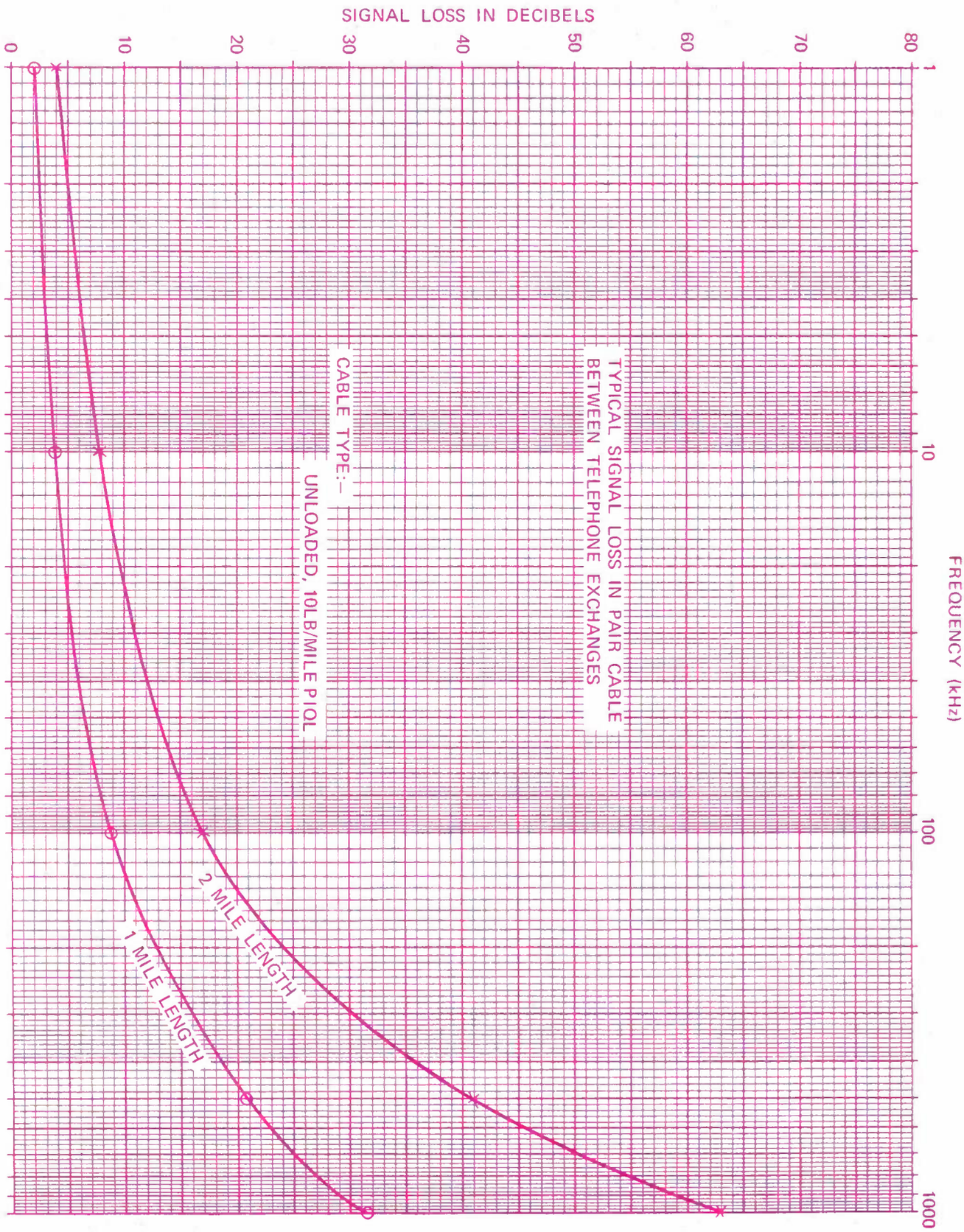


equaliser without repeaters, a 1 MHz bandwidth signal has been transmitted over about 0.6 mile of telephone subscriber cable and about 1.5 mile of junction cable of the type commonly used between telephone exchanges. More exact equalisation may be desirable where changing line conditions occur particularly in a switched network. For this reason, the design of an automatic equaliser is under consideration.

Apart from work on cable equalisation, experimental work is being carried-out on other problems of video transmission over subscribers' cables. The more important of these are video-signal crosstalk between cable pairs, cable pair impedance discontinuities, and impulsive noise due to switching interference.

On the switching side, a modified crossbar switch has shown promise as a suitable switching device; however, a better solution may be achieved by the use of reed relay or semiconductor switching techniques.

The information obtained from the present experimental work will assist in the formulation of interim standards for a possible future public T.V. telephone network. It is hoped that international standards will be in existence before the interim T.V. telephone network becomes too large.


SIGNAL LOSS IN DECIBELS
0
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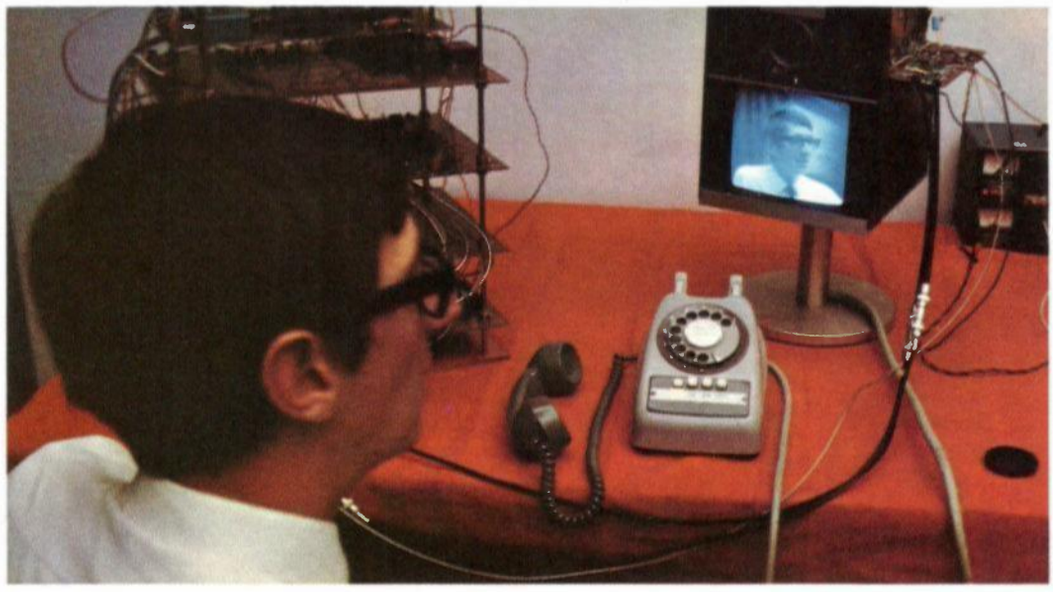
20
30
40
50
60
70
80
1
10
100
1000
FREQUENCY (kHz)
TYPICAL SIGNAL LOSS IN PAIR CABLE
BETWEEN TELEPHONE EXCHANGES
CABLE TYPE:-
UNLOADED, 10LB/MILE PIOL
2 MILE LENGTH
1 MILE LENGTH

T.V. PHONE SHOWING A SELF-VIEW OF THE SPEAKER, THE CONTROL TELEPHONE AND AT LEFT, THE EXPERIMENTAL DPCM ENCODER



DIGITAL CODING AND TRANSMISSION STUDY FOR MONOCHROME T.V. PHONE SIGNALS

If one regards the ideal telecommunication medium as the one which supports the illusion of direct human sensory contact then the television telephone brings us closer to that ideal than ever before. To the communication engineers however, the introduction of a T.V. Phone service will not be without challenge. A prime reason for this is that the T.V. Phone signals which conform to current standards require a large channel capacity for their transmission, with a single link between two persons requiring the equivalent of some 250 telephone channels. This, together with a predictable demand for long distance transmission, will place a heavy strain on existing long distance transmission facilities. Digital coding to reduce the channel capacity required for T.V. Phone signals is one attractive means of meeting this situation. In such a circumstance, the cost of the terminal coding equipment would be offset by the channel capacity freed. Besides the economy associated with a digital system there are significant advantages inherent in a digital signal representation. These include the ability to employ error correcting measures, the ease of multiplexing, switching and recording, the ability to regenerate the digital signal, and the ease of either adaptively or non-adaptively equalising the digital channels.

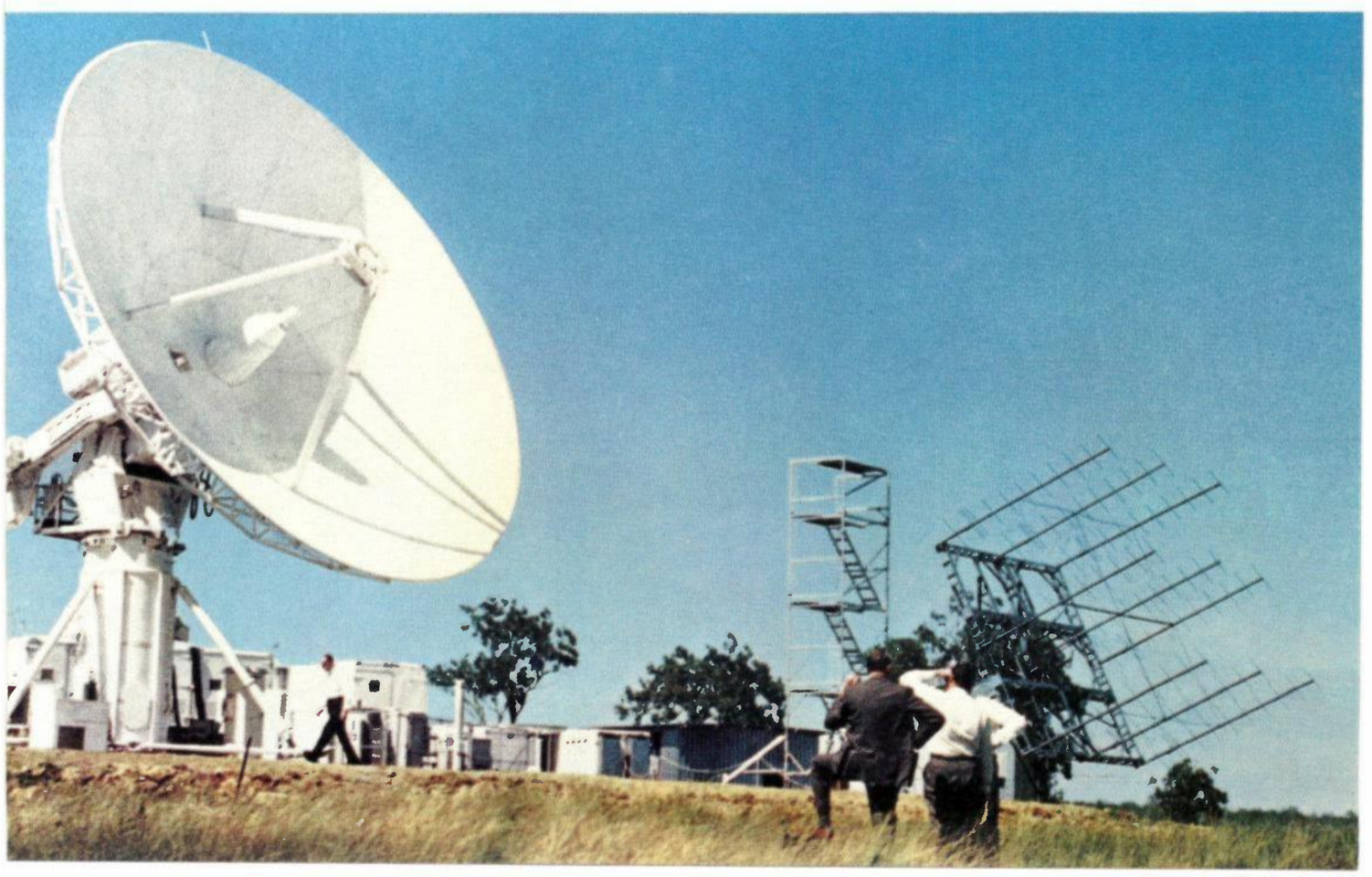
Of the various first-level source coding techniques available Delta Pulse Code Modulation (D.P.C.M.) offers perhaps the best performance with the least complexity. Even without additional statistical encoding D.P.C.M. produces excellent quality pictures at a bit rate of 3 bits/picture element which, for a T.V. Phone whose slot bandwidth is of the order of 1 MHz, would be compatible with a second hierarchy P.C.M. system operating at approximately 6 Mbits/sec.
Shown opposite is a photograph of a D.P.C.M. encoder implemented in the Laboratories. This encoder has now been commissioned and an investigation into the various D.P.C.M. coding algorithms, as they relate to both error-free perturbed transmission systems, is being undertaken.
The straight coded D.P.C.M. signal has been made capable of transmission on second hierarchy P.C.M. systems. Transmission studies are also being carried-out on multiple first hierarchy (1.536 Mbit/s) systems. The design of the D.P.C.M.-P.C.M. coder interface and the differential channel-phase and synchronisation problems are in the design stage. Studies are being planned to determine whether it will be possible to use such first hierarchy systems to accommodate bit streams, whose rates lie between those of the first and second hierarchy P.C.M. systems.

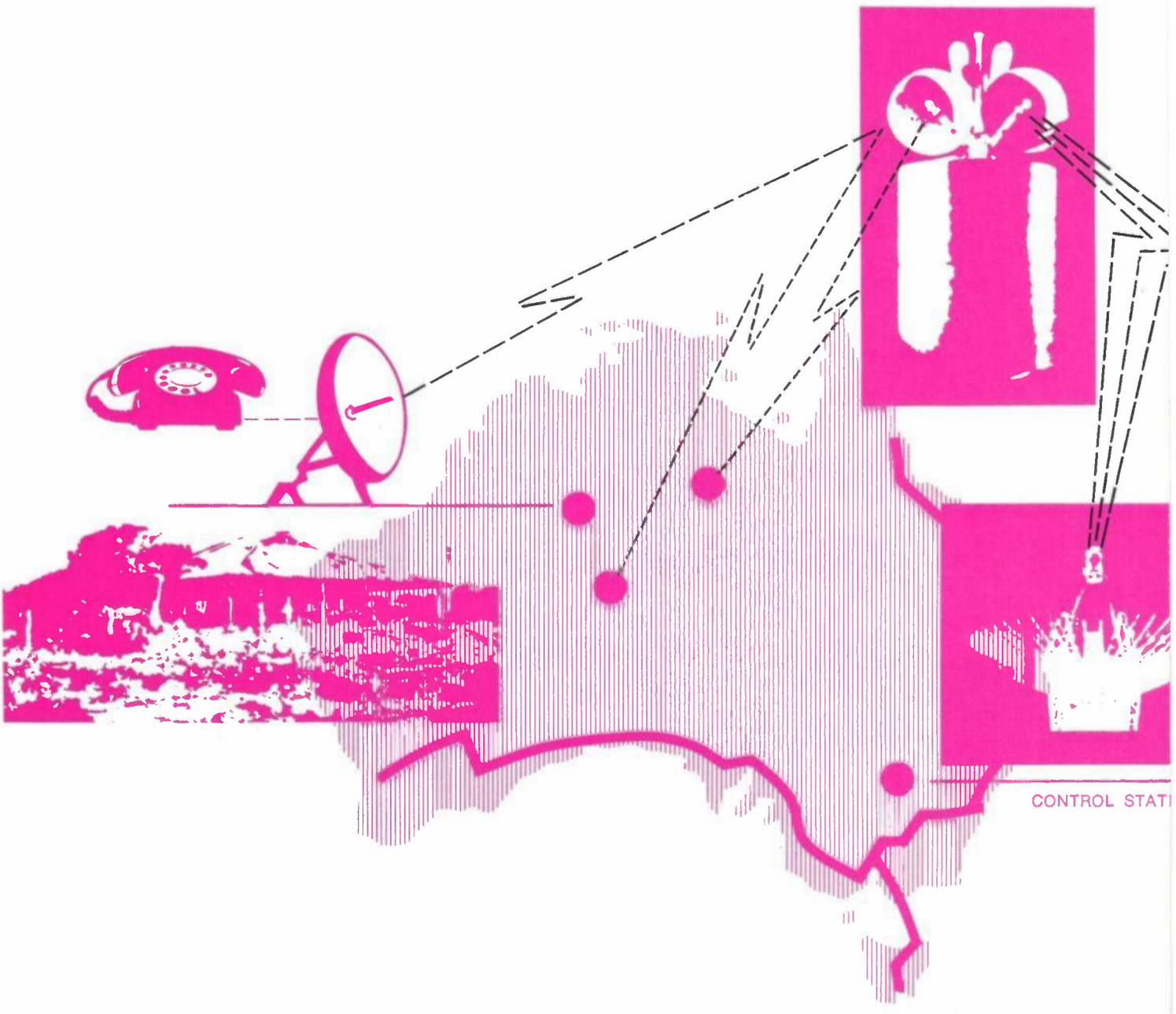
GENERAL ACTIVITIES

There has been continuous activity in this field since 1961 when the first Laboratories' paper was published on the subject. Present activities encompass the following broad areas.

A member of the Laboratories' staff is outposted on a long-term basis to the Goddard Space Flight Centre of the U.S. National Aeronautics and Space Administration (N.A.S.A.) near Washington D.C. He is a roving "trouble-shooter" for the communications aspects of the Applications Technology Satellite (ATS) Programme, and is also engaged in communications systems studies for the Synchronous Meteorological Satellite Programme. This outposting helps to provide

EARTH STATION ANTENNA ARRAYS AT COOBY CREEK, QUEENSLAND




CONTROL STATI

up-to-date knowledge of the latest developments in the art.

One of the functions of the Research Laboratories is to provide a technical consultative service to the Department. In the space communications field this has been concerned to a large extent with specific Australian problems of co-ordination between space and terrestrial systems which share common frequency bands. The object of the co-ordination is to keep mutual interference down to tolerable levels, and work on this subject suggested that antenna radiation patterns which included a deep null in specific controlled directions would be very desirable. This was made the subject of a research contract with the University of Sydney, and the preliminary results, which show considerable promise, could be applicable not only to the problem which inspired the investigation, but also to the allied problems of controlling overshoot interference and path intermodulation in terrestrial radio relay systems.

Because the technology of space communications is developing at such a fast rate, and because each satellite in orbit is visible to and can affect many countries, many international meetings have been necessary to recommend standards for equipment and systems. One of the bodies concerning themselves with this matter is Study Group IV of the International Radio Consultative Committee (C.C.I.R.). Delegations to Study Group meetings and to the XIIth Plenary of C.C.I.R. have been led by the Assistant Director-General (Apparatus and Services) of the Laboratories, and a member of the Laboratories has been elected Vice-Chairman of the Study Group IV.

As a particular part of the study of the possible role of satellite communications in the A.P.O. telecommunications network, the Laboratories have given special attention to the problems of serving subscribers in remote areas of Australia, and have evolved a conceptual model of a possible system which might have application to the solution of the problem. Some new and untried techniques are crucial to the technical practicability of the proposal and with the co-operation of N.A.S.A., experiments using the ATS-1 satellite which is in orbit over the Pacific Ocean have been carried-out. This project is described in more detail below.

RURAL TELEPHONE SERVICE BY SATELLITE

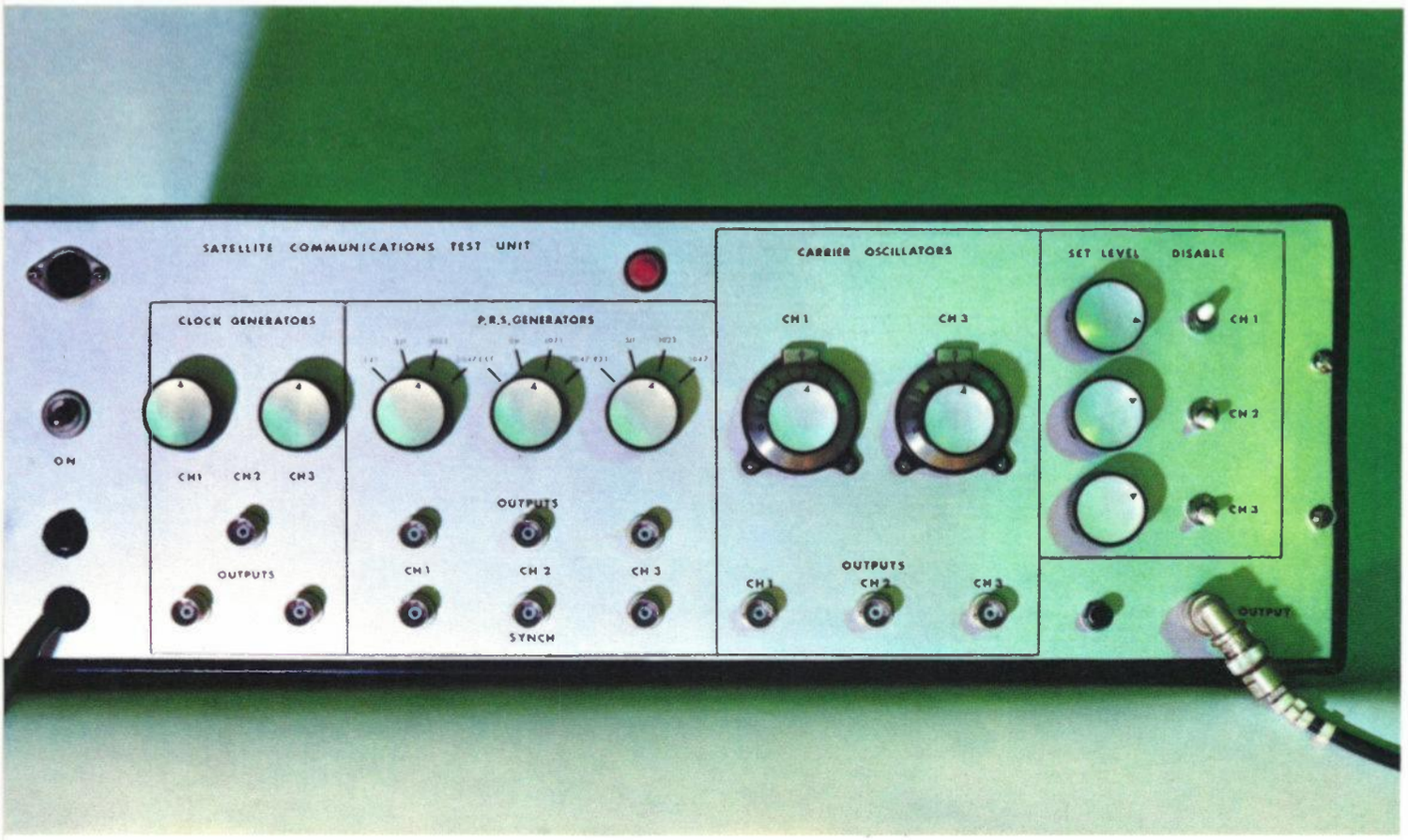
Small Station Concept

The problem of providing telecommunications service to remote areas of Australia within the limits of existing rural telephone policies is one for which no universally satisfactory solution has yet emerged. One of the major difficulties is represented by the sheer distances involved; but a communications satellite, which would be accessible from any point in Australia, would overcome this. Consequently, a fresh look at the problem seemed to be desirable, and a preliminary systems study to take into account the various telecommunications services, which remote subscribers might desire, was carried-out. The scope of the study encompassed television, facsimile and data services, but the major effort was devoted to a subscribers' telephony service.

The systems study included consideration of the factors arising because any new service must be able to co-exist and preferably be fully integrated with the existing telecommunication network. Thus, in addition to considering the satellite and associated earth station terminals, it is necessary to consider methods of setting-up and terminating calls, and the signalling, switching, numbering and control arrangements possible had to be given attention. Echo control is also a significant factor.

After surveying several possible means of meeting the objectives initially postulated, it was concluded that a suitable network model could be based on a "port" station or stations to give access to and from the existing terrestrial network. A group of subscribers using the satellite could be routed through a port station and the system could expand by forming new groups of subscribers and adding port stations.

One of the characteristics of telephone subscribers service is that the individual subscriber uses his equipment for part of the time only. Thus, it is economically advantageous to endeavour to concentrate the complex and expensive parts of the system as common equipment to be shared by several or many subscribers. In this case, both the satellite repeater (transponder) and the port station would be shared. The satellite necessarily represents a large capital investment, and it is important to use it effectively. For this reason, a "demand assignment" mode of operation is envisaged. The channels through the satellite would not be permanently allocated to individual subscribers but, instead, would be individually assigned as the instantaneous traffic demanded. A group of about 100 subscribers might therefore be served by about 10 channels in the satellite. No echo suppressor would be needed at the satellite subscriber telephone terminal if a special four-wire instrument were used, and the Australian network is so arranged that it is relatively easy to arrange for echo suppressors to be inserted at that end of the connection where the subscriber served by the terrestrial network is situated.

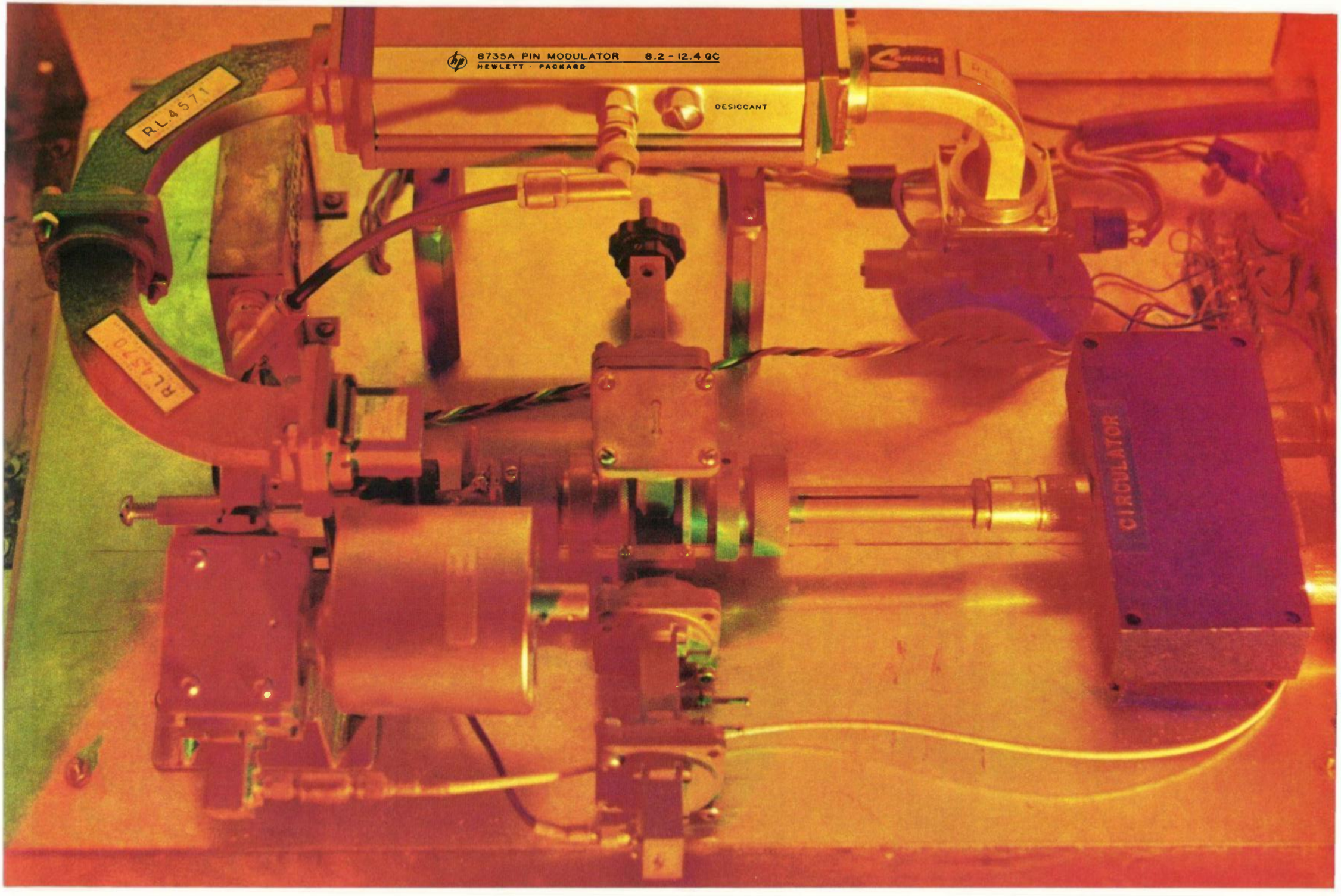


THREE-CHANNEL SATELLITE COMMUNICATIONS TEST UNIT

Demand assignment means that the subscriber-end (as distinct from the port station-end) needs some means to choose the correct channel. The channel separation means proposed is frequency division, so channels would be chosen by a tuning process. Simplicity of subscriber equipment dictated that the number of discrete channel frequencies to be catered for should not be too great and this was one factor affecting the number of subscribers per group.

Another factor which influenced the system study conclusions was the fact that many channels must simultaneously use a single satellite repeater. This "multiple access" has a profound effect on system design because the mutual effect between channels is quite complex to control. The modulation method used is important in this context; delta modulation was chosen for the experiment.

Mention has already been made of the need to keep the subscriber end equipment as simple and inexpensive as practicable. One primary factor affecting this is the available power flux per unit bandwidth at the receiving antennae. This factor increased in value in the newer designs of satellite transponders, most of the improvement coming from the use of "spot-beam" antennae, which have greater usable gain than earlier satellite antennae. A system to serve individual subscribers appears to be technically feasible using relatively simple equipment at the subscriber's end now that such satellite spot-beam antennae have proved feasible.


8735A PIN MODULATOR 8.2 - 12.4 GC
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CIRCULATOR

Programme of Experiment

The development and the introduction of new systems technology into plant use is generally an iterative process starting with a paper study which is added to and modified by experimental work until sufficient data are acquired to allow planning and procurement to proceed. In the case posed by a subscriber service by satellite, the initial paper study revealed specific areas of satellite communications technology in which insufficient knowledge was available to allow system design to be optimised.

The primary objective of the programme of experiments, using the ATS-1 satellite, was to obtain engineering data for later system study and development purposes. In particular, three major items had to be probed over an adequate range of parameters. The items were:

Channel performance against received signal power level;

Frequency spacing needed between channels to control crosstalk;

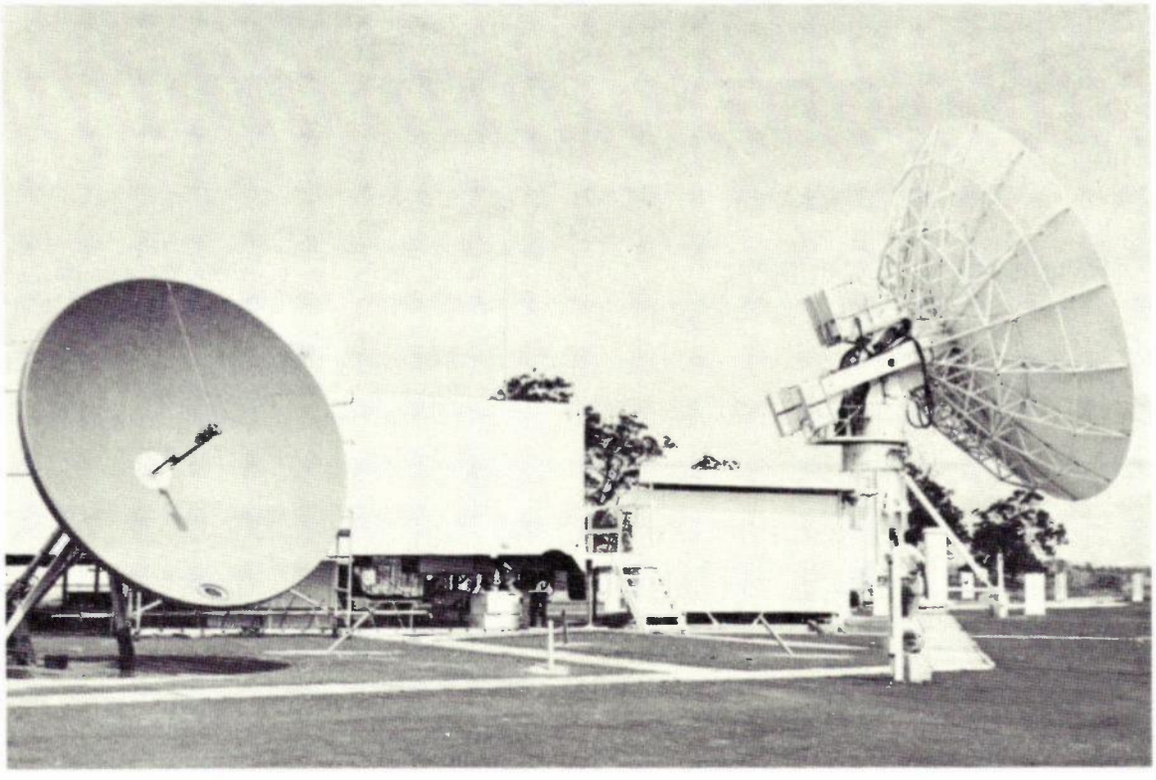
Tolerance on outstation transmitter power for equitable sharing of satellite available power between channels.

After a brief exploratory phase, seven separate experiments to explore detailed aspects of these items were defined and specified. This programme of experiments, using the N.A.S.A. earth station equipment at Cooby Creek, Queensland, and the ATS-1 satellite, together with a small experimental prototype earth station developed by the Laboratories, was carried-out over the period January to June, 1970.

Ideally, any system proposed for providing telephone service to remote subscribers via satellite, as outlined above, should give a quality of service comparable to that provided by a normal terrestrial telephone system. Early studies indicated that under the expected conditions, digital modulation with its inherent advantages would be most suitable to achieve the required quality. Delta modulation was chosen for encoding the voice signal into digital form because of its better performance under conditions of moderate error rates when compared with other known methods.

The prototype small receiving station constructed in the Laboratories was equipped with a twelve foot diameter antenna and low noise amplifiers typical of the equipment which might be considered for a subscriber's installation. The adoption of digital modulation inherently requires a somewhat complex receiver but the design adopted employed a number of modern techniques to maintain as much simplicity as possible while attempting to optimise the process of signal demodulation. However, even in an optimum system, noise and interference will cause errors in the digital signal recovered at the receiving end. The measurement of this error rate under various conditions was one of the primary aims of the small station experiments since error rate is an essential factor affecting the ultimate quality of the system.

To measure the error rate, a unit was constructed to simulate the simultaneous transmission of three channels through the satellite. The channel spacing and relative power of each channel were independently variable. Each channel was modulated with a recurrent pattern of digits, in a pseudo-random sequence, which could be recorded at the receiving end, and compared in an error counter with a locally generated pattern of the same form. The error rate counter detected the number of digits for which the two sequences did not agree and counted these errors over a given time. With three modulated channels available, the error rate could be measured under various conditions of channel spacing and signal to noise ratios. To simulate a greater number of channels, a "noise loading test set" was constructed. This unit transmitted wideband noise but was equipped with switchable filters arranged to provide noise free slots of various spectral widths into which the three modulated carriers could be inserted with varying channel spacing. These tests simulated the conditions under



ANTENNA SYSTEM AT COOBY CREEK, QUEENSLAND.
12' PARABOLIC REFLECTOR (LEFT), N.A.S.A. ANTENNA (RIGHT).

which a fully loaded operational system would work. The equipment used in the experiments was designed to interface with existing delta speech coders and decoders so that the system could carry a speech channel. The equipment and the speech channel quality available was demonstrated to representatives of the press, other interested Government Departments and instrumentalities, and to delegates attending C.C.I.T.T. Study Groups XII and XVI meetings in Melbourne.

The broad conclusions drawn as a result of the experiment are:

The transmission parameters of a system of the type proposed are technically feasible;

The delta modulation equipment fulfilled all expectations and can provide good quality telephone channels;

The small station has no difficulty in acquiring and holding the satellite despite the absence of complex and expensive automatic servo tracking equipment.

A large amount of engineering data was obtained, and will be published in a comprehensive project report. These data are intended for input into the next stage of the overall study of the systems problem to allow the optimum parameters for an operational system to be defined. After this phase has been completed, possible systems for operational use can be analysed and subsequently implemented if desired.

Subscriber Station Antenna Design

A small, yet effective, antenna was needed at the subscriber's earth station. The antenna was constructed by using a 12 ft parabolic reflector available from terrestial microwave communication systems. As the antenna had to operate in two frequency bands, 4 GHz and 6 GHz, the dimension of the aperture of the feed unit had to be compatible with the operating wavelength. To ensure maximum antenna efficiency and minimum boresight misalignment at both frequencies, the coincidence of the feed phase centres for these frequencies was desirable, and to meet these requirements a cylindrical horn was chosen as the primary feed.

The primary feed unit was provided with two ports for the individual operating frequencies. The port consisted of a N-type connector connected to a tuned probe which was inserted transversally into the primary feed unit. The two ports were placed perpendicular to each other. Adequate isolation between these ports is necessary to avoid objectionable interaction between the two frequencies, and to prevent damage and performance impairment of the receiving system. To separate and isolate the two signals, a diplexer system was built in the primary feed unit.

The diplexer consists of two polarisation filter elements placed a suitable distance apart, between the 4 GHz and 6 GHz ports. The polarisation filter consists of copper conductor grids shaped to follow the E-lines of the signal being suppressed; for signals whose E-lines arrive perpendicularly to the gridlines the filter will be ineffective and hence transparent. The polarisation filter elements were made by the double photo etching method from thin copper plate.

The characteristics of the antenna are as follows:

1. Capable of simultaneous reception at 4 GHz and transmission at 6 GHz.
2. The polarisations of the received and transmitted signals are linear and orthogonal to each other.
3. Gain (relative to an isotropic radiator) — 40.6 dB at 4 GHz, 45.6 dB at 6 GHz
4. 3 dB beamwidth — 1.6° at 4 GHz, 1° at 6 GHz
5. VSWR over 10 MHz — 1.3
6. Isolation between ports — 35 dB
7. Boresight misaligment between transmit and receive beams — 0.16°

In a commercial system, it is envisaged that a simple but rigid antenna mounting design would be used with facilities for manually aiming each subscriber's antenna at the stationary satellite. The mounting would consist of a tubular triangular frame pivoting on two ground anchorage points and supporting the antenna. The elevation angle of the antenna and frame and the "azimuth" angle of the antenna would be independently controlled by two adjustable rear legs to a third ground anchorage point.

In the experimental system, the mountings were built using this basic principle but were made more complex to suit the special requirements of the experiment, which included frequent re-aiming from the satellite to a dummy satellite on a tower 90° away in azimuth. The dummy satellite was used during ground station equipment tests during periods when the ATS-1 satellite was being used for other experiments.

Data transmission is a rapidly expanding component of the traffic in the telephone network. Many large public and private institutions now have the need for a rapid transfer of information between geographically dispersed computing and data processing installations.

The digital data to be transmitted is fed into a modem (such as those provided with the A.P.O. DATEL service), and is modulated into a form suitable for transmission over a communications channel. Upon reception, another modem demodulates this signal back into digital data suitable for connection to terminal equipment. A variety of modems is available to cater for various rates of information transfer.

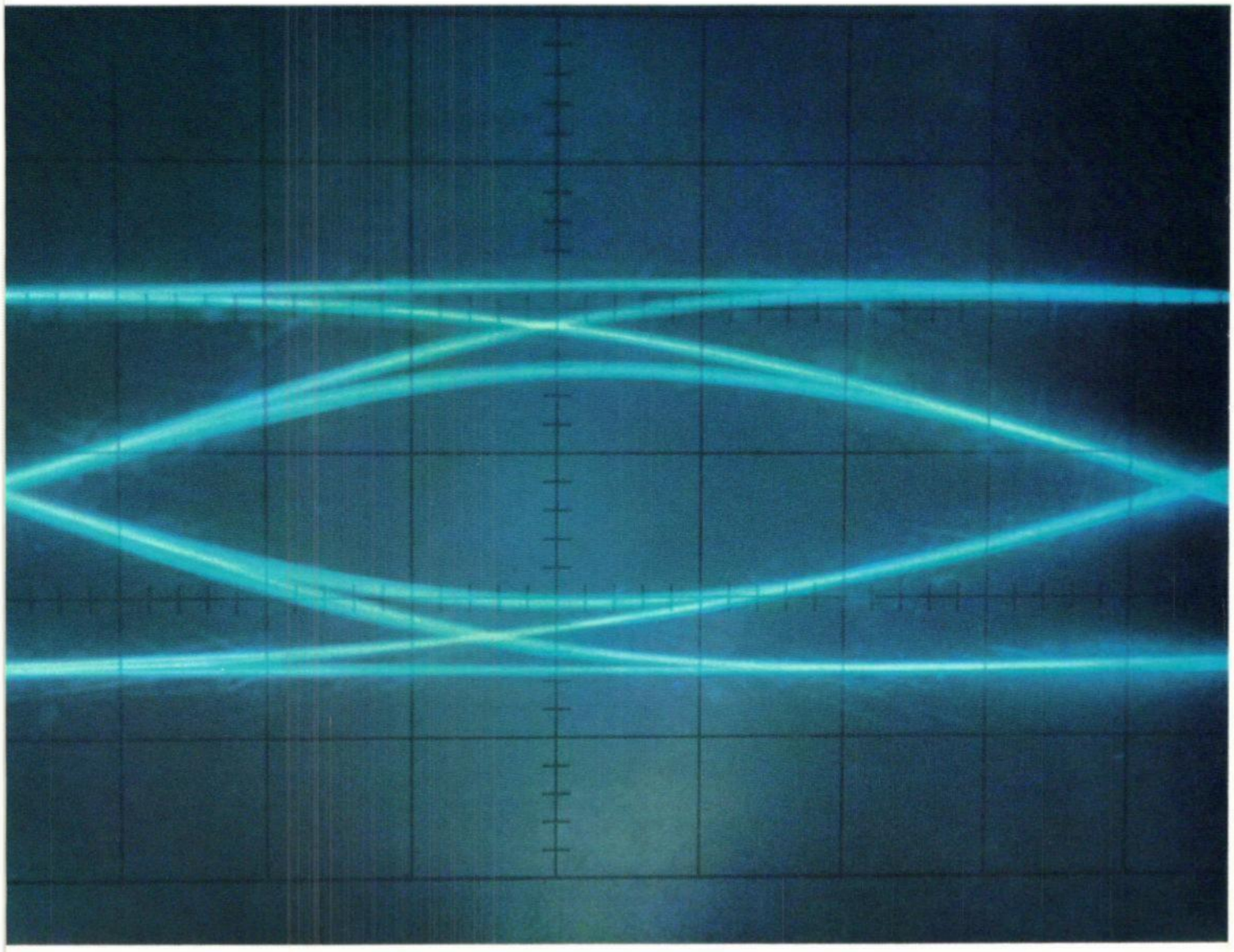
The Research Laboratories are actively involved in studying data transmission. These studies cover both the capability of the present network to carry data at various speeds, and the properties and technical features of the various modems available and proposed in the future. At present, Australia has one of the highest voice/data circuit mileages in the world. Considerable time has been given to the study of the principles of transmission of digital signals. Consequently, the Laboratories are able to form their own judgement on the merits or otherwise of new techniques being proposed for data transmission as well as on the effect of different line impairments on various types of data modems.

Controlled and repeatable tests are an important tool in assessing the relative performance of various data modems, and this type of laboratory test is being actively pursued. Following a study of the possible impairments on data transmission resulting from the use of the telephone network to provide data channels, a range of equipment has been developed to assist laboratory simulation of these impairments. These include equipment to simulate timing jitter, attenuation and group delay distortion and the like.

Although the theoretical and laboratory studies are essential for a full understanding of data transmission, the performance of data transmission equipment must be ultimately measured on actual circuits. During the past year, the Laboratories have arranged programmes of data transmission tests on the telephone network. The most important of these, as far as voice frequency bandwidth transmission is concerned, relates to data transmission performance over the switched telephone network and private lines at data rates of 1200 and 2400 bit/sec. The results of these tests have been used to assist in the selection of suitable A.P.O. DATEL modems. Measurements were made of attenuation and group delay characteristics as a function of frequency, impulse noise counts and error rates of the data circuit. Currently tests in the Melbourne metropolitan area have been completed, and a similar series of tests is planned for the Sydney network.

Another series of tests at 2400 bit/sec. has been made on private lines over a 1,200 mile route over both mi-

BINARY EYE-PATTERN



crowave radio and coaxial cable bearers in order to compare the data transmission performance of the two types of bearer.
The maximum speed of reliable data transmission on specially treated voice frequency telephone circuits is limited at the present time to about 9600 bit/sec. As a consequence of this speed limitation, and the demand for data circuits capable of higher speeds, an investigation of data transmission employing the basic 12-channel frequency division multiplex system group bandwidth (60-108 kHz to transmit data at 40.8 kbits/sec. is in progress. This study is related to the study of the provision of other wideband networks, such as a T.V. Phone network.

The largest single voice/data network over private lines is the N.A.S.A. data network. The equalisation techniques for this network posed problems because of the size and complexity of the network, and because a high degree of flexibility was required. The necessary fundamental studies were carried-out in the Research Laboratories, whilst other Headquarters Sections and State Administrations assisted in the implementation. The initial stages were implemented using "fixed" equalisers; however experience soon indicated the desirability of using variable equalisers, which could be adjusted rapidly in situ. An inexpensive variable equaliser was designed in the Laboratories, and these equalisers are now in widespread use.

ECHO SUPPRESSORS

In line with the Department's efforts to achieve the optimum performance of the trunk telephone network and establish international-subscriber trunk dialling, pools of echo suppressors are being provided at various switching centres to enable suppressors to be added to the longer connections for purposes of controlling echoes. Because of the tendency towards the use of geostationary communication satellites in providing international and national telephone circuits, and the inherent long transmission delays in such circuits, it is desirable that echo suppressors should be of a type suitable for use on long delay (satellite) circuits.

At the present time, it is not possible to specify the characteristics of such echo suppressors objectively in such a manner that optimum performance under conversation conditions is ensured during all domestic and international telephone calls. Samples of commercially available echo suppressors of the type sought were therefore obtained and were thoroughly evaluated using a variety of methods aimed at determining the likely reaction by actual subscribers under different conditions.

In one trial, the suppressors were set up in turn in a special test telephone circuit in which variable transmission delays were artificially inserted. Using this circuit, engineers were able to originate telephone calls both in the local and in the trunk network and were able to gauge, both directly and by called party reactions and solicited comments, the effectiveness of each of the suppressors.

In another trial, the suppressors were connected in a laboratory test telephone circuit and recorded speech signals were fed in at various levels in both directions of transmission, in such a way that the suppressors were subjected to a series of artificial doubletalk conditions. The transmitted speech signals were re-recorded and subsequently analysed for incidence of speech mutilation and for presence of echoes and doubletalk.

The final trial was a laboratory type user-preference test involving about 40 telephone users recruited from Central Office engineering groups, who were used in pairs to converse over a special test telephone circuit which included echo suppressors and transmission delay and means for simulating a variety of conditions likely to be encountered by calls in the long distance network. For each test condition, the two conversing subjects were exposed alternatively to two types of suppressors and were required to state a preference for one type. This test was particularly useful in assessing performance differences between suppressors operating under specific operating conditions.

The results of the above tests were used in determining the type of echo suppressor to be procured, and as a result, the Department can anticipate that the echo suppressors selected for the Australian telephone network are among the best available and

will provide a high level of subscriber satisfaction on long distance calls, national or international. Once they are installed in the network, standard service appraisal methods can be used to ensure that the expected high standard of service is both obtained and maintained.

ECHO CANCELLERS

With the advent of communications satellites and the rapid growth of international telephone traffic, there is a strong interest in improving the control of echoes which arise mainly from imperfect impedance matching at 2/4-wire transitions in the telephone connections.

Conventional means of reducing the adverse subjective effects of such echoes involve the use of echo suppressors. However on long telephone links these devices exhibit characteristics which give rise to other objectionable phenomena such as "syllable clipping" and hence other methods of overcoming the echo problem are currently being investigated.

Echo cancellation appears to be one of the more fruitful approaches to the problem, and has received some attention at a number of research establishments. The method is based on the removal of the echo by adding an equal and opposite signal to the echo into the echo path of the 2/4-wire terminating sets, thereby effectively "cancelling" the echo. The investigation of such cancellers has been proceeding in two phases.

Phase one called for the development of a preset type canceller which required each conversation to be preceded by a short time interval in the order of a fraction of a second during which the degree of mismatch was sensed and a suitable echo synthesising network (to cancel the echo) automatically adjusted. The state of cancellation so achieved was then maintained for the duration of the conversation.

Phase two of the project includes the development of an echo canceller capable of achieving the required degree of cancellation using the speech signal itself so that no "setup" period (as described for phase one above) is required. The principal advantage of this mode of operation over the "preset" type is that any change in the state of mismatch is adjusted for as it occurs. Furthermore, the speed at which the device can adapt to changes in the state of mismatch will make it suitable for use in links containing "asynchronous" carrier systems, some of which cause the echo signal to vary in phase at a rate determined by the amount of the "out-of-synchronism".

The successful completion of phase one of the investigation has been reported in the literature. In addition the hardware developed in phase one has been successfully tested in an operational environment on telephone connections, which included a Sydney-Perth link established via a geostationary satellite.

The hardware development of phase two is still in progress, and is based on all-digital techniques as opposed to the all-analogue approach adopted for phase one.

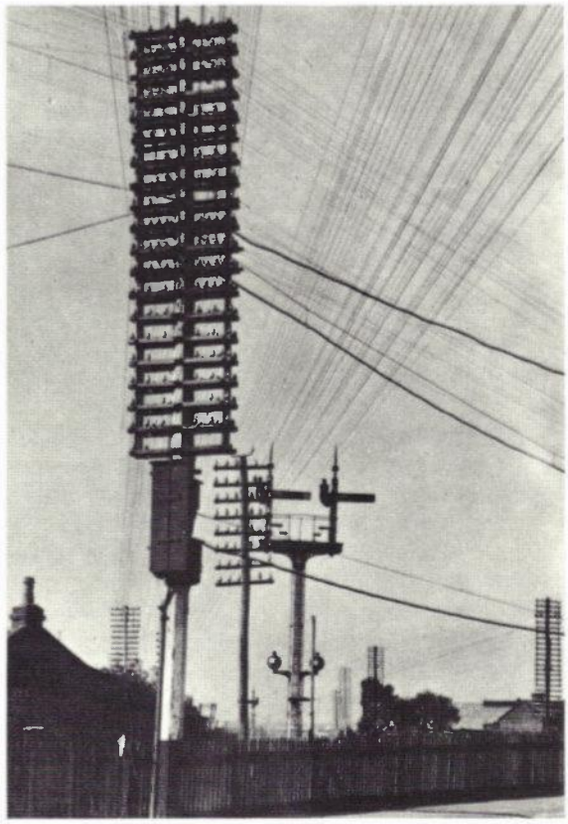
COAXIAL CABLES

Since the 1950s coaxial cables have become a major transmission medium in the Department's broadband "highway" communication network as well as for broadband tributary links to that network. Since their introduction, utilisation of coaxial cables in terms of telephone channel capacity has been steadily increasing, and the latest systems installed carry 2,700 channels in a bandwidth of 12 MHz. However, already in 1967, work commenced in the Laboratories to determine the capability of locally produced coaxial cables of carrying over 10,000 telephone channels using carrier frequencies up to 60 MHz, for which special measuring techniques were developed. The application of these new techniques led to the discovery and subsequent elimination in the manufacturing process, of structural defects of the coaxial tubes which otherwise may have needed special measures in the circuit development for repeaters and equalisers to remedy their adverse effects on the transmission performance.

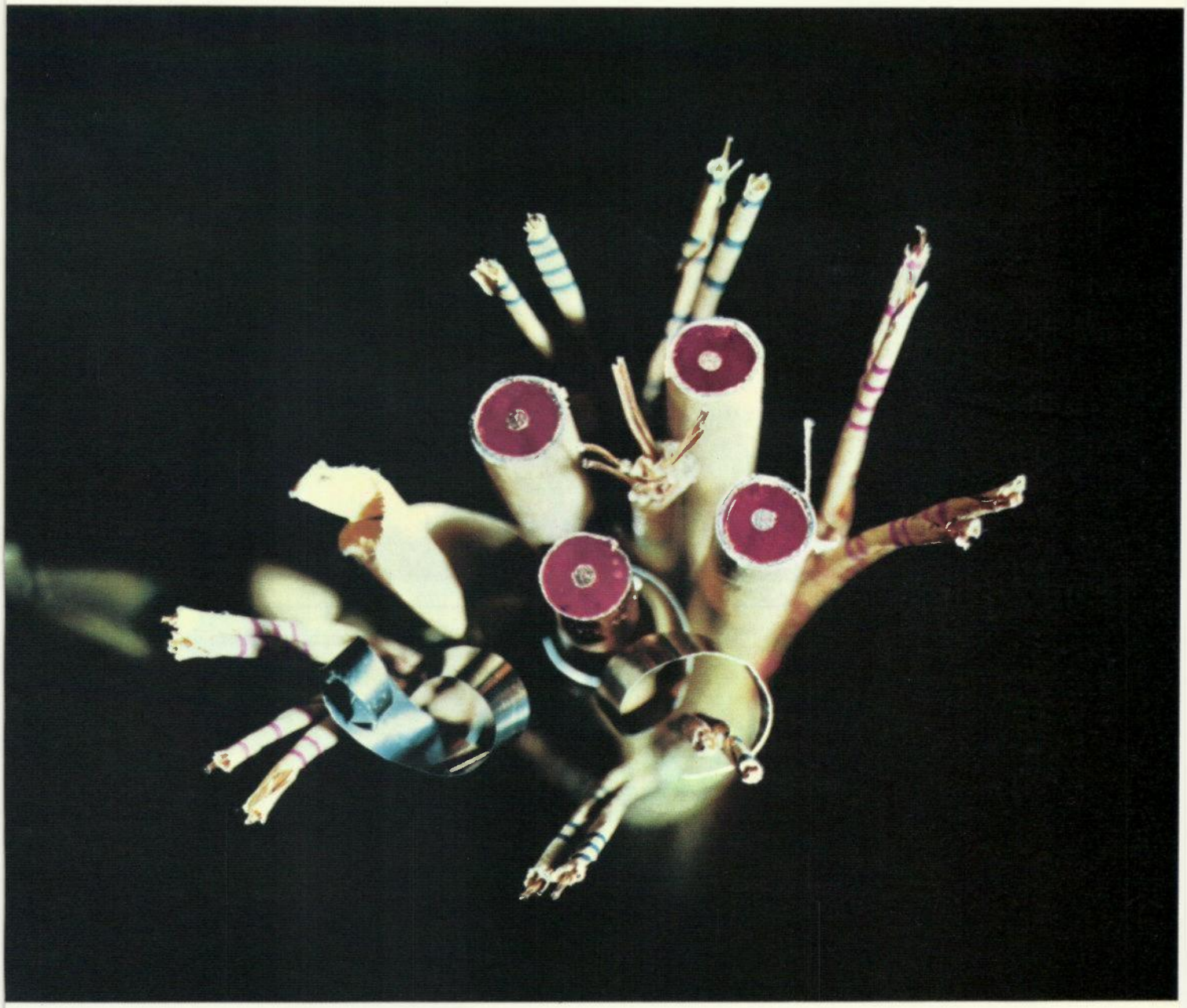
This work has been extended into studies of cable performance in the frequency range up to 250 MHz, to provide information serving as a basis for assessment and design of high capacity transmission and reticulation systems.

As a result of publications of the Laboratories results, interest was aroused overseas in the then new measuring techniques.

A member of the Laboratories staff operating in this area is attached to the U.K. Post Office Research Laboratories for a period of approximately one year, and it is hoped that this attachment will be of benefit to both parties.

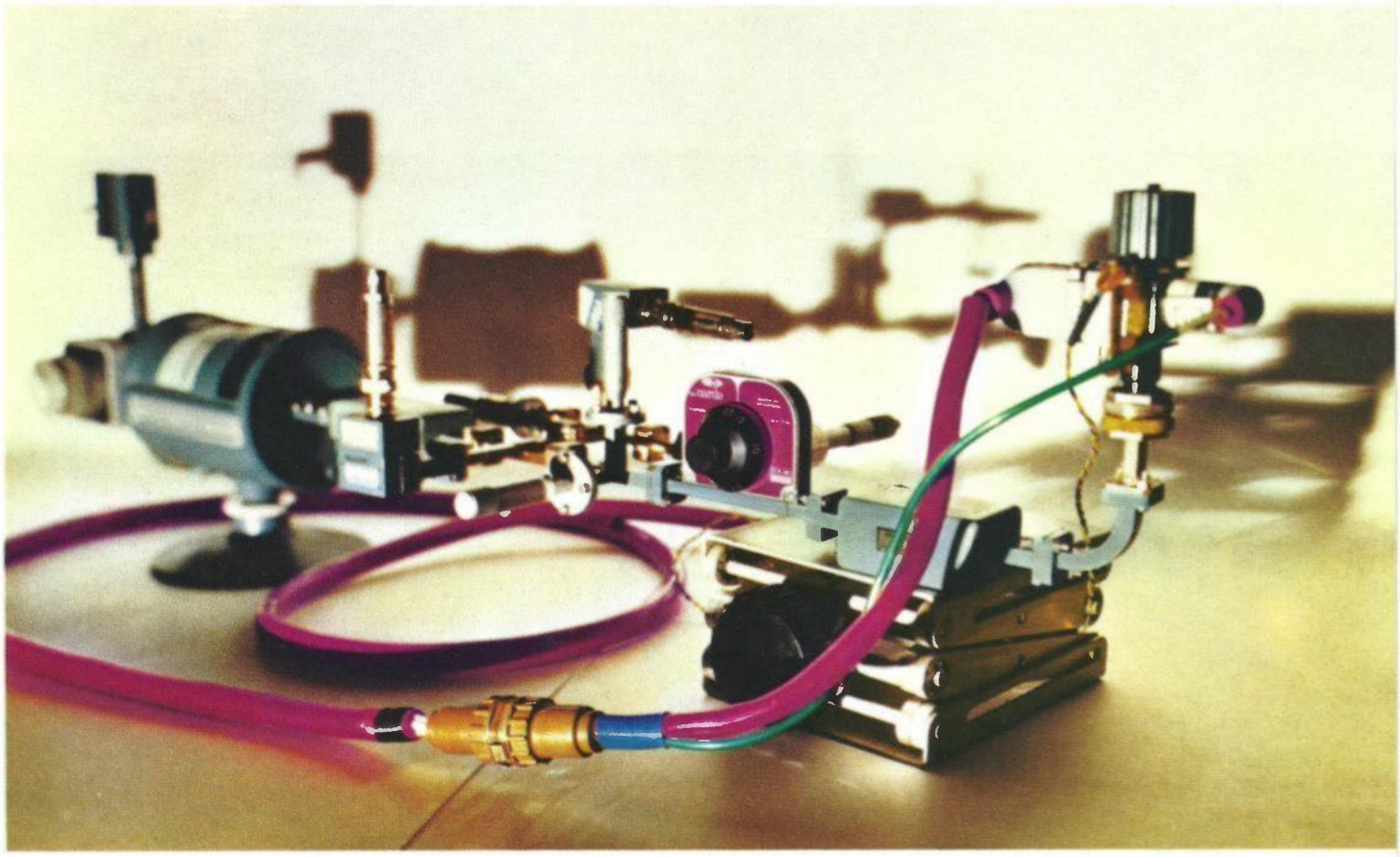


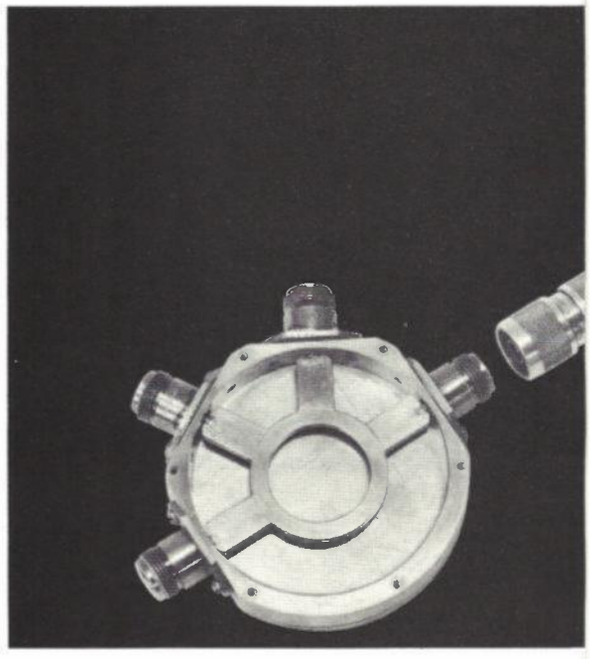
SUBURBAN STREET, MELBOURNE 1931, WITH CONCENTRATION OF AERIAL WIRES



SIX-TUBE COAXIAL CABLE WITH INTERSTITIAL WIRE PAIRS

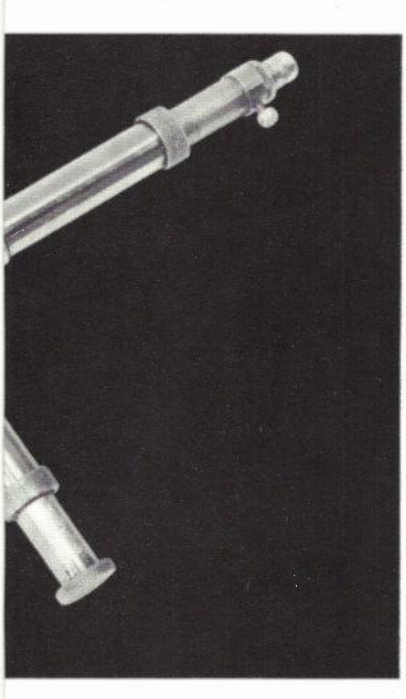
RECTANGULAR WAVEGUIDES WITH MICROMETER ADJUSTABLE STUBS





SLAB LINE HYBRID

WAVEGUIDES



Existing transmission systems — cable and radio — handling conventional forms of traffic such as telephony, telegraphy, teleprinter and data can be expanded to cope with further capacity but only to a limited degree.

Demand for these services is increasing quite rapidly and will expand much more in the future. However, the greatest demand for additional traffic capacity will come from the introduction of T.V. phones and other advanced exotic services. For example a T.V. phone, as being specified by the C.C.I.T.T., requires as much transmission capacity as 250 telephone circuits.

To increase the capacity of communications systems significantly, involves bandwidth reduction measures or the use of much higher frequencies than those in use at present. By international agreement frequency bands in the millimeter-wave range between 30 and 100 GHz are being used. A system in which the information to be transmitted is sent through hollow "waveguides" at these higher frequencies appears to offer the earliest possible relief for the high traffic demands. The A.P.O. Research Laboratories are undertaking a research project which will assist the introduction of such waveguide systems into the nation's communication network.

Up to the present, the type of waveguide used in telecommunication equipment has been almost exclusively of rectangular cross section, but it appears that the waveguide employed to cover long distances at least initially may be a round tube having an internal diameter of 5 to 7 cm consisting of lengths of 3 to 5 meters joined together. Most lengths may have a smooth inner surface coated with a thin layer of low-loss dielectric material. Single lengths with a closely wound spiral of thin conducting wire embedded in the dielectric layer may be inserted at intervals, the lengths of these intervals depending on the accuracy of manufacture and construction of the "normal" lengths.

The traffic carrying capacity of such a waveguide wideband system is expected to be such that all the traffic sent along 100 coaxial tubes with present day techniques could be sent along one circular waveguide.

MICROPHONES AND ARTIFICIAL EAR

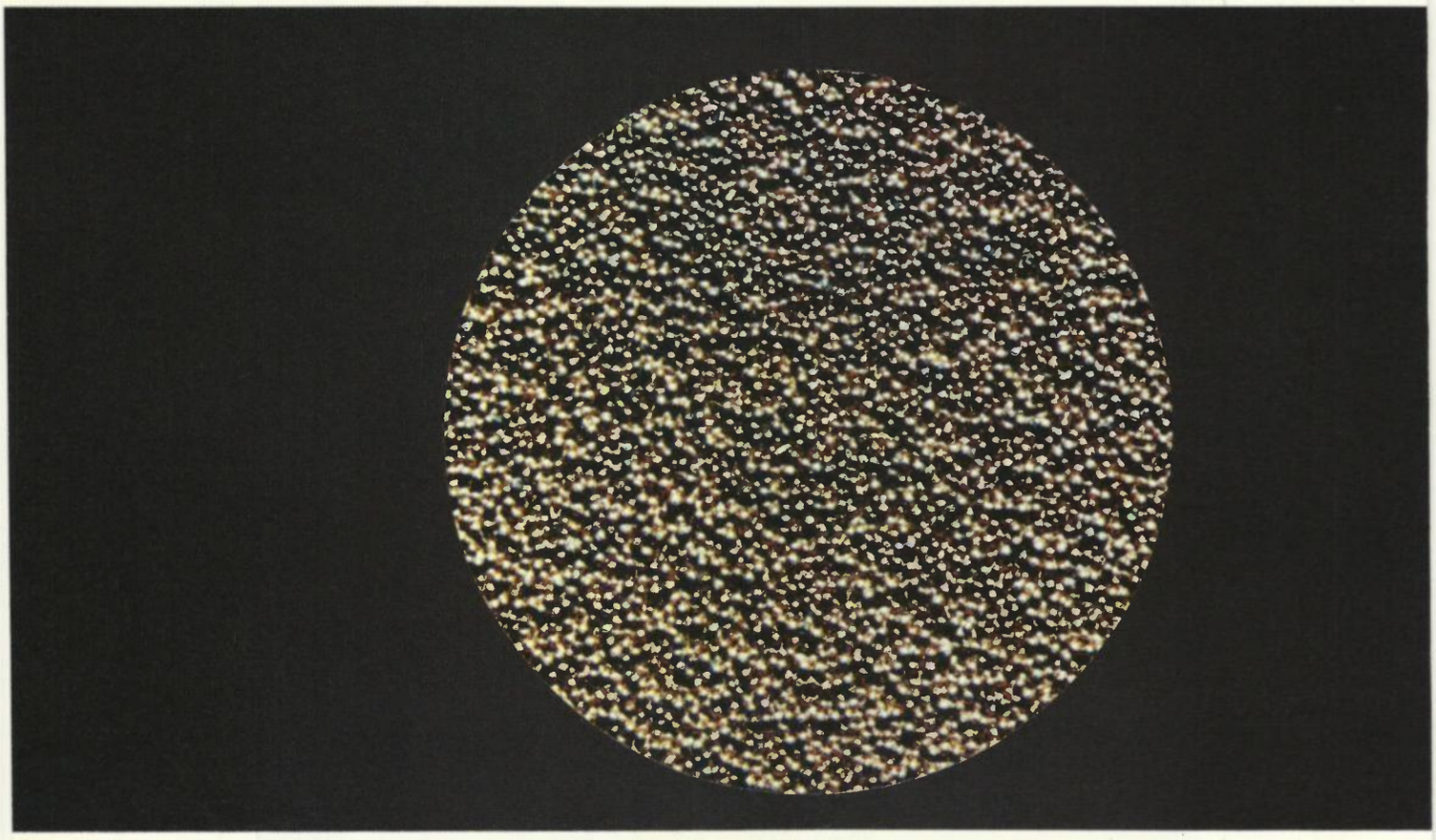
ALTERNATIVE TO CARBON TRANSMITTER

In common with other administrations, the A.P.O. is examining alternatives to the carbon transmitter. Carbon transmitters while providing a high output level and significant effective amplification suffer from problems of ageing and instability. They are however comparatively cheap, if the costs of a visit to the subscriber's premises when replacement is required, are ignored. A successful replacement must provide on an economical basis a long life, higher sensitivity (if possible), and improved frequency response with lower distortion.

Two problems must be solved, namely, the provision of a cheap, reliable transducer and a suitable solid state amplifier. In the quantities required, integrated circuits offer a solution to the latter problem. One form of transducer being investigated is the electret, a form of electrostatic microphone which is both simple and robust. This may be either self polarised or externally polarised. To gain experience a small production run of the externally polarised version coupled with a specially designed integrated circuit has been arranged.

OPINION TESTING OF TELEPHONES

50 SINTERED PHOSPHOR-BRONZE-PELLET DISC USED AS HIGH FREQUENCY AUDIO FILTER

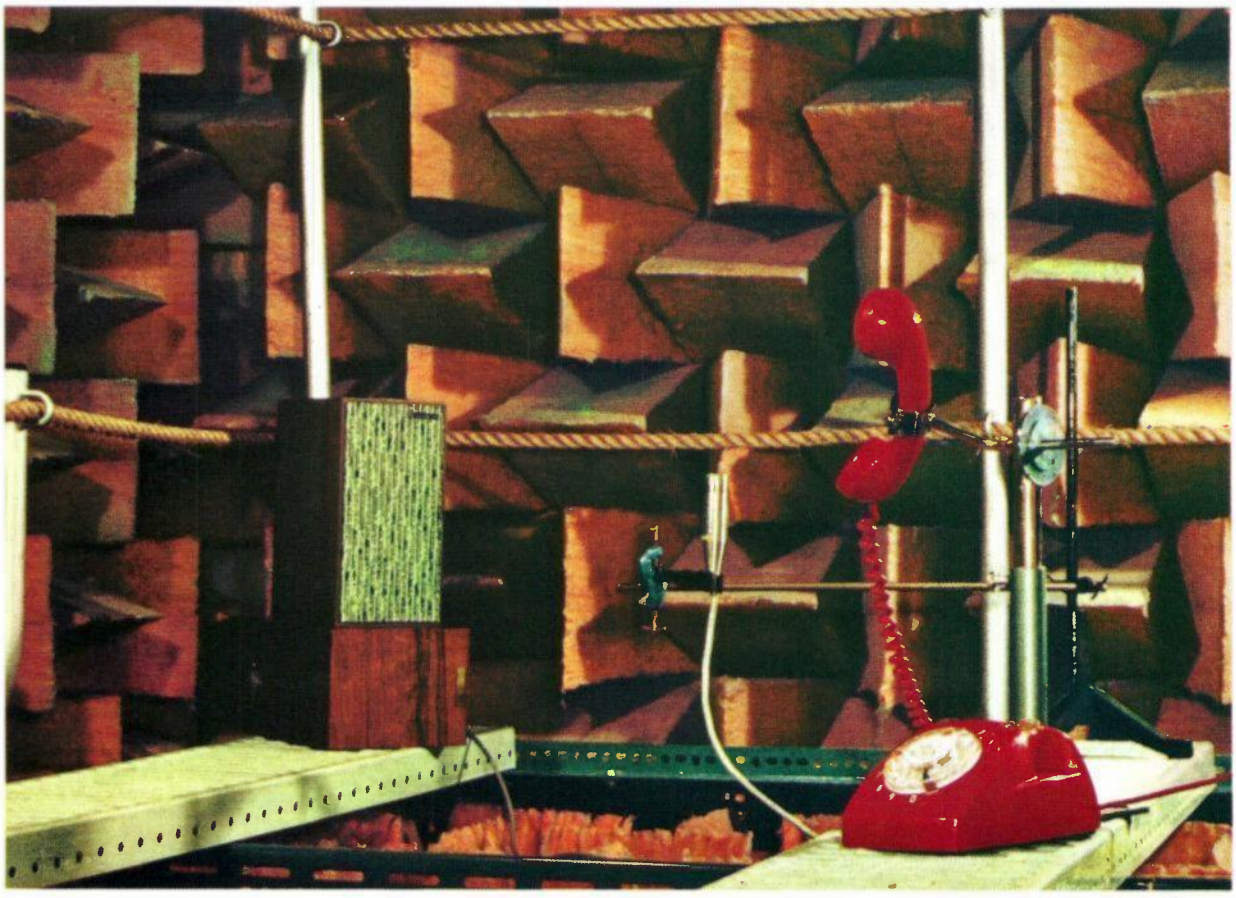


LONG LINE TELEPHONE SHOWING SIDE-TONE NETWORK PLUG-IN CARDS

DEVELOPMENT OF A LONG LINE TELEPHONE

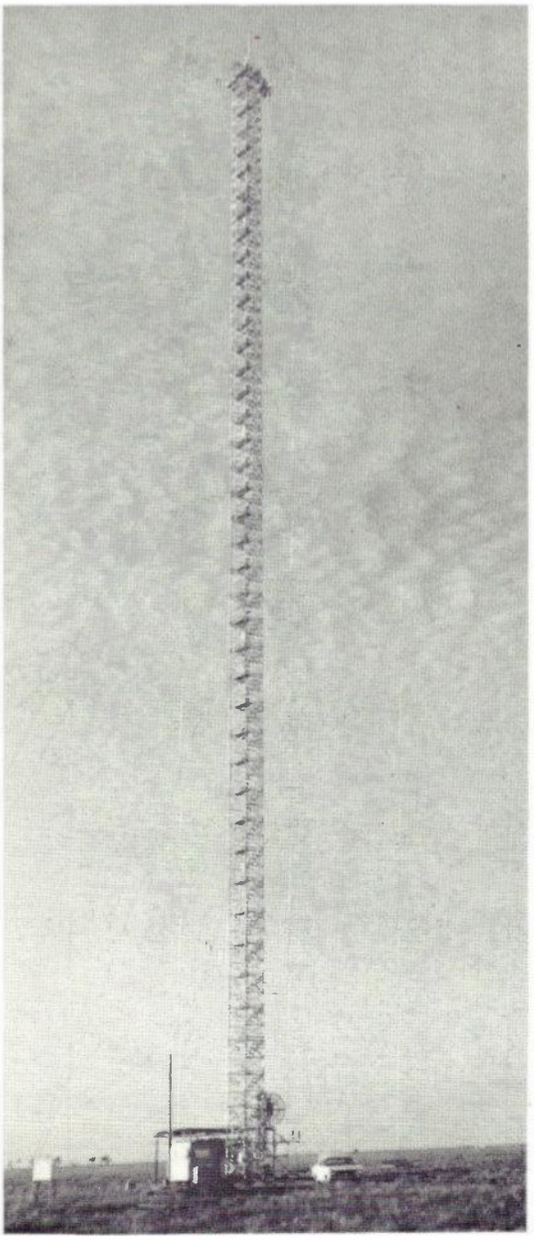
Economic studies of the costs of providing service to subscribers distant from an exchange have shown that savings in expenditure on line construction are possible, if a telephone having enhanced sensitivity could be provided at reasonable cost.
The standard 801 telephone, employing a carbon transmitter is limited in respect of its application with long subscribers' lines by the need to supply it with adequate feeding current.
Studies have led to the development of a so-called Long Line Telephone, in which a 4T-receiver associated with a solid state amplifier is used in lieu of the usual carbon microphone, resulting in a substantial increase in sending efficiency. A redesign of the induction coil and the use of high sensitivity receiver capsules (selected from production batches of ordinary receivers) has led to an improvement in receive efficiency. The improvements in send and receive efficiencies are such that the Long Line Telephone may be used on lines of nearly twice the length of those on which the standard 801 telephone may be used without exceeding the Department's transmission limits.
However, higher send and receive efficiencies lead to higher sidetone levels. This increase affects the subscribers in two ways, namely: they hear their own voice at a relatively high volume which causes them to reduce their speaking levels; secondly ambient noise at the receiving end is heard by that subscriber via the sidetone path, and thus decreases the signal to noise ratio. The overall effect of these two features is that the benefit from the increased sending and receiving efficiencies is largely insignificant, unless practical means of reducing the sidetone can be found. This problem is under examination.

ANECHOIC ROOM WITH SOUND ABSORBING WALLS FOR ACOUSTIC MEASUREMENTS



MICROWAVE PROPAGATION STUDIES

250 FEET MAST AT JULIA CREEK, QUEENSLAND



Within the Australia-wide A.P.O. trunk network more than half the channel miles are now provided by microwave relay systems. Each system carries at least 600 telephone circuits, or a T.V. programme.

Although "optical" paths are employed, the radio signals involved experience varying attenuations and distortions in transmission, as meteorological conditions fluctuate along each path.

These propagation phenomena are, as yet, predictable only in very general terms, and the propagation characteristics must be determined statistically by field measurements to provide a secure basis for engineering a microwave system.

Commencing in 1949, before installation of the first microwave relay system, Laboratory teams have continued such studies over the years, on paths which pose particular problems.

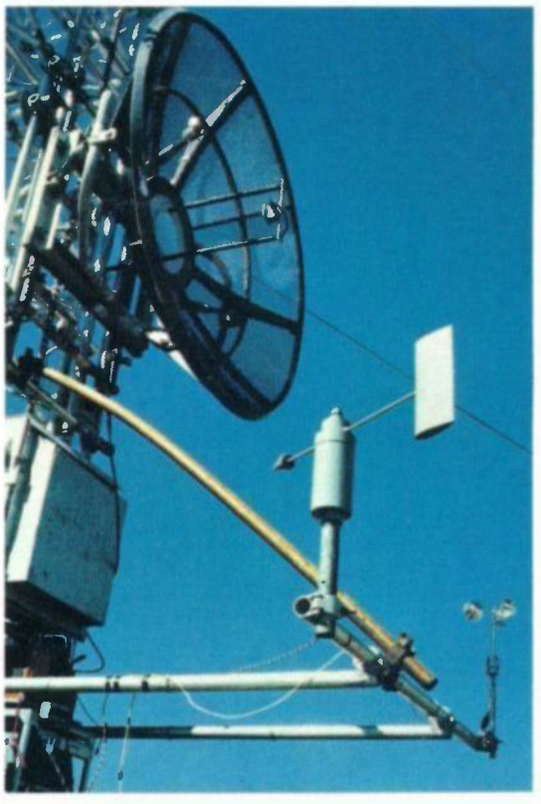
Early measurements showed that signal fading of two broad types could affect microwave systems. Firstly, signal levels could drop from their normal steady value to minima 30 or 40 dB below, and then quite rapidly return to close to normal level. In this way the signals would oscillate for an hour or more between normal and quite low levels. The period of one cycle is typically a few minutes or so and, as the signals mostly are close to normal level for much of the time, the median signal level is little affected.

Much less frequent, but potentially much more damaging, are "median depressions", or occasions when the signal level slowly falls, sometimes to 40 dB or more below normal, remains there for perhaps one-two hours, and then slowly returns to normal.

Early studies, abroad and locally, have provided a general understanding of these phenomena. Central to the radiophysical processes involved is the radio refractive index of the air. This index depends on air temperature, pressure and humidity. The spatial variation of refractive index and predominantly the vertical gradient, is the controlling factor in radio propagation.

In the temperate south-east of Australia, the terrain is generally undulating and substantially covered by vegetation. As a result strong vertical gradients are not frequent. Propagation variations hence remain within acceptable limits, except on unusual paths.

Microwave systems are now being installed in increasing quantities in semi-desert and desert areas. These mostly flat and bare areas exhibit considerably greater vertical gradients, and hence increased pro-



pagation hazards. On the flat, treeless Nullarbor Plains, for example, inland and maritime air masses, which represent refractive index extremes, can come into juxtaposition. Over such flat and bare terrain relatively little air turbulence is produced, and quite a sharp interface between air masses can occur. The Laboratories enjoy the co-operation of the Commonwealth Bureau of Meteorology in the detailed studies of the effects of the weather on radio propagation. Because of these phenomena, extensive propagation measurements were made at Ivy Tanks on the Nullarbor Plains (where the above phenomena should be prominent) with battery powered measuring equipment developed by the Laboratories. Severe median depressions were observed, with signal levels falling by over 40 dB for more than an hour. The severity of this condition was such that the previously planned route through this area was changed to avoid these severe conditions.

Such studies are necessary in several regions, and they are currently being made at Julia Creek in North-Western Queensland. Challenging problems of logistics and maintenance are involved in keeping precision radio instruments operating reliably in these remote, temporary field installations and under extreme climatic conditions. Equipment operates 24 hours a day, and measurements generally continue for 15 months at each site.

The radio propagation measurements involve concurrent recordings at several frequencies, with aerials at different heights, and on paths of various lengths. The recordings thus obtained present the overall effects of the propagation variations along the entire path between the two terminals. In contrast, refractive index data is needed on a point-by-point basis through the volume threaded by the radio rays, and its derivation currently offers considerable difficulty. The meteorological elements (temperature, humidity and wind velocity) are recorded at several heights on the terminal towers, and from these variables we obtain some indication of the refractive index structure out along the path. More direct measurements can also be made with a microwave refractometer, either mounted in a light aircraft or on a moveable carriage running on a terminal mast. Another most valuable tool, still in the developmental stages, is the acoustic sounder. Operating like a sonar set, it reveals details of atmospheric structure, often disclosing formations of unsuspected complexity.

From an understanding of those radio meteorological mechanisms, which cause unacceptable propagation conditions, adjustments to improve path performance may be made. Changes of aerial height, of system frequency, of path length or even path position may be necessary. From these studies also emerge a gradual refinement of our understanding of the physics of tropospheric propagation and some general conclusions, e.g., that higher aerial towers are desirable in a particular region.

The radio tests made to date have primarily been "narrowband" and take no account of the variations of fade phenomena across the modulation band. As the system capacity increases to 1,800 and 2,700 channels per bearer the risk of differential propagation losses occurring over this increased bandwidth also increases. Differential losses may produce unacceptable intermodulation. Special measuring equipment is employed to probe for such frequency sensitivity in a path.

▲ ACOUSTIC SOUNDER

VARIABLE HEIGHT ANTENNA DISH AND METEOROLOGICAL INSTRUMENTS ON MAST ▲

METAL FAILURE

In the provision of postal and telecommunication services in Australia, the Department consumes considerable quantities of steel, copper, aluminium, lead, zinc, tin, nickel, silver and gold annually. Typical items consuming metals are radio masts, cables, public telephone cabinets, motor vehicles, bicycles, exchange switches, manhole covers, etc. As in all of man's achievements, man's use of materials is imperfect and the materials used are imperfect. Typical problems investigated metallurgically are failures of radio and television masts, fatigue of lead sheathed cable, fracture of hardened steels in pneumatic tools, failure of diesel engines, corrosion of plugs and sockets, and the failure of hand tools. In examining causes of actual or probable metal failures, features such as hardness, chemical composition, strength and corrosion resistance are of importance. One very useful technique in the examination of metals is to polish a section until it is scratch free, and then examine the crystal structure microscopically after treatment with chemicals.
The photo shows a metallurgist examining a sample of cast iron using a microscope. By this technique it is possible to learn some of the metallurgical history of the sample, to foretell its properties, and to ascertain by what mechanism it is likely to fail. With this information the designer can take steps to minimise risk of failure.

POLISHED AND ETCHED SURFACE OF METAL SAMPLE

MICROSCOPIC EXAMINATION OF CAST IRON SAMPLE

FATIGUE FAILURE OF LEAD SHEATHED CABLE

The Australian Post Office, in common with other cable users, has experienced fatigue failures in lead sheathed cables during transport, due mainly to the vast distances over which cables have to be transported.

Available literature on the problem of fatigue in lead is mainly centred around work done on small laboratory type samples, the results of which are difficult to correlate with actual practice. The Laboratories are therefore experimenting with lead fatigue under conditions which simulate the conditions which occur during the road transport of lead sheathed cables.

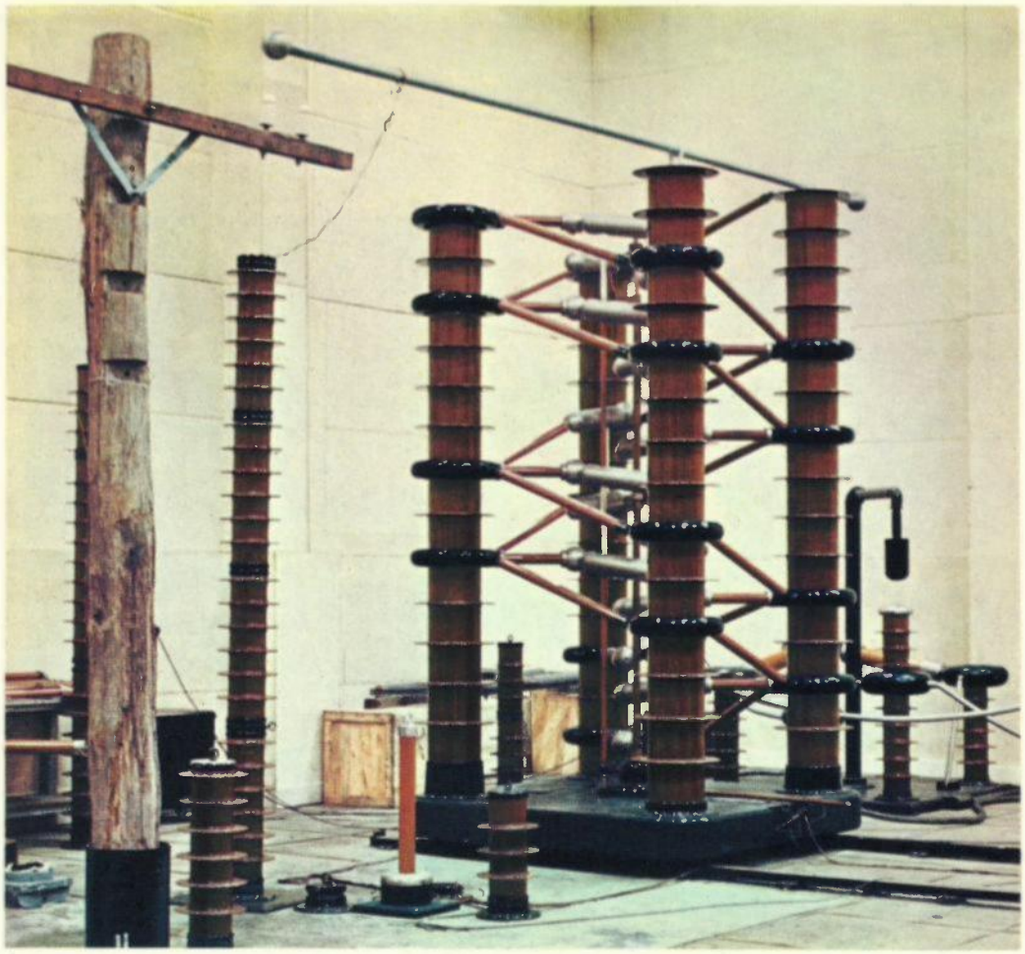
A fatigue testing machine, capable of testing six lengths of actual cable at any one time, has been built. The lengths of cable to be tested are bent around a former to give a semi-circle of 4 ft in diameter. This dimension approximates the winding diameter of cable on a drum. The cables are gripped in the machine by split cylindrical clamps at each end. One of the clamps is capable of being vibrated, and the other is fixed.

The machine has been built so that the vibrating cable is contained within an insulated box which is temperature controlled, so that any predetermined temperature can be selected and maintained. Facilities have also been included to enable pressurisation of the cable. This is felt to be necessary as cables are transported under an air pressure of 10 p.s.i., and are hence subjected to hoop stresses. The air pressurisation system also doubles as a failure indicator. When the cable pressure falls 2 p.s.i. below the nominal pressure the machine automatically cuts out, and the number of vibrations to which it has been subjected are read from a counter.

Strain in the cable sheath is measured using wire resistance strain gauges in conjunction with strain measuring and switching equipment and a high speed pen recorder.

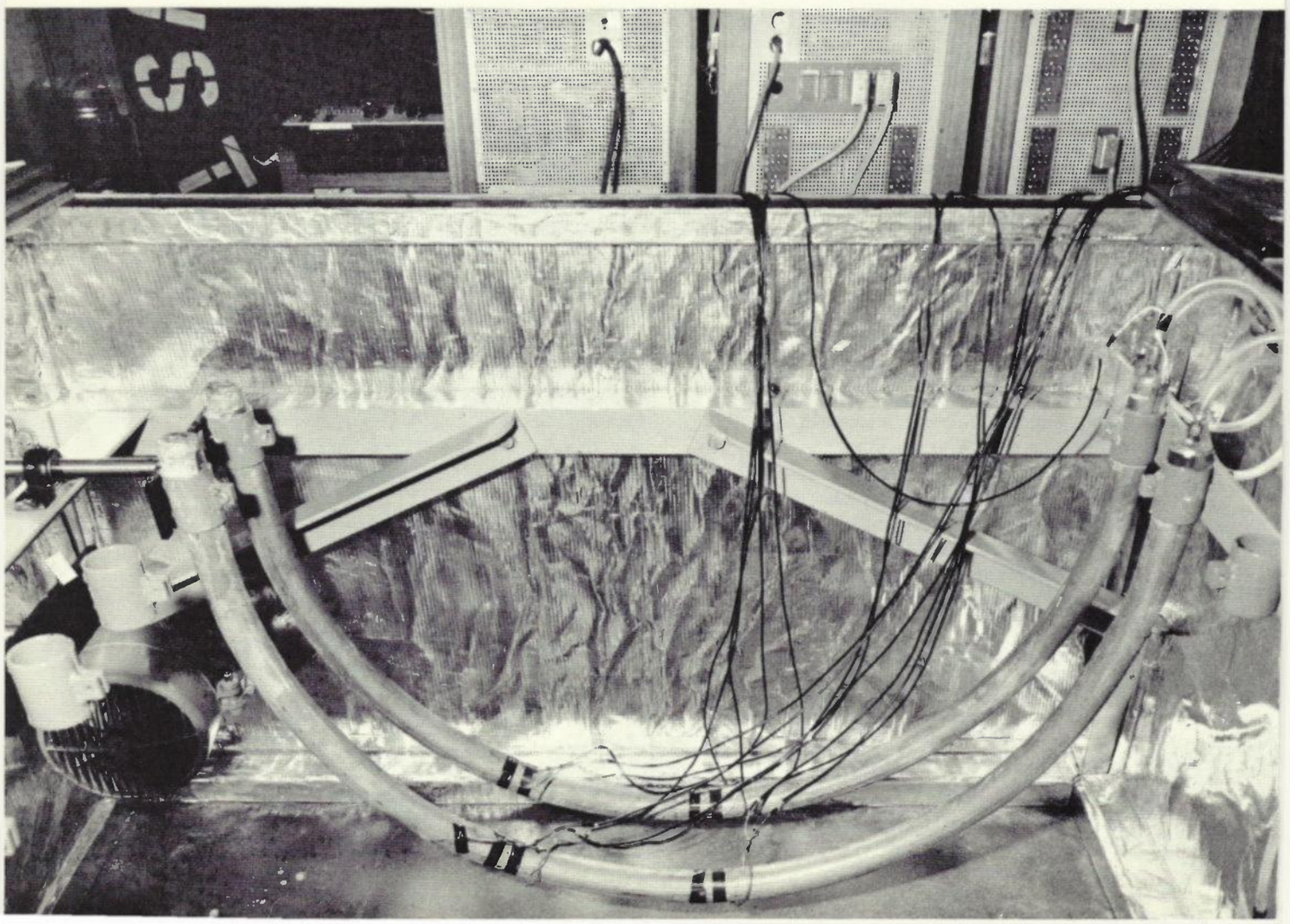
Initially it is proposed to test cables using the following parameters:

Temperature	80 and 120° F
Frequency of Vibration	2 and 10 Hz
Strain	50 and 125 x 10^{-6} in/in
Internal Air Pressure	2 and 10 p.s.i.



▼ FATIGUE TESTING MACHINE FOR LEAD CABLES

1.4 MILLION VOLT GENERATOR ▲



ENVIRONMENTAL CHAMBERS — THE FOUR CHAMBERS CAN PROVIDE TEMPERATURE RANGES OF —40°C to 93°C AND RELATIVE HUMIDITIES FROM 11% TO 100%

CORROSION

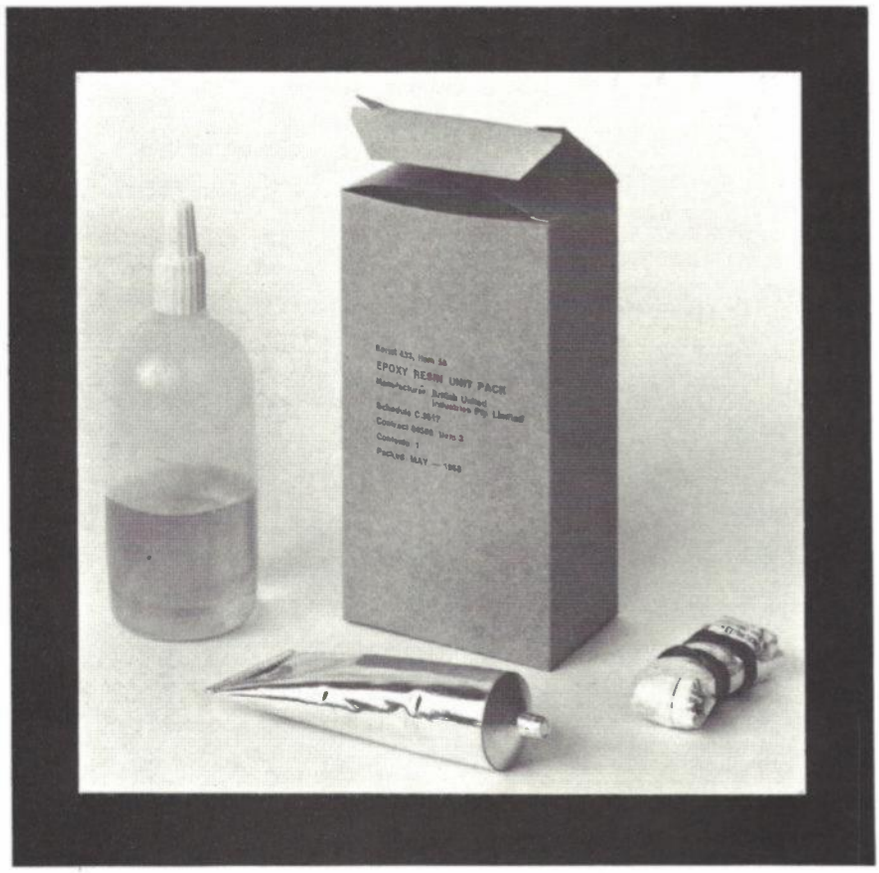
The Laboratories are continuously involved in the elucidation of the causes of corrosion and in employing and seeking more effective means of combating it. Corrosion is a serious Departmental problem because of the vast amount of metal used in masts and towers, in the nationwide installations of telecommunication equipment, and the large mileage of aerial and cable routes.

The main causes of corrosion are stray current electrolysis, galvanic and chemical action. Phenomena associated with, and frequently precursors of corrosion are fatigue, insect damage and bacteriological attack.

The main corrosion problem in urban areas is the erosion of sub-surface structures and cables by electrolytic action of stray currents. Damage due to galvanic action can be produced under a variety of conditions whereby potential differences are created. The most common causes of chemical corrosion are: the reactivity of certain soils, alkalinity from concrete, sewage and industrial effluents.

The mitigation of corrosion involves, in the short term, the identification of the causal agency and the application of appropriate means of protection.

The type of investigational work performed includes the evaluation of improved protective coatings, selection of more resistant and effective materials, studies of chemical means for passivating metallic components and equipment, ascertaining the extent of corrosion produced by alternating current, the determination of more reliable electrical criteria, and more efficient operation of cathodic protection systems.



EPOXY RESIN FIELD PACK — FOR JOINTING PLASTIC SHEATHED CABLE

JOINTING OF LARGE-SIZE POLYTHENE-SHEATHED CABLES

Polythene has proved an excellent substitute for lead as a sheathing material, but its application to large size cables has been somewhat restrained by the difficulty in making sheath joints with the same degree of security and speed enjoyed with the techniques long established on lead sheaths.
A great deal of success has however been obtained in the A.P.O. with auxiliary lead sleeves anchored to the cable either side of the conductor joints with epoxy resin to which the main lead sleeve is plumbed by conventional methods. The only real criticism of this type of joint from the field has been the necessity to install the auxiliary lead sleeves at least one day prior to commencing conductor jointing to permit the epoxy resin to attain full cure characteristics.

An alternative method is being investigated where the auxiliary lead sleeves of the above method are replaced by a metal flange (tinned copper) onto which is chemically bonded a polythene tube, the end of which is in turn anchored to the polythene sheath by electric element welding. The number of sleeves being required for the full range of cable diameters is being minimised by pre-expanding the polythene tube under heat in such a manner as to retain the induced stress. The tube is shrunk down to the diameter of the cable inserted by application of heat to release the "frozen-in" stress to the point where the close fit obtained provides a situation suitable for the electric element welding techniques to be effective.

MAIL HANDLING

The establishment of the Sydney Mail Exchange at Redfern represented a significant venture by the Department into the mechanisation of letter sorting operations. With it came a need for careful assessment of the efficiency of new types of machines and of the materials used in them.

The Research Laboratories have participated in this work. In particular, there are certain types of investigation in this field for which the Laboratories are well equipped by reason of their specialised scientific apparatus and past experience. Physicists and chemists in the Laboratories have assisted in the preparation of standard tests, and specifications for the luminescent materials used for coding letters, and in the testing of conveyor belt materials.

One of the difficulties encountered in the handling of letters by machinery is the effect of electrostatic charge. This tends to make the letters adhere to some surfaces when they should slide freely. The elimination of electrostatic charge, or at least the reduction of the importance of it, is important in automatic mail handling. The Laboratories have carried-out an extensive investigation of the matter, with the assistance of the Defence Standards Laboratories, resulting in a series of recommendations for modification of some of the Redfern equipment.

In several areas of mechanical design, the Laboratories have suggested improvements to the letter sorting equipment. One such improvement is a new design for the torque-limiting clutches fitted to letter stackers at Redfern. The final model of the new clutch resulted from extensive tests conducted on prototypes on a special test rig built for the purpose. Other investigations in the mechanical engineering area were related to the operation of the coding heads of the letter coding machines, and the basic principles of alignment of the 30-channel diverters with their associated conveyors.

A steady improvement has been achieved in the performance of the Redfern plant over recent years, as a result of concentrated effort by all of those sections of the Department which have been concerned with it. Consequently, the need for Research Laboratories participation in this work is diminishing and the Laboratories will be able to undertake investigations, some already begun, of a more fundamental nature in the Mail Handling field.

Such investigations would include a study of Optical Character Recognition techniques, which promise to obviate the need for manual coding of at least a worthwhile proportion of letter mail, and the development of letter transport and switching systems using the principles of "fluidics". Fluidics is a recently developed science in which a fluid, usually air, is used as a control medium as well as a means of power transmission. It is thus a parallel of the science of electronics in the control of electric power.

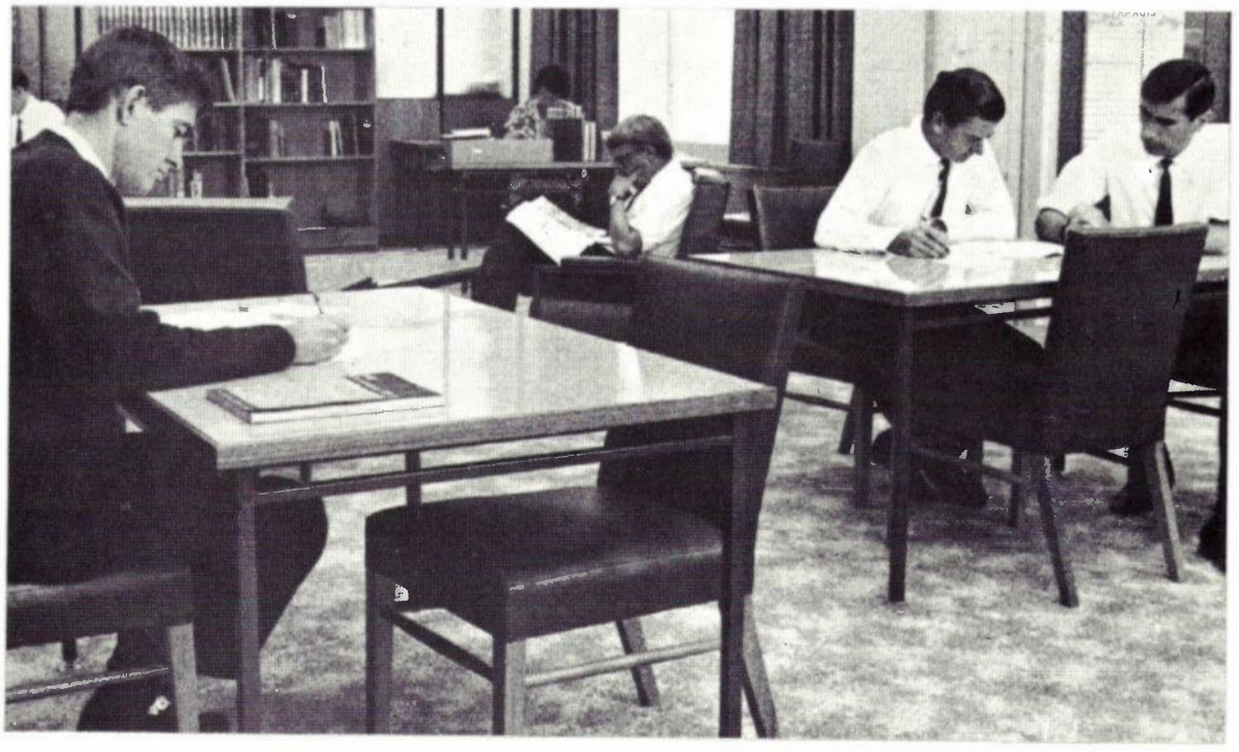
Advances in the manufacture of mail handling equipment will lead to the introduction of new types of machines at an increasing rate, and the Laboratories will continue to assist in the assessment of such equipment, its specification and, where necessary, its modification to suit local conditions.

LIBRARY ACTIVITIES

The function of the Department's Engineering Library Service, which is administered by the Laboratories, is to support the efficient operation of the Department's engineering activities by providing information in all forms in anticipation of demand and on request. This information service is a back-up to the functions of research, planning, design, installation, operation and maintenance of telecommunications throughout Australia. Administration of the Library Service is guided by the advice of a Library Committee comprising senior officers from each Engineering Branch in Headquarters. There is a main library and five branch libraries in the Department's Headquarters, and a library in each State Administration.

The major aspects of service from the Library are current awareness (which includes selective dissemination of information (SDI) and periodical circulation, accessions and conference lists), literature searches, compilation of bibliographies, general reference work and a translation service. The Library supplies entries of all its acquisitions to an interdepartmental computerised listing of publications. These entries are also being used to build a data bank. Investigations are being conducted into the application of mechanised methods of library routines. The Library participates in training activities by providing in-service training for its own staff, students of librarianship, Commonwealth Public Service librarians and library officers-in-training.

THE F. P. O'GRADY READING ROOM OF THE ENGINEERING LIBRARY



MISCELLANEOUS

Other Projects

TIP WELDING OF CABLE CONDUCTORS

The rapid growth of the telecommunication network, the introduction of aluminium conductors, and the demand for higher reliability, particularly for the growing volume of data transmission, has resulted in some of the methods used for jointing conductors becoming inacceptable on the grounds of cost, speed or reliability.

Of the various methods investigated or used by the Australian Post Office such as crank twisting, the use of crimped sleeves or connectors, cold welding, soldering and tip welding, the soldered and tip welded joints were found to be the most reliable, and the connector joint by far the quickest to achieve.

The connector jointing method however is at present relatively expensive, and still has a number of problems associated with it. Some of these problems are the low reliability of joints between some conductor sizes and their combinations, the limitation of the small number of conductors that can be joined by the one connector, and the unavailability so far of any connector that can be used to joint the largest diameter aluminium conductor presently proposed for use in underground cables.

The method of soldering the conductors is, on the other hand, relatively time consuming, the quality of the joint depends on the operator's skill, and in the case of soldering aluminium conductors, it is necessary to use fluxes which often are toxic, corrosive or otherwise deleterious to personnel and to the materials used in the cable construction.

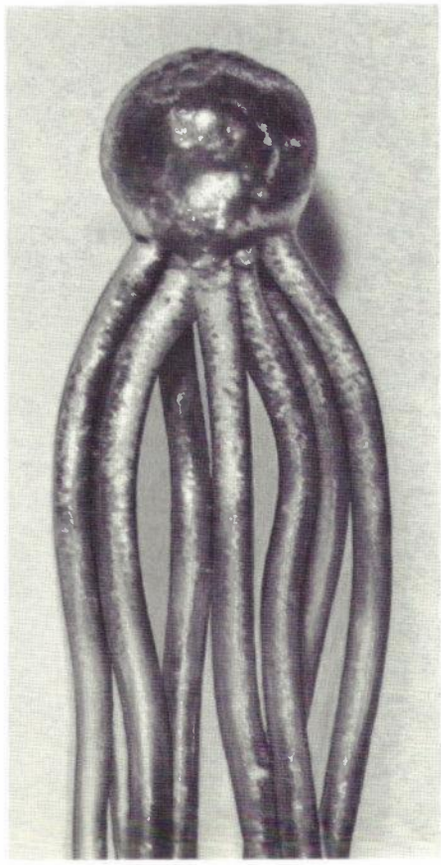
Currently used tip welding methods are also time consuming, and are very dependent on the operator's skill.

During recent investigations of conductor jointing methods, an improved method of tip welding was developed which is more reliable, quicker, consumes less energy than the methods used previously, and is essentially independent of the user's skill or judgement. The basic principle of this method is as follows; a pair of twisted conductors to be welded is inserted into a hand-held tool, which when operated by hand, grips the conductors and locates them a preset distance from a metallic electrode. The air gap between this electrode and the conductors, which now become the second electrode, is bridged with short duration high potential pulses initiated by a switch which is automatically actuated at the end of the gripping process. This discharge is then maintained by a low potential, low impedance source. The discharge which terminates at the electrode and the tips of the conductors melts the conductors, and as a result the air gap keeps widening until the available potential cannot maintain the arc over the increasing distance any longer. The whole process takes place in tens of milliseconds, depending on the conductor material and size, and consumes a relatively small amount of energy. The energy consumption can be further reduced by interrupting the arc after a pre-set time which could be much shorter than the time required for self extinction of the arc due to the gap length increase.

Joints between copper and aluminium conductors produced by this method in the laboratory are highly reliable, mechanically sound and of very low and stable resistance. The effectiveness of the method is now being assessed under field conditions.

This improved tip welding method has been published in a number of technical journals, and has attracted considerable interest in Australia and overseas.

TIP WELDING — EIGHT FOUR-POUND COPPER CONDUCTORS WELDED AT THE TIP

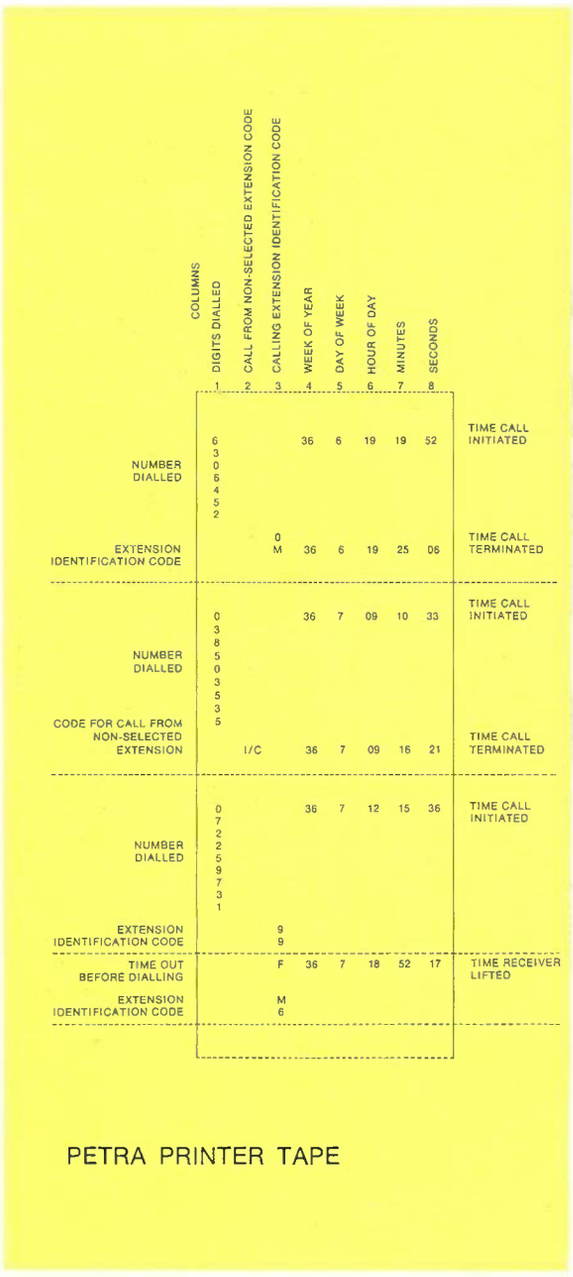


THE PETRA CALL ANALYSER

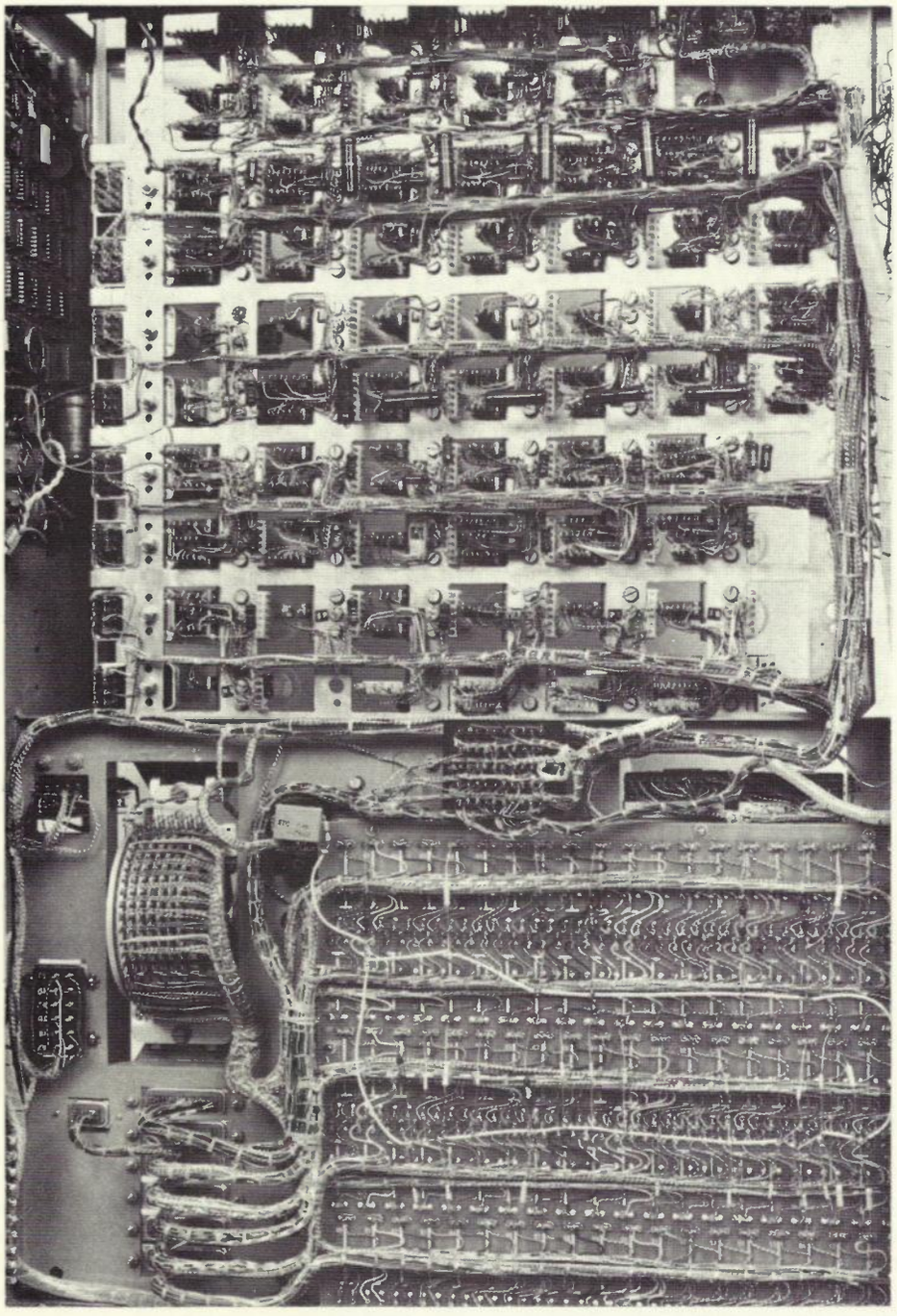
PETRA (PBX Extension Traffic Recorder and Analyser) has been designed and developed by the Laboratories for use by Private Branch Exchange (PBX) customers as a management aid in supervising the use made of the Subscriber Trunk Dialling (S.T.D.) service.

PETRA monitors all originating extension traffic up to a maximum of five supervised exchange lines on a sampling basis. Of the extension traffic monitored any extension from a selected group of 100 extensions can be identified by a code printed on the paper tape together with number dialled, duration of call, and time of day. The diagram shows the range of information available on the printed tape. It should be noted that no conversation is recorded, and that an extension is identified only as a number not as a person. The printer, together with its separate control unit consisting of relay and solid state circuitry, is attached to the customer's PBX by Post Office staff.

The customer has the option of recording all external traffic or S.T.D. traffic only.



PETRA PRINTER TAPE



PETRA CALL ANALYSER (REAR VIEW)

CHANNEL DOUBLING EQUIPMENT

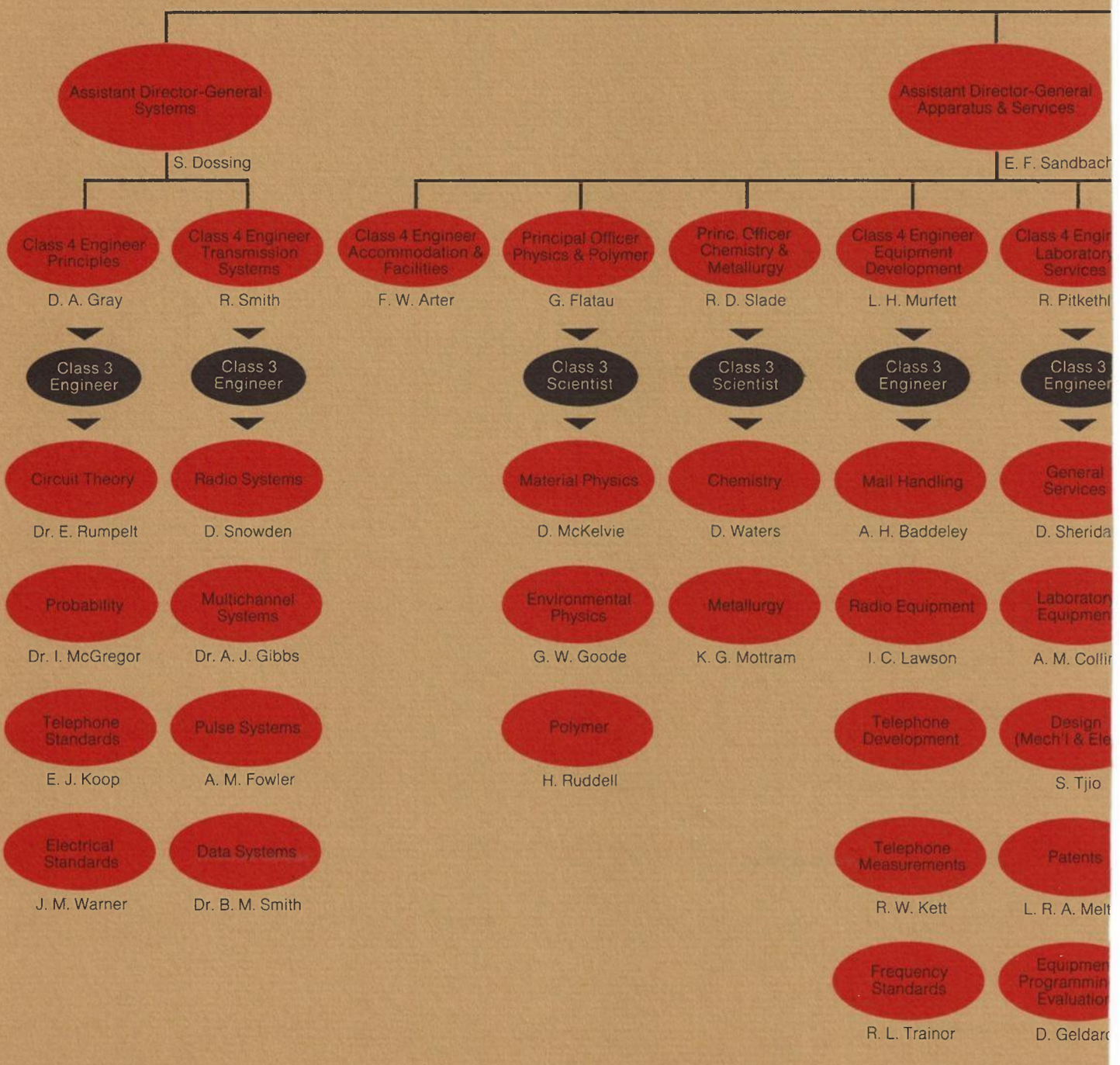
Eleven additional trunk telephone circuits have been provided over the open route linking Perth and Port Hedland. These additional circuits were provided over the aerial trunk route by the application of special channel doubling equipment which was manufactured by Hawker de Havilland Australia Pty. Ltd., to information supplied by the Laboratories.
Channel doubling equipment is used to derive 24 telephone channels of approximately 2 kHz bandwidth in the 60-108 kHz band normally used to carry a 12 channel group with 3.1 kHz bandwidth circuits (4 kHz carrier spacing). The circuits so derived are of inferior transmission performance compared with standard bandwidth circuits, and would not normally be acceptable in the A.P.O. network. However, experience with the performance of these circuits is that they are tolerated by telephone subscribers for point to point use, i.e. provided they are not included in a multi-link connection.
The decision to provide channel doubling equipment on the Perth to Port Hedland route was made about the middle of 1968. It was taken in the light of existing congestion on the route and the knowledge that the congestion would approach an intolerable level if no additional circuits were provided before the broadband system could be completed in 1971.
The special feature of the Perth to Port Hedland channel doubling equipment is that it was manufactured in Australia by private industry in close collaboration with the Research Laboratories. An unusually short manufacturing time for special custom made equipment was achieved. This arrangement was necessary because doubling equipment is no longer available from the original supplier nor available from any other source. In fact, only a small amount has ever been manufactured – by T.M.C. (U.K.) – for use on T.A.T.1, the first submarine telephone cable between the United Kingdom and North America.
For this reason, it was decided to manufacture sufficient equipment in Australia to double twelve channels to Port Hedland. The manufacturing contract was placed with Hawker de Havilland, a firm which does not regularly supply carrier equipment. The basic design information for the manufacture of the equipment was made available by T.M.C. (U.K.) and by the B.P.O., at nominal costs. However, considerable redesign was necessary to eliminate the use of components which were no longer procurable and components with long delivery. In addition, valve circuitry was replaced by solid state circuits to shorten manufacturing time. As a result, the Hawker de Havilland system is of much more up-to-date design and more reliable than the original T.A.T.1 equipment.
The successful cutover of the circuits into traffic nine months after the placement of the contract represented a significant achievement both on the part of the Department and of Hawker de Havilland.
While the additional circuits provided did not eliminate congestion and delays on trunk calls to and from the northwest of Western Australia, they did to some extent relieve the situation. The additional revenue obtained from the extra circuits during the first 12 months of operation well covered the cost of producing the equipment.
Because of the inferior quality of the narrow bandwidth circuits, special network arrangements have had to be made to prevent them being used in multi-link switched connections. In particular, connection of the narrow bandwidth channels to the northwest of Western Australia in tandem with similar channels between Perth and the Eastern States had to be avoided.

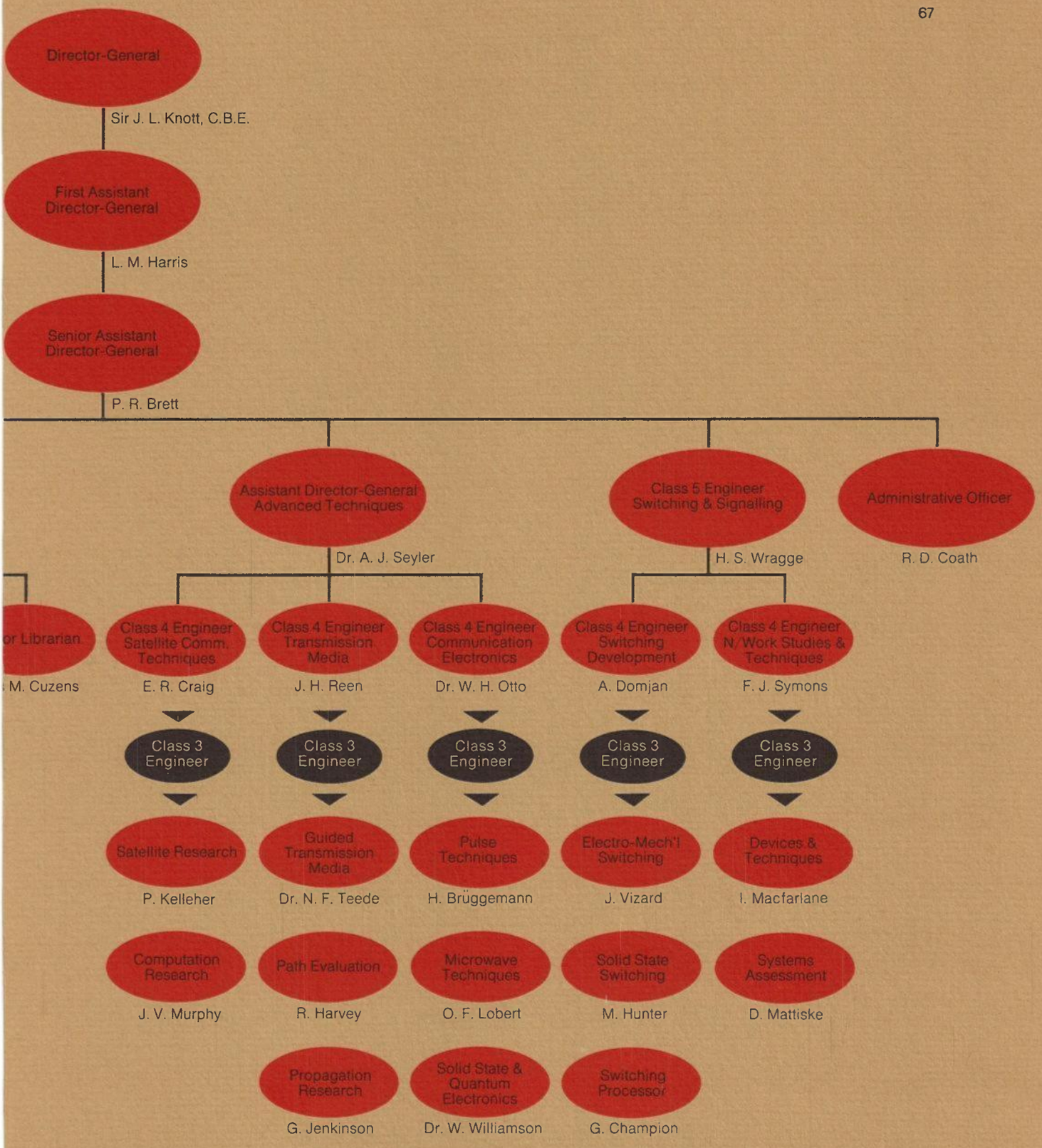
The Laboratories and its Staff

ORGANISATION

The Australian Post Office (A.P.O.) is a Department of the Government of the Commonwealth of Australia. The chief permanent officer is the Director-General, Posts and Telegraphs who, assisted by Headquarters staff, controls, supervises and directs the individual State Administrations. The Research Laboratories is a "Branch" of Headquarters. The chief of the Laboratories carries the title of Senior Assistant Director-General (S.A.D.G.), and is responsible to the First Assistant Director-General, Planning and Research (F.A.D.G., P. & R.) for the affairs of the Laboratories. The F.A.D.G., P. & R. is responsible directly to the Director-General.

The organisational structure of the upper levels and the occupants of positions at the end of the review period are shown on the charts.


Assistant Director-General Systems
S. Dossing
Assistant Director-General Apparatus & Services
E. F. Sandbach
Class 4 Engineer Principles
D. A. Gray
Class 4 Engineer Transmission Systems
R. Smith
Class 4 Engineer Accommodation & Facilities
F. W. Arter
Principal Officer Physics & Polymer
G. Flatau
Princ. Officer Chemistry & Metallurgy
R. D. Slade
Class 4 Engineer Equipment Development
L. H. Murfett
Class 4 Engl Laboratory Services
R. Pitkethl
Class 3 Engineer
Class 3 Engineer
Class 3 Scientist
Class 3 Scientist
Class 3 Engineer
Class 3 Engineer
Circuit Theory
Dr. E. Rumpelt
Radio Systems
D. Snowden
Material Physics
D. McKelvie
Chemistry
D. Waters
Mail Handling
A. H. Baddeley
General Services
D. Sherida
Probability
Dr. I. McGregor
Multichannel Systems
Dr. A. J. Gibbs
Environmental Physics
G. W. Goode
Metallurgy
K. G. Mottram
Radio Equipment
I. C. Lawson
Laboratory Equipmen
A. M. Collir
Telephone Standards
E. J. Koop
Pulse Systems
A. M. Fowler
Polymer
H. Ruddell
Telephone Development
Design (Mech'l & Ele
S. Tjio
Electrical Standards
J. M. Warner
Data Systems
Dr. B. M. Smith
Telephone Measurements
R. W. Kett
Patents
L. R. A. Melt
Frequency Standards
R. L. Trainor
Equipmen Programmin Evaluatio
D. Geldard



NOTE: Names given are those of ***actual*** *occupants (appointed or acting) as at 30.6.1971*

Senior Assistant Director-General: P. R. Brett, B.Sc., F.I.R.E.E.
Clerk: J. Luke, B.A.

SYSTEMS SECTION

Assistant Director-General: S. Dossing, M.Sc.E.E. (Hons.), M.E.E., F.I.E. Aust.

Blackwell, D. M., B.E. (Elec.)
Blair, R. H., B.E. (Hons.), M. Eng. Sc.
Bourke, S., B.Sc., Dip. Elec. Eng.
Caporicci, D., Dott. Ing.
Dempsey, R. J., B.E. (Elec.)
Duke, P. F., B. Tech., Ass. Dip. Maths.
Erwin, J. B.
Fowler, A. M., M.I.E. Aust., M.I.R.E.E.
Gibbs, A. J., B.E. (Elec.), M.E., Ph.D., A.M.I.R.E.E., M.I.E.E.E.
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Gray, D. A., B.E.E., Dip. Mech. & Elec. Eng., M.I.E. Aust.
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Lewis, J. A., B.E. (Hons.), A.M.I.E.E.
Martin, G. T., B.E. (Hons.), M.E.
McGregor, I., B.E. (Elec.), M.E., Ph.D.
Pinczower, E., Dip. Elec. Eng., M.I.E. Aust.
Pyke, R. W., B.E. (Elec.), Dip. Elec. Eng., M.I.E. Aust.
Quan, A., B.E. (Hons.), M.E.
Rumpelt, E. H., Dip. Ing. (Hons.), Dr. Ing.
Sargeant, V., B.E. (Hons.), Dip. Elec. Eng., M.I.E.E.E.
Semple, G. J., B.E.E. (Hons.), M. Eng. Sc.
Smith, B. M., B.E. (Hons.), Ph.D., M.I.E.E.E.
Smith, R., B.E. (Hons.), M.E., M.I.E.E., A.M.I.R.E.E.
Snowden, D. R. C., B.E., Grad. I.E. Aust., A.M.I.R.E.E.
Steel, J., B.E.E., B.Sc.
Tyers, P. J., B.E. (Hons.)
Warner, J. M., B.Sc., M.I.E.E.
Wood, R.
Yelverton, W.

SWITCHING AND SIGNALLING GROUP

Group Leader: H. S. Wragge, B.E.E. (Hons.), M. Eng. Sc. (Hons.), M.I.E. Aust., M.I.E.E.

Baker, A. S., A.M.I.E.E.
Bowtell, P.
Champion, G. J., B.E.
Chan, M. C., B.E. (Hons.)
Curley, K. A.
Domjan, A., B.E.E., A.M.I.E. Aust.
English, J. F., B.E. (Elec.)
Even-Chaim, A., B.Sc., M.I.E. Israel
Gale, N., B.E.
Gerrand, P. H., B.E. (Hons.), M. Eng. Sc., Grad. I.E. Aust., M.I.E.E.E.
Hunter, M. A., B.E. (Hons.), A.M.I.E.E.
Jones, P. S., B.E. (Elec.), M. Eng. Sc. (Elec.)
King, D. J., B.E. (Hons.), M. Eng. Sc., M.I.E.E.E., M.I.E.E.
Macfarlane, I., B.E. (Elec.), A.R.M.T.C. Elec. Eng.
Mattiske, D. D., B.E., A.I.M.E.E.
Mazzaferri, F., B.E. (Hons.)
McEvoy, W.
McLeod, N., B.Sc.
Symons, F. J., B.E. (Hons.), D.I.C., A.M.I.E.E.
Tjia, S. M. (Miss), B.E. (Elec.)
Vizard, R. J., B.E.E., Dip. Elec. Eng.
Wise, J. B., B.E.
Wolstencroft, N.

APPARATUS AND SERVICES SECTION

Assistant Director-General: E. F. Sandbach, B.Sc., B.A.

Aizenstros, D., B.E. (Elec.)
Andersson, M. G., B.E.E. (Hons.)
Arter, F. W., B.E.E., M. Eng. Sc.
Battlay, P. I. J., B. Mech. E., A.M.I.E.E., Grad. I.E. Aust.
Bondarenko, E. J., Dip. App. Phys., F.R.A.S.
Casley, G. M., B.E. (Elec.), M. Eng. Sc., Grad. I.E. Aust.
Cederholm, I., M.Sc., A.R.A.C.I.
Charles, S. (Miss), Ass. Dip. App. Phys.
Chisholm B. A., Dip. App. Chem., Grad. R.A.C.I.
Collins, A. M., B.Sc.
Cuzens, M. I. (Miss), B.A., A.L.A.A., A.L.A.
Dalrymple, L. N., Ass. Dip. Elec. Eng., Grad. I.E. Aust.
Day, W. L., B. Mech. E., Grad. I.E. Aust.
Der, J., B.Sc., A.M.R.A.C.I.
Dew, I. A., B.Sc., A.A.I.P.
Everett, B. P., Dip. Comm. Eng., Grad. I.E. Aust.
Eyre, C.
Flatau, G., Fell. Dip. App. Phys.
Geldard, D. S., M.I.E.E., M.I.E. Aust.
Godfrey, J., Dip. Met.
Goode, G. W. G., B.Sc.
Hamilton, A. N., B.E. (Hons.)
Harris, R. W., B.Sc. (Hons.), B.E. (Hons.)
Heath, R. M. (Mrs.), B.A., Dip. Lib.
Hicks, A. S. (Miss), B.Sc.
Hicks, P. R., B.E. (Elec.)
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Keir, K. E., Dip. Met.
Kelso, D. R., B.E. (Elec.), M. Eng. Sc., Grad. I.E. Aust.
Keogh, T. J., Dip. Met.
Kett, R. W., Dip. Comm. Eng., A.M.I.R.E.E.
Kidd, H. J. (Miss), B.A., Dip. Lib.
Kilby, R. L., Ass. Dip. Elec. Eng., Grad. I.E. Aust.
Lane, M.
Lawson, I. C., B.E.E.
Lloyd, I. J., B.Sc. (Hons.), M.Sc., Ph.D.
McOrist, W., B.Sc.
McKelvie, D., B.Sc. (Hons.)
Melton, L. R. A., B.Sc., D.C.U., M.I. Inf. Sc.
Metzenthen, W. E., Fell. Dip. Comm. Eng., M.E.
Miles, D. T., M.R.S.H., F.C.S., A.R.I.C.
Mitchell, G. G., B.Sc. (Hons.), M.Sc.
Mottram, K. G., Fell. Dip. Met. Eng., M.A.I.M., A.M.A.I.M.M.
Murfett, L., B.Sc.
Noble, S. H., B.Sc. (Hons.), M.I.E.E., A.M.I.P.
O'Rourke, A. H., Dip. Rad. Eng., Grad. I.E. Aust.
Petchell, F. M., Dip. App. Chem.
Peters, S. M. (Mrs), B.A., B.Sc., Dip. Ed., Dip. Lib., M.L.A.A.
Pether, H.
Pitkethly, R., Dip. Mech. & Elec. Eng., B.E.E., M.I.E. Aust.
Proudlock, R. E., B.E. (Elec.)
Rodd, H. V. (Miss), B.A., Dip. Lib., M.L.A.A.
Ruddell, H. J., Dip. App. Chem., M.P.I.A.
Sadler, N. J., B.Sc., M.I.R.E.E., F.R.A.S.
Sheridan, D. E., Dip. Elec. Eng., Dip. Mech. Eng.
Slade, R. D., Ass. Dip. Met., M.A.M.I., M.I.M., M.A.E.S., M.A.I.M.F., M. Non-Dest. T.A. Aust.
Staley, W.
Stevens, A. J., B.E. (Elec.), A.M.I.E.E.
Thomas, V., A.M.I.R.E.E.
Tjio, H. S., B. Mech. E., Ass. Dip. Electron. Eng.
Townsend, A., B.E. (Elec.), Grad. I.E. Aust., A.M.I.E.E.
Trainor, R L., B.Sc.
Waters, D. M., Dip. App. Chem., A.R.A.C.I., M.O.C.C.A.
Wellby, P. J., B.E. (Hons.), B.Sc.
Westbrook, P.
Western, R., Dip. App. Chem.
Willis, G. M., Fell. Dip. Comm. Eng., Grad. I.E. Aust.
Wilson, L. D., B.Sc.
Wylie, R. F., B.E., M.I.E.E.E.

ADVANCED TECHNIQUES SECTION

Assistant Director-General: A. J. Seyler, Dip. Ing. (Hons.), M.E.E., D. App. Sc., F.I.R.E.E.

Abeyasekere, D., B.Sc., M.Sc. (Hons.), Ph.D., Grad. I.R.E.E. Aust.
Barnard, S.
Brueggemann, H., B.E. (Elec.)
Bundrock, A. J., B.E. (Elec.) (Hons.)
Cahill, L., B.E. (Elec.), M. Eng. Sc., M.I.E.E.E.
Court, R. A. G., B.Sc.
Craick, J. K., B.E. (Elec.) (Hons.), B.Sc.
Craig, E. R., B.Sc. (Hons.), M.I.E.E.
Davies, W. S., B.E. (Elec.)
Demytko, N., B.E. (Elec.) (Hons.), B.Sc.
Denger, L. A., E.N.S.E.M.N., M.I.E.E.E., M. Soc. Fr. de Phys., M. Soc. Fr. de Elec., Grad. I.E. Aust.
Grant, J. H., B. Eng. Sc. (Hons.)
Harvey, R. A., B.Sc., Dip. Rad. Eng., A.M.I.R.E.E.
Howard, S. E., B.E. (Elec.) (Hons.)
Hullett, J. L., B.E. (Hons.), Ph.D.
Ja, Y. H., B.E., Ph.D.
Jacoby, G. H., B.E. (Hons.)
Jenkins, G. K., B.Sc., B.E. (Hons.), M.E.
Jenkinson, G. J., B.Sc., M.I.R.E.E.
Junghans, H., Dip. Ing.
Kelleher, P., B.Sc., M.I.E. Aust.
Kidd, G. P., B.E. (Hons.), B.Sc.
Lavery, W. J., B.E. (Hons.)
Lobert, O. F., B.E.E., M.I.E. Aust., A.M.I.E.E.
Lucas, J. E. W.
Mackechnie, L. K., B.E., M. Eng. Sc.
Morgan, R. J., B.Sc.
Murphy, J. V., B.E. (Elec.) (Hons.), B.A.
Otto, W. H., Dr. Sc. Nat.
Reen, J. H., B.E., M.I.E. Aust.
Ridge, I., B.E. (Elec.), Grad. I.E. Aust.
Rosman, G., B.E.E.
Sastradipradja, S., B.E. (Elec.)
Teede, N. F., Ph.D., B.E. (Hons.), Dip. Mgt.
Williamson, W. J., Ph.D., B.E. (Elec.) (Hons.)
Wills, H., Ass. Dip. Rad. Eng., A.M.I.R.E.E.

SENIOR CLERICAL STAFF

Administrative Officer: R. D. Coath.
Chippendall, C.
Chirgwin, M. A.
Conroy, A. B.
Conroy-Welby, G.
Dillon, T. W.
Guilliard, K. H.
Hill, P.
Jabour, A. (Miss)
Nolan, L. B.
Scates, E. J.
Walker, N.

PAPERS, LECTURES, TALKS AND REPORTS BY MEMBERS OF THE STAFF

■ Members of the Laboratories contribute articles regularly to Australian and overseas professional and technical journals as well as presenting papers to learned societies. Reports are also issued on work undertaken within the Laboratories, and 97 were distributed during the year 1970/1971.

PAPERS

Baddeley, A. H., and Goode, G. W. G.	"The Evaluation of Telephone Dial Performance", Telecomm. Journal of Aust., June, 1971.
Blair, R. H.	"A Receiving System for a Binary Phase-Shift Keyed Communication Channel", Aust. Tele. Res., May, 1971.
Blair, R. H.	"Relationship Between S/N Levels and Error Rates in a Linear Digital Communication System", Aust. Tele. Res., May, 1971.
Brüggemann, H.	"A New Feed-Back Stabilised Four-Quadrant Analogue Multiplier", I.E.E.E. Journal Solid State Circuits, August, 1970.
Craig, E. R., and Barnes, P. D.	"Telecommunications Transmission Media, Present and Future", I.E. Aust. Elect. Eng. Trans., March, 1971.
Craig, E. R., and Kelleher, P.	"Performance of a Multiple Access System Suitable for Domestic Satellite Communications", Aust. Tele. Res., May, 1971.
Craig, E. R., and Snowden, D. R. C.	"Single Subscriber Telecommunications Via Satellite", Aust. Tele. Res., May, 1971.
Dempsey, R. J.	"Standard Level Meter with Calibration Facilities", Proc. I.R.E.E., October, 1970.
Dossing, S.	"Future Telephone Switching Systems", Proc. I.R.E.E., April, 1971.
Flatau, G.	"Reliability Testing of Components", Telecomm. Journal of Aust., October, 1970.
Fowler, A. M.	"Electroplating for Electronics", Galvanotechnik, February, 1971.
Gerrand, P. H., and Kerr, A. R.	"Stability of Parametric Networks", Electronic Letters, January, 1971.
Gibbs, A. J.	'On Stable Linear Systems and Bounded Linear Operators on Separable Hilbert Space", Aust. Tele. Res., November, 1970.
Glick, P.	"A Method of Detecting and Removing Clicks and Reducing Noise in P.C.M. Transmissions", Aust. Tele. Res., November, 1970.
Gray, D. A.	"The Work of the Telephone Transmission Study Groups XII and XVI of C.C.I.T.T.", Telecomm. Journal of Aust., October, 1970.
Hullett, J. L.	"Impairment of Differentially Quantised TV Signals by Transmission Errors", Aust. Tele. Res., November, 1970.
Jenkinson, G. F.	"Radio Refractive Index Investigations on the Nullarbor Plain, South Australia", Proc. I.R.E.E., September, 1970.
King, D. J. E.	"An Analysis of Coding Based on the Binary Symmetric Channel", Aust. Tele. Res., November, 1970.
Macfarlane, I. P.	"A Digital Phaseable Clock and Time Code Generator", Proc. I.R.E.E., February, 1971.
McLeod, N. W.	"An Analogue Switch Using a Digital Integrated Circuit", Proc. I.R.E.E. (A.E.C.), February, 1971.
McLeod, N. W.	"Complementary Data Line Receiver and Driver Circuits", Proc. I.R.E.E., June, 1971.

Melton, L. R. A.	"Patents and the Australian Post Office", Telecomm. Journal of Aust., June, 1971.
Richardson, J. K.	"A Semi-Empirical Formula for the End-Coupled Symmetric Strip Line Filter", Elect. Letters, September, 1970.
Rosman, G.	"Use of Pilot Signals to Indicate Delay Distortion in Operating FM-FDM Radio Systems", Elect. Letters, September, 1970.
Sargeant, V. K.	"P.C.M. for Transmission of High Quality Music", Aust. Tele. Res., November, 1970.
Sastradipradja, S.	"A Small Station Antenna for Satellite Communication", Aust. Tele. Res., May, 1971.
Seyler, A. J., Brüggemann, H., Mackechnie, L., and Kidd, G. P.	"An Adaptive Echo Canceller for Long Distance Telephone Circuits", Proc. I.R.E.E., March, 1971.
Shaw, D. L., Dempsey, R. J., and Semple, J. G.	"The Perth-Port Hedland Channel Doubling System", Telecomm. Journal of Aust., October, 1970.
Smith, B. M.	"A Brief Introduction to Data Transmission Techniques", Telecomm. Journal of Aust., June, 1971.
Smith, B. M.	"Error Behaviour of Linearly Distorted Binary FM Signals", Aust. Tele. Res., November, 1970.
Smith, N. M. H.	"A Preliminary Switching System Engineering Study of a Proposed Customer Usage Satellite System", Aust. Tele. Res., May, 1971.
Symons, F. J. W., and Ward, M. K.	"Programme Control of the I.S.T. Project", Telecomm. Journal of Aust., October, 1970.
Teede, N. F.	"Thin Film Fuses Compatible with Integrated Circuits", Aust. Tele. Res., November, 1970.
Williamson, W. J.	"The Effect of Bias and Cathode Boundary Conditions on GaAs Space Charge Amplifiers", Appl. Phys. Letters, May, 1971.

LECTURES AND TALKS

Abeyasekere, D.	"Integral Equations of the Cylindrical Dipole Antenna", I.R.E.E. 13th National Convention, May, 1971.
Brüggemann, H., and Hullett, J. L.	"In Search of an Optimum CCTV Conference Configuration", I.R.E.E. 13th National Convention, May, 1971.
Cahill, L.	"Computer Aided Design of Charge Storage Diode Frequency Multipliers", I.R.E.E. 13th National Convention, May, 1971.
Cahill, L.	"Some Limitations of Computer-Aided Design of Non-Linear Networks", I.R.E.E. & I. E. Aust., 4th Circuit Theory Colloquium, University of N.S.W., Feb., 1971.
Cralg, E. R., and Barnes, P. D.	"Telecommunications Transmission Media, Present and Future", I.E. Aust. Annual Conf., March, 1971.
Craig, E. R.	"Possible Application of Communication Satellites for Services to Remote Areas", ANZAAS 43rd Congress, May, 1971.
Dempsey, R. J.	"Transmission Aspects of a Visual Telephone Facility", I.R.E.E. 13th National Convention, May, 1971.
Demytko, N., and Mackechnie, L.	"The Performance of a Continuously Adaptive Echo Canceller", I.R.E.E. 13th National Convention, May, 1971.
Domjan A., and Symons, F. J. W.	"A Fully Electronic Stored Programme Control Digital Telephone Exchange for the Melbourne Network", I.R.E.E. 13th National Convention, May, 1971.
Harvey, R. A.	"Radio Propagation at VHF and Above for the Radio Amateur", Wireless Inst. of Aust., October, 1970.
Hullett, J. L.	"The Choice of TV-Phone Picture Standards — A Case of Compromise", I.R.E.E. 13th National Convention, May, 1971.
Hullett, J. L., and Budrikis, Z. L.	"A Second Order DPCM Coder for Visual Signals", I.R.E.E. 13th National Convention, May, 1971.
Junghans, H.	"Frequency Multiplier for cm and mm Wavelengths", I.R.E.E. 13th National Convention, May, 1971.
Lobert, O. F.	"A Parametric Amplifier for a Small Satellite Ground Station", I.R.E.E. 13th National Convention, May, 1971.

MacGregor I., and Getreu, I.	"An Integrated Class AB Hearing Aid Amplifier", I.R.E.E. International Solid State Circuits Conf., U.S.A., February, 1971.
McLeod, N. W.	"Digital Circuitry and Components", Footscray Inst. of Tech., May, 1971.
Seyler, A. J.	"Face-to-Face Telecommunications —An Historical Review", I.R.E.E. 13th National Convention, May, 1971.
Smith, R., Feenaghty, B., Feder A., and Clarke, G.	"Wideband Subscriber Reticulation", I.T.T./A.P.O. Symposium, February, 1971.
Symons, F. J. W.	"Application of Digital Computer Control in Telecommunications", I.E. Aust. Symposium, June, 1971.
Symons, F. J. W.	"I.S.T. Project", Telecomm. Soc. of Aust., February, 1971.
Teede, N. F., and Junghans, H.	"Microstrip Circuits for mm Wavelengths", I.R.E.E. 13th National Convention, May, 1971.
Teede, N. F.	"Materials Research in Electronics", I.R.E.E. (Melb. Div.), March, 1971.
Teede, N. F.	"Recent Developments in Solid State Materials", Res. Labs. Seminar, December, 1970.
Warner, J. M.	"Radio Frequency Power Level Calibration", I.R.E.E. 13th National Convention, May, 1971.
Warner, J. M.	"The Traceability of Accuracy in Measurement", N.S.L., Uni. of Sydney, August, 1970.
Williamson, W. J.	"Amplification in Stabilised GaAs Bulk Effect Devices", I.R.E.E. 13th National Convention, May, 1971.
Williamson, W. J.	"Travelling Wave Amplification in Gallium Arsenide", Intern. Conf. on Microelectronics, Sydney, August, 1970.
Williamson, W. J.	"Materials Research in Electronics", I.R.E.E. (Melb. Div.), March, 1971.
Williamson, W. J.	"Travelling Wave Amplification in Sub-Critically Doped Gallium Arsenide", Elec. Eng. School Colloquium, Monash, March, 1971.
Wragge, H. S.	"Control Systems in Modern Communication Systems", I.R.E.E. 13th National Convention, May, 1971.

RESEARCH LABORATORY REPORTS

REPORT No.	AUTHOR'S NAME	TITLE
6106 Addendum No. 1	E. Rumpelt	"Computer Programs for the Computation of Smooth Group Delay Characteristics".
6118	R. A. Harvey	"2 GHz Propagation Measurements on Long Overwater Paths: Mt. Tanner (Flinders Is.) — Waterhouse (Tasmania) 68 Miles".
6294 Addendum No. 1	S. H. Noble	"Protection of Transistorized Long Line Equipment Against Lightning Surges".
6345 Addendum No. 1	H. J. Ruddell	"Adhesion of Epoxy Resin to Aluminium Pot Head Castings".
6359 Addendum No. 1	E. J. Bondarenko	"Climatic Test Facilities Available in Environmental Physics Division".
6367 Addendum No. 2	J. K. Lynch	"Transmission Characteristics of Single-Quad Polythene Carrier Cable".
6387	R. Wylie	"Meter Response – Time Measuring Set".
6425	N. Teede	"A Versatile Scanning Electron Beam Zone Melter".
6433	G. Jenkinson	"Radio Refractive Index Investigations on the Nullarbor Plain, South Australia".
6475	I. Macfarlane	"A Standard Frequency and Time Signal Installation — VNG, Lyndhurst, Victoria".
6486	B. J. Meehan	"Investigation into Reactive Flexibilisers for Epoxy Resin Systems".
6494	G. P. Kidd	"Circular Waveguide as a High-Capacity Communication Medium".

REPORT No.	AUTHOR'S NAME	TITLE
6496	H. J. Ruddell	"Non-Skid Surface Coat for Manhole Covers".
6502	D. McKelvie	"Report on Overseas Visit, October-December, 1969, (i) High Quality Electronic Components. (ii) Fire Detection Devices".
6512	H. Brueggemann	"Report on Overseas Visit, September-October, 1969, (i) T.V. Transmission C.C.T.V. Conferencing. (ii) T.V. – Phone Facilities".
6513	M. Lane	"Transistor Crystal Oscillators to Cover Frequency Range 1 kHz — 100MHz".
6514	K. Keir	"Failure of Emergency Power Supply Engines for Television Transmitter ABLV-4, Mt. Tassie, Victoria".
6516	A. M. Fowler	"Report on Overseas Visit, April 1970, (i) C.C.I.T.T. Study Group XV and Joint Working Party LTG. (ii) Investigation of Data Transmission Problems".
6517	J. Godfrey	"Magnetic Properties of 45% Nickel Iron".
6518	E. Koop	"Subjective Tests on Echo Suppressors".
6519	T. Keogh	"Failure of Wind Generators on the East-West Route".
6521	T. Keogh	"Pickling and its Influence on the Embrittlement of Structural Steels".
6522	I. Lawson	"A 4000 MHz Transmitter for Microwave Propagation Measurements".
6524	P. Glick	"Tables for the Double Exponential Pulse".
6529	A. R. Bauer	"British Xylonite X 600 D Paper Bakelite Base, Copper Clad Board-Suitability for use in 800 Series Telephones".
6533	H. S. Wragge	"Report on Overseas Visit, Oct.-Nov., 1969, (i) C.C.I.T.T. Special Study Group D. (ii) Visits to France, U.K., Norway and Japan".
6534	D. A. Gray	"Report on Overseas Visit, Sept. 1969: Use of Mathematicians in Telecommunications Research Establishments".
6539	P. R. Brett	"Report on Overseas Visit to Investigate Management of Research and Development in Telecommunications — April-May, 1970".
6551	G. G. Mitchell	"Comparison of Printed Wiring Board Connectors".
6551 Addendum No. 1	G. G. Mitchell	"Comparison of Printed Wiring Board Connectors".
6556	H. J. Ruddell	"Evaluation of Hauling Eyes for Large Size Plastic Cables".
6558	J. Godfrey	"Effect of Bush and Grass Fires on Aerial Line Wire".
6560	H. J. Ruddell	"Polythene for use in Telecommunication Cable".
6563	H. J. Ruddell	"The Re-use of Sheathing Grade Polythene in A.P.O. Cables".
6565	E. Bondarenko	"Joints to Aluminium Power Cable used in Telephone Exchanges".
6567	G. Crew	"C.C.I.T.T. Signalling System No. 6 Field Trial — Project Review".
6568	E. Rumpelt	"Design of Filters for Data Logging System".
6573	T. J. Elms	"Bonding of Freshly Poured Epoxy Resin to Cured Epoxy Resin".
6576	H. J. Ruddell	"Embrittlement of Nylon 12 Cable Jacket".
6577	E. Bondarenko	"Detection of Radio Frequency Arcs in Unattended National Broadcasting Stations".
6581	R. Smith	"Report on Overseas Visit, Sept.-Nov., 1970, (i) Working Parties of C.C.I.T.T. Study Group XV". (ii) Investigation of Integrated Wide-band Facilities for Subscribers".
6589	K. Mottram	"Resistive Short Circuits in Crossbar Relay Sets".
6591	N. Sadler	"Professional Grade Aluminium Electrolytic Capacitors Initial Report".

*In addition 54 other Reports were distributed on a limited or restricted basis.

STAFF AFFILIATIONS WITH EXTERNAL BODIES

Some of the staff of the Laboratories are active members of the governing bodies of educational establishments, learned and professional bodies and institutions. In addition, members of the Laboratories serve on various national and international committees.

NATIONAL

Department of Education and Science	
Metric Conversion Board (M.C.B.)	P. R. Brett
Transport Advisory Committee of M.C.B.	P. R. Brett
Victoria Institute of Colleges	
Committee on College Staffs	P. R. Brett
Course Development Committee	A. J. Seyler
Equipment Review Committee	A. J. Seyler
Monash University	
Engineering Faculty Board	A. J. Seyler
Adelaide University	
Electrical Engineering Department — Hon. Consultant for Post Graduate Studies	A. J. Seyler
Standards Association of Australia (S.A.A.)	
Council	P. R. Brett
Telecommunications and Electronics and Industry Standards Committee	P. R. Brett (Chairman)
	E. Sandbach
Wires and Cable Committee	G. Flatau
Semiconductors Committee	I. P. Macfarlane
Integrated Circuits Sub-Committee	I. P. Macfarlane
Environmental Testing Committee	G. Flatau (Chairman)
Electro-Acoustics and Recording Committee	E. J. Koop
Acoustics Standards Committee	D. A. Gray
Committee on Instrumentation and Techniques for Measurement of Sound	E. J. Koop
Winding Wires Committee	G. Flatau
Electrical and Recording Instrument Committee	J. M. Warner
Electrical Insulating Materials Committee	G. Flatau
Dry Cells and Batteries Committee	G. Flatau
Committee on Control of Undesirable Static Charges	S. H. Noble
Tensile Testing of Materials Committee	K. G. Mottram
Reliability Committee	G. Flatau
Graphical Symbols	I. P. Macfarlane
Chemical and Electroplating Finishes on Metals Committee	R. D. Slade (Chairman)
Pressure Sensitive Adhesive Tapes Committee	G. Flatau
Zinc and Zinc Alloys Committee	K. G. Mottram
Plastics Industry Standards Committee	E. Sandbach
Phenolic Laminated Sheeting Committee	G. Flatau
Methods of Testing Plastics	G. Flatau
The Institution of Radio and Electronics Engineers	
Federal Council	A. J. Seyler
Victorian Division Committee	A. J. Seyler
	A. Fowler
The Institution of Engineers, Australia	
Research and Development Committee	P. R. Brett
Victorian Division Committee	H. S. Wragge
Electrical and Communication Engineering Br. Committee	D. A. Gray
	H. S. Wragge
Victorian National Book Resources Committee	M. Cuzens
Australian Advisory Council on Bibliography Services	M. Cuzens
Communication Sub-Committee of the Aust. National Committee for Antarctic Research	E. R. Craig

INTERNATIONAL

The Laboratories participate in the work of a number of international committees and bodies, such as the International Telephone and Telegraph Consultative Committee (C.C.I.T.T.), International Radio Consultative Committee (C.C.I.R.), World Administrative Radio Conference (W.A.R.C.), Australian and New Zealand Association for the Advancement of Science (ANZAAS), Electrical Research Association (E.R.A.), International Electrical Commission (I.E.C.), Asia Electronics Union (A.E.U.), and the International Telecommunications Satellite Consortium (INTELSAT).

PATENTS

A.P.O. policy in relation to the protection of its interests in inventions, designs and developments was revised in 1968. The results of Post Office research and development work were formerly made freely available to Australian industry in the interests of establishing the industry on a healthy footing. It is now considered that the A.P.O. should expect some return from its contribution to new developments in its fields of interest. A greater emphasis is therefore being placed on the use of patents to increase the possibility of earning royalties or entering into exchange licensing agreements.

Responsibility for examining new A.P.O. developments for possible patentability, and initiating the necessary action where appropriate, rests with the Laboratories. In the past three years applications for patents have been lodged in respect of fourteen new inventions made by Post Office staff, most of these arising within the Research Laboratories. Three were allowed to lapse at the provisional stage, but most have been followed up by equivalent applications overseas. The subjects of current patent applications are listed below:

SUBJECT	INVENTOR(S)	COUNTRIES
Vandal Proof Public Telephone	K. B. Smith, A. A. Rendle } Sub. Equipt.	Australia U.K. Japan
Dual Vibrating Tine Cable Plough	E. W. Corless (Mech. & Elec. Services)	Australia South Africa
Tip Welding Tool for Cable Jointing	E. Bondarenko (Research)	Australia U.K. U.S.A.
Analogue Multiplier	H. Brueggemann (Research)	Australia U.K. Germany Japan U.S.A.
Semiconductor Light and Magnetic Field Detector	N. F. Teede (Research)	Australia U.K. Germany Japan U.S.A.
Improved Trunking Method for Integrated Switching and Transmission	A. Domjan (Research)	Australia Belgium Sweden Holland France U.K. Germany Japan

PATENTS

Self Adaptive Filter and Control Circuit (Echo Cancellation)	L. K. Mackechnie (Research)	Australia U.S.A. U.K. Germany Japan Italy Sweden France Holland
Digitally Tuned Detector (Petra)	J. Lewis (Research)	Australia U.K. Sweden
Pulse Generator and Flip Flop	I. Macfarlane (Research)	Australia
Faulty Circuit Detector	N. McLeod (Research)	Australia (Prov.) U.K. France Germany Japan
Suppressed Zero Voltmeter	A. Stevens (Research)	Australia (Prov.)

In addition the Post Office has acquired an interest in a patent application made by the University of N.S.W. for a novel form of cable with built-in amplification and in a patent application by Monash University for an improved hybrid network. It also has rights in mail handling equipment developed under contract by the Plessey Company.
The bargaining power which a patent portfolio can give in the exchange of know-how with other organisations is probably as important as the possibility of direct royalty earnings. During 1970 the Post Office signed a patent licensing exchange agreement with the Western Electric Co., U.S.A., representing the Bell Telephone System. This agreement is designed to remove inhibitions to the flow of information between the two organisations. An arrangement is also being worked out with the British Post Office to cover inventions made by staff on exchange visits between the two organisations.

PRESENT AND FUTURE ACCOMMODATION

The Research Laboratories have now grown to comprise approximately 500 staff engaged in a wide variety of research and development activities. From a modest start in 1923 in part of the building at 59 Little Collins Street, they now occupy seven buildings at the eastern end of the city of Melbourne. The more specialised and bulky test equipment of the Environmental Physics Division is housed in an eighth building two miles north of the city.

This scattering of activities into a number of separate inadequate buildings presents administrative problems and inhibits the development of the degree of communication necessary in a research establishment. These problems and others associated with the more specialised accommodation requirements of the Laboratories were recognised some years ago, and a policy decision was made in 1968 to re-establish and consolidate the Laboratories in new specially designed laboratory buildings on Departmentally owned sites as soon as possible.

Two sites were initially selected for the purpose — one of 2¾ acres at South Melbourne, and one of 17½ acres near the Monash University. Preliminary plans envisaged the consolidation of "development" activities at South Melbourne, and of "research" activities at Monash.

Briefs were prepared and feasibility studies undertaken for the project during 1970, as a joint project involving staff of the Laboratories, the Engineering Works Division, and the Headquarters Architectural Design Group of the Department of Works.

The work to date has shown that significant economic and practical advantages as regards site planning and funding could be gained by grouping all laboratory activities on a single expansive site, which would permit the predominant use of low rise buildings to meet the long-term requirements. All factors concerned in the choice of location for the Laboratories are now being assessed with a view to establishing firm plans for the Laboratories' future accommodation. It is hoped that the first moves into the new accommodation may take place in 1975 or 1976.

VISITORS TO THE LABORATORIES

A number of Colombo Plan Fellows have spent varying periods of time in the Research Laboratories to further their knowledge of telecommunications. The Fellows are usually attached for some months to the A.P.O., and divide their time between the different divisions in both Central Office and State areas.

Experts from overseas countries such as Japan, France, United States, Holland, West Germany, Sweden and the United Kingdom have visited the Laboratories during the year for discussions, and to give lectures, and there have been numerous visitors from universities, industry and other establishments in Australia.

Tours through the Laboratories have also been arranged for professional societies, universities, other government establishments, technical schools, etc.

OVERSEAS VISITS BY LABORATORY STAFF

In order to interchange experience, technical know-how, opinions and ideas, a programme of overseas visits is arranged each year. These visits are generally to other Administrations, universities, industry and the like, and for attendances at international conferences.

The following staff members have been on such overseas visits during the review period:

Craig, E.R.	Rosman, G. A.	Snowden, D. R.
Kett, R. W.	Ruddell, H. J.	Teede, N.
Kidd, G. P.	Sandbach, E. F.	Willis, G. M.
Perkins, B. R.	Smith, R.	Wragge, H. S.

ASSISTANCE WITH STUDIES

The policy of the Laboratories is to encourage studies by staff who have appropriate aptitudes. In the case of professional officers, these studies are often aimed at obtaining higher degrees, and in other cases, aimed at obtaining post-graduate experience outside the Laboratories.
In the case of non-professional staff, the studies may be aimed at obtaining professional qualifications and furthering their experience. The encouragement may take the form of part or full time leave without pay, appropriate arrangements with universities and technical colleges, scholarships, etc.
The following professional staff have enjoyed such encouragement during the review period:

WITHIN AUSTRALIA
Court, R. A. G.: Monash University, Vic.
Morgan, R. J.: University of N.S.W., N.S.W.
Smith, N. M. H.: Melbourne University, Vic.
Steel, J.: Melbourne University, Vic.

OVERSEAS
Casley, G. M.: U.K.
Mackechnie, L. K.: U.S.A.

SPONSORED EXTERNAL RESEARCH AND DEVELOPMENT

The Laboratories have placed the following contracts for research and development with outside bodies during the review period:

- Low Energy Sputtering of Indium Antimonide Thin Films.
- Surface Acoustic Waves.
- Integrated Digital Communication System.
- P.C.M. for Programme Transmission.
- Transmission Equalisers for T.V.-Phones.
- Acoustic Sounding and Radio Propagation.
- Coding of T.V. Signals.
- Phase Variation in HF Radio.
- Self Adapting Hybrids.

In addition, the Laboratories have co-operated with other bodies in the co-ordination of research programmes in order to achieve maximum efficiency.