Research Laboratories Review of Activities 1976-1977

Telecom Australia

Review of Activities

Research Laboratories 59 Little Collins Street Melbourne 3000 Australia

Telecom Australia

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Foreword

The dramatic growth of scientific and technical knowledge and invention in the last two decades plus the associated technological advances, have created new opportunities for telecommunications administrations to improve the standard, or reduce the cost, of the services they provide to their customers, or to diversify these services.

Telecom Australia recognises the opportunities which new technology can offer, and regards the management of new technology as an important facet of its task in fulfilling its responsibilities to provide telecommunications services of high standard and variety to the Australian public. It also recognises that new technology offers the means to expand and upgrade the Australian telecommunications network with improved economy and flexibility for its future development.

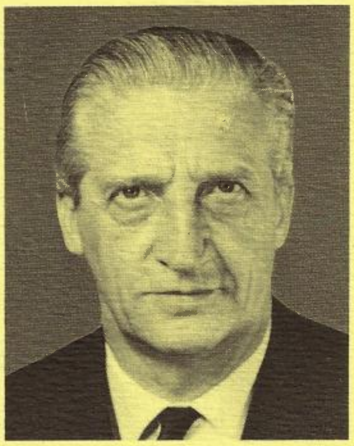
In managing new technology, Telecom Australia is aware that it must first of all develop its own in-house knowledge and competence to assess scientific and technical advances and to make independent judgements regarding their adoption in the form of new customer services or network systems in the Australian environment. Having made these judgements, Telecom Australia must then programme the actual adoption of new services and systems after further consideration of social and economic, as well as technical, benefits and costs, and implement the programme within the limits of its available resources.

The Research Laboratories fill the forward role by advising other Departments of Telecom Australia on the scientific and technical aspects of new technological developments in telecommunications. The Laboratories conduct selected R & D projects of relevance to the whole spectrum of network applications and through these projects develop the necessary knowledge and expertise to fulfil their role. This knowledge and expertise is also turned, as occasion warrants, to assisting other Departments with the solution of present day technical "problems" of the Australian network.

This Review of Activities provides an outline of some of the more important activities and projects conducted by the Laboratories during 1976/77. The variety and depth of the the articles herein illustrate not only the calibre and capacity of the staff of the Research Laboratories but also, the scope of the technical and scientific work encompassed. I commend this Review of Activities to you.

W.J.B. Pollock

(W.J.B. Pollock)
Chief General Manager



Albert J. Seyler

The staff of the Research Laboratories were shocked and saddened by the sudden death, in April this year (1977), of Dr. Albert J. Seyler, Head of the Advanced Techniques Branch; he was sixty-three.

Dr. Seyler was well known to telecommunications authorities throughout the world and was recognised for his research work on human communication systems and teleconferencing. In 1968/69 and 1973/74 he was engaged by Bell Laboratories, Homdel and Bell Northern Research, Ottawa, as a consultant, mainly in research on human communication systems and teleconferencing.

He graduated in 1938 from the Technical University Munich with the Diploma Ingenieur (Hon.) Degree in Electrical Engineering, and was awarded the Master of Electrical Engineering and Doctor of Applied Science by Melbourne University in 1956 and 1966 respectively.

For the first ten years of his career, he was engaged in research on air navigational aids, radar and radar-countermeasures. In 1948 he joined the Research Laboratories of the Australian Post Office where his research was primarily in the areas of television techniques and the coding and processing of visual information, with particular emphasis on the interaction of human visual perception with the engineering of visual communication systems.

In 1964 he became Head of the Advanced Techniques Branch directing research in the fields of guided and unguided media, computer applications, solid state and quantum electronics and visual communications. In recent years Dr. Seyler's personal research interests were centered on man-technology interaction problems in telecommunication, on the psychological and social impact of such systems, on human communication and the future lifestyle of society.

He was a Fellow of the Australian Academy of Technological Sciences, and a Fellow and Past President of the Institution of Radio and Electronics Engineers, Australia.

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The cover shows the pattern produced by the light output from an optical waveguide. Each colour represents a contour of equal light intensity. See article on page 42

The Role of the Research Laboratories

The Telecommunications Act charges Telecom Australia with the national responsibility to provide and operate telecommunications services best meeting the needs of the social, industrial and commercial needs of the Australian people - as economically and effectively as possible throughout Australia. In meeting this responsibility, Telecom Australia is mindful of the economic and practical benefits to be gained by the adoption of new and improved techniques, equipment and systems that result from advances in telecommunications science and technology.

The correct choice of technology and the increased emphasis on the efficient management of this technology in planning, developing and operating the telecommunications network ensures economy, efficiency and continuing flexibility in the ongoing task of developing the network which provides the services to the community.

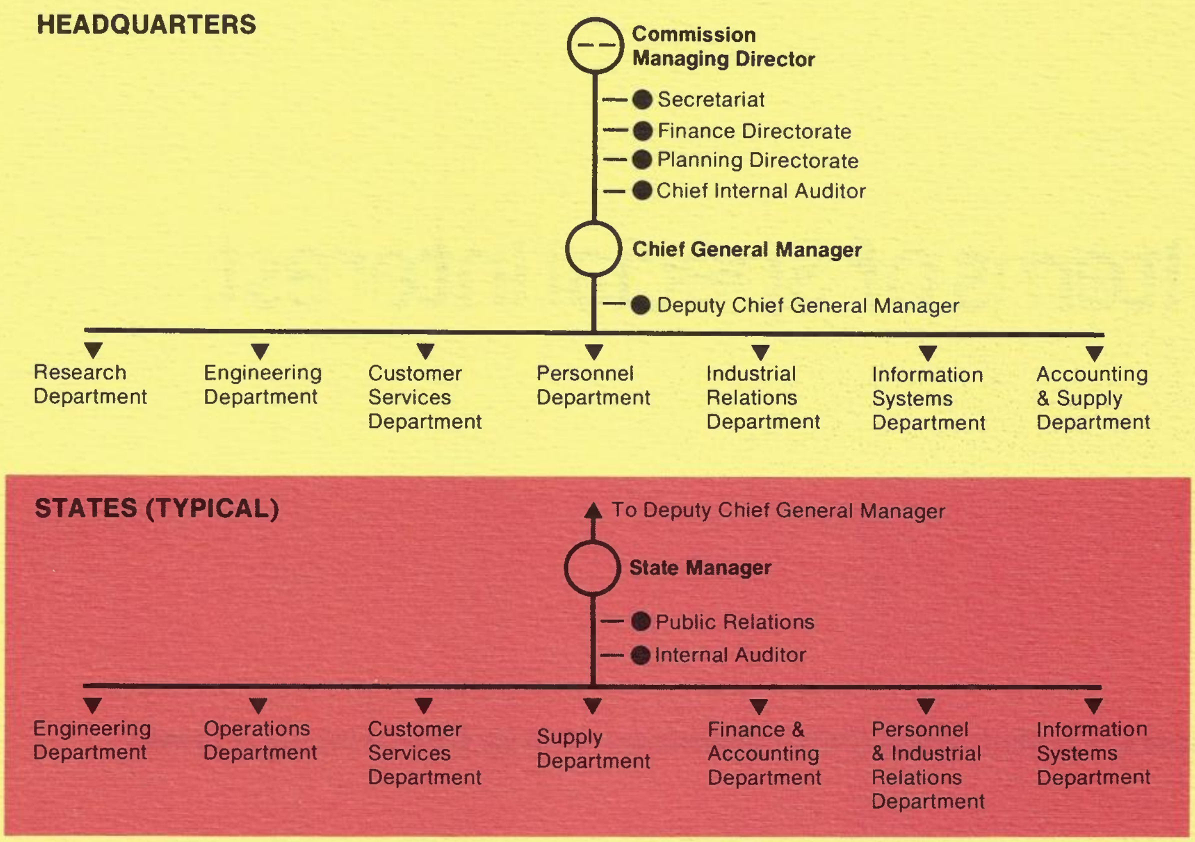
The Research Laboratories are the focal point for much of Telecom Australia's research and development work and effort. The Laboratories began in 1923 as a Research Section in the Headquarters Administration of the then Postmaster-General's Department, established to provide specialist technical advice to the Chief Engineer on "the latest discoveries, inventions and developments in electrical communications and their promising and likely benefits to the Department's telephone and telegraph services". Today the Laboratories are a Department in the Headquarters Administration of Telecom Australia and are headed by the Director, Research, who is directly responsible to the Chief General Manager. The Laboratories' work programme is determined in consultation with other Departments in Headquarters, predominantly the Engineering Department, and with the State Administrations.

The Laboratories, through relevant research and development (R & D) projects, seek to develop expertise in the scientific and technological fields to assist Telecom Australia in its implementation and formulation of plans and policies for new or improved services, systems, equipment and practices. Through the application of this expertise, the Laboratories also assist Headquarters and State Administrations in the solution of technical problems that arise in the design, manufacture, installation, operation and maintenance of plant items in service in the telecommunications networks.

These responsibilities of the Laboratories are met by maintaining a high level of expertise in the telecommunications and associated engineering disciplines, and in the related disciplines of physics, chemistry and metallurgy. This is done by conducting research and advanced development work on topics that are relevant to the Australian network, having regard to the work known to be in progress elsewhere in Australian research laboratories and in similar institutions overseas.

Many of the innovations, ideas and improvements proposed for the Australian network originate overseas. However, it is necesary for Telecom Australia to have advanced knowledge of these proposals so that they may be evaluated soundly, on social, economic and technical grounds, before they are accepted, or adapted and modified for incorporation into the Australian telecommunications system.

To help make these decisions and judgements with confidence it is necessary for Telecom Australia to have, at first hand, sound and competent technical advice. This is best derived from its own conduct of advanced development in each relevant technological or scientific field. Much of the advice received by Telecom Australia in these new and developing fields of telecommunications is offered by the staff of the Research Laboratories. Most of the projects undertaken by the Laboratories, rather than being directed at production specifications, find their ultimate expression in the



Organizational relationships of the Research Laboratories with other units of Telecom Australia

performance requirements of procurement specifications for the systems and equipment which is bought from the world-wide telecommunications industry. Other work is expressed in the assessment of materials, components and assembly practices used by suppliers in equipment tendered against Telecom Australia procurement specifications. However, some projects are carried to production when it is evident that the innovation, design and development work of the Laboratories will yield equipment directly suitable for field application.

Apart from carrying out a research and development role, the Laboratories have specialist staff with knowledge and facilities in a number of disciplines, including the physical sciences, who conduct investigations into difficult technical problems that arise in the operation of telecommunications plant. Further, the Laboratories are responsible for Telecom Australia's scientific reference standards of time interval and frequency and for the measurement of electrical quantities. In the former case, they are an agent of the National Standards Commission.

Telecom Australia, through its Research Laboratories, recognises the great variety and depth of research talent which exists in centres of higher learning and in industry in Australia. The Laboratories encourage these other research organizations to undertake specific projects of interest to Telecom Australia and acts as focus for this work for Telecom Australia.

The role of the Research Laboratories remains basically the same as it was when they were first established. In essence, their basic function is to develop knowledge and skills in the advancing areas of telecommunications science and technology to assist Telecom Australia to decide when, and to what extent, new technology should be introduced into the operational networks.

In the selection of activities reported in the following pages, this edition of the Review of Activities of the Research Laboratories illustrates the ways in which the Laboratories have sought to fulfil their role during 1976-1977.

Items of Special Interest

Pulse Code Modulation (PCM) Seminars— Visit by Commission Chairman

Telecom Australia has been monitoring for some time the viability of PCM transmission systems as an alternative means of provision of inter-exchange telephone circuits in urban areas. These systems have been used extensively in some overseas countries and their use in others is becoming significant.

- A policy decision to install PCM systems, where economically viable, was taken by Telecom Australia during 1976 and a choice of system type was made early in 1977.

Pulse Code Modulation represents a major shift in transmission techniques from the existing methods and, in gearing up for the introduction of PCM, it became very apparent that there was a need for an educational programme for engineers and others who were responsible for major decisions in the area, but who had little relevant experience in this new technique. The Laboratories have been studying PCM transmission for several years in anticipation of its introduction and it was decided to conduct a one-day PCM seminar by Laboratories' staff for interested engineers in Headquarters. That the seminar was successful is seen from the fact that it has since been expanded to a series of three seminars on digital line transmission, PCM encoding and time-division-multiplexing, and bearer utilization. The first two have been repeated some fifteen times to groups of engineers, and some technical officers, from Headquarters and the Victorian Administration. The third in the series, on bearer utilization is currently in progress and a similar attendance is expected. The total series have also been given to two groups of engineers from Queensland and two groups from New South Wales. It is highly likely that the series will be repeated in South Australia and Western Australia.

Towards the end of 1976, the series of seminars came to the notice of the Commission Chairman, Mr. R.D. Somervaille, who expressed a desire to join one of the groups, clearly indicating his interest in the important decisions being debated within Telecom Australia concerning the policy decision and system type. In the event, this proved impossible due to timetable difficulties. However, Mr. Somervaille did make a special visit to the Laboratories at Clayton to a half-day briefing with the seminar leaders. The topics discussed were wide-ranging and embraced the various factors relevant to the policy dicision and the system-type choice as well as the potential of digital transmission for data transmission and other services in addition to normal telephony. That Mr. Somervaille found the session valuable is clear from his subsequent letter of appreciation to the Chief General Manager.

Contributions to World Standards for New Telecommunication Switching Systems

Based upon experimental work, field trial experience and development of state-of-the-art switching systems, Research Laboratories staff have made substantial contributions to international standards in the telecommunication switching field. The contributions have in many cases been made by participation in Study Groups and Working Parties of the International Telegraph and Telephone Consultative Committee (C.C.I.T.T.) of the International Telecommunication Union (I.T.U.).

Two members of the Laboratories have recently taken up important roles in the current study period of the C.C.I.T.T.

Mr. H.S. Wragge, Assistant Director of the Switching and Signalling Branch, has been elected a Vice-Chairman of Study Group XVIII, Digital Networks; the Group has a major role to fulfil in setting internationally agreed guidelines for the implementation and operation of Integrated Services Digital Networks (ISDN). The Study Group was previously constituted as Special Study Group D. As Vice-Chairman, Mr. Wragge is responsible for studies of switching and signalling in digital networks.

Mr. P.H. Gerrand, Senior Engineer, has become Chairman of Sub-Group XI/3-4. The Sub-Group is to provide recommendations for part of Question 7/XI (Pictorial Elements and User Guidelines) concerned with the international development of a new Specification and Description Language for switching systems.

The First Australian Workshop on Optical Communications

On 14-15 March 1977, The First Australian Workshop on Optical Communications was convened by Professor A.E. Karbowiak at the School of Electrical Engineering, University of New South Wales. The meeting was jointly sponsored by the Radio Research Board and Telecom Australia. Present were staff members from Telecom Australia Research Laboratories, and representatives from local industry, Universities and the Defence Department.

Delegates presented a total of eleven papers covering many different aspects of optical communications research current in Australia. Topics included; the theoretical study of light propagation along optical fibres, methods of measuring fibre parameters, semiconductor lasers, optimum receiver design for fast optical systems, and the manufacture of low loss optical fibres and fibre cables.

After each formal session, delegates divided into informal discussion groups. These groups looked into problem areas under the topic headings : optical fibre theory, fibre and cable manufacture, terminal devices, system design, and integrated optics. Reports from these groups were later combined and a workshop report is in preparation.

A second Workshop will be convened early in 1978.

Echo Cancellation on Long Distance Telephone Circuits

As a result of work done in the investigation of new concepts in echo cancellation, Telecom Australia Research Laboratories were awarded a study contract by INTELSAT about two years ago. The contract (IS-668) was concerned primarily with the problems confronting echo cancellers in telephone networks which exhibit rapidly varying echo path characteristics and was awarded in two phases. Phase I provided for an investigation of the Victorian telephone network to demonstrate that time variant echo paths (specifically, cyclic variation termed "phase roll") constitutes a significant problem for communications through the INTELSAT satellite system. Work on phase 2 of the programme was conditional on the affirmative results from phase I and provided for a study of echo control techniques, and the design and development of a prototype echo canceller capable of coping with the problem.

Work under this contract was completed in January 1977, with the delivery to COMSAT (acting as managers on behalf of INTELSAT) of an echo canceller embodying a number of features not yet realised by similar equipment developed under INTELSAT contracts in Japan and in U.S.A. A Research Laboratories' engineer accompanied the Telecom Australia canceller to the COMSAT Laboratories where he instructed the staff in operating, alignment and testing procedures.

Although the Telecom echo canceller is still undergoing acceptance tests at the COMSAT Laboratories, favourable reports have already been received with regard to the work effort on the contract. This is testified by the statement made at a recent INTELSAT Board of Governors meeting:

> "Phase roll rates as high as 4 Hz have been reported, and the IS-668 echo canceller is the first canceller capable of operating in such a circuit while providing 16 dB of echo return loss enhancement. In contrast, the present model echo canceller, which relies only on convergence speed to track phase roll, provides the same amount of echo return loss enhancement at phase roll rates up to 0.3 Hz."

Prior to delivery of the echo canceller the Research Laboratories staff set up a demonstration of the canceller in a simulated operational environment in order to familiarize Telecom management and staff with the new concept of echo cancellation. Considerable interest in this concept was generated by the demonstration.

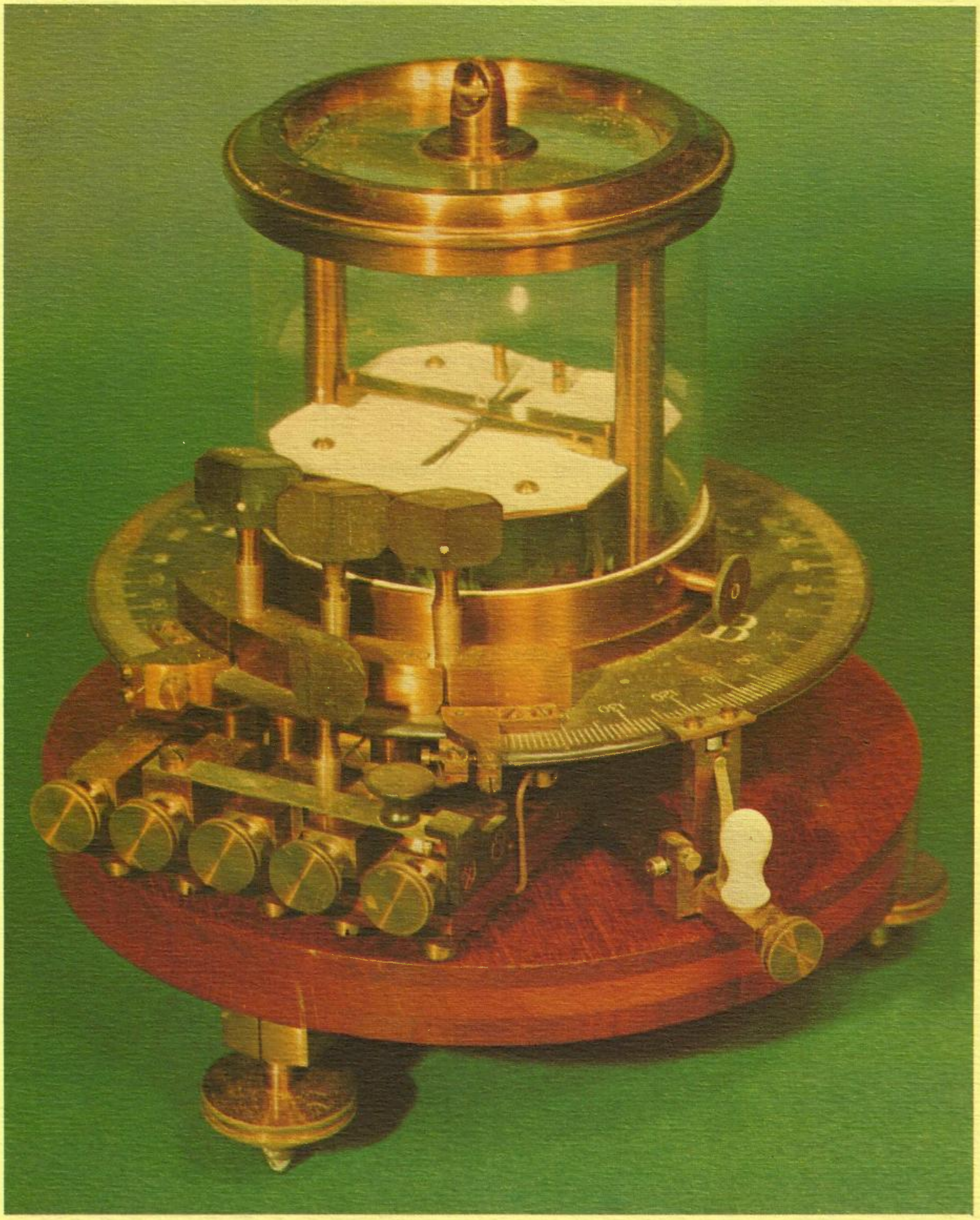
The Telecom echo canceller, following COMSAT evaluation, will be subject to world-wide field trials together with and in comparison with those from other sources.

Equipment of Historical Interest

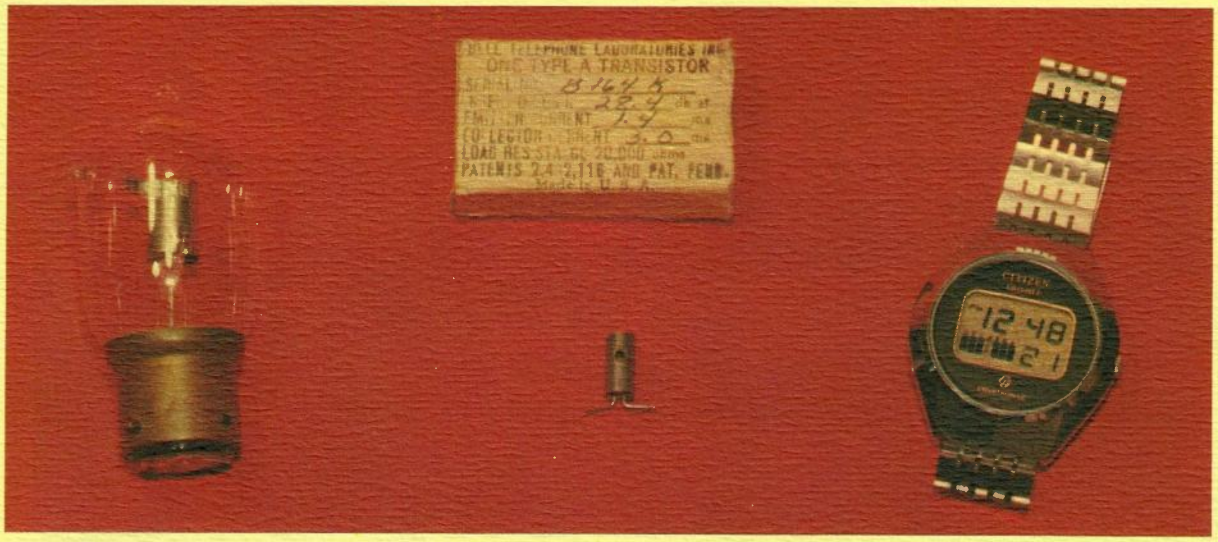
Bronowski in his book and TV series "The Ascent of Man" describes man's first invention, the sharp stone implement which was used without change for some one million years.

When one looks at some of the historical objects held by the Laboratories and considers them against later developments, a sense of respect arises.

Over 500 items of historical interest including measuring instruments, carrier equipment and telephone apparatus are carefully put aside for future display; one such item is a Fleming "Oscillation Valve", made by Ediswan, (England) probably about 1906, which fathered electronics as we know it today. There are other vacuum type tubes in our keeping, which can trace the development of these devices up to the present time. Further notable items include, carbon microphones, phonographic equipment of early radio



A Galvanometer from the late nineteenth century



A Fleming oscillation valve (1906), a Bell Laboratories type "A" transistor (1949) and a digital watch of today

broadcasting times, and submarine cable and carrier equipment recovered from communication installations linking Tasmania to the mainland.

Bell Telephone Laboratories, U.S.A., invented the transistor in 1948 and our Laboratories obtained some of these transistors in May 1949. They are now held as an historical record, illustrating the technological advances made in this field, in just under three decades.

The advent of the transistor began a spate of inventions in solid state devices, thick and thin film circuits, culminating with the recent developments in large scale integrated circuits. Modern pocket electronic calculators are a good example of this rapidly developing microelectronic field.

An item of considerable interest is the Kelvin Standard Current Balance. This instrument was made to a design of Lord Kelvin by a James White, Glasgow, Scotland, probably about 1910. A magnificent example of

Kelvin current balance

Cambridge thermionic voltmeter

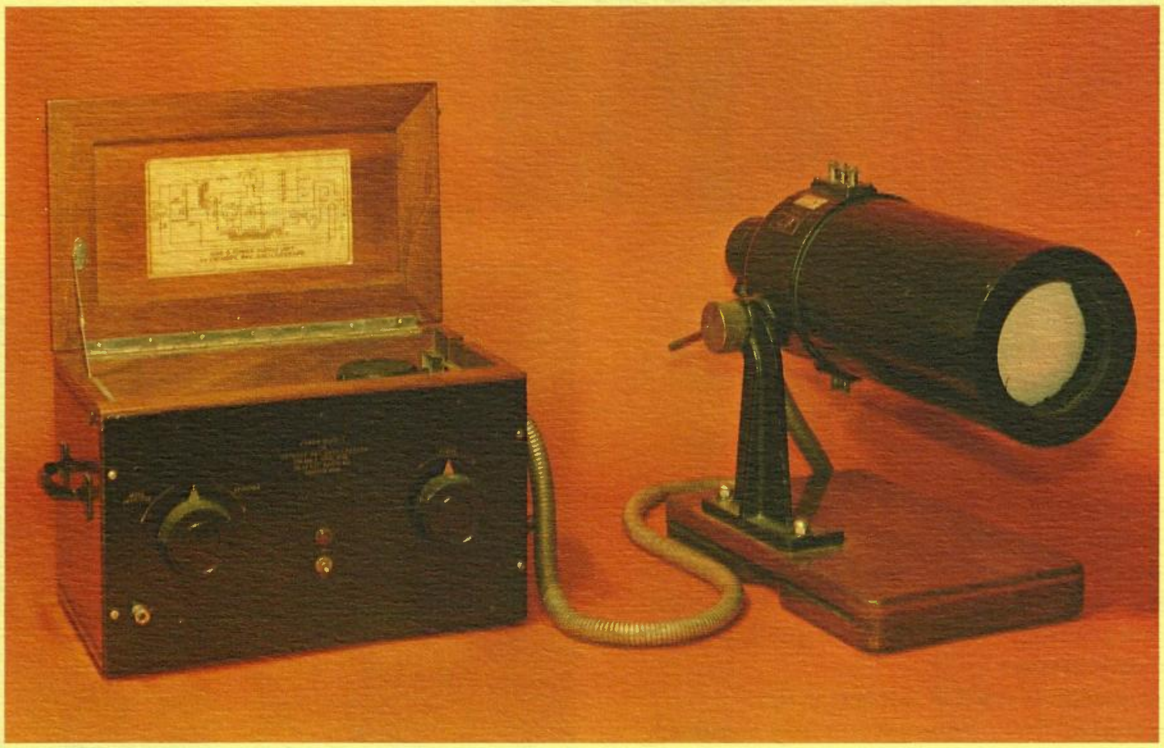
▼ Valve maintained tuning fork frequency standard (1928)

instrument-making at that time, it provided a measure of current balanced by the force of gravity. Under laboratory conditions the accuracy was about 0.2%. A 1924 Cambridge Thermionic Voltmeter is another historical instrument kept for future display. This instrument was one of the earliest valve voltmeters and consisted of a single range to 1.5 V full scale. Probable accuracy would be about 10% and readings had to be made quickly to avoid drift errors.

Of special historical interest is the Laboratories' first primary frequency standard. This was a 1000 Hz tuning fork oscillator; oscillations being maintained by a valve; made by H.W. Sullivan, England, in the late 1920s. The accuracy was considered to be a few parts in 10^6 under laboratory conditions.

A modern Cathode Ray Oscilloscope provides extreme complex performance, when compared with the General Radio (G.R.) Oscilloscope used by the Laboratories in the early 1930s; the improved performance is nothing short of staggering. The G.R. oscilloscope in the Laboratories' collection is no more than the viewing tube mounted in a frame and a simple power supply, all other accessories had to be provided by the user. It was considered so fragile that only certain people could use the instrument, have a good reason for doing so and, in addition, keep a log of operating times. The performance of this oscilloscope was of course limited, but it enabled some electrical events to be viewed as never before.

A museum, located in a suitably designed area for the display of these valuable and interesting historic items of equipment, is provided in the building plans of the new Research Laboratories' complex at Clayton North, approximately 20 km east of Melbourne. There visitors will be able to view and ponder with respect on the work of past engineers and scientists whose pioneering efforts made possible our present technological achievements.



The first oscilloscope used in the Laboratories

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 telecommunication 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 of the Laboratories' projects 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 the "Research Quarterly" 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 "client" and other interested sections of Telecom Australia, and in many cases, to other telecommunications agencies and industry as well as to other research bodies, both local and overseas.

The Laboratories have recently commenced publication of the Research Laboratories Report Summaries Booklet, which contains summaries of freely available reports. The booklet will be widely distributed both within Australia and overseas.

In addition the staff of the Laboratories often contribute to Australian and overseas technical journals and present 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.

Specialized Engineering Activities

During the past review year the staff of the Research Laboratories have been engaged in a variety of developmental, investigatory, design and innovative work, related to the wide range of telecommunications services provided or planned by Telecom Australia.

Some projects are initiated in the Laboratories, but many projects are undertaken at the request of other Telecom Australia departments. In some cases the work done by the Laboratories takes a consultative form, whilst in other cases it is work done jointly with these other departments, especially where the special expertise and specialized facilities of the Laboratories can be utilized.

The wide range of engineering activities engaged in by Telecom Australia requires a team of highly developed specialists who can provide the necessary assistance and advice to the Commission. In the Engineering field there are Laboratories groups working in such diverse areas as antenna development, solid-state research, satellite investigations, switching and transmission development and mechanical design and construction. A glance at the Research Laboratories' organization chart, which is located towards the end of this Review, will indicate the scope of the expertise employed.

The articles below cover a small portion of these specialized engineering activities and indicate the breadth and range of the specialities employed in solving some of Telecom Australia's engineering problems.

Tracing TV Signal Interruptions

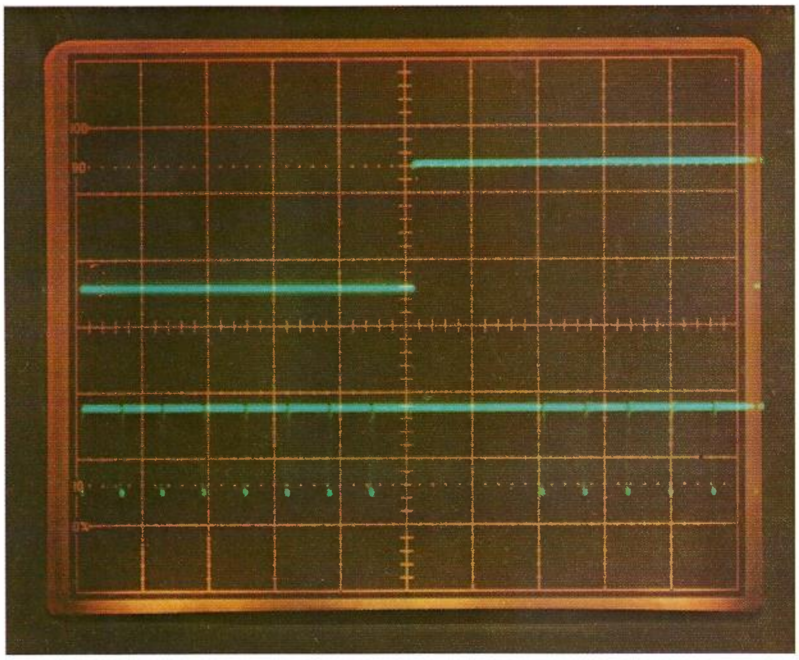
Telecom Australia operates a number of closed circuit television relay links between capital cities, and to major provincial cities. These links are used by television stations to provide live coverage of distant sporting events and news programme items, and to exchange programmes between stations. Confravision service, a closed circuit television conference service operating between terminals in Melbourne and Sydney, also makes use of these links.

In recent years, television stations have been using colour videotape recorders to store programmes prior to transmission. It is becoming common practice for programmes to be sent from a source station to other stations which store the programme on tape and replay it when required. These recorders are elaborate instruments, and require a very stable incoming video signal for proper operation.

The Confravision service uses Sound-in-Vision to relay its audio signals. The audio signals are coded and transmitted as a part of the video signal during the vertical blanking region of that signal. This provides a secure audio link, and also results in a substantial cost saving because audio programme lines are not required.

During tests of the Sound-in-Vision transmission system, short term breaks in the incoming video signal received at the Confravision terminal were discovered by Research Laboratories' staff. These breaks or signal losses can be very brief, in some cases as short as a few microseconds, and are difficult to detect by conventional methods. However, they can upset the Sound-in-Vision system under certain conditions, and are also believed to be the cause of problems with videotape recorders experienced by television stations.

In order to study these short term signal losses and to determine their nature and frequency of occurrence, a new test instrument has been designed in



Display of stored fault record

▼ Experimental instrument for classifying and counting interruptions in video signals

the Research Laboratories. This instrument can be used at television studios and switching centres to detect signal losses and count the number of occasions on which these losses occur.

The instrument examines the composite synchronising pulse waveform which it extracts from the video signal. If a synchronising pulse is faulty, in that it is unusually low in amplitude, is chopped, is misplaced by more than one microsecond, or is missing altogether, an alarm is given. The instrument then determines whether only a single pulse was faulty, whether two or more pulses in a small group were faulty, or whether the signal failed completely. One of three display counters representing these conditions is incremented accordingly.

The instrument also stores eight video line periods of signal before and after the first faulty pulse. This stored information is displayed on an external oscilloscope, and is very useful in identifying the nature of such transient faults. Several instruments monitoring different sections of the same link may be interconnected so that each counts only those faults occurring on its own link section, thus enabling faulty link sections to be identified.

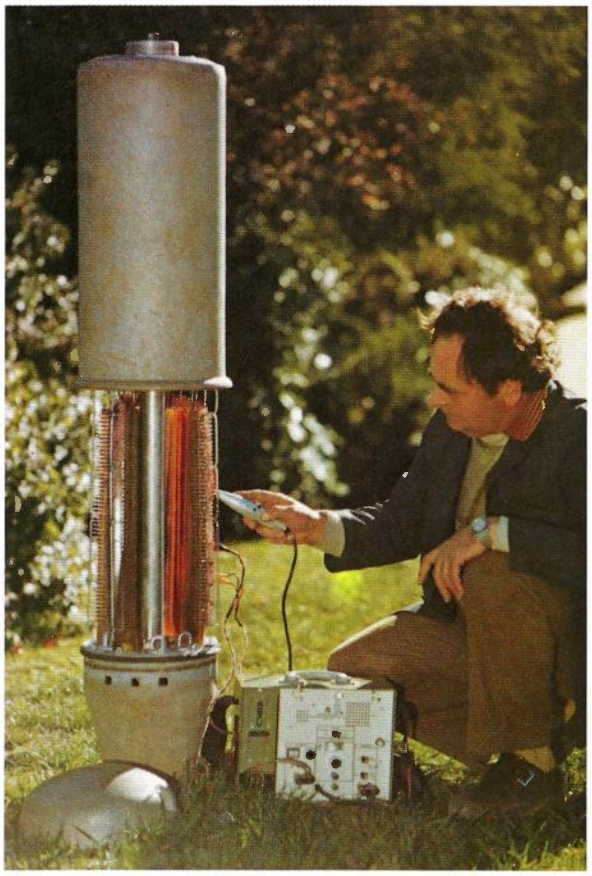
Experience with the few prototypes available indicates that this instrument will be a valuable tool in helping to maintain and improve the quality and reliability of Telecom Australia's television distribution network.

General Purpose Cable Pair Identification Set

Identification of a particular telephone pair for maintenance or cut-over purposes at a site remote from an exchange, is an increasing problem, particularly in the case of large random-jointed cables where pairs cannot be identified by colour code methods, and major cut-overs, where operations may extend into months.

Compounding this problem still further is Telecom Australia's charter to provide its customers with a service that is reliable and free from interference or interruption. This important criterion renders older identification methods unsatisfactory.

To solve these difficulties a General Purpose Cable Identification Set has been jointly designed and developed by the Research Laboratories and the Network Performance and Operations Branch, Engineering Department, Headquarters.Capable of a wide range of applications and tests, it uses a tone search method of identification. Basically, a signal is transmitted along the pair from a known or reference end, for example from an exchange, and detected at the remote site using capacitive coupling of the signal into a high input impedance probe. By this method the insulation on the pairs is not pricked or cut in any way, in fact, identification can be made without actually touching the pair. Whilst very substantially decreasing the identification time, it has also reduced the number of cable faults brought about by older pricking



The general purpose cable identification set with search probe being moved over the pairs to identify them

methods which pierced the insulation, leaving small holes for moisture to permeate.

Field trials of prototypes have been greeted with enthusiasm by field staff, particularly in relation to the very much improved signal-to-noise ratio as compared with other tone-search equipment. This improvement has been achieved by using a frequency modulated signal above the audible range and response of normal telephone equipment, thus allowing the removal of unwanted signals such as speech and induced noise, by sharp electronic filters.

The Set also performs many other functions required by linesmen and jointers not previously available in one unit, these are :

- Intercommunication facilities are provided between jointers and/or exchanges.
- Identification can be carried out in either high frequency or voice frequency modes.
- Conductive tone identification (direct connection) and dc resistance checks can be made.
- Leg identification can be performed under the control of the identifier at his remote site.

While designed to work in pairs, the set can operate alone, simultaneously sending and receiving to identify each pair. This requires that one pair in the cable be already identified, and that someone is located at the known or reference end of the cable to jumper pairs.

The entire unit in its pre-production format is quite compact (290 × 220 × 170 mm) but replaces and surpasses in performance a veritable wagon load of gear.

Worthy of note is the smaller, simpler version of this Set, the Type F Set. A spin-off of the early days of the General Purpose Set, it is a simple voice-frequency identifier with no other facilities. It is very compact and inexpensive but effective enough to warrant general issue. Thousands of these Sets have already been produced and its popularity is seen as an indication of the reception the General Purpose Set is likely to receive.

While more limited in its circulation than the Type F Set, the General Purpose Cable Identification Set should prove to be one of the most useful tools put into the field, allowing reduced pair identification time, thus resulting in less inconvenience and ultimately less cost to the public.

Microelectronics Phototools Using Computer Graphics

The Microelectronics Section of the Research Laboratories is currently using a Gerber Interactive Design System (IDS-2) for the preparation of phototools for microelectronics circuits. The term phototools is used to describe the photographic films or glass plates used in the manufacture of all types of microelectronics circuits. IDS-2 is a computer based graphics system which is particularly suitable for converting and storing graphical patterns into digital form for manipulation by computers.

A proposed layout of a Printed Wiring Board (PWB) or a semiconductor pattern is converted into digital form using a free-moving cursor fitted to a digitizer/plotter table. This enables automatic recording (or digitizing) of co-ordinates of points. A rounding-off feature in the system enables the position of an approximately placed X-Y cursor to be recorded exactly on the nearest of an operator predetermined set of grids. In this manner, recording of co-ordinates in the computer is not dependent upon the accuracy of the manually prepared layout. Frequently used patterns of a layout are composed only once, and then stored in the computer library ready for use in other layouts as required.

During digitizing, information on the size of lands and conductor tracks for PWBs are entered into the computer by an operator. In the case of thick film circuits, semiconductor devices and microstriplines, two functions, "Shape" and "Island" are mostly used. These functions are used to selectively "paint" that is, expose controlled areas of the pattern on photographic film by means of a photoplotter photohead. Since phototool patterns for thick and thin film devices are usually in the form of regular geometric shapes, the computer software has been designed so that the operator only enters the co-ordinates of the outlines of these shapes, the computer controls the automatic painting of the appropriate areas.

An important feature of the system is its capability of recording information in "levels". The concept of levels can be best described as a stack of transparent layers which may be displayed or output singly, or in any combination. This is a necessary feature for the composition of a multilevel structure such as multilayer PWBs, thick film and semiconductor devices.

The design of the pattern is finalized using a Visual Display Unit (VDU). This extremely flexible device resembles a small television screen in appearance. It has a very fast response, and is particularly suitable for editing, modifications and text addition. Selected areas of the pattern displayed on the VDU can be enlarged or reduced to assist editing of a complex pattern.

The final pattern design output is on a photoplotter which exposes photographic film or glass plate to produce a very accurate copy of the original layout. The accuracy of the photoplotter is ± 0.025 mm over an area of 510 mm $\times$ 410 mm. Hence the phototool produced has tolerances sufficiently accurate for direct use in the subsequent processing of the PWB. In cases such as semiconductor devices, thick films, and others requiring accuracy to several μm, reduction by a process camera is necessary.

The introduction of computer graphics has reduced markedly the time to produce microcircuit phototools as compared with earlier manual methods. In addition, the inherent accuracy of the system makes production of close tolerance phototools routine, thus allowing wider tolerances to be used on some subsequent processing operations. Other advantages, such as storing information in digital form, speed up and simplify future modification.

Although the system does not perform automatic layout of circuits, it is a step towards automation where the drudgery of a task can be relegated to a computer and the creative aspects become the main function of the operator.

The photo plotter

A Simple Algorithm for the Design of Optimal Equalizers for Data Transmission

The use of the existing frequency-division-multiplex (FDM) telephone network to carry digital data signals is now well established in Australia. More specifically the use of 4 kHz voice channels and to a lesser extent, 48 kHz group bands (12 voice channels) is widespread, while the requirement for higher rates of digital data transmission over 240 kHz supergroups (or combinations of supergroups) is expected to come from a digital data network currently under consideration in Telecom Australia.

One of the first problems encountered when transmitting digital data over FDM-derived channels is the phase distortion of the channel; this occurs because of the steep-sided channel filters and is normally left unequalized because of the tolerance to phase distortion of speech signals. This phase distortion, often characterized as group delay distortion, causes components of the data signal at different frequencies to arrive at the receiver with different delays and hence neighbouring data pulses overlap and interfere with each other. This either directly causes errors in the received data or reduces the immunity to errors from other causes such as noise.

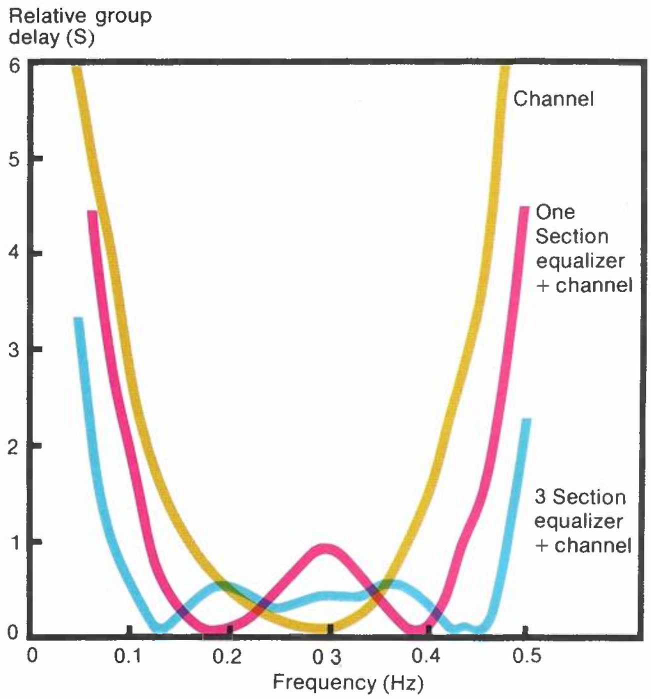
There are several possible approaches to overcome this problem of group delay distortion. For example, the traditional approach has been to use a fixed group delay equalizer to reduce the distortion below a somewhat arbitrarily chosen bound in the frequency domain, while more recently automatic adaptive equalizers have been used to minimize directly the interference between neighbouring pulses.While the latter technique is obviously advantageous on several counts, it nevertheless may be much more difficult to construct such an equalizer, especially for higher speeds of data transmission and because of this we have investigated the design of fixed group delay equalizers for data signals.

The technique of designing these equalizers to meet arbitrarily chosen frequency domain criteria does not directly minimize the interference between neighbouring pulses. In addition this approach is deficient in further ways as follows:

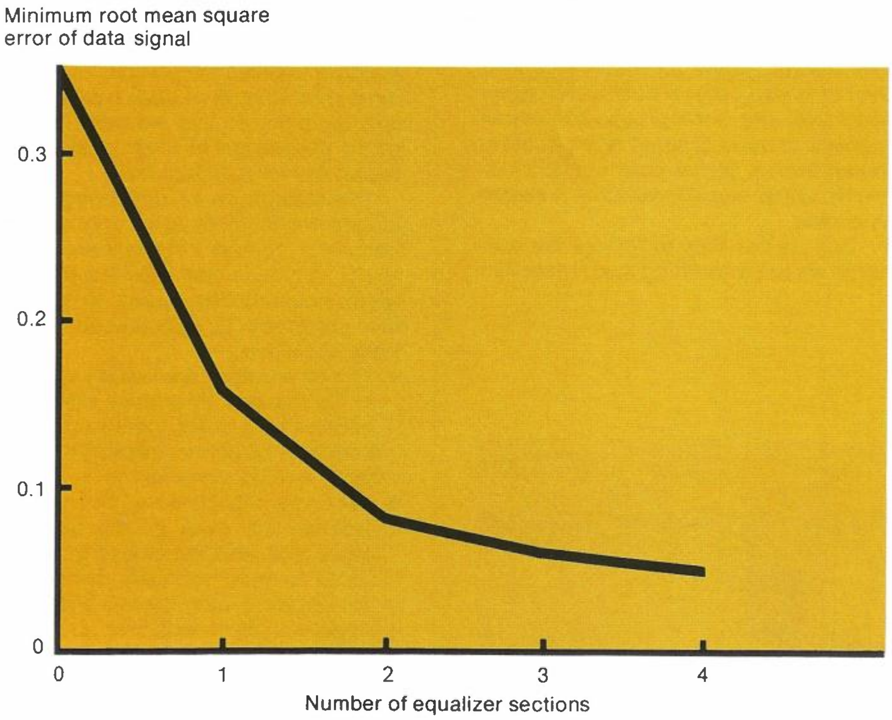
- The data pulses are usually sampled at the receiver by a clock signal and hence the less stringent criterion of interference at the sampling instants, only need be considered.
- Secondly, the freedom to vary at the receiver the delay of this sampling clock and also the phase of carrier (used to synchronously demodulate the received data signal) should be exploited, as a judicious choice of these parameters can partially overcome the group delay distortion.

The Laboratories have developed an efficient algorithm for designing fixed group delay equalizers taking into account these factors. This algorithm is applicable to a particular widely used type of data signal, for example, single-sideband amplitude-modulated (SSBAM) with Class 4 Partial Response spectral shaping. One interesting fact is that an equalizer designed by this algorithm optimally shapes itself to minimize the phase in proportion to the power spectrum of the data signal. Finally the performance of equalizers designed by this algorithm can be readily computed and used to determine what complexity of equalizer is required in a given application.

Equalized group delay characteristics showing the effect of one and three section equalizers



Example of the mean square error of an equalized data signal as a function of the number of sections in the equalizer
▼



Comparison of Measured and Computer Predicted Field Strength for Mobile Radio Telephone Service

One major problem in introducing a new mobile radio telephony service is the estimation of the satisfactory service area. A typical requirement could be to satisfactorily service 90% of the Extended Local Service Area for 90% of the time.

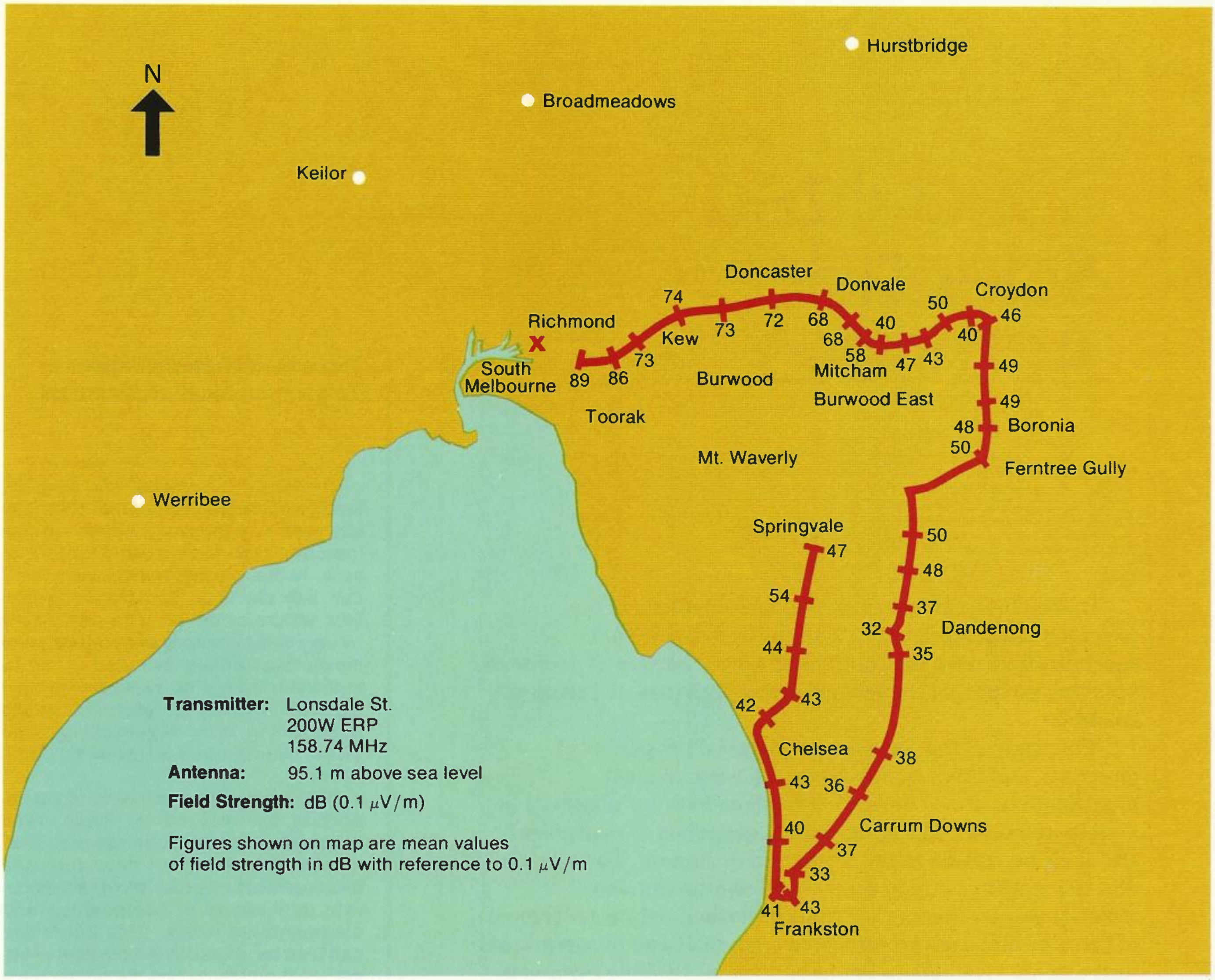
The service area can be roughly estimated by the use of published approximate curves, or precisely determined by a detailed measurement at sites intended to be serviced. An alternative method which does not suffer from large inaccuracies and does not require vast numbers of measurements uses a computer field strength prediction program. Such a program has been written in the Engineering Department, Headquarters. For this program the geographical area of interest is subdivided into squares of side 460 metre on a contour map and a height above sea level is determined for each square. Using these stored height data, the program will determine an average field strength for each square given the transmitter location, carrier frequency, effective isotropic radiated power (EIRP) and the transmitting and receiving antenna heights.

To help in the determination of mobile service areas, a mobile field strength meter has been designed and constructed in the Research Laboratories to operate in the VHF and UHF mobile frequency bands at around 150 MHz and 500 MHz respectively. The instrument measures instantaneous values of field strength and records them on magnetic tape for subsequent analysis. These measurements are made by driving the vehicle carrying the field strength meter around a predetermined route. For the study of the fine structure of the field strength signal, sampling is done at every 5 cm, the smallest intervals possible, whereas for studying the mean signal levels it has been found that sampling once every metre will suffice.

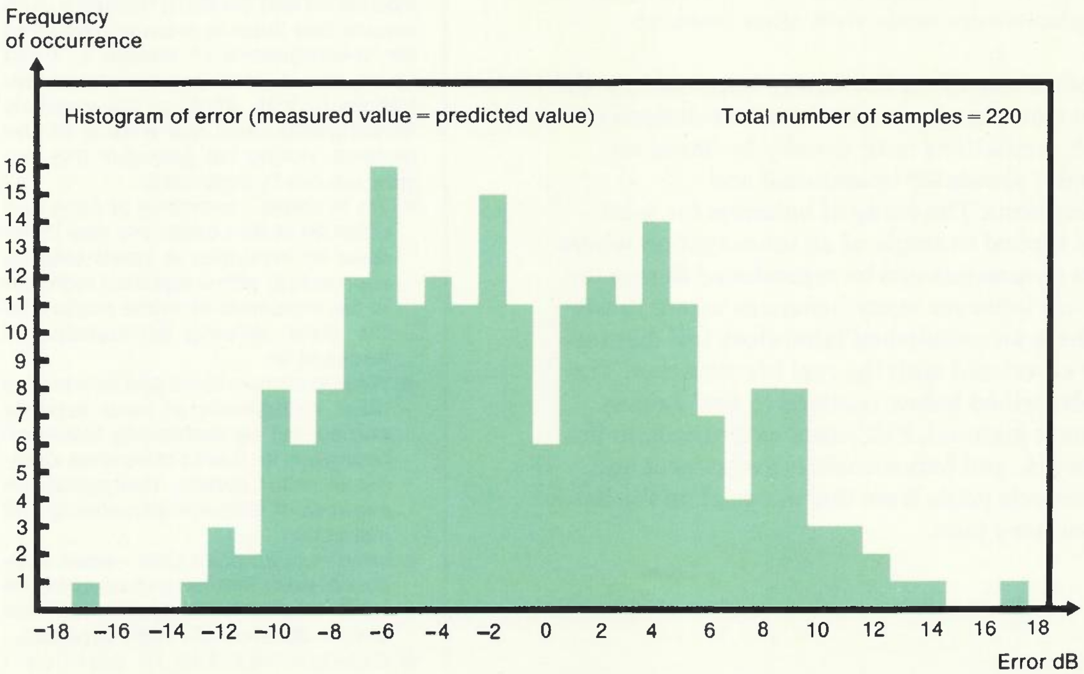
Besides being used for studying the received field strength signal, the field strength meter is being used to evaluate the accuracy of the computer field strength prediction program.

With the transmitter located 100 metres above sea level on the Lonsdale Street Exchange Building, Melbourne, and transmitting at 158.74 MHz with 200 W EIRP, the field strength meter sampled the field strength along the route indicated in the illustration. The route taken crossed 220 of the 460 metre squares of the prediction program. All measurements taken within each square were averaged to give a mean value of field strength for each square. Some of these values are shown along the route. The prediction program was run simulating the above transmitter parameters, and provided in its output, predictions of field strength for each of the 220 squares previously measured.

A histogram of the errors encountered is shown, from which it can be deduced that the errors have a mean of 0.6 dB and a standard deviation of 6 dB. Further, it can be seen that 93% of estimates are within ±10 dB, but only 53% are within ±5 dB. Further comparisons will be carried out at 500 MHz and if the errors are found to be equally significant, attempts to modify the prediction program will be made to improve its accuracy.



Map showing route travelled by vehicle



Histogram showing errors

Specialized Scientific Activities

During the year under review, the scientists of the Research Laboratories have continued to apply their specialized skills to the solution of a great variety of problems, touching on most of the technological activities of Telecom Australia.

The study of the physical or chemical properties of materials, and their composition, are basic to most investigations aimed at seeking explanations for observed or anticipated failures of components, materials or equipment, and their behaviour in the service environment. To carry out this task requires highly specialized equipment and techniques, and the two methods described below are typical of the uses made of the extensive analytical and observational instruments available in the Laboratories. In some instances, where the rate of utilization would not justify the purchase of very costly equipment, use is made of commercial analytical services, or arrangements are made with other research organizations.

A prediction of service life is frequently required in order to assess the relative merits of new or alternative designs or practices, and such predictions must usually be based on laboratory tests under simulated operational and environmental conditions. The study of batteries for solar power systems is a typical example of an investigation where most of the service parameters can be reproduced during the evaluation. There are however many instances where this is not possible, or where an established laboratory test method cannot be directly co-related with the real life situation. The co-relation study described below is aimed to find such a factor for a polymeric material, PVC, used extensively in the external plant network, and hence enables assessment and comparisons of products made from this material on the basis of accelerated laboratory tests.

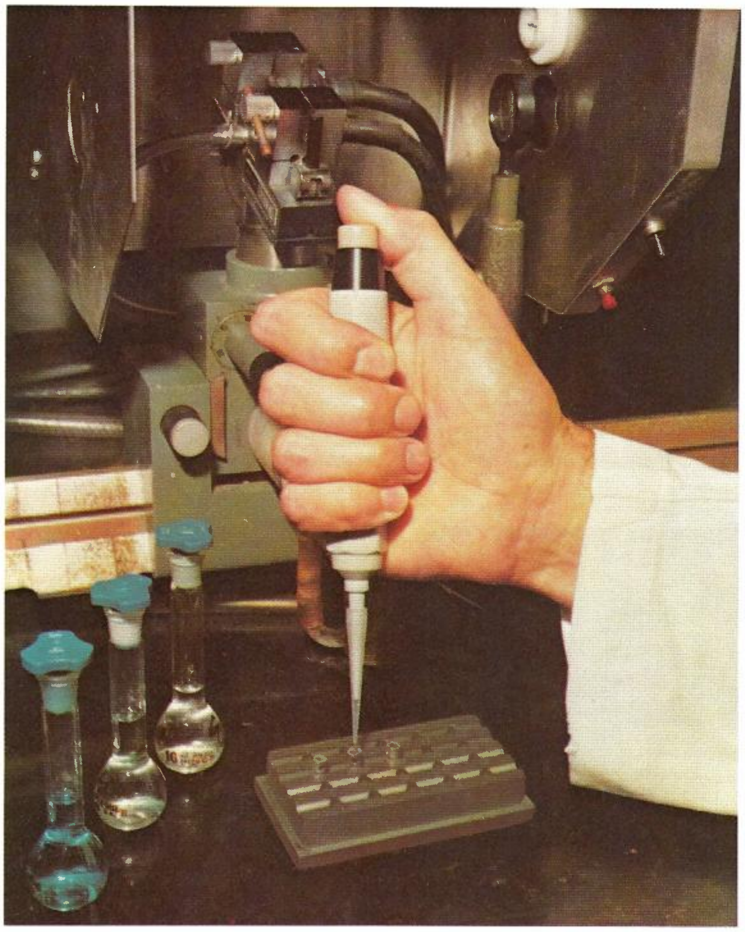
Trace Metal Determinations in Telecommunication Materials

The term "trace metal" can have differing meanings in various contexts. For example, in agricultural science it can indicate essential growth factors in soils. In the environmental sciences it can indicate toxic substances in surface waters or the air. The part played by very small amounts of non-functional metals accidentally included in, or intentionally added to, various engineering materials used by Telecom Australia is becoming more significant as their often deleterious effects become known.

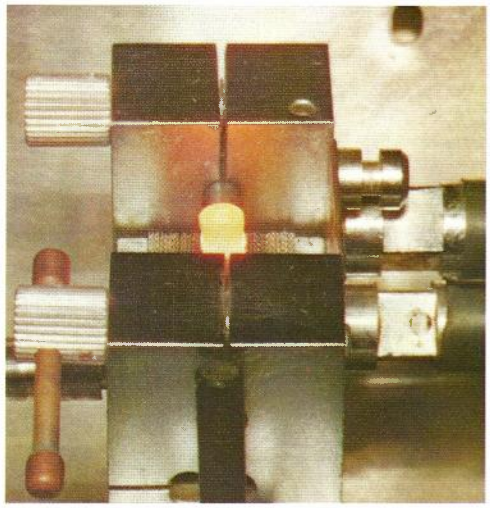
With increasing awareness of the important part played by these trace metals, the analytical chemist must seek improved methods of detection and measurement in order to obtain accurate indications of composition and concentration levels. This informtion can then be utilized in the solution of operational problems and the consequent remedial actions.

The wide range of Telecom Australia operations and the many materials used ensure that there is a continuing need for investigations of metals at trace levels, that is, parts per million concentrations or less. Some of the materials investigated, and the nature of the problem, during the period of this Review are briefly described:

- Tin in steels - recycling of cans and other tin plate containers may introduce tin impurities in steels utilizing such scrap, with a resultant increase in the incidence of brittle fracture in the steel, directly attributable to traces of tin.
- Wear in compressors and automotive plant - diagnosis of wear rates is carried out by monitoring the lubricating oils for traces of bearing, cylinder or piston metals. This avoids the expense of frequent dismantling and inspection.
- Lead in dried paint films - small samples of paint finishes can be checked for residual amounts of lead, and thus ensure absence of health hazards.
- Catalyst residue in plastics -



A small volume sample of 5μl (5 millionths of a litre) being loaded into flameless atomizer cups for analysis



▲
Atomization of samples with an incandescent carbon rod being employed on trace metal analysis

chemically active metals, left behind from catalyst aided processing of polyethylene, are known to accelerate the degradation of cable insulants in service.

- Electrolytes for power sources - active depolarizers, such as traces of platinum, affect the duty cycles of lead-acid batteries to a significant degree.
- Cooling water used in broadcast transmitters - traces of metal reduce the high resistivity levels necessary in the vapour cooling of transmitters as used by Radio Australia.
- Analysis for trace metals can be applied to measure those metals deliberately added to special glass compositions used in wave guide applications.

In all the above examples the instrumental analysis technique employed was Atomic Absorption Spectrophotometry. The flameless atomic absorption Spectrophotometer consists of five basic elements:

- Hollow cathode lamp energy source.
- Sample atomiser.
- Light monochromator.
- Detector.
- Readout system.

The hollow cathode lamp emits the spectrum of the metal being determined.

The sample solution is placed into the carbon cup using a micro-pipette and is atomized by the passage of a high current through the cup.

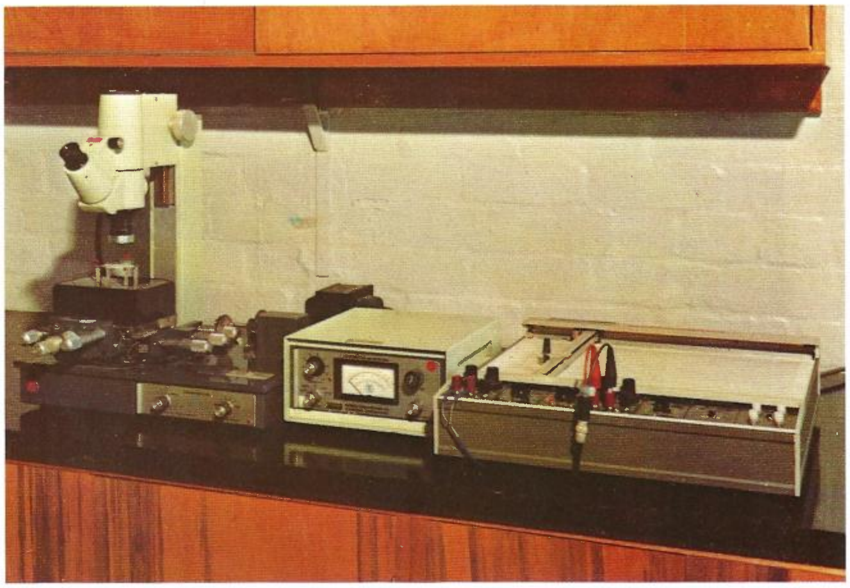
The light from the lamp passes through the atomic vapour, enters the monochromator which has been pre-set to an atomic resonance line of the metal to be determined, and then falls on a photomultiplier detector. The hollow cathode lamp output is modulated at the same frequency as the detector so that only the selected wavelength radiation from the hollow cathode lamp is "seen" by the detector.

The readout system comprises an ac amplifier which feeds its signal to a chart recorder.

The concentration of the element being analysed is related to the amount of light absorbed in the atomic vapour by comparison with standard graphs produced from the absorption of a series of calibrations using known amounts of the element.

Recently developed procedures in this field have resulted in the achievement of improved sensitivity and power of resolution, required for the satisfactory assessment and problem solution. Flameless atomization methods and background correction facilities have been employed to progressively improve the methods of quantitative chemical analysis for such trace metals.

Infra-red microscope measuring apparatus



Integrated circuit temperature being measured by infra-red microscope
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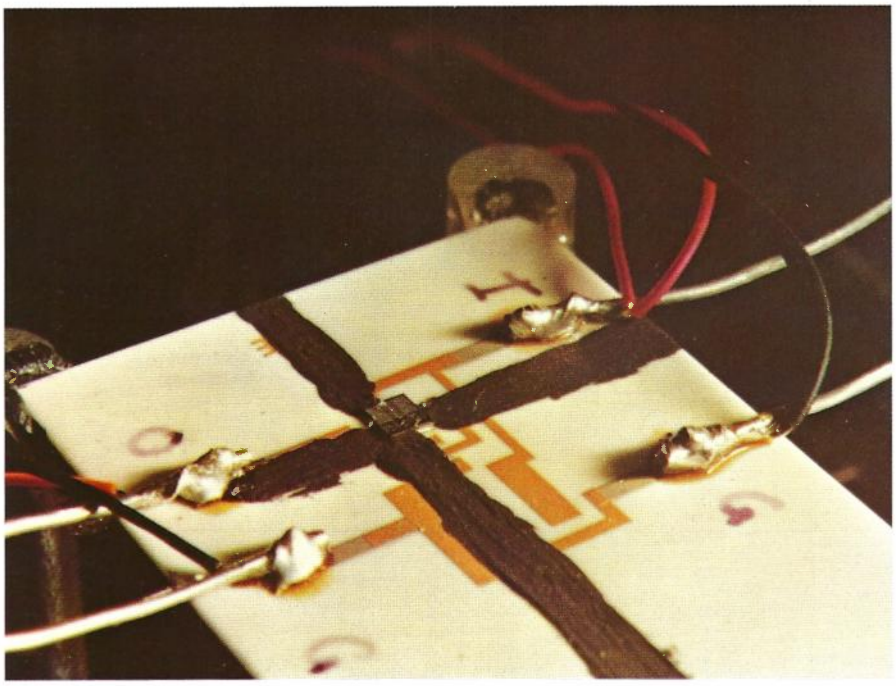


Infra-Red Microscopy

The infra-red microscope can survey surface temperatures by measuring the energy being emitted by a small area of the surface and then electronically converting this measurement to the equivalent temperature. The Barnes infra-red microscope (Model RM-2B) used in the Research Laboratories, is capable of directly indicating temperatures in the range 15°C to 165°C. Indirect measurement of temperatures up to 650°C can be made using a radiance scale and graphically converting radiance to temperature. The infra-red method of temperature measurement does not require sensors, such as thermocouples, to be placed in contact with the sample, but a disadvantage of this technique is the requirement to know the emissivity factor for the surface being measured. However in many cases a small portion of a surface can be coated with a paint of known emissivity, and the microscope then calibrated for this value. An alternative method is to heat a surface of unknown emissivity to a known temperature and then calibrate the instrument so that it indicates the same temperature.

The microscope has been used to locate and measure the temperature of hot spots on resistors and integrated circuits, to measure the heat transfer efficiency of heat conducting pastes used with heatsinks, and for the determination of surface temperatures on and near voltage regulator integrated circuit chips mounted on thick film substrates. The aim of this last investigation was to determine whether the regulator chips would operate within their temperature limits when placed on a thick film substrate, and how close other integrated circuit chips could be placed to the regulator chips without danger of their being exposed to excessive temperatures. The chips were operated at their expected electrical load, and measurements of the surface temperature were made at several points. Typical temperatures found were in the range of 110°C to 160°C, depending upon the power being dissipated in the chips and the heat sinking capability of the substrate on which the chips were mounted. To determine the temperatures on the thick film substrate in the region of the regulator chips, lines of black paint of known infra-red emissivity were painted onto the substrate and a plot of temperature versus distance from the regulator chips was obtained on an XY recorder. A typical measurement showed a temperature of 138°C very close to the regulator chips with a drop to 90°C approximately 5 mm away from the chips.

Development of Gas Seals for Telecommunications Conduits Containing Cables

The underground conduit system provided to accommodate telecommunications cables is subject to infiltration by gas from leaking gas mains. This creates potentially hazardous situations for staff and plant. The situation has been exacerbated in recent years by the introduction of natural gas which is reticulated at higher pressure than town gas.

Unoccupied conduits can be readily sealed using mechanical closures, but to seal conduits in which telecommunications cables have already been installed, is a problem without a simple solution.

The conduits to be sealed are usually made from unplasticized (rigid) polyvinyl chloride (UPVC) or asbestos cement and are nominally 100 mm diameter. The cables contained in a conduit may vary from a nominal diameter of 25 mm to 90 mm with one or more cables contained in a single conduit.

As well as sealing conduits against gas entry, the seals must be unaffected by water, petrochemicals and other wastes which infiltrate into manholes and drain along the conduits. The seals themselves or their constituents should not have any deleterious effects on polyethylene or lead cable sheaths or the conduits.

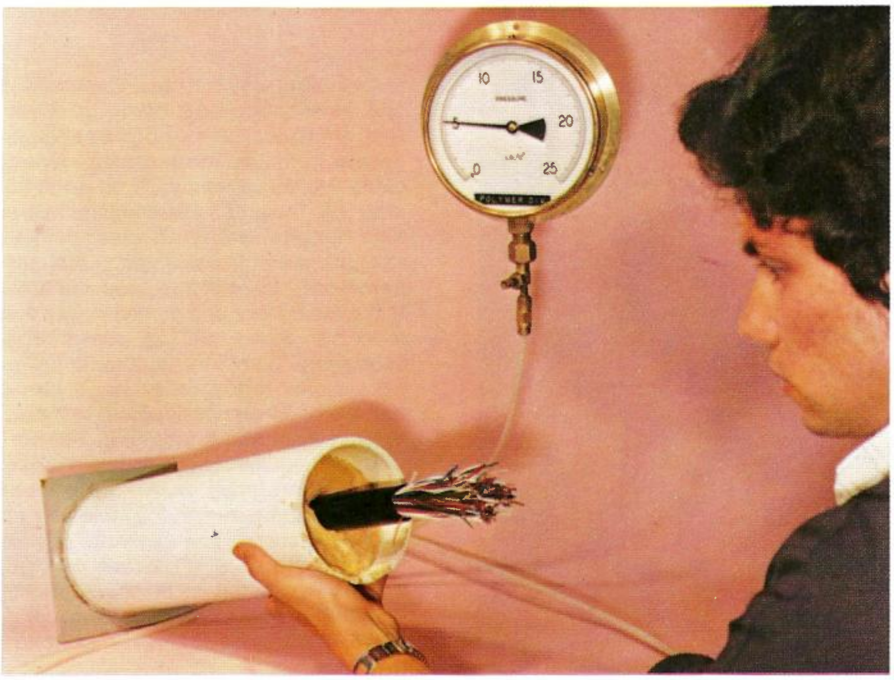
After consideration of the function and design aspects of the seals, it was decided that mechanical closures and sealing systems were not practical. Neither were mastics and adhesive pastes because they dry out, crack and retract, and thus provide short term sealing only.

It seemed that the most feasible solution to the problem would be to seal the conduit with a material that:

- Could be injected into the conduits by means of a hand-held gun, thereby overcoming the problem of access to the innermost conduit in a nest of conduits.
- Will adhere to both the cable sheath and the internal wall of the duct.
- Will expand in-situ to fill the interstices between cable sheath and conduit wall, exerting a positive pressure on the sheath and wall thereby providing an impervious seal against gas and liquids.
- As it ages, will not retract from the conduit wall or cable sheath.

Several pour-in-place plastics foams have been investigated, including urea-formaldehyde, epoxy, silicone, polyester and polyurethane. Of these, rigid polyurethane foam has so far been most successful for producing a satisfactory seal against gases and liquids. The polyurethane foam can be easily removed from the conduit with hand tools if a faulty or inadequate cable needs replacement. However, there are some aspects of occupational hygiene associated with the in-situ formation of polyurethane foams, which will require detailed investigation before these materials can be recommended for field practice.

Laboratory sample of a gas seal between a cable and conduit



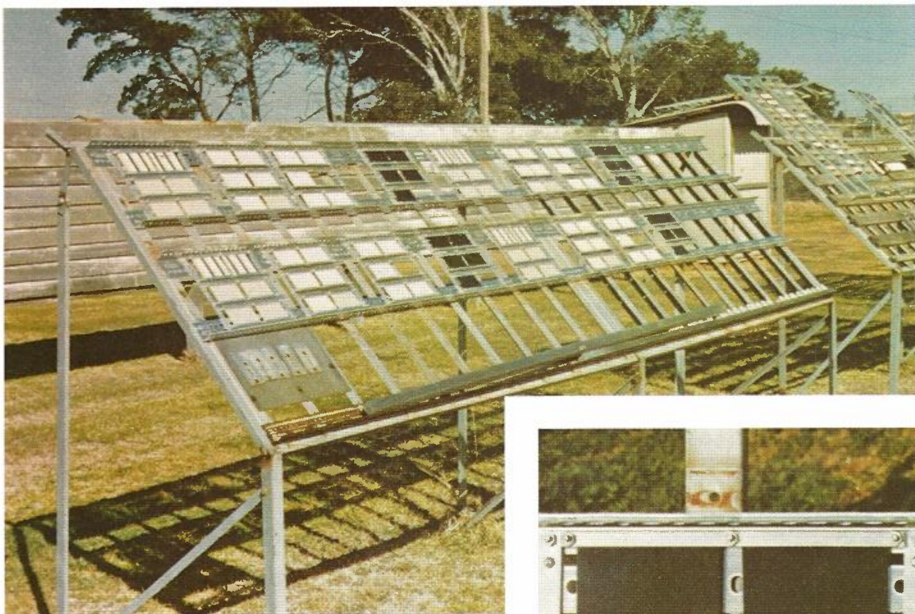
Correlation Between Outdoor and Laboratory Ageing of PVC

When an assessment of the life expectancy of a plastics material is required, it is often found that the only test data available has been derived solely from laboratory tests designed to simulate in the shortest possible time the most damaging aspects of the expected outdoor environment, particularly the ultra-violet component of solar radiation. In these tests, ultra-violet radiation is applied continuously at a constant intensity to give the earliest possible results. This compresses the time scale of exposure as compared with the natural life and results in test conditions which are accelerated in time and intensity.

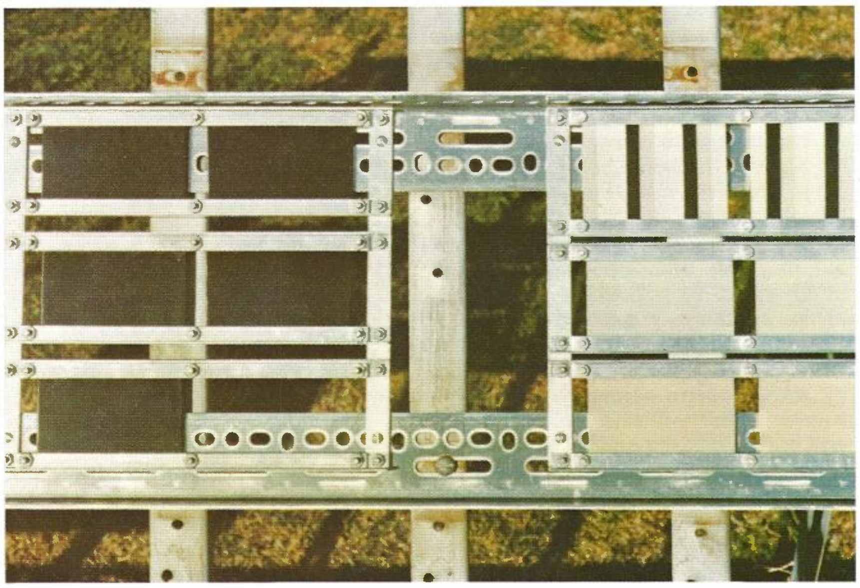
There is no accepted theoretical relationship between hours of standard artificial ultra-violet exposure and hours of exposure at a given outdoor site. This is the case even if the long term statistics of solar ultra-violet component versus time are known for the site. Likewise there is no generally applicable empirical formula relating the two types of exposure. A correlation must be established for each specific variety of plastics material and for each particular site by an actual trial conducted over the full period for which life expectancy figures are desired.

Unplasticized polyvinyl chloride (UPVC) is already in large scale use in Telecom Australia for conduits and its use for other applications is under consideration. A trial has begun to determine the correlation between artificial and outdoor exposure for this material so that data from artificial exposures in the laboratory can then be used to predict reliably and rapidly the performance to be expected in outdoor service.

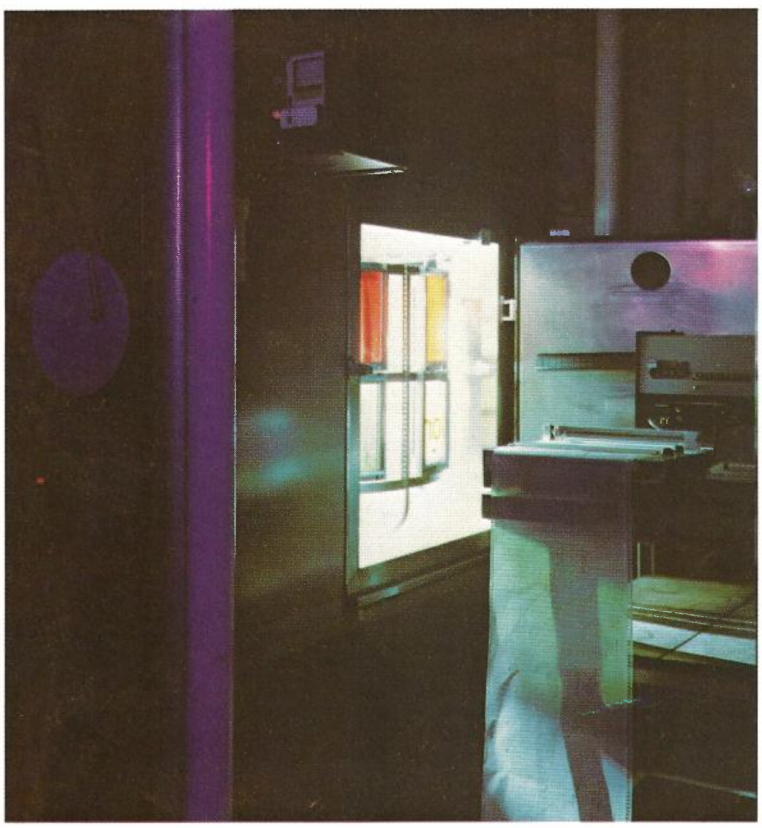
Four compositions, containing respectively 6 mg/g titanium dioxide, 50 mg/g titanium dioxide, 10 mg/g carbon black or no ultra-violet inhibitor at all, have been chosen and standard test pieces produced under precisely controlled conditions. Outdoor exposures commenced on 1 August 1976



Method used to expose test panels Maribyrnong, Victoria, with closeup showing specimens used



Xenon arc chamber exposing samples to equivalent radiation of summer noon day sun



at Cloncurry and Innisfail, Queensland, and at Maribyrnong, Victoria. These sites are typical of dry, hot/wet and temperate climates respectively. Specimens will be withdrawn from each site after 0.5, 1, 2 and 5 years and measured for changes in colour, gloss, impact strength, dielectric strength and relative permittivity. Control specimens retained in the laboratory and stored under optimum conditions, will be tested simultaneously. The intensity of incident ultra-violet radiation at each site is being monitored continuously at a number of wavelengths, including 340 nm.

Replicate specimens will be exposed in the Laboratories' xenon arc and carbon arc chambers and the incident radiation monitored. The exposure periods before withdrawal of batches of specimens is expected to be much shorter than that of the outdoor exposure specimens, and may be as short as a few hundred hours.

Investigation on the Service Life of Lead-Acid Stationary Batteries with Solar Generators

With the imminent construction of a new microwave link between Alice Springs and Tennant Creek (Northern Territory) it is proposed to power the system from solar generators. Interposed between the solar generators and the communication system, it is essential to have an electrical energy storage system and lead-acid batteries appear at this stage the most suitable.

Charging of stationary batteries from solar-cell power generators result in an entirely different working cycle compared with more conventional applications. Beside the rather low charge and discharge rates there is a seasonal variation in charging rate during a 24 hour period over the year, due to the fluctuating solar radiation.

There are a number of problems which have to be considered to ensure that the right type of battery is selected for the operation. The regular radiation difference in the yearly cycle produces a continuously under charged battery during the winter months and some over charge can be expected in summer. The radiation intensity and the consequent power generation has a regular daily cycle with a maximum available charging power at midday. Superimposed on these regular changes are the variations in the weather pattern with its random influence on the solar power generation plant.

In order to obtain some information on expected performance, stationary batteries have been subject to conditions as near as possible to those occuring in solar charge operation, and several tests have been suggested. In the initial part of this test programme, the capacities of 2V 500 Ah stationary batteries at low discharge rates have been determined.

Two fully charged 500 Ah batteries were test discharged at the 300 hour and 500 hour rates. The low rate discharges have been repeated twice. The 10 hour rate capacities of the batteries were determined before and after the low rate cycles. Cell and half-cell potentials, temperatures and acid densities were recorded periodically. The temperature of the batteries was maintained at 30 ±0.2°C. Between the low rate discharges the batteries were charged at the 50 hour rate for the first 150 Ah. This was followed by the 10 hour charging rate to 2.35V. The charge was completed at the 20 hour rate to constant potential. The full discharge is very deep at the 300 or 500 hour rate. As the expected internal resistance at the end of discharge is very high, an initial 10 hour charging rate is considered detrimental to the battery. This was the reason why the first 150 Ah was returned at the comparatively low 50 hour rate (maximum).

During the first series of test runs (at 30°C) the capacities of the batteries were as follows:

Test No.	Discharge Rate	Battery No.	Capacity in Ah at 30°C Battery No.1	Battery No.2
1	10h	1 and 2	633	716
2	300h	1	1020	
2	500h	2		1002
3	300h	1	1030	
3	500h	2		903
4	10h	1 and 2	642	578

The sulphuric acid concentration of the electrolytes were as follows:

	Acid Concentration Battery No.1	Battery No.2
At the start of discharge	34.6%	33.2%
At the end of 10h rate discharge	23%	18%
At the end of 300h rate discharge	6%	
At the end of 500h rate discharge		4%

As can be seen, the capacities at the low discharge rates are about twice as high as the nominal capacities for these batteries. In battery No.1 the test for capacity was very reproducible, while in battery No.2 there is a continual drop in capacity. The reason for this dissimilarity has not yet been established. Equally, there is some difference in their sulphuric acid utilization characteristics as well as in their charging potential change versus number of ampere-hours returned. To make the evaluation of the test results more reliable these tests are being repeated at 25°C and again at 30°C.

In the second stage of the test programme a new batch of batteries will be cycled to simulate winter and summer charge and discharge conditions. For winter simulation batteries will be discharged at the 10 hour rate to about half charge. At this level of charge they will be cycled with small discharges and charges. Similarly for summer simulation, batteries will be cycled with small discharges and charges in the fully charged condition.

From the results of all the tests, it is anticipated it will be possible to assess the suitability of stationary lead-acid batteries for coupling with solar generators.

Transmission

The affectiveness of the introduction of new transmission systems into the Telecom Australia network is governed, to a large extent, by our knowledge of the transmission performance of both the new systems and the existing transmission network. Both of these areas have been under active study in the year under review, and studies are continuing.

The investigation of the transmission performance of new transmission systems is potentially much simpler than investigating the transmission performance of the existing network. Much of the former entails evaluation of equipment techniques, the operation of which is, to a large extent, unaffected by the characteristics of the network, whereas the latter entails gaining statistically meaningful estimates of pertinent network characteristics. These estimates can only be obtained by extensive field measurement, which is costly and time consuming. On the equipment side, laboratory investigations have been carried out on, for example, facsimile transmission, data modems, data multiplexers, digital radio and primary level pulse code modulation (PCM) equipment. On the network side, studies have also proceeded on a number of fronts including mobile radio propagation, rain attenuation at microwave frequencies and crosstalk in junction cables; all of these have been measured in the field.

The results deriving from these investigations are important inputs to transmission system studies being carried out in the Research and Engineering Departments. More detailed accounts of some of these studies within the Research Laboratories are highlighted in this section of the Review.

Technical Evaluation of Primary Level PCM Regenerators

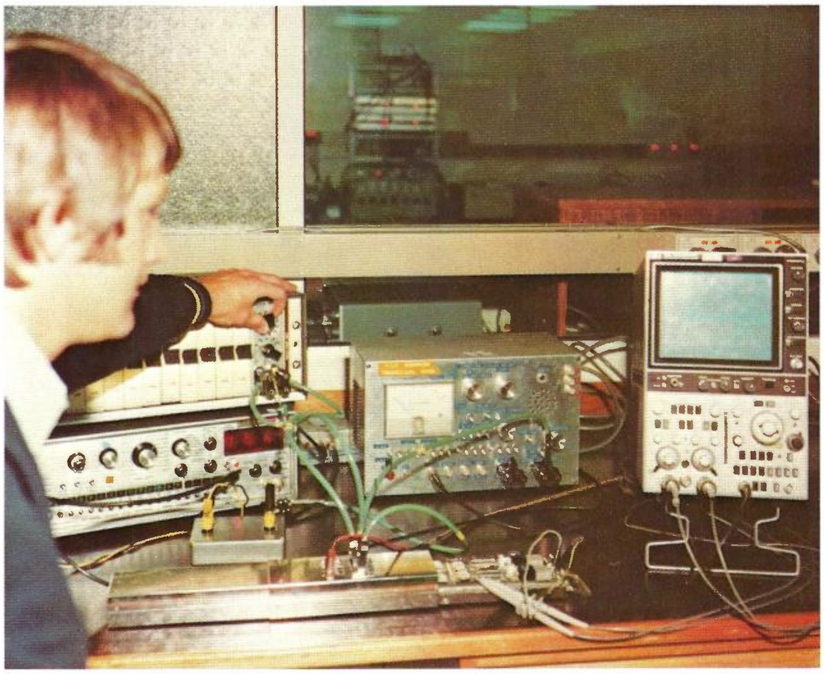
An important function of a PCM line regenerator involves equalization of the input line signal. In commercial PCM line regenerators of recent design, this operation is performed by a variable equalizer which automatically adjusts itself to compensate for the attenuation and distortion produced by the preceding cable span. The automatic equalizer circuit is designed to cater for a range of cable section lengths and cable types. Thus, provided the cable loss (at a particular frequency) is within the range catered for by the particular regenerator design, there is no need for the actual loss to be known.

The performance of a PCM regenerator depends to a large extent on the equalization operation. PCM line errors can occur in a regenerator when the amplitude of an interfering signal exceeds a preset threshold level at the decision point in the regenerator. The noise margin against interference at the decision point is dependent on how well the line signal is equalized. Imperfect equalization leads to intersymbol interference which causes a reduction in the noise margin and this in turn increases the regenerators sensitivity to noise, crosstalk, etc., and generally results in more line errors arising than ideally expected. For example, a 0.5 dB (approx.) reduction in noise margin due to the affects of misequalization can cause an order of magnitude increase in error rate and therefore if a regenerator's equalization characteristics can be measured and quantified, one has a useful method of predicting its performance capabilities prior to its installation in the field.

With the above in mind a technique has been developed within the Research Laboratories to quantify the equalization performance of commercial PCM regenerators. The equalization performance is assessed by monitoring the pulse pattern (that is the eye diagram) produced at the output of the regenerator equalizer. A pseudo random test signal is used. The eye diagram is displayed on a cathode ray oscilloscope and the reduction in noise margin due to misequalization calculated from measurements of the amount of eye closure. The reduction in noise margin in a particular regenerator is quantified in dBs and plotted as a function of line loss. Since the operation of the automatic equalization circuits used in commercial PCM regenerators is never perfect, the noise margin is less than that ideally possible and considerable variation in noise margin can occur with different cable span losses.

The equalization performances of a range of commercial PCM regenerators have been examined and considerable experience gained about the various equalization techniques used by different manufacturers. The relative technical performance of regenerators of different manufacture have been assessed and other aspects of their operation examined.

For example, in a particular situation, a PCM line regenerator may be unknowingly, or even deliberately, installed on a regenerator section with a preceding cable span which has a loss outside the range nominally catered for by the regenerator design. Consequently, when examining the equalization of a commercial regenerator, it is of interest to establish how rapidly its performance, for example its noise margin, deteriorates when the preceding cable loss limits are exceeded. If only a gradual deterioration occurs it may be possible to tolerate cable span lengths with losses exceeding those nominally catered for by the regenerator. However if a rapid degraduation occurs outside the loss limits, it may be necessary to include extra safety margins when specifying PCM cable section lengths, to ensure that the loss limits are never exceeded. From these types of invesitigations, any restrictions which may apply to the application of a commercial PCM regenerator can be identified prior to its installation in the field and thus greater reliability of service operation achieved.



Measuring equalizer performance of a PCM regenerator

Special Impulse Noise Measurements Designed to Facilitate the Installation of PCM Systems

Impulse noise arising from both natural (lightning), and man made causes (switching transients in exchanges and dc loop/disconnect signalling pulses in adjacent cable pairs), is a potential cause of bearer errors in PCM transmission systems. However, on most PCM routes the impulse noise arising from natural causes is generally negligible and the dominant cause is due to man made interference. Since most of this latter type of interference arises from exchange equipment, the level of impulse noise in cable pairs at the point of connection to an exchange is usually significantly higher than that at more remote points from the exchange. In addition, the amount of impulse noise is strongly correlated with the amount of telephone traffic and is most evident during the busy hours of a day.

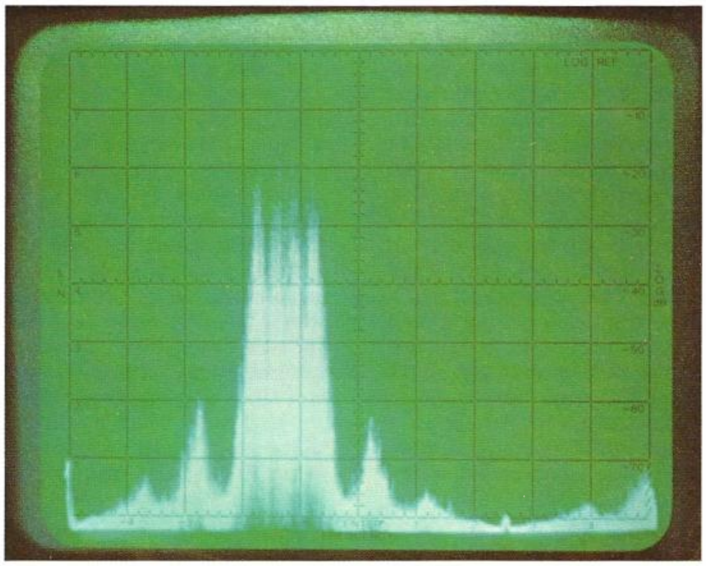
At this stage, due to the limited number of PCM systems installed in the Australian network, it is not known whether the levels of impulse noise existing on junction cables is sufficient to affect the operation and performance of PCM systems. In the short term, the overseas practice of using regenerators at intermediate exchanges and half nominal span lengths on regenerator sections adjacent to exchanges is likely to be followed with the installation of PCM systems. However, since on the one hand there are economies to be achieved if this practice can be relaxed or avoided, or on the other hand more stringent installation procedures may need to be adopted if impulse noise levels are higher than those encountered in overseas networks; there is an urgent need to characterize this type of interference.

Although it is well known that impulse noise consists of short spikes of high energy, little is known about the shape and amplitude probability distribution of the noise spikes and their spectral content. The main investigations of impulse noise made in connection with PCM systems were carried out in the early 1970s on the PCM field trial routes. The impulse measurements made on these routes were performed with commercial impulse noise meters designed mainly for application with VF data transmission systems. In particular they contained input filters which removed the spectral content of the impulse noise above about 10 kHz.

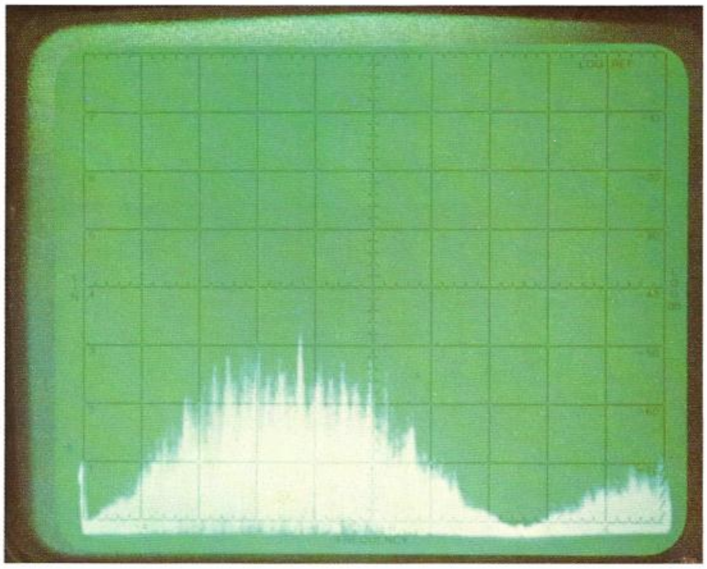
Recent measurements carried out in the Research Laboratories on current commercial PCM regenerators has shown that impulse noise in the frequency band below about 10 kHz is not likely to cause errors due to the low frequency roll-off used in the input equalizers. For example, the gain of the input equalizer of a commercial regenerator typically begins to roll-off at about 10 kHz and decreases at a rate of about 40 dB/decade for decreasing frequencies below 10 kHz. Consequently, the results of previous impulse noise measurements give little indication as to whether impulse noise will affect the operation of future PCM systems.

In current PCM regenerator designs the input equalizer automatically adjusts itself to compensate for the pulse dispersion and attenuation produced by the preceding cable span. Consequently, the level of impulse noise necessary to cause line errors depends on both its spectral content and the loss of the preceding cable span.

In view of the above, a new investigation has been undertaken to gather impulse noise data directly relevant to PCM. The measurement technique being used involves a commercial PCM regenerator which has been modified to allow the level of impulse noise at its decision point, that is, at the output of the input equalizer to be monitored and the number of times the noise level exceeds that level required to cause a line error, counted. Since this measurement includes the effect of the input equalizer it gives a direct indication of the number of line errors which would be caused by the level of the impulse noise at the particular test locations involved. The impulse noise measurements are being carried out initially in Victoria and Queensland by the State Administrations and will provide valuable data which will assist in the planning of regenerator locations on PCM routes, particularly in respect to the regenerator span lengths which should be used adjacent to terminal and intermediate exchanges.



▲ Spectrum for unscrambled 24 channel PCM signal
▼ Spectrum for scrambled 24 channel PCM signal



The Application of Scramblers in PCM Systems

One of the important aspects of the current Laboratories' research in the area of primary level PCM transmission equipment concerns the transmission of data over PCM channels. The type of line signal used is particularly important in this regard. Since PCM regenerators use changes of state of the line signal to obtain signal retiming information, the pulse density of the line signal should always be maintained at a satisfactory level. For speech signals, coding methods can be chosen to obtain a satisfactory pulse density, however difficulties may be encountered with data transmission.

A data user should be allowed a free choice of the information which he can send over the transmission system; for example he should be able to send a signal of very low pulse density. That is, it is desirable to provide the user with bit sequence independent transmission even though the transmission system might be bit sequence dependent. This can be accomplished by scrambling the signal which is to be transmitted.

A scrambler takes a binary input signal and combines it with a pseudo-random signal to produce a pseudo-random binary output. This type of signal has pulse density of approximately 1 in 2 and a low probability of long strings of zeros, consequently it is quite satisfactory for transmission. The scrambler can be placed in the transmit terminal equipment. After transmission it is necessary to unscramble the signal to obtain the original binary information. The descrambler is similar in form to the scrambler and can be placed in the receive terminal equipment.

In the investigations carried out, scramblers of both the self-synchronizing and reset types have been designed and tested with a 24 channel PCM system. They have been designed to scramble either the complete line signal or only the output of a data interface.

As well as providing bit sequence independence, scramblers have another attractive feature. When the majority of the channels of a PCM system are in an idle condition, for example during the night, each of these channels will transmit a similar signal. At these times the output spectrum may contain large peaks and consequently the crosstalk between systems may deteriorate. A scrambler helps to break up any such repetitiveness and hence smooths the spectrum. The result may be an increased system penetration of cable.

The investigations have shown that only a small amount of circuitry is necessary to realize the above advantages and that scramblers are not difficult to include in PCM terminal or data interface equipment.

PCM System Penetration in Existing Pair Cable

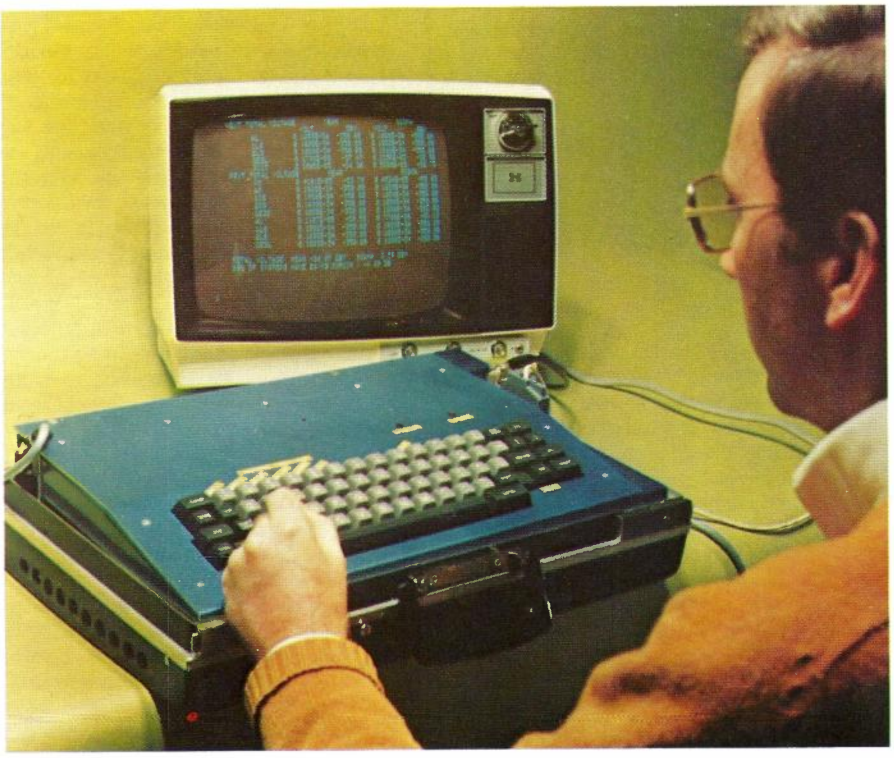
The number of primary level PCM systems which can be accommodated under a pair-cable sheath is primarily a function of the level of near-end crosstalk (NEXT) in the cable and the regenerator span loss. Both of these quantities are statistical in the sense that both vary from pair to pair and cable to cable, and therefore both quantities cannot be predicted with certainty. This in turn leads to the result that the penetration of primary level PCM systems in pair cable cannot be predicted with certainty - there is always a finite probability that a particular number of systems will not operate with better than a prescribed error rate. Nevertheless, this probability can be made small, for example, 1%, provided the statistics of NEXT and cable loss are known with sufficient accuracy.

The accurate estimation of the statistics of NEXT and cable loss is in itself a difficult problem which requires an extensive programme of field measurements of pair cable. A start has been made in Queensland and Victoria on this field measurement programme, this is being supplemented by laboratory measurements on drum lengths of cable. Both PIQL and PIUT cable has been measured to date and it is planned to progressively gather NEXT and loss statistics from future PCM installations so that the penetration on all types of cable in the Telecom Australia network can be determined.

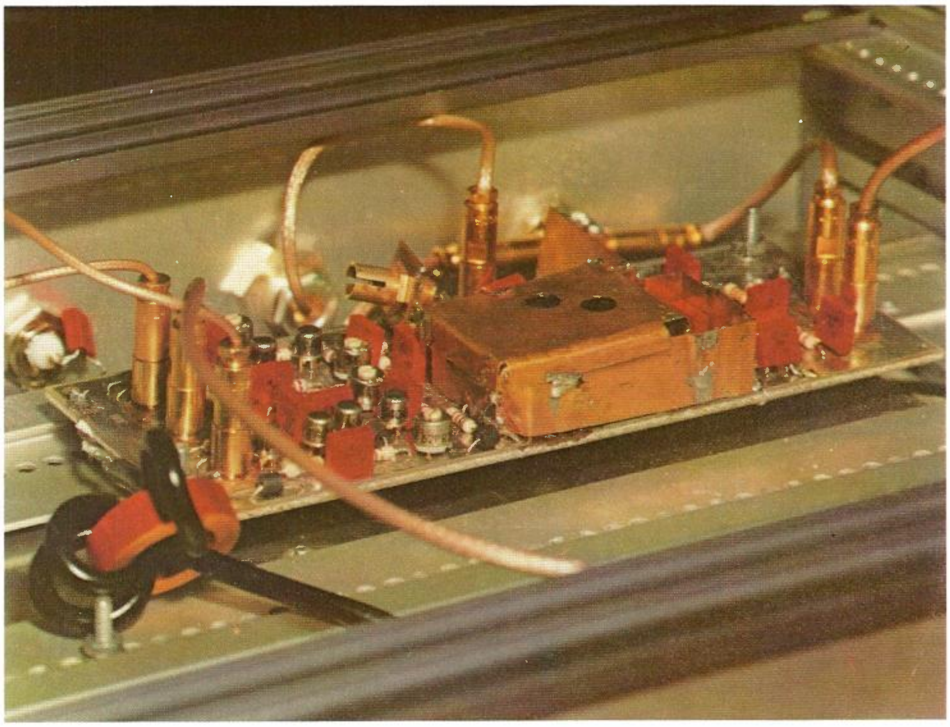
The measurements of crosstalk taken so far have indicated that the dominant NEXT interference is third circuit crosstalk between outputs and inputs of regenerators operating with the same direction of transmission. The mechanism of this type of crosstalk is not fully understood and a programme of measurement and investigation of third circuit crosstalk has been given high priority. It is interesting to note that overseas Administrations have not encountered a third circuit crosstalk problem with the use of primary level PCM, but have indicated it is a problem with secondary and higher level PCM systems. It is clear therefore, that the extent of third circuit crosstalk in Australian pair cable is worse than in overseas pair cable, it has also been found from field measurements that in general the NEXT and cable loss characteristics are also inferior.

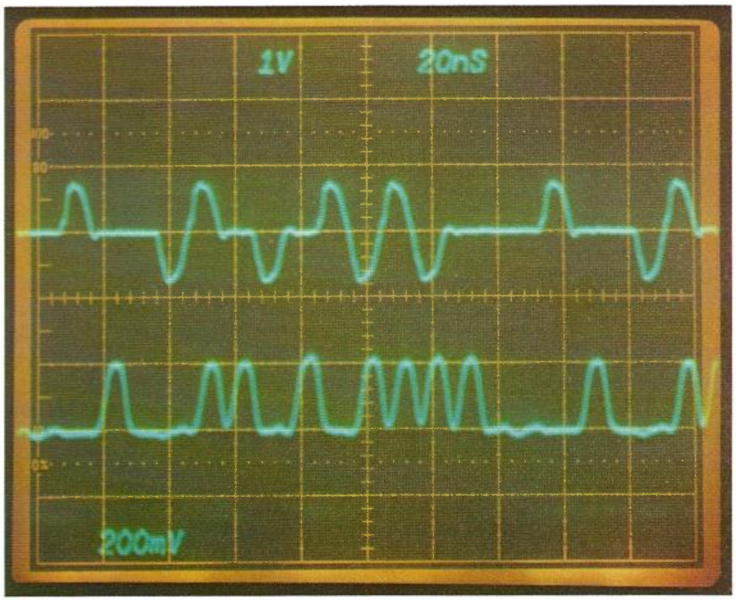
A computer program has been written which allows the calculation of the penetration of primary level PCM systems in pair cable. The inputs to the program are regenerator span loss, cable crosstalk and pair selection geometry, and the program output is the number of PCM systems and the associated probability of this number of systems meeting an acceptable error rate. Eventually, when the cable crosstalk and loss data base is sufficiently accurate and extensive, a computer program such as this will be used by the Engineering Department to specify the allowable penetration of primary level PCM in the Telecom Australia network.

Running the computer program to determine the penetration of primary level PCM systems in pair cable



High speed regenerator circuits





Transmitted ternary signal

Received binary signal after equalization

High Speed Digital Transmission on Coaxial Cable

The proposed introduction of primary level PCM equipment encourages the investigation of higher level digital transmission equipment. Attention has been centred on the use of standard 2.6/9.5 mm coaxial cable for baseband digital systems with regenerator spans of 4.5 km (the repeater span of 12 MHz analogue FDM systems). The aims of the investigations have been to obtain an understanding of the limits placed on high speed systems by technology and the criteria by which the performance of such systems sould be judged. To this end, studies by the Laboratories have involved the design, construction and testing of a high speed regenerator and terminal equipment.

The equipment has been designed for an information transmission rate of 140 Mbit/s. In order to allow dc power feeding over the line a three level code was used. This code, 4B3T, uses a look up table to obtain a three bit ternary word to represent a four bit binary word. The code reduces the transmission rate by threequarters. The equipment can also be used with a simpler code, Alternate Mark Inversion or AMI, which does not have a reduction in transmission rate, at the slower speed of 104 Mbit/s. This code obtains its three levels by alternately inverting the marks in the input signal.

Digital computer techniques have been employed to determine the optimum equalizer configuration for minimizing the probability 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.

Careful consideration has been given to the methods of implementing the various functions of a baseband digital transmission system. In particular, the system requirements demanded a high output pulse level of a narrow width, low noise amplifiers and fast switching circuits. One important consideration was that the total power consumption should be low to allow a wide spacing of power feed stations.

The system has been tested over one regenerator span using the AMI code and has given an error rate of approximately 1×10^{-10} at a transmission rate of 104 Mbit/s. The regenerator power consumption is approximately 1.7 W.

Switching and Signalling Studies

The increasing use in the Australian telephone network of Stored Program Controlled (SPC) analogue exchanges, and the potential use of SPC Time Division Multiplexed (TDM) exchanges, continues to generate needs for the development of expertise in the processor control and digital technology and techniques fields. Such needs are increased by developments taking place in the non-telephony areas of the switched network, including data and telex.

For a number of years the Laboratories have been carrying out exploratory investigations in these fields, the knowledge and expertise gained being applied to both current network needs and the evaluation of future trends and requirements.

The development of a model remotely controlled subscribers' switching stage, to be operated at the Telecom Australia Research Laboratories, Clayton, under control of the model digital tandem integrated switching and transmission (IST) exchange located at St. Kilda in the Melbourne telephone network, has proceeded almost to completion during the year under review.

Investigation is continuing of electro-magnetic compatibility (EMC) factors in general. In particular, during the period under review, this work has concentrated upon gaining an understanding of the mechanisms involved in the penetration of interfering signals into shielded transmission lines, developing practical means of assessing the performance of various shielded cables, and in devising means of gathering statistical information on mains-borne interference.

The system independent technique for representing the processes involved in sequential machines, such as SPC systems, known as the call state transition diagram (CSTD) technique, has been further developed and applied to an expanding range of small and large systems. Use of the CSTD technique has spread to other areas of Telecom Australia, aided by consultation and the conducting of training courses and seminars for the benefit of potential users.

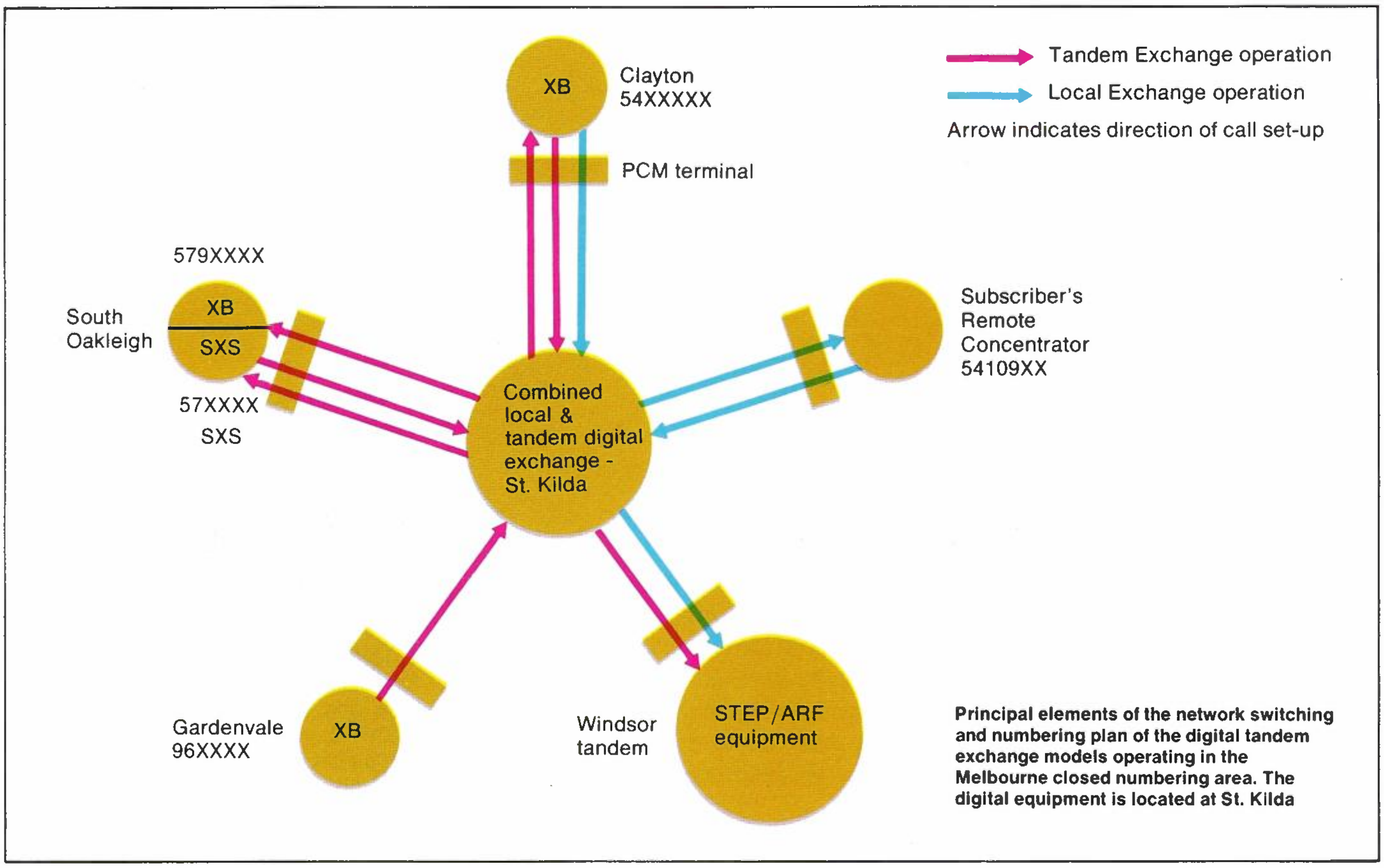
Several other current activities are briefly described in this section of the Review.

Experimental IST Exchange at St. Kilda — 24 Hour Operation

A digital telephony study plan is being conducted in the Research Laboratories as part of the Telecom Australia continuing search for better service at lower cost. Studies are now to the stage of evaluating field experience of a model digital tandem exchange in service and operating under stored program control in the Melbourne telephone network at St. Kilda. The evaluation objectives relate to switching, transmission, operation, installation and maintenance characteristics. Where possible, comparison is made between performance figures already achieved and either C.C.I.T.T. standards or Telecom Australia specifications. To increase the scope of the experience, the model is now continuously operating.

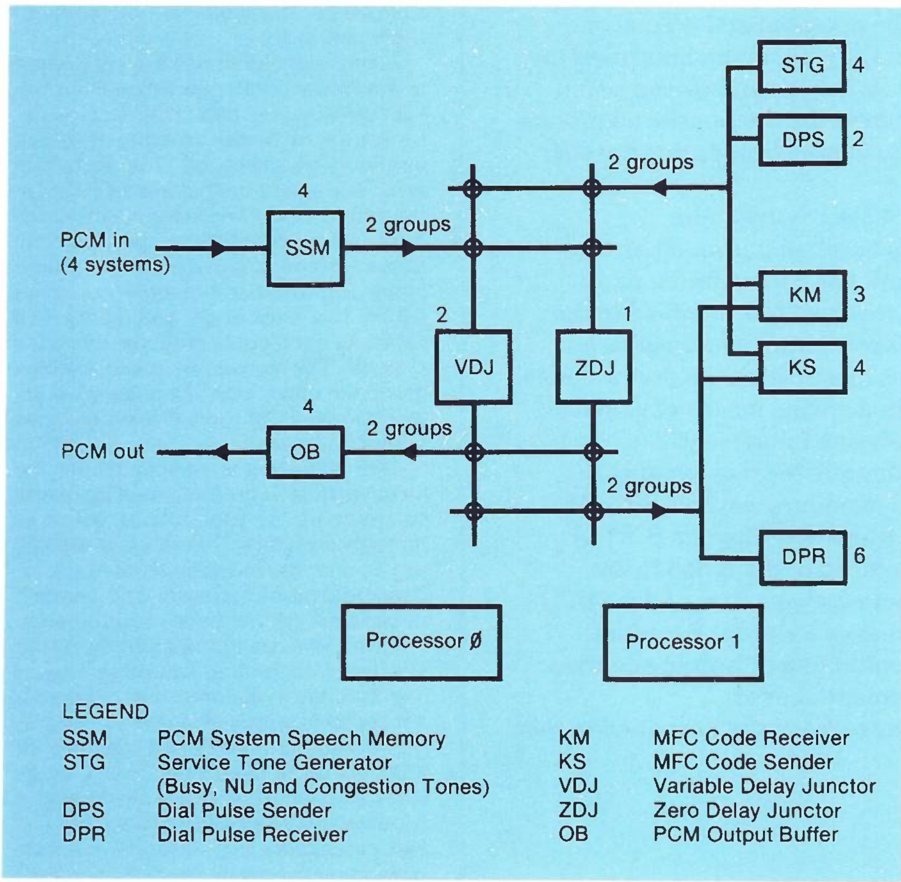
Eighty-eight junctions are connected to the Model Exchange which interconnect step-by-step and crossbar type exchanges in order to fully explore interworking problems. The switching array is a space-time-space (STS) configuration operating either synchronously or asynchronously because full frame storage is provided at the switch input. Highways are parallel switched within the exchange and carry 192 timeslots each containing one 64 kbit/s channel. The highway structure enables groups of either eight 24 channel or six 30 channel PCM transmission systems to be connected.

Line signalling is removed from the incoming bits at the exchange input and re-inserted at the output prior to through switching. Information signalling is via multi-frequency tone or decadic sets of receivers and senders depending on network requirements. The two processor configuration is load sharing with mutual updating via an interprocessor channel. Each processor contains a copy in memory of all programs and data tables and operates on a 20 ms cycle subdivided into a clock level (information processed) and a base level (housekeeping routines). The two processors are offset 10 ms from each other to provide overlap operation.



Principal elements of the network switching and numbering plan of the digital tandem exchange models operating in the Melbourne closed numbering area. The digital equipment is located at St. Kilda

Trunking diagram of digital tandem exchange, which shows the incoming and outgoing PCM channels interlinked by the exchange highways through junctions



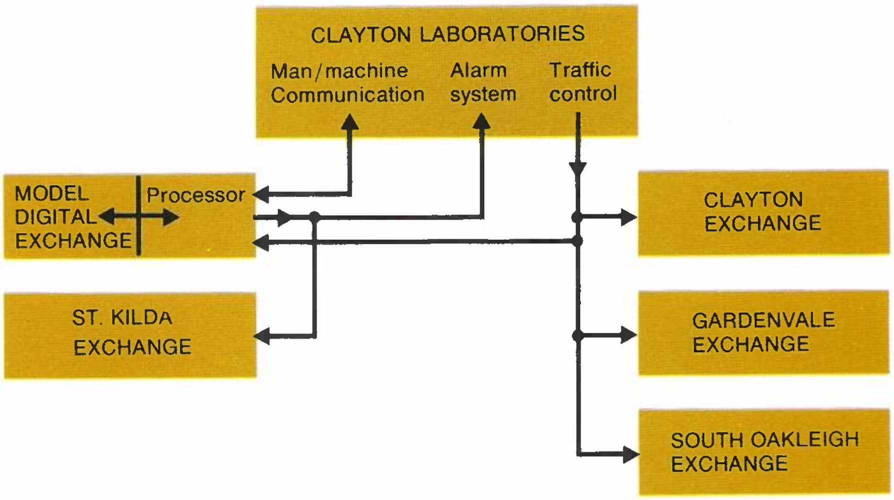
The exchange was commissioned in August 1974 at another location, and later recommissioned at the St. Kilda site. Fault statistics were kept and analysed in order to assess the performance of the equipment and efficiency of design techniques. During this time the exchange was operated only during the day in order to quickly monitor performance and diagnose faults. This procedure confirmed that the model exchange was performing satisfactorily in all areas of operation. Emphasis was placed on using the exchange as a vehicle for assessing:

- Average mean time to repair faults.
- The relative merits of ceramic and plastic package integrated circuits under operational conditions.
- The usefulness of specially developed maintenance aids: for example, a display panel which can display the contents of up to 32 registers of memory locations.
- The efficiency of hardware/software test techniques in installation and commissioning.
- Design error rates.

The exchange is now operating 24 hours a day with one processor. The

The model IST exchange at St. Kilda showing equipment cabinets

Block diagram of remote supervision from Clayton Laboratories of the operation of the digital tandem exchange at St. Kilda. The diagram illustrates the basic control functions. Clayton is situated approximately 16 kilometres from St. Kilda



series of test measurements previously instituted will be maintained. However, emphasis will now be placed on further studies concerned with establishing knowledge of operational features likely to influence digital networks of the future. For example, the limiting factors on error rate through the exchange were not sufficiently identified to enable a design figure to be set with confidence and further analysis is necessary.

Additional studies will be undertaken in the monitoring of network switching and numbering patterns and variations from normal. The model exchange has already produced statistics which, when analysed, detected minor switching and numbering aberrations due to activity in the Melbourne network. These facilities could be widened to monitor device performance of other exchanges in the network (for example, multi-frequency code (MFC) signalling devices).

Availability and survivability characteristics will be studied particularly with respect to either extensions or major proposals for redesign of software to accommodate the addition of remote terminal exchanges. Restoration of service by remote control is another facet now under study together with the characteristics of remote maintenance operations.

The exchange is, in effect, a valuable test bed providing first hand experience of both SPC and digital switching systems. This experience will assist in accurately specifying network switching requirements and evaluating future commercial systems using digital switching technology and integrated transmission and switching concepts.

Development of DIMEX Exchange Dimensioning Programs

DIMEX (DIMension EXchanges) is a set of FORTRAN programs which dimension telephone exchanges from an input of subscriber and network requirements, developed under sponsorship of Telephone Switching and Facilities Branch, (T.S.and F.), Engineering Department Headquarters. Following earlier work in T.S.and F. Branch, the Research Laboratories in 1975/76 extensively redeveloped a set of DIMEX programs and documented them for general use. This program set covered the dimensioning of ARF exchanges. Later work to include ARE-11 exchanges has been undertaken by ADP Branch, Information Systems Department Headquarters. In future, programs for SPC local exchanges may be developed if not otherwise available.

The overall dimensioning task may be divided into three stages. In the first stage, basic system-independent parameters (SIPs) describing the environment in which the exchange is to function (parameters such as traffic dispersion, signalling types, etc.) are input and processed. A variety of ancillary non-specified SIPs are calculated at this stage, and a printout is provided of all SIPs including titles, denomination (of the units in which each SIP is expressed) and subheadings which are sprinkled throughout the listing.

In the second stage the numbers of equipment items required are calculated. This information is provided in the form of either "how many extra items" or "how many items in total" in order to dimension either extensions or new exchange installations, as required. Printouts of this information are provided, as specified by the user.

A third stage of dimensioning is allowed by provision of DIMEX output information in a format suitable for input to the Exchange Network Provisioning Aid (ENPA). ENPA is a previously developed system and can be used to take the rather broad level of detail provided by DIMEX and break up the figures of equipment quantities into numbers of specific serial-numbered store items.

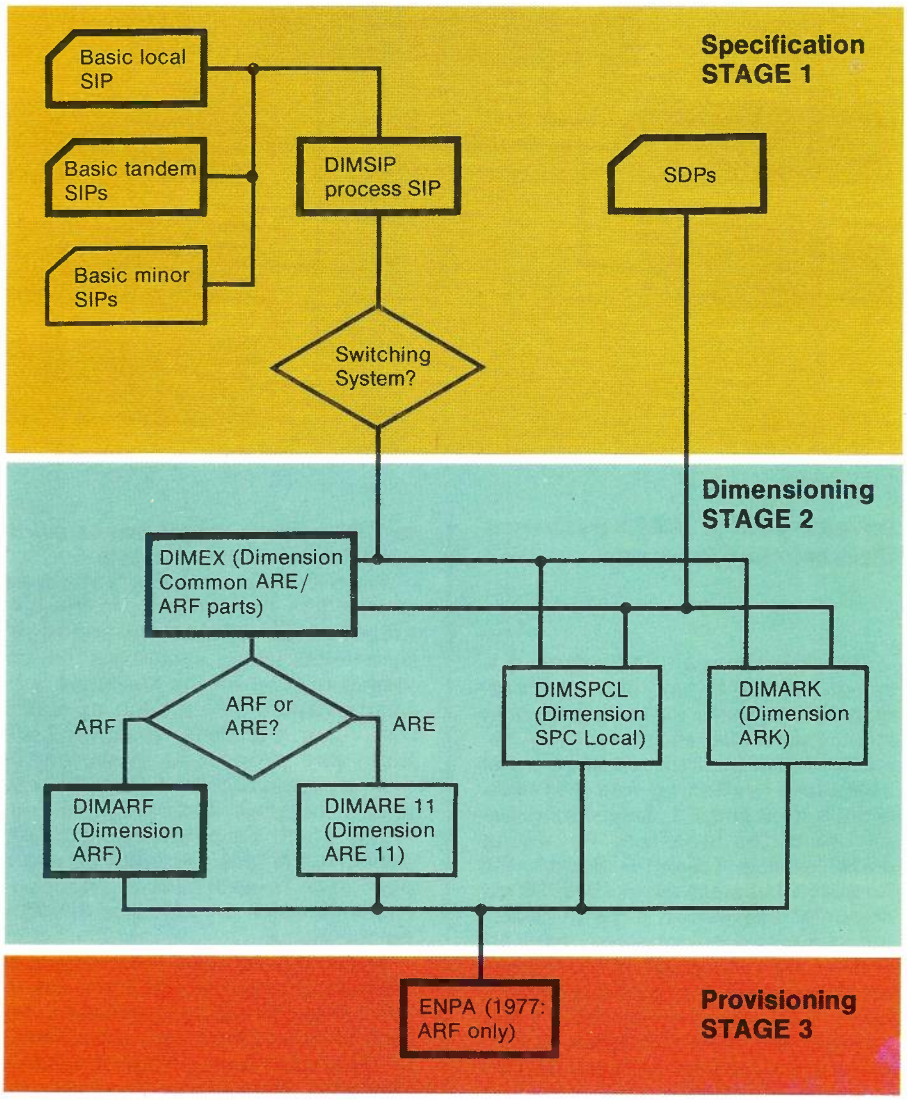
Use of DIMEX is made easier by the use of a primitive instruction language. For each action by the program there is a corresponding instruction code; the program does only what it is told to do by the instruction codes included in the input data.

These instruction codes include the input of data such as the SIPs. The instruction code SIN for instance, is put in the data deck to indicate that SIPs should be read in and the cards with the actual SIP data are placed afterwards. The data must finish with a specific code ("xxxxx") and after this card, more instruction codes are expected. Each data card for SIPs, etc. also has its own identifying code which makes data input less error-prone, since the order of the cards in a data deck is not critical.

The "design philosophy" for DIMEX has emphasized modular design, adequate prior documentation of subroutines and flexibility of the program code for later modification. The individual subroutines are intended to be "self documenting", that is, the coding is direct and well spaced out, and richly interspersed with comments. Subroutines were "unit tested" before being included in the entire suite of subroutines.

It is expected that the comprehensive documentation supplied will allow relatively easy further applications of DIMEX, and will facilitate use for planning studies in both Headquarters and the States.

DIMEX System Survey (heavy outline indicates already working programs)



Microprocessor Applications in an Exchange Environment

Telecommunications is perhaps one of the biggest and most important areas of electronic circuit application. As telecommunication needs become more complex and the requirement grows for electronic circuits with flexibility, compactness, low cost and reliability, designers must look to new devices and techniques to provide these features. Large scale integrated circuits—in the form of microprocessors, semiconductor memories and logic arrays—are being used in a range of applications in telecommunications from stand-alone test equipment and data logging devices to distributed control of switching systems.

The Research Laboratories have been studying and using microprocessors since their introduction on the market in 1972. Different categories of applications are being investigated to determine where microprocessors are most likely to offer cost-effective alternatives to present design methods.

Applications in an exchange environment fall into four main categories:

- Data logging.
- Monitor and test equipment.
- Replacement or modification of present switching and signalling equipment.
- As an integral part of the distributed control in future generations of exchanges.

Work done within the Research Laboratories has included the development of a prototype of an automatic exchange tester which is now undergoing evaluation in an exchange. An example in the third category which has been effectively implemented with a microprocessor is a multi-frequency code tone generator.

The inclusion of microprocessors in a design calls for new skills from the designer experienced in previous generations of electronic devices. Two techniques which are relatively new to many engineers are introduced, that is,

The thin end of the veg(etable)!

software development and real-time processor control. Software development can contribute as much as 90 per cent to the development cost of a microprocessor based system, so it is particularly important that efficient methods of software development are used, and that the effort required is recognized when cost-benefit studies or resource allocation is carried out prior to commencing a project.

Information in the form of a series of Newsletters has been circulated throughout Telecom Australia in an attempt to ensure that designers and managers, in other areas, benefit from the experience gained within the Research Laboratories with microprocessor based projects. The Newsletters contain a variety of information, including a guide to planning and carrying out a microprocessor based system, and recommendations on the selection of suitable microprocessors. The Research Laboratories have also provided software support in the form of cross assemblers and simulators on the Telecom Australia timeshare system.

The Application of 24 Channel PCM in an IST Environment

Digital transmission (for example primary level PCM) is being increasingly employed in telecommunication networks throughout the world to achieve a more economic utilization of existing cable plant on inter-exchange cable routes. In the future significant economies will also be realized in the telephone switching area with the introduction of digital telephone exchanges and the integration of the transmission and switching operations into a so called IST network.

At present only a relatively few PCM systems are employed in the Australian telecommunications network. However, a policy decision has been made to take positive steps to install PCM on routes where it is economically justified and it is anticipated that the wide scale application of PCM will commence in the near future. To ensure that economies can be gained from the immediate introduction of PCM and that the potential economies of a future IST network can be realized, it is important that the type of PCM system used be not only compatible with the existing network configuration and cables, but that its inherent facilities be adequate to satisfy the likely requirements of future digital switching equipments without incurring significant performance, operational, maintenance or cost penalties.

The selection of a PCM system type for Australian conditions was restricted to a choice between two internationally standardized systems : A 30 channel system used widely in Europe and a 24 channel system used widely in North America and Japan. The choice between these two system types was dependent on a large number of complex technical and economic considerations which are beyond the scope of this review. However, one particular technical aspect associated with the possible application of 24 channel PCM systems in an IST environment is briefly discussed to illustrate the type of consideration given by the Research Laboratories to the question of system choice.

With 24 channel PCM systems a signalling technique known as "bit stealing" is used to provide channel associated signalling channels to carry the control and supervisory information necessary to set up and maintain a telephone connection over a PCM system. It was considered possible that if channel associated signalling was used between the digital exchanges in a future IST network, the use of a PCM transmission system which employs bit stealing may lead to a deterioration in the voice quality of the PCM channels with successive stages of digital switching. A study was undertaken to examine this aspect as it appeared a possible disadvantage of 24 channel PCM systems since 30 channel PCM systems do not use bit stealing.

The study showed that with "bit stealing" and channel associated signalling, successive stages of digital switching caused a deterioration in signal quality. It was found that the maximum possible deterioration did not increase beyond that produced by five switching stages, but that both the probability of the maximum deterioration arising in a particular connection and the mean deterioration, averaged over a number of calls, continued to increase as the number of switching stages increased. However, it was also found that the deterioration in signal quality with digital switching is less than that obtained when PCM links are interconnected by conventional telephone exchanges. Because the PCM system parameters have been established internationally to cater for the interim period (that is with PCM transmission and analogue switching) the introduction of digital switching in the future, if 24 channel PCM was adopted now, would lead to an overall network improvement in transmission quality above that considered adequate for the existing network.

The value of the above and many similar studies conducted by the Research Laboratories has been that the relative technical advantages of the two system types have been clearly identified and quantified and this has provided the factual basis necessary for a sound assessment of their technical and economic significance.

Customer Services and Apparatus

In recent years increased emphasis has been placed by Telecom Australia on the systems engineering study of customer services as distinct from the previous approach based on studies of the technology involved in apparatus design. This new slant given to research results more frequently in comprehensive new service simulations which can be used as a "jumping-off" point for market research and estimates of customer demand and cost of services.

This approach led to the examination of the viability of a video telephone service. However, as a consequence of the slow development of video telephone business overseas, the resources of the Telecom Australia Research Laboratories have been turned to other projects with anticipated greater public acceptability. These include television conferencing, now in service between Sydney and Melbourne, telephone conferencing, the subject of a fresh attack in the light of current technological developments, and facsimile for which, despite its long and often disappointing history, rapid expansion similar to that which has occurred in office copiers, is now thought to be iminent.

The strong imminent contribution of business telephone services to the income of telecommunications administrations has led in recent times to increasing attention being given by manufacturers to new developments in private branch exchanges, and to a related development, the automatic call distributor. The automatic call distributor switches incoming telephone calls for a large public office, to individuals, forming a group of people assigned to a single type of task in that office. Transmission questions associated with the latter equipment have been under study during the year.

In introducing change into the customer services of large telecommunication systems it has to be kept in mind that there is so much investment in veteran technology and in fixed assets of long life, that new services need intensive investigation to determine not only that any adverse effect on existing services should be negligible, but that they do not require extensive and therefore tremendously expensive changes to the existing telecommunications network in order to implement them. At the same time, both the business community and Telecom Australia's customers are becoming more knowledgeable about the potential of their communications and more demanding in their desires for features designed to meet their needs. Consequently it is also the job of the Research Laboratories to anticipate these needs and to acquire an advance knowledge of the technology necessary and its network implications, so that this knowledge can be put to use when the demands materialize.

Loudspeaking Attachment for the Telephone

A conventional loudspeaking telephone (handsfree type) is a fairly complex device and is priced in the range of \$250 to \$400. Only a few subscribers can afford to have one, but there would be many who would be interested in a simple loudspeaking (non handsfree) attachment for their handset telephone, if one could be provided at a reasonable cost.

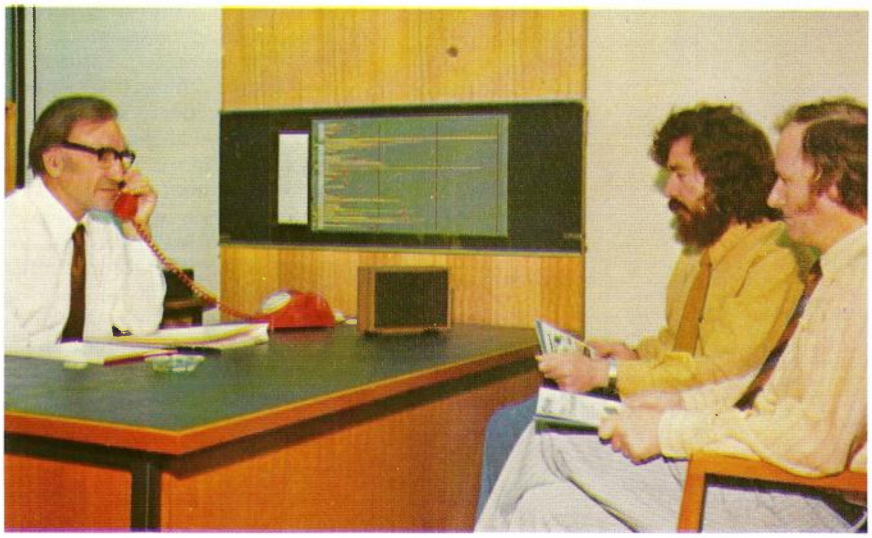
Such a loudspeaking attachment would provide:

- A conference telephone facility for a small group of people - either in a business or domestic situation, for example when a long distance call is being made to a business associate, or a close relative or friend of the family.
- A call progress monitor - particularly useful in conjunction with an automatic dialler or an impulsing type pushbutton telephone; also for monitoring while waiting for a called party to gather requested information.
- A loudspeaking reproducer of recorded message services, such as time, weather, stockmarket, etc., and of long verbal reports, such as telephone dictation.

For the latter two applications, the subscriber could (temporarily) place the handset on the table and have his hands free for other activities.

In its simplest form such as attachment is simply an amplifier (usually line-current powered) which reproduces the electrical signal across the telephone receiver, through a small loudspeaker. In the past, such devices have not performed well, mainly because of a tendency for acoustic feedback to occur between the loudspeaker and the telephone, through the telephone sidetone path. On long lines there has also been a limitation of the maximum acoustic output level.

A Research Laboratory investigation of some of the factors which contribute to performance limitations yielded some interesting results. For example, it was found that for most of those situations in which sidetone was sufficient to cause acoustic feedback, the sidetone loss was inadequate only at high frequencies. An amplifier circuit in which the high frequency response was rolled-off at high gain settings, but remained flat at lower gains, could give the attach-



A loudspeaking attachment enables small group conferencing

"Close field" testing of loudspeakers permits their evaluation on a laboratory bench

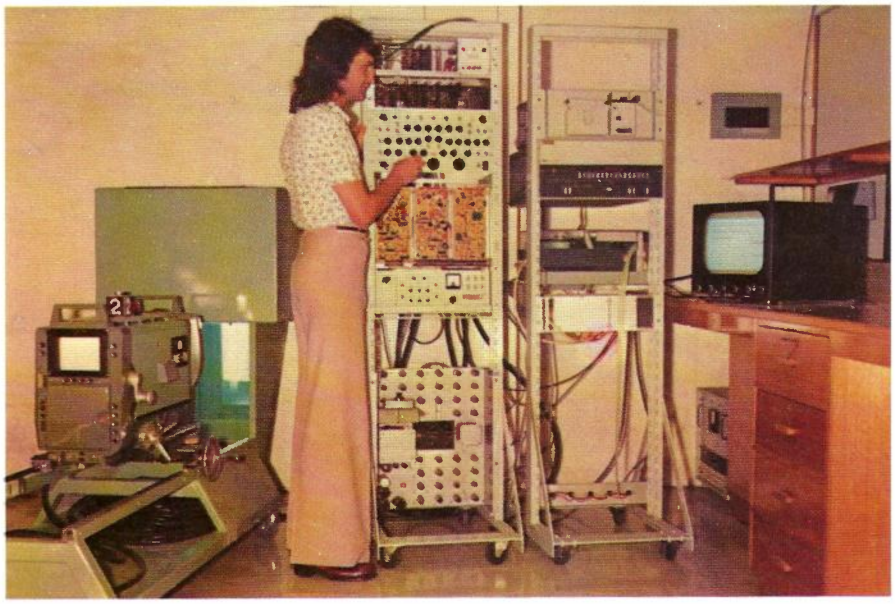
ment a margin against instability. Used with an efficient loudspeaker of suitable impedance and smooth response an acceptable standard of performance could be obtained under most conditions.

A number of laboratory prototype loudspeaking attachments have been constructed to the above principles and are currently being evaluated both in the Customer Services Department and in the Customer Equipment Branch of the Engineering Department with a view to confirming their usefulness in a range of locations, and to estimate their market potential.

Facilities for Facsimile System Studies

In communications, facsimile is the name used for systems which use a scanning technique to reproduce fixed images at a distance in permanent form. Until recently facsimile (fax) has been applied mostly to limited applications such as for the transmission of news photographs or weather maps. A new type of fax machine has become available for the transmission of business documents via switched telephone networks. These machines can provide a cheaper alternative to other techniques available for the transmission of documents and therefore have potentially a large market. Recognising this, the Research Laboratories are investigating the characteristics of these machines to ensure that information is available to Telecom Australia when critical policy decisions must be made, for example, to ensure compatibility within Australia and internationally.

One class of document fax machine which is of particular interest and which is likely to become more important in the future is the one which is capable of



▲
A fax test bed comprising TV camera and signal processing equipment enables 150:1 reduction in data rate for coding studies

transmitting an A4 size document in approximately one minute. These machines make use of digital techniques in coding to reduce redundancy and hence reduce transmission time by reducing the number of bits which must be transmitted. In order to study the problems associated with such machines, a fax test-bed has been constucted in the Laboratories which uses a broadcast quality television camera output. The output of the camera is sampled 16 million times per second and the resulting data is further sampled to reduce the data rate to 62.5 kbit/s. This rate is slow enough to enable the information to be processed with standard logic circuits or to be fed to a mini-computer for processing.

An experimental redundancy reducing coder and decoder have been constructed and tested using the fax test-bed. Programs have been written for a mini-computer to take data from the test-bed and analyse the statistics of that data. The characteristics of the scanned information from various documents is thereby being investigated.

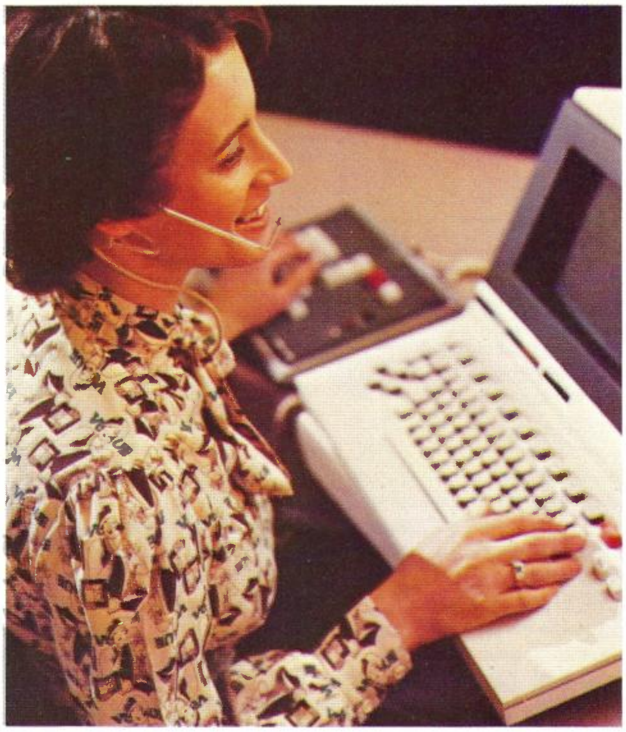
Further hardware has been constructed to allow the scanned information from the test-bed to be recorded on magnetic tape and replayed at a lower speed thereby enabling the scanned information to be transferred to a punched paper tape. This tape is then read into the Telecom Australia computer via a time share terminal where it may be analysed by the large central computer. Whole documents have been stored in the computer and analysed by this means.

Transmission Performance of an Automatic Call Distribution System

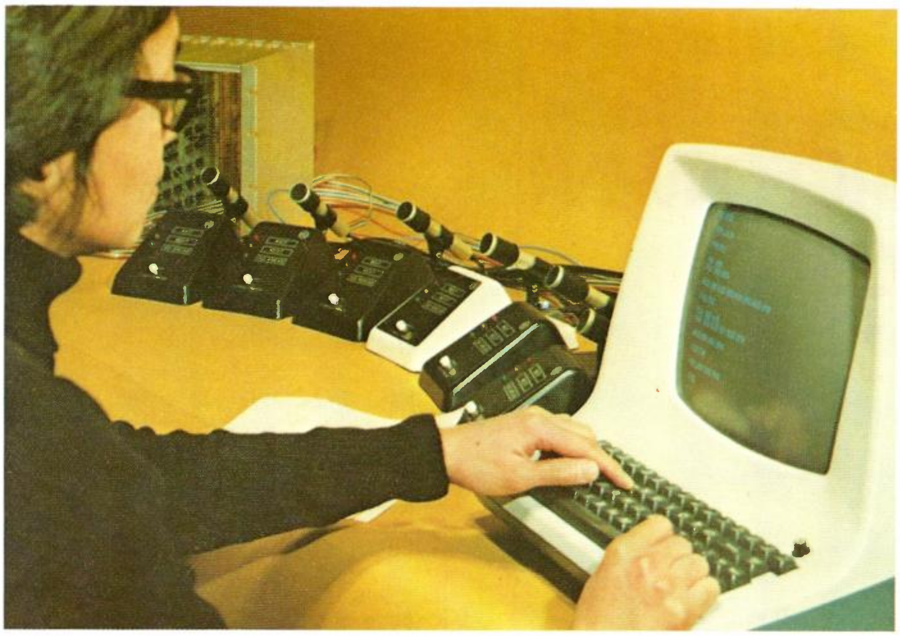
During September 1976, a milestone was reached for Telecom Australia with the cutover of the first automatic call distribution system (ACDS) employing digital switching techniques. This system, manufactured by Collins Radio (U.S.A.), was installed in the Trans Australia Airlines (T.A.A.) reservation centre, Sydney, N.S.W.

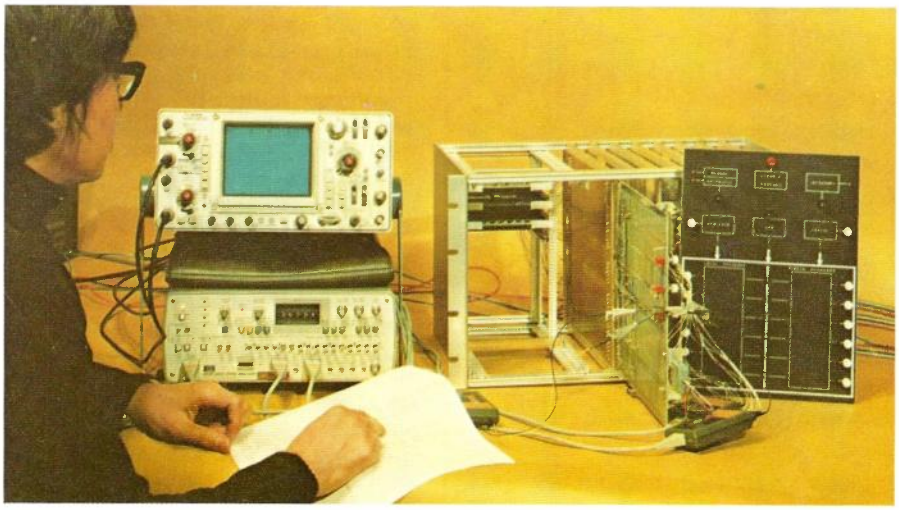
The Collins Radio ACDS is a processor-controlled call queuing system which provides considerable flexibility in establishing connections between (in this instance) 110 reservation clerks' consoles and 150 incoming/outgoing trunks to the public network. Switching is accomplished by a digital technique based upon a number of 24-channel PCM terminals. The system provides such features for the customer as queuing in strict chronological order and recorded announcements when appropriate, and, for the reservation clerk, assistance calls, add-on calls and/or transfer calls to a supervisor. Special features of processor control provide the system user with valuable analytical data on traffic statistics, staff efficiency for example calls answered, time per call, etc. and lost calls, etc.

Prior to cutover an intensive effort by officers of Telecom Australia (Headquarters and N.S.W.), T.A.A. and Collins Radio was necessary to approve and where necessary modify the system to interface with the Australian telephone network. The Research Laboratories were called upon to assess (among other items) the overall transmission performance of the system. The most significant feature in this respect is the ultra- lightweight headset, commercially known as the StarSet, which may be used by the reservation clerk. Compared to an ordinary telephone, the StarSet is an unusual device - its features include an insert type ear-piece, voice-switched gain, and a voice-tube which is virtually invisibile to the wearer, factors which prevail against a defined



ACDS operator using a lightweight headset at the T.A.A. reservation centre, Sydney (photo, courtesy T.A.A.)





speaking position. As a consequence its transmission performance is strongly influenced by human factors and therefore a subjective asessment technique using the Laboratories' reference telephone transmission system and trained team of speakers and listeners was necessary for its evaluation.

Although the evaluation of the Star-Set was prompted by its use in the Collins ACDS, it does have other areas of potential application in the Australian telephone network, namely as a handsfree facility in conjunction with an ordinary handset type telephone (indeed it is this feature that is promoted by its manufacturer) and as an operator's headset, and these aspects were also assessed by the Laboratories.

Design and Assessment of Teleconference Facilities

Much of today's organizational communication and decision making takes place at meetings and conferences and the provision of telecommunications based conference facilities must be considered by Telecom Australia in planning for the future. A programme of exploratory design and assessment of teleconference facilities has therefore been undertaken by the Research Laboratories.

The commercial viability of any teleconference facility will ultimately be determined both by the extent to which it facilitates effective communication between the participants in a conference and by a number of larger scale sociological and economic factors. Some insight into the influence of these latter factors may be obtained by market research and by surveying the reactions of users to experimental and existing services in real-life situations. However, the communications effectiveness of a proposed facility can only be investigated as a design evolves by means of laboratory and field experiments using early prototypes of the facility. The communications requirements and processes of conferring persons are still poorly understood and the basic understanding of these human aspects of conferencing may itself be advanced by appropriate experiments using teleconference facilities.

The designer of a new facility must select the specific features which it is to incorporate and must carry through their detailed design. For example, in an "audio only" facility, speaker identification is a feature which may be incorporated and it may be implemented in a number of different ways. The speaker identification sub-system must determine who is, in fact, speaking and communicate that information in an appropriate manner to the conference participants. Identification algorithms and display hardware must be designed in detail with the aim of maximizing the overall communications effectiveness of the facility.

For systematic prototype assessment it is desirable to have measures of the processes and performance of conferring groups or, preferably, quantitative measures of the interaction between participants that have been found to significantly correlate with conference effectiveness.

A small interdisciplinary project team within the Laboratories is attempting to develop and test such measures using a two terminal processor controlled audio conferencing facility. This provides a useful experimental tool for such work as it is functionally variable under software control and incorporates comprehensive data logging facilities. In addition to laboratory experimental work, field experiments are being undertaken leading towards possible commercial operation of the facility.

The experimental methods and effectiveness of measures developed will have application to other types of teleconference facility; for example it is hoped to extend this work to multi-terminal conferences including the case in which individual subscribers confer from their offices through the existing telephone network.

R & D at Microwave and Optical Frequencies

The increasing technical complexity of advanced telecommunications equipment requires Telecom Australia to maintain an informed knowledge base in relevant areas of science and technology. A limited scale research and exploratory developmental programme in the fields of solid state and quantum electronics is undertaken to provide some local expertise in this area, so that practical experience can be gained with the sophisticated experimental and production facilities used in equipment and device manufacture, thus making Telecom Australia a more informed customer as well as providing new innovative devices and advanced techniques for Australian telecommunication systems.

The activities undertaken in this programme involve a number of small individual investigations generally directed towards specific areas of application to Telecom Australia, although they often have more general interest and relevance. The main thrust of the solid state materials and devices activities has been directed towards devices for use in microwaves and optical communication systems, and some of the projects are described in this section. The resources employed in these areas by the Laboratories are relatively small by world standards and it has been important to keep the immediate areas of activity restricted to a relatively small field so that some useful contribution is possible.

While both microwaves and optical topics are dealt with in this section, the relative maturity of the two fields is reflected in the number of topics in each area. Microwave systems are a well established part of telecommunication networks, and one on which solid state technology has already made a significant impact. On the other hand, optical fibre communications is a new and emerging field in which solid state technology must play a major role if it is to provide a viable alternative to existing communication systems.

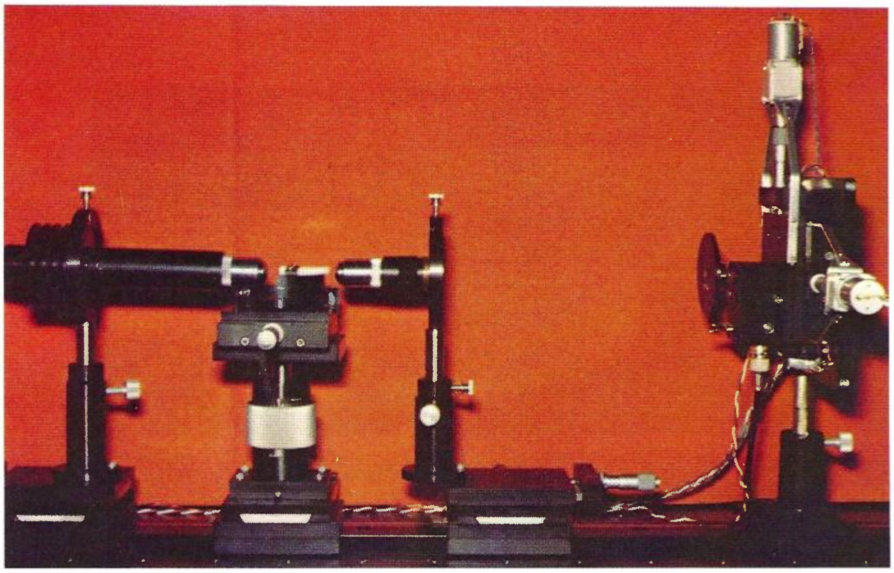
Refractive Index Profiling of Optical Waveguides

Improved fabrication techniques have decreased dramatically the transmission loss of optical fibres. Attention has now been directed towards the control of other fibre parameters. Perhaps the most significant is the refractive index profile (RIP) measured over the cross-section of the fibre. The availability of low-loss fibres has also stimulated interest in integrated optical circuits. An essential circuit design parameter is the RIP of the channel waveguides that are the basic building blocks for these miniature optical circuits.

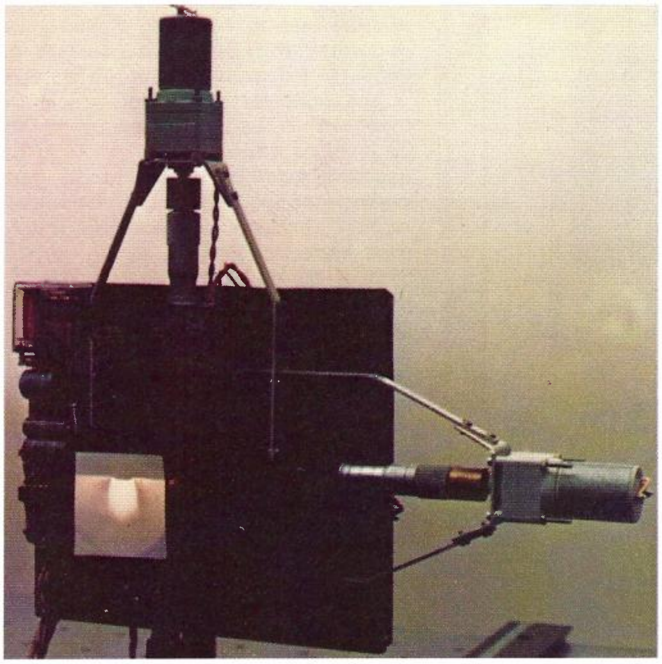
Many techniques have been developed for measuring the RIP of optical waveguides. Two techniques have proved to be most informative. The first is optical interference microscopy, in which a thin transverse slice of the waveguide is examined. The second is near field scanning, which depends upon the close resemblance between the near field intensity distribution of a suitably excited waveguide and the RIP. At the Research Laboratories both techniques have been employed to study low-loss fibres, manufactured by A.W.A. in Sydney, and channel optical waveguides.

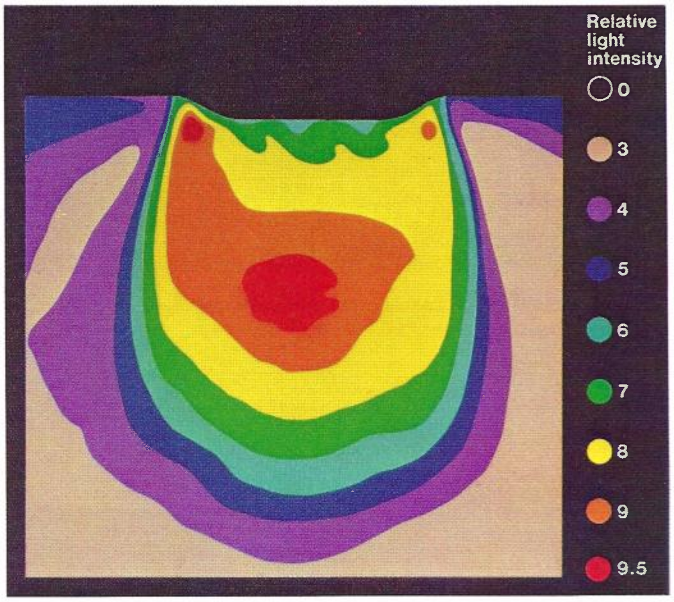
Of particular interest have been near field measurements of stress-induced channel optical waveguides. These waveguides are fabricated by an embossing process developed and patented by the Research Laboratories. In this process a suitable die is used to emboss a narrow groove into the surface of a thermoplastic substrate. Light guiding can be established in a region of residual stress in the substrate beneath the embossed groove. Near field intensity distributions are measured in the following manner. Light from a diffused tungsten filament source is focussed on to the end-face of the waveguide. For this measurement the guide is a straight section, typically 35 mm long, with flat, polished end-faces. A magnified image of the waveguide

Experimental arrangement for near-field measurements of optical waveguides



Projected near-field pattern of a stress-induced waveguide ▼





▲ Near-field intensity contour plot of a stress-induced waveguide

output face is formed in the plane of an apertured silicon PIN photodiode, which can be scanned automatically in two dimensions. The amplified photodiode output is input to a set of comparators and then to an x-y recorder. The x-y recorder plots directly an intensity contour map, and hence an approximate RIP, of the waveguide output.

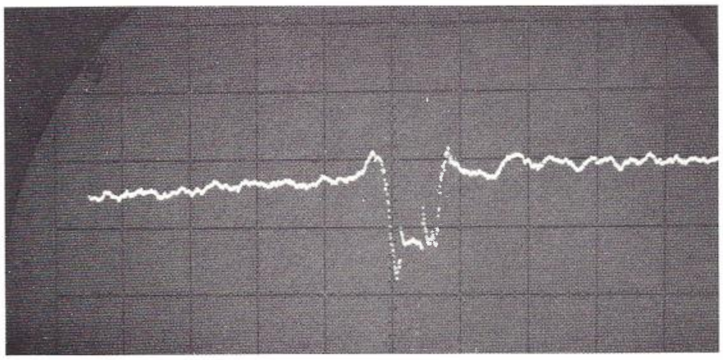
Previous experimental results have shown that stress-induced waveguides can exhibit sufficiently low transmission loss to be of use in practical optical devices. The near-field measurements show that these waveguides have a graded RIP of quasi-circular symmetry. This means that stress-induced waveguides possess focussing properties and may find further applications as image transmission devices.

Ultra-High Speed Switching Devices

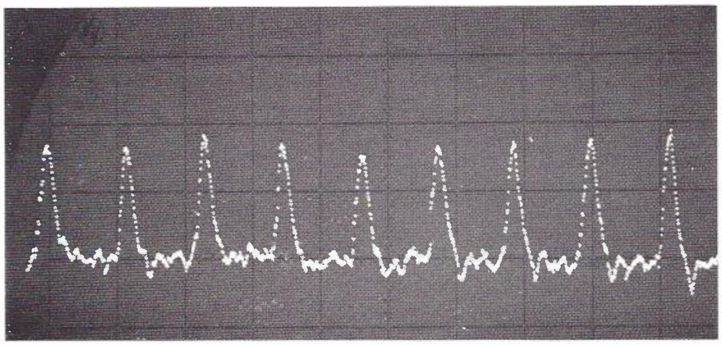
A number of the improvements in electronic equipment in recent years, have been due to the availability of high speed and/or low power solid state devices. If efficient use of expensive transmission channels is to be achieved, it is necessary to operate telecommunications equipment at increasing speeds. Fabricating devices from silicon to meet this requirement is becoming more difficult and thus attention has been turned to other semiconductors - notably Gallium Arsenide - whose electron transport properties are favourable for high speed device fabrication.

The success of Gallium Arsenide (GaAs) for making GHz frequency range devices is illustrated by the commercial availability of GaAs Field Effect Transistors, Impatt Diodes, Gunn Diodes, etc. and research is presently being carried out, particularly by laboratories concerned with telecommunications, into using the Gunn effect as a means of performing some novel digital and switching functions.

Early work in this area centred on Gunn Diodes, but it was soon found that a more useful device could be made by modifying the structure of a planar Gunn Diode by the addition of a third electrode, a Schottky Barrier Diode, located near the cathode terminal. This electrode (called the gate) is used to trigger the generation of Gunn domains



Current pulse for single domain transit in a Gunn diode
(Time base = 1ns/div. Vertical = 10mA/div.)



Current pulses from successive transits of domains in a Gunn diode
(Time base = 1ns/div. Vertical = 10mA/div.)

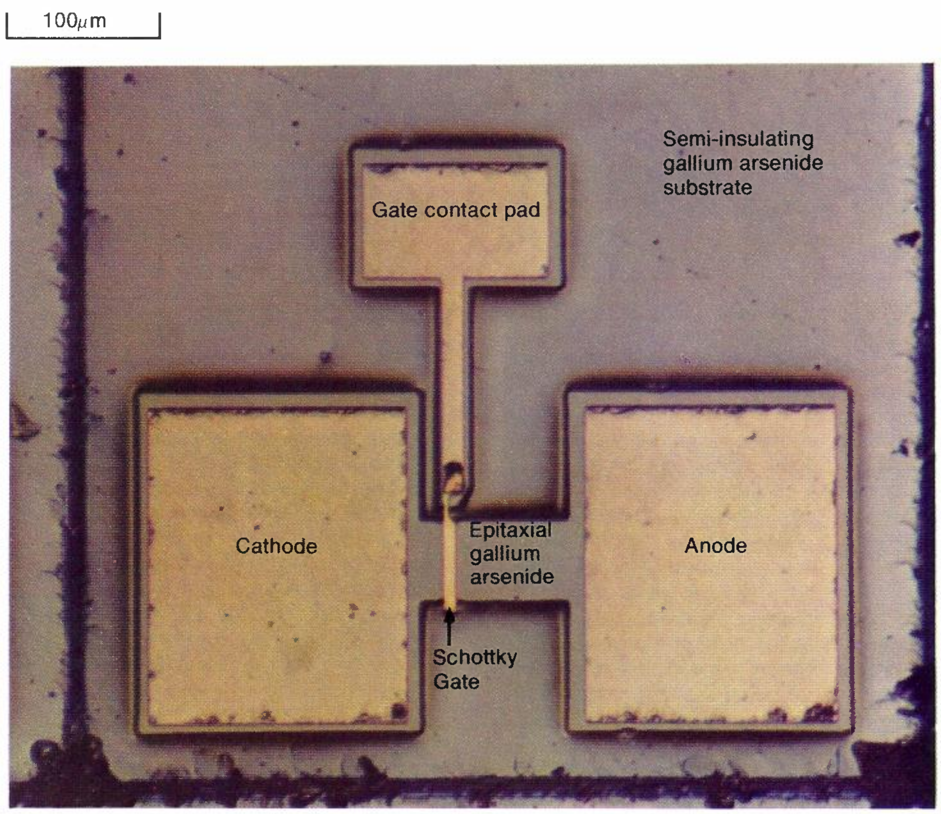
in the device which in turn causes the device current to switch between two values; a low current state, when a domain is in transit and a high current state, when no domain is in transit.

The first oscilloscope trace shows the current waveform when a single domain is generated (current drops), travels to the anode and then disappears at the anode (current rises). Successive transits of domains with current spikes signifying the disappearance of one domain and the generation of another are shown in the second trace. The various features of a Schottky Barrier Gate (SBG) - Gunn Diode are illustrated; this Diode was made in the Research Laboratories of Telecom Australia.

The usual mode of operation is to apply a constant bias voltage across the device via a load resistor. This bias voltage is slightly less than the value required to generate domains when no trigger voltage is applied to the gate. On reverse biasing the gate, domains are generated, thus pulsing the current, as shown in the second oscilloscope trace.

The principal application areas are those where the SBG Gunn Diode can be used as a functional block to make use of its pulse generating (and regenerating) properties such as pulse regeneration, analogue to digital conversion, fixed frequency division, etc.

Due to thermal and material problems, SBG Gunn Diodes are often operated with the bias circuits pulsed. Devices which will operate with continuous bias voltages are at present being investigated in the Laboratories.



Schottky barrier gate Gunn diode
(Magnification × 200)

Scanning electron microscope showing a secondary electron image of an etched microgrid

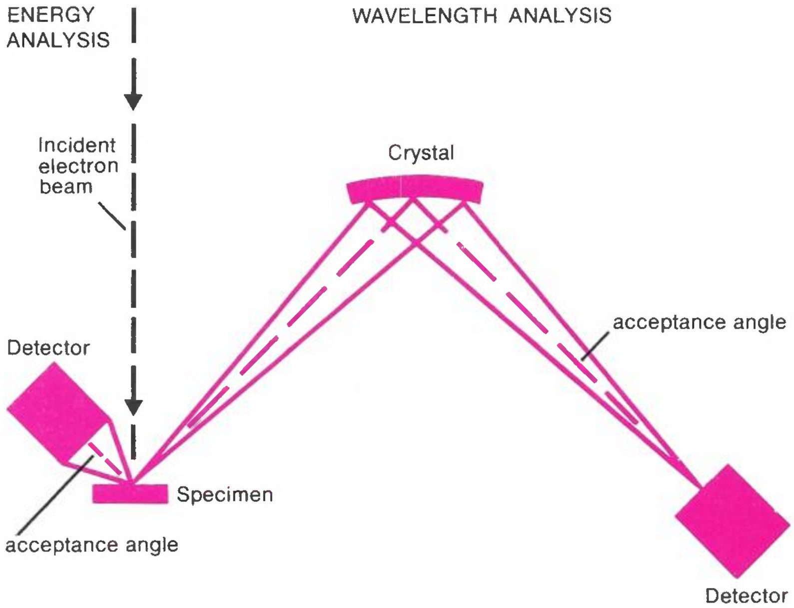


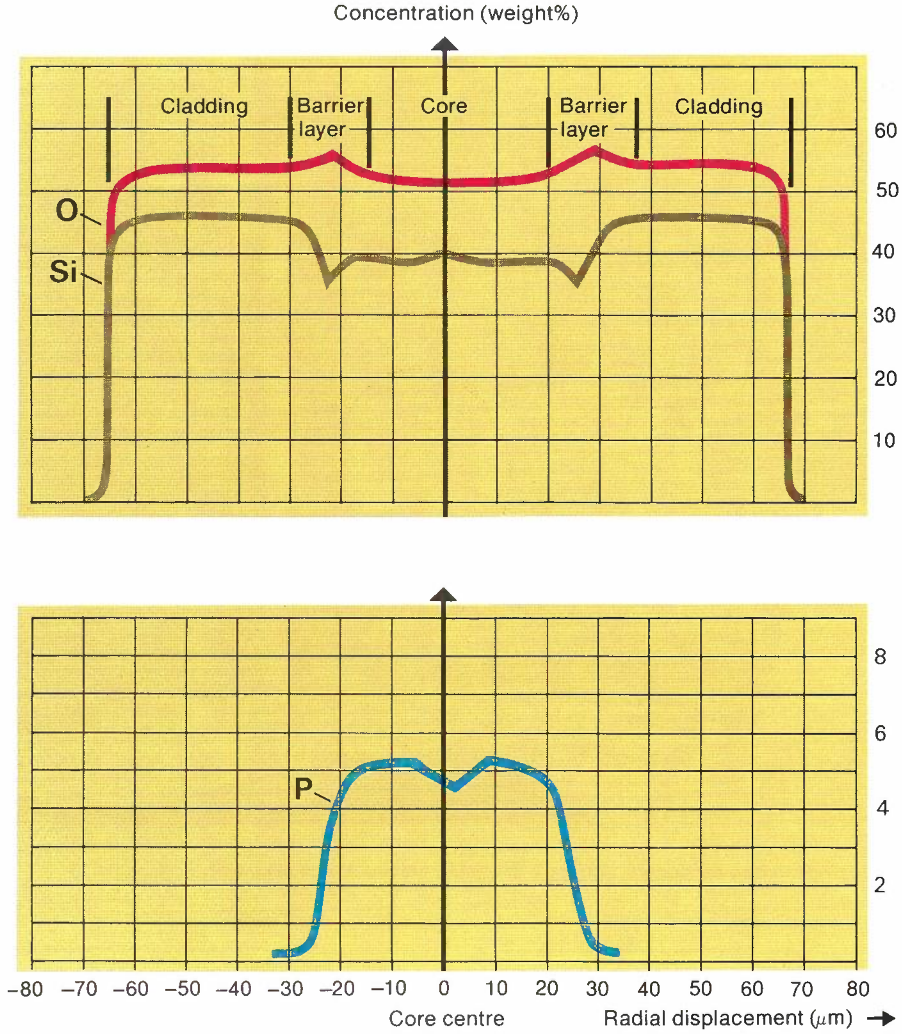
Diagram illustrating non-dispersive and dispersive x-ray spectrometers

Scanning Electron Microscopy and Microprobe Analysis

The Research Laboratories' scanning electron microscope (SEM) facility has been extended to include x-ray microprobe analysis. X-ray spectrometers can be realized as either a wavelength dispersive analyser or a non-dispersive energy analyser, and each has certain advantages for both qualitative and quantitative analysis. For x-ray emission to occur, the energy of the incident electron beam must exceed the excitation potential of a core electron so that ejection from the parent atom leaves an orbital vacancy. This vacancy is quickly filled by an electronic relaxation process which is accompanied by the simultaneous emission of an x-ray. This x-ray is either emitted from the sample or has its energy transferred to another orbital electron which is then ejected from the

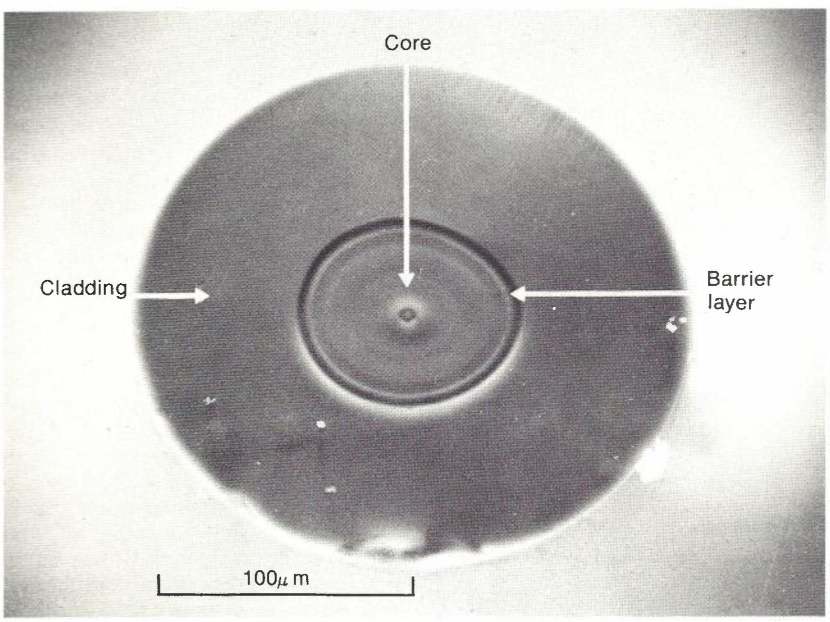
Microprobe analysis across the end section of optical fibre CVD 129 (shown below) showing the silicon, phosphorus and oxygen distribution ▶

sample (the latter effect is called Auger electron emission and can also be used for compositional analysis). The emitted x-ray can be analysed in two different modes. If the x-rays are collected via a small part and allowed to strike an analysing crystal that has only certain permitted reflection angles (as given by Bragg's law), then the geometrical position of the detector is directly related to the x-ray wavelength. The detector is a gas flow proportional counter that both detects the x-rays and acts as a pre-amplifier to the main amplifier and pulse shaper, the compositional signal being taken from either the main amplifier or the pulse ratemeter. The second mode of x-ray spectrometers is a non-dispersive analysis and uses a solid state detector that transforms the energy of the x-ray photons into charge pulses. The detector is followed by an amplifier and shaping circuits, and the pulses are sorted according to height with a multichannel analyser. The stored information corresponds to the energy spectrum of the characteristic x-rays of the specimen and can be dis-

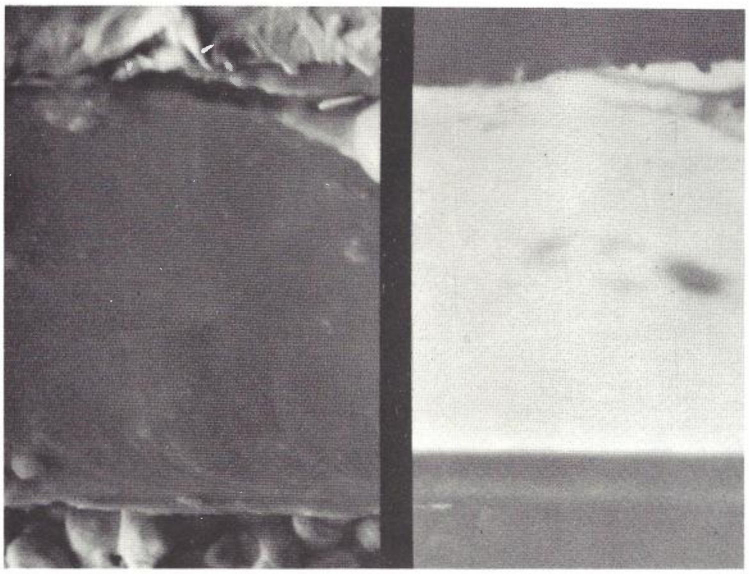


Single hetrostructure semiconductor laser diode ▶

Secondary electron image of a cleared and etched end section of A.W.A. optical fibre CVD 129



Secondary electron image



Cathodoluminescence image

Right and below: laser end face ▶ ▼

Combined secondary electron and cathodoluminescence image

10 μm

played on a cathode ray tube for composition identification.

The energy resolution of crystal spectrometers far exceeds that of the solid state detectors (typically 5eV compared to 160eV), so that characteristic peak overlap problems are minimized and peak-to- background signal ratios are greater. However, the solid state detector has a larger acceptance angle and hence greater collection efficiency, so that combined with simultaneous counting of all x-ray energies, faster material identification is possible than with the mechanically scanned crystal spectrometer. The overall spatial resolution of both analysing techniques is of the order of one micrometer and the compositional resolution of the crystal spectrometer is better than 0.005% for many elements, compared to the solid state detector resolution of a few tenths of a percent.

Two recent applications of the SEM have been the characterisation of optical fibres (manufactured and supplied by A.W.A. Sydney) and the study of semiconductor injection laser diodes. The examination of the cleaved and etched end section of an optical fibre can reveal such characteristics as ellipticity, dopant volatilisation and any other structural defects, and also delineates between the cladding, core and barrier layers. X-ray analysis can provide information relating to dopant distribution and show the degree of dopant diffusion and volatilisation, and quantitative analysis allows the direct calculation of the refractive index profile. Examination of semiconductor laser diodes provides information on the diode mounting technique, facet quality of the cleaved end faces, the lead and contact condition, the sawn side walls for reduced side reflections, and also allows junction delineation (the region of radiation). The latter feature is most readily highlighted by combining the infrared cathodoluminescence image with the secondary electron image.

To summarize, the recent addition of a full wavelength dispersive x-ray spectrometer to the Research Laboratories' SEM has significantly extended the scope of the instrument. The planned installation of energy x-ray microprobe analysis will then establish the facility as one of the most comprehensive and powerful in Australia.

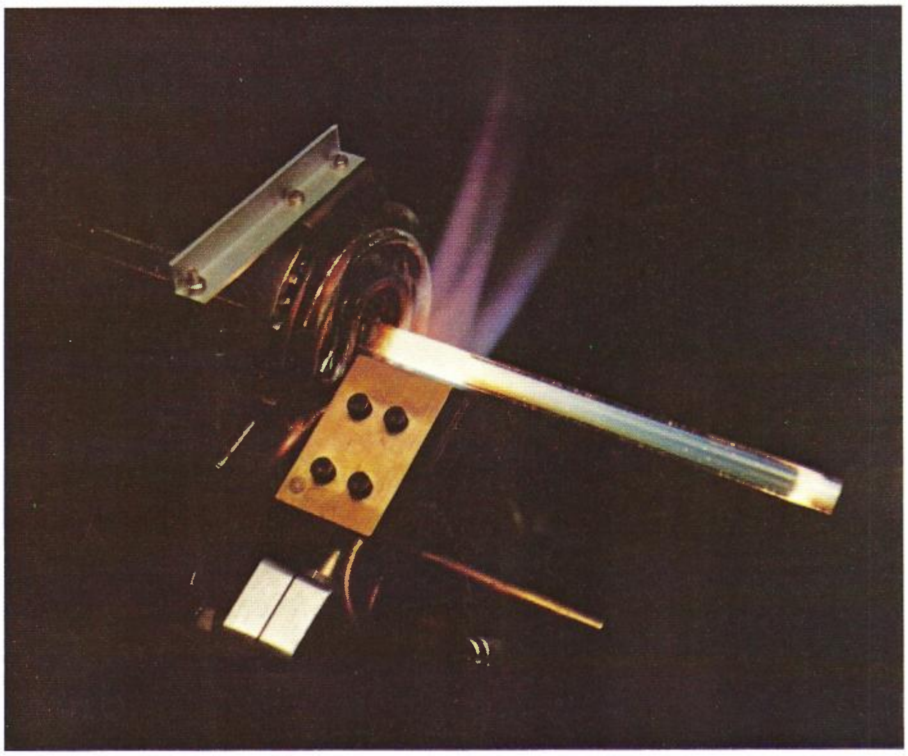
Co-operative Research Programme on Low Noise Microwave Amplifier Studies

In recent years, the Research Laboratories have been investigating solid state devices and integrated circuits for use at microwave radio frequencies, with such techniques being applicable to both satellite communications and broadband radio relay. The incentives behind these investigations stem from attendant advantages of reliability, low power consumption, miniaturisation, and the economies associated with any large scale introduction of solid state equipment.

More recently, the developed capability in circuit technology and design of microwave integrated circuits within the Laboratories has been directed towards amplifiers for sensitive microwave receivers. These amplifiers incorporate Field Effect Transistors made from gallium arsenide instead of the more usual silicon, and these devices, which have emerged only recently, represent a very significant breakthrough in microwave device technology. Amplifiers designed with them offer extremely low noise performance and high reliability.

Over the years there has been a considerable amount of contact between the C.S.I.R.O. Division of Radiophysics and the Telecom Australia Research Laboratories, with the microwave area providing common ground of interest. The Radiophysics Division includes radio astronomy as one of its major activities, and this involves the reception of extremely weak signals. They therefore have a very keen interest in low-noise amplifiers which have the potential to augment, or in some circumstances even replace parametric amplifiers, the cost of which is prohibitive enough to slow down the observing programme. Parametric amplifiers can also present severe maintenance problems. The Radiophysics Division also has a growing capability in the design, fabrication, and measurement of microwave integrated circuits.

With this background, the skills and technology available in both organizations have come together in a co-operative research programme to study and design low noise microwave FET amplifiers for use in frequency bands between 408 MHz and 22 GHz, which covers the mutual interests of both parties and produces the desired results more quickly and cost-effectively than if either organization were to pursue this course alone.



CVD taking place in a silica glass tube

Joint Research Programme to Develop Low Loss Optical Fibres

Throughout the world, many major communications authorities are poised on the brink of introducing a new era of lightwave communications into commercial service. This will involve the transmission of large groups of telephone channels, data, and television signals through hair-thin fibres of silica glass (or optical fibres) as pulses of light, emanating from miniature solid state laser diodes or light emitting diodes at the input to the fibre. At the output end of the fibre, a photodetector serves to re-convert the optical signal to its more conventional electrical form.

Made from the basic material of silica, one of the earth's most abundant materials in the common form of beach sand, fibres offer welcome relief at a time of dire predictions of the dwindling supplies of certain metals, such as copper, which are traditionally used in communication cables. They also offer significant technical advantages. For example, the silica used is so pure that light travelling along the fibres looses less intensity in 150 m than in passing through an ordinary window pane, which means that the need for boosters, or repeaters, is less frequent than in equivalent metal cable transmission. Furthermore, the basic information carrying capacity of fibres is greater, and together with the extremely small cross-section of a fibre and immunity from electrical interference this all adds up to a telecommunications cable which cannot afford to go unexploited.

The secret of confining light so that it doesn't escape as it travels along the fibre is to make the centre, or core, of the fibre optically more dense, by doping the silica with controlled amounts of oxides, and one recipe gives a phosphosilicate core, surrounded by a borosilicate cladding, which in turn is surrounded by the pure silica of the fibre. A popular method of achieving this doping is by the Chemical Vapour Deposition (CVD) process in which vapours are made to deposit on the inside of a hollow tube of pure silica glass, following which the tube is collapsed under flame and drawn into the required length of fibre. During drawing a protective resin coating is applied to the outer surface of the fibre. Under contract to Telecom Australia, A.W.A. Research Laboratories have developed this process to produce fibres one kilometre in length, and of suitable quality for telecommunication purposes. Close co-operation between both parties from the beginning of the project has enabled the detailed practical evaluations of propagation properties of the fibres, performed by Telecom Australia to be succesfully related back to the manufacturing process, and its improvement.

Measurement of Attenuation on Earth-space Paths at Microwave Frequencies

In planning for a possible future satellite communication system for Australia, suitable frequency bands to link the satellite and earth stations must be considered. With lower bands becoming ever more crowded, frequency allocations above 10 GHz offer some advantages. However, one penalty is the attenuation or weakening of the signals due to heavy rain, and this effect becomes more serious as the frequency increases.

The theoretical basis of the attenuation of radio signals due to scattering and absorption by raindrops is fairly well understood. However, the application of this theory to practical radio communication paths, where the rainfall varies rapidly in time and from place to place can be a difficult and unreliable process.

Some of the tropical regions of Australia can experience extremely heavy rainfall, which could seriously degrade a satellite communication circuit using the higher microwave frequency bands. In order to study and evaluate such conditions, the Research Laboratories have for the last few years been measuring attenuation characteristics near Innisfail, Queensland and Darwin, Northern Territory. Almost five years' results at 11 GHz have been obtained from Innisfail to date, with the co-operation of the Army, under a range of conditions. Since late 1976, measurements have also been made at 8 GHz by Weapons Research Establishment, in a joint project. Simultaneous measurements at 11 and 14 GHz have so far yielded two years' results from Darwin.

In the absence of suitable satellite transmissions, we are measuring attenuation characteristics by means of radiometers. These measure, over a narrow bandwidth at 8 GHz, 11 GHz, or 14 GHz the radio noise emitted by the sun or rain clouds, from which attenuation can be calculated.

Networks of tipping-bucket rainguages, provided by the Bureau of Meteorology, measure rain intensities at various locations around the radiometers, so that correlation between attenuation and rainfall can be investigated.

Some of the results of the investigations to date include:

- Cumulative distributions of attenuation exceeded, related to percentage time.
- Empirical relationships between rain intensity and attenuation, to aid future predictions.
- Demonstration of very large variations in rain intensity at sites only 2-3 km apart, indicating good "space diversity" performance.
- Effect of frequency on attenuation - the ratio of attenuation at 14 GHz to that at 11 GHz varies markedly with rain conditions.
  The effect of elevation angle, of an earth-space path, on attenuation is much more complex that commonly assumed.

Progressive results have been published in several papers and Research Laboratories Reports, and also contributed to C.C.I.R. (International Radio Consultative Committee). Most overseas investigations to date have been confined to temperate climates, so that the Australian tropical results form a significant contribution to international studies of the subject.

The Darwin 11 anD 14 GHz radiometer - about to measure some heavy rain attenuation

Consultative Activities

Consultative activities continue to form a significant proportion of the scientific and engineering effort of the Physical Scientists and Engineers in the Laboratories. The examples described are indicative of the wide range of subject matters dealt with during the year. In many cases such projects involve only a few days of investigation, but it happens that what looks like a minor problem at the outset, is subsequently shown to require extensive studies over a wide front. However, the objective in this kind of work is to provide some advice and answers as rapidly as possible in order to alleviate technical problems encountered in the field, or to enable provisioning action to be taken; the more complete long term solution can then be pursued over a longer time span.

Not all consultative activities do require laboratory investigations, and much of the advice given is verbal and based on experience and available information. Dissemination of specialist knowledge is also achieved through conferences, colloquia, reports and papers. The latter are most valuable because they make the names of specialists in various fields known to others who may in future be in need of such advice.

Research Laboratories' Colloquia

Each year the staff of the Research Laboratories conduct a number of colloquia on a selection of projects being undertaken in the Laboratories. Some of the more important colloquia held during the last twelve months were:

- Sources for Fibre Optic Communications
- The Measurement of Antenna Characteristics
- Two Social Scientists in a Technological World
- Optical Integrated Circuits
- Gunn Effect Digital Devices
- Propagation Factors in Microwave Link Engineering
- Selected Activities of the Physical Sciences Branch
- Pulse Code Modulation Talks - a series
- Duplexers and Multicouplers at VHF and UHF
- Solar Energy Research in Japan
- A Precision Frequency Tracking Generator
- Thick Film Hybrid Microcircuit Technology
- Semiconductor Memories
- CSTD Lectures

These colloquia are a very suitable medium for explaining to other parts of Telecom Australia and beyond, what is being done in the Research Laboratories. But, more importantly, they are a means whereby the staff of the Laboratories can obtain a greater appreciation of the telecommunications problems and difficulties which are faced in the field, are met in industry, commerce, and in the tertiary institutions.

Apparatus to determine the response characteristics of combustible gas detectors

Return Loss of a Cable Splice

A recent request concerned reflections from splices in quad carrier cable used for short haul colour television links. Multiple reflections between splices and terminal equipment can cause ghosting and other picture degradations, in certain cables.

Reflections from some short spliced specimens were measured, using another length of quad carrier cable as a reference. Careful analysis shows that the large measurement uncertainties caused by impedance tolerances of the various pieces of cable can be reduced when the test specimen is short and lossless. It was concluded that reflections from the splices would not cause picture degradation.

Evaluation of Instruments for the Detection of Explosive Gases

For some years, the Research Laboratories have been engaged in the critical evaluation of portable combustible gas detectors of varying degrees of complexity, in order to assess their suitability to maintain safe working practices in the underground cable network of Telecom Australia.

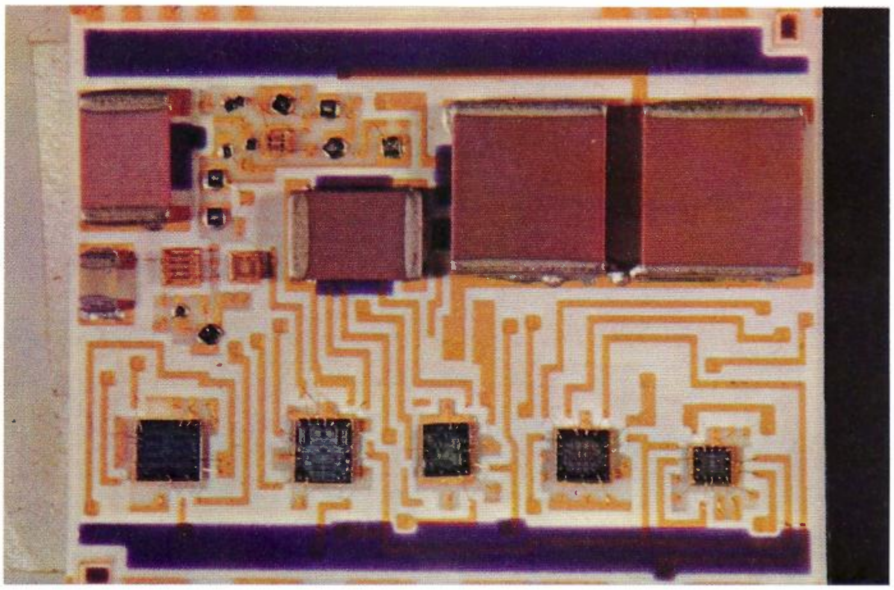
The same attention is now being focussed on more sophisticated combustible gas alarm systems of static type for building protection. Five fixed installation systems from overseas manufacturers have been extensively tested. The determination of the combustible gas response characteristics of one such system is shown in progress.

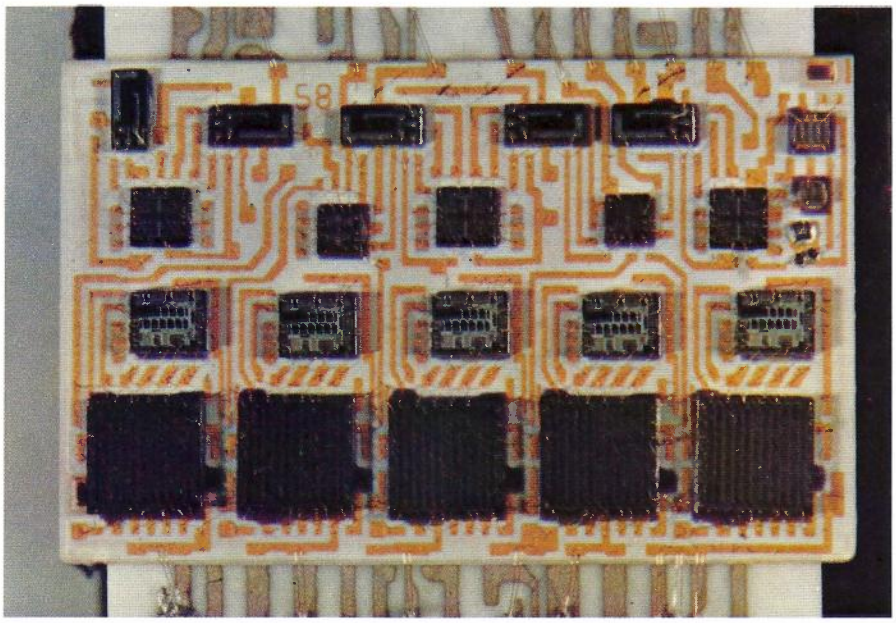
Laboratory and practical tests, when pooled, are of value in specifying a common, fixed alarm system, which will be particularly suitable for the protection of Telecom Australia premises, such as cable chambers in telephone exchanges and other, possible hazardous, areas.

Core Balance Earth Leakage Circuit Breakers

Several brands of these devices have been evaluated by the Laboratories to determine their effectiveness and reliability. They are claimed to protect users of electrical equipment from receiving hazardous electric shocks from the equipment. When the devices detect earth leakage currents greater than about 10 mA they disconnect the load from the supply within 30 ms. One brand was found to be more suitable than others for the proposed use with portable generating equipment. Some electronic component changes were recommended however to improve the long term reliability of this device.

Two of the three tiers of the implanted hearing aid. The devices were bonded by a commercial firm





Implanted Hearing Aid

The Eye and Ear Hospital and the Melbourne University Departments of Otolaryngology and Electrical Engineering requested the development of a thick-film microcircuit for implanting beneath the skin behind the ear. The resulting three-tiered multi-layer hybrid receives power and signals by inductive coupling and stimulates a small number of the auditory nerve endings of the inner ear thus providing an "artificial ear" for people with severe nerve deafness. The Research Laboratories produced state-of-the-art thick film hybrids with high packing density which form the heart of the complete "bionic" device.

Power Outlet and Appliance Test Set

At the request of the Buildings Branch, Engineering Department Headquarters, the Research Laboratories designed and constructed, in prototype form, an electronic test set to facilitate the routine testing of single phase power outlets and appliances. The unit provides a unique single instrument facility to test polarity, earth potential and active-earth loop impedance of an outlet, and tests the earth resistance and insulation resistance of appliances. Indication is by "good/no good" lamps and may be simply operated by field staff. The instrument is being manufactured in quantity under a commercial contract.

Components for an Interviewers' Console

The Transmission Planning Branch of the Engineering Department Headquarters, is designing a telephone interviewers' console to solicit customers' opinions on transmission conditions. It will be temporarily located, in turn, at selected metropolitan exchanges and will be used to initiate test calls to customers of these exchanges. A major function of this console is the simulation of portions of the Telecom system including for example, junction loss and noise. The simulation circuitry was designed within the Research Laboratories.

Evaluation of Solar Cell Array Packaging

Three types of solar cell array have been subjected to artificial weathering, as part of an investigation of solar cell array packaging. The silicon cells were encapsulated in flexible silicone rubber and mounted in a supporting framework of glass or rigid plastic. After weathering, each of the arrays had suffered some significant physical or electrical deterioration. However, it appears that a combination of the best features of each type tested could be made to yield a solar cell array packaged in a way suitable for use by Telecom Australia in isolated areas.

High Potentials on Plastic Underground Cables

Following reports that several Telecom Australia field staff had received electric shocks when contacting pillar terminals connected to spare unearthed conductors, the reason why these conductors become charged is being investigated. The reported incidents involve hard jacketted plastic cables in high resistivity soil. Continuous recordings of the voltage on the open circuit conductors and of the earth's electric field near such cable are being made in conjunction with laboratory simulations.

An Alternative to Silicone Grease

Silicone "grease", a silicone oil thickened with expanded silica, is used to provide a long term moisture barrier in small size cable connector joints. Silicone oils are known stress crack agents for the polyolefins (polyethylene, polypropylene, etc.) used as insulating materials, although no cases of failure to solid insulation attributable to this cause have ever been reported from the field. However, with the proposed introduction of cables containing foamed insulation, compatability between insulant and connector filler will become more important. It is also desirable that the fillers used in the connector and in the cable be of similar composition. For these reasons, various polymer thickened "grease" compositions have been formulated and investigated. They are required to have good water resistance and electrical properties, adhere to the wire and all parts of the connector, and be easily placed into the connector and stay in place during use. At present, the most successful solution for these requirements appears to be a blend of polyethylene and low molecular weight polybutene.

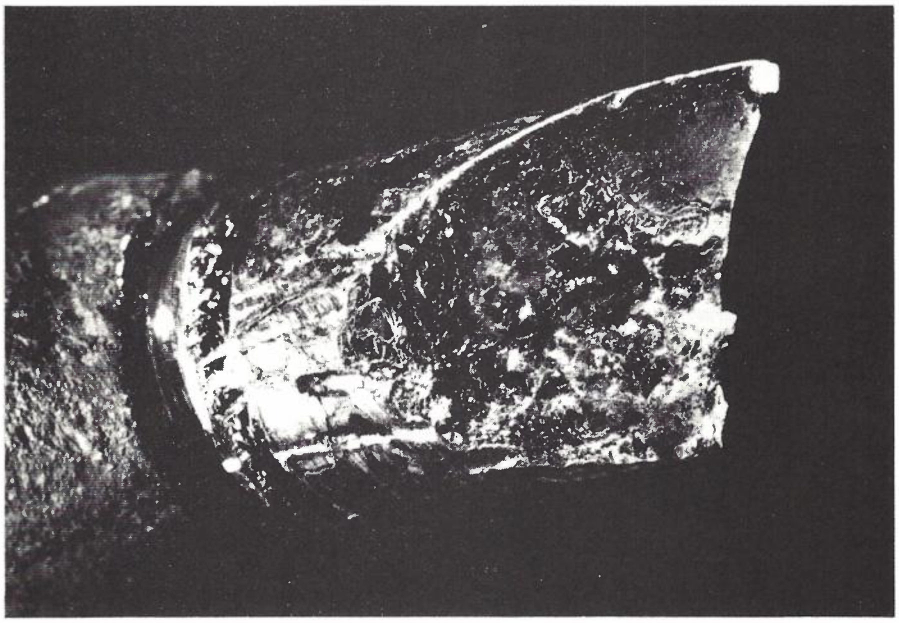
Samples of solar cells tested in the laboratory

Plastics Materials for Cable Jointing Pits

Traditionally, asbestos cement has been used for the manufacture of cable jointing pits for Telecom Australia. The main disadvantage with this material is the high breakage rate. The Lines Construction Branch of the Engineering Department Headquarters, sought tenders for supply and design of pits made from alternative materials. Accordingly, the Research Laboratories were consulted regarding the properties of the materials offered, which included high density polyethylene structural foam, sheet moulding compound, polyester/glass, reaction injection moulded polyester glass, and integral skin polyurethane foam laminate.

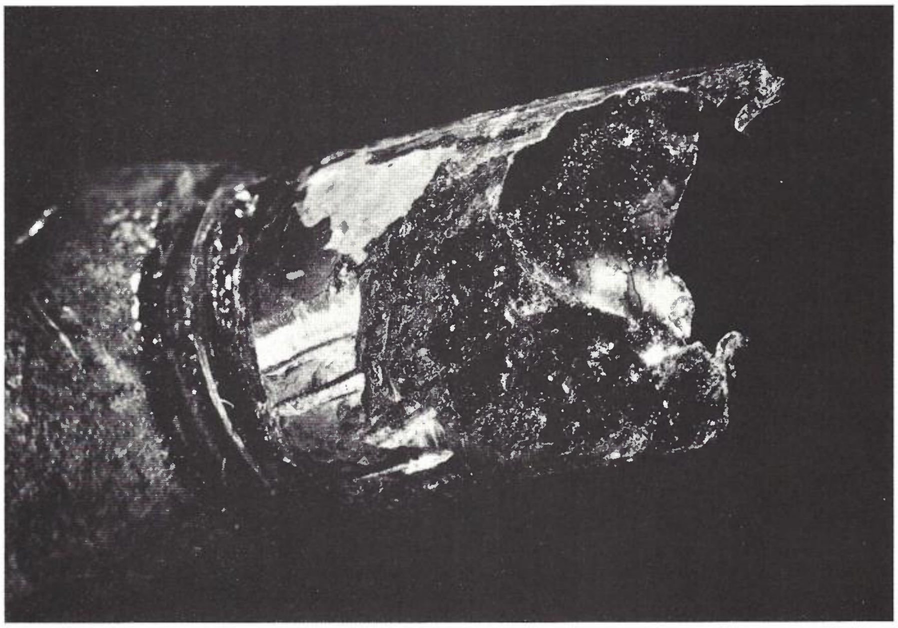
Bass-Strait Cable Equipment

The only remaining cable system connecting Tasmania to the main land (Victoria) was laid in 1935 via Naracoopa, King Island. In 1954 a nine channel extension system was installed making the highest operating frequency over the cable 108 kHz. To offset the attenuation of the cable at 108 kHz, transmitting amplifiers with 100W output power were required. Recently two of these amplifiers have been overhauled in the Research Laboratories and returned to service.



A copper bit after 4500 operations using tin/lead/copper solder. (60/38/2)

A copper bit after 600 operations using a tin/lead solder (60/40)



Erosion of Copper Soldering Bits

During soldering, copper soldering bits are rapidly eroded by tin-lead solder. To prove that by saturating the solder alloy with 2% copper this rate of erosion may be reduced, experiments with a standard soldering cycle have been conducted. It has shown that the rate of erosion could be reduced by a factor of about 20 by using a copper bearing solder alloy.

Improving Microwave System Propagation Performance

The Moomba gas pipeline microwave communication system has suffered a number of severe traffic failures due to abnormal fading. By studying the available meteorological data and the path configurations, the probable fading mechanisms have been derived. Changes in certain antenna heights are proposed to alleviate the fading.

Tender Schedule for Telephone Transmitter Development — C.8825

The Laboratories have participated in the preparation of this Schedule by drafting the technical specifications SEM051 and SEM072 which are included as appendices to the Schedule. This work was carried out at the request of, and in consultation with Customer Equipment Branch of the Engineering Department, Headquarters These specifications were based upon the results of a number of years experience of testing and specifying earlier experimental telephone transmitters. In addition, some man months effort was devoted to laboratory work aimed at determining feasibility and developing test methods.

Time Clock for Telephone Traffic Measurement

Modernization of exchange equipment necessitates improvement of the traffic measuring equipment used to predict future network growth. In line with this requirement, the Research Laboratories has developed a fully digital clock-sequencing control unit for Telecom Australia's Switching Design Branch, Engineering Department, Headquarters. This unit uses Complementary Metal Oxide Semiconductor (CMOS) logic and replaces a mechanical, mains powered device which incorporates relays as logic elements. The new unit features crystal controlled accuracy, increased programming flexibility, inherent noise immunity and an overall enhancement of reliability.

Earthing of Lightning Arrestors at Subscriber Premises

Because of high earth resistivity in certain localities, difficulties have been experienced in effectively earthing lightning protection circuits at subscribers' premises.

Studies are under way to determine the feasibility of equalizing overpotentials that may develop between a telephone installation and its surroundings, at those subscriber premises having concrete foundations or slab floors, by bonding the protective circuit earth to the steel reinforcing grids in the concrete.

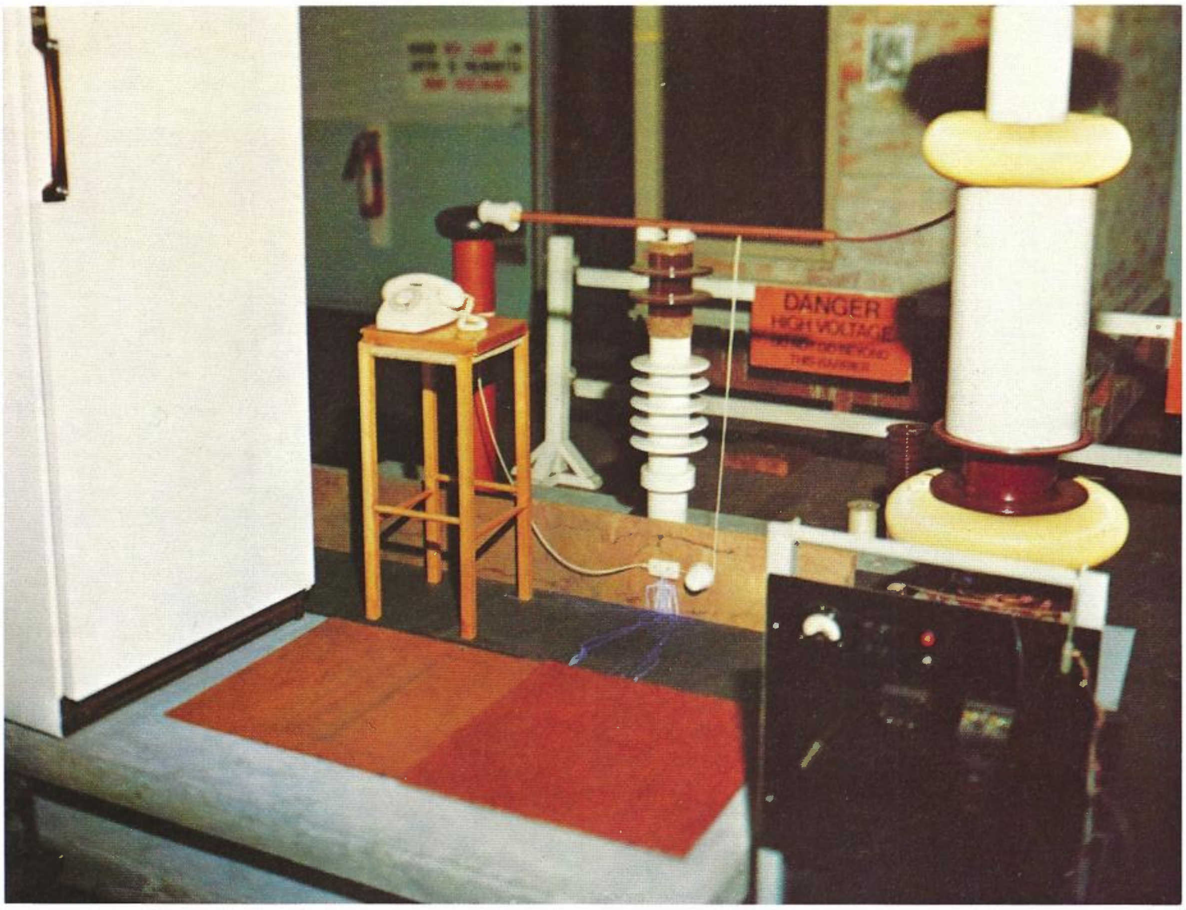
Assessments for N.A.T.A.

Officers of the Electrical Standards Section of the Research Laboratories participate in the technical assessment of the laboratories of Austral Standard Cables, the State Electricity Commission of Victoria, Olex Cables and Hewlett-Packard Australia on behalf of the National Association of Testing Authorities (N.A.T.A.). N.A.T.A. is supported by industry and government instrumentalities to oversight the quality of precision electrical measurements and the assessment work involves examining each laboratory and their staff for technical competence in such measurements. The Section also calibrates many electrical reference standards for use by N.A.T.A.-registered bodies and Telecom Australia's contractors.

Dust Retaining Mats for Exchange Entries

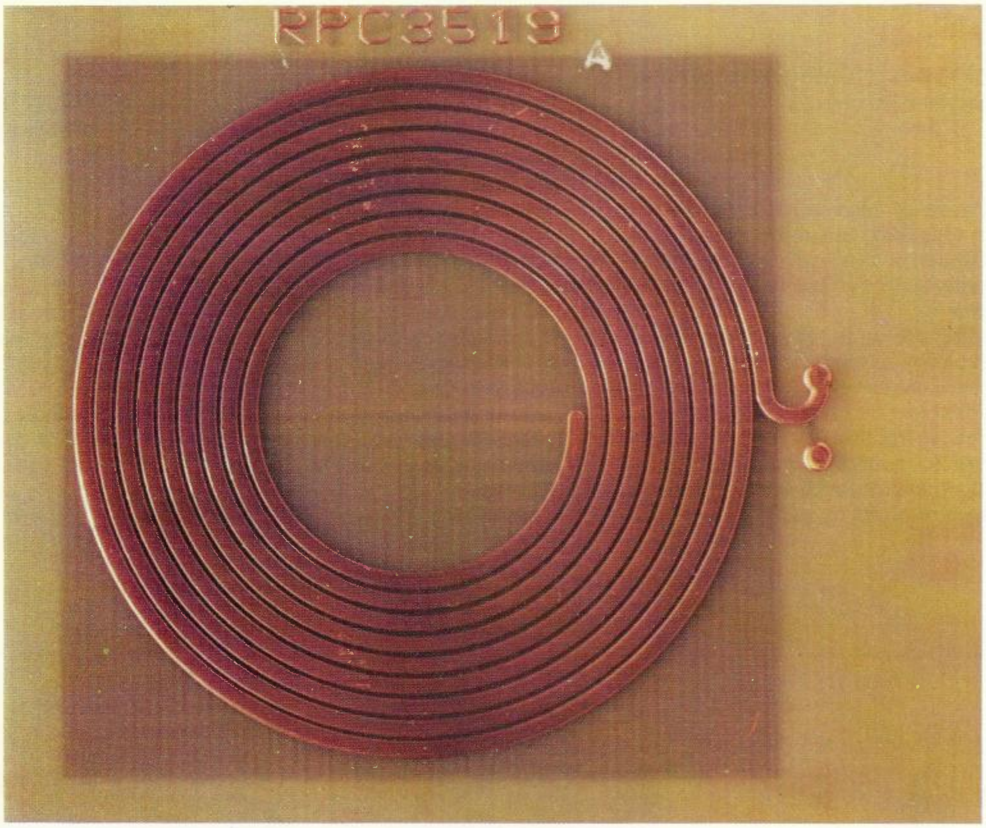
Laboratory studies have been made of the dust collection and retention efficiencies of proprietary "walk-on" dust mats, based on either the adhesive principle (impregnated mat) or the electrostatic principle of attraction of these mats in the entrances to exchange areas considered most vulnerable to dust contamination.

This investigation has been carried out in conjunction with a field trial conducted in exchanges in the Sydney metropolitan area.

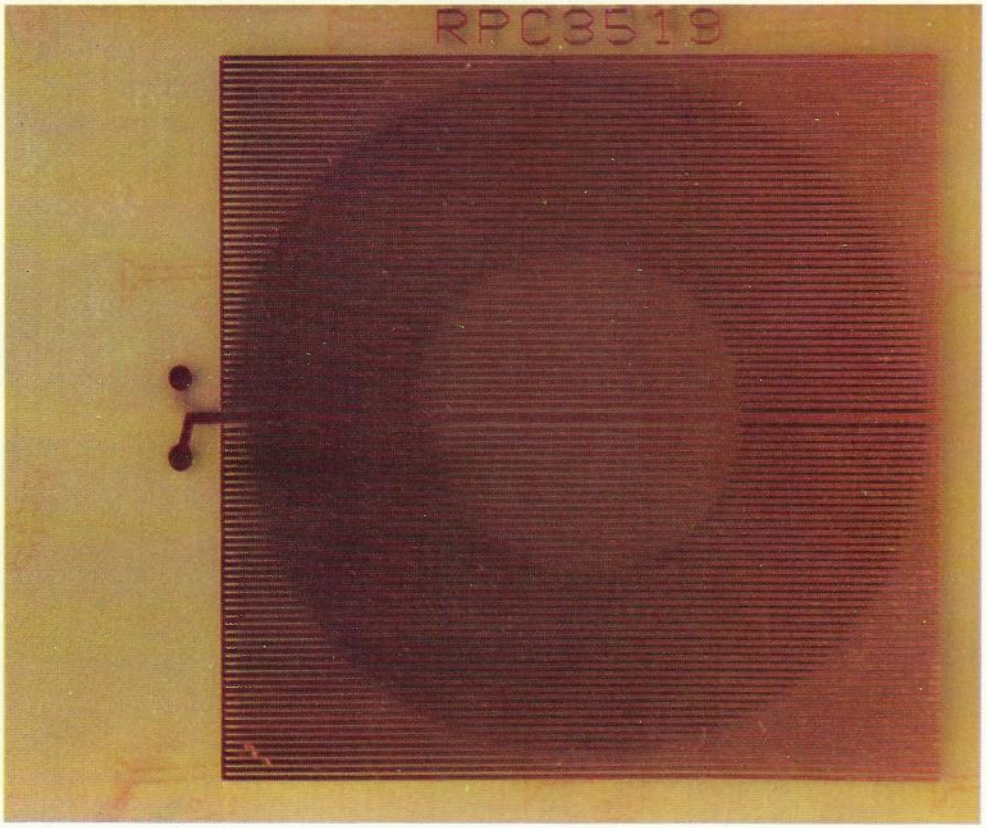


Laboratory simulated lightning discharge from a telephone installation to the steel reinforcing grid in a domestic type concrete floor

The printed circuit filter with the spiral conductor side shown



The parallel conductor side of the filter



Radio Instrument Design

The Baker Medical Research Institute is about to develop improved techniques for measuring the flow of blood through arteries. Ultra-sonic waves traversing an artery are back-scattered and doppler-shifted by the moving blood corpuscles. Measuring system concepts and advice on circuits and methods of measuring circuit performance were given, to achieve improvements in sensitivity and versatility of the measuring facility, as well as greater ease of operation by the medical staff.

Printed Circuit Filter

A 14 MHz filter using printed circuit techniques was produced by the Research Laboratories for the Long Line Equipment Construction Branch, Engineering Department, Headquarters. The filter comprises an epoxy-glass board with a spiral-shaped conductor on one side and a number of parallel conductors on the other. The tolerance required for the spiral (0.025 mm) necessitated the use of the interactive design system for the production of the necessary phototools. A plating process was also employed to increase the thickness of the parallel conductors to suit the electrical specification.

The Public Automatic Mobile Telephone Service

Assistance has been given to the Transmission Planning Branch, Engineering Department, Headquarters, in the preparation of transmission specifications and line-up procedures for a Public Automatic Mobile Telephone Service which Telecom Australia plans to introduce into the Melbourne and Sydney network.

Studies have been made of the dynamic characteristics of volume compressors and constant volume amplifiers and how their performances can be specified for speech signals, and on the specification of interface levels between the mobile system and the public telephone network, to ensure adequate transmission performance for both mobile and public network subscribers.

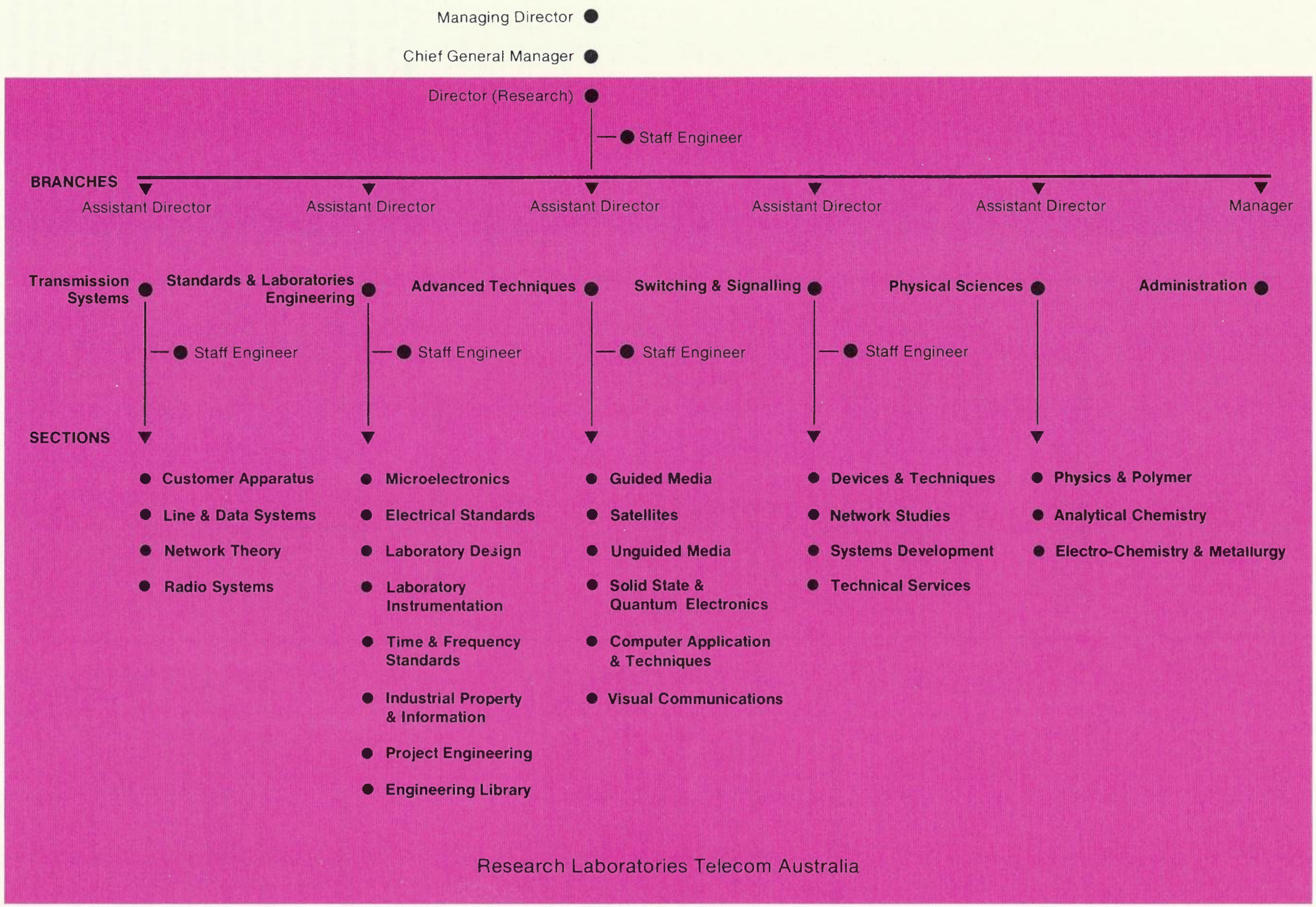
Coaxial Cable Standards

In the past the impedance standards used by the two major coaxial cable makers have been calibrated by the Research Laboratories' Electrical Standards Section. A specialized facility for the measurement of cables is being established at Maidstone by the Cable Design and Specification Section of the Lines Construction Branch, Headquarters.

These company standards as well as Telecom Australia's working standards for cable end impedance will be calibrated there on a routine basis using methods developed in the Research Laboratories. The reference standards and equipment from the Lines Branch laboratory will be calibrated by the Research Laboratories in order to maintain traceability to Telecom Australia's and the National Standards.

Primary Level PCM

One aspect of the Research Laboratories past activities in PCM involved the development of a comprehensive range of specialized test equipment and testing techniques for monitoring and/or quantifying the performance of PCM line and terminal equipment. These facilites have a wide range of applications but in particular have been used to assist the Long Line Equipment Construction Branch Engineering Department, Headquarters, with the evaluation of commercial PCM equipment. The Transmission Network Design Branch (Engineering Department) and other State Branches have also made use of an impulse noise measuring test instrument, developed within the Laboratories, in connection with a measurement programme designed to characterise impulse noise levels in the junction cable network, to establish the likely effect of impulse noise on the operation of PCM systems.



The Laboratories' Organization

The Laboratories — Staff and Organization

Organization

The Research Laboratories are a Department at Headquarters. The Director, Research, heads the Laboratories' organization. He is responsible to the Chief General Manager who in turn is responsible to the Managing Director of Telecom Australia.

The Laboratories comprise 25 scientific and engineering sections, grouped into five branches, and an administrative section. The scientific and engineering sections comprise, professional, technical and clerical support staff, with each section possessing expertise in particular areas of the engineering and scientific fields.

OVERALL OBJECTIVES OF THE LABORATORIES

- Ensure that Telecom Australia has available the necessary advice in the relevant fields of advanced science and technology.
- Provide services to Telecom Australia in the solution of problems requiring the application of specialized scientific and technological skills and experience.

Professional and Senior Staff

The names given below are those of the actual occupants of the positions (appointed or acting) at 20 April 1977.

Director: E.F. Sandbach, B.A., B.Sc.

Staff Engineer: F.W. Arter, B.E.E., M.Eng.Sc.

TRANSMISSION SYSTEMS BRANCH

BRANCH OBJECTIVES

- Maintain a reference competence in telecommunications transmission systems, and terminal equipment.
  Maintain the reference standards for telephonic transmission for Telecom Australia.

Assistant Director: R. Smith, B.E.(Hons.), M.E., M.I.E.E., M.I.R.E.E.

Staff Engineer: M. Cassidy, B.Sc., M.E., D.P.A., F.I.E.Aust., F.I.E.E., M.A.I.P., M.Inst.P.

Customer Apparatus Section

SECTION FUNCTIONS

- Research the generation, transmission and reception of speech signals in the telephone system, and new telephone services and telephone customer apparatus.
- Develop new telephone customer apparatus and components.
- Investigate and specify performance of subscribers' telephone attachments and study associated impedance and loss compatibility.
- Develop measuring apparatus and techniques for telephone customer equipment in laboratory, field and workshop applications; determine performance levels to be expected in the production of subscribers' instruments.
- Research psycho-acoustic methods of rating speech transmission systems for engineering purposes.
- Develop an Australian reference standard of telephonic transmission including appropriate fundamental acoustic and electro-acoustic standards.
- Research the acoustic environment experienced by telephone system users.

Section Head: D.A. Gray, B.E.E., Dip.Mech. & Elec.Eng., M.I.E.Aust., M.A.A.S.

Principal Engineer: E.J. Koop, B.E.(Elec.), Fell.Dip.Elec.Eng., M.A.A.S.

Senior Engineers:
P.F. Duke, B.Tech., Assoc.Dip.Maths.
R.W. Kett, Fell.Dip.Comm.Eng., A.M.I.R.E.E.
W.E. Metzenthen, F.R.M.I.T., M.E., M.I.R.E.E.

Engineers
D.M. Blackwell, B.E.(Elec.)
G.M. Casley, B.E.(Elec), M.Eng.Sc., D.I.C., Ph.D., M.I.E.Aust., A.M.I.E.E., M.I.E.E.
J.P. Goldman, Assoc. Dip.Rad.Eng., Assoc.Dip.Comm.Eng., Grad.I.E.Aust.
D.J. Kuhn, B.E.(Elec.), M.Eng.Sc.
B.W. Sneddon, B.E.(Elec.)

Senior Technical Officers:
S.G. Beadle
T.R. Long
J.E.W. Lucas

Line and Data Systems Section

SECTION FUNCTIONS

- Investigate and study line and data transmission systems and the inter-working with other parts of the transmission and switching network.
- Develop special line and data transmission systems and/or equipment peculiar to the Australian environment and not available commercially.
- Develop special line and data transmission measuring equipment.

Section Head: A.J. Gibbs, B.E.(Elec.), M.E., Ph.D., S.M.I.E.E.E. M.I.R.E.E.,

Principal Engineers:
A. Domjan, B.E.E., M.I.E.Aust.
B.M. Smith, B.E.(Hons.), Ph.D., M.I.E.E.E.

Senior Engineers:
G.J. Semple, B.E.(Hons.), M.Eng.Sc.
A.Y.C. Quan, B.E.(Hons.), M.E., A.M.I.E.E.

Engineers:
R.J. Dempsey, B.E.(Elec.)
N.Q. Duc, B.E.(Hons.), Ph.D., M.I.R.E.E., M.I.E.E.E.
J.A. Bylstra, B.Sc.(Hons.), M.Sc., M.I.E.E.E., M.I.E.Aust.
P.J. Wellby, B.E.(Hons.), B.Sc.
J.L. Snare, B.E.(Hons.)

Senior Technical Officers:
J. Gillies
J.L. Kelly
W. Yelverton

Network Theory Section

SECTION FUNCTIONS

- Conduct research into the theory and design of communication equipment circuits, including filters and equalizers.
- Conduct circuit synthesis and analysis in frequency and time domains.
- Develop mathematical models for the theory of circuits.
- Develop and test active and passive networks.

Section Head: I.M. McGregor, B.E.(Hons.), M.Eng.Sc., Ph.D.

Senior Engineer: R.L. Gray, B.E.(Hons.), M.E., Ph.D. (M.I.E.E.E.)

Engineers:
F.G. Bullock, B.E.(Hons.), Grad.I.E.Aust.
O. Tenen, Dip.Rad.Eng., M.I.E.Aust.

Senior Technical Officer: R. Owers, T.Eng.(C.E.I.) M.I.T.E.

Radio Systems Section

SECTION FUNCTIONS

- Investigate and study radio transmission systems and the interworking with other parts of the transmission and switching network.
- Develop special radio transmission systems and/or equipment peculiar to the Australian environment and not available commercially.
- Develop special radio transmission measuring equipment.

Section Head: O.F. Lobert, B.E.E., M.I.E.Aust., M.I.E.E.

Senior Engineers:
I.C. Lawson, B.E.E.
J. Steel, B.E.(Hons.), M.E., Ph.D., M.I.E.E.

Engineers:
R.A. Court, B.E.(Hons.), B.Sc., M.Eng.Sc., M.I.E.E.E.
R.W. Harris, B.Sc.(Hons.), B.E.(Hons.), B.Comm.
P.R. Hicks, B.E.(Elec.), B.Sc., M.I.E.E.E.
E. Vinnal, B.E.(Hons.)

Senior Technical Officers:
F. Temby
D.J. Thompson

STANDARDS AND LABORATORIES ENGINEERING BRANCH

BRANCH OBJECTIVES

- Maintain the standards of measurement and time for Telecom Australia.
- Protect Telecom Australia's patents, registered design and industrial property interests.
- Provide laboratory services for the Department.

Assistant Director: L.H. Murfett, B.Sc.

Staff Engineer: G.M. Willis, F.R.M.I.T. Grad I.E. Aust., Grad. I.R.E.E.

Microelectronics Section

SECTION FUNCTIONS

- Conduct research studies of advanced techniques and technologies for the design and physical realization of electronic circuitry, in particular those involving miniature and microminiature techniques and components, and for the interconnection and mounting of these circuits.
- Investigate and develop process sequences for the realization of these techniques and technologies.
- Develop specifications and test criteria for quality control and reliability of packaged microelectronic circuitry.
- Develop microelectronic circuit packaging design expertise and facilities for all Laboratories sections.
- Provide in-house facilities for producing prototype microelectronic circuits in experimental quantities.
- Advise other areas of the Research Laboratories and of Telecom Australia (e.g. Telecom Australia Workshops) on the selection of techniques and processes for specific purposes, and the means to implement these.
- Assist and encourage Telecom Australia Workshops and local industry to establish suitable manufacturing facilities and quality assurance systems to meet Telecom Australia's needs.
- Oversight the on-the-job training of trainee technical staff in the telecommunications field, for the whole of Laboratories.

Section Head: D.E. Sheridan, Dip.Elec.Eng., Dip.Mech.Eng.

Senior Engineers:
G.J. Barker, Assoc.Dip.Mech.Eng., M.I.E.Aust.
H.S. Tjio, B.E.(Mech.), Assoc.Dip.Electron.Eng.

Engineers:
A. Brunelli, Dip.Electron.Eng., B.E.(Comm.).
G. Heinze, Dip.Electron.Eng., B.E.(Elec.).

Senior Technical Officers:
C.D. Barling
M. Crarey

Electrical Standards Section

SECTION FUNCTIONS

- Plan and oversight the implementation, operation and further development of a system of electrical calibration facilities involving Headquarters and all States.
- Development and operation of Telecom Australia's central reference electrical standards, for all measurements from dc to SHF excepting those of frequency.
- Investigate measurement techniques in new areas of advancing technology where appropriate standards facilities are not currently available.
- Develop special measuring techniques and standardization procedures for the verification of working standards for all requirements of Telecom Australia.
- Liaise with and advise other national standardizing laboratories and participate in appropriate national and international standardization programmes, in particular the Standards Association of Australia and the National Association of Testing Authorities.

Section Head: J.M. Warner, B.Sc., M.I.E.E.

Senior Engineer: E. Pinczower, Dip.Elec.Eng., M.I.E.Aust.

Engineers:
J.B. Keeble, B.E.(Elec.).
R.W. Pyke, B.E.(Elec.), Dip.Elec.Eng. M.I.E.Aust.

Senior Technical Officer: J.B. Erwin

Industrial Property and Information Section

SECTION FUNCTIONS

- Maintain an industrial property advisory service and information dissemination service in scientific and technological fields of interest to Telecom Australia.
- Develop and exploit Telecom Australia's portfolio of patents and registered designs, and protect Telecom Australia's interests in industrial property aspects of contracts and licensing arrangements.
- Edit and control standards of technical publications and technical manuscripts emanating from the Laboratories.

Section Head: L.N. Dalrymple, Assoc.Dip.Elec.Eng., Grad.I.E. Aust.
ENGINEER: P.C. Hey, Dip.Elec.Eng., Dip.Mech.Eng.

Senior Technical Officers:
A.K. Mitchell
W.W. Staley

Laboratory Design Section

SECTION FUNCTIONS

- Plan and specify, in conjunction with other Telecom Australia staff, the future accommodation requirements of the Laboratories. Liaise with construction authorities and contractors during the alteration/construction phase to ensure those requirements are met.
- Plan, specify, and arrange or re-arrange accommodation, building services, and facilities for the Laboratories in existing owned and leased buildings. Plan and co-ordinate the movement of sections to new accommodation.
- Maintain special laboratory fittings, services, facilities, and equipment installed in accommodation occupied by the Laboratories. Co-ordinate Laboratories' requirements for building and building services repairs and maintenance with the Buildings Branch.
- Co-ordinate all safety, security, and fire protection matters within the Laboratories.

Section Head: D.S. Geldard, M.I.E.E., M.I.E.Aust.

Engineer: R. Day, Dip.Elec.Eng., Dip.Mech.Eng., M.I.E.Aust.

Senior Technical Officer: N.G. Chandler

Laboratory Instrumentation Section

SECTION FUNCTIONS

- Provide instrumentation services for the laboratories including the co-ordination of procurement action, preparation of technical schedules and technical reports on items offered under tender, acceptance testing of new equipment, development and operation of a specification assurance programme for the calibration of instruments, fault diagnosis and preventative and corrective action and specification of instrument making facilities.
- Design and develop laboratory instrumentation where commercially unobtainable.
- Investigate measurement and instrumentation problems and provide consultative advisory services in this field.

Section Head: A.M. Collins, B.Sc.

Senior Engineers:
A.J. Stevens, B.E.(Elec.), M.I.E.E., M.I.E.E.E.
F.R. Wylie, B.E., M.I.E.E.E.

Engineers:
R.E. Proudlock, B.E.(Elec.)
M.J.J. Valk, B.E.(Comm.)
L. Davidovits, B.E.(Elec. Hons.), M.I.E.E.E.
N.A. Leister, B.E.(Elec.), Grad.I.R.E.E.

Senior Technical Officers:
P.S. Dawson
S. Curlis
P. Dalliston
B.J. McEwen

Time and Frequency Standards Section

SECTION FUNCTIONS

- Operate, maintain and calibrate standards of frequency and time.
- Research the development of improved frequency standards and devices for the use and application of such standards.
- Verify frequency and time interval references both within and without Telecom Australia.
- Liaise with other standardizing laboratories and national and international standards groups.
- Research and investigate the propagation of high precision frequency and time signals in various media with minimum loss of precision.
- Investigate applications of standard frequency and time techniques and the scientific basis of radio frequency allocations.

Section Head: R.L. Trainor, B.Sc.

senior Engineer: A.A.R. Townsend. B.E.(Elec.), M.I.E.E.

Engineers:
B.R. Ratcliff, Assoc.Dip.Comm.Eng.
D.A. Latin, B.E.(Elec.)

Senior Technical Officers:
J. Freeman
V.E. Thomas, A.M.I.R.E.E.
R. Yates

Project Engineering Section

SECTION FUNCTIONS

- Provide for the Laboratories, a specialist engineering service involving mechanical and electromechanical engineering design, including the hardware involved in construction of telecommunication models. Liaise with other areas of Telecom Australia and with industry to arrange production of these designs; and when these sources are unsatisfactory, arrange production within the Laboratories.
- Conduct research into the application of new materials and fabrication techniques, and apply these to the design and construction of mechanical and electromechanical devices, equipment and tools which cannot be procured otherwise.
- Establish specification criteria and perform quality assurance inspections to ensure that equipment produced, either in-house or outside the Laboratories, is adequate to its function and reflects a high standard of competence in the field. Establish techniques and facilities for associated metrological measurements.
- Oversight the on-the-job training of apprentice artisans and trainee technical staff in the mechanical engineering field, for the whole of the Laboratories.

Section Head: P.F. Meggs, Assoc.Dip.Mech.Eng., M.I.E.Aust.

Senior Engineer: W.F. Hancock, Dip.Elec.Eng.

Engineers:
R. Gilchrist, Assoc.Dip.Mech.Eng., B.E.(Mech. Hons.), Grad.I.E.Aust.
C. Mangalore, B.E.(Mech.), M.I.E.Aust., Grad.Dip.Data Processing.

Senior Technical Officer: C.V. Eyre

Engineering Library Section

SECTION FUNCTIONS

- Provide a complete library service to the Engineering and Research Departments at Headquarters.
fc393Oversight the provision and conduct of library services to the Engineering Department within the State Administrations and provide consultative services thereto.

Section Head: M.I. Cuzens, B.A., F.L.A.A., A.L.A., F.R.I.P.A.

Librarians:
S.M. Peters, B.A., B.Sc., Dip.Ed., Dip.Lib., A.L.A.A.
S.E. Roberts, B.Soc.Sc.(Lib.).
H.M. Wisdom, B.A., A.L.A.A., Dip.Lib.
A.F. Parkhowell, B.A., Dip.Lib., A.L.A.A.
D. Richards, Dip.Lib.

ADVANCED TECHNIQUES BRANCH

BRANCH OBJECTIVES

- Maintain a reference competence in frontier technology, systems and techniques relevant to the needs of Telecom Australia.

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

Computer Applications and Techniques Section

SECTION FUNCTIONS

- Conduct fundamental studies on the application of computers and processors to advanced interpersonal and business communication facilities providing optimum man/machine interface conditions, including the design and evaluation of associated hardware and software systems and peripherals.
- Investigate methods of mathematical analysis best suited to the application of computers to problem solving in telecommunications engineering.
- Investigate, define and co-ordinate the provision and development of computer systems and facilities to meet the needs of the Research Department.

Section Head: G.K. Jenkins, B.Sc., B.E.(Hons.), M.E., M.A.C.S.

Senior Engineer: P.J. Tyers, B.E.(Hons.), B.Sc., M.I.E.E.E.

Engineers:
K.S. English, B.E. (Elec. Hons.)
I.L. Jenkins, B.E.(Elec. Hons.)
R.A. Seidl, B.E.(Elec. Hons.), Ph.D.
L.A. Denger, E.N.S.E.M.N., M.I.E.E.E., M.Soc.Fr.de Elec., Grad.I.E.Aust.
R. Frizzo, B.E. (Elec. Hons.)

Senior Technical Officer: I.J. Moran

Guided Media Section

SECTION FUNCTIONS

- Conduct research and exploratory development into the transmission of electromagnetic waves in situations where they are guided from end to end by some form of physical structure (such as an aerial line, a telephone cable, a coaxial cable, a waveguide or an optical fibre) with special reference to the development of high capacity transmission systems, the provision of wideband subscriber facilities, and associated problems.

Section Head: R.J. Morgan, B.Sc.(Eng. Hons.), Ph.D., A.M.I.E.E., M.I.E.E.E.

Senior Engineer: R.W. Ayre, B.E.(Elec.)(Hons.), B.Sc.(Hons.), M. Eng. Sc.

Engineer: J.P. Colvin, B.E.(Elec.) Dip. Elec. Eng.

Satellites Section

SECTION FUNCTIONS

- Conduct research and investigation into applications of communication satellite technology in Australia, including system and technique studies, hardware development and experimentation.

Section Head: E.R. Craig, B.Sc.(Hons.), M.I.E.E.

Principal Engineer: G.F. Jenkinson, B.Sc., M.I.R.E.E.

Senior Engineer: R.K. Flavin, B.Sc., M.Sc., M.I.E.Aust.

Solid State and Quantum Electronics Section

SECTION FUNCTIONS

- Investigate the properties of materials and compounds that are applicable to the development and fabrication of devices and circuit elements whose functions are based on the exploitation of special material properties. Conduct exploratory development and fabrication of such devices.
- Investigate active and passive circuit configurations employing such devices for the generation, amplification, modulation and processing of electro-magnetic and electro-acoustic signals and their application in microwave integrated circuits and sub-systems.

Section Head: W.J. Williamson, B.E.(Elec. Hons.), Ph.D.

Principal Engineer: N.F. Teede, B.E.(Hons.), Dip.Mgt., Ph.D.

Senior Engineers:
P.V.H. Sabine, B.Sc., B.E.(Elec. Hons), Ph.D.
R. Horton, B.Sc.(Hons.), Ph.D., A.M.I.E.E., M.I.R.E.E.

Engineers:
J. Hubregtse, Fell.Dip.Comm.Eng., Grad.I.R.E.E.
E. Johansen, B.E.(Hons.)
G.K. Reeves, B.Sc.(Hons.), Ph.D., M.I.E.Aust.
G.O. Stone, B.E.(Elec.), M.Eng.Sc., Ph.D., M.I.E.E.E., M.I.R.E.E.

Senior Technical Officers:
B. Cranston
H. Wills, Assoc.Dip.Rad.Eng., A.M.I.R.E.E.

Unguided Media

SECTION FUNCTIONS

- Conduct research and exploratory development in the field of freely propagated electromagnetic waves, with particular reference to the study of performance and design characteristics of high capacity communication systems. (This includes the study of propagation phenomena and of the interrelation of physical and meteorological mechanisms).
- Conduct research related to antennas for launching and receiving electromagnetic radiation, for application both in the design of antennas for exploratory development work and in practical engineering projects.

Section Head: J.H. Reen, B.E.E., M.I.E.Aust.

Principal Engineers:
S. Sastradipradja, B.E.(Elec.)
J.V. Murphy, B.E.(Elec.), B.A.

Senior Engineers
W.S. Davies, B.E.(Elec.), M.Eng.Sc., Ph.D.
R.A. Harvey, Dip.Rad.Eng., B.Sc., A.M.I.R.E.E.

Engineers:
A.J. Bundrock, B.E.(Elec. Hons.)
J.M. Burton, B.E.(Elec. Hons.)
Y.H. Ja, B.E., Ph.D.

Senior Technical Officers:
B.W. Booth
R.J. Francis
S.J. Hurren

Visual Communications Section

SECTION FUNCTIONS

- Investigate methods and systems for the transmission, generation, presentation and processing of visual information of all kinds, including engineering aspects of human visual perception.
- Study means of economising the bandwidth used to convey visual information from one point to another.
- Study advanced time domain and waveform techniques related to the processing and transmission of information.

Section Head: G. Rosman, B.E.E., M.E.

Senior Engineers:
J. Craick, B.E.(Elec. Hons.), B.Sc.
N. Demytko, B.E.(Elec. Hons.), B.Sc.

Engineers:
A.M. Duncan, B.Sc., B.E.(Elec. Hons.)
D.Q. Phiet, B.E.(Elec. Hons.), Ph.D.
G.R. Smart, A.R.M.I.T., A.M.I.R.E.E., J.P.

Psychologist: L.A. Albertson, B.A.(Hons.), Dip.Ed.

Senior Technical Officer: G. Quirk

SWITCHING AND SIGNALLING BRANCH

BRANCH OBJECTIVES

- Maintain a reference competence in advanced telecommunications switching and signalling techniques and systems and the related components.

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

Staff Engineer: I.P. Macfarlane, A.R.M.T.C., B.E.(Elec.)

Devices and Techniques Section

SECTION FUNCTIONS

- Assess the potential of new devices and techniques for application in switching and signalling systems.
- Develop new techniques to exploit the latent potential of new devices and techniques.
- Participate in the design and assessment of field trials of new systems and equipment which use novel devices and techniques.
- Prepare recommendations for the adoption or trial of new devices and/or techniques.

Section Head: A.M. Fowler, M.I.E.Aust., M.I.R.E.E.

Senior Engineer: P.S. Jones, M.Eng.Sc.

Engineers:
J.L. Park, B.E.(Hons.), M.Eng.Sc., M.I.E.E.E.
E. Tirtaatmadja, B.Eng.(Elec.)
M.R. O'Keefe, B.E.(Hons.), M.Eng.Sc.

Physical Scientist: C.J. Scott, B.App.Sc., Grad.A.I.P.

Network Studies Section

SECTION FUNCTIONS

- Conduct research into the basic nature of switching networks, and the manner in which changes in network parameters influence the technical and economic characteristics of the network.
- Assess the potential of new systems in relation to future network needs.
- Provide specialist consultative advice and assistance in relation to progressive integration of new systems into the Telecom Australia's networks.
- Examine detailed requirements for switching and signalling systems in new environments and conduct feasibility studies of possible approaches.

Section Head: R.J. Vizard, Dip.Elec.Eng., B.E.E.

Senior Engineers:
N.W. McLeod, B.Sc., M.I.E.Aust.
P. Gerrand, B.Eng.(Hons.), M.Eng.Sc., M.I.E.Aust.
P.J. Reid B.E. (Comm.)

Engineers:
J.L. Collins, Dip.Elec.Eng., B.E.
S.M. Jong, B.E.(Elec.)

Senior Research Officer: R.G. Addie, B.Sc.(Hons.)

Systems Development Section

SECTION FUNCTIONS

- Develop switching and signalling systems and equipment using new techniques and/or principles, or to meet new requirements.
- Develop and arrange production of equipment for field trials, arrange installation, and conduct of trials.

Section Head: E.A. George, A.S.T.C., M.I.E.

Principal Engineer: G.J. Champion, B.E.

Senior Engineers:
M.A. Hunter, B.E.(Hons.), A.M.I.E.E.
A. Even-Chaim, B.Sc. M.I.E.E.
M. Subocz, B.E.(Elec.), M.I.E.Aust.

Engineers:
B. Wickham, B.Sc., B.E., M.I.E.Aust., M.I.R.E.E., M.I.E.E.E.
G. Millsteed, Dip.Elec.Eng., B.E.(Hons.)
F. Eastaughffe, B.Sc., B.E.(Hons.)
V. Peska, B.E.(Elec.)

Technical Services Section

Section Function

- Provide technical support to the other Sections within the Branch.

Section Head: W. McEvoy, A.A.I.M.

Senior Technical Officers:
D.J. Duckworth
A. Romagnano
N.W. Wolstencroft
H.G. Fegent
B.C. Gilbert
P.C. Murrell

PHYSICAL SCIENCES BRANCH

BRANCH OBJECTIVES

- Provide services to Telecom Australia in the fields of Physics Chemistry and Metallurgy.

Assistant Director: R.D. Slade, Assoc.Dip.Met., M.I.M., M.A.I.M.F.

Physics and Polymer Section

SECTION FUNCTIONS

- Conduct exploratory research and investigation in the field of Physics and Polymer to the depth necessary to enable this scientific knowledge to be applied to the solution of telecommunications problems.
- Conduct scientific studies into the electrical, magnetic, mechanical, optical and thermal attributes of new materials and components.
- Carry out scientific studies into polymeric materials and develop methods for their application within Telecom Australia. Develop polymer materials with special properties for particular applications as required.
- Conduct research into the nature and simulation of the effects of the natural and man made environment of plant and staff, and where necessary devise means of protection from any deleterious influences.
- Investigate and develop new techniques in X-radiation, colour measurement photometry, spectroscopy and other methods of instrumental analysis directed at facilitating an understanding of the composition or physical structure of materials.

Section Head: G. Flatau, F.R.M.I.T.(App.Phys.)

Principal Physical Scientist (Physics Group): D. McKelvie, B.Sc.(Hons.)

Senior Physical Scientists:
I.A. Dew, B.Sc., M.Sc., M.A.I.P.
G.W. Goode, B.Sc.

Physical Scientists:
E.J. Bondarenko, Dip.App.Phys., B.App.Sc., M.A.I.P., M.I.R.E.E., F.R.A.S. S.J. Charles, Assoc.Dip.App.Phys., B.App.Sc. Grad. A.I.P.
I.J. Lloyd. B.Sc.(Hons.), M.Sc., Ph.D.
B.A. MacLennan, B.Sc.
G.G. Mitchell, B.Sc.(Hons), M.Sc.
A.J. Murfett, B.Sc.(Hons.) Grad.A.I.P.
I.K. Stevenson, B.App.Sc., A.R.M.I.T., Grad.A.I.P.
Principal Physical Scientist (Polymer Group):
H.J. Ruddell, Dip.App.Chem., A.P.I.A.

Senior Physical Scientist:
B.A. Chisholm, Dip.App.Chem., Grad. R.A.C.I.

Physical Scientists:
D.J. Adams, Dip.App.Chem., Grad.R.A.C.I.
D.T. Miles, F.C.S., C.Chem., M.R.I.C., M.R.S.H.
R.J. Boast, Dip.App.Chem., Grad.R.A.C.I.

Senior Technical Officers:
M.C. Hooper
E.L. Wallace, A.R.M.I.T.(App.Phys.)
C.W. Downing

Analytical Chemistry Section

SECTION FUNCTIONS

- Conduct exploratory research and investigations in the field of chemistry to the depth necessary to enable the newly acquired scientific knowledge to be applied to the solution of telecommunications engineering problems.
- Conduct chemical studies into materials and develop methods for their application within Telecom Australia. Develop materials with special properties for particular applications as required.
- Provide the scientific backing for the operations of the Australian Government Stores and Tender Board, including the formulation of new specifications and approval testing of all relevant types of materials and consumer products.
- Carry out scientific studies involving chemical phenomena in such fields as microelectronics and printed circuitry and exploratory development and fabrication of such devices.

Section Head: F.C. Baker, Dip.App.Chem., Dip.Chem.Eng., A.R.A.C.I., A.A.I.S.T., F.C.S.

Physical Scientists:
I. Cederholm, M.Sc., A.R.A.C.I.
S. Georgiou, B.App.Sc.(App.Chem.) F.M. Petchell, Dip.App.Chem.
R.J. Western, Dip.App.Chem.

Senior Technical Officer: R.R. Pierson, M.A.I.S.T.

Electro-Chemistry and Metallurgy Section

SECTION FUNCTIONS

- Conduct exploratory research and investigation in the fields of electro-chemistry and metallurgy to the depth necessary to enable the newly acquired scientific knowledge to be applied to the solution of telecommunications engineering problems.
- Perform scientific studies involving electrochemical phenomena in such fields as corrosion, protection and electrical power sources, and exploratory development and fabrication of such devices.
- Investigate metallographic and crystallographic techniques and apply these to studies related to the functions, properties and composition of materials and equipment.
- Investigate, develop and adopt methods of non-destructive testing.
- Investigate theoretical and practical aspects of surface protection and electrodeposition and development of practices for the satisfactory and economic protection of equipment and plant.

Section Head: K.G. Mottram, Fell.Dip.Met.Eng., A.M.A.I.M.M.

Senior Physical Scientist (Electrochemistry Group):
J. Der, B.Sc., A.R.A.C.I.

Physical Scientists:
P.J. Gwynn, Dip.App.Chem.
Z. Slavik, Dip.Eng., A.R.A.C.I.

Senior Physical Scientists (Metallurgy Group):
T.J. Keogh, Assoc.Dip.Sec.Met.

Physical Scientists:
J.R. Godfrey, Assoc.Dip.Met.
K. Keir, Fell.Dip.Met.Eng.
J.R. Lowing, Dip.Sec.Met.

Senior Technical Officers:
M. Jorgensen, Assoc.Dip.Met.
J.W. Smith

SENIOR ADMINISTRATIVE STAFF

Manager Administration: A.B Conroy

Executive Assistant: T.W. Dillon

Senior Planning Officer: J.F. Reid

Office Manager: B.F. Donovan

Budgets Officer: E.J Scates

Equipment Officer: R.J. Beveridge

Branch Administrative Officers:
T.H. Brown
C.J. Chippindall
M.A. Chirgwin
D. Forster
J.S. Sergeant

Papers, Lectures, Talks and Reports

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

PAPERS

Albertson, L.A.	"Telecommunications as a Travel Substitute: Some Psychological, Organisational and Social Aspects", The Journal of Communication, Vol. 27, No. 2, Spring 1977. (also published as a monograph by the N.S.W. Division of the Telecommunications Society of Australia).
Albertson, L.A.	"Are Telecommunications a Substitute for Travel?", Intermedia, Vol. 4, No. 2, April, 1976.
Albertson, L.A. and (Cutler, T. Customer Services)	"Social Science in a Technological World", Newsletter of the Occupational Psychologists' Division of the A.P.S., No. 12, 1976 and No. 14, 1977.
Albertson, L.A. and (Cutler, T. N.T.P.)	"Delphi and the Image of the Future", Futures, October 1976
Bennett, J.A.,	"A Definition of Pulse Delay in the Presence of Distortion", Proceedings I.E.E.E.
Cahill, L.W.	"Semiconductor Light Sources for Fibre Transmission Systems", Australian Telecommunication Research, Vol. 10, No. 2, 1976.
Cassidy, M. and (Peake, D. N.S.W. Institute of Technology)	"Co-operative Operational National Information System for Australia", Canberra, August 1976, The Australian Library Journal, October 1976.
Coutts, R.P. and (Davis, B.R. Department of Electrical Engineering Adelaide University	"Buffer Requirements for Intermittent Data Transmission Over a Rayleigh Fading Channel", I.E.E.E. Transactions on Communications, Vol. Com-24, No. 10, October 1976.
Coutts, R.P. and Beare, C.T. Department of Electrical Engineering, Adelaide University)	"Simulation of Data Communication Systems" I.E. Aust. Conference on Computers in Engineering, Perth, September 1976.
Crew, G. and Hunter, M.A.	"A Common Channel Signalling System", Australian Telecommunication Research, Vol. 9, No. 1.
Davies, W.S.	"On Optical Diffusion Coefficient for Step-Index Multimode Guides", Optical and Quantum Electronics Vol. 9 No. 1 January 1977.
Dossing, S., Lobert, O. Bondarenko, E.J. (Haydon, S.C. and Plumb, I.C. Department of Physics, University of New England, Armidale, N.S.W.)	"Investigations Towards the Understanding of the Properties and Formation of Plumes on R.F. Aerials", Australian Telecommunication Research, Vol. 10, No. 1, 1976.
Even-Chaim, A.	"Demand Assignment System for Subscribers Digital Loop", I.E.E./I.E.E.E. International Symposium on Subscribers Loops and Services (I.S.S.L.S.) London, May 1976.
Fegent, H.G.	"Call State Transition Diagrams for Crossbar Exchanges", The Telecommunication Journal of Australia, Vol. 26, No. 1, 1976.
Gibbs, A.J.	"Optimization of Binary Transversal Filters with Constrained Sampled Impulse Response", International Journal of Circuit Theory and Applications, Vol. 4, No. 2, April 1976.
Hicks, P.R.	"A Wide Dynamic Range True Root Mean Square Detector", Australian Telecommunication Research, Vol. 10, No. 2, 1976.
Horton, R.	"Analogue FDM Telephony Transmission in Optical Fibres : The Limitations of Intermodulation Distortion", Electronic Letters, Vol. 12, No. 15, July 1976.
Horton, R. and Morgan, R.J.	"Optical Fibre Systems in the Australian Context" Monitor (Proceedings of I.R.E.E.) January/February 1977.
Horton, R.	"Prospective Applications of GaAs FETs in Analogue Communication Equipment at Microwave Frequencies", Monitor (Proceedings of I.R.E.E.) November 1976.
Jones, P.S.	"Code-Division-Multiplexed Delta Modulation for the Subscriber Loop", I.E.E./I.E.E.E. International Symposium on Subscribers Loops and Services (I.S.S.L.S.) London, May 1976.
Jenkinson, G.F.	"Tropical Rain Attenuation at 11GHz on Earth-space Paths - Radiometric Measurements in Australia" Proc. I.E.E.E., March 1977.
Keogh, T.J.	"Failure of Diesel Engine Cylinder Liner by Cavitation", Metals Australia, July 1976.
Keogh, T.J.	"Metal Whiskers Cause Electronic Failure", Metals Australia, February 1977.
Mazzaferri, F.D.	"The Concept of an Improved Digital MFC Generator", Australian Telecommunication Research, Vol. 10, No. 2, 1976.
Metzenthen, W.E.	"The Long Line Telephone : Telephone 804", The Telecommunication Journal of Australia Vol. 26, No. 1, 1976
Miles, D. and Flatau, G.	"Selection of Telecommunication Materials" Metals Australia, October 1976

Morgan, R.J.	"Design Consideration for Digital Systems Using Multimode Fibre with Lossy Cladding" Electronic Letters, Vol. 12, No. 15, July 1976.
Park, J.L.	"A High-Speed Digital Regenerative Repeater for Coaxial Cable", Australian Telecommunication Research, Vol. 10, No. 1, 1976.
Rosman, G. and Berzins, G.	"Intercontinental Television Conference Trials", Proceedings of I.E.E.E., Vol. 65, No. 3, March 1977.
Sabine, P.V.H.	"Refractive Index Profiles of Stress Induced (Embossed) Optical Waveguides", Electronics Letters, Vol. 13, No. 2, January 1977.
Smith, B.M.	"The Mean Square Error of SSBAM Class 4 Partial Response Data Signals Distorted by Parabolic Group Delay", I.E.E.E. Transactions on Communications, Vol. COM-24, No. 11, November 1976.
Smith, B.M.	"Digital Data Transmission Techniques", Research Laboratories Information Bulletin No. 8, 1976.
Steel, J. and Smith, B.M.	"Carrier and Clock Recovery From Transversal Equalizer Tap Settings for a Partial Response System", I.E.E.E. Transactions on Communications, September 1975.
Steel, J.	"Partial Response Pulses for Data Transmission", Australian Telecommunication Research, Vol. 10, No. 2, 1976.
Teede, N.F. (Kataoka, S.)	"Growth of Native Oxides on InP" Japanese Applied Physics Society, Spring Meeting, May 1977, Tokyo, Japan.
Williamson, W.J.	"Variations in the Outer Dimensions of Quartz Tubes for Optical Fibres", Australian Telecommunications Research, Vol. 9, No.1.
Williamson, W.J.	"GaAs and Related Compounds for Optical Integrated Circuits", Monitor (Proceedings of I.R.E.E.), January/February 1977.

LECTURES AND TALKS

Albertson, L.A.	"People Communicating", Lecture to Swinburne College of Technology August 1976.
Barker, G.J.	"Thick Film Hybrid Microcircuit Technology" Telecom Australia, South Australian Engineers Group, Adelaide, July 1976.
Burton, J.M.	"Fields of Activity for Graduate Engineers", Engineering Seminar for RMIT Students, October 1976.
Cahill, L.W.	"Characteristics of Semiconductor Lasers" First Australian Optical Workshop at University of New South Wales, March 1977.
Cassidy, M.	"Research and Development in Colleges of Advanced Education", panel discussion at the Australian Annual Conference on Electrical Engineering, Melbourne, December 1976.
Cahill, L.W.	"Transient Effects in GaAs Injection Lasers" Radio Research Board Symposium on Optical Communications and Integrated Optics, Melbourne, August 1976.
Chisholm, B.A.	"Properties of Plastics and Their Application within Telecom Australia", Lecture to N.S.W. Engineering Staff District Works, July 1976.
Chisholm, B.A.	"Aspects of Plastics Education within the Australian Telecommunications Commission", The First Australian Conference on Plastics Education, Sydney, July 1976.
Chisholm, B.A.	"Materials for Telecommunications", Conference of Materials Science Lecturers at Bendigo College of Advanced Education, December 1976.
Craig, E.R.	"Communications Satellite Research" I.R.E.E. Melbourne Division, September 1976.
Denger, L.A.R.	"Difference Method Applied to Gloge's Partial Differential Equation" Radio Research Board Symposium on Optical Communications and Integrated Optics, Melbourne, August 1976.
Davies, W.S. and Sastradipradja, S. Hurren, S.J.	"The Measurement of Antenna Characteristics", Melbourne, June 1976.
Dew, I.A.	"Light-Emitting Diodes - Promise and Reality" Telepost Engineers Group, Melbourne, August 1976.
Flatau, G.	"Reliability, Myth and Reality", Symposium on Reliability, Australian Statistical Society, Sydney, November 1976.
Flatau, G.	"Objectives, Scope and Organization of the Physical Sciences Branch of Telecom Australia Research Laboratories", Seminar on Applied Physics in Australia. School of Applied Physics and Optometry, University of New South Wales, August 1976.
Frizzo, R.A.	"A Case Study in Microprocessor Software Development", 1977 State Circuit Standards Engineers Conference, March - April 1977.
Gray, D.A.	"Research into Acoustics in Telecommunications", Australian Acoustic Society Conference, September 1976.
Harvey, R.A.	"Basic Propagation Involved in Link Engineering", Melbourne, November 1976.
Hont, J.	"Planning Considerations for Microprocessor Projects", I.E. Aust. Colloquium on Microprocessor Systems, Sydney, November 1976.

Horton, R.	"The Limitations of Analogue FDM Transmission Over Optical Fibres" Radio Research Board Symposium on Optical Communications and Integrated Optics, Melbourne, August 1976.
Horton, R.	"UHF Amplifier and Oscillator Design", Victoria Institute of Colleges - Footscray Institute of Technology, May 1976.
Horton, R., Barker, G.J. and Flavin, R.K.	"The Technology and Design of Low-Noise, Solid State, UHF Amplifiers", A Colloquium at C.S.I.R.O. Division of Radio Physics, N.S.W., October 1976.
Horton, R. and Morgan, R.J.	"Potential Optical System Configuration for the Australian Network using Currently Available Sub-system Components", Department of Electrical Enginering, Monash University, November 1976.
Horton, R. Morgan, R.J. and Ayre, R.W.	"Optical Systems for Telecommunications", Melbourne Division I.R.E.E., February 1977.
Jenkins, G.K., Tyers, P.J.	"Host-Resident Microprocessor Support Software", University of W.A. Colloquium on Microprocessors, May 1977.
Jenkins, G.K., Jenkins, I.L., and Tyers, P.J.	"Microprocessors, Resident and Host Software Development Processors", Telecom Australia Staff, Sydney, November 1976.
Jenkins, G.K.	"Cross-Assemblers and Emulators", Telecom Australia Staff, Adelaide, February, 1977.
Jenkins, G.K., Jenkins, I.L.	"Microprocessors, Cross-Assemblers and Emulators", Telecom Australia Staff, Melbourne, November, 1976.
Jenkins, G.K., Jenkins, I.L., and Tyers, P.J.	"Microprocessor Software Development Techniques", Telecom Australia Staff, Perth, May 1977.
Jenkins, I.L.	"Microprocessor Applications in Telecommunications", University of W.A. Colloquium on Microprocessors, May 1977.
Jenkins, I.L.	"Use of Microprocessors in Intelligent Terminals", I.E. Australia, Colloquium on Microprocessor Systems, Sydney, November 1976.
Jenkins, I.L.	"A Computer Terminal for Use in an Office or Home Environment", The Seventh Australian Computer Conference, Perth, August 1976.
Johansen, E.	"Characterising Optical Fibres Using a Scanning Electron Microscope", First Australian Workshop on Optical Communications, University of New South Wales, March 1977.
Kidd, G.P.	"Transmission Characteristics of Fibres and Their Effects on System Specification", I.E.E. Victoria, Melbourne, June 1976.
Kidd, G.P.	"Optical Fibre Telecommunication Systems", Radio Research Board Symposium on Optical Communications and Integrated Optics, Melbourne, August 1976.
Macfalane, I.P.	"Digital Semiconductor Technology Present and Future", South Australian Telecom Engineers Lecture Programme, May 1976.
Mazzaferri, F.D. Wragge, H.S.	"Evaluation of the Model Digital Tandem Exchange Currently in Service as part of the IST Project" P.O.A. Engineers Group, Melbourne, November 1976.
Morgan, R.J. Ayre, R.W.	"Telecom Australia's Proposed Field Demonstrations", First Australian Workshops on Optical Communications, University of New South Wales, March 1977.
Morgan, R.J.	"Digital Transmission Over Optical Fibres", Telepost Engineers Group, Melbourne, July 1976.
Morgan, R.J.	"Fibre Optic Digital Transmission Systems - An Overview", Telecommunications Society of Australia, Adelaide, February 1977.
Morgan R.J., Horton, R. and Ayre, R.W.	"Optical Systems for Telecommunications", I.R.E.E. (Aust.) Symposium on Fibre Optics, Melbourne, February 1977.
Morgan, R.J.	"Design of Digital Systems Using a Class of Multimode Optical Fibres", Radio Research Board Symposium on Optical Communications and Integrated Optics, Melbourne, August 1976.
Mottram, K.G.	"The Effect of Galvanizing on Mechanical Properties of Steel", Australian Corrosion Association, Melbourne, September 1976.
O'Keefe, M.	"Software Aspects of Microprocessor Projects", I.E. Aust. Colloquium on Microprocessor Systems, Sydney, November 1976.
Park, J.L.	"PCM Transmission Systems", Monash University Electrical Engineering Students, September 1976.
Payne, J.P.	"Introduction to the H6000 EDIT System", Telecom Australia Staff, Melbourne, February 1977.
Reen, J.H.	"Paths With Severe Fading", Research Laboratories Colloquium, Melbourne, November 1976.
Reeves, G.K.	"Gunn Effect Digital Devices", Telecom Australia Research Laboratories Colloquium, September 1976.
Ridge, I.	"Use of a Mini-Computer in a Multi-Experiment on Line Data Acquisition System", The I.E. Aust. Conference on Computers in Engineering, Perth, September 1976.
Rosman, G.	"The Effects of Frequency Selective Fading On F.M. Transmissions", Melbourne, November, 1976.

Sabine, P.V.H.	"Refractive Index Profile Determination in Optical Waveguides", Radio Research Board Symposium on Optical Communications and Integrated Optics, Melbourne, August 1976.
Sabine, P.V.H.	"Integrated Optical Circuits", Research Laboratories Colloquium Melbourne, July 1976.
Sabine, P.V.H.	"Refractive Index Profile Determination in Optical Waveguides", Radio Research Board Symposium on Optical Communications and Integrated Optics, Melbourne, August 1976.
Sabine, P.V.H.	"Near Field Scanning Systems for Measuring Refractive Index Profiles of Optical Waveguides", First Australian Workshop on Optical Communications, March 1977.
Sabine, P.V.H.	"Towards Integrated Optical Circuits", Melbourne Division I.R.E.E., May 1976.
Seidl, R.A. and Tyers, P.J.	"A Multi-Media Information Preparation System", The Seventh Australian Computer Conference, Perth, August 1976.
Smith, B.M.	"Base Band Data Transmission Over Local Cables", Lecture at Clayton to H.Q. Branch, March 1977.
Smith, B.M.	"Digital Data Modulation Techniques", part of Continuing Education Course for Practising Engineers, (R.M.I.T.), November 1976.
Smith, B.M.	"Digital Data Modulation Techniques", School of Electrical Engineering, University of New South Wales, November 1976.
Smith B.M.	"Digital Data Modulation Techniques", Victorian Telecommunications Training Centre, Tooronga, December, 1976.
Smith, R.	"High Capacity Transmission Systems", Telecom Society
Smith, R.	"Pulse Code Modulation Systems", POA Telepost Engineers Group, Melbourne, April 1976.
Stone, G.O.	"A System for Evaluation of High Radiance LEDs for Optical Fibre Sources", Optical Workshop, University of New South Wales, March 1977.
Teede, N.F.	"Semiconductor Devices for Optical Communications", Institute of Electronic and Communication Engineers of Japan, Symposium on Devices for Ultra-High Speed Communications, Tokyo, December 1976.
Teede, N.F.	"Solar Cell Research in Japan" Telecom Australia Research Laboratories Colloquium, March, 1976.
Teede, N.F.	"Design Criteria for Optical Communication Sources", Presented at Kyoto University, Kyoto, September 1976.
Townsend, A.A.R.	"A Precision Frequency-Tracking Generator", Telecom Australia Research Laboratories Colloquium, Melbourne, September 1976.
Tyers, P.J.	"An Introduction to Use of Block Transmitting Terminals", Telecom Australia Staff, Melbourne, May 1977.
Tyers, P.J.	"Microprocessor Development Systems", 1977 State Circuit Standards Engineering Conference, Melbourne, April 1977.
Warner, J.M.	"Doubt, Uncertainty and Confidence", I.E. Australia Symposium on Electrical Measurement and Testing, Melbourne, April 1977.
Williamson, W.J.	"GaAs and Related Compounds for Optical Integrated Circuits", Radio Research Board Symposium on Optical Communications and Integrated Optics, Melbourne, August 1976.

RESEARCH LABORATORIES REPORTS

Report No.	Author	Title
7019*	G.W. Goode	Bank Wear in Step by Step Switches
7020*	Z. Slavik	Corrosion of Dropwire at Terminal Stip
7022	P.V.H. Sabine	Stress-Induced Channel Optical Waveguides Fabricated by an Embossing Process
7023	P.V.H. Sabine	Measurement of Attenuation in Stress-Induced Optical Waveguides Fabricated by an Embossing Process
7031*	G.J. Barker	Report on Overseas Visit, June-July 1975
7035*	J.A. Bylstra	Laboratory Evaluation of Two Commercially Available Data Multiplexes
7038	J.M. Burton & J.V. Murphy	Tropospheric Multipath Propagation Analysis Using A Microwave Holographic Array
7042*	B.M. Smith	Tests of Cable Pairs for Group Bandwidth Data Transmission Between Melbourne and Clayton
7045	J. Steel	Data Under Voice Transmission on FDM/FM Radio Systems
7049*	G.J. Semple	The Effect of Excessive Cable Span Loss on the Operation of PCM Regenerators
7050	G.J. Semple	Restrictions on the Maximum Regenerator Cable Span for Primary Level 1.544 Mbit/s and 2.048 Mbit/s PCM Regenerators

7054*	P.J. Wellby	The Evaluation of an Ultra Lightweight Telephone Headset
7056*	I.A. Dew	Mini-switch for the Minimat PABX
7059	D.J. Adams	Evaluation of Three Alternative Semiconductive Jacketing Materials
7060	A.A.R. Townsend	A Study of the Synchronisation of the Trunk Network Using a Phase Tracking Frequency Generator
7062*	D.T. Miles	An Alternative Encapsulant to Epoxy Resin
7063	D.T. Miles	Heat Bending of Moisture Barrier Cable
7064*	B.A. MacLennan	Machine Jointing of Helical Paper Insulated Aluminium Alloy Conductor
7065*	N.J. Sadler	Surface Temperature of Resistors
7066*	N. Demytko	Overseas Visit to Japan, November 1975
7068*	D.T. Miles	Investigation of PVC Heat Shrink Sleeves Used on Exchange Cable Terminations
7069*	D.J. Adams	Evaluation of a Commercial Lubricant for Cable Hauling
7070*	F.G. Bullock	Community Antenna Television (CATV) Tap Studies
7071	G.K. Reeves	Computer Simulation of the Gunn Effect
7072	J.A. Bennett	The Calculation of Microwave Attenuation by Rain from Radar Measurements
7073*	B.R.A. Nigli	Man/Machine Communication Language for the IST Project
7074	P.V.H. Sabine	A He-Ne Laser Mode-Locked by an Intra-Cavity Acousto-Optic Modulator
7075	O. Tenen	Design of a Polynomial Wide-Band Crystal Filter
7076	G.K. Jenkins	An Input/Output Port and Trap Device for Nova-Compatible Computers
7077*	E.R. Gray	Evaluation of an A.P.O. Electronic Erlanghour Meter - First Production Units
7079*	R. Horton	Microwave and Optical Devices/Techniques - An Overseas Study (August - October 1975)
7080	A.J. Stevens	Interface for Paper Tape Reader Tally R2050 to HP98330A
7082*	G.G. Mitchell	Copper Clad Printed Wiring Board Laminates Grade FR-4 - Suitability for Use
7083*	G.G. Mitchell	Tests on Commercial Illuminated Push Button Key Switches
7084	R.A. Seidl	A Plotting/Data Manipulation Facility for Paper-Tape Data-Loggers
7085	J.M. Warner	Report on Overseas Visit, July/August 1974
7087*	D.A.Gray	Visual Communications via Voice-Grade Facilities - Overseas Visit, March 1976
7090*	G.W. Goode	Tests of Cable Sheath Labelling Materials
7091*	E.L. Wallace	Evaluation of a Telephone Dial
7092	E.J. Bondarenko	Pinholes in Plastic Jacketed Lead Sheathed Cables
7093*	B.M. Smith	Overseas Visit, February/March 1976
7094	B.M. Smith	The Peak-to-rms Value of a SSBAM Class 4 Partial Response Data Signal
7095*	E. Rumpelt	Networks for End-Impedance Measurements on Standard Coaxial Tubes
7096	R. Proudlock	A Single Phase Appliance Test Set
7097*	I.P. Macfarlane	Trends in Digital Semiconductor Technology and Techniques - Report on Overseas Visit, August-October 1975
7099	R.A. Seidl	A Database Management Program for Manpower Resource Allocation
7100	J.L. Snare	Inductor Simulation
7104	I.L. Jenkins	'Action' - Advanced Communications Terminal for Interface to On-Line Network
7106	J.H. Gillies	An Automatic Cable Equalizer for Television Telephone Transmission
7107	L.A. Denger	Explicit Solution of Gloge's Partial Differential Equation
7108*	B.A. MacLennan	A Connector for Large-Sized Cable Joints
7109	L.A. Denger	Tunnelling Effect in Liquid Filled Optical Fibres
7111*	B.A. MacLennan	Connector System for Jointing Distribution Cable
7112*	E.J. Bondarenko	Modified Wall Telephone for Bathroom Use
7115	J.L. Park	Scramblers for Primary PCM Systems
7116*	B.M. Smith	The Calculation of the Power Spectral Densities of 24 Channel PCM Systems When in the Idle Condition
7119*	I. Cederholm	Alice Springs - Tennant Creek Microwave Project Soil and Water Characteristics
7121	R.J. Dempsey	Colour TV Transmission Over Single Quad Cable - Transmission Limits Imposed by Noise
7125*	K.H. Jones & H.J. Ruddell	Epoxy Resin for Gas Seals fo Directly Terminated Cables
7126*	D.J. Adams	Combustible Characteristics of Filled Cables: a Preliminary Report
7130*	E.L. Wallace	A Commercial Multipin Connector

Note: The reports marked * are not available beyond Telecom Australia. In addition 14 reports of a limited distribution were produced.

Staff Affiliations with External Bodies

Some of the staff of the Laboratories are active members of the governing bodies of educational establishments, learned societies and professional bodies and institutions. Staff members also serve on a variety of national and international committees. These include:

NATIONAL PROFESSIONAL BODIES (EDUCATIONAL)

Victorian Education Department	
Higher Technician (Applied Science) Certificate Course Development Committee	G. Flatau
Victorian Institute of Colleges	
Academic Committee - Engineering	M. Cassidy
Monash University	
Faculty of Engineering	A.J. Seyler
Adelaide University	
Electrical Engineering Department - Hon. Consultant for Post Graduate Studies	A.J. Seyler
University of New South Wales	
Visiting Committee of School of Electrical Engineering	A.J. Seyler
Footscray Institute of Technology	
Course Advisory Committee	H.S. Wragge G.F. Jenkinson
Swinburne College of Technology	
Electrical Engineering Departmental Advisory Committee	L.H. Murfett
Master of Engineering Ad Hoc Advisory Committee	L.H. Murfett
Caulfield Institute of Technology	
Course Advisory Committee	H.S. Wragge
Royal Melbourne Institute of Technology	
Capital Funds Committee	M. Cassidy
Course Advisory Committees	M. Cassidy R.D. Slade

NATIONAL PROFESSIONAL BODIES

Council for an Australian Academy of Technological Sciences	
Executive Committee	A.J. Seyler
Australian National Committee for Radio Science	E.F. Sandbach
Radio Research Board	E.F. Sandbach
Australian Institute of Metals	
Metals Technology Division	J.R. Lowing (Chairman)
Australian Institute of Science Technology	
Victorian Branch Council	F.C. Baker
Australian Advisory Council on Bibliography Services	
Federal Committee	M.I. Cuzens
Victorian Regional Committee	M.I. Cuzens
Working Party on Systems and Communications	M. Cassidy
The Institute of Radio and Electronics Engineers, Australia	
Federal Council	A.M. Fowler
Publications Board	R. Horton
Melbourne Committee	R. Horton (Hon. Secretary) H.A. Wills (Hon. Treasurer) A.M. Fowler
1977 Convention Board	R. Horton H.A. Wills A.M. Fowler
The Institution of Engineers, Australia	
Board of the College of Electrical Engineers	M. Cassidy H.S. Wragge
Electrical and Communications Engineering Branch Committee	M. Cassidy H.S. Wragge
National Committee on Electronics and Telecommunications	H.S. Wragge (Chairman) E.A. George
Australian Acoustical Society	
Victorian Division Committee	D.A. Gray
Federal Council	D.A. Gray
Telecommunications Society of Australia	
Council of Control	E.A. George H.S. Wragge
Board of Editors: "Australian Telecommunication Research"	H.S. Wragge G. Flatau A.J. Gibbs G.F. Jenkinson W. McEvoy I.P. Macfarlane L.H. Murfett
Board of Editors: 'Telecommunication Journal of Australia'	D.A. Gray
Standards Association of Australia (S.A.A.)	
Telecommunications and Electronics Standards Board and Executive Committee	G. Flatau E.F. Sandbach
Australian Electrotechnical Committee	E.F. Sandbach
Acoustic Standards Committee	D.A. Gray
Plastics Industry Standards Board	R.D. Slade
Co-ordinating Committee on Fire Tests	F.C. Baker
Metallography Committee	T.J. Keogh
Technical Committees	
Acoustic Standards	
• Instrumentation and Techniques for Measurement of Sound	E.J. Koop
Chemical Industry Standards	
• Adhesives	F.C. Baker
Electrical Industry Standards	
• Indicating and Recording Instruments	J.M. Warner
• Electrical Insulating Materials	G. Flatau
• Dry Cells and Batteries	G.G. Mitchell
• Electrolytes	F.C. Baker
• Control of Undesirable Static Charges	G.W. Goode
Mechanical Engineering Industry Standards	
• Tensile Testing of Metals	K.G. Mottram
Miscellaneous	
• Pressure Sensitive Adhesive Tapes	G. Flatau

Metal Industry Standards

• Zinc and Zinc Alloys	K.G. Mottram
• Lead and Lead Alloys	K.G. Mottram
• Coating of Threaded Components	R.D. Slade
• Galvanised Products	R.D. Slade
• Electroplated and Chemical Finishes on Metals	R.D. Slade

Plastics Industry Standards

• Methods of Testing Plastics	G. Flatau
• Outdoor Weathering of Plastics	G.W. Goode
• Polytetrafluoroethylene	B.A. Chisholm
• Flammability of Plastics	H.J. Ruddell

Safety Standards

• Industrial Safety Gloves	F.C. Baker

Telecommunications and Electronics Industry Standards

• Capacitors and Resistors	G. Flatau D. McKelvie
• Printed Circuits	D.E. Sheridan
• Wires and Cables	G. Flatau
• Semi-Conductors	I.P. Macfarlane
• Environmental Testing	G. Flatau
• Reliability of Electronic Components and Equipment	G. Flatau
• Electro-Acoustics and Recording	E.J. Koop

National Association of Testing Authorities (N.A.T.A.)

Electrical Registration Advisory Committee	J.M. Warner
Assessor for Environmental Testing	G. Flatau
Assessor for Laboratories Engaged in Testing Plastics	B.A. Chisholm
Assessor for Aerial Equipment and Measurements	O.F. Lobert
Assessor for Laboratories Engaged in Electrical Testing	J.M. Warner E. Pinczower J.B. Erwin

INTERNATIONAL BODIES

The Laboratories participate in the activities of a number of international bodies and committees. These include:

- The International Telephone and Telegraph Consultative Committee (C.C.I.T.T.).
- The International Radio Consultative Committee (C.C.I.R.).
- 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 International Standards Organisation (I.S.O.).
- The Asia Electronics Union (A.E.U.).
- The International Federation of Documentation, Committee for Asia. and Oceania (F.I.D./C.A.O.)

Industrial Property

It is a policy of Telecom Australia to protect its interests in any worthwhile industrial property, notably patentable inventions but also registerable designs, which might be generated by its staff in the course of their work. Many of the inventions patented by Telecom Australia have been made by the Laboratories' staff, and the staff of the Laboratories also contribute to assessments of the novelty and likely usefulness of new ideas as they arise as possible subjects for patent or similar action. The list below summarises the portfolio of industrial property held by Telecom Australia. The property includes applications for letters patent and registered designs.

PATENT APPLICATIONS AND PATENTS

Invention Title (Inventor/s)	Patent Application Numbers Provisional Specification	 Complete Specification	Patent Number (if granted)	Country
Method and Apparatus for Testing Subscribers Telephone Instruments in Situ under Service Conditions (J.F.M. Bryant & R.W. Kett)		11057/61	286959	Australia
		233699	3,261,926	U.S.A.
Self Adaptive Filter and Control Circuit (L.K. Mackechnie)	65671/69	23649/70	448805	Australia
		P2063183.8		Germany
		60513/70	1,334,250	Britain
		45-115560		Japan
		70-18580		Netherlands
		33,333A/70	913733	Italy
		70-45,859	70-45859	France
		17270/70	362,763	Sweden
		98800	3,732,410	U.S.A.
Earth Working Implements (E.W. Corless)		45479/68	450397	Australia
		52280/69	1,292,844	Britain
		69/7565	69/7565	Sth. Africa
Dual Speed-Ratio Automatic Telephone Dial (R.J.W. Kennell)		23115/62	264,679	Australia
Tip Welding Means (E.J. Bondarenko)	49395/70	10361/70	455004	Australia
		4714/71	3,657,512	U.S.A.
Analogue Multiplier (H. Bruggemann)	43033/68	43033/68	414207	Australia
		43817/69	1,271,813	Britain
		P1945125.3		Germany
		GbmH6934984.4		Germany
		70940/69	728044	Japan
		855543	3,629,567	U.S.A.

Invention Title (Inventor/s)	Patent Application Numbers Provisional Specification	 Complete Specification	Patent Number (if granted)	Country
Apparatus for Routing Discrete Telecommunication Signals (A. Domjan)	61428/69	19808/70 94405 12968/70 70-14122 70-35267 44636/70 P2046069-9 83533-70	448958 756684 1,326,626 	Australia Belgium Sweden Netherlands France Britain Germany Japan
Apparatus for Monitoring a Communications System and a Detector Therefor (J.A. Lewis)	PA1474/71	29415/70 19986/71 7445/71	458997 1,359,508 7107445-4	Australia Britain Sweden
Monostable and Bistable Devices (I.P. Macfarlane)	PA2298/70	32612/71	465242	Australia
Control of Operation of a System (N.W. McLeod)	PA2035/70	31550/71 35385/71 166819 71-28121 P2136516.2 56442/71	466670 1,362,707 3,745,418 	Australia Britain U.S.A. France Germany Japan
Apparatus for Use in Feeding Alternating Electric Current to a Load and an Antenna including such Apparatus (R.P.Tolmie)	PA7174/71	49340/72		Australia
Smoke Detector (L. Gibson & D.R. Packham)	PA9230/72	56513/73 8221/73 25660/73 63703/73 367260	 564238 1,419,146 3,874,795	Australia Switzerland Britain Japan U.S.A.
Method and Apparatus for Detecting the Presence of Signal Components of Pre-determined Frequency in a Multi-frequency Signal (A.D. Proudfoot)	PB24/72	59138/73 387855 PV134.478 38106/73 178402	480006 3,882,283 803494 1,439,035 984,068	Australia U.S.A. Belgium Britain Canada
Time Delay Cut-out for Battery Operated Equipment (F.R. Wylie)	PC1281/75	12217/76		Australia
Optical Fibre Terminations (G.P. Kidd)	PC1194/75	12933/76		Australia
Improved Electrical Connector (C.R. Bomball, B.C. Bladier & T.E. Woodward)	PC1618/75	13977/76		Australia
An Improved Nephelometer (L. Davidovits)	PC4285/75	20510/76		Australia
Nephelometer with Laser Source (L. Davidovits)	PC4286/75	20511/76		Australia
Tamperproof Telephone Apparatus (C.M. Hamilton & J.A. MacCaskill)	PC5285/76	23264/77		Australia
Television Signal Fault Monitor (R.W. Ayre)		17251/76		Australia
Plastic Coupling for Rigid and Semi-Rigid Pipes (A.D. Pontin)	PC4019/75	19789/76		Australia
Stress Induced Optical Waveguides Fabricated by an Embossing Process (P.V.H. Sabine & P.S. Francis)	PC4499/76	21232/77		Australia
Heat Conductive Filler for Solid State Heat Sinks (I.K. Stevenson & S.C. Georgiou)	PC8576/76			Australia
Paging System Using Modulating Frequencies (I.R. Bryce and J.C. Blackburn)		22403/77		Australia
Testing Voice Frequency Data Modems Using a Tape Recorder (K. Webb)		24926/77		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.

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 U.N./I.T.U. and Colombo Plan Fellows, whose visit to the Laboratories is a part of a more extensive period of training in Telecom Australia.

Overseas Visits by Laboratories Staff

It is an important responsibility of any viable organization 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:

E.R. Craig
P.F. Duke
K.S. English
G. Flatau
P.H. Gerrand
P.S. Jones
N.W. McLeod
A.J. Seyler
R.D. Slade
B.M. Smith
A.J. Stevens
W.J. Williamson
H.S. Wragge

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 expertise 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 postgraduate studies or to seek wider professional experience during the past year:

N.Q. Duc, Syracuse University, New York State U.S.A.
N.J. Gale, University Sains Malaysia,
H. Junghans, Siemens Central Research Laboratories, Munich, Germany.
G.P. Kidd, B.P.O. Research Laboratories, U.K.
P.A. Kirton, Monash University, Melbourne.
A.R. Newton, University of California, Berkeley, U.S.A. F.J. Symons, University of Essex, U.K.
I. Young, University of California, Berkeley, U.S.A.

Sponsored External Research and Development

Telecom Australia 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 organizations 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:

- Techniques for Automatic Speech Synthesis.
- Electrical Field Strength and Noise Distribution and Communication Relevant to Mobile Radio Systems.
- Development of Chemical Vapour Deposition-In-Tube (CVD) Method for Manufacturing Solid-Cored Stepped Index Fibres.
- Transmission Characteristics of Trunk Waveguide Systems.
- Solid State Technology for Circular Design in Microstrip Form.
- Electrical Discharges and Plumes on High Power HF Antennas.
- Computer Based Correlator for Broadband System Transfer Function Measurements.
- Assignment of Tolerance to Minimum Sensitivity Networks.
- Theoretical Studies of Optical Fibres.
- Channel Capacity of Stepped-Index Optical Fibre Systems.
- Active Devices for Integrated Optics.

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.

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