REVIEW OF ACTIVITIES

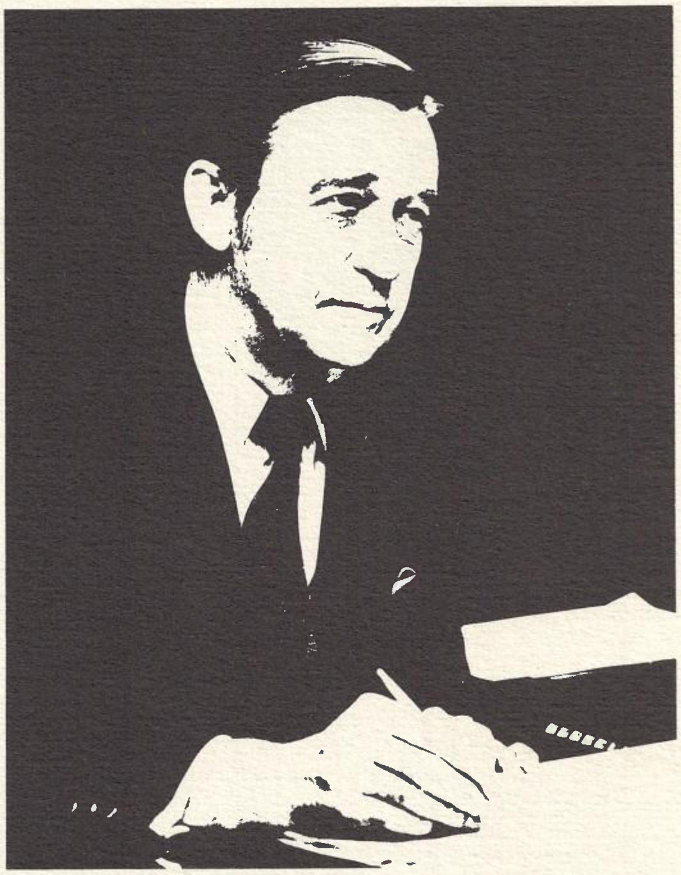
AUSTRALIAN POST OFFICE RESEARCH LABORATORIES 1973-1974

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

The harnessing of technology and science to the provision of community needs for communications services pervades the engineering activities of the Australian Post Office. The timely choice of appropriate technology can lead to economic gains in establishing or maintaining existing network services, improved standards of these services or the introduction of new services to meet community demands.

The science and technology of telecommunications is continually advancing, and the Post Office has a policy of conducting its own research and advanced development projects as a means of keeping itself informed of those advances which may be of benefit in its operations.

The focal point for Post Office research and advanced development in the scientific and technical fields is found in the A.P.O. Research Laboratories. The work of the Laboratories is directed towards assisting the planning of future networks and services on one hand and towards solving problems in the existing network on the other. It also includes specialist tasks such as those of maintaining and applying scientific and technical reference standards of measurement.

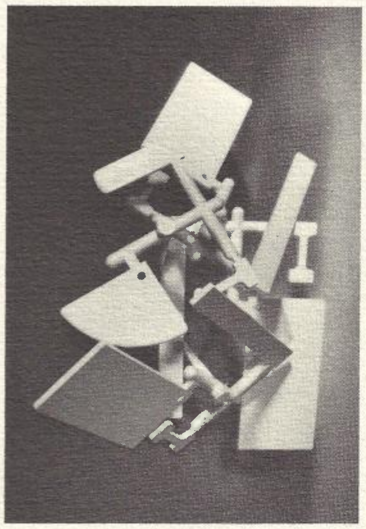


This review of the activities of the A.P.O. Research Laboratories illustrates the scope of the work and its relevance to the present and future operations of the Post Office. As well as providing an interesting insight into the Laboratories, it also demonstrates that through its laboratory activities, the A.P.O. is contributing, in a degree commensurate with its resources, to the international fund of knowledge in the science and technology of telecommunications.

I am sure that you will find this review both interesting and informative.

E Lane

DIRECTOR-GENERAL
AUSTRALIAN POST OFFICE



INJECTION MOULDED TEST SPECIMENS OF PLASTICS OF POTENTIAL USE IN THE MANUFACTURE OF TELEPHONES

Contents

THE ROLE OF THE RESEARCH LABORATORIES

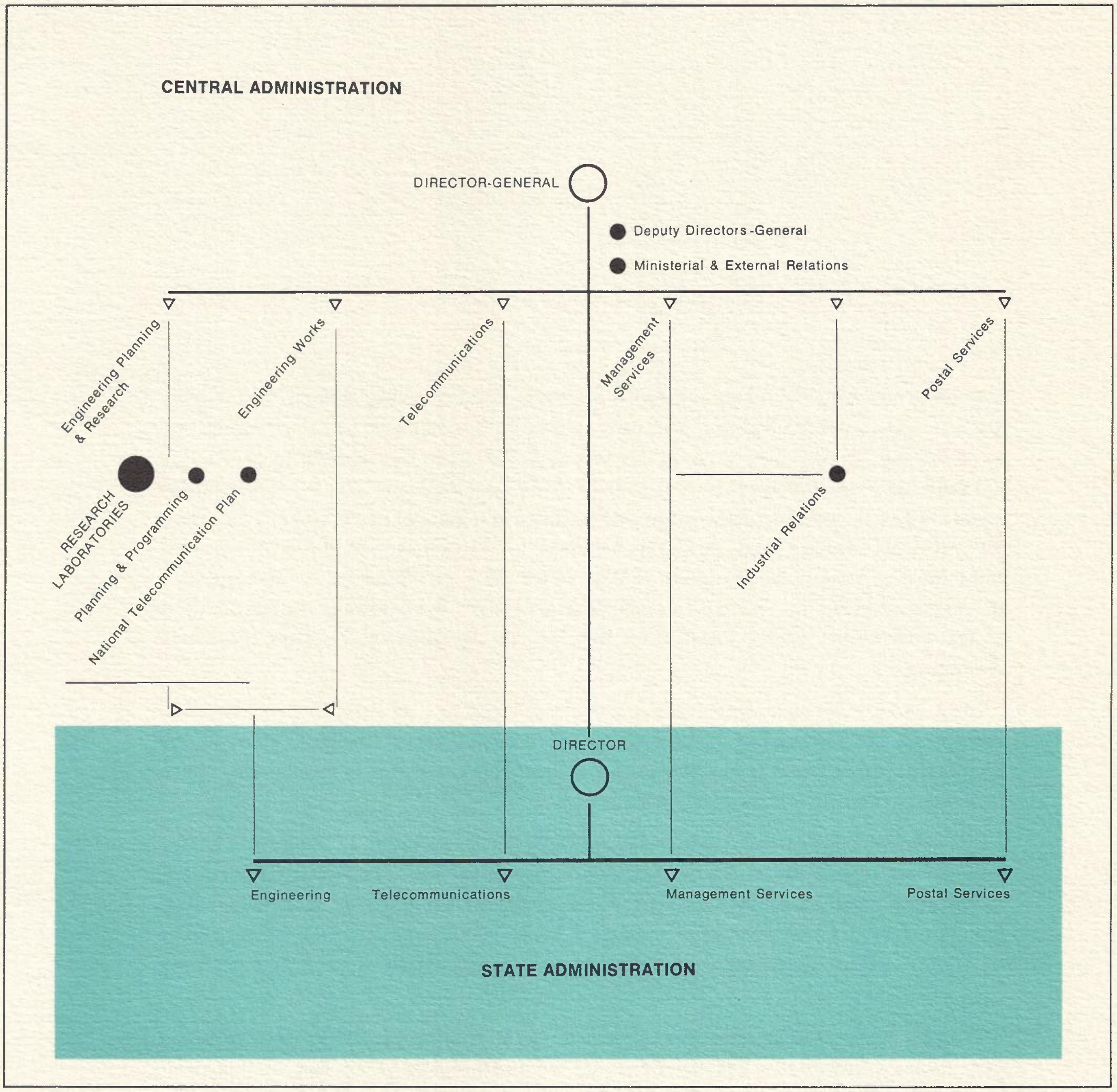
The Australian Post Office is charged with the responsibility of providing the nation's internal telecommunications services and must do this economically, on a scale appropriate to the demand, and with a degree of sophistication that matches the needs of modern society. The discharge of this responsibility requires the timely adoption of new and improved apparatus and systems that result from advances in the science and technology of telecommunications.

The task of planning and developing the telecommunications and postal networks economically, efficiently and with continuing technical flexibility for their future growth relies heavily on the right choice of technology. The determination of the appropriate technology and concern for the efficient management of technology thus pervade the activities of the engineering sections of the Post Office, both in the Central and State administrations.

The focal point of the Post Office effort directed at technical and scientific research and advanced development is found in its Research Laboratories, a Sub-Division of the Central Administration. Coupled with the Planning and Programming Sub-Division and the National Telecommunication Plan Branch, the Laboratories seek to maintain a position at the forefront of the relevant science and technology in order that they may participate expertly in the formulation and implementation of Post Office policies for the introduction of new or improved equipment, systems and services. In addition, the Laboratories are called on to assist in the solution of the technical problems that arise in the design, manufacture, installation, maintenance and operation of Post Office plant.

The execution of these responsibilities means that the Laboratories must maintain a high level of expertise in all forms of telecommunications and in the related disciplines of physics, chemistry and metallurgy. This is done through the conduct of research and advanced development on topics that are relevant to operations in Australia, having regard to work that is known to be in hand elsewhere in Australia and overseas.

It is recognised that telecommunications research and development engages the attention of very large organisations in overseas countries and it is inevitable that many of the improvements proposed for adoption in the Australian Post Office will originate overseas. Nevertheless, long experience has shown that without advanced knowledge available within the Post Office, there is a danger that our technical judgements and decisions will be influenced by suggestions and pressures from outsiders whose interests differ from the long term interests of the Post Office. The Post Office must be in a position to judge for itself the way in which a new development can be incorporated into the network and be able to assess the special requirements and adaptations necessary to make it effective.



To provide the knowledge and expertise necessary to enable these judgements to be made with confidence, it is necessary to have first hand knowledge of the technology concerned, and the best way to achieve this is through the conduct of advanced development in the field concerned. Some of the advanced development projects in the Laboratories are undertaken with the understanding that they will not be carried to the production stage and that the principal benefit will be knowledge which will find application in the specification of new requirements and the assessment of offers from manufacturers.

At the same time, the Laboratories do not underrate the ability of their own staff to produce successful innovations, and each advanced development project is monitored carefully and, in appropriate cases, the development is carried through to production and field use. In addition to playing a research and development role, the Laboratories house staff with specialist knowledge and facilities in a number of disciplines, including the physical sciences, and they also conduct investigations into difficult technical problems that arise in the operation of Post Office plant. Furthermore, the Laboratories are responsible for the electrical standards and the time and frequency standards used by the Post Office. In the latter case, they are an Agent of the National Standards Commission.

The Laboratories cannot, of course, operate in isolation, and extensive collaboration exists with the Planning and the Engineering Works units of the Post Office in the selection of projects and in the application of specialist knowledge in those areas where the prime responsibility rests with other groups.

It is also recognised that a great deal of research talent exists in centres of higher learning and in industry in Australia, and the Post Office would be foolish to ignore the contribution that these sectors can make to telecommunications knowledge. The Research Laboratories attempt to provide a focus for telecommunications research in Australia and to encourage other organisations to undertake appropriate research tasks.

The preceding remarks have been concentrated on telecommunications and, in fact, a very large proportion of the resources of the Laboratories is applied in this field. Nevertheless, the Laboratories have an equivalent responsibility for the postal area and for many years a small proportion of resources has been applied to postal problems.

Although modes of expression have altered and resources have multiplied, the role of the Research Laboratories remains basically the same as it was when they were established 51 years ago. In essence, the Laboratories are responsible for acquiring relevant new knowledge and new skills and applying them to the technical problems facing the Post Office. The pages that follow give some indication of the way in which this role is being fulfilled by the current programme.

HIGHLIGHTS OF THE YEAR

GOLDEN JUBILEE OF THE LABORATORIES

During August 1973, the Laboratories celebrated their Golden Jubilee Year with several public functions. These included a 2-day Symposium on the theme "Whither Communications?" and a week of OPEN DAYS, during which interested members of the public were invited into the Laboratories to view demonstrations and displays of Post Office research and development projects and specialist activities.

Readers may recall that the last edition of this annual Review of Activities was a special one. In addition to outlining current activities, it recalled some of the past achievements of the Laboratories since their establishment as an organisational entity in the Post Office Headquarter's Administration in June, 1923.

The object of the August celebrations was to demonstrate the developing role of the Laboratories as the focal point of Post Office research studies and advanced development projects. Through these, the Post Office seeks to maintain its own expertise in the science and technology of communications as an essential pre-requisite for the forward planning of the Australian networks.

The Symposium demonstrated the link between planning and new technology. Thirteen speakers from telecommunications administrations, universities and industry, both local and overseas, addressed themselves to different topics around the theme "Whither Communications?". The comprehensive range of the topics discussed is illustrated by the list of speakers and the titles of their papers:

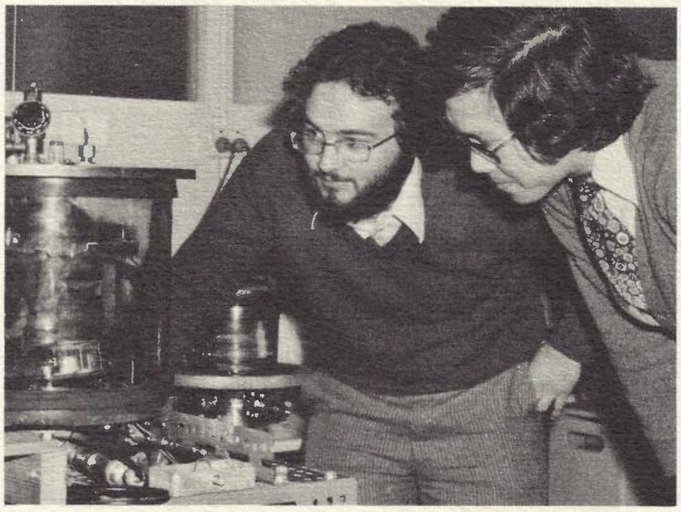
DR. W. A. TYRRELL PRESENTS A CONGRATULATORY MESSAGE FROM BELL LABORATORIES TO MR. E. F. LANE

IN CONVERSATION AT THE OFFICIAL OPENING ARE (L TO R) MR. E. F. LANE, DIRECTOR-GENERAL, PROF. W. J. BRAY, B.P.O., THE HON. L. F. BOWEN, POSTMASTER-GENERAL, AND DR. W. A. TYRRELL, BELL LABORATORIES.

- "The Integration of Communications" — Professor W. J. Bray, Director of Research, British Post Office.
- "Changing Patterns of Creativity and Innovation in Telecommunications" — Dr. W. A. Tyrrell, Executive Director, Technical Relations, Bell Laboratories.
- "A Discussion of the Sociological Implications of Telecommunications Services of the Future" — Professor S. Encel, Professor of Sociology, University of New South Wales.
- "Aspects of Future Telecommunications Services of Particular Relevance to Australia" — Mr. P. R. Brett, Senior Assistant Director-General, Research, Australian Post Office.
- "Communications, Technology, Society and Education — Reconciled?" — Professor A. E. Karbowiak, Professor of Electrical Engineering (Communications), University of New South Wales.
- "Trends and Research in Telecommunications — The Future to the Year 2000" — Dr. H. Busignies, Senior Vice-President and Chief Scientist, International Telephone and Telegraph Corporation.
- "Information in 1984" — Dr. Ir. K. Teer, Director of Engineering Sciences, Philips Research Laboratories, Eindhoven, The Netherlands.
- "New Devices for Future Telecommunications" — Dr. M. Uenohara, General Manager, Central Research Laboratory, Nippon Electric Company Ltd., Japan.
- "Custom Microelectronics in Communications Development" — Dr. G. A. Rigby, Senior Engineer, A.W.A. Microelectronics Pty. Ltd., Australia.
- "The Role of Computers in Future Communications Systems" — Mr. J. R. Pollard, Special Projects Executive, Telecommunications Group, The Plessey Company, England.

- "Telecommunication Trends in Japan" — Mr. M. Yamauchi, Deputy Director General of Research and Development, Nippon Telegraph and Telephone Public Corporation.
- "Future Developments in Sound and Vision Broadcasting in Australia" — Mr. E. J. Wilkinson, Director, Technical Services, Australian Broadcasting Control Board.
- "The Future Scene in International Communications" — Mr. W. G. Gosewinckel, Chief Planning Officer, Overseas Telecommunications Commission, Australia.

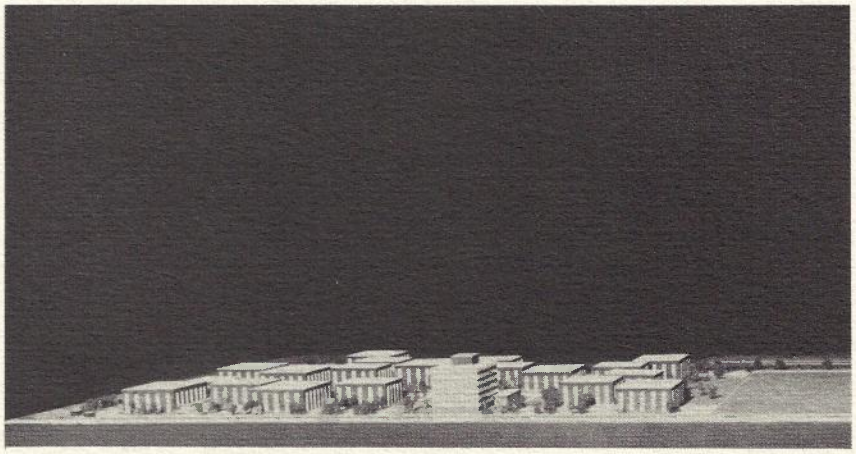
MR. R. J. WOOD (AT RIGHT) DEMONSTRATES TELEPHONE TRANSMISSION DELAY AND ECHO EFFECTS TO VISITORS DURING OPEN DAYS



The Symposium was inaugurated by Mr. E. F. Lane, Director-General, on 15th August, 1973. An invited audience of about 750 took part in three panel discussion sessions, during which the various speakers, prompted by questions from the audience, enlarged upon their papers. The papers were later published in a special edition of the journal "Australian Telecommunication Research", Volume 7, Number 3, 1973.

The week of OPEN DAYS attracted about 5,000 visitors who inspected 80 displays and demonstrations of Laboratories' activities, present and past, in five of the Laboratories' buildings. The OPEN DAYS were inaugurated by the Postmaster-General, the Honourable Mr. L. F. Bowen, on 17th August, 1973. The exhibits portrayed the spectrum of Laboratories' activities. Research projects which attracted special interest were those directed at new high capacity transmission systems, such as those concerned with new media such as optical fibres, circular waveguides and satellites. Other displays demonstrated the roles of the specialist standards and scientific Sections, the functions of which are of fundamental significance to many Post Office activities. The conclusions of the Symposium that future telecommunication services would provide integrated services and rely heavily on digital switching and transmission techniques were also reflected in the project displays.

VISITORS VIEWING DISPLAYS OF THE WORK OF THE LABORATORIES DURING OPEN DAYS



ARCHITECT'S MODEL OF A.P.O. MONASH SITE DEVELOPMENT TO 1995

NEW LABORATORIES BUILDING PROJECTS

From their beginnings in 1923 as a one-man research unit, the Research Laboratories have grown until they are now an established Sub-Division of the Central Office organisation, with a staff exceeding 500.

The provision of building accommodation over this 50 year period of expansion has largely followed an ad-hoc pattern of leasing buildings in the Melbourne city area as and when these could be obtained. At the present time, the Laboratories occupy seven buildings at the eastern end of the city and an eighth building in the nearby suburb of Carlton. The buildings are old, having been erected variously as factories, display rooms and warehouses as the city of Melbourne expanded from the 1880's through to the early 1930's. More particularly, they are extremely limited in the extent to which building services can be provided to meet the changing needs for present day laboratory facilities. Consequently they are inordinately costly to lease, renovate and maintain.

The shortcomings of acquiring further leased buildings had been realised for some time but it was not until 1968 that it became established Departmental policy to seek future accommodation for the Research Laboratories in specially designed buildings on a Departmentally-owned site.

The first positive step in pursuance of this policy was taken in 1972 when a 7.08 hectare site was purchased in Blackburn Road, North Clayton, near Monash University, and architectural design work was commenced. Following a Department of Housing and Construction recommendation, this site was extended to 19.222 hectares by the purchase of an adjoining site in 1973. The acquisition of the second site included a ten

PERSPECTIVE SKETCH OF LABORATORIES BUILDINGS, LYON PARK INDUSTRIAL ESTATE

year lease-back agreement which precludes A.P.O. development of the site prior to 1983. Initial development will therefore take place on the original site. The combined site has become known as the "Monash" site.

The overall plan for the development of the Monash site envisages a series of laboratory buildings of not more than three stories in height arranged in a campus style setting. Buildings will be erected in a number of stages in a planned development of the site which matches the availability of funds and other A.P.O. priorities. Landscaped courts and gardens between buildings will create a stimulating and visually pleasing environment. Vehicular traffic is to be confined to an external ring road so that the inner campus area is reserved for pedestrian traffic.

The total development plan provides for expansion up to the turn of the century, by which time the Laboratories staff is expected to be approaching some 2,000 people.

Parliamentary approval to proceed with the first three stages of the project on the 7.08 hectare section of the site was received in November 1973. The first stage provides for the erection of two 3-storey laboratory blocks, a central plant building and a special single storey building for the environmental physics activity. It will accommodate the Sections presently occupying three buildings on the Australian Government

Centre site in the city and the environmental physics activity from North Carlton. One advantage is that all Sections of the Physical Sciences Branch will then be united on the site. This first stage of the project is scheduled for completion by mid-1976 at an estimated cost of $5.4 million.

The second stage of the project aims to complete the evacuation of the Laboratories from the Melbourne city area by transferring the Sections that will be left remaining in three city buildings after 1976. This stage is to be completed by the end of 1979.

More immediately, the leases on two other city buildings have expired and the Laboratories have to vacate these premises as soon as possible. Buildings cannot be erected on the Monash site to provide a timely solution and alternative leased accommodation is being provided at the Lyon Park Industrial Estate, Clayton, during 1974. Arrangements have been made with Ronald Lyon (Australia) Pty. Ltd. for the erection of two buildings, fitted out to Post Office specifications, to accommodate the Switching and Signalling Branch and some Sections from the Advanced Techniques, Transmission Systems, and Standards and Laboratories Engineering Branches. These Sections will thus form the vanguard of the Laboratories' move to the Clayton area. They will ultimately be transferred to the A.P.O. Monash site after 1983.

1973 I.R.E.E. NATIONAL CONVENTION

The Institution of Radio and Electronic Engineers, Australia, held their 14th National Convention in the Exhibition Buildings, Melbourne, from 20th to 24th August, 1973. The convention, a biennial event, is a focal point for the Australian electronics industry, bringing together engineers, scientists, technical staff, business executives and educators. The convention includes an extensive lecture programme and a comprehensive display of equipment from local and overseas manufactures.

The staff of the Laboratories have always taken an active part in the convention and this year prepared and presented some twenty four papers on the recent work of the Laboratories, out of a total of one hundred and forty papers. The Department also staged an exhibition of both current activities and items of historical interest. These ranged from historic details of the Bass Strait Cable Project to more recent projects on microwave and satellite transmission. Participants in the convention were invited to visit the Laboratories during their OPEN DAYS which were held concurrently.

Members of the Laboratories' staff were also deeply involved with the planning and organisation of the convention. The Chairman of the I.R.E.E. convention board was Mr. A. M. Fowler, a Principal Engineer in the Laboratories, and he was ably supported by a team that included four other members of the Laboratories' staff.

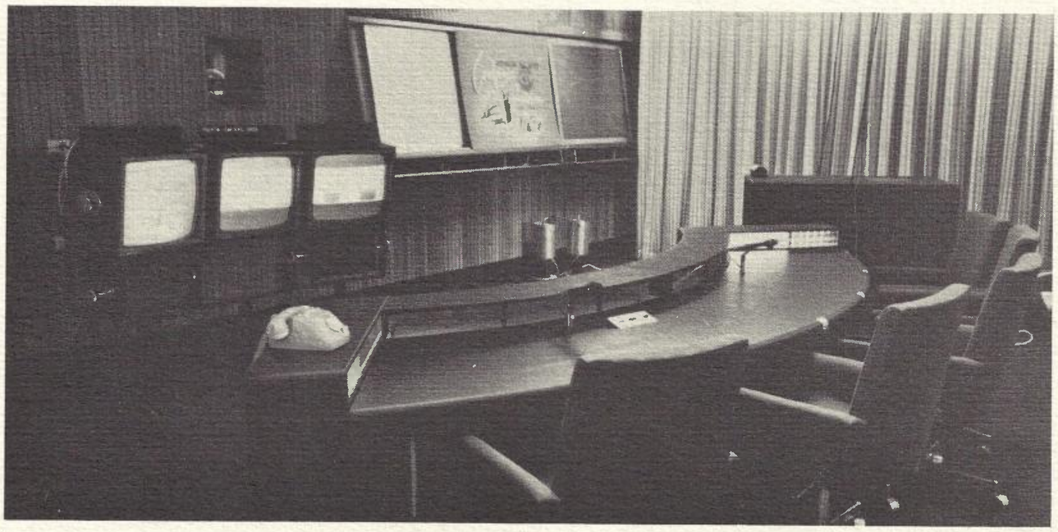
RESTRUCTURING OF THE LABORATORIES' ORGANISATION

A comprehensive review of the organisation of the engineering Divisions of the A.P.O., started in 1971, resulted in changes in the organisational structure of the Laboratories and in the classifications of a number of engineering positions. Implementation of these changes commenced on 10th February, 1972, but the complete re-organisation of the Laboratories is only just coming to fruition. Reviews of the technical grade, scientific, and clerical and administrative positions of the Laboratories have since been conducted to almost complete the re-organisation of the Laboratories. Re-organisation of the Engineering Library Section has yet to be finalised.

The review of Laboratories technical grade positions was discussed with the Public Service Board during 1972, and final approvals on the reorganisation of the technical grade structure to match the new engineering structure were granted on 3rd October, 1973. The restructure resulted in the creation of 25 new technical grade positions and the reclassification of 81 existing positions out of the total of 195 positions now comprising the technical grade staff complement of the Laboratories.

Public Service Board approval was given on 17th December, 1973, to the restructuring of the scientific positions in the Applied Science and Laboratory Services Branch. This resulted in the creation of a new Branch, the Physical Sciences Branch, and the renaming of the remainder of Applied Science and Laboratory Services Branch as the Standards and Laboratories Engineering Branch. The Physical Sciences Branch is under the control of a Deputy Assistant Director-General who is now responsible for all applied science activities of the Laboratories. The Branch comprises three restructured Sections: Physics and Polymer, Analytical Chemistry, and Electro-Chemistry and Metallurgy. The engineering functions of the old Applied Science and Laboratory Services Branch are now the responsibility of the Assistant Director-General, Standards and Laboratories Engineering. No changes were made in the sectional structure of this latter Branch.

An interim reorganisation proposed for the administrative Section of the Laboratories was examined by representatives of the Public Service Inspector in August 1973, and a total of 24 new positions and 9 reclassifications were approved in November. At present the whole of the clerical administrative structure of the Engineering Divisions is being considered, to accord with the 1972 engineer restructure, and it is expected that further administrative changes within the Laboratories will result from this exercise.



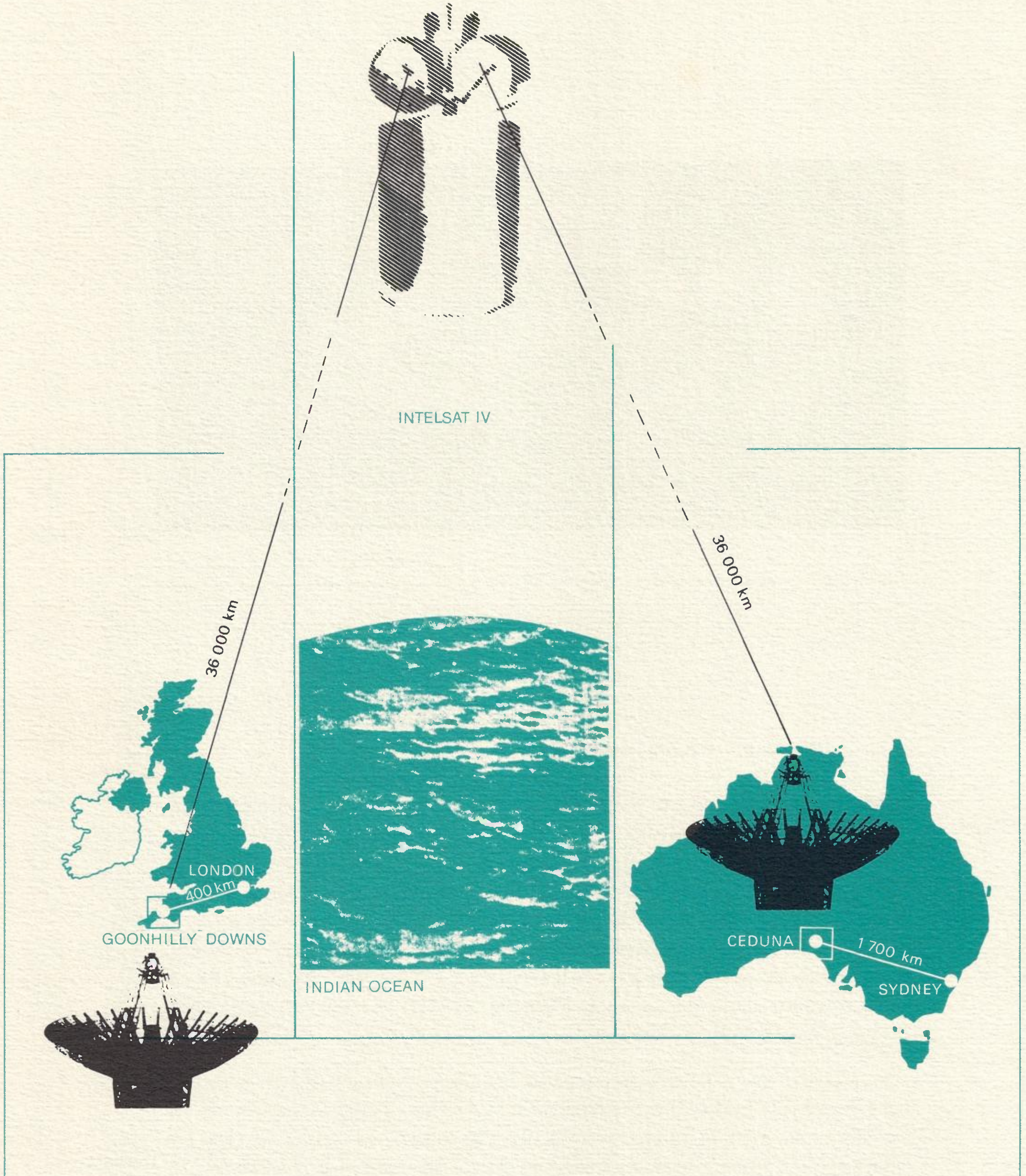
TV—CONFERENCE STUDIO, SYDNEY G.P.O.

AUSTRALIA — U.K. TELE-CONFERENCING TRIAL

The first international conference using a television link-up was held on 1st November, 1973, between Australia and the United Kingdom. Participating in this "tele-conference" were representatives from the senior managements of the Australian Post Office, the Overseas Telecommunications Commission and the British Post Office. The circuit was set up between the A.P.O. TV-Conference studio in the Sydney G.P.O. and the Euston Tower Confravision studio of the B.P.O. in London. Transmission between Sydney and London was via the O.T.C. Earth Station at Ceduna, South Australia, the Indian Ocean Satellite INTELSAT IV F 5 and the British Earth Station at Goonhilly Downs, Cornwall.

Results from this trial conference showed that intercontinental television conferencing is technically feasible. Despite differences in the video display formats chosen for the Australian and U.K. national systems, the trial showed that the two systems are sufficiently compatible to provide a medium for the effective conduct of a conference.

Further trials are planned to identify problem areas, improve instrumentation and add features desirable for an intercontinental conference facility.



INTERCONTINENTAL APO-BPO TV-CONFERENCE TRIAL

A SELECTIVE REVIEW OF

Current Activities

In accord with their functions, the Laboratories are engaged in a large number of investigatory and developmental projects and specialty activities in the engineering and scientific fields. This work has application in both the telecommunications and postal networks, and comprises a wide variety of specific topics pertinent to the present technical standards and future technical advance of these networks.

It is not possible to report, even briefly, on all the Laboratories' projects and activities in this review. As a consequence, the activities reviewed in the following pages have been selected to give an overall picture of the type and breadth of work undertaken, and of the degree to which the Laboratories are keeping abreast of world developments in communications science. A more comprehensive list of current projects is issued in a "Quarterly Progress Report" and this is available to selected bodies with special and more specific interest in the work of the Laboratories.

The normal method of publishing the detailed results of a research project is through a Research Laboratories Report, prepared when an investigation has reached a conclusion or a conclusive stage. It is the vehicle by which the results of the work are conveyed to the A.P.O. "client", other interested sections of the Department and in many cases, to other telecommunications agencies and industry as well as to other research bodies, both local and overseas.

In addition, the staff of the Laboratories often contribute to Australian and overseas technical journals and they also present occasional papers to learned societies. An indication of the scope of this activity can be gained from the lists given in the last section of this Review of Activities.

CUSTOMER APPARATUS AND SERVICES

New Telephone Transmitters

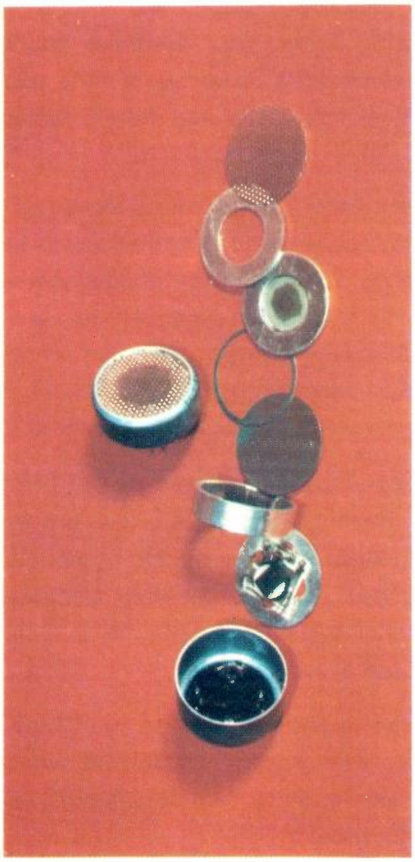
The carbon microphone, used as the transmitter in almost all telephones, has the advantages of being simple, rugged and inexpensive. Unfortunately, it has the disadvantages of a relatively short lifetime and a tendency to become noisy and its sensitivity depends on orientation and feed current.

Many other types of microphone transducer exist which do not have these inherent disadvantages, but all require the addition of an amplifier to bring their sensitivity up to the level suitable for use as a telephone transmitter. Fortunately the development of integrated circuit technology has reduced the cost of such amplifiers to a reasonable level. Alternative telephone transmitters, while having a higher initial cost, may in fact have an overall economic advantage over the carbon type, principally because of reduced maintenance costs.

In recent years, the Post Office has been investigating two basic types of replacement transmitters for A.P.O. telephones, one based upon a piezo-ceramic microphone and another upon an electret microphone. A local telecommunications manufacturer with experience in the manufacture of ceramic devices has been encouraged by the Department's interest to start development work on a piezo-ceramic replacement transmitter. Similarly, another manufacturer is developing an electret version.

During 1973, the Laboratories took delivery of a substantial quantity of samples of experimental piezo-ceramic transmitters from the local manufacturer. Samples of the electret version were supplied early in 1974. The samples have been subjected to extensive testing aimed at determining their suitability for use in the telephone network. Measurements performed on all the samples include their d.c. characteristic, frequency response and sensitivity versus feed voltage. In addition, precise measurements have been made on all samples of their sensitivity, d.c. voltage drop and impedance under defined conditions. This enables small shifts which may occur during environmental testing to be determined. The transmission performance of telephones using the new transmitters, and their compatibility with existing types of telephone, for example, in parallel telephone services, is under examination.

CERAMIC MICROPHONE — DISASSEMBLED



ARTIFICIAL VOICE FOR TESTING NEW MICROPHONES

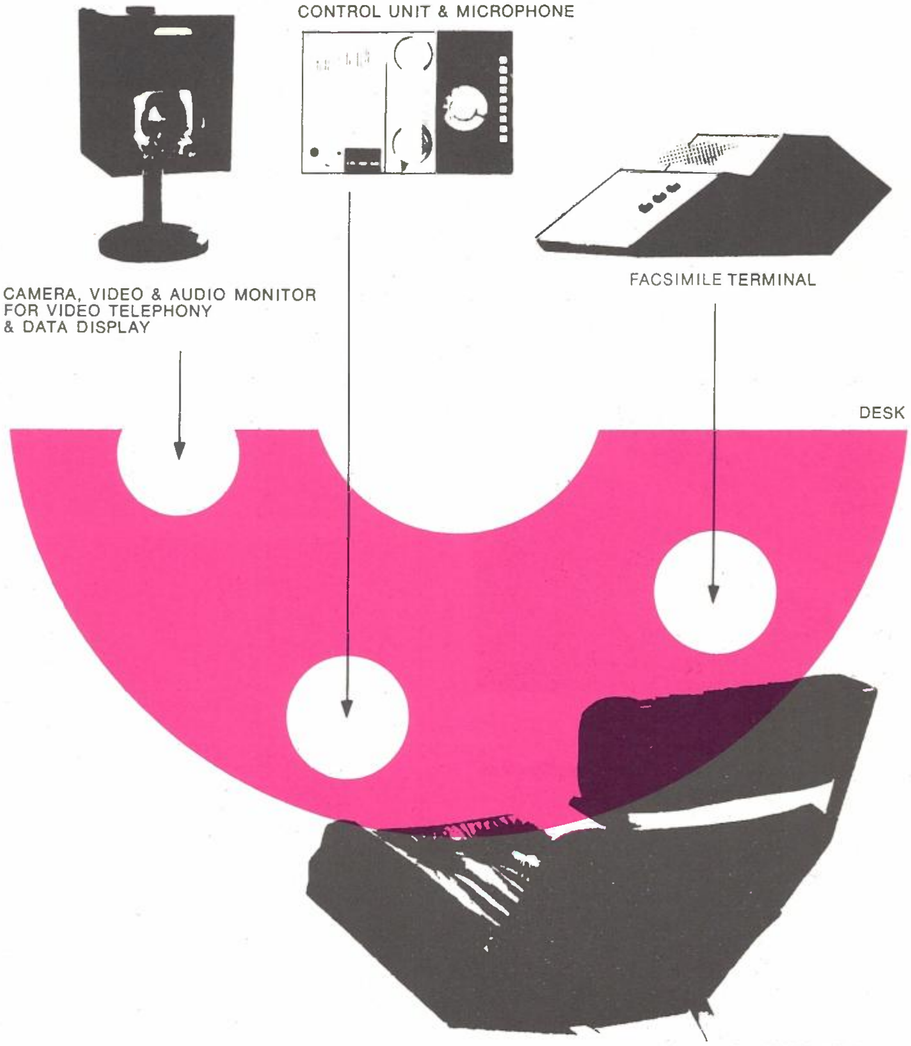
Data Transmission Trials over Standard and Narrow Band VF Circuits

There has been a rapid increase in the requirement for trunk circuits to Darwin which has made it necessary, as an interim measure, to install equipment which provides additional telephone circuits with reduced VF channel bandwidth. Darwin is at present connected to the other major cities in Australia mainly by such narrow band circuits, which run east through Mt. Isa to Brisbane and Sydney, and south through Alice Springs to Adelaide.

Only one full width VF channel, through Adelaide, is available for data services. Access to this channel for incoming calls can only be obtained by a system of revertive booking. Further, it can only be established from the Darwin end. The increasing number of data customers and volume of data calls was causing traffic delays on this full width channel and these conditions were expected to become worse until the Darwin-Mt. Isa broadband system became operational in mid-1974.

A laboratory investigation was therefore made to provide a data service over narrow band circuits. Two standard G type 600/1200 bit/s data modems were modified to operate as a pair at 1200 bit/s over such circuits. Alternatively, they could be switched to operate at 1200 bit/s to other standard G type modems over a full width VF circuit. The 600 bit/s option normally available on this type of modem was deleted to simplify the switching operation which is performed by a change-over switch installed in the associated telephone. When operating over narrow band circuits, a variable group delay equalizer is included in the receiving terminal, this equalizer being previously adjusted to compensate for an average narrow band circuit.

In May 1973, these modified modems were installed for field trial in the RAAF data terminals at Darwin and Canberra. The error rates measured during the installation tests indicated that the modified service over the narrow band channels would provide a grade of service comparable to that of a full width channel at 1200 bit/s operating over the same route. Revertive call booking is not required and booking delays are considerably reduced. This system has now been continuously in operation since installation, and the RAAF reports very satisfactory performance over this period.



AN OFFICE WITH ADVANCED COMMUNICATION FACILITIES

Advanced Communication Facilities

The A.P.O. is continually making improvements to its existing telecommunications services and investigating new facilities for the communication network. In recent years, the Research Laboratories have realized that it may be necessary to make longer range plans for the introduction of new facilities than in the past. This situation has arisen as a result of the enormous telecommunication potential being made available by rapid advances in electronics technology.

To assist in formulating A.P.O. policy for the period up to the year 2000, a new National Telecommunication Planning Branch (N.T.P.) has been created. One aspect of the N.T.P. studies is a joint investigation with the Research Laboratories on the practicability of setting up an experimental network with advanced facilities and the study of the impact of these facilities on a selected group of participants.

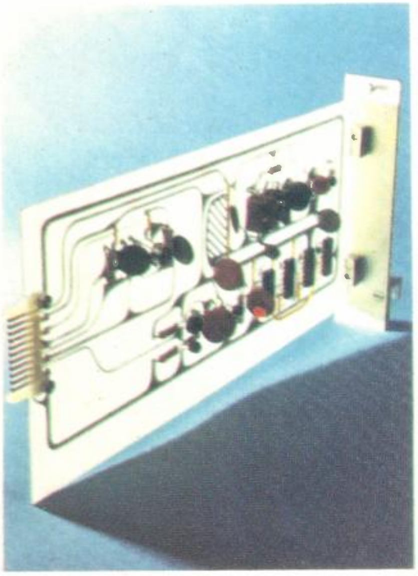
The features being considered for introduction into the experimental network are those which might find application in an executive environment and include:

- push-button control of all facilities,
- computer-controlled switching,
- concentration of special equipment for time-shared access,
- computer access,
- hands-free telephony,
- facsimile communication,
- video telephony,
- special information services,
- message answering,
- conferencing.

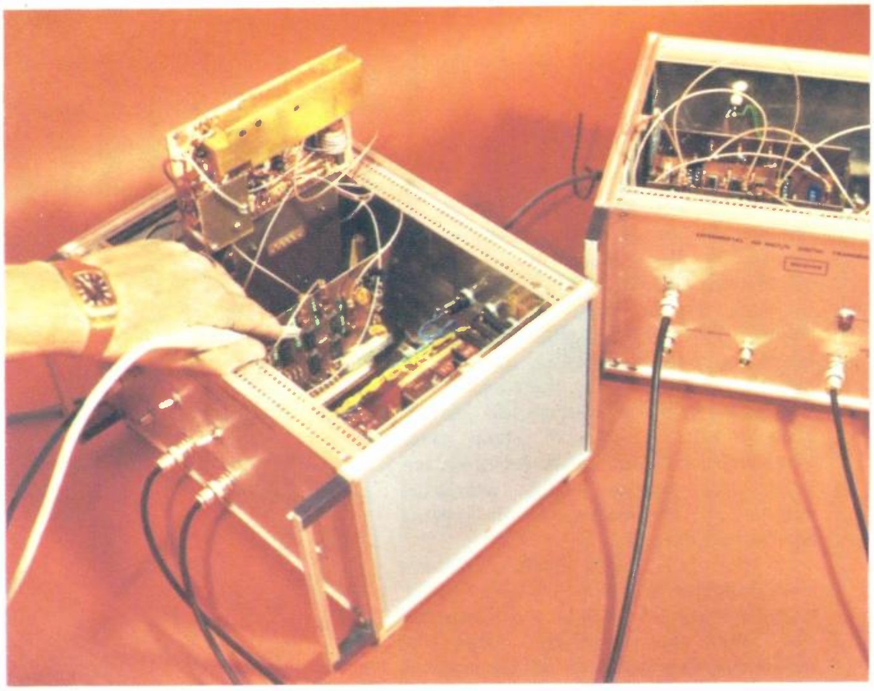
There are many possible configurations for a terminal providing these services. In the terminal design, it is important that the operation be simple, so that the various services can be manipulated with maximum efficiency. Only the control unit needs to be close at hand and would probably take the place of the present telephone. The remainder of the equipment does not need to be within reach and can be placed to avoid obstruction of the office.

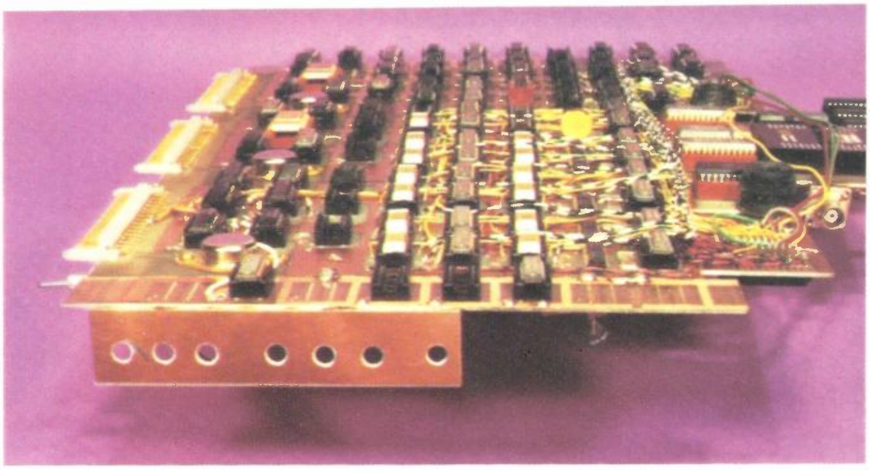
A feasibility study is presently being pursued to determine whether to assemble the experimental network and the form it ought to have for the first phase of the experiment.

NOISE GENERATOR FOR TELEPHONE MEASUREMENTS



EXPERIMENTAL 150 MBIT/S LINE EQUIPMENT





CIRCUITRY FOR DIGITAL CODING OF VIDEO SIGNALS

Telephone Apparatus Measuring System

The performance levels of telephone instrument components at the manufacturer's works are controlled currently by means of an instrument known as the Telephone Efficiency Tester (TET). The present version, Type R3. was put into service in 1962. It is equipped with a range of facilities which varies according to the range of components it is intended to test. At present, there are about 50 TET's of various types in use in Australia. These are situated in the A.P.O. Materials Inspection Laboratories, A.P.O. Workshops and the premises of several manufacturers.

Although the R3 TET has worked well in practice, it was designed for the telephones in use in the 1960's. During the last ten years, the A.P.O. has introduced a range of new telephones, some incorporating active circuitry and requiring tests of a type not provided for in the original R3 design. Further adaptation of the R3 TET to provide these new testing facilities did not appear to be economic and work has been commenced on a new design, to be known as the Telephone Apparatus Measuring System — Series 4 (TAMS-4).

The R3 TET was fundamentally a laboratory type of instrument, whereas TAMS-4 is being designed primarily for continuous reliable factory use. Relays will be used for all switching. Test circuits and acceptance levels will be easily programmed, and there will be a minimum of front panel controls. For Inspection Laboratory use, a meter readout will be provided. This will be interchangeable with a "Pass/Fail" indicator for production line applications. A study is being made of the human factors involved in these two testing environments, with a view to reducing errors while still giving the operator some decision-making responsibility.

To reduce testing time on a healthy production line, it will be possible to programme the system to apply a small group of essential tests to every item. Alternatively, it will also be possible to subject a pre-determined fraction of the items to the complete range of tests required by the specification. Any individual test may be designated as essential or otherwise.

The TAMS-4 is being designed to reduce the overall cost of testing, while providing inspecting officers and production managers with a greater range of information about particular products.

DIGITAL TRANSMISSION

Digital Coding of Video Signals

The economic viability of digital transmission for long distance relaying of video signals is strongly dependent on the channel capacity (bit rate) required to transmit each video signal. This channel capacity is determined by the efficiency of the basic analogue to digital conversion stage — the video codec. In television pictures, there exist significant redundancies, and an efficient video codec should exploit such redundancies to reduce channel capacity requirements.

Several experimental video coding systems have been developed for evaluation in the Laboratories.

A simple Pulse Code Modulation (PCM) codec for 5 MHz bandwidth signals was operated at 75 Mbit/s as part of a demonstration of 150 Mbit/s digital transmission over 9.5 mm coaxial cable. A feature of this codec was the excellent performance of its novel statistical synchronisation scheme.

More efficient coding has been employed in Differential Pulse Code Modulation (DPCM) coding of video-telephone signals of 1 MHz bandwidth. Using a fixed length (3 bits per sample) coding system and an efficient synchronising scheme to allow exploitation of the redundancy in the video blanking intervals, a rate of 5 Mbit/s has been achieved.

Still further reductions have been achieved with variable length coding, where words of variable length are assigned to each sample. With these techniques, it appears probable that a rate between 3 and 4 Mbit/s may suffice for video telephony. However, the circuit complexity and sophistication required becomes almost prohibitive. The board in the photograph represents about ten per cent of the circuitry per codec.

Another important aspect is the vulnerability of the coded signal to bit errors occuring during transmission. Any reduction in bit rate is usually accompanied by an increase in error vulnerability. Consequently, techniques for secure synchronisation and error concealment have been devised and evaluated. Evaluation of two error concealment schemes has involved a series of subjective tests.

In the forseeable future, video coding research will concentrate on 5 MHz bandwidth signals for specific applications, such as the transmission at 18 Mbit/s of signals from the A.P.O. TV Conference facility. In the longer term, the aim is for efficient coding of colour broadcast standard television signals.

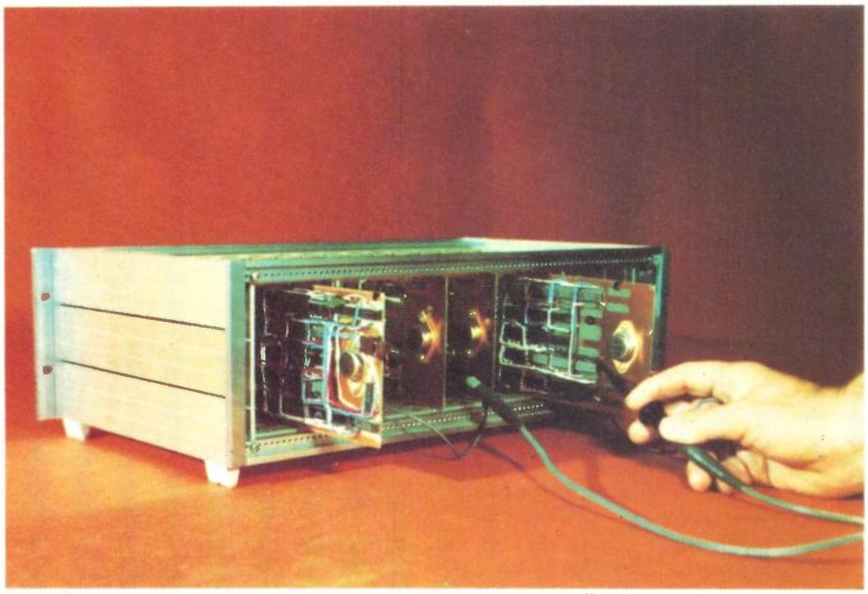
Digital Line Systems for Coaxial Cable

The study of digital line systems for standard 2.6/9.5 mm cable is a continuing activity. These systems appear to have advantages for the transmission of non-voice signals, such as video, when compared with analogue transmission systems using similar repeater spans. Attention has been focussed on the capacity of digital systems with regenerator spans of 4.5 km and 1.5 km (the repeater spans of 12 MHz and 60 MHz analogue FDM systems, respectively).

Activity in the past year has centred on the areas of system optimisation and system implementation.

Digital computer techniques have been employed to determine the optimum equaliser configuration for minimising the probabality of error in a digital line system, taking into account such factors as timing imperfections and variation of system parameters with temperature. This optimisation is made possible by the development in the Laboratories of very efficient methods of computing the probability of error in digital transmission.

On the system implementation side, equipment capable of operating at 150 Mbit/s has been constructed and used to transmit TV Conference video signals over a link of about 2 km. The digital line equipment contains a synchronous multiplexer, making possible the simultaneous transmission of two video signals, each coded at 75 Mbit/s. Current and future activity is aimed at increasing the equipment capability to regenerator spans of 4.5 km and speeds in the region 200-250 Mbit/s.



ASYNCHRONOUS DIGITAL MULTIPLEXER

Asynchronous Digital Multiplexing

In digital transmission networks, the need often arises to form a higher capacity system by time division multiplexing several low capacity digital systems. Normally, this requires that the tributary and the multiplex signals be synchronous. However, often this is not the case because incoming sources are usually derived from autonomous clocks. In such cases, a process called "justification" is used to equalise the bit rates of the incoming streams. In the Laboratories, an 8.448 Mbit/s multiplexing system using +/0/− justification to combine four 2.048 Mbit/s streams has been developed. It is thought that this justification system has significant advantages over the positive justification technique which is used extensively overseas.

In the positive justification technique, every tributary of a multiplex system is read with a clock rate which is always equal to or higher than the maximum clock rate of the tributary. In this case, information can only be repeated and is never lost. The exact location of the repeated information is sent to the receiver via a signalling channel incorporated in the multiplex frame structure.

The justification technique developed by the Laboratories has the nominal clock rate of the multiplex reading clock equal to the nominal clock rate of the tributary. Both repetition and loss of information can occur in this case. Loss of information is prevented by signalling the location of the lost information bit and its binary value to the receiver, via the signalling channel incorporated in the multiplex frame structure. Three commands are normally transmitted: positive (repetition of information), zero (no justification), and negative (loss of information plus value of erased bit).

Some of the advantages of the +/0/− justification technique over others are:

(i) easy adaption to synchronous networks, where the tributary and multiplex signals are synchronous, with no multiplex jitter introduced;

(ii) more flexible choice of multiplex frequency and frame make-up;

(iii) symmetrical justification capacity.

Supermastergroup Data Transmission Systems

The development of an 18 Mbit/s digital transmission modem for operation over the analogue FDM network has been undertaken for two main reasons:

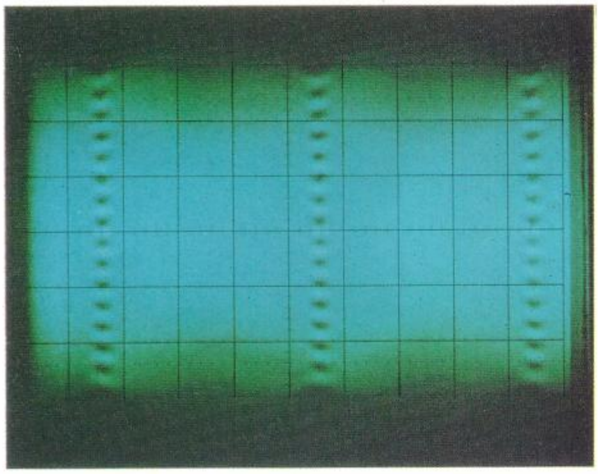
— to provide for the use of the trunk telephone network as a digital bearer for TV conference, TV telephone, high speed data, secure communications using cryptically encoded signals, and any other non-speech signals to be transmitted in the digital mode;

— to provide a facility for higher order PCM multiplex systems to be connected over the FDM network.

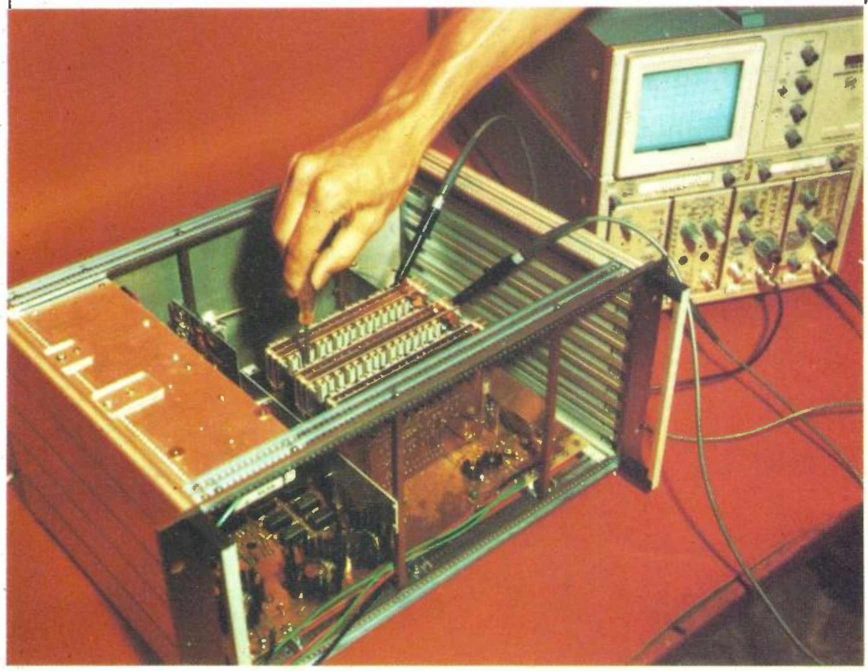
The techniques under study are applicable to lower capacity channels, such as group and supergroup channels, where there is possibly a need to transmit high speed data and digitized facsimile signals. To achieve the most efficient utilization of the supermastergroup channel, the modulation technique chosen for the modem is single side band amplitude modulation (SSBAM) with class 4 partial response shaping.

The construction of a transmitter has been completed and the receiver design is nearly completed. The system has the flexibility of operating at 6, 12 or 18 Mbit/s. In order to obtain the required high speed operation, emitter coupled logic circuits had to be used throughout both the transmitter and receiver. The SSBAM signal is generated in the transmitter by six binary transversal filters supplying both the class 4 waveform and its Hilbert transform, which is required for sideband cancellation. The class 4 waveform obtained gives an excellent spectrum and an acceptable 15 level eye pattern.

A number of original theoretical contributions are being made and reported on. One paper has been accepted for publication and a second is being written on the effects of carrier phase error, timing phase and transversal linear equalization on the eye patterns of SSBAM class 4 signals.



15—LEVEL EYE PATTERN



SUPERMASTERGROUP DATA MODEM

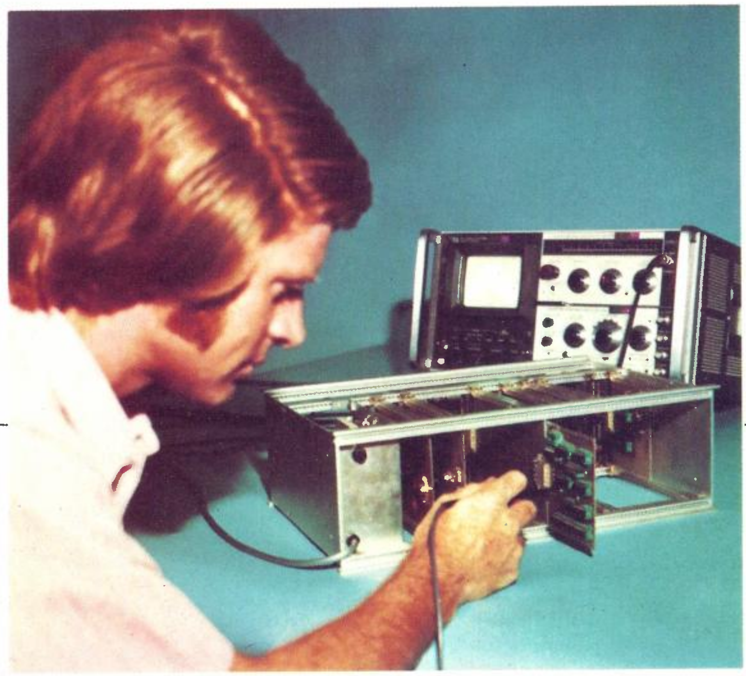
Digital Radio Transmission Studies

Digital radio systems can be used for interconnecting two or more digital networks, catering for increasing growth in data transmission, providing links for coded video signals and interconnecting digital telephone exchanges.

Existing analogue frequency division multiplexed (FDM) frequency modulated radio systems can feasibly be modified to accept a digital bitstream on one or several of the RF bearers. This can be done by disconnecting the FDM equipment and connecting a digital modem utilising either binary or multi-level frequency shift keyed (FSK) modulation. However, there may be problems in the design of such a system arising from the co-existence of analogue and digital radio transmission in adjacent RF channels along the same route. This necessitates care in the shaping of the spectrum of the digital signal to avoid excessive interference with the analogue signals.

To this end, the Laboratories are carrying out spectral and interference studies of digital signals. These studies take the form of computer calculations of the power spectrum for various types of baseband coding techniques and premodulation filter shapes.

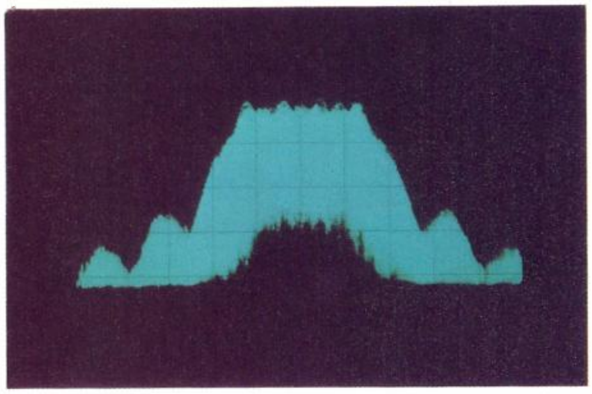
Other studies are directed to the specification of the design parameters of a digital modem, compatible with existing Australian radio relay bearers, for both FSK and phase shift keyed (PSK) systems.



MEASUREMENT OF THE TRANSMITTED SIGNAL SPECTRUM IN A DIGITAL RADIO SYSTEM

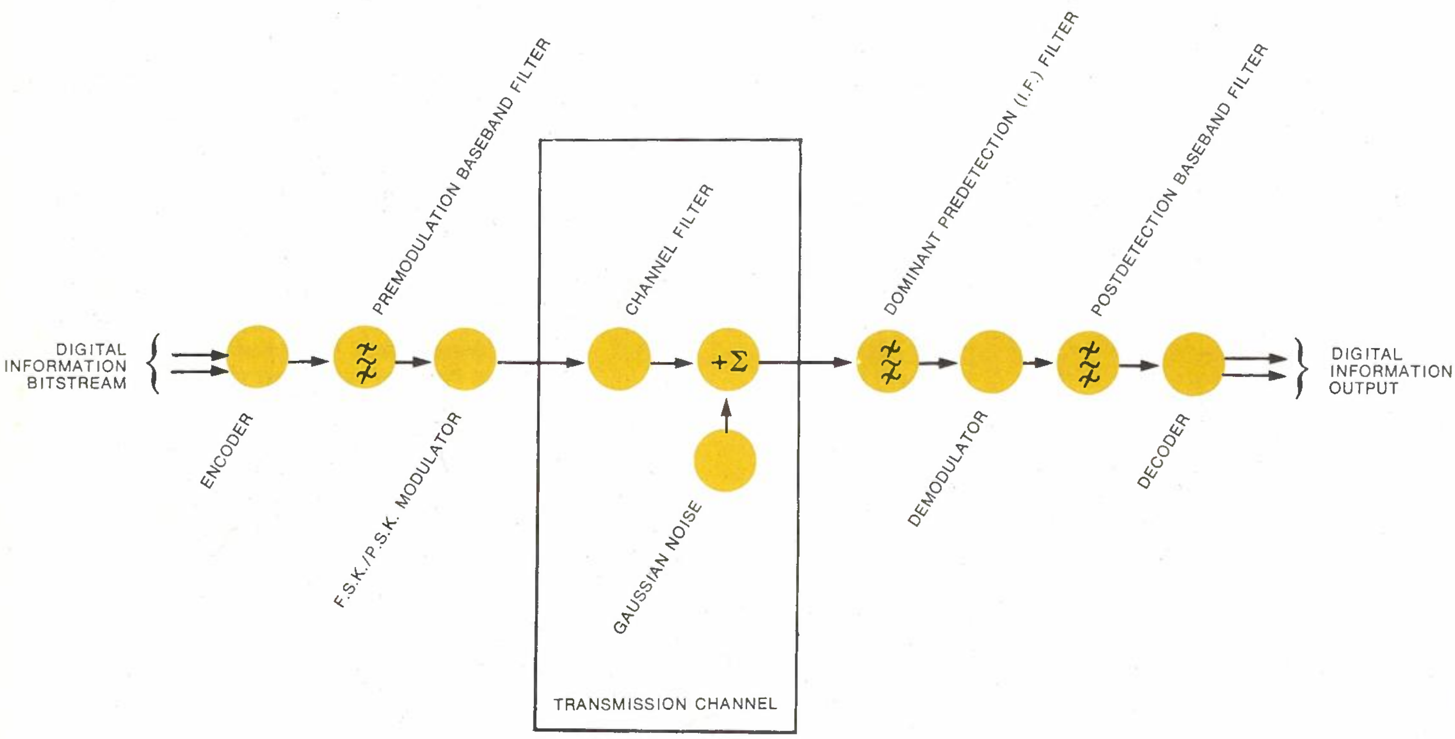
Hardware simulation entails considerable disadvantages regarding cost and delay in implementation if important parameters have to be made variable, for example, bit rate, base-band and channel filter types, and frequency or phase deviation constants. Because of this, system simulations are performed on a digital computer and the hardware experimental models are used only to verify performance for a few selected operating conditions.

In addition to these studies, plans are being made for the establishment of a radio test route on which radio systems experiments can be performed and commercial systems evaluated. In particular, evaluation of 11 GHz systems for the Australian network is envisaged.



C.R.O. DISPLAY OF THE SPECTRUM ▶

A DIGITAL RADIO TRANSMISSION SYSTEM ▼



INVESTIGATIONS OF INTEGRATED SWITCHING AND TRANSMISSION (IST) SYSTEMS

MODEL IST EXCHANGE AND PCM TRANSMISSION EQUIPMENT

Digital Tandem Exchange

The Laboratories have developed a stored program controlled digital telephone exchange, a working model of which was displayed during the Laboratories' Golden Jubilee OPEN DAYS. A larger version of this model is being installed in the Windsor exchange to perform a tandem switching function for traffic from the Clayton, Gardenvale and South Oakleigh terminal telephone exchanges.

The exchange will connect together junctions which use a digital coding technique known as Pulse Code Modulation (PCM) and Time Division Multiplexing (TDM), with the information remaining in a digital form throughout.

The stored program control is provided by a pair of processors (real-time digital computers) working in a load sharing mode. Security against failure of the exchange due to a processor or program fault is provided, as one processor will be capable of carrying the entire exchange load.

The experimental exchange is being installed during 1974 and will be used to test the concepts of digital switching, stored program control and exchange security in a central processor exchange.

Remote Controlled Subscribers Switching Stage

The principles used in the tandem exchange are being expanded into the subscriber traffic area by developing a remotely controlled subscribers line concentrator stage. Depending on the subscribers' originating and terminating traffic rates, a full-scale concentrator would provide for up to 2000 subscribers with 120 junctions to the parent exchange. The concentrator will be remotely controlled by the processors in the parent IST exchange, with all switching, equipment selection, numbering analysis and signalling control being done by them. A data link will be provided to enable the processors to receive information about the concentrator and its subscribers, and to send commands to the concentrator.

The first concentrator will employ metallic crosspoints and be designed for telephony service only. It will be located in the Laboratories' new buildings at Clayton and be connected to the PCM tandem exchange at Windsor over standard 32-channel PCM systems. These systems will provide both the voice circuits needed between the concentrator and its parent, and the data links needed for remote control of the concentrator by the parent exchange at Windsor. The concentrator will also have direct analogue circuits to a conventional crossbar and a step-by-step exchange.

While this development is proceeding, investigations will be conducted into the feasibility of a digital concentrator for a wide variety of subscribers' services. Accordingly, the initial concentrator development will focus attention on a number of system aspects and not attempt to optimise other aspects. These will be explored more fully with the digital version.

The concentrator project is aiming at a field experiment in the second quarter of 1975, and will pay particular attention to signalling for remote control, trunking arrangements (direct circuits and local switching) and security.

Cost Optimisation of IST Systems

During the last decade, a dramatic reduction in the cost of digital integrated circuits has taken place. As a result, many manufacturing organisations and administrations are now pursuing the development of digital switching machines for telephony networks. The drop in component costs has three aspects of particular interest to the designer of digital switching machines:

- a very rapid fall in cost *per package* due to increasing scale of manufacture up to 1971, with a levelling off since then;
- a steady and continuing decline in *per function* costs due to progressively higher levels of integration, that is, more functions per package;
- a progressive increase in logic *speed*, allowing the designer to seek still further economies from time division.

These trends, together with the reducing cost of processor control equipment, have presented the systems designer with a range of building blocks and techniques sufficient to design digital switching machines that have potential for cost advantages over existing alternatives. However, a considerable amount of investigation is needed to optimise their design and to determine the role they should fulfil and the network structures which best suit their use. For this reason, a number of studies have been commenced within the Laboratories.

One study involves the comparative evaluation of different switchblock configurations. Digital switching machines may use various combinations of space or time switching stages; time switching is only possible if the switching element has capacity to store a coded speech sample between differing timeslots. The IST experimental exchange uses, for example, a space-time-space switchblock. The relative costs of space and time switching elements will continue to change with developments in integrated circuit and memory technology.

Cost optimisation studies of the present IST switchblock design, with respect to further exploitation of current technology, are also being undertaken in the Laboratories.

Studies are also being made of other cost factors directly influenced by switchblock design, such as the use of building space, power consumption and environmental requirements. Digital switchblocks are considerably more compact than conventional exchanges. Power consumption has tended to be high, although a satisfactory reduction in comparison with crossbar equipment is now possible with the use of new low-power digital logic components.

As with switching equipment, but to a somewhat lesser extent, the line transmission field is experiencing a steady decrease in digital (PCM) transmission costs relative to those of analogue methods using voice-frequency cable pairs. While analogue costs are roughly proportional to distance, PCM costs are dominated by the fixed cost of terminals at each end of a route. In a mixed analogue/digital network, terminal costs are reduced by deletion of terminals at the digital exchanges. Such a network is likely to differ substantially from existing networks and may require differing functions to be carried out by the switching machines. Studies are therefore in progress to establish the relative roles of nodal (parent) exchanges and concentrators in an optimised "pure" IST metropolitan network, and the preferred structure and traffic routing in a local network comprising a parent exchange and dependent concentrators. These studies use computer models of possible networks and are supported by a number of subsidiary investigations of likely network cost components.

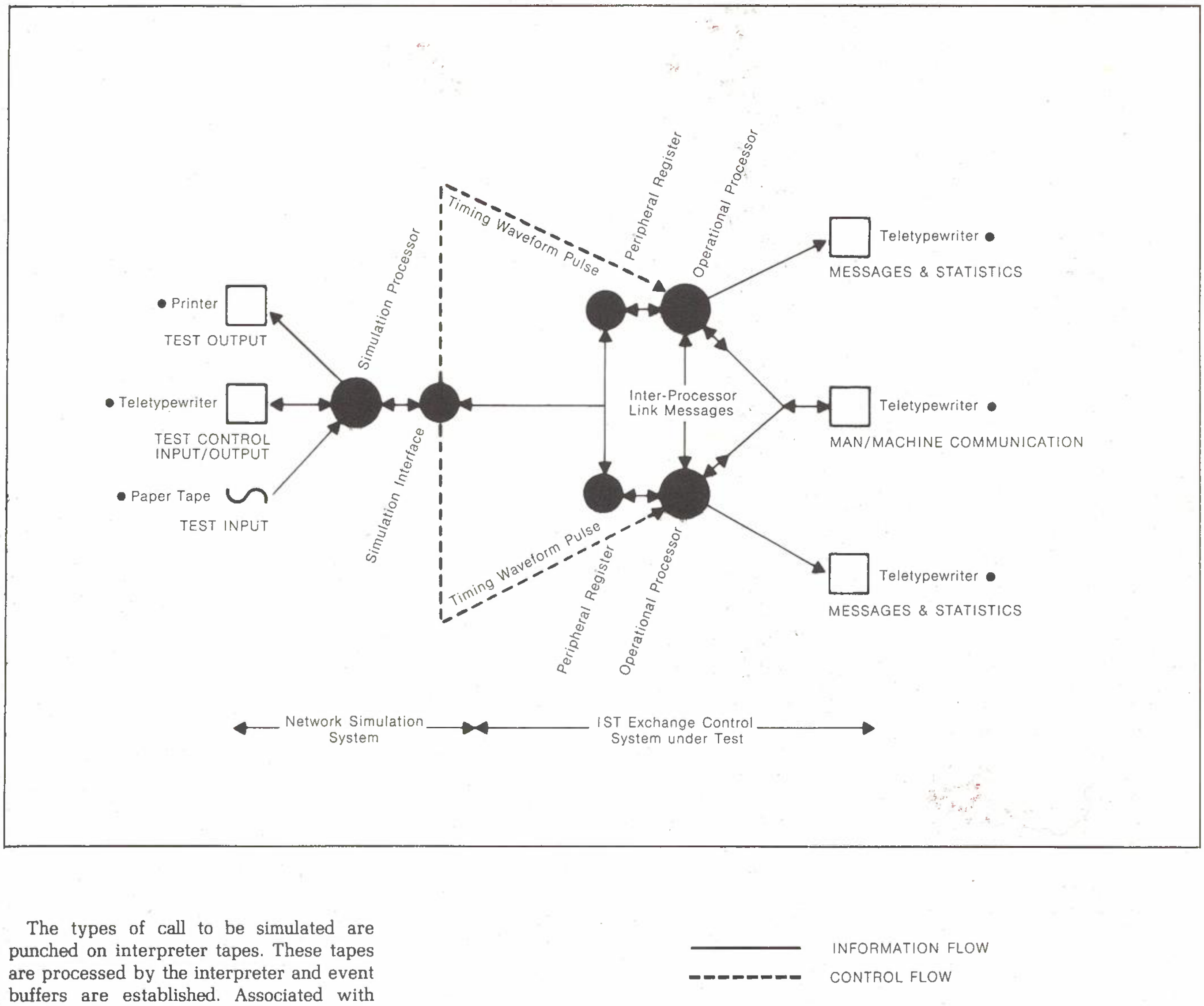
Simulation Testing of the IST System Software

The experimental IST tandem telephone exchange being developed by the Laboratories is controlled by two ITT 1600 processors working in a duplex, load-sharing mode. Because of the complexity of the processors and their software control system, it has proved essential to perform extensive testing before attempting to control the actual exchange. Ideally, the testing system used should not only completely simulate the processors' real environment, but also have facilities for detecting and tracing errors in the control programs. The development of such a simulation system is a major task, which is nearly as difficult as the task of developing the operational system to be tested.

Simulation of the IST exchange and telephone network is provided by a third ITT 1600 processor and an additional control interface as shown in the diagram. The interface allows the simulation processor to intercept drive and scan instructions from the system under test. The simulation system then returns the appropriate response, while maintaining a sense of real-time in the operational system by controlling the timing waveform pulse which drives the operational processors.

The simulation software consists of a number of distinct program groups as follows: control monitor, interpreter, update and action handling. The control monitor provides facilities for system initialisation and start up. When the system is running, it handles monitor and interrupt facilities. Should system investigation be necessary or table or event buffer interrogation be required, the control monitor provides access.

NETWORK SIMULATION TESTING SYSTEM

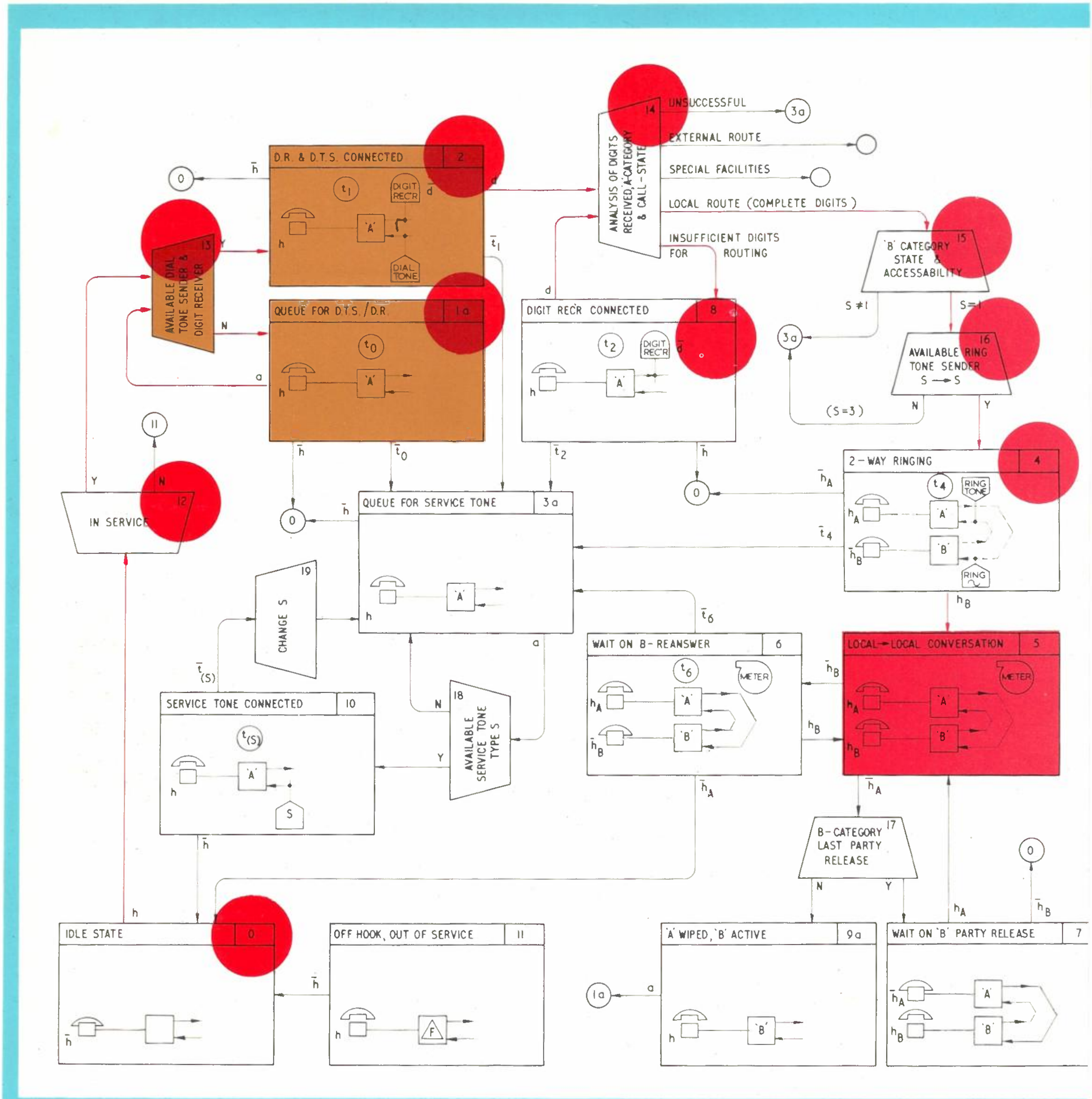


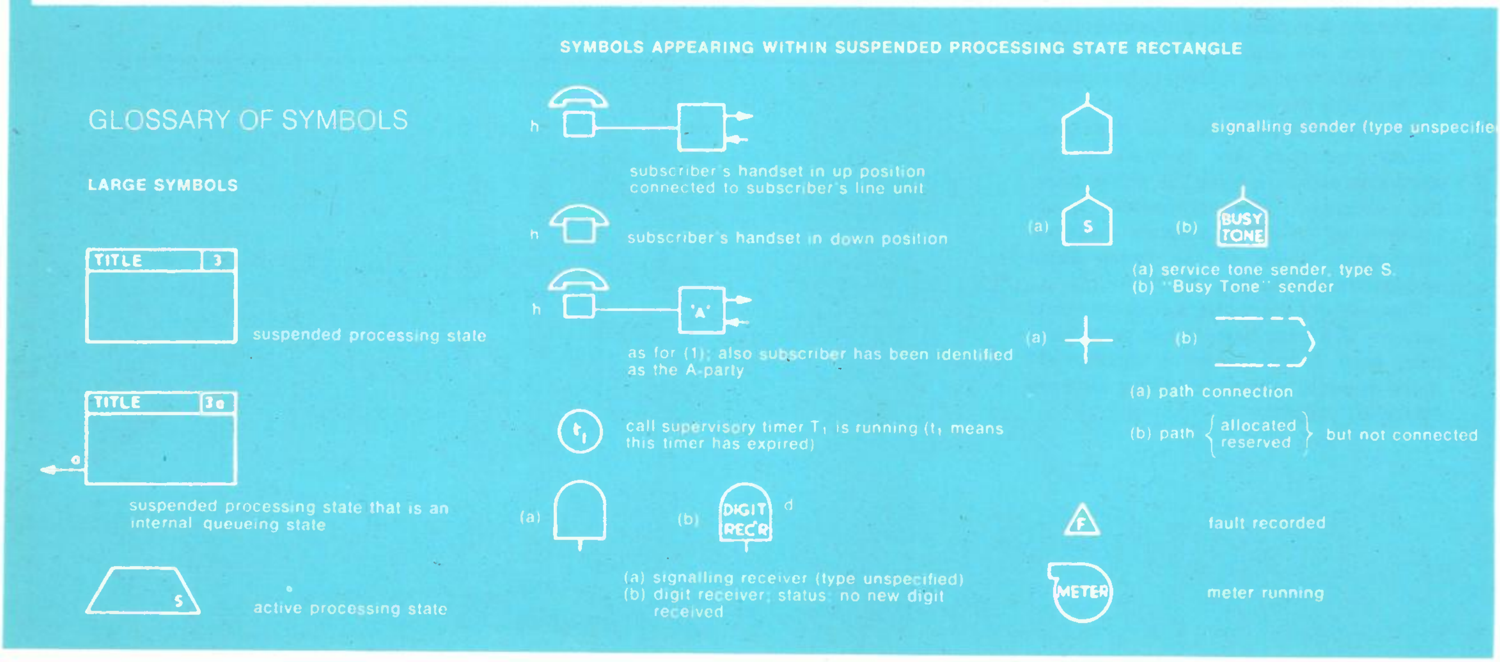
The types of call to be simulated are punched on interpreter tapes. These tapes are processed by the interpreter and event buffers are established. Associated with each event is a timing field. Periodic interrupts from the simulation interface cause timing fields in event buffers to be updated by the update programs.

The instructions issued by the operational processors are analysed by the simulation software using the action selection program. The appropriate action program is called to generate response information, based on the timing fields within the event buffers.

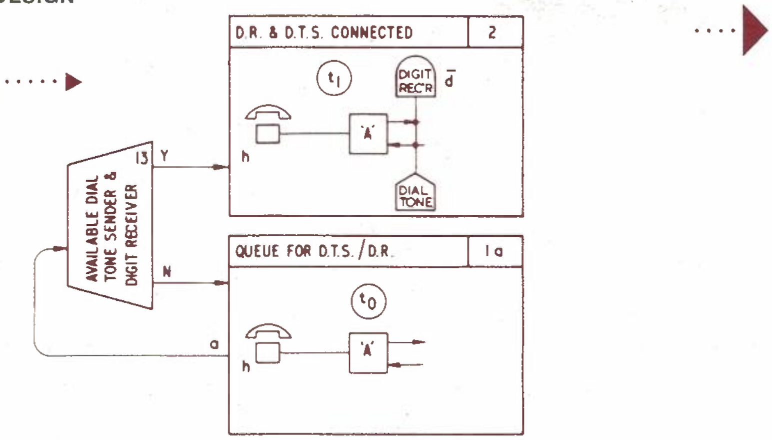
The network simulation testing system is only one of a large range of test procedures being used. It has proved an effective aid to the dynamic testing of real-time software for the IST project.

EXCERPT FROM A CALL-STATE TRANSITION DIAGRAM FOR A PROCESSOR CONTROLLED TELEPHONE EXCHANGE



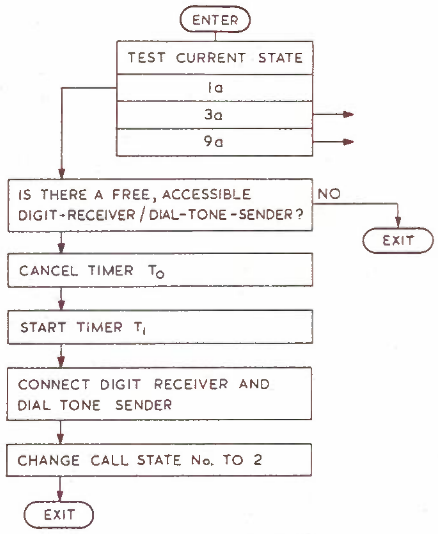


USE IN DESIGN



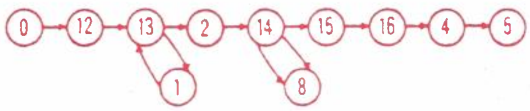
A SUBGRAPH FROM THE CALL-STATE TRANSITION DIAGRAM

MACHINE-INDEPENDENT FLOW CHART SPECIFICATION



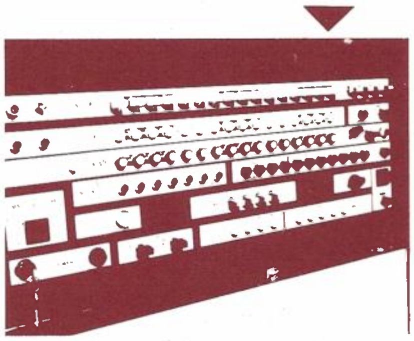
VIEW IN ANALYSIS

SUBGRAPH SHOWING THE PERMITTED PATHS FROM THE IDLE STATE TO THE CONVERSATION STATE



$$P_{0,5} = \frac{P_{0,12}\ P_{12,13}\ P_{13,2}\ P_{2,14}\ P_{14,15}\ P_{15,16}\ P_{16,4}\ P_{4,5}}{(1-P_{13,1}\ P_{1,13})\ \ (1-P_{14,8}\ P_{8,14})}$$

= PROBABILITY OF REACHING STATE 5 FROM STATE 0



A PROCESSOR

Call-State Transition Diagrams

Call-State Transition Diagrams have been developed in the Laboratories as a new technique of specifying, designing, testing and analysing computer-controlled telephone exchanges. It is hoped that these diagrams will become as versatile a design tool for telephone exchanges in the future as electrical circuit diagrams have been for conventional electrical networks of the past.

A Call-State Transition Diagram is based upon the two kinds of processing states, *suspended* and *active*, that occur in the control of a telephone call. The *suspended* processing states, represented by large rectangles, define the states and interconnection of network elements at a particular stage in the call. When an appropriate signal informs the processor that it should change the state of a call, the processor proceeds via *active* processing states, represented by trapeziums, to the next suspended processing state. In proceeding from one suspended processing state to another, the diagram specifies what decisions the central processor must make in connecting and disconnecting network elements, and in performing any other essential call-handling tasks. In building a telephone exchange, all the information in the diagram can be methodically translated by programmers into logic patterns stored in the central processors of the telephone exchange. The diagram can then be used to test whether the system is controlling telephone calls in the way originally intended.

The diagram also has mathematical properties that enable it to be used in analysis. The probability of call failure is a prime indication of system performance. The diagram takes into account virtually every mechanism of call-failure, and can be used as a convenient analytical framework on which to calculate the total probability of call failure.

The diagrams have attracted international interest, and are currently being studied by an expert sub-committee within the International Telecommunication Union.

DIGITAL RECEIVER COMPARED WITH CONVENTIONAL COMPONENTS NEEDED FOR EIGHT BAND-PASS FILTERS

Receiver for Digitally Coded Tones

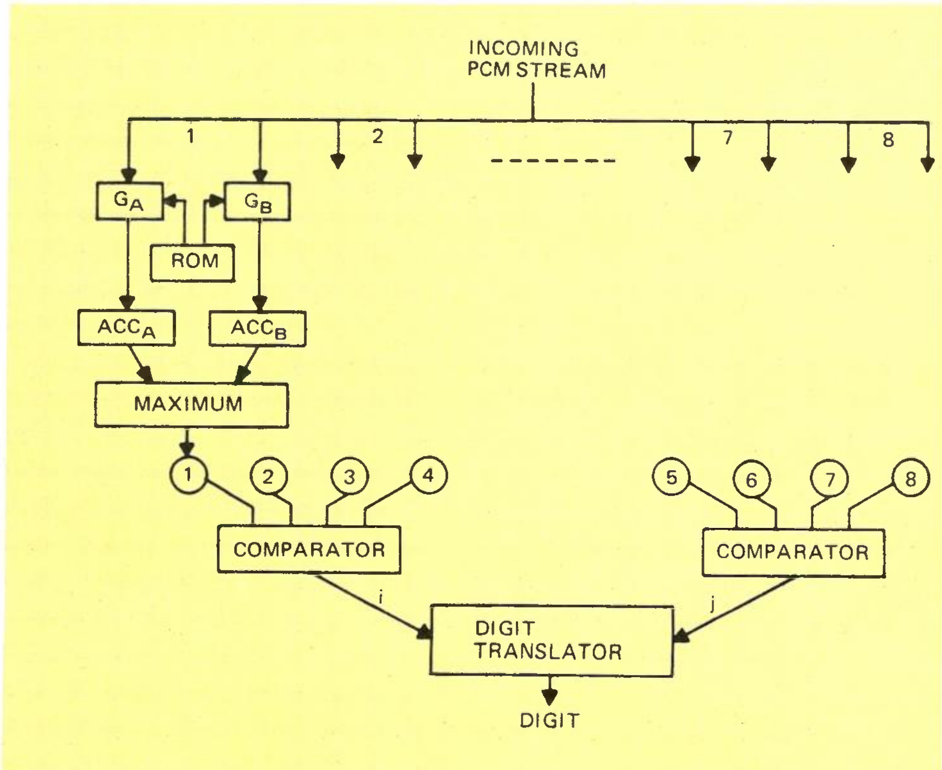
In the event of digital switching and transmission being introduced into the Australian telecommunications network, there will be a period of several decades in which the new processor-controlled time-division exchanges will have to interwork with the existing crossbar and step-by-step exchanges, and with a variety of subscribers' instruments. A processor-controlled exchange is more versatile than a conventional exchange, and can communicate with a crossbar exchange using the same multifrequency code tones that two crossbar exchanges use in communicating together. By simulating the signalling patterns of existing exchanges, a processor-controlled digital exchange can be introduced into the network without the necessity of modifications to the existing exchanges.

The receiver for digitally coded tones (RDCT) is a device capable of detecting multifrequency code signalling tones that have been digitally encoded onto a pulse code modulation (PCM) bit stream, such as may be used in an Integrated Switching and Transmission (IST) network. In a digital telephone network employing processor-controlled exchanges, such inter-exchange signalling tone pairs must be recognised, captured and decoded and the decoded information presented to the processor that controls the operation of the exchange. A conventional approach is to convert the signals back to their analogue form so that the tone pairs may be separated and detected by conventional filtering methods. A wholly digital detection scheme, such as that used in the RDCT, offers potential advantages including reduced cost, size, and power consumption, and compatibility with the rest of the equipment employed in a digital exchange.

Mathematical studies performed within the Laboratories have led to the development of a simple algorithm suitable for a digital detection scheme. Using computer simulation, the resulting mathematical model was comprehensively tested for its efficiency as a digital detector required to meet both multifrequency code (MFC) and voice frequency push-button (VFPB) signalling specifications. Because of its inherent simplicity, a hardware VFPB receiver was designed and built first. The successful completion of tests on this model led to a revised design suitable for multifrequency code.

The detection scheme is to establish the correlation between the incoming bit pattern and the expected bit patterns of specific tones that are stored in memories on the circuit card. This is illustrated in the diagram. When a particular correlation gate shows that an expected bit is present in the data stream, an associated accumulator has its contents incremented. There are as many accumulators as there are tones to be detected. After a certain number of bits have been processed in this way, the contents of the accumulators are compared with a threshold that is to be established by statistical investigation. Accumulators whose contents exceed the appropriate threshold indicate the presence of a signalling tone. Additional logic circuitry performs error checks and encodes the outputs of the accumulators into a format acceptable to the control processor.

Construction of the RDCT is well advanced and documentation of a receiver suitable for inclusion in the IST Switch is being prepared.



FUNCTIONAL DIAGRAM OF THE RECEIVER FOR DIGITALLY CODED TONES

NEW COMMUNICATIONS SYSTEMS

SUN-TRACKING 11 AND 14 GHz RADIOMETER AT DARWIN

Satellite Communications

Communications satellites providing international telephony and television relays are now well established and familiar to all. More recently, considerable interest has been shown by a number of countries in the use of satellites for internal communications. Australia, with its vast distances and remote regions, is one of these. Over the past three years, a "Satellite Task Group" has been examining the technical and economic aspects of such a system. The Task Group consists of eight engineers, four from the Research Laboratories and four from the Planning and Programming Sub-Division of the A.P.O.

An Australian national satellite system is seen as complementing the existing terrestrial network by providing additional blocks of trunk circuits for telephony, television and data between capital cities or major regional centres, and smaller numbers of circuits to smaller, and often remote, communities. Beyond this, a satellite system could provide services not always feasible by other means, for example, automatic telephony and television programmes to individual homesteads anywhere in the Australian outback.

Many aspects of possible systems are currently being studied by the Task Group. These include network configurations, spacecraft types, earth station characteristics, traffic requirements for various types of service and transmission performance objectives. During 1973, industry provided consultant services on spacecraft and earth-station systems as part of the first phase, a techno-economic feasibility study. This was finished early in 1974. The next phase planned is a system-definition study, aimed, subject to Government approval, at establishing a national satellite system in about 1978.

Task Group studies are shared between Planning and Research members. One current Research Laboratories' contribution is the study, using solar radiometers, of tropical rain attenuation in the 11-14 GHz frequency bands. These bands offer some advantage to an Australian system over the commonly used 4-6 GHz bands. However, they carry a significant penalty in terms of additional system margin to overcome the extra rain attenuation. The investigations to determine attenuation characteristics above 10 GHz in wet tropical areas are yielding results which form an important contribution to the satellite system studies.

The Review of Activities for 1972/73 described the solar radiometer experiments being made near Innisfail, Queensland. The first year's investigations have been described in a number of reports. A second radiometer system, again designed and constructed in the Laboratories, was installed in Darwin in December, 1973. It is a dual frequency unit and, like the Innisfail radiometer, will operate through 1974 to provide more comprehensive attenuation characteristics.

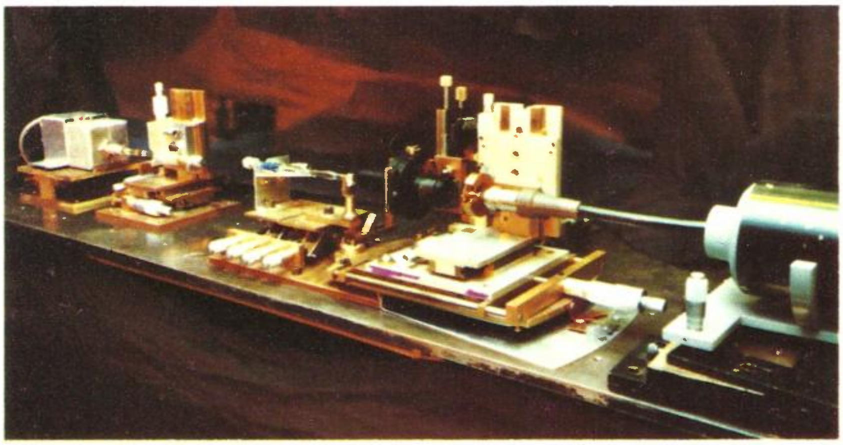
Optical Fibre Transmission Characteristics

Over the past two years, there has been a world-wide renewal of interest in optical fibres and their possible application in telecommunications networks. This has been stimulated in part by the invention of low-loss liquid-filled fibres and the more recent attainment of lower loss glasses for use in solid fibres. The C.S.I.R.O. Division of Tribophysics was one of the first laboratories in the world to develop low loss multi-mode liquid-filled fibres, and, as reported in previous reviews, the Research Laboratories are carrying out a programme of measurement of the transmission characteristics of these fibres.

Previously, the Laboratories measured the attenuation characteristics of fibres filled with different liquids, showing that losses as low as 7 dB/km could be obtained over some portions of the infra-red spectrum. More recently, the measurement of fibre bandwidth has been made by observing the dispersion of a fast risetime pulse over lengths of fibre. The dispersion, and therefore the bandwidth, is a function of length, diameter of the core, difference in refractive index between core and cladding, and cladding loss. It has been demonstrated both theoretically and experimentally that the bandwidth, for a given set of fibre parameters, tends to a constant value when the fibre length exceeds about 500 m. For the C.S.I.R.O. liquid-filled fibres, this bandwidth is of the order of 10 MHz.

Multi-mode liquid-filled fibres, when used with inexpensive light-emitting diodes as the source of optical power, appear to offer an economic means of transmitting broadband analogue signals, for example TV signals, over distances of a few kilometres. Such a combination could therefore form the basis of a network for the distribution of, for example, commercial and educational television, video telephone signals and data to, from and between subscribers. Investigations are continuing into the requirements for this type of network.

TEST RIG FOR BANDWIDTH MEASUREMENTS ON OPTICAL FIBRES USING FAST RISETIME PULSES



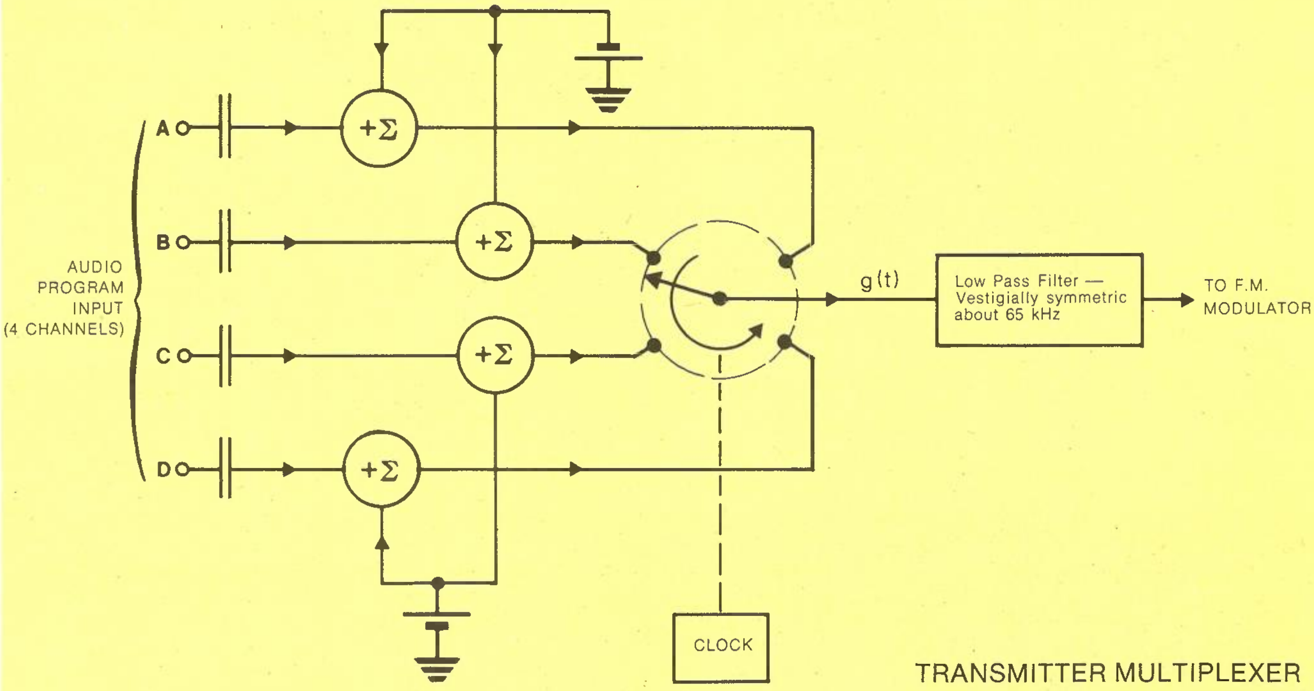
F.M. Broadcasting System Studies

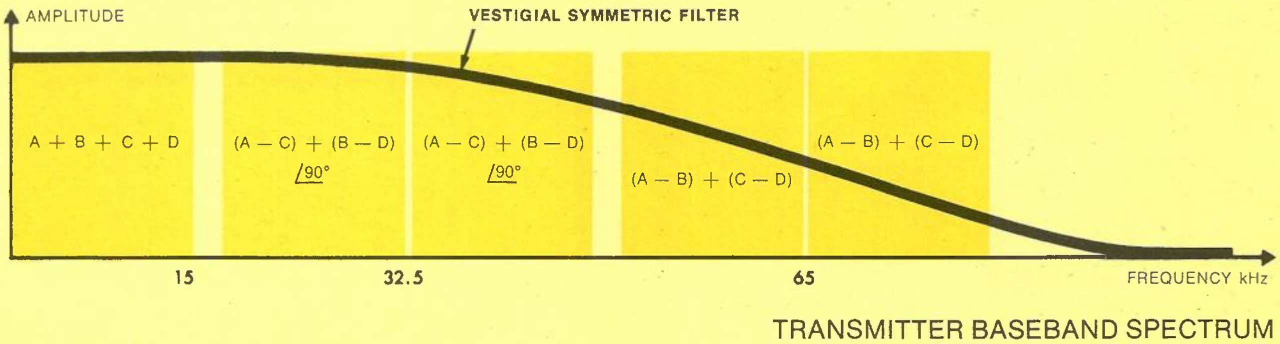
A modulation method suitable for F.M. broadcasting in the V.H.F. and U.H.F. bands has been developed in the Laboratories. The method is suitable for application in a broadcast system transmitting multiple channel (stereophonic, quadraphonic) or monaural program material.

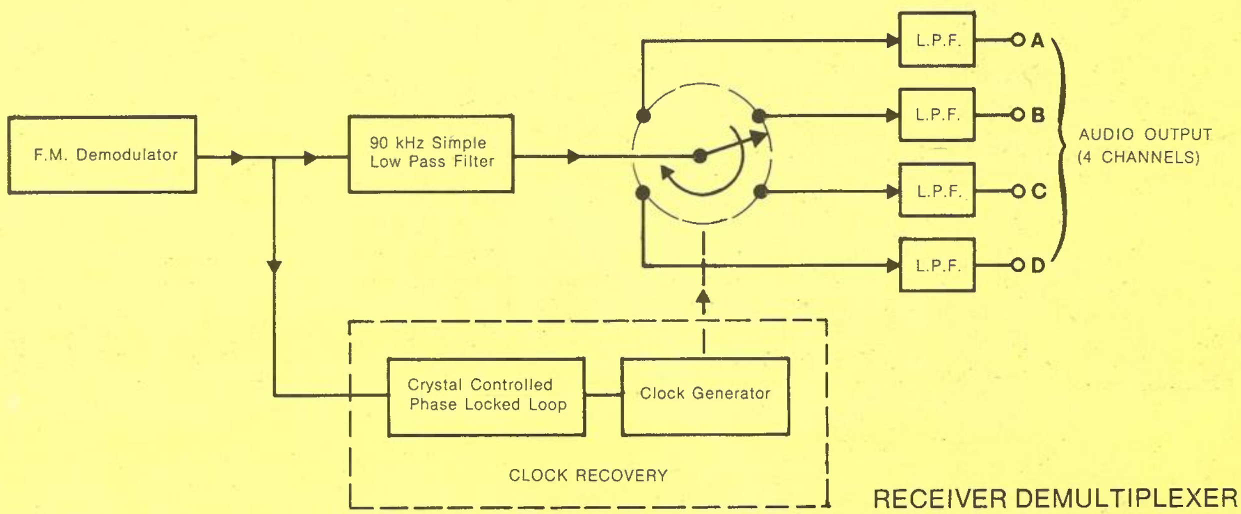
When multiple channel broadcasting is used, the audio inputs are multiplexed using a time division multiplexed switching process. A synchronising or "clock" signal is added and the resultant pulses are passed through a filter with a vestigial symmetric property. The output of this filter is a composite baseband signal derived from the input program channels. The spectrum of the baseband signal for the case of four quadraphonic program channels A, B, C and D is shown in the diagram. This signal frequency modulates the transmitted carrier.

Various receiver configurations can be used to demodulate the transmitted information, depending on the number of desired output channels and, of course, total receiver cost. The simplest solution is a conventional F.M. receiver with no additional circuitry. Its detector output is the monaural signal (A + B + C + D)/4. This would be used for the inexpensive portable receiver. When high fidelity audio reproduction of the broadcast program is required, the output of a receiver similar to that described above can be connected to high quality monaural domestic sound equipment. When stereo or quadraphonic reception is desired, a switched demultiplexer is incorporated after the receiver frequency demodulator. This demultiplexer separates the demodulated signal into two or four audio channels, as required, and is driven by a clock signal which is recovered from the received signal. The output of the demultiplexer is correspondingly connected to stereo or quadraphonic audio equipment. The two recovered stereo signals are (A + B)/2 and (C + D)/2. In the case of quadraphonic demultiplexing, the outputs are A, B, C and D.

A feature of this method is that the achievable system performance is equal to that of the international standard reference monaural F.M. system. This is attained in the modulation method described above by selecting a suitably wide frequency deviation at the transmitter modulator, together with some increase in transmitter power compared with that of the single channel case.


A
B
C
D
AUDIO PROGRAM INPUT (4 CHANNELS)
+Σ
g(t)
Low Pass Filter — Vestigially symmetric about 65 kHz
TO F.M. MODULATOR
CLOCK
TRANSMITTER MULTIPLEXER


AMPLITUDE
VESTIGIAL SYMMETRIC FILTER
A + B + C + D
(A — C) + (B — D) /90°
(A — C) + (B — D) /90°
(A — B) + (C — D)
(A — B) + (C — D)
15
32.5
65
FREQUENCY kHz
TRANSMITTER BASEBAND SPECTRUM

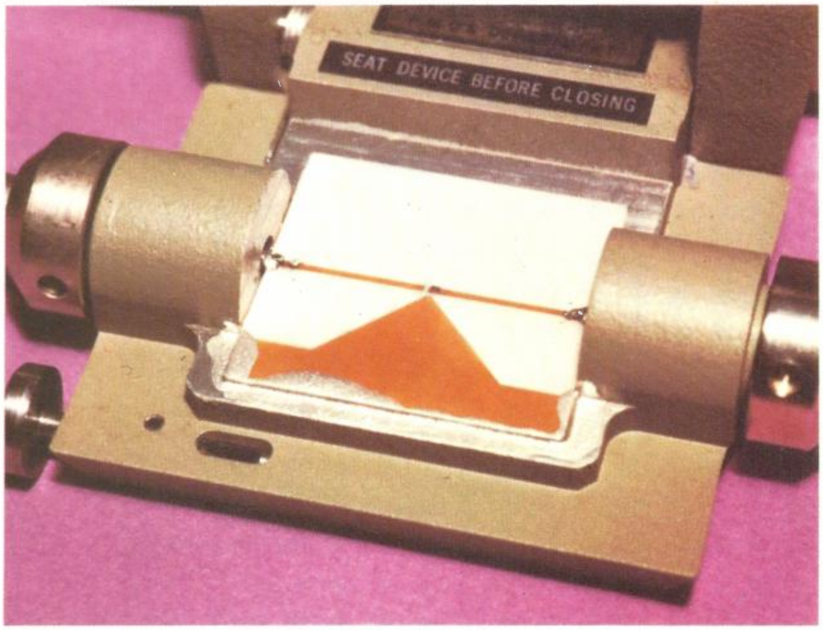

F.M. Demodulator
90 kHz Simple Low Pass Filter
L.P.F.
A
B
C
D
AUDIO OUTPUT (4 CHANNELS)
Crystal Controlled Phase Locked Loop
Clock Generator
CLOCK RECOVERY
RECEIVER DEMULTIPLEXER

DEVICES AND TECHNIQUES

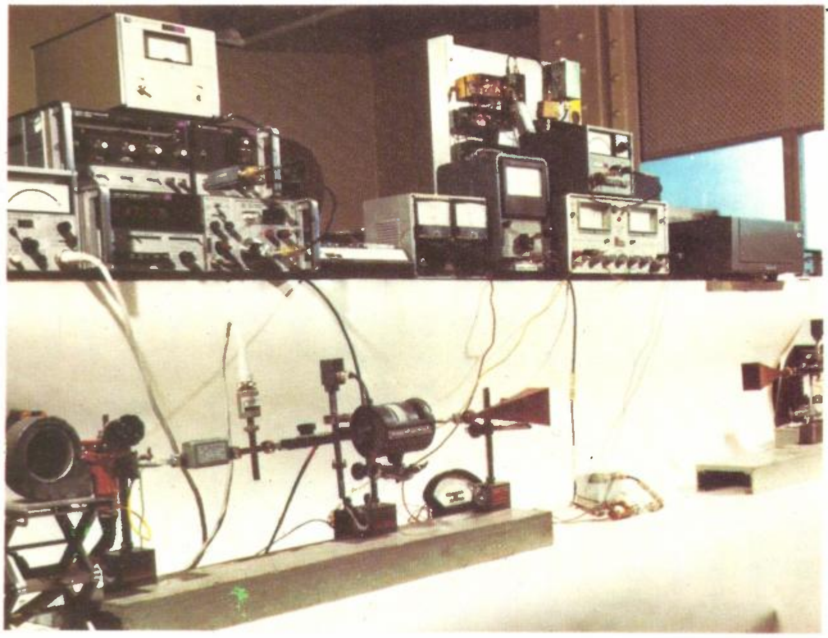
Microwave and Millimetre-Wave Circuits and Devices

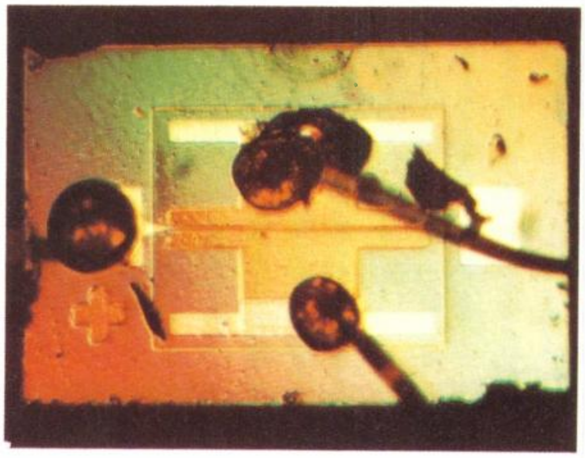
In a continuing trend for microwave systems to be built from a series of sub-system modules, each providing several circuit functions, microstrip has emerged as the major contending medium of hybrid integration. In the manufacture of hybrid microstrip circuits, passive circuit elements are first defined on a thin ceramic substrate (for example, alumina) by thin film techniques. This is followed by the individual insertion of active devices, in chip or packaged form, into the circuit. The advantages of such an approach are solid-state reliability and lifetime, cost-effectiveness, repeatability and miniaturisation. A further technical advantage of using devices in chip form is the reduction of parasitic package reactance.

The design accuracy of these passive configurations has been limited in the past by a distinct lack of theoretical data. In addition, the design procedures for assemblies, such as parametric amplifiers, transistor amplifiers, mixers, filters and couplers, have been confined to a laborious iterative routine of cut-and-try. To overcome these problems, a representative variety of commonly occurring discon-



◀ FIELD EFFECT TRANSISTOR BEING TESTED IN A MICROSTRIP ENVIRONMENT





FIELD EFFECT TRANSISTOR THROUGH MICROSCOPE

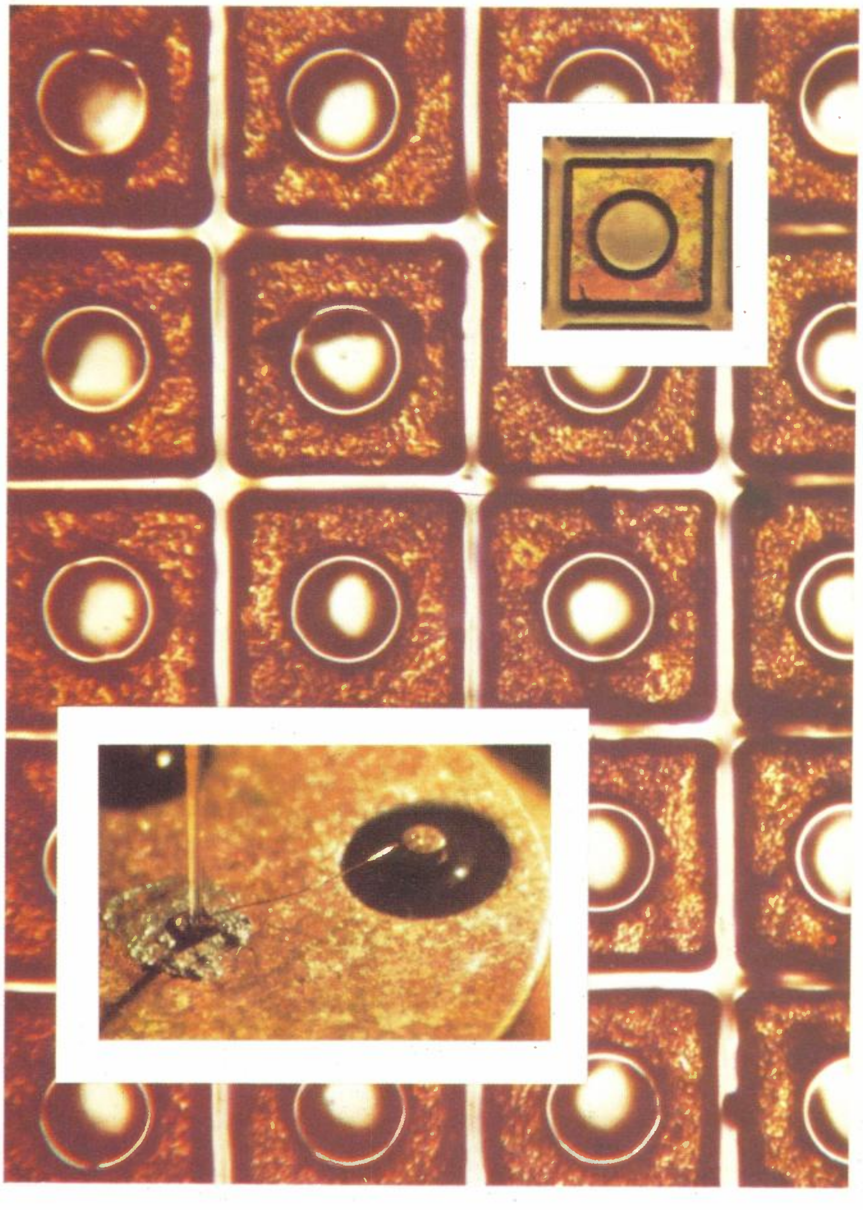
SYSTEM FOR MEASURING PROPAGATION PHENOMENA AT 36 GHz tinuities, such as bends, impedance-steps, "T" junctions and open-circuits in equivalent circuit forms compatible with conventional microstrip design has been investigated. This has yielded theoretical data more accurate than previously available. Other investigations have been made of the coupling and attenuation encountered by coupled sections of lines. Experimental validation of the theories evolved was then instrumented in a dual programme: measurement of isolated discontinuities, and a sensitivity evaluation of circuits involving a complex of interacting discontinuities, as would normally occur in practice.

Precision processing equipment and techniques have been established for the fabrication of prototype circuits required in a number of microwave projects in the Laboratories. Techniques have been developed for high resolution photolithographic circuit delineation in thin gold films on alumina substrates.

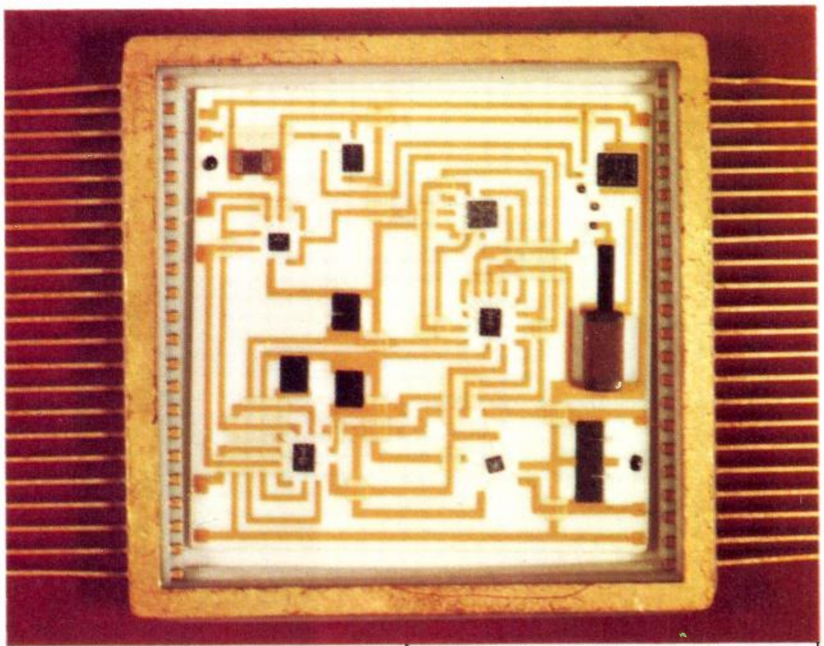
One of the practical problems experienced in the use of these circuits has been the poor adhesion between the vacuum evaporated gold-chromium and dielectric substrate. To counter this, a new electroless deposition technique was developed within the Laboratories. This provides a substantial increase in adhesion, with a slight increase in surface roughness. The technique includes a flux treatment at elevated temperatures before the pre-treatment and subsequent copper reduction on the alumina substrate. Gold is then electroplated on to the thin copper layer, to a prescribed thickness. Compared with an untreated surface of the same grade, surface roughness approximately doubles for both smooth and lower grade surfaces. The increase in adhesion is almost five-fold: an average of 75 N/cm^2 was achieved with the standard method of chemical deposition, whilst an average of 370 N/cm^2 was attained with the improved technique.

The photographs illustrate the hybrid techniques involved. In one example, a simple microstrip test fixture has been fabricated to test the gain and noise performance of a field-effect transistor chip at 4 GHz in a microstrip environment. This is part of a project directed towards attaining low-noise transistor amplifiers for possible use in front ends at microwave frequencies. The other example shows a propagation measuring system, designed to investigate propagation phenomena at 36 GHz. This is in service, and incorporates some sub-system design in microstrip.

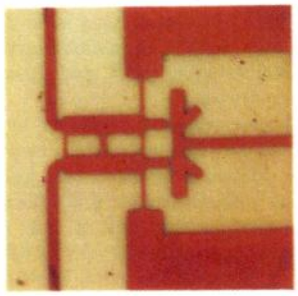
LIGHT EMITTING DIODES AT SEVERAL STAGES OF PRODUCTION



BACKGROUND: AN ARRAY OF L.E.D. CHIPS — MAGNIFIED VIEW
UPPER INSET: ENLARGED VIEW OF SINGLE CHIP — ACTUAL SIZE 0.375 MM SQUARE
LOWER INSET: CHIP MOUNTED ON HEAT SINK WITH OPTICAL FIBRE COUPLING SECTION



A THICK FILM HYBRID PACKAGE



STRIPLINE CONFIGURATION FOR A 10 GHz BRANCH LINE COUPLER

Semiconductor Device Research

The increasing need for high capacity transmission systems provides continuing stimulus for the discovery and exploitation of new semiconductor device phenomena. Improved performance, higher reliability and lower costs are added incentives in the search for new materials and devices. Frequently, however, state-of-the-art devices are not available to the Research Laboratories for early prototype systems evaluation, or they are not optimized for the application proposed. To alleviate some of these supply problems, semiconductor epitaxial crystal growth and device processing facilities have been established in the Laboratories.

Most of the effort has been directed towards growing and fabricating gallium arsenide high radiance incoherent electroluminescent diodes for source applications in optic fibre communication systems. Gallium arsenide diode sources emit infrared radiation near the spectral absorption minimum of liquid core optic fibre guides and are readily modulated by current injection up to about 500 MHz. However, their output is of comparatively low intensity, and it is difficult to couple the output efficiently into optic fibres because of the isotropic radiation pattern. These disadvantages have been partially overcome by optimizing the material parameters and the device design.

A programme undertaken to prepare gallium arsenide with specified properties has resulted in the establishment of two processing techniques: liquid phase epitaxial growth and dopant diffusion. The initial gallium arsenide prepared by these techniques has been optimized for fast, efficient electroluminescent diodes.

Diodes designed for high output radiance are fabricated from these gallium arsenide wafers in a four mask process, yielding about two hundred diodes per wafer. After mounting, the radiance of these high intensity sources is 30 watt centimetre^{-2} steradian^{-1}. In comparison, the radiance of commercially available infrared diodes typically ranges from 0.01 to 0.26 watt centimetre^{-2} steradian^{-1}.

The epitaxial growth, diffusion and device processing facilities which have been developed are very versatile. They will be used later for preparing microwave devices and monolithic microwave integrated circuits.

Advanced Microcircuit and Printed Wiring Techniques

Thin and Thick Film Technologies

The increasing number of applications and popularity of thin and thick films arise from several advantages, such as miniaturisation, high frequency applications and reduced weight and cost in volume demand situations. The product of both technologies is a modular hybrid circuit in which active and passive devices are bonded into passive film circuits.

Thin film circuits are currently produced by initially coating ceramic substrates (for example, alumina) with a thin layer of gold, followed by a layer of photoresist which is exposed and developed to define the circuit pattern. The circuit is then gold-plated up to the required thickness, and remaining unwanted materials etched away. With this procedure, the circuit resolution achieved is typically of the order of 4 microns, and provides for a versatility in line and gap dimensions to meet the stringent demands of some microwave circuits, such as bias injection networks, filters and impedance matching networks. The range of line widths needed is illustrated in the photograph, which depicts the passive circuit configuration of a branch-line coupler operational at 10 GHz.

Thick film circuits are produced by screen printing a ceramic metallic paste on to a ceramic substrate (for example, alumina). The film is then fired, and the hybrid circuits completed by bonding-in the devices. The film itself can be conductive, resistive or dielectric, or a combination of these, depending on the requirements. At present, the finest screen meshes used are 128 wires per centimetre which limits line widths to about 125 microns, whilst a wide range of resistors can be produced to within the close tolerance of 0.1 per cent. Compared with thin film technology, the initial cost is marginally higher due to the setting up of the screen. However, lower recurrent costs add great attraction to this process for large quantities.

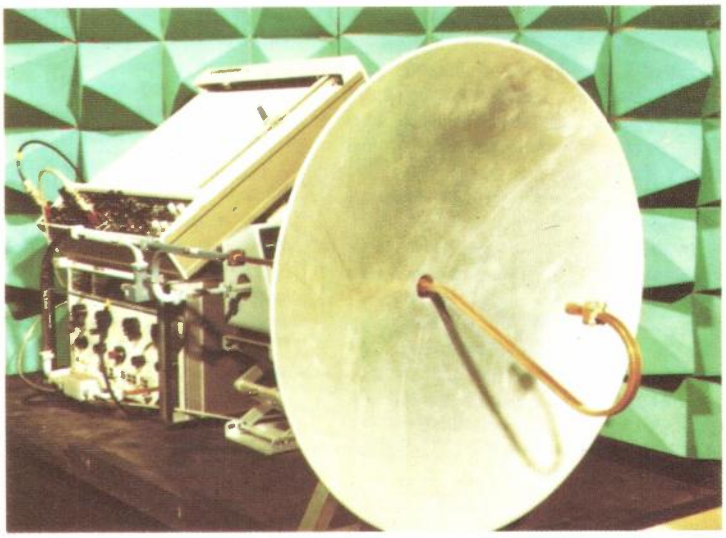
Widespread interest in thick film circuits has been shown throughout the Laboratories, particularly in association with the Integrated Switching and Transmission, Digital PCM Systems, and Coaxial Cable Link projects. Applications in the microwave field are at present fairly restricted by the resolution mentioned. However, the use of fine-grain pastes and photolithography could bring line width and gap tolerances down to 3 microns, thereby offering a flexible alternative to thin films in all microwave applications.

Printed Wiring Technology

Present capabilities are in prototype quantities of single and double-sided boards, with or without plated-through holes, and multilayer boards. Conventional etched foil and subtractive processing techniques are used. These have been developed to their practical limit of 0.25 mm conductor width and spacing, the limiting factor being the etching operation. To achieve greater packing densities, the "plate up", or additive process, by which unclad glass epoxy sheets are copper plated, is under investigation. This should permit conductor widths and spacings of 0.15 mm.

For cost reasons, the double sided plated-through-hole board is preferred to the multilayer board. In order to achieve ultra high packing densities, it is necessary to use fine line conductors and spacings, and route conductors between the integrated circuit pins. Nevertheless, where shielding is mandatory, multilayer boards are used.

ANTENNA MEASUREMENT IN A MICROWAVE ANECHOIC CHAMBER



Investigations into the Polarization Purity of Antennas

The use of two orthogonal polarizations in terrestrial and satellite microwave communication systems provides, in principle, a means of doubling the channel capacity of a radio communication system, because the two orthogonal polarizations can be used simultaneously on the same path and frequency. Alternatively, interference protection between adjacent systems may be achieved by polarization decoupling.

In such systems, the cross polarization distortion of the signal must be kept to a minimum. Cross polarization distortion is caused by the interference of a signal of one polarization with another signal which has polarization nominally orthogonal to it. This can be caused by several factors, such as the depolarization experienced by the radio waves along the propagation path, the departure of the direction of arrival of the received wave from the antenna axis due to various atmospheric conditions, the misalignment of the transmit and receive antennas and the polarization purity characteristics of the antennas used.

To identify and measure the various factors contributing to the polarization distortion of a radio communication system, it is essential to define the degree of polarization purity of its antenna system. To meet this requirement, an investigation into the development of a standard antenna with a calibrated polarization is being undertaken in the Laboratories.

The measurement and calibration of antenna polarization is conducted in a microwave anechoic chamber, where a controlled and reflection-free environment can be obtained.

To ensure minimum cross polarization distortion in high capacity radio communication systems utilizing two orthogonal polarizations, antenna systems possessing a high degree of polarization purity are required. For this reason, the above investigation will be extended to include the development of antenna systems having this property.

TECHNICAL STANDARDS AND MEASUREMENTS

ARRANGEMENT FOR PRECISION TIME COMPARISONS BETWEEN SYDNEY, CANBERRA AND MELBOURNE ▶

EQUIPMENT FOR PRECISION TIME COMPARISON USING TV SYNCHRONISING PULSES

Precision Time Comparison Using TV Synchronising Pulses

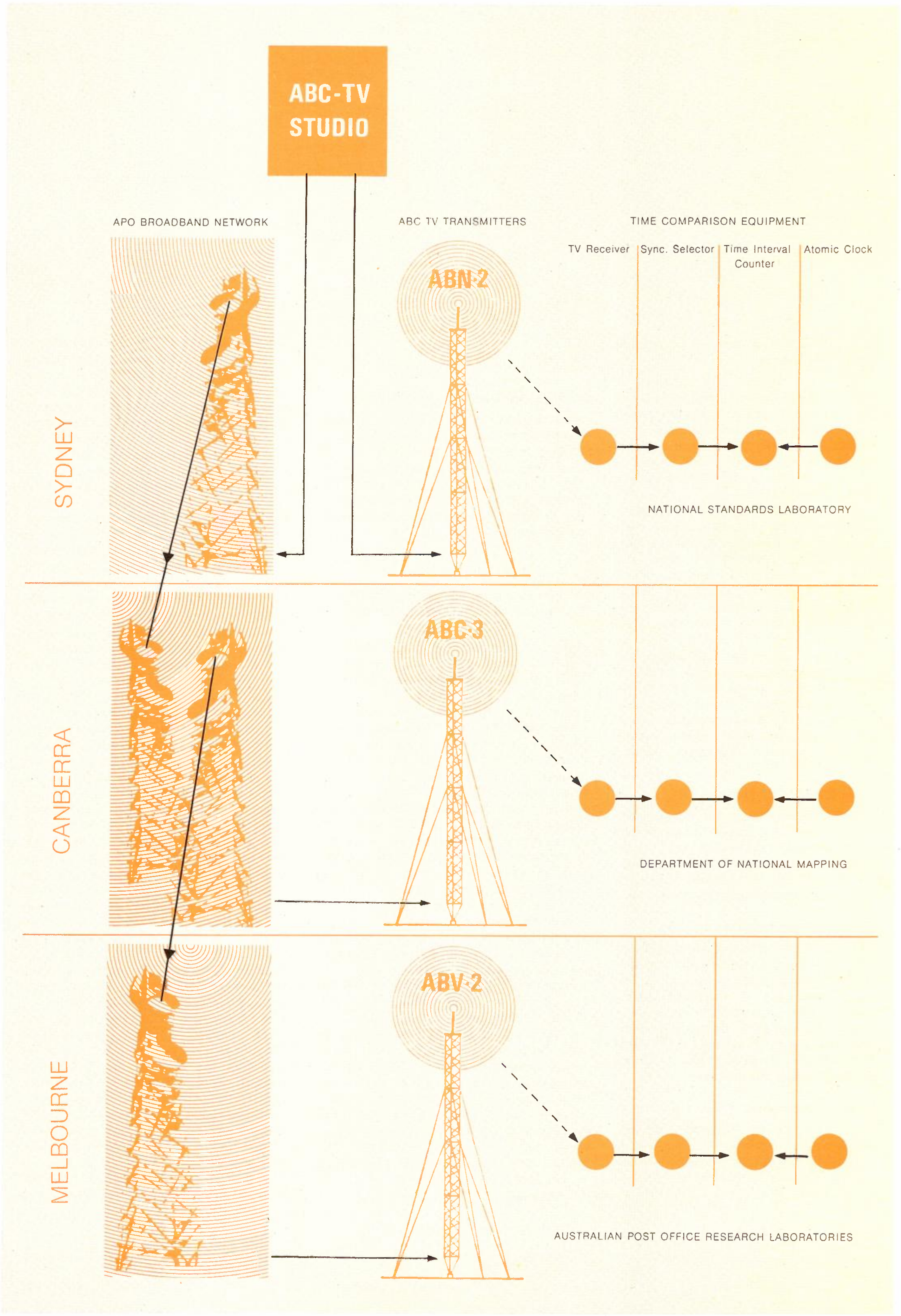
The Laboratories, in co-operation with other time keeping organisations in Australia, is engaged in a program of precise time comparison by the reception of television synchronising pulses. This technique allows the time scale generated by a caesium beam clock to be compared with similar time scales in different parts of Australia to an accuracy of a few microseconds.

This time comparison "network" presently contains over ten clocks located in Canberra, New South Wales and Victoria. The diagram shows the propagation paths of TV signals to the two Australian Working Standards of Time Interval (Australian Post Office, Melbourne, and Department of National Mapping, Canberra) and the Australian Primary Standard (National Standards Laboratory, Sydney). The TV program used is an A.B.C. news broadcast, which originates in Sydney and is distributed, via the A.P.O. broadband network as shown, to A.B.C. transmitters in Canberra and Melbourne.

The equipment shown in the photograph is used in the Research Laboratories to perform the time comparison and similar equipment is used at each participating laboratory. A composite video signal is obtained from the video output stage of the TV receiver and is applied to a TV synchronising pulse selector. This device was developed by the Research Laboratories and is now in use by all participating laboratories. The unit separates the synchronising pulses from the composite video signal and generates an output pulse in coincidence with the leading edge of the second pulse in each field synchronising interval.

To perform a comparison, each participating clock starts a time interval counter at a specified instant. On the arrival of the next vertical synchronising pulse, the pulse selector stops the time interval counter, which now reads the arrival time of the required synchronising pulse with respect to the participating clock's time scale. Subtracting the respective TV network propagation times (including equipment delays) from each arrival time gives the emission time of the required synchronising pulse with respect to each time scale. Differences between these times give the time differences between each participating clock.

The accuracy of this technique depends on the accuracy with which propagation times may be determined and their constancy. In practice, portable clock determinations of propagation times are made periodically and have shown that propagation times on the Sydney-Canberra-Melbourne TV bearer system remain within about one microsecond. Present comparisons yield a standard deviation of approximately one microsecond where broadband bearers are involved and about 0.5 microsecond where clocks have access to the same TV transmitter. This means that comparison accuracies of a part in 10^{12} are accomplished in about 10 days.


ABC-TV
STUDIO
APO BROADBAND NETWORK
ABC TV TRANSMITTERS
TIME COMPARISON EQUIPMENT
TV Receiver
Sync. Selector
Time Interval Counter
Atomic Clock
SYDNEY
ABN-2
NATIONAL STANDARDS LABORATORY
CANBERRA
ABC-3
DEPARTMENT OF NATIONAL MAPPING
MELBOURNE
ABV-2
AUSTRALIAN POST OFFICE RESEARCH LABORATORIES

Maintaining the Quality of Laboratory Instrumentation

Too often the test equipment used and relied upon to carry out important research is taken for granted. It is sometimes forgotten that the end result of the investigation must obviously be limited by the accuracy and reliability of the measuring equipment.

The demand for equipment with more facilities and better specifications has been met by the use of complex design concepts, continued development of new and improved componentry, modern circuit construction such as multi-layer printed circuit boards, and expensive manufacturing quality control programmes. The Laboratories' servicing facilities have had to keep pace with these developments. The art of diagnosing functional problems associated with modern electronic instrumentation can only be achieved with a combination of a high level of technical knowledge and practical ability. Modern servicing and diagnostic aids must also be utilised.

Digital Servicing Techniques

The ever increasing use of digital equipment has created a demand for specialised techniques and equipment for rapid repair. Servicing aids include logic clips, logic probes, an integrated circuit functional tester and an integrated circuit comparator.

Linear Servicing Problems

The wide use of operational amplifiers with varying forms of interactive feedback loops has made classical sequential isolation approaches to servicing nearly obsolete. This necessitates a much more detailed knowledge of the design philosophy and theory of operation of instruments. Ready access to reference books and design data is thus essential.

Automatic Techniques

Increased use of automatic diagnostic and monitoring equipment is required to overcome slow and tedious point-by-point methods, and to solve the problem of intermittent faults.

Soldering and Desoldering Techniques

To maintain a high level of quality control during service on single, double or multi-layer printed circuit boards, special re-working equipment is necessary. Even with this equipment, training and the development of operational skills is essential if damage to expensive boards and components is to be avoided.

VHF Receiver and Digital Tape Recorder for Mobile Field Intensity Measurements

The development of a VHF receiver and digital tape recorder for mobile field intensity measurements has been undertaken by the Laboratories at the request of the Radio Branch of the Engineering Works Division. The equipment will be used to obtain information on the spatial distribution of VHF field intensity as received in a moving motor vehicle. This information is required in the planning of new and improved mobile radio services being contemplated by the A.P.O.

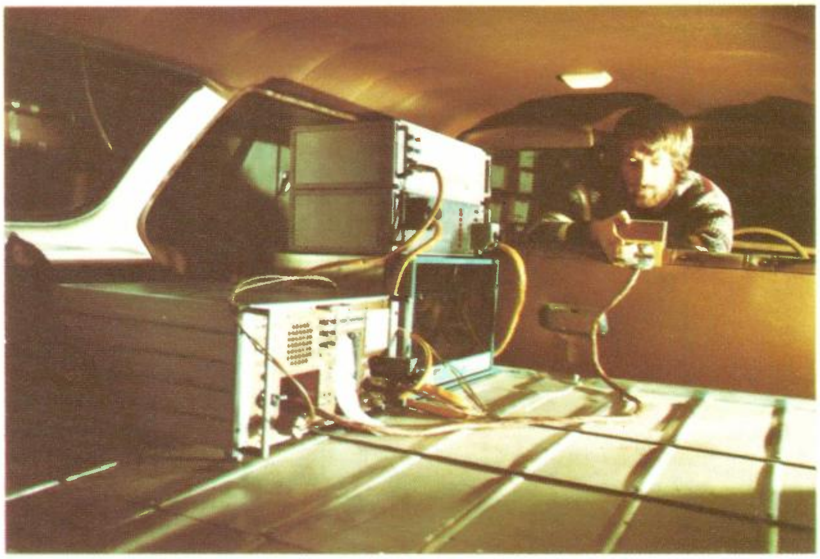
In a typical VHF mobile radio situation, transmission is between a fixed station with an antenna at a height of tens or hundreds of metres and a motor vehicle with an antenna at a height of a few metres. Generally, there will not be a line of sight between transmitter and receiver; transmission will be by signals scattered from objects such as buildings, trees and power wires. The received signal will be the sum of a number of these scattered signals. As the mobile antenna moves, the amplitude and phase of the various components will vary and the sum will vary. These variations can occur rapidly and be substantial in magnitude. This effect, as well as the average transmission loss and other effects, determines the reliability of transmission. The practical value of theoretical analysis is not yet known and this equipment is intended to obtain information to supplement that obtained from theoretical analysis.

It has been established that field intensity patterns are statistically stationary over areas of about 1 km square. To determine the parameters of the distribution over such an area with sufficient accuracy, some 100 — 200 samples of the field intensity are required. This is impractical with conventional techniques; quick and largely automatic methods must be used.

The equipment developed to make these measurements is in two major assemblies, the receiver and the digital tape recorder. The receiver operates at VHF and has an analogue output indicating the field intensity. It also contains various circuits for digitising, control, generating 'housekeeping' data, displays and power supply. The digital tape recorder is in three units: a data formatter, a commercial synchronous digital tape transport and a power supply.

The receiver has operational control over the digital tape recorder. It has the controls required to set up the detail of a particular experiment and the controls and displays required by the operator during an experiment. An attachment to the vehicle's speedometer drive generates sampling signals at regular intervals as the vehicle moves along the road. At each sampling signal, the analog data is digitised and this, together with other data required to facilitate analysis, is presented to the digital tape recorder. The digital tape recorder draws on this as required and makes the actual tape record. This record is later analysed by computer to obtain the required information.

The digital tape recorder operates in a 'burst' mode in which the data is first registered in one of two buffer memories. When the first buffer memory is filled, the tape transport is activated and the data in the buffer memory is recorded on the tape as a block. Meanwhile, further data is registered in the second buffer memory. After recording the data in the first buffer memory, the tape transport is de-activated and awaits the completion of the next block in the second buffer memory. This method allows the speed of the synchronous recorder to be exploited while recording data that many be presented at irregular intervals. The speed available is sufficient to simultaneously record two parameters at



THE VHF FIELD STRENGTH MEASURING EQUIPMENT READY FOR MOBILE USE

10 cm intervals at vehicle speeds in excess of 56 km/h (35 mph).

The control circuits within the receiver and the digital tape recorder have been designed so that proper and complete tape records will be made under all likely conditions and operations of the controls. A standby battery within the digital tape recorder supplies power to properly end the tape record if there is a power failure. The system can be used to record up to eight parameters simultaneously. The digital tape recorder has been designed so that it may be readily adapted or expanded for other purposes. Similarly, the receiver may be used as an interface between other devices and the digital tape recorder. The receiver has been designed for the frequency range 148 MHz — 174 MHz, but it can be adapted for other frequencies. A chart recorder is fitted to make records of field intensity over short distances.

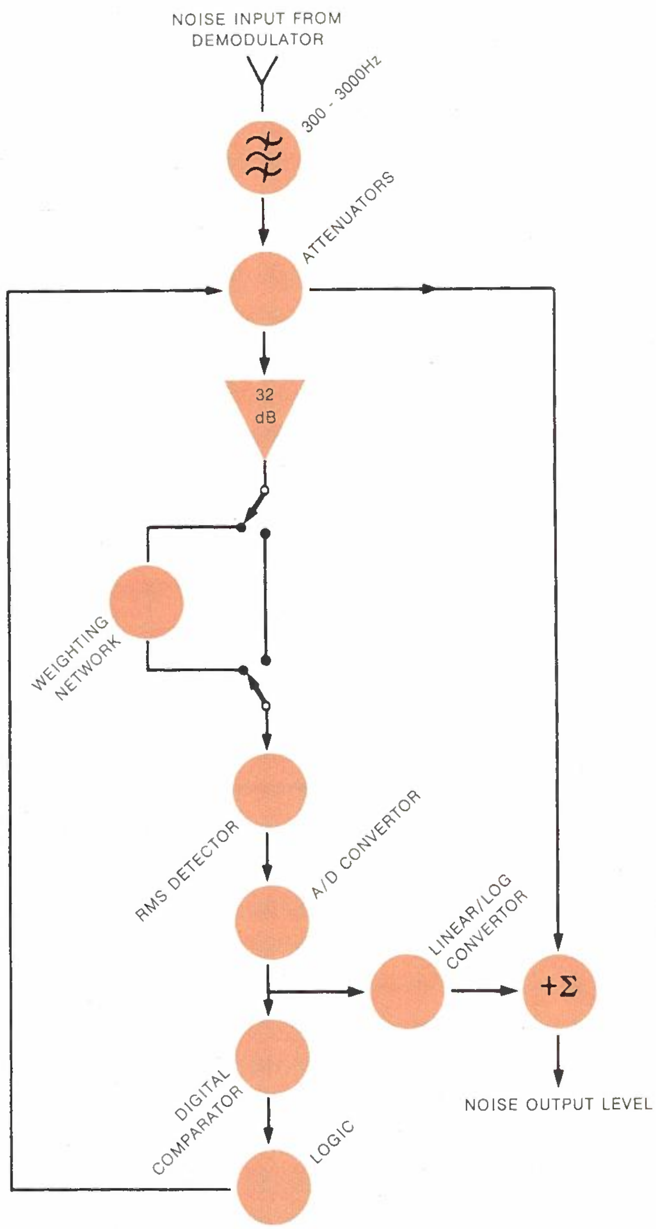
Audio Noise Detector for the Mobile Field Intensity Receiver

One of the major factors affecting the quality of reception of a mobile receiver is the electrical noise field in the area where the receiver is operating. In addition to the radio frequency noise generated by the vehicle in which the receiver is located, other vehicles, electricity supply lines, street lighting, tramways, electric welders and advertising signs all contribute to the noise in an urban location. These noise fields extend to the V.H.F. band where the mobile systems in Australia operate at present. For this reason, their strength and distribution warrant investigation.

In order that such an investigation can be made, an Audio Noise Detector is being developed within the Laboratories for incorporation into the Mobile Field Intensity Receiver. The detector will measure the true root-mean-square value, to moderate accuracy, of the output noise from an FM demodulator situated in the Field Intensity Receiver, with an unmodulated carrier being transmitted.

The design of the detector is such that it will allow measurements to be made of noise levels over a range of sixty decibels. Levels varying up to a rate of about 15 Hz can be accommodated. The large effective dynamic range of the system is achieved by having a set of digitally controlled attenuators at the detecting circuit input. These

EXPERIMENTAL NOISE DETECTOR



SIMPLIFIED BLOCK DIAGRAM OF AUDIO NOISE DETECTOR

attenuators are continuously reset to ensure that the noise signal at the detecting circuit input is always within the dynamic range of the detecting circuit. The dynamic range extends from 0.25 to 2 volts (18 dB). Over this range, the circuit is accurate to within half a decibel. Outside this range, the accuracy is reduced but it is still sufficient to enable the logic to make a decision to reset the attenuator if necessary. The attenuator setting is then added to the detecting circuit output to obtain the noise level. This is expressed in decibels relative to a test tone, and represented in binary form. In order to account for the subjective effect of noise, provision is made to weight the noise signal being measured. The weighting follows the C.C.I.T.T. recommendation for psophometer filters for commercial telephone circuits.

Measurement of Speech Levels in the Telephone Network

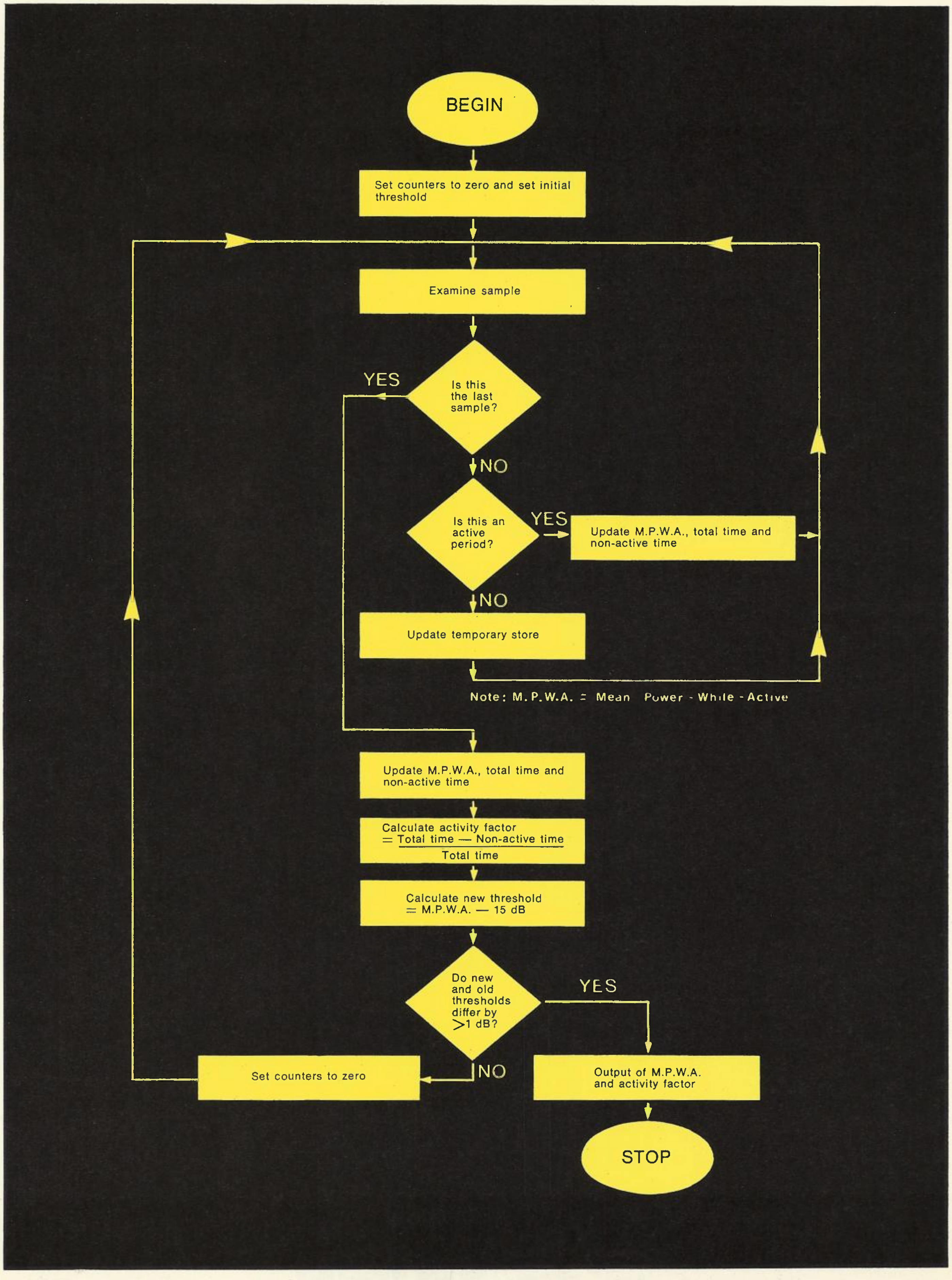
The design and application of telecommunication equipment requires that a knowledge of the levels existing within the network be available. These levels are dependent upon many factors among which are the speaker's volume, the condition and type of the handset used, the length and type of local line and user habits.

In order to gain a meaningful view of the levels existing within the network, it is necessary to apply statistical methods and carry out measurement surveys from which the relevant parameters of mean power, distribution and activity factor may be deduced. In the past, these surveys were carried out using Volume Unit (VU) meter measurements which are tedious and prone to both objective and subjective errors. As reported in an earlier review, a new form of measuring apparatus has been developed within the Laboratories. This allows more comprehensive surveys to be made and thus more accurate statistics to be derived. This machine has been used to carry out tests in a C.C.I.T.T. co-ordinated programme. As a consequence of feedback of results from this programme, further work was felt necessary to verify the accuracy of the algorithm used to calculate activity factor.

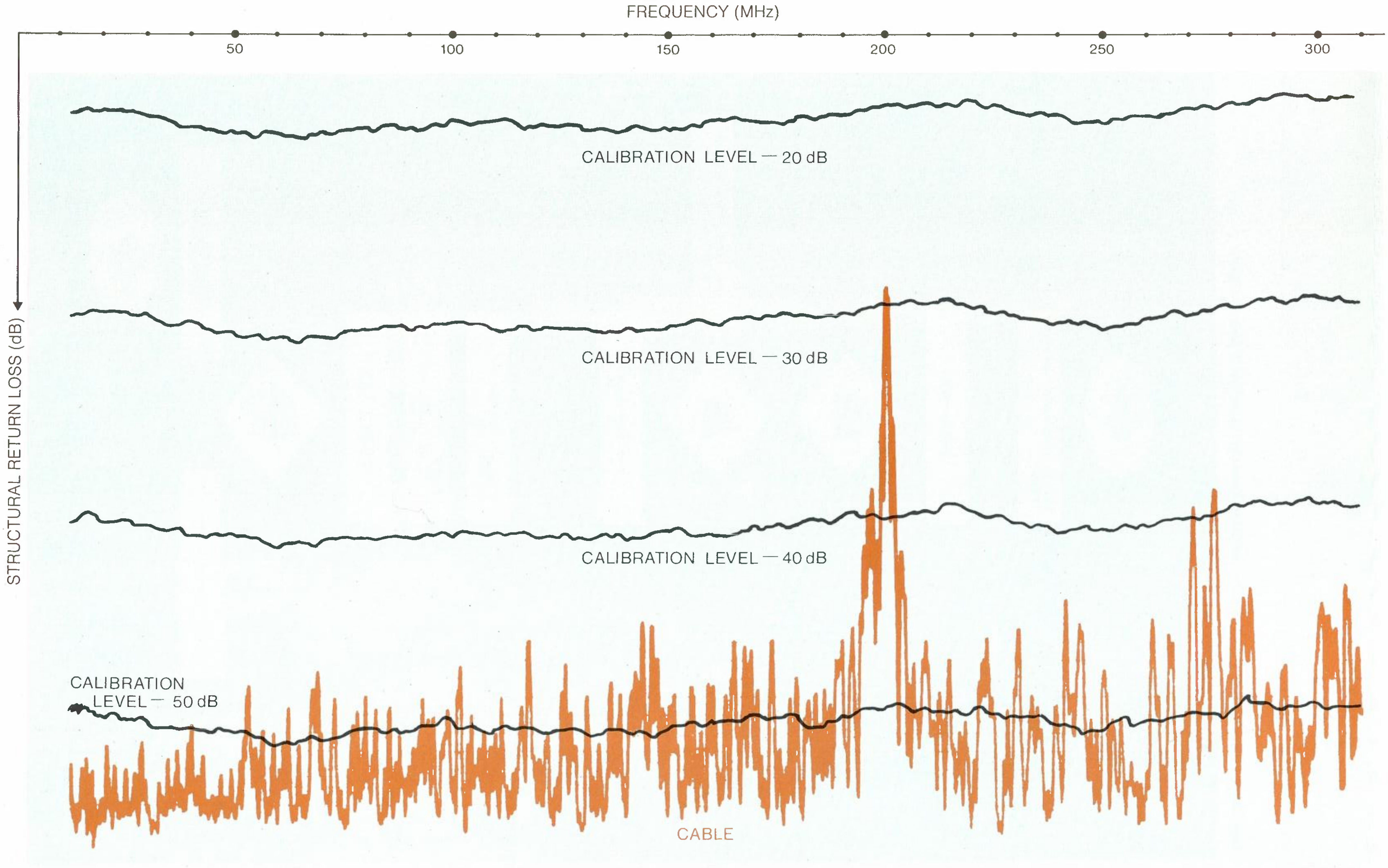
The method of verification used has been two-fold. Firstly, comparisons between results obtained using the speech level meter and an improved version normally used for wideband measurements have been made. Secondly, computer simulations have been and are being carried out to further define the accuracy of the system. As an adjunct, an additional algorithm with several advantages has been investigated. This algorithm, unlike methods presently being used, does not require storage of results or iterative calculations.

The usefulness of this algorithm has only recently become apparent, since advances in technology have made available small processors which can be incorporated into measuring equipment.

During the year, surveys have been made of levels existent on programme lines and in multi-channel groups. The latter survey was co-ordinated by the Engineering Works Division, with the Research Laboratories supplying the necessary equipment and acting as consultants.


BEGIN
Set counters to zero and set initial threshold
Examine sample
Is this the last sample?
YES
NO
Is this an active period?
YES
Update M.P.W.A., total time and non-active time
NO
Update temporary store
Note: M.P.W.A. = Mean Power - While - Active
Update M.P.W.A., total time and non-active time
Calculate activity factor = Total time — Non-active time / Total time
Calculate new threshold = M.P.W.A. — 15 dB
Do new and old thresholds differ by >1 dB?
YES
NO
Set counters to zero
Output of M.P.W.A. and activity factor
STOP

STRUCTURAL RETURN LOSS OF 9.5 mm COAXIAL CABLE



MATERIALS AND PRACTICES

Measurement of Structural Return Loss by the Carrier Burst Method

As the upper frequency limit of cable systems continues to rise, so the problem of assessing cable uniformity to the required accuracy becomes more difficult. The overall attenuation in such a system can be tens of thousands of decibels, and therefore any fractional deviation of this attenuation from a smooth function of frequency can be very difficult to equalise. Irregularities in impedance along the cable length, even if very small, can combine to produce such deviations, especially if the irregularities are periodic over long lengths.

Measurement of Structural Return Loss as a function of frequency is being adopted by some administrations, in addition to the usual pulse reflection test, because of the sensitivity of this parameter to any periodic irregularity. However, difficulties arise if the measurement is attempted with a standard return loss bridge due to spurious reflections from connectors, terminations, and hybrid imbalance of one form or another. This is especially true for measurements to better than 40 dB return loss up to several hundred megahertz.

A method of overcoming these difficulties by using a carrier burst technique was demonstrated in the Laboratories in 1967. Essentially, the usual continuous wave is gated so that the spurious reflections can be eliminated on a time basis. During leave with the B.P.O. Research Laboratories in 1971, the principal investigator developed equipment implementing a sweep frequency version of the method. Similar equipment has since been built in the A.P.O. Research Laboratories. The figure shows the trace obtained for a length of 9.5 mm coaxial cable with an average return loss of around 50 dB to beyond 200 MHz. (A reflection from 0.1 picofarad is sufficient to cause this level of reflection at 200 MHz). The peak of 30 dB return loss is due to periodic fluctuations in tube impedance caused by the lay of the multi-tube cable.

Prototypes of the equipment made in the Laboratories are now being field tested by typical users with a view to letting a contract for local manufacture.

Thermal Methods of Analysis of Engineering Materials

The materials scientist has in the past been called on to synthesise complex substances or systems to meet exacting physical and chemical requirements. Telecommunications engineering has made considerable demands for new polymeric materials to meet electronic, structural, aesthetic and safety criteria.

Space age science, concerned with atmospheric re-entry phenomena and high vacuum performance of materials on one hand, and earthbound environmental science, concerned with biodegradability and recycling of resources on the other hand, have together brought about a close examination of the breakdown of synthetic and composite materials. These wide-ranging activities have had some effect on the trend of investigations in the Laboratories. Biological and thermal degradation of plastics are two of the main processes being studied.

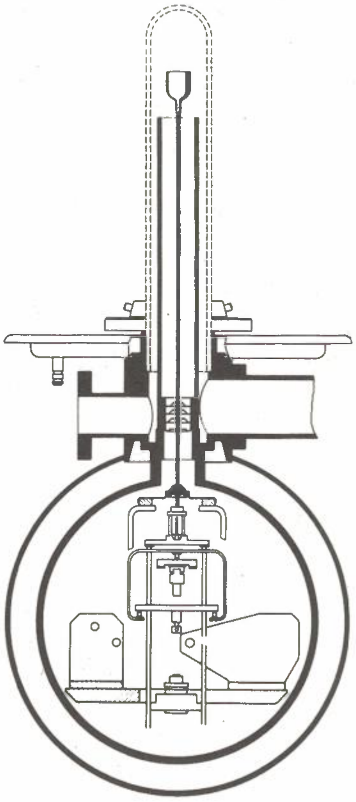
Breakdown of components by natural means has involved a qualitative study of micro-biological processes in some materials used by the A.P.O. The effectiveness of various fungicides, disinfectants and insecticides has been under investigation for some time. More recently, the biodegradability of discarded wastes, such as "one trip" mail bags, has been considered.

However, it is with depolymerizing thermal processes that the A.P.O. analytical research chemist has recently been able to commence more rewarding investigations at a fundamental level. These studies should yield early benefits to engineering activities by providing information on the behaviour of commercial materials already in A.P.O. use, such as plastics, textiles, elastomers, coatings and lubricants. Under closely defined and controlled conditions of elevated temperature and gaseous environment, characteristics such as flammability, combustion, charring behaviour, oxidative changes and gas evolution may be readily evaluated and compared.

In addition to this empirical information, the A.P.O. analytical chemist can use recently acquired instrumentation to identify unknown substances and to examine quantitatively the molecular make-up of many solids, both natural and synthetic, incorporated in engineering materials.

The heart of this instrumentation is a Thermal Analysis System. This uses the "substitution method" of accurately comparing small masses, freeing analytical laboratories from the picturesque but tedious double-arm beam balances and standard weights of earlier days. A delicate microbalance is one of the main functional components in the instrument.

MICROBALANCE ▶

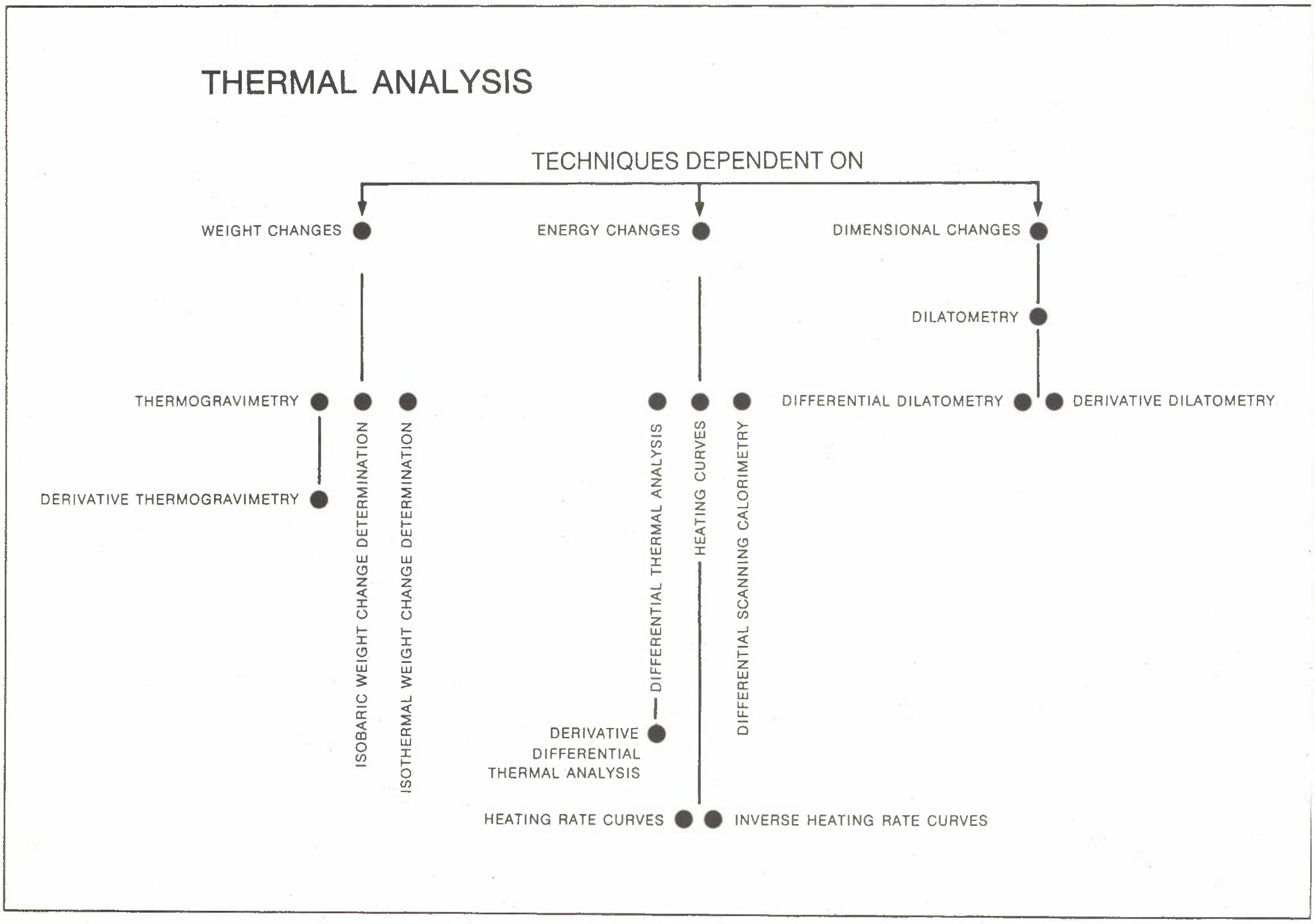


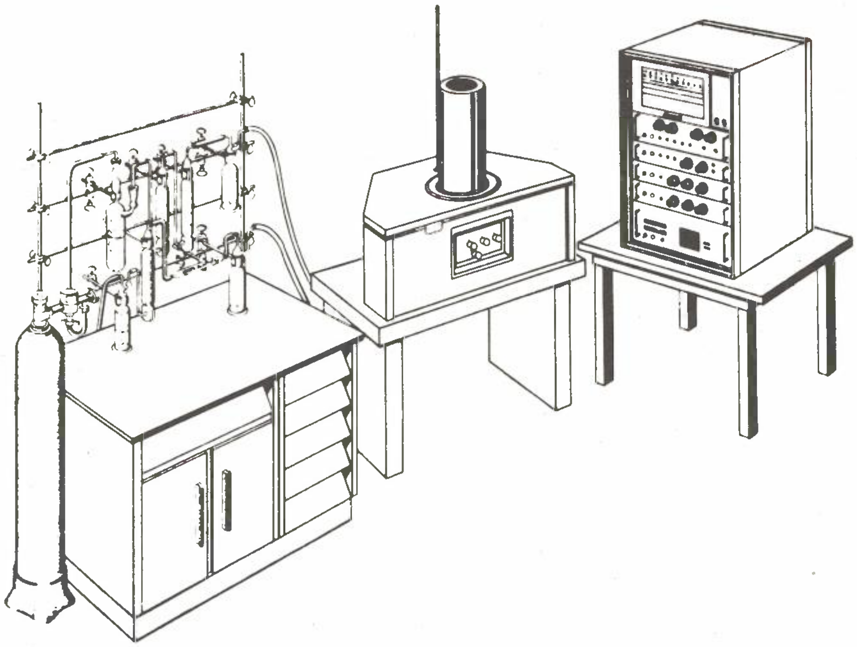
The techniques available to the Laboratories with such an apparatus are varied. In the short term, activities in the Laboratories are centred on the end products of controlled pyrolysis of the more widely used non-metallic materials. It is anticipated that a more complete knowledge of the behaviour of such materials as polyethylenes, epoxy resins, polyvinyl chloride, and polyurethane will be obtained, and the complex functions of antioxidants, stabilizers and similar additives will be elucidated with this analytical technique.

Weight loss or gain experiments are performed in the thermal analyser. Alternatively, by plotting the first differential of temperature differences between a sample and a reference material (D.T.A.), energy changes are indicated. All phase transformations occurring are thus displayed, not only melting and vaporization but also polymorphic transitions and solid state reactions.

The diagram shows the range of techniques made available by the Thermal Analysis System. These techniques will assist in the development of safer and more economical applications of materials.

THERMO-ANALYTICAL TECHNIQUES AVAILABLE IN THE LABORATORIES





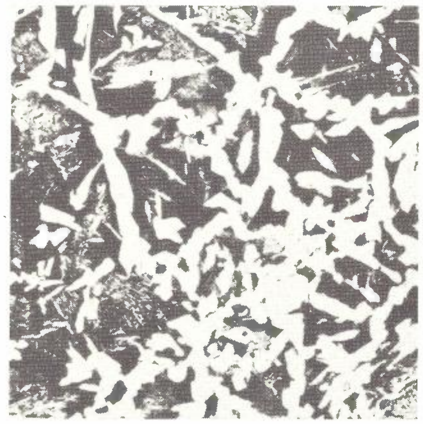
GENERAL LAYOUT OF THERMAL ANALYSIS SYSTEM

Metallurgical Examination of Service Failures

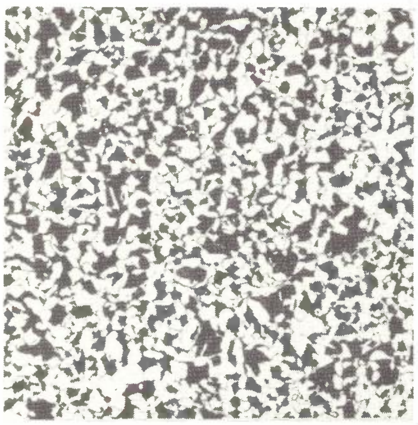
In common with other technologically based industries, the communications industry uses metals in the construction of many items of equipment and plant. In the A.P.O., the range is from minute contacts in exchange equipment to masts and towers for radio and television antennas. Because of the quantity and range of plant and equipment used, service failures are regular events. These failures may originate in a number of ways, such as from poor design, poor manufacture, abuse, unforeseen service conditions, or an expected limited life.

Service failures need to be investigated thoroughly to reduce the risk of accident to operating personnel and the public, to minimise loss of capital investment or loss of income from idle plant, to prevent future failures in similar equipment and to correct errors of design or manufacture. To illustrate these points, two recent service failures are described below.

The mast of a truck mounted crane failed on the first lift, which was at maximum rating, one morning after a cold night. Metallurgical examination established that fracture had initiated in an exceptionally hard and brittle zone which had been formed by an electric welding arc strike on the surface of the mast. It is a practice of some welders to warm up the welding rod by indiscriminately striking an arc on the structure to be welded before commencing the main run. On some steels, this practice is unimportant, but on the mast steel, which was a medium carbon steel, it was very damaging. In addition, microscopic examination established that the steel microstructure of the mast was very coarse and that it had not been correctly heat treated after forging. This is illustrated in the photographs. Mechanical tests established that the impact strength of the mast steel was halved with a temperature drop from 20°C to 2°C, and that at 2°C, the impact strength of the mast steel was only a quarter that of correctly heat treated steel. Thus, the metallurgical investigation established that fracture initiated at an arc strike through poor welding practice on the type of steel used; the fracture propagated easily through steel which had not been correctly heat treated after forging: the whole fracture process was assisted by this type of steel having a poorer resistance to crack propagation when it is cold. Risk of fracture is minimised by improving welding controls, by specifying correctly heat treated steel for the mast, and by derating the crane during initial operation until the hydraulic oil in the mast has been warmed.

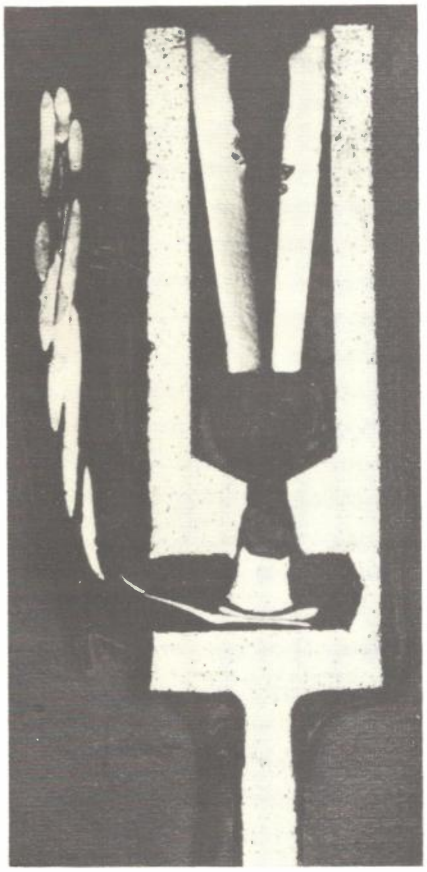


MICROSTRUCTURE OF STEEL FROM MAST THAT FAILED



MICROSTRUCTURE OF CORRECTLY HEAT-TREATED STEEL

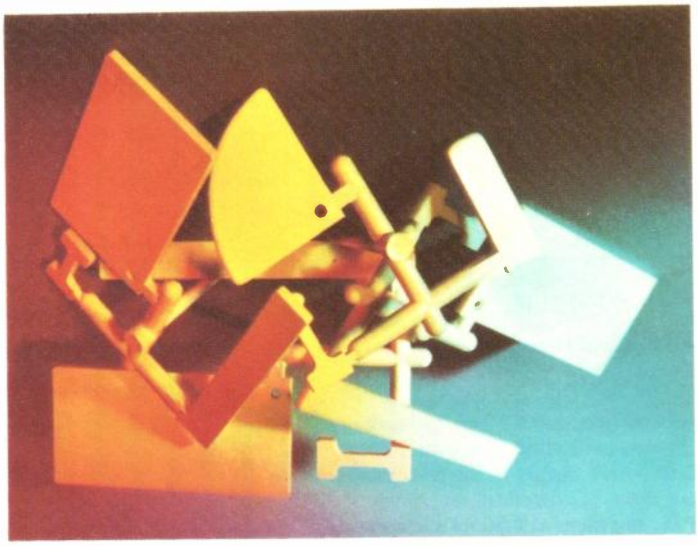
Another example of service failure was the high incidence of contact faults in terminating plugs which had been used extensively for wiring experimental logic circuits. Metallographic mounting and sectioning of plugs established that, instead of a normal crimp, a whole bung of metal had been completely sheared away. This can be seen from the photograph. The result was that no permanent pressure was exerted on



METALLOGRAPHIC SECTION SHOWING FAILURE OF TERMINATING PLUG

the wires, making a faulty contact inevitable. It was apparent that the hole for the wires was too large. Due to the wrong ratio of wire to hole size, the crimping tool was punching out a complete bung of metal. The manufacturer of the plug was advised of the defect.

INJECTION MOULDED TEST SPECIMENS



Plastics for New Generation Telephones

The thermoplastic moulding material A.B.S. — a terpolymer of Acrylonitrile, Butadiene and Styrene, has been satisfactorily used by the A.P.O. since about 1964 for housings and handsets of coloured telephones. It has also been used by telecommunication organisations in almost every country throughout the world with the notable exception of Japan, which has a cheap and plentiful supply of polyvinylchloride (P.V.C.).

The choice of A.B.S. was a good one at the time and the material has served well. However, it has some shortcomings which have become apparent during its years of service. The elastomeric component, butadiene, is chemically unsaturated; residual unsaturation in the polymer makes it unstable. The combined action of ultraviolet light and atmospheric oxygen causes embrittlement, discolouration and dulling of the surface. The aesthetic appearance of handsets moulded from A.B.S. is often impaired by stains from lipstick and ink from ball-point pens and removal of gloss where parts come into contact with each other.

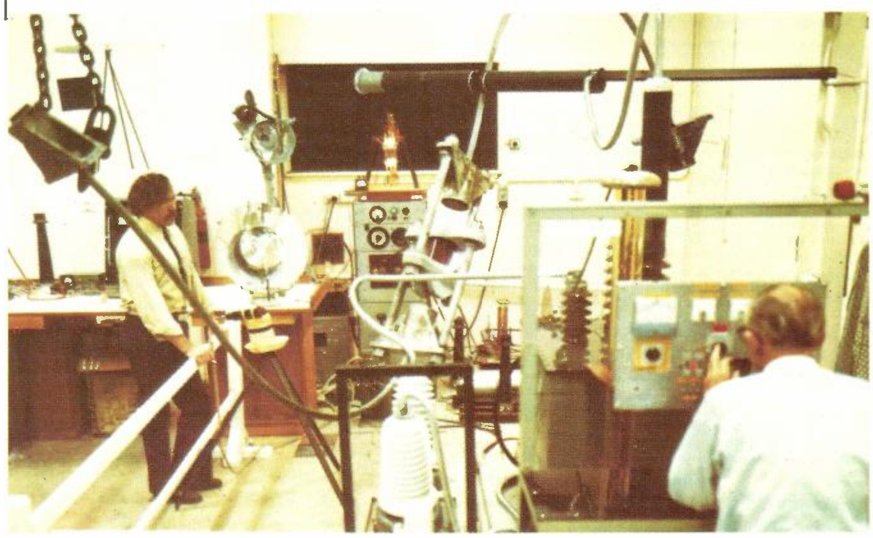
These shortcomings have been known for some time and evaluation of alternative thermoplastics is being carried out by all the major telecommunication organisations throughout the world. The A.P.O. is also investigating new polymers for telephone housings, with the aim of supplementing the information already available from overseas administrations and determining the most suitable polymer for Australian conditions.

The project involves a preliminary investigation to screen fifteen different grades of plastics derived from six polymer types. These include: unplasticised P.V.C. (u P.V.C.); polycarbonate; polypropylene; polyethylene terephthalate; acetal; and modified A.B.S., such as A.S.A. (Acrylonitrile-Styrene-Acrylic) and A.C.S. (Acrylonitrile-Chlorinated-Polyethylene-Styrene). Standard test specimens have been moulded from these materials and changes in properties before and after various periods of natural ageing will be compared with the performance of "Cycolac" T and DM under the same conditions. These last two materials are the A.B.S. grades presently used by the A.P.O. Based on the results of these tests, three or four plastics will be chosen for further detailed examination.

The final investigation will be conducted on telephone housings moulded from these chosen materials. Ultimately, a material will be selected which offers the best combination of technical performance, price and availability.

RF ARC DISCHARGE ACROSS A DAMAGED RIGGING INSULATOR

HIGH VOLTAGE TESTING OF A GUY WIRE INSULATOR



Insulators for Radio Transmitter Installations

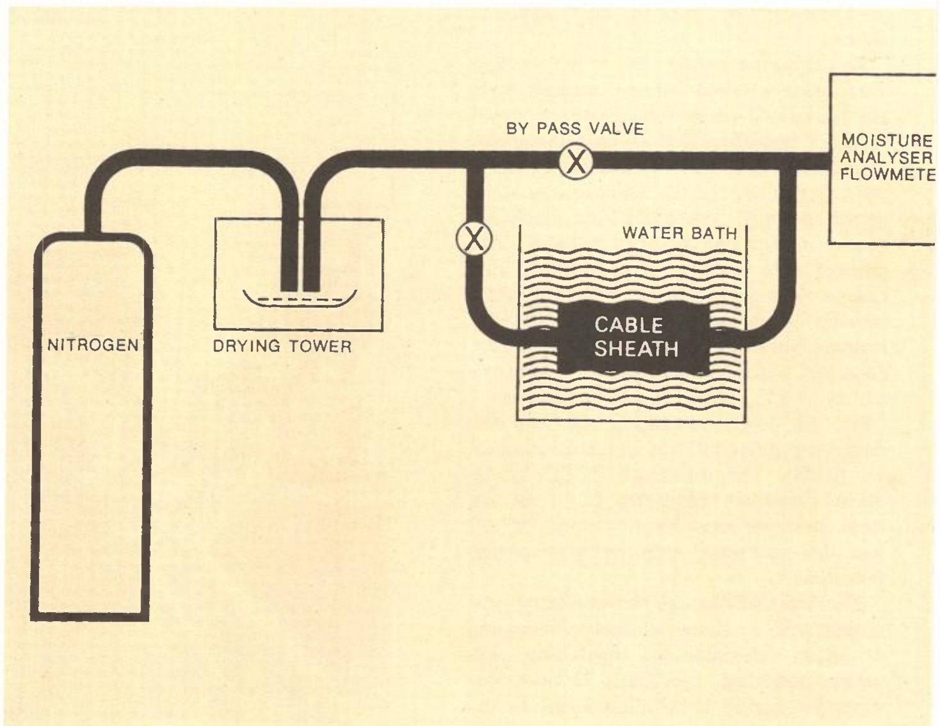
Insulators in radio transmitter installations are subjected to a greater variety and severity of operational stresses than any other class of insulators in Departmental use. For example, some of the insulators may be simultaneously subjected to the following stresses: large mechanical forces causing compressive twisting and bending stress; high working potentials at radio frequency; high external potentials, such as generated by storm clouds and lightning discharges; and adverse outdoor conditions such as fog, rain, salt spray, solar radiation, dust and bush fire by-products. All of these can have deleterious effects on the insulators resulting in temporary malfunction, gradual degradation of performance, or sudden and complete failure.

To safeguard against this, or to ascertain the causes of field failures, various tests are performed on new or previously used types of insulators and ceramic materials. The photographs show typical high voltage tests performed in the Laboratories. One shows a radio frequency arc discharge across a damaged rigging insulator. The damage was caused by a localized discharge through the body of the insulator, causing differential expansion of the ceramic insulating material. This failure occurred with a test potential of approximately 6 kV (RMS) at a frequency of 1 MHz. At power frequency (50 Hz), the flash-over potential was approximately 25 kV (RMS). The difference in the breakdown potentials illustrates the need for tests, because local manufacturers do not test the insulators with radio frequency potentials.

The other photograph shows a large type of guy wire insulator assembly undergoing a test to determine the breakdown path under abnormal conditions in use, for example, during a lightning strike to the structure.

AN ARRAY OF L.E.D. INDICATORS
CENTRE INSET: L.E.D. CHIP PHOTOGRAPHED USING ITS OWN LIGHT

APPARATUS USED TO MEASURE MOISTURE PERMEATION IN CABLES

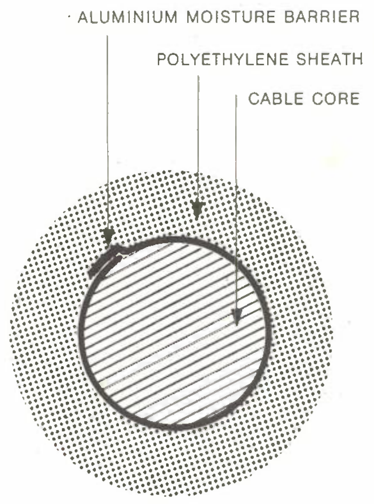


Reliability of Light Emitting Diodes

Light emitting diodes (L.E.D.'s) have been available for about five years. In that time, there has been an increase in their efficiency together with a decrease in their cost, as well as a proliferation in the types of L.E.D. devices available, based mainly on red-emitting diodes. Green and yellow L.E.D. indictor lamps are made but their light emission contains a large proportion of red light making them less attractive than the red devices. Because they are solid state devices, high reliability can be expected from L.E.D. indicators and displays.

The Physical Sciences Branch is currently examining a number of makes and types of L.E.D. indicators so that quantitative comparisons may be made against the incandescent lamp indicators now used by the A.P.O. Features which are of interest include colour, luminous intensity and spatial distribution of the light emitted, as well as reliability. Factors which effect the reliability of L.E.D. sources include the chip manufacturing processes and the use to which the finished device is put. Degradation of the light output may be caused by process induced stresses and faults in diffusion. Crystal imperfections may also be expected to educe light output while non-radiative recombinations, resulting from mobile ionic impurities, also reduce the efficiency.

The photograph shows an enlargement of an L.E.D. chip taken using the light emitted by it. Dark, non radiative, areas are visible as well as a clearly defined crack across one corner. Defects such as these may be expected not only to reduce the expected luminous intensity but to also reduce the expected life of the device. Also shown are a few complete L.E.D. indicators which are typical of the finished product.



CROSS SECTION OF CABLE WITH ALUMINIUM MOISTURE BARRIER

Moisture Permeation through Plastic Cable Sheaths

As a cable sheathing material, polyethylene has numerous advantages but suffers two serious limitations. It tends to crack when stressed in the presence of surface active materials and it is permeable to water vapour. The latter problem has been overcome by interposing an aluminium foil between the cable core and the polyethylene sheath during manufacture. This reduces water permeation by a factor of over 100. Cables incorporating this development have been used overseas for some years. When their manufacture was commenced in Australia, it became necessary for the Department to be able to check that cable being supplied had a consistently low rate of moisture permeation.

Permeation measurement by direct weighing of dessicant, which was adequate for measurements on unbarriered polythylene sheath was not sufficiently sensitive for the new cable and so a coulometric technique based on a B.P.O. method was developed. The basic principle is shown in the diagram. Dry oxygen-free nitrogen is passed through a drying tower, which reduces its moisture content to below 1 part per million, and then through the length of cable sheath on test. The sheath is immersed in a water bath held at 60°C. Water vapour permeating the sheath is carried away by the dry nitrogen stream to the electrolytic cell where it is electrolysed. The electrolysis current is measured, providing a very sensitive indication of the water permeation rate. Typical values obtained are of the order of 0.5 milligram meter $^{-1}$ week $^{-1}$ at 60°C.

THE ENGINEERING LIBRARY

The A.P.O. library information services concerned with subject matter of technical and scientific nature are administered from the Main Library, located in the Laboratories. It supports five smaller branch libraries and two reading rooms located in close proximity to engineering groups in other Headquarters' premises, and engineering libraries in each State Administration.

A variety of information services is provided to support the engineering, scientific and technical staff of the whole Department in their daily work. The library service is guided by the advice of a Library Committee whose membership includes senior officers from each Engineering Division at Headquarters.

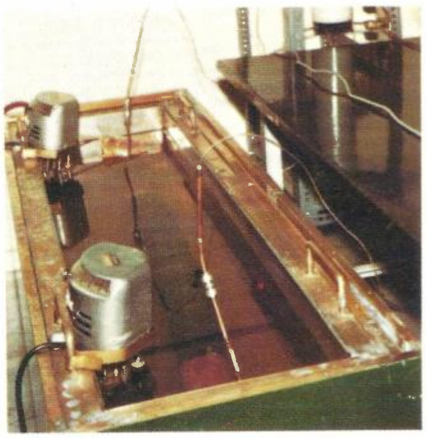
The services provided by the Library include information and literature searches, compilation of bibliographies, reference work, and translations. Selective dissemination of information is provided on key subjects chosen by individual officers. A new method of compiling subject profiles has been introduced which provides a more accurate selection of items and is greatly appreciated by staff. The Library also compiles and circulates a quarterly list of international conferences and a fortnightly list of Australian conferences, seminars and meetings.

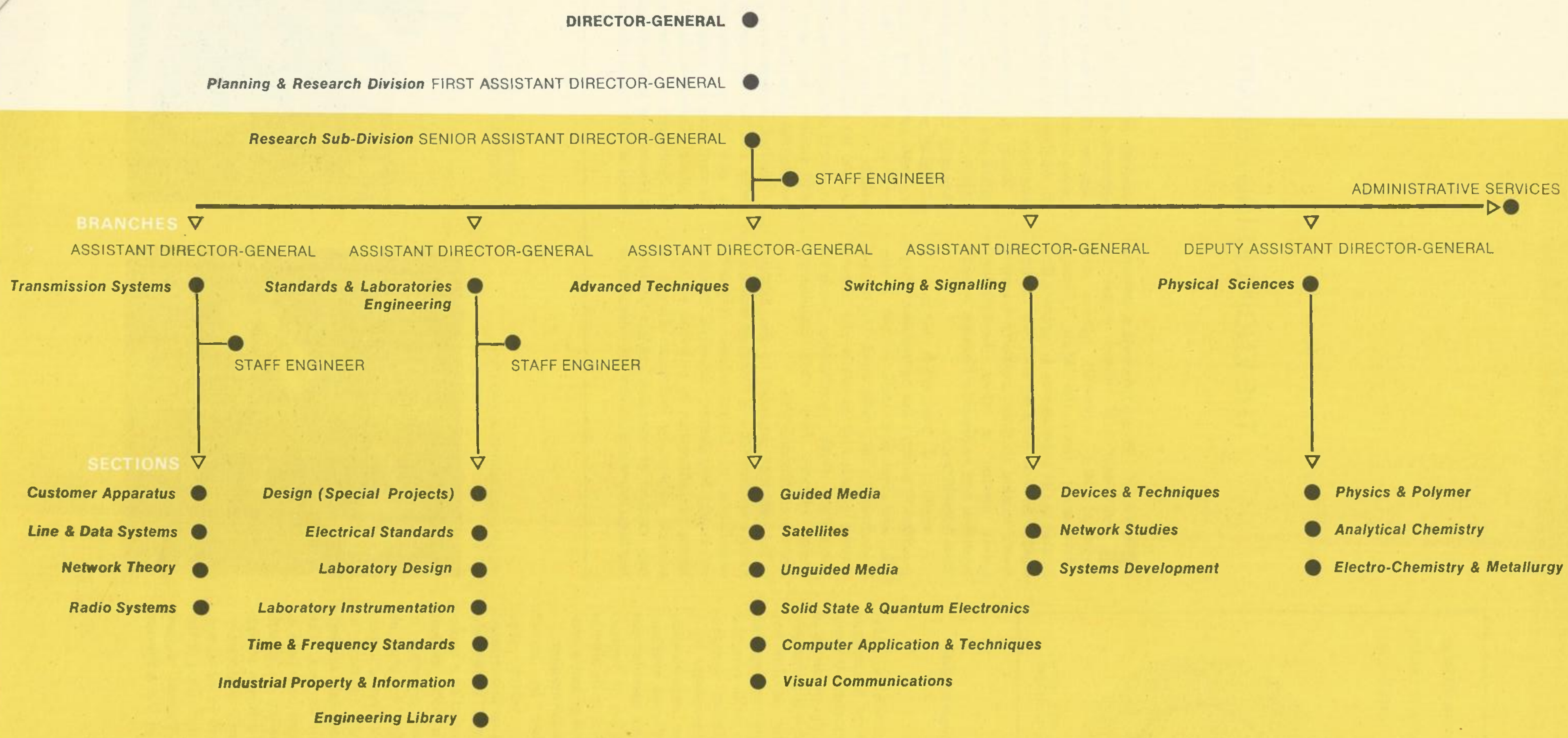
Work is progressing using computer techniques to provide improved listings of library material. A computerised index of Research Laboratory Reports will soon be published with classifications according to number, author and subject. The physical problem of storing the ever-increasing volume of library material is also being tackled by transferring periodical holdings to microfiche and equipping the Library with suitable equipment for reading and copying the stored information.

The link between library information services and the telecommunications network is also being considered through the forward looking planning studies of the National Telecommunications Plan Branch at Headquarters. These studies encompass a diversity of advanced communication services including new information services.

ACTUAL MEASURING APPARATUS

ELECTROLYTIC CELL FOR MEASUREMENT OF MOISTURE CONTENT OF NITROGEN





THE A.P.O. RESEARCH LABORATORIES

The Laboratories and its Staff

ORGANISATION

The Australian Post Office is a Department of the Australian Government. Its chief executive is the Director-General, Posts and Telegraphs. With the assistance of five Headquarters Divisions, he controls and directs the operations of the Department through six individual State Administrations.

The Research Laboratories are a Sub-Division of the Planning and Research Division at Headquarters. The Senior Assistant Director-General, Research, heads the Laboratories organisation. He is responsible to the First Assistant Director-General, Planning and Research Division, who in turn is responsible to the Director-General.

The Laboratories are comprised of 23 Sections which are grouped into 5 Branches, and each Branch is under the direction of an Assistant Director-General. The Sections comprise professional, technical grade and other staff, with each Section possessing expertise in particular areas of the engineering and scientific fields.

PROFESSIONAL AND SENIOR STAFF

The names given below are those of actual occupants of the positions (appointed or acting) as at 30th April, 1974.

Senior Assistant Director-General: P. R. Brett, B.Sc., F.I.R.E.E.
Staff Engineer: F. W. Arter, B.E.E., M.Eng.Sc.

TRANSMISSION SYSTEMS BRANCH

Assistant Director-General: S. Dossing, M.Sc. E.E.(Hons.), M.E.E., F.I.E.Aust.
Staff Engineer, M. Cassidy, B.Sc., M.E., D.P.A., F.I.E.Aust., M.I.E.E., A.A.I.P., A.Inst.P.

Customer Apparatus Section

SECTION HEAD: D. A. Gray, B.E.E., Dip.Mech & Elec.Eng., M.I.E.Aust., M.A.A.S.
PRINCIPAL ENGINEER: Koop, E. J., B.E. (Elec.), Fell.Dip.Elec.Eng., M.A.A.S.
SENIOR ENGINEERS:
Duke, P. F., B.Tech., Assoc.Dip.Maths.
Kett, R. W., Fell. Dip.Comm.Eng., A.M.I.R.E.E.
Metzenthen, W. E., Fell.Dip.Comm.Eng., M.E., M.I.R.E.E.
ENGINEERS:
Blackwell, D. M., B.E.(Elec.)
Casley, G. M., B.E.(Elec.), M.Eng.Sc., D.I.C., Ph.D., M.I.E.Aust., M.I.E.E.
Goldman, J. P., Assoc.Dip.Rad.Eng., Assoc.Dip.Comm.Eng., Grad.I.E.Aust.,
Wellby, P. J., B.E.(Hons), B.Sc.
SENIOR TECHNICAL OFFICERS
Beadle, S.G.
Long, T. R.
Wood, R. J.

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Domjan, A., B.E.E., A.M.I.E.Aust.
Gibbs, A. J., B.E.(Elec.), M.E., Ph.D., M.I.R.E.E.
SENIOR ENGINEERS:
Semple, G. J., B.E.(Hons), M.Eng.Sc.
Smith, B. M., B.E.(Hons), Ph.D., M.I.E.E.E.
ENGINEERS:
Bylstra, J. A., B.Sc.(Hons), M.Sc., M.I.E.E.E., M.I.E.Aust.
Dempsey, R. J., B.E.(Elec.).
Duc, N. Q., B.E.(Hons), Ph.D., Grad. I.R.E.E., M.I.E.E.E.
Park, J. L., B.E.(Hons)
Quan, A. Y. C., B.E.(Hons), M.E., A.M.I.E.E.
Steele, J., B.E.(Hons), Ph.D.
Tyers, P. J., B.E.(Hons)
SENIOR TECHNICAL OFFICERS:
Gillies, J.
Kelly, J. L.
Yelverton, W.

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SECTION HEAD: I. M. McGregor, B.E.(Hons), M.Eng.Sc., Ph.D.
ENGINEERS:
Gray, R. L., B.E.(Hons), M.E., Ph.D.
Snare, J. L., B.E.(Hons).
Tenen, O., Dip.Rad.Eng., M.I.E.Aust.

Radio Systems Section

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Lawson, I. C., B.E.E.
Sargeant, V. K., B.E.(Hons), M.Eng.Sc., Dip.Elec.Eng.
ENGINEERS:
Court, R. A., B.E.(Hons), B.Sc., M.I.E.E.E.
Harris, R. W., B.Sc.(Hons), B.E.(Hons)
Hicks, P. R., B.E.(Elec.)
Vinnal, E., B.E.(Hons)
SENIOR TECHNICAL OFFICERS:
Temby, F.
Thompson, D. J.

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Staff Engineer: L. H. Murfett, B.Sc.

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Sheridan, D. E., Dip.Elec.Eng., Dip.Mech.Eng.
Tjio, H. S., B.Mech.E., Assoc.Dip.Electron.Eng.
ENGINEERS:
Brunelli, A., B.Eng.(Comm.), Fell.Dip.Electronics, Assoc.Dip.Eng.
Day, R. J., Dip.Elec.Eng., Dip.Mech.Eng., Grad.I.E.Aust.
Gilchrist, A. R., B.E.(Mech.)(Hons), Assoc.Dip.Mech.Eng., Grad.I.E.Aust.
Kilby, R. L., Assoc.Dip.Elec.Eng., Grad.I.E.Aust.
Mangalore, C., B.E.(Mech.), Grad.I.E.Aust.
Meggs, P. F., Assoc.Dip.Mech.Eng., Grad.I.E.Aust.
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Hider, P.
Mackin, R. J.
Staley, W. W.

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SECTION HEAD: J. M. Warner, B.Sc., M.I.E.E.
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ENGINEERS:
Pyke, R. W., B.E.(Elec.), Dip.Elec.Eng., Grad.I.E.Aust.
SENIOR TECHNICAL OFFICER
Erwin, J. B.

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SECTION HEAD: A. H. O'Rourke, Dip.Rad.Eng., Grad.I.E.Aust.
PHYSICIST: Robertson, R. P., B.Sc.(Hons), M.Sc.
SENIOR TECHNICAL OFFICER:
Mitchell, A. K.

Laboratory Design Section

SECTION HEAD: D. S. Geldard, M.I.E.E., M.I.E.Aust., A.M.I.I.C.Aust.
ENGINEER:
Dalrymple, L. N., Assoc.Dip.Elec.Eng., Grad.I.E.Aust.

Laboratory Instrumentation Section

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Wylie, F. R., B.E., M.I.E.E.
ENGINEERS:
Davidovits, L., B.E., M.I.E.E.E.
Proudlock, R. E., B.E.(Elec.)
SENIOR TECHNICAL OFFICERS:
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FitzSimons, H. B.
Jepson, R. R.
McEwen, B. J.

Time and Frequency Standards Section

SECTION HEAD: R. L. Trainor, B.Sc.
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ENGINEERS:
Hamilton, A. N., B.E.(Hons), B.Comm.
Ratcliff, B. R., Assoc.Dip.Comm.Eng.
Townsend, A. A. R., B.E.(Elec.), M.I.E.E.
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Thomas, V. E., A.M.I.R.E.E.
Yates, R.

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Peters, S. M. (Mrs.), B.A., B.Sc., Dip.Ed., Dip.Lib., A.L.A.A.
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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.
Duncan, A. M., B.Sc., B.E.(Elec.) (Hons)
English, K. S., B.E.(Elec.)
Jenkins, G. K., B.Sc., B.E.(Hons), M.E.
Jenkins, I., B.E.(Elec.) (Hons)

Guided Media Section

SECTION HEAD: G. P. Kidd, B.E.(Elec.) (Hons), B.Sc.
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ENGINEERS
Colvin, J. P., B.E.(Elec.), Dip.Elec.Eng.
Morgan, R. J., B.Sc.(Eng.) (Hons), A.M.I.E.E., M.I.E.E.E.

Satellites Section

SECTION HEAD: G. F. Jenkinson, B.Sc., M.I.R.E.E.
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Flavin, R. K., B.Sc., M.Sc., M.I.E. Aust.
ENGINEER
Stone, G. O., B.E.(Elec.), M.Eng.Sc., Ph.D., M.I.E.E.E., M.I.R.E.E.

Solid State and Quantum Electronics Section

SECTION HEAD: W. J. Williamson, B.E.(Elec.) (Hons), Ph.D.
PRINCIPAL ENGINEER:
Teede, N. F., B.E.(Hons), Dip.Mgt., Ph.D.
SENIOR ENGINEERS
Cahill, L. W., B.E.(Elec.), M.Eng.Sc., Ph.D., M.I.E.E.E., M.I.R.E.E.
Sabine, P. V., B.Sc., B.E.(Elec.) (Hons), Ph.D.
ENGINEERS
Horton, R., B.Sc.(Hons), Ph.D., A.M.I.E.E., M.I.R.E.E.
Hubregste, J., Fell.Dip.Comm.Eng., Grad. I.R.E.E.
Johansen, E., B.E.(Hons)
Lind, L. F., B.S.E.E.(Hons), M.S.E.E., Ph.D., M.I.E.E.E.
Reeves, G. K., B.Sc.(Hons), Ph.D., M.I.E. Aust.
SENIOR TECHNICAL OFFICERS
Cransto , B. P.
Wills, H., Assoc.Dip.Rad.Eng., A.M.I.R.E.E.

Unguided Media Section

SECTION HEAD: J. H. Reen, B.E.E., M.I.E. Aust.
PRINCIPAL ENGINEER:
Murphy, J. V., B.E.(Elec.) (Hons), B.A.
SENIOR ENGINEERS
Harvey, R. A., B.Sc., Dip.Rad.Eng., A.M.I.R.E.E.
Sastradipradja, S., B.E.(Elec.)
ENGINEERS
Burton, J. M., B.E.(Elec.).
Caro, N.W., B.E.(Elec.) (Hons)
Howard, S.E., B.E.(Elec.) Grad. I.R.E.E.
Lee, H. S., B.E. (Comm.), Grad. I.R.E.E.
Ridge, I. T., B.E.(Elec.), Grad. I.E. Aust.
SENIOR TECHNICAL OFFICERS
Barnard, S. A.
Francis, R. J.
Lucas, J. E. W.
Woolcock, F. B.

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PAPERS, LECTURES, TALKS AND REPORTS

□ Research Laboratories Reports are the vehicle by which the results of research studies and investigations, development projects and other specialised tasks undertaken in the Laboratories are officially documented. The staff of the Laboratories also regularly contribute articles to Australian and overseas technical journals and present papers to learned societies.

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Kelso, D. R.	"Equalisation of Cables for Digital Transmission in the Presence of Noise", I.R.E.E. 14th National Convention, Melbourne, August 1973.
Kett, R. W.	"Sound Recording Equipment", Victorian School of Speech Studies, June 1973.
Kilby, R. L. & Sastradipradja, S.	"An Antenna for a Radiometer Operating at 11 and 14 GHz", I.R.E.E. 14th National Convention, Melbourne, August 1973.
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Lavery, W. J. & Craick, J. K.	"Synchronisation and Error Protection of Variable Length Coded TV Signals", I.R.E.E. 14th National Convention, Melbourne, August 1973.
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Sabine, H.	"An Acoustic Surface Wave Coupling Technique with Diverse Device Applications", I.R.E.E. 14th National Convention, Melbourne, August 1973.
Sargeant, V. K.	"A Time Division Multiplexed, Pulse Amplitude Modulated System for the Transmission of Monaural, Stereophonic or Quadraphonic Programs in an FM Broadcast System", I.R.E.E. 14th National Convention, Melbourne, August 1973.
Sargeant, V. K.	"Digital Radio Systems", I.R.E.E. Lecture, November 1973.
Semple, G. J.	"Timing Jitter in Digital Signal Regeneration", I.R.E.E. 14th National Convention, Melbourne, August 1973.
Shipway, J.	"Software Control (Simplex) for an I.S.T. Tandem Telephone Exchange", Caulfield Institute of Technology, Seminar on Computer Control Systems, July 1973.
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Teede, N. F.	"The Optimization of Doping Levels in Eectroluminescent Diodes for Optical Communication", I.R.E.E. 14th National Convention, Melbourne, August 1973.
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RESEARCH LABORATORIES REPORTS

REPORT No.	AUTHOR	TITLE
6591 Add. 3	N. J. Sadler	Professional Grade Aluminium Electrolyic Capacitors — Pulse and Vibration Tests.
6638	W. S. Davies	Integral Waveguide — Mast and Slot Array.
6647	A. J. Gibbs	Multistate Digital System for Standard Coaxial Bearer — Preliminary System Design.
6648	G. T. Martin	An Automatic Speech Level Meter.
6651	A. Townsend	A 5 MHz — 150 MHz Phase Locked Multiplier.
6662	N. W. McLeod	C.C.I.T.T. Signalling System No. 6 Field Trial — Digital Addressing and Control of Switching Equipment.
6669	N. W. McLeod	C.C.I.T.T. Signalling System No. 6 Field Trial — Phases B2 and C Test Traffic and Line Traffic Results.
6711	A. Duncan	A Test Set to Measure Impulse Responses using Pseudo-Random Noise.
6715	H. J. Ruddell	Plastic Seals as Replacements for Lead Seals for Mail Bags.
6722	I. Lawson	I.F. Level Recorder for Radio Propagation Measurements, Mark II.
6726	D. T. Miles	Analysis of Anti-Oxidants.
6730	F. J. W. Symons	The Boston International Switching Symposium: Remote Control of Telephone Switching Systems — Report on Overseas Visit, May-July 1972.
6735	A. Chisholm	Encapsulation of High Stability Resistors in Polyurethane Foam.
6737	S. Mallia	Guide to Computer Programs for Network Analysis, Synthesis and Function Optimisation.
6743	P. Tyers	Solid State Ring Generator.
6746	M. Lane	H.F. Quality Crystal Oscillators of High Frequency Stability.
6749	A. Townsend	Design of Analogue Bit Timing Recovery System to 120 Mbit/s.
6750	H. Brueggemann, J. Grant	A Sound-In-Vision System for the A.P.O. T.V. Conference Facility.
6751	G. Mitchell	Dry Cells — Field Trials No. 6 and No. 9.
6755	M. A. Wilson	Simulation Testing of a New Digital Detection Scheme for Digitally Encoded Multi-Frequency Tones.
6756	G. K. Jenkins	CDC 160A Epsylon Datalog Interface.
6760	F. M. Petchell	Industrial Solvents.
6762	B. M. Smith	Laboratory Tests on the Lenkurt 26C Group Band Data Modem.
6763	G. T. Martin	Signal Loading on Radio Broadcast Program Circuits.
6765	W. V. North	Evaluation of Reed Push Button Keys to Replace Licon Push Button Keys in AFG and AFM Key Senders.
6767	S. H. Noble	Minimum Barrel Diameter for Moisture Barrier Cable Drums.
6779	M. W. Wawn	Failure of Red "Rega" Water Container.
6780	P. H. Gerrand, A. D. Proudfoot	Simulation Study of the Call Handling Capacity of the Central Processors in an I.S.T. Tandem Exchange.
6781	G. Flatau, K. Mottram, K. Keir	Study of the Corrosion of Plug 603 and Socket 610.
6783	G. G. Mitchell	McMurdo "Red Range" Connectors.
6784	T. J. Elms	Single Quad Carrier Cable Joints.
6785	N. J. Sadler	Performance Tests on R.J.K. 378 Type CR Units.
6787	M. W. Wawn	Glass Bead Filled 'Nylon' for Private Letter Box Doors.
6789	I. Dew	Evaluation of S.T.C. and B.T.M. Illuminated Keys for the Minimat P.A.B.X. and the 10C Exchange.

6791	T. J. Elms	Re-evaluation of Component Proportions in Epoxy Resin Cable-Seal Formulations.
6793	A. Hamilton	A Sampling Device for Phase Locking and Tracking.
6794	W. Lavery	Research and Development in Visual Communications — Report on Overseas Visit, Jan.-Feb. 1973.
6796	D. King	A Traffic Generator for the IST Project.
6802	M. Chan	The Peripheral Register for the IST Project.
6803	R. J. Western	Development of a Coating Process for Liquid Filled Optical Fibres.
6804	G. M. Casley	Voice Identification, Speech Synthesis, Speech Recognition — a Survey of Current Achievements.
6805	M. Chan, D. King	The Simulation Testing System for the IST Project.
6806	J. M. Balderston, V. Laats	A Set of Satellite Link Calculation Programmes.
6807	P. Duke	Performance of 801/802 Telephone with Loaded Cable.
6809	A. Quan	A Proposal For Generating Very Fast Pseudo-Random Binary Sequences.
6811	J. M. Balderston	Multiple Access Telephony for an Australian Satellite System.
6815	R. J. Vizard	Higher Level Languages for Switching Systems — Report on Overseas Visit, United Kingdom, April 1973.
6816	R. Smith	Medium and High Capacity Digital Transmission Systems — Report on Overseas Visit, May-June 1973.
6820	W. Yelverton	Installation and Field Trial of V-23 Modems for 1200 Bit/s Operation on Standard or Narrow Band VF Channels.
6821	N. Q. Duc	A Review of Line Coding Techniques for Baseband Digital Transmission.
6822	G. F. Jenkinson	Tropical Rain Attenuation at 11 GHz — Initial Results.
6829	J. L. Kelly	Tests of Four Acoustically Coupled Data Modems Against A.P.O. Specification 1037.
6830	B. M. Smith	Analysis of Data Tests Conducted in the Melbourne Telephone Network.
6838	W. Lavery	Coding of Conference T.V. Signals for Digital Transmission Over Supermastergroup Channels.
6840	C. Barling	An Investigation of Equipment Maintenance.
6843	G. Flatau	Environmental Testing: International Physical Standards — Report on Overseas Visit, June-July 1973.
6850	G. P. Kidd	Optical & Millimeter Wave Guided Transmission Media — Report on Overseas Visit Sept.-Oct. 1973.

In addition 17 other reports were distributed on a limited or restricted basis.

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• Zinc and Zinc Alloys		K. G. Mottram
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• Phenolic Laminated Sheeting		G. Flatau
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Telecommunications and Electronics Industry Standards		
• Capacitors		G. Flatau
• Resistors		D. McKelvie
• Printed Circuits		D. Sheridan
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- the International Telephone and Telegraph Consultative Committee (C.C.I.T.T.)
- the International Radio Consultative Committee (C.C.I.R.)
- the World Administrative Radio Conference (W.A.R.C.)
- the Australian and New Zealand Association for the Advancement of Science (A.N.Z.A.A.S.)
- the Bureau International de l'Heure (B.I.H.)
- the International Electro-Technical Commission (I.E.C.)
- the Asia Electronics Union (A.E.U.)
- the International Federation of Documentation, Committee for Asia and Oceania (F.I.D./C.A.O.)

PATENTS

It is A.P.O. policy to establish a patent portfolio to cover the inventions of its staff. Many of these inventions are made by staff of the Laboratories. They also contribute largely to the assessment of novelty and likely usefulness of new ideas which may lead to patentability.

A summary of current A.P.O. patents and patent applications is given below:—

SUBJECT	INVENTORS	COUNTRIES
Joint Enclosure for Electric Cables	H. J. Ruddell J. D. Feehan (Research)	U.S.A.
Method and Apparatus for Testing Subscribers' Instruments in situ	J. F. M. Bryant R. W. Kett (Research)	Australia U.S.A.
Impulse Sender Mechanisms of Automatic Telephone Dials	R. J. W. Kennell (Assgd. 1968) (Non-A.P.O.)	Australia
Automatic Telephone Dials	R. J. W. Kennell (Assgd. 1968) (Non-A.P.O.)	Australia
Public Telephone Installation (Vandal Proof)	K. B. Smith A. A. Rendle (Tel. Subs. Equipt.)	Australia United Kingdom Japan
Analogue Multiplier	H. Brueggeman (Research)	Australia United Kingdom Fed. Repub. of Germany Japan U.S.A.
Vibrating Cable Plough	E. W. Corless (Mech. & Elec. Serv.)	Australia United Kingdom South Africa
Tip Welding Means	E. Bondarenko (Research)	Australia United Kingdom U.S.A.
Semiconductor Light Detector	N. F. Teede (Research)	Australia United Kingdom Fed. Repub. of Germany Japan
Apparatus for Routing Discrete Telecommunications Signals (I.S.T. Junctor)	A. Domjan (Research)	Australia Belgium Sweden Holland France United Kingdom Fed. Repub. of Germany Japan

SUBJECT	INVENTORS	COUNTRIES
Self Adaptive Filter and Control Circuit (Echo Canceller)	L. K. Mackechnie (Research)	Australia Fed. Repub. of Germany United Kingdom Japan Holland Italy France Sweden U.S.A.
Apparatus for Monitoring a Communication System and Detector (PETRA)	J. A. Lewis (Research)	Australia United Kingdom Sweden
Control of Operation of a System (Faulty Circuit Isolator)	N. McLeod (Research)	Australia United Kingdom U.S.A. France Fed. Repub. of Germany Japan
Monostable and Bistable Devices (Edge Triggered Pulse Generator)	I. Macfarlane (Research)	Australia
Suppressed Zero Voltmeter	A. Stevens (Research)	Australia
Broadband VHF Antennas	R. P. Tolmie (Queensland)	Australia
Polarisation Diversity in Domestic Radio Receivers	D. Rodoni (Radio) T. van Bemmel (Non-A.P.O.)	Australia Philippines United Kingdom India Japan
Cable Pair Identifier	G. Devey (Victorian Admin.)	Australia New Zealand United Kingdom
Detection of Digitally Encoded Multi-Frequency Signals	A. Proudfoot (Research)	Australia U.S.A. Belgium Holland France Switzerland Sweden United Kingdom U.S.S.R. Canada Japan Fed. Repub. of Germany
Methods of Bonding Thermoplastic Material to Substrates	H. J. Ruddell R. Western (Research)	Australia

VISITORS TO THE LABORATORIES

The work of the Laboratories often calls for close liaison with various Australian universities and other tertiary colleges and with the research establishments of other Commonwealth departments, statutory authorities and private industry. Reciprocal visits are made by the staff of the Laboratories and of these other establishments for mutual participation in discussions, symposiums and lectures. In some instances, visitors with expertise in particular fields contribute more directly to the work of the Laboratories as consultants.
Laboratories' activities are also demonstrated to specialist and non-specialist groups from professional societies, other government departments, universities and other centres of tertiary education.
This is achieved through arranged inspection tours and exhibitions, and at longer intervals by formal "Open Days", when the work of the Laboratories is exhibited to invited guests from many walks of life. The Golden Jubilee of the Laboratories was marked by a week of "Open Days" in August 1973.
During the year, experts from overseas telecommunications authorities, universities, government departments and manufacturing companies have also visited the Laboratories. Other overseas visitors have participated in the work of the Laboratories for longer periods to further their training in telecommunications technology. Often, these visitors are Colombo Plan Fellows, whose visit to the Laboratories is a part of a more extensive period of training in the Department.

OVERSEAS VISITS BY LABORATORIES STAFF

It is an important responsibility of any viable organisation to keep abreast with developments and changes in particular fields of interest. To this end, the Laboratories arrange a programme of overseas visits each year during which members of staff interchange experience, technical knowledge, opinions and ideas. The visits are normally to other administrations, universities and industry, as well as to international forums and conferences of world telecommunications bodies and related organisations.
The following staff members have travelled overseas during the past year:—

Arter, F. W.	Macfarlane, I. P.
Brett, P. R.	Sandbach, E. F.
Cahill, L.	Sheridan, D. E.
Craig, E. R.	Slade, R. D.
Flatau, G.	Smith, B. M.,
Kidd, G. P.	Smith, R.
Lobert, O. F.	Wragge, H. S.

ASSISTANCE WITH STUDIES

The Laboratories have a policy of encouraging staff to further their educational qualifications and technical expertise by study in fields relevant to the work of the Laboratories. Professional staff are selected to pursue postgraduate courses, often leading to higher degrees, at universities and colleges of advanced education, or to broaden their experience by working outside the Laboratories for short periods. Non-professional staff are also encouraged to seek higher technical or professional qualifications through part or full-time study. Incentives are offered in the form of paid study leave and other concessions for part-time studies, or of extended leave without pay for full-time studies.
The following professional staff have been encouraged to engage in post-graduate studies or to seek wider professional experience during the past year:

Kuhn, D. H., University of Melbourne
Mattiske, D. D., University of Melbourne
Newton, A. R., University of Melbourne
Park, J. L., Monash University
Young, I., University of Melbourne

SPONSORED EXTERNAL RESEARCH AND DEVELOPMENT

The Department is aware of the external telecommunications research and development capabilities which exist in universities and similar institutions, and also in local industry. Recognising the mutual benefits of co-operative effort, it actively supports pertinent projects in these organisations through formal contracts and agreements, and through its participation in the activities of bodies such as the Radio Research Board.
The Laboratories, in particular, support outside research and advanced development projects in specialised fields, particularly those conducted by universities and other centres of higher learning. Current contracts administered by the Laboratories involve research on the topics below:

- PCM for Programme Transmission
- Transmission Equalisers for T.V.-Telephones
- Coding of T.V. Signals
- Mathematical Optimisation Techniques
- Very High Speed Pseudo-Random Noise Generation and Detection
- Solid State Technology for Microwave and Millimetre Wave Sources
- Liquid Filled Fibre Optics
- Electrical Discharges and Plumes on High Power HF Aerials
- Transmission Characteristics of Trunk Waveguide Systems
- Interdependence of Physical and Chemical Properties of Plastics with Insect Resistance

In addition, the Laboratories participate in joint projects with other national and international bodies, and where appropriate, seek to co-ordinate their research programme with those of the participating bodies to achieve the most effective use of the resources available.

Printed by F D. Atkinson, Government Printer of Australia