REVIEW OF ACTIVITIES 1983-84

Research Laboratories

Telecom Australia

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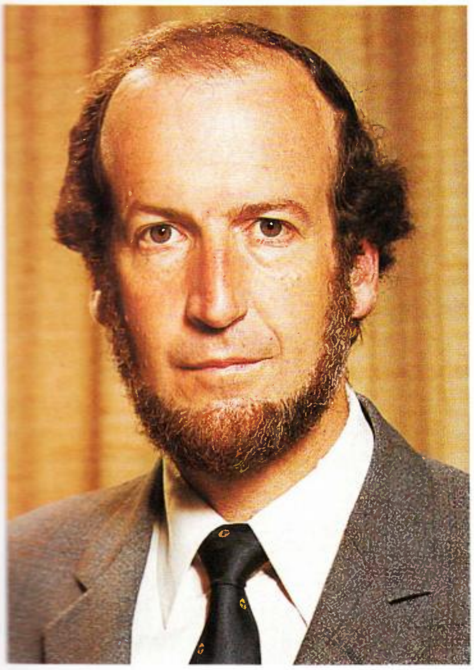
Research Laboratories, 770 Blackburn Road Clayton, Victoria 3168 Australia

Telecom Australia

FOREWORD



The timely and effective application of new technology is an important key to the fulfilment of Telecom Australia's objective of providing the people of Australia with an increasing variety of world-standard telecommunications services at reasonable costs. In the pursuit of this objective, Telecom has identified the following areas of technologically innovative activity as having corporate strategic priority:

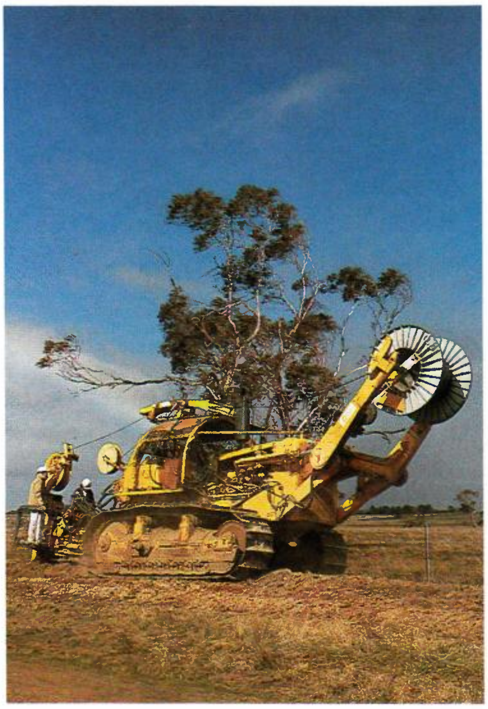
- the introduction of new services, in addition to the enhancement of existing services, to meet the social, industrial and commercial needs of people throughout Australia
- the provision of automatic telephone and data services to people living in the more remote parts of Australia
- the introduction of digital technology into its network infrastructures, with flexibility for the ultimate evolution of the Integrated Digital Services Network concept
- the enhancement of the integrity and survivability of the network infrastructures and of their operational management.

Telecom's Research Laboratories contribute to the leading edge of this innovative activity by investigating relevant world developments in telecommunications science and technology. This work covers a wide range of research topics in a corporately determined work programme. The output of this work provides expert technical advice to other organisational units of Telecom which are responsible for planning, introducing or improving telecommunications services or developing and operating the networks.

This review of the activities of Telecom's Laboratories illustrates the comprehensive scope and content of the Laboratories' work programme for 1983/84. It demonstrates well Telecom Australia's commitment to remain abreast of, and to contribute to, world developments in telecommunications.

M.K. WARD
CHIEF GENERAL MANAGER

OUR COVER



The cover photograph shows optical fibre cable being installed near Ballan by staff of Telecom's Victorian Administration for Telecom's field trial of the installation and operation of single-mode optical fibre systems over a 76 km route between Melton and Ballarat in Victoria. Several alternative direct ploughing techniques were used to install the cable, and Research Laboratories' staff continuously monitored the strain imparted to the fibres during ploughing operations. As reported in this Review, this data will be correlated with transmission performance measurements to be made on the installed systems by the Engineering Department at Headquarters.

CONTENTS

THE ROLE OF THE RESEARCH LABORATORIES

Under its Charter established by the Telecommunications Act, Telecom Australia has the national responsibility to provide, maintain and operate telecommunications services in Australia which best meet the social, industrial and commercial needs of the people of Australia, and to make its services available throughout the country so far as reasonably practicable. The Charter also requires that services are to be kept up to date and operated efficiently and economically, with charges as low as practicable.

In meeting this responsibility, Telecom is mindful of the economic and practical benefits to be gained by the timely adoption of new and improved techniques, equipment and systems that result from advances in telecommunications science and technology. The correct choice of technology and emphasis on the efficient management of this technology in planning, developing and operating the telecommunications network ensures economy, efficiency and continuing flexibility in the on-going task of developing the network which provides the services to the community.

The Research Department, known as the Telecom Australia Research Laboratories, is the focal point for much of Telecom's research and development effort. The Laboratories began in 1923 as a Section in the Headquarters Administration of the then Postmaster-General's Department, having been 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, and the Director, Research, is directly responsible to the Chief General Manager.

The Laboratories' work programme is reviewed and determined annually through a corporate process which yields a rolling three-year Programme of Research, Development and Innovation (RDI). The RDI process encompasses all technical activities performed within Telecom which, through the use of new or existing technology and techniques, will or could change the telecommunications services provided by Telecom to its customers, the technological nature or the technical performance standards of the systems used in the ongoing development of the telecommunications network, or the operational efficiency by which Telecom provides services over the network.

About 90% of the Laboratories' work programme comprises R&D projects and activities which are within the scope of the RDI programme. As such, this work obtains corporate endorsement and is co-ordinated with the work of other Departments, primarily the Engineering and Commercial Services Departments at Headquarters. The remaining 10% of the Laboratories' work programme comprises consultancy services in the specialised fields of precise technical and scientific measurement and analysis, technical information services and industrial property services. These latter functions are a natural extension of the primary investigatory functions of the Laboratories.

The Laboratories, by selecting relevant R&D projects, seek to ensure that Telecom has available the necessary advice in the relevant fields of advanced science and technology to assist in the formulation and implementation of policies and plans for new or improved services, systems, service standards and operational practices. Through the application of their special expertise and facilities, the Laboratories also provide assistance to other Departments in Headquarters and the State Administrations in the solution of technical problems that arise in the design, manufacture, installation, operation and maintenance of equipment in service in the telecommunications network.

To fulfil these responsibilities, the Laboratories try to maintain 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.

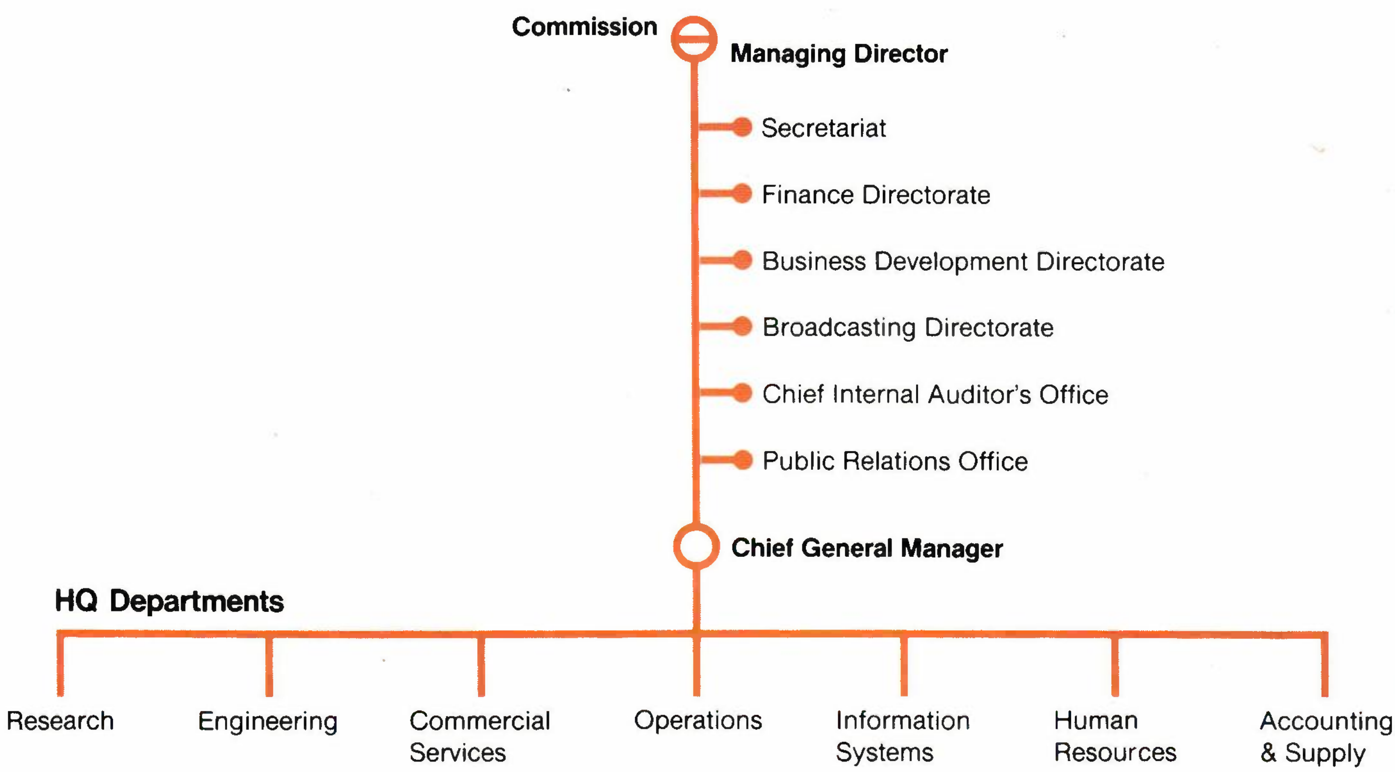
Many of the innovations, ideas and improvements proposed for the Australian network originate overseas. However, it is necessary for Telecom to have advance knowledge of these developments so that they can be evaluated soundly on social, economic and technical grounds, before they are accepted or adapted and modified for incorporation into the Australian telecommunications network. To help make these decisions and judgements with confidence, it is necessary for Telecom to have, at first hand, sound and competent technical advice. This is best derived from its own R&D, conducted in relevant technological or scientific fields.

Most of the projects undertaken by the Laboratories, rather than being directed at manufacturing or production specifications, find their ultimate expression in the performance requirements incorporated in procurement specifications for the systems and equipment which are bought by Telecom from the international telecommunications industry. Other work is expressed in the assessment of materials, components and assembly practices used by suppliers in equipment tendered against Telecom procurement specifications. Occasionally, a project is carried to production when it is evident that the initial, experimental development performed by 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 applied sciences, who conduct investigations into difficult technical problems that arise in the operation of telecommunications plant. The Laboratories are also responsible for Telecom's scientific reference standards for the measurement of time interval, frequency and electrical quantities. In the former case, they are an agent of the National Standards Commission.

Telecom, 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 organisations to undertake specific projects of interest to Telecom and act as a focus for this activity for Telecom.

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 to decide when, and to what extent, new technology is to be harnessed to provide new or improved customer services and systems. 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 1983/84.



Organisational relationship of the Research Laboratories with other Headquarters units of Telecom Australia

ITEMS OF SPECIAL INTEREST

Distinguished Visitors to the Laboratories

Like most research organisations, Telecom's Research Laboratories are frequently visited by a number of people notable because of their high distinction or because the purpose of the visit is one of significant importance.

The following paragraphs record details of five such notable visits which occurred during the year.

(i) **Visit by The Hon. L.F. Bowen, MP, Acting Prime Minister and Minister for Trade, The Hon. M.J. Duffy, MP, Minister for Communications, and Messrs K.L. Fothergill, Federal Vice-President, and D.M. Farr, Vice-President (Victorian Branch) of the Australian Telecommunications Employees Association (ATEA).**

On 18 April 1984, The Honourable Lionel Bowen and The Honourable Michael Duffy visited the Laboratories in company with Mr Kevin Fothergill and Mr Doug Farr of the ATEA. The visitors were welcomed by Mr Ed Sandbach, Director, and Mr Roger Smith, Deputy Director. After general discussions of the role of the Laboratories and their relationships with other units of Telecom Australia, other research organisations and local industry, the visitors toured the Laboratories, meeting with staff engaged on a variety of projects. These projects included social and technical studies of small group teleconferencing, developments in optical fibre technology and transmission systems, and digital radio concentrator systems for providing automatic services in the Australian outback. The visitors also inspected the Laboratories' facilities for lightning detection and simulation, environmental testing of telecommunications plant, experimental fabrication of microelectronics components, and for the reverse engineering of such components for failure analysis.

(ii) **Visit by Commissioner Margaret Jackson**

On 19 October 1983, Commissioner Margaret Jackson visited the Research Laboratories very soon after she had been appointed. Commissioner Jackson was accompanied by Mr. John Anglin of the Telecom Headquarters Secretariat. She was welcomed by Mr Ed Sandbach, who introduced her to the Assistant Directors and other members of the Laboratories' management team.

After a brief discussion of the role, functions and activities of the Laboratories with senior management, Commissioner Jackson toured the Laboratories, inspecting and discussing current work in the fields of digital radio and optical fibre transmission, occupational safety and health aspects of the work of the Applied Science Branch, radiocommunications antennas, the use of plastics in telecommunications plant, microelectronics technology, satellite communications and the international field trial between Japan and Australia of the CCITT Common Channel Signalling System No. 7.

Commissioner Margaret Jackson, Mr. Ed Sandbach, Director, and Dr. Alan Gibbs, Assistant Director (Transmission), discuss optical fibre transmission activities

(iii) Visit by Mr T. Sharp, Assistant Secretary, Telecommunications Division, Department of Industry, United Kingdom and Mr B.A. Marshall, Vice-Consul (Commercial), British Consulate-General, Melbourne.

Messrs Sharp and Marshall visited the Laboratories on 30 June 1983 for general discussions of items of mutual interest and inspections of related Laboratories' activities. The visitors met first with Laboratories' management and discussed such items as the privatisation of telecommunication services, the telecommunications R&D environment in Australia compared with that in the UK, Telecom's role in relation to other telecommunications organisations and industry in Australia, and Telecom's dual service/business enterprise role, including geographical/demographical constraints on the provision of services in Australia. The visitors then toured the Laboratories and inspected current projects related to solid state electronics, microelectronics and the application of polymers in telecommunications plant. They also inspected the Laboratories' facilities for environmental testing and discussed these in the context of the Laboratories' role in reliability assessment and quality assurance of plant equipment.

(iv) Visit by Japanese Delegates to the International Seminar on the Application of New Telecommunication Technologies, Melbourne, 26-27 October 1983.

On 28 October, 11 Japanese delegates from the above Seminar visited the Laboratories. The visiting party comprised:

Dr. Oshima	President - KEC Engineering and Consulting, Inc.
Professor Y. Fuji	Professor, Institute of Industrial Science, Tokyo University
Mr T. Iwakami	Research Manager, Communication Research Laboratory, Computer Communication Systems Research Laboratories, NEC Corporation
Mr S. Inao	Deputy General Manager, Research and Development, Telecommunication Division, Furukawa Electric Co. Ltd.
Mr M. Hoshikawa	Chief Research Associate, Yokohama Research and Development Department, Sumitomo Electric Industries Ltd.
Mr Y. Suzuki	Manager, Network Control Section, Information Processing Group, Fujitsu Ltd.
Mr S. Tomita	Staff Engineer, Data Communications Network Division, Engineering Bureau, NTTPC
Dr. S. Wanatabe	Director, Office Automation Department, KDD Co. Ltd.
Mr H. Ohmura	Manager, Data Switching System Division, Switching System Engineering Department, KDD Co. Ltd.
Mr T. Inami	Director, Engineering Department, KEC Engineering and Consulting, Inc.
Mr S. Maruyama	Assistant Director, Engineering Department, KEC Engineering and Consulting, Inc.

The visitors were welcomed by the Director, Mr. E. Sandbach, and Research management. In discussion, the role, responsibilities and work programme of the Research Department were outlined in general terms to the visiting party. These discussions were amplified and illustrated by laboratory demonstrations of experimental work relating to molecular beam epitaxy growth of semiconductor materials and devices, applications of the scanning electron microscope in optical fibre research, and investigations of four-wave mixing techniques for optical image processing. Work in the optical fibre transmission field was also outlined, including a demonstration of a newly designed optical regenerator test instrument and a technique developed to measure strain imparted to optical fibres during cable ploughing/hauling operations in the field.

The visitors also took the opportunity to discuss digital and data transmission developments, in general, and related work being performed in the Laboratories. The visit concluded with discussions of the Japan-Australia Field Trial of CCITT Common Channel Signalling System No. 7 and an inspection of the equipment developed by the Switching and Signalling Branch to allow it to participate in the trial.

(v) Visit by Chinese Scientists

On Wednesday, 2 November 1983, four Research Scientists from the Guongzhon Institute of Electronic Technology of the People's Republic of China visited the Laboratories, under the sponsorship of the Australian Academy of Science. The visitors were:

Dr. Deng Naijong	Director of the Institute
Professor Lin Jingxi	Head of the Communications Laboratories at the Institute

Dr. Chen Yamji	Research Associate at the Institute
Dr. Hu Dinglian	Research Associate at the Institute
Ms. Corrie Steffen	Research Assistant, Australian Academy of Science.

The visitors first met with the Director and Laboratories' management for general discussions of the role and work programme of the Laboratories. The visiting party then inspected a number of laboratories where discussions and demonstrations of selected projects took place. These included work related to optical fibres and transmission systems, non-linear optics and molecular beam epitaxy, signal processing, voice coding and voice synthesis, software engineering in the switching field, data networks, digital transmission, satellite communication techniques and electro-magnetic compatibility aspects of telecommunications equipment.

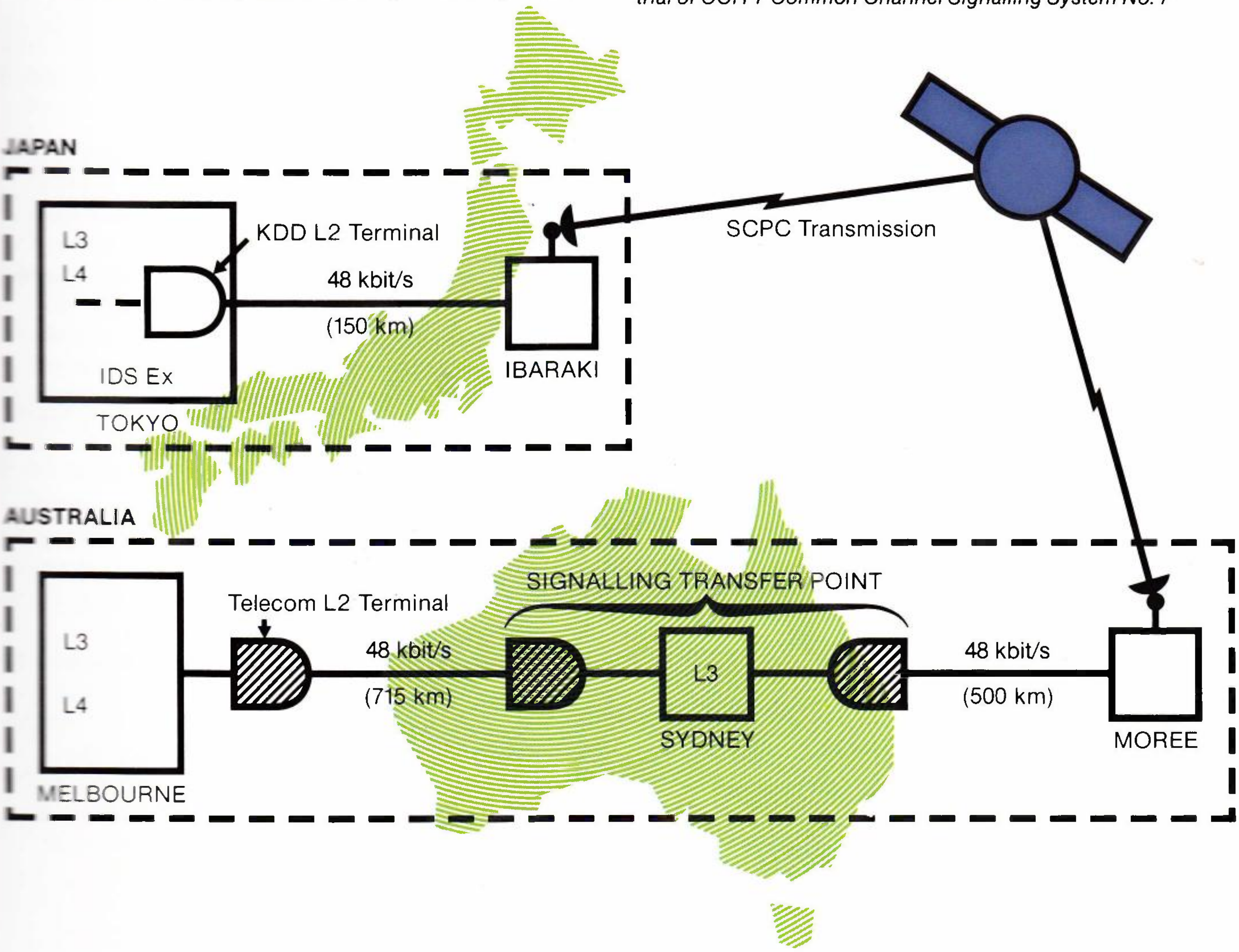
The interest shown by the visitors and their informal discussions with a variety of Laboratories' staff indicated that their visit to the Research Laboratories had been a mutually beneficial and pleasant experience.

CCITT Signalling System No. 7 Field Trial between Japan and Australia

Studies of the Common Channel Signalling System No. 7 (CCSS7) began in the Laboratories in 1978, before the relevant specifications were published by the CCITT in 1981 in the "Yellow Book". CCSS7 is specifically designed for a digital network environment and uses a layered architecture to describe the signalling protocol.
The Laboratories' studies of the signalling system have covered most aspects, including the development of equipment for the Message Transfer Part (MTP), which provides reliable transfer of signalling messages from originating point to destination point in the signalling network.

A number of other organisations have also been studying CCSS7, and in 1982, an opportunity arose to organise an international field trial between Australia and Japan. This first international field trial of the MTP took place from August to October 1983 and from February to March 1984 as a joint project by Kokusai Denshin Denwa

One of the network configurations for the Japan-Australia field trial of CCITT Common Channel Signalling System No. 7



Company, the overseas telecommunications organisation of Japan, and Telecom Australia and the Overseas Telecommunications Commission (Australia) working together at the Australian end.

The objectives of the field trial were as follows:

- to verify the operation and reliability of CCSS7 under operational conditions,
- to compare the performance of the three alternative error correction schemes and to verify theoretical delay equations derived for CCSS7, and
- to verify some of the basic MTP network recovery procedures.

The MTP does not include exchange control or other functions to generate signalling traffic and therefore the testing was performed using artificial test messages.

The inter-continental transmission facilities provided for the trial consisted of the following channels:

- one Single-Channel-Per-Carrier (SCPC) at 48 kbit/s via satellite,
- two standard satellite voice channels with modems at 4.8 kbit/s, and
- two standard submarine cable voice channels with modems at 4.8 kbit/s.

The tests were very successful. No real problems were found in the MTP procedures and only a few minor operational problems were encountered. Joint contributions were submitted to the CCITT proposing amendments to the specifications to overcome the observed problems. All suggestions were accepted, except those relating to areas intended for major revision in the next CCITT study period.

In particular, the theoretical equations were substantially verified for the various error correction methods over a range of traffic and error values, and therefore may be used with confidence in dimensioning No. 7 signalling networks. Most importantly however, the field trial has shown that it is possible for implementors to independently interpret the CCITT specifications and to develop different but compatible systems. It is considered that this can be attributed largely to the use of CCITT Specification and Description Language (SDL) for the specifications. Previous Reviews have outlined Laboratories' contributions to the development of SDL in previous years, thereby establishing background expertise which was utilised in the preparations for and conduct of the field trial of CCSS7.

Local Area Networks for Office Automation

Between August and November 1983, a project investigating the application of local area networks with particular reference to office automation applications was conducted jointly by experts drawn from government, industry and university organisations. The project was pursued at the Warren Centre for Advanced Engineering at the University of Sydney. Telecom Australia staff from Headquarters and State Administrations were involved in the project. In particular, engineers from Telecom's Research Laboratories played major roles in the project's organisation, project study activities, project documentation and public presentations.

The project was led by Dr. John Limb of Bell Laboratories, Holmdel, New York, who came to Australia for three months to take up the position of Senior Project Fellow. Dr. Limb was formerly employed in the Research Laboratories and is now world-renowned for his research achievements in picture processing, broadband local networks and office automation. Dr. Limb teamed up with Professor Trevor Cole of the Electrical Engineering Department of the University of Sydney to make public presentations on the project findings in various capital cities around Australia. A full two-day seminar involving a number of additional Project Fellows took place in Sydney in late October.

The project studies involved consideration of relevant technological developments, public networking issues, applications case studies and some organisational aspects associated with changes in functions and skills in the automated office. The possible role for Australian industry in the local area network field was also examined. This aspect was facilitated by the use of local Australian network products by the project team.

The team comprised representatives from a wide range of organisations, including Amalgamated Wireless (Australasia) Limited, the Colonial Sugar Refining Company Limited, Australian Iron and Steel Pty. Ltd., Standard Telephones and Cables Pty. Ltd., the Lend Lease Corporation, the Commonwealth Scientific and Industrial Research Organization, the Overseas Telecommunications Commission (Australia), the New South Wales Government Health Commission, James Hardie Industries Limited, and several Australian Universities. The sharing of ideas, development of personal contacts and the valuable information discovered and reported made the project thoroughly worthwhile. The substantial report prepared under Dr. Limb's guidance has been made available to the public, and copies may be obtained through the Warren Centre at the University of Sydney.

Reorganisation of Telecommunications Technology Branch

In November 1983, the Telecommunications Technology Branch of the Laboratories was restructured to give increased emphasis to research activity in emerging fields which have a fundamental and pervading relevance to future network development and operation. These fields are optical device technology, optical signal processing techniques, electromagnetic compatibility and energy technology.

The Branch was restructured into five Sections, with an additional smaller but independent Group dedicated to work in the field of electromagnetic compatibility. The titles of the Sections/Group are indicative of the field of activity of each, as follows:

- Applied Mathematics and Computer Techniques Section
- Energy Technology Section
- Radio, Satellite and Antenna Technology Section
- Solid State Electronics Section
- Optical Technology Section
- Electromagnetic Compatibility Group.

Key aspects of the new structure are:

- **Applied Mathematics and Computer Techniques Section**

  This Section emanated from the previous Computer Applications and Techniques Section. It now provides an additional stream of expertise in the applied mathematics field, which is made available to other areas within Telecom Australia on a consultancy basis. It has expanded the previous consultancy activity on computer applications for research purposes. The Section will also undertake new work related to the acquisition, development and application of VLSI design techniques and tools.

- **Energy Technology Section**

  The need for a new Laboratories' initiative in the energy technology field arose both out of a changing scenario for future energy availability and cost and out of the rapid change of new energy technology concepts which could be applicable to telecommunications. The functions of this new Section include the investigation of energy sources, the conversion, storage and recovery of energy in both electrical and thermal forms, and the assessment of potential applications of new energy technologies in Telecom's operations.

- **Radio, Satellite & Antenna Technology Section**

  This Section has the responsibility for investigating developments in satellite technology which may permit new types of satellite services and cheaper or more efficient utilisation of satellite systems. In addition, investigations of antennas and the operation of Telecom Australia's new antenna test-range at Caldermeade (near Westernport Bay in Victoria) come under the Section's responsibilities.

- **Solid State Electronics Section**

  The activities of this Section have been expanded to cover the experimental fabrication of specialised and advanced semiconductor materials and devices. A depth of expertise and extensive laboratory facilities related to this field of device technology have now been established with a view towards the fabrication of specialised devices for use in other systems-oriented investigatory projects of the Laboratories.

- **Optical Technology Section**

  Previous Laboratories' activity in this field has centred on non-linear optical effects and optical signal processing. These activities are now being extended to provide emphasis on R&D investigations of the technologies and techniques applicable to next generation optical communications systems operating in the mid-infra-red region of the spectrum. Laboratory facilities for work in this field are being developed in collaboration with the Solid State Electronics Section.

- **Electromagnetic Compatibility Group**

  Work in this field is rapidly growing in importance with the increasing application of more complex electronic systems in telecommunications plant, particularly in customer premises where diverse electromagnetic environments can be encountered. These new systems are more sensitive to, and in some cases, productive of radiated or conducted interference. The new Group will extend previous studies of electromagnetic shielding and filtering techniques and establish design rules to ensure satisfactory performance of telecommunications systems in typical electromagnetic environments.

A SELECTIVE REVIEW OF CURRENT ACTIVITIES

In accord with their functions, the Laboratories are engaged in a large number of research investigations and developmental projects in the engineering and scientific fields. This work is chosen for its relevance to Telecom Australia's customer services and network systems, and it comprises a wide variety of specific topics pertinent to the present technical standards and future technical advance of these services and networks.

It is not possible to report, even briefly, on all Laboratories' projects in this Review. As a consequence, the activities outlined 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 telecommunications science and technology. A more comprehensive list of current projects is issued in the "Research Quarterly" and this is available to selected bodies with 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. The report 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, industry and research bodies, both local and overseas. Conclusions resulting from research studies are, on appropriate occasions, documented as contributions to the deliberations of national and international bodies concerned with technical standards relating to telecommunications.

The staff of the Laboratories also 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.

Human Factors in Telecommunications

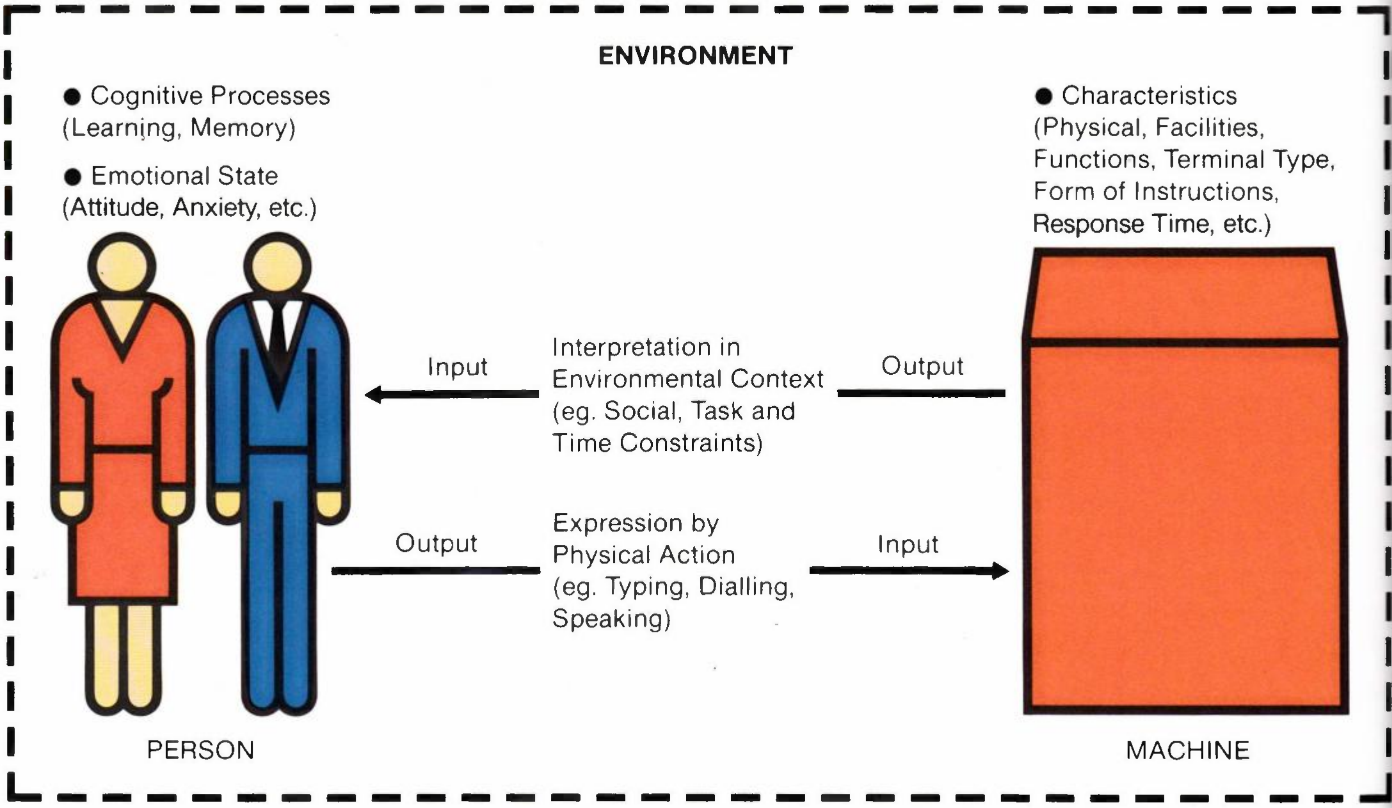
In the near future, people will be able to access an expanding range of new telecommunications services, most of which will be considerably more complicated to use than their standard telephones. In these circumstances, it is important to investigate the so-called "human factors" that affect person-machine interactions – in other words, to examine the capabilities of users and how to design machines which match these capabilities.

Human factors research is primarily concerned with the mental processes of people rather than their physical characteristics. For instance, human factors research is concerned with the way people learn and remember how to operate a new service, the types of errors they make and the feedback which a machine could give to minimize their errors. The consequences of not paying attention to these matters may be services which people are reluctant to adopt because they find them too difficult to learn and to use.

Human factors research is at an early stage world-wide. Bodies which are concerned with the effectiveness of international communications, such as the CCITT, have formulated questions for study with the aim of specifying general guidelines for designing telecommunications services which can be easily used. However, such general knowledge can only be accumulated gradually, by conducting a large number of studies of people actually using various telecommunications services and systems.

The Research Laboratories are currently studying human factors in relation to Message Handling Systems (MHS). An MHS will allow a user to record a message of some sort (e.g. text, voice, graphics or perhaps a combination of these) and to instruct the system about delivery details such as the recipient(s), the degree of urgency and the level of security for the message, after which the system delivers the message as instructed.

In the Laboratories' experimental programme, people chosen to be representative of potential users of new services complete a series of typical messaging tasks. Their performance in terms of time taken and errors made and their satisfaction with the interaction are recorded.



Model of the major characteristics of person-machine interactions

In fact, the participants in the programme do not interact with a working message handling system, but with a computer which simulates those aspects of the system that are visible to its users. Because the system's behaviour is being simulated in this way, the conditions under which different people perform the assigned tasks (e.g. the type and amount of feedback they receive from the machine) can be easily varied by altering the computer program. Different sets of conditions can thereby be evaluated with respect to the way people are able to learn and to use message handling services. At a future stage, this research activity will be extended to apply its conclusions to other types of systems.

This human factors research programme is only in its early stages. Results to date have provided a preliminary guide to methods for making new computer-based services easy for customers to adopt in their communications activities. Its future pursuit will provide an essential complement to associated technical research into new services.

Computer-based Message Systems

A Computer-based Message System (CBMS) provides a specific form of electronic mail in which communication between entities (usually people) takes place using computers. Messages are both created and read by means of the computer, which also serves to mediate the actual communication between systems.

During the year, the Laboratories have been studying computer-based message systems and the potential fields of future use of these systems. The study examined some commercially-available systems and identified their common features. The general characteristics of a CBMS were examined, with particular reference to the logical model developed by IFIP Working Group 6.5 and CCITT Study Group VII in relation to Message Handling Facilities and to Message Transfer Protocols within the ISO Reference Model, with special emphasis on features provided for CBMS users and for internal use within the CBMS.

Since it would be counter-productive for a user to have to interrogate several CBMSs each day in order to retrieve his mail, the study also examined the requirements for CBMSs to interwork with one another. The work done on this aspect by CCITT, IFIP and the GILT Message Group was reviewed, and the broad requirements for interworking of a CBMS with telex, teletex, videotex and other future telematic services were examined.

Consideration was also given to the potential introduction of CBMSs into Australia and their impact on the Australian telecommunications network.

Interactions of CBMSs with communicating word processors were one aspect considered relevant to telecommunications implications. Since many actual and potential CBMS users have in-house system terminals or microcomputers on their desks, provision must be made for such users to accept incoming messages in batch mode for processing and storage. Since word processors could be used to prepare outgoing messages, different provisions must be made for these messages to be delivered to a CBMS for subsequent distribution in batch mode to another CBMS or individually to terminals.

The Laboratories' study has been documented to provide a basis for further discussion within Telecom of the future implications of CBMSs on the planning and future development of the Australian telecommunications network.

New Digital Processing Techniques for Speech Signal Processing

Speech processing techniques have seen a recent revolution with the development of new processing architectures, resulting in general purpose digital signal processor (DSP) chips capable of performing complex signal processing tasks, in real-time, on audio bandwidth signals. These complex integrated circuits will find application in the areas of speech coding, synthesis and recognition, as well as filtering, adaptive equalization, echo cancellation and tone decoding, among others.

A specific area of interest to Telecom is that of speech coding. Currently, within the Research Laboratories, two specific algorithms are under investigation, making use of DSP technology to provide real-time implementations.

The first of these algorithms is a 32 kbit/s ADPCM algorithm based on the draft recommendations relating to Question 7 of CCITT Study Group XVIII. The encoder and decoder each use two DSP chips. The additional complexity, when compared with most other ADPCM algorithms, is brought about by the necessity to encode not only speech signals but also voice band data signals. This complexity manifests itself in the necessity for an adaptive predictor, whereas most ADPCM algorithms employ a fixed predictor, and also in the quantizer step-size adaptation and adaptation rate control, which must detect the presence of voiceband signals. Further, to prevent the accumulation of quantization distortion in successive transcodings between 32 kbit/s ADPCM and 64 kbit/s PCM, a synchronous coding adjustment is a necessary part of the decoder.

The second algorithm is a linear predictive coder (LPC) for the encoding of speech at 2.4 kbit/s. The LPC encoder requires two DSP chips. The first of these analyses the incoming speech and determines whether the speech is voiced or unvoiced, and if voiced, its pitch period. The second calculates the input signal energy; and from this, an amplitude parameter for the reconstituted speech; and via an autocorrelation analysis, the inverse filter parameters which yield the log area ratio of the vocal tract model for the speech production process. The speech is reconstituted by a lattice synthesis filter, implemented by a single DSP chip.

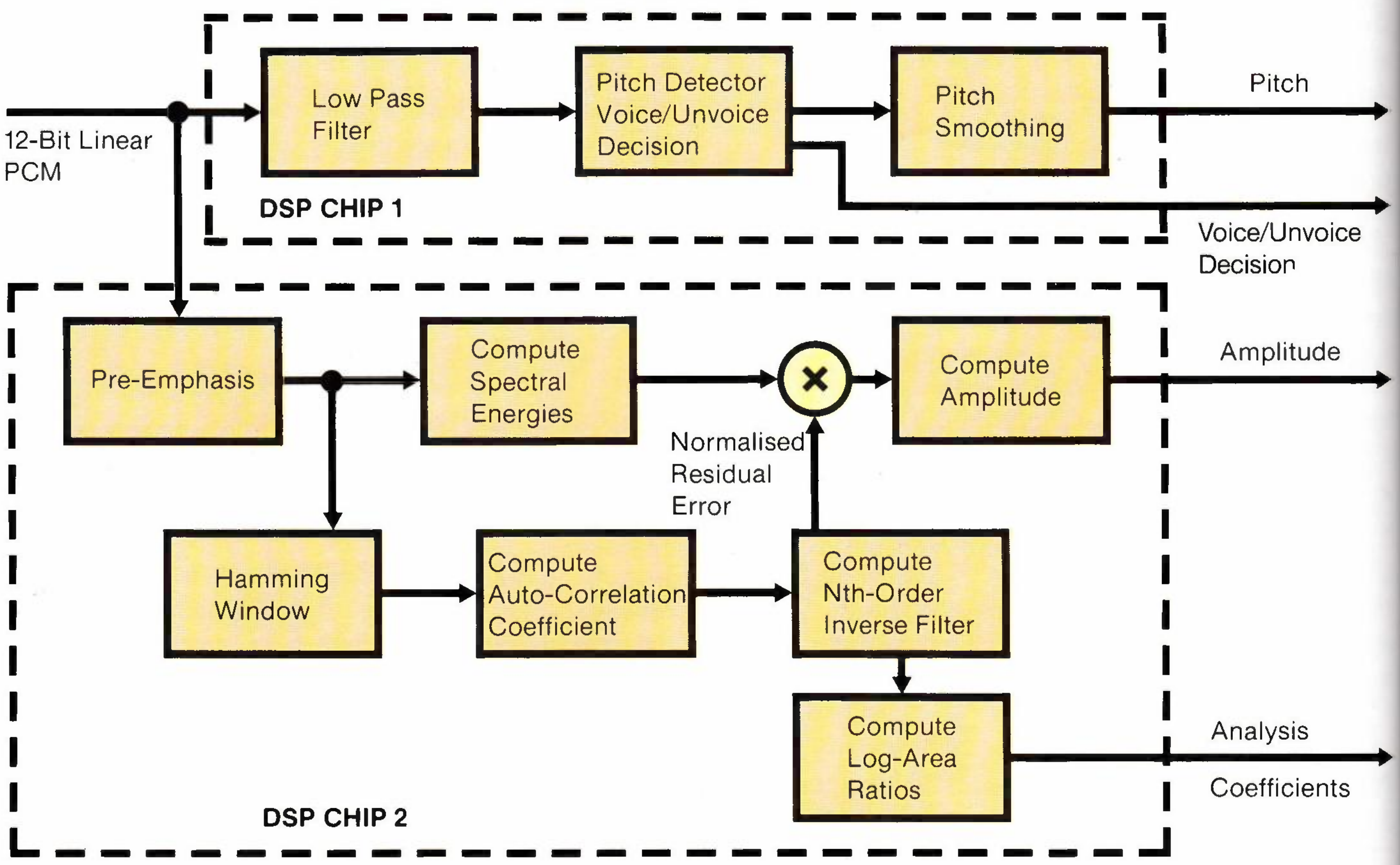
The 32 kbit/s ADPCM is perceptually indistinguishable from the 64 kbit/s PCM currently used in telephony circuits, and can be employed over such circuits to double the transmission capacity. The low bit rate LPC algorithm could be used on circuits where transmission capacity is expensive. However, the perceived speech quality is much degraded. The decoder itself, along with some storage containing speech parameters and a controlling processor, can be used as the speech output for voice response systems.

(See diagrams over)

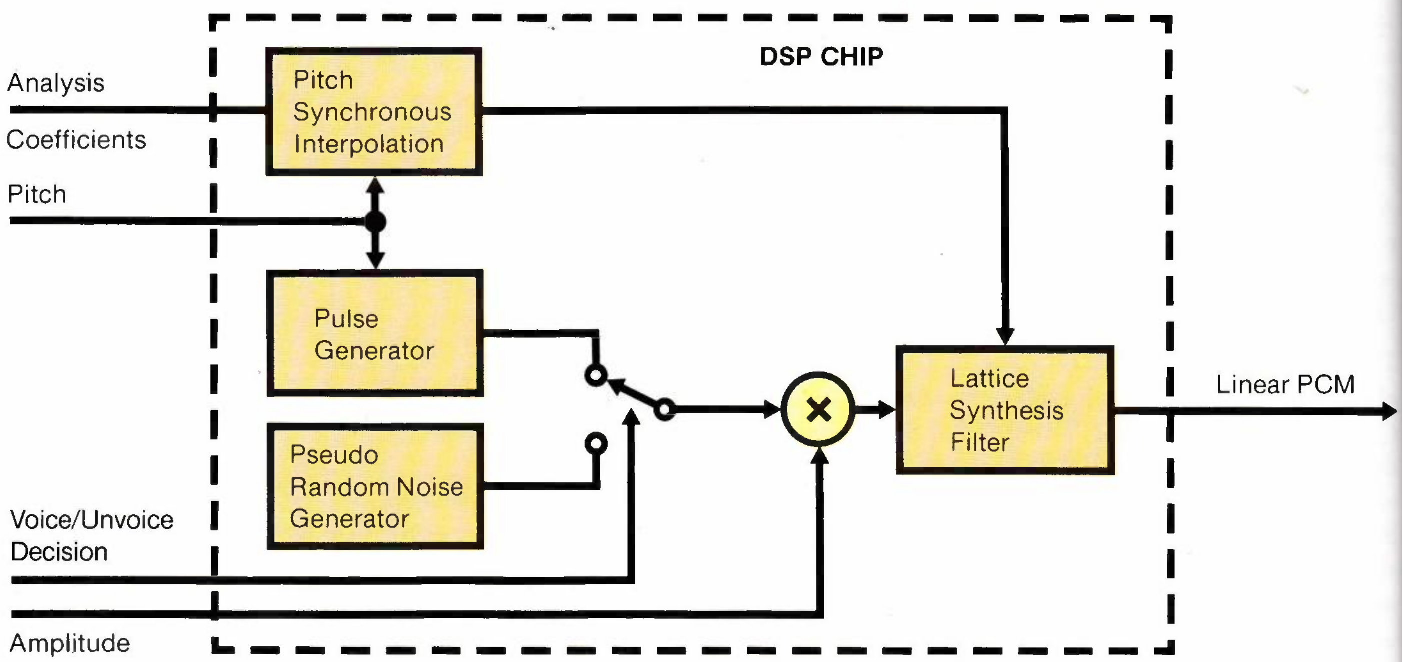
Schematic diagrams of:

(i) a linear predictive encoder comprising two digital signal processing (DSP) chips

(ii) a linear predictive decoder on a single DSP chip



(1) LPC ENCODER



(2) LPC DECODER

Speech Level Measurement in the Telephone Network

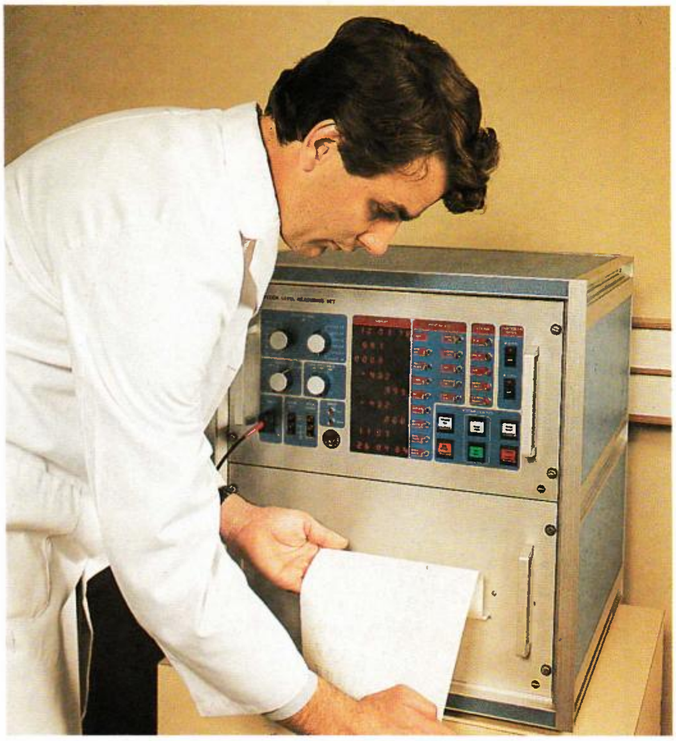
In the past, speech levels in the telephone network have generally been measured by methods using analogue indicating meters, which involve tedious attention and/or subjective judgements by an operator. For these reasons, only very limited surveys of speech levels have been carried out by Telecom Australia in its telephone network. However, with the advent of microprocessor-based instrumentation, fully automatic measurement of speech signal levels is now possible.

As a first step towards undertaking such measurements in the future, the Laboratories prepared a detailed technical specification of a microprocessor-based speech level measuring set which was subsequently the basis of a contract placed with Plessey Australia Pty. Ltd. for the development of a prototype. The prototype instrument, which is also capable of measuring certain statistics of radio broadcast programme signals, measures long term mean power, activity factor, mean power while active and distribution of signal levels, all for the duration of a particular telephone connection. In order to measure the power from one end of the connection only, an auxiliary power flow detector is required.

The CCITT Study Group XII (Telephone Transmission Quality, Local Networks and Telephone Installations) has re-opened the study of techniques for measuring speech level in order to standardize the methods to be used, not only for making field measurements, but also for reporting the results of special investigations on telephone transmission quality, particularly those carried out in the laboratory. As a first step in the CCITT study, British Telecom has distributed a set of tape recordings of speech having various properties, such as type of language, to interested organizations who have modern as well as traditional speech level measuring equipment, to see what degree of agreement can be reached.

The prototype speech level measuring set has been used to quantify and analyse speech levels on the tape recordings and the results have formed the basis of a report forwarded to the CCITT Special Rapporteur concerned.

(See photograph above right)
Prototype speech level measuring set



The Rating of Room Noise Sidetone

Telephone sidetone can affect a customer's satisfaction with a telephone connection in the following three major ways:

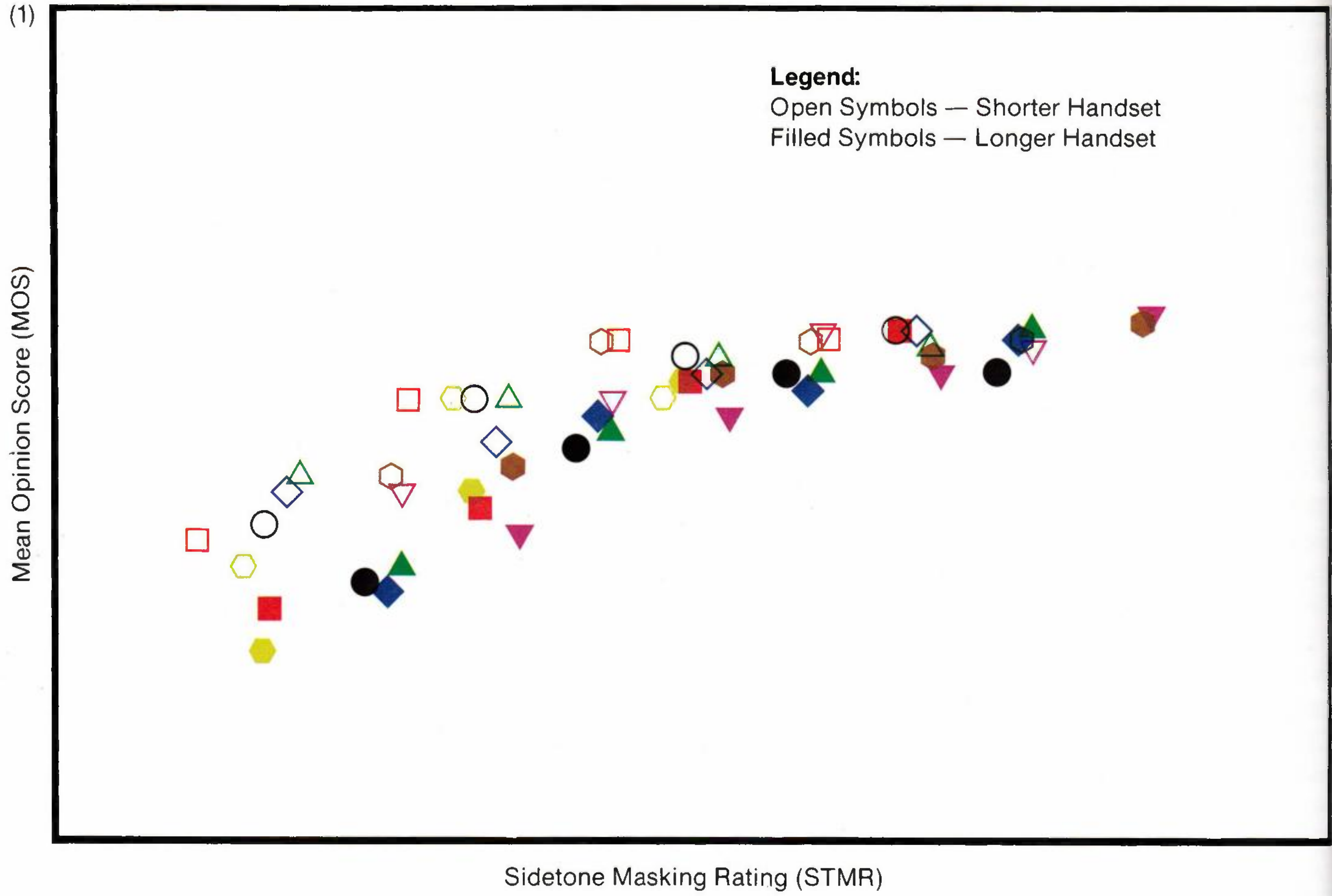
- regulation of talker level,
- user comfort and expectations (neither too faint nor too loud), and
- masking of received speech by picking up room noise.

The CCITT is currently studying techniques for rating sidetone. At the moment, it favours a method known as Sidetone Masking Rating (STMR), which is based on the premise that when a telephone user speaks into a telephone, speech passes through the head by bone conduction and creates a sound in the talker's ear which tends to mask the speech which he would otherwise hear via the sidetone path. As well as STMR, there are other methods of rating sidetone which have also been proposed, but which do not as yet have wide acceptance.

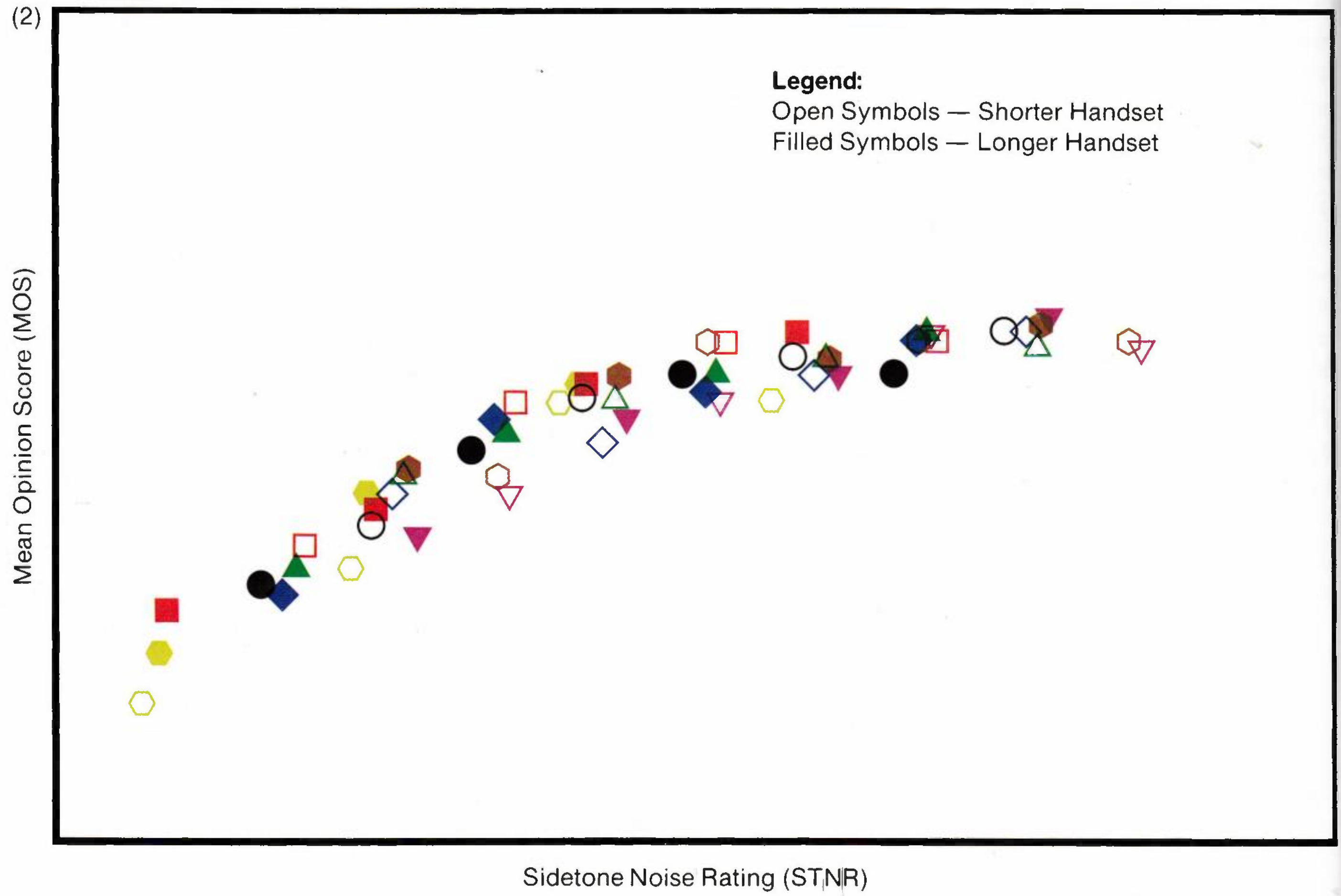
The Laboratories have been following and contributing to the CCITT studies of this and related topics, by virtue of their specialist role to maintain and develop Telecom Australia's reference standards for the measurement of telephone transmission performance.

Under high connection loss and/or high ambient room noise conditions, the level at which a talker hears his own voice is not as important as his ability to hear speech from the distant end. Psycho-acoustic models of the masking of speech by noise suggest that more weight should be given

(1)


Legend:
Open Symbols — Shorter Handset
Filled Symbols — Longer Handset
Mean Opinion Score (MOS)
Sidetone Masking Rating (STMR)

(2)


Legend:
Open Symbols — Shorter Handset
Filled Symbols — Longer Handset
Mean Opinion Score (MOS)
Sidetone Noise Rating (STNR)

to the higher frequencies than the lower, which fortuitously is what STMR does. However, the frequency sensitivity characteristic of the sidetone path in STMR is based on the sensitivity to the talker's own voice, and not on the sensitivity to room noise. Since handset shapes may vary widely, various telephones will not have the same relative sensitivity to both speech and noise. Thus, a long handset (i.e. with the microphone distant from the mouth) with the same sensitivity to speech as a short handset will be more sensitive to ambient noise.

In order to test the suitability of STMR to rate sidetone when room noise masking is likely to be significant, a series of conversational tests were carried out in the Laboratories. To simulate the effect of variable handset length, two small microphones were mounted on the mouth cap of the handset used in the tests. In addition, several different sidetone frequency responses and sidetone path losses were also used, together with moderately high room noise levels and circuit losses.

The test results showed that the STMR technique is a reasonably satisfactory method for accounting for different sidetone frequency responses. However, the results showed rather large discrepancies between the graphs of Mean Opinion Score plotted as a function of STMR for the two different handset "lengths" adopted for the tests.

Consequently, the STMR method was modified slightly by using room noise sensitivity rather than voice sensitivity. This method, called the Sidetone Noise Rating (STNR) technique, gave much better agreement between the results obtained for the two different handset "lengths".

(See diagrams opposite)
Comparison of test results obtained using two techniques for rating telephone sidetone:
(i) the Sidetone Masking Rating technique
(ii) the Sidetone Noise Rating technique

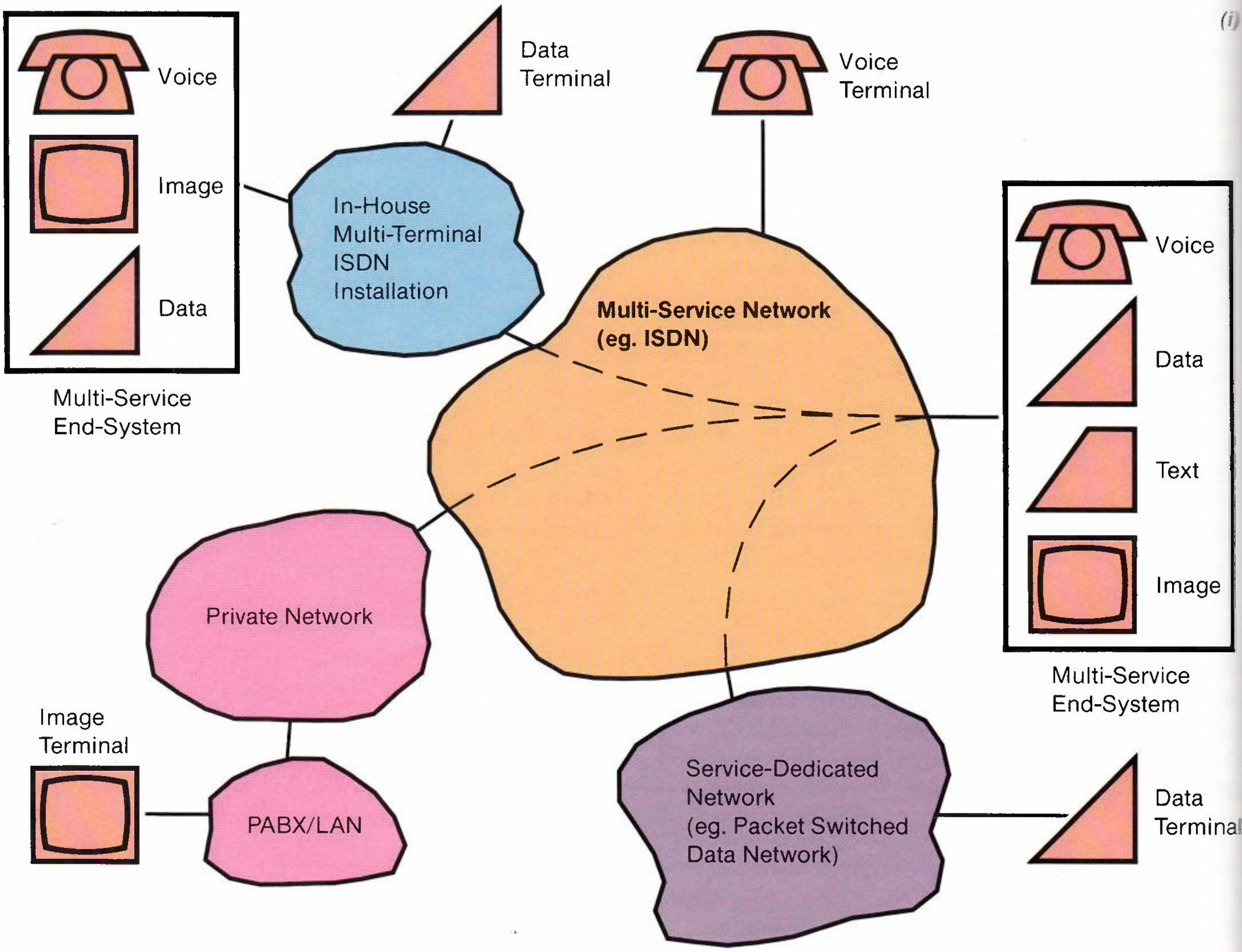
Naming and Addressing in a Multi-service Telecommunications Environment

The need for appropriate addressing or numbering schemes for unique identification of end-user terminals is well recognised in established telecommunication networks such as telephone, telex and data networks. However, the addressing requirements in a multi-service environment such as an Integrated Services Digital Network (ISDN), involving the interworking of a number of different services and/or network types, are not yet well established. This multi-service environment can support a variety of services such as voice, data, image and graphics either individually or simultaneously. As each of these different service types requires different network or terminal facilities, unique identifications are essential for the successful establishment of communication paths. Moreover, as the ISDN is expected to support a large variety of terminals, the compatibility of communicating terminals needs to be checked before a connection is established. An appropriate identifier is required for this purpose.

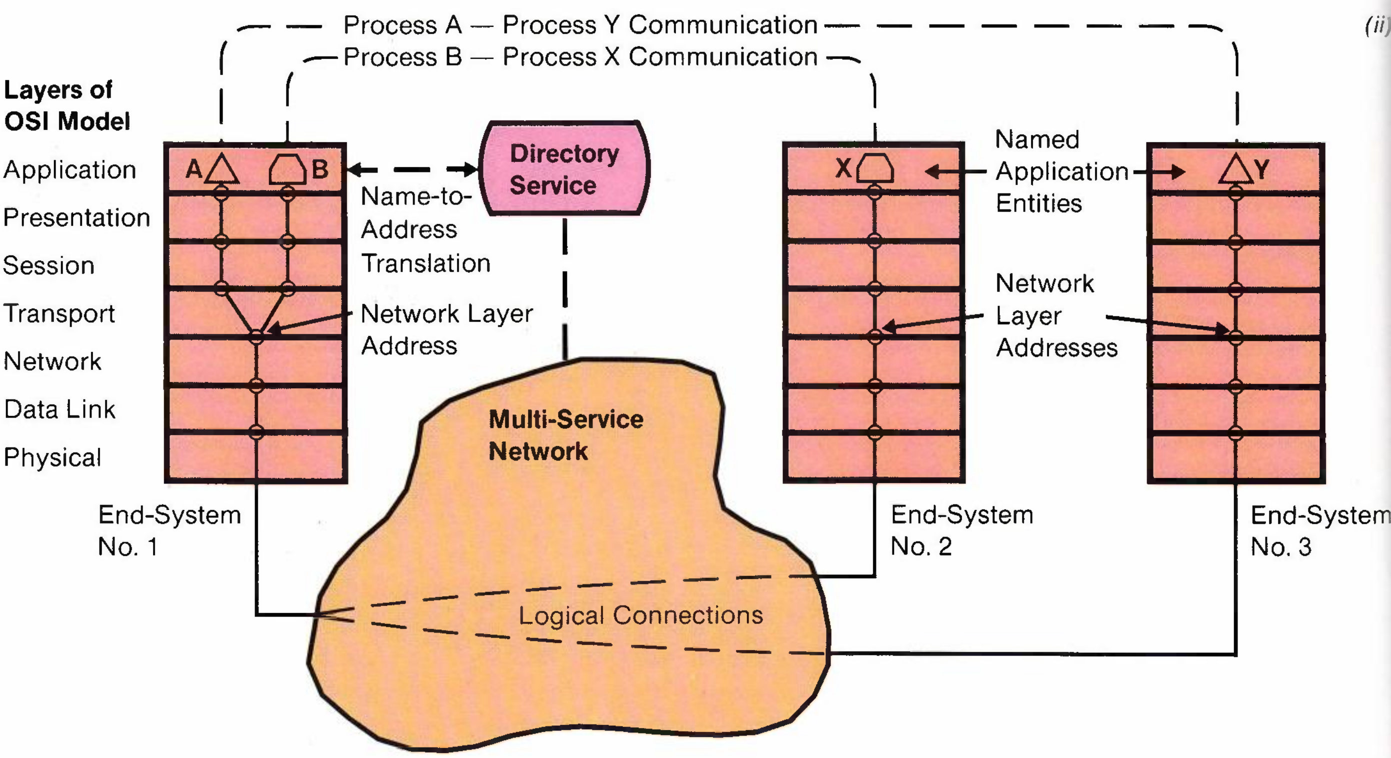
Application processes (e.g. programs, mailservers, humans) may be accessed via terminals attached directly to public ISDNs, private ISDNs, or service-dedicated networks (e.g. packet switched networks). Several multi-functional terminals may also be connected to the public ISDN via a single customer access link. Suitable identifiers (addresses) must be defined to enable the selection of the pertinent destination network and/or the identification of end-user terminal within such a network. Additional addressing is required to distinguish different application processes within the one terminal. The identification issues in a multi-service environment are further complicated when application processes need to retain their identity on relocation to other end-user systems or networks.

In developing an identification scheme which caters for the above addressing requirements, due consideration must also be given to human factors issues in the use of sophisticated multi-service systems. It is difficult for human users to remember or comprehend machine-oriented addresses, especially in future network applications where an address would comprise a long string of digits (up to 32 digits in some cases). On the other hand, the use of names, which are meaningful to the human users, to identify application processes would facilitate the necessary communication procedures. This implies the need for a standard naming convention and an appropriate mechanism for translating the human-oriented names into machine-oriented addresses. This translation mechanism is commonly known as an Electronic Directory Service. The translation is necessary as the addresses will be used by the underlying network(s) to perform switching and

(i)


Voice
Image
Data
Multi-Service
End-System
Data
Terminal
Voice
Terminal
In-House
Multi-Terminal
ISDN
Installation
Multi-Service Network
(eg. ISDN)
Voice
Data
Text
Image
Multi-Service
End-System
Private Network
Image
Terminal
PABX/LAN
Service-Dedicated
Network
(eg. Packet Switched
Data Network)
Data
Terminal

(ii)


Process A — Process Y Communication
Process B — Process X Communication
Layers of
OSI Model
Application
Presentation
Session
Transport
Network
Data Link
Physical
A
B
Directory
Service
Name-to-
Address
Translation
Network Layer
Address
X
Named
Application
Entities
Y
Network
Layer
Addresses
Multi-Service
Network
End-System
No. 1
End-System
No. 2
End-System
No. 3
Logical Connections

routing functions to set up the communication path between the corresponding application processes.

Several other issues related to the development of an identification scheme need careful consideration. The most prominent of these is concerned with the integrity and security of transferred messages. The multi-service networks are expected to convey the majority of business and personal information such as mail, documents, and funds transfer detail. Secured transferral of this information is therefore vital. Integrity and security could be obtained through:

- the use of the Electronic Directory Service to provide up-to-date user identifiers to eliminate the possibility of incorrect delivery
- the use of address encryption and route selection to protect users against monitoring
- the use of access control to prevent unauthorised access to end-user systems, directories and data bases.

The complexity of naming and addressing issues in a multi-service environment is apparent from the above discussion. Detailed studies of these issues are of significant importance as they will assist Telecom's network/service planning and development towards the ISDN environment. A detailed review of these issues has been completed recently by the Research Laboratories. It included the definition of fundamental naming and addressing principles with the objective of developing a unified identification scheme and its associate directory service function.

In particular, this preliminary work has made extensive use of the principles defined for the Open Systems Interconnection (OSI) Reference Model, which is internationally accepted as the basic framework for specifying the services and protocols for future communication systems and networks (including ISDNs). In the OSI context, communicating user-end systems can be represented in a seven-layer model. Two key identification issues are significant from this OSI model, namely:

- naming of communicating application processes by the end-users in the Application Layer,
- identifying the Network Layer Address (through which the intended application process can be found) by the Network Layer so as to perform routing and relaying functions across heterogeneous networks.

(See diagrams opposite)

(i) Schematic illustration of a multi-service telecommunications environment

(ii) Representation of communicating user-end systems using the 7-layer OSI Reference Model

The mapping of a process name to a corresponding Network Layer Address would be accomplished by an abstract directory service. These issues are also gaining increasing importance in international standardisation activities. Naming conventions and OSI Network Layer addressing are being standardised by both the CCITT and the ISO. Addressing and numbering standards for ISDN are also being developed by the CCITT for ISDN terminal and service identification. Standards on the directory service aspect are being formulated by the ISO and extensive study of this topic by the CCITT is also anticipated in the next plenary period (1985-88). As the studies by both the CCITT and ISO are closely related, common and unified solutions are essential for the support of the future multi-service environment. Contributions to the CCITT on these issues have been made by the Laboratories.

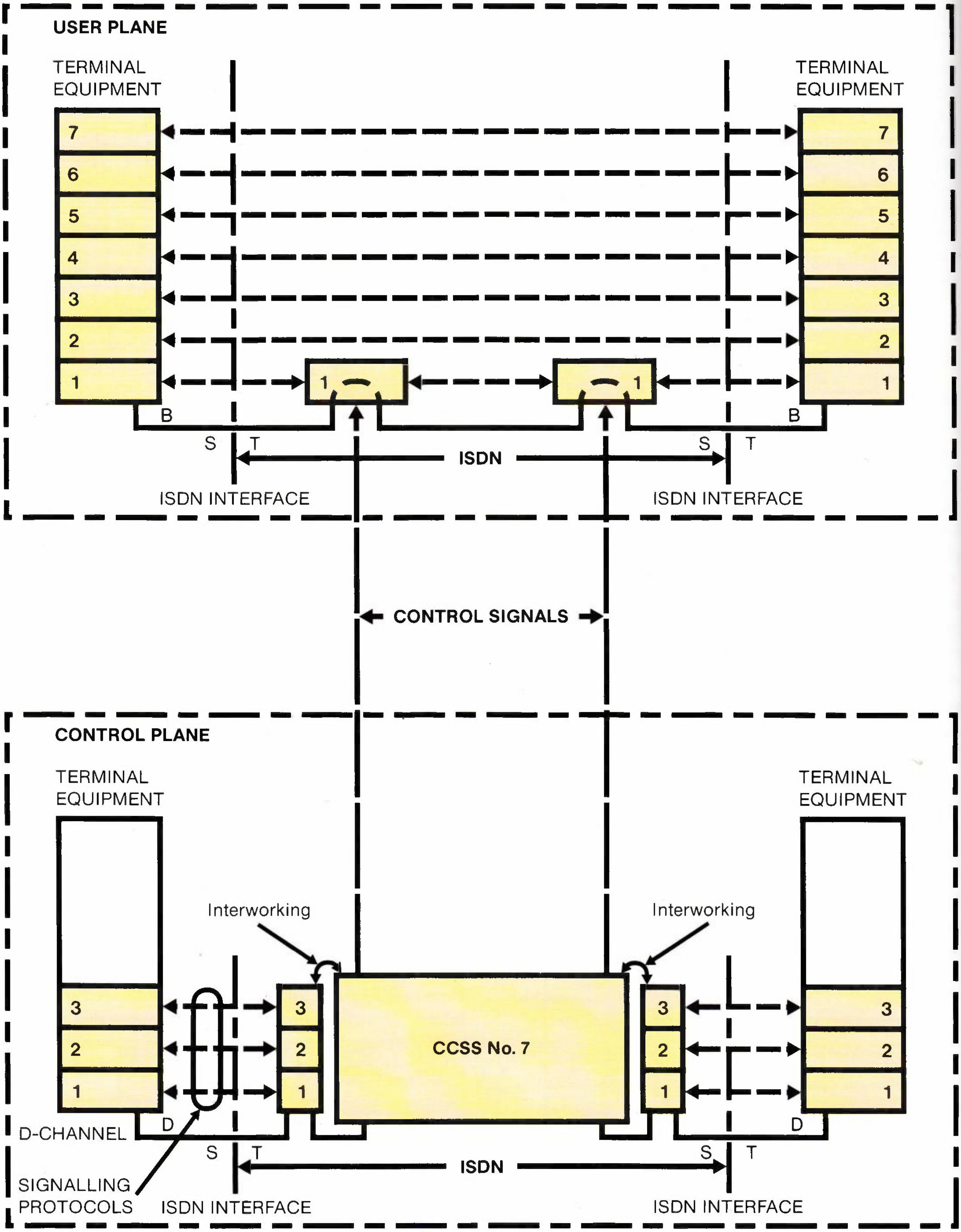
ISDN Protocol Reference Model

It is now widely recognised that the Integrated Services Digital Network (ISDN) concept is providing a useful framework for the development of future telecommunications networks and services. An ISDN can be regarded as a general-purpose digital network capable of supporting (or integrating) a wide range of services (e.g., voice, data, text, image) using a small set of standard multi-purpose customer-network access interfaces. Relevant CCITT Recommendations (or standards) on ISDN interfaces are expected to be available in 1984, the final year of the current study period.

Another key feature of ISDNs is the use of common channel signalling techniques to control circuit-switched connections between customer terminals. Between the customer premises and the ISDN local exchanges, these take place over the control channel (known as D- or E-channel, depending on the access structure). Within the network, Common Channel Signalling System (CCSS) No. 7 is used between exchanges.

Packet-switched communication is also envisaged in ISDNs. This can be supported using either established circuit-switched connections (e.g., B-or H-channels over the customer-network access link) or the control channels.

With such a diversity of ISDN capabilities in terms of information flows and modes of communication, a need has been identified within the CCITT to model all these capabilities within a common framework, known as the ISDN Protocol Reference Model. Such a model would enable the attendant critical protocol architectural issues to be readily identified and would therefore facilitate the development of ISDN protocols and associated features.



An ISDN circuit-switched connection under common channel signalling control

The model is based on the concepts and principles of layered communication defined by the ISO/CCITT Open Systems Interconnection (OSI) Reference Model. A key feature of the proposed ISDN Protocol Reference Model is the recursive application of the OSI seven-layer structure in modelling two generic types of ISDN information flows, namely, User and Control information flows. These flows can take place between the ISDN users; between an ISDN user and a functional entity outside the network; between various functional entities inside the network; and between an ISDN and other networks. They can also be one-to-many and many-to-many communications.

User information flows relate to digitised voice, data, text, image and other information. The information may be transmitted transparently through the ISDN, or it may be processed or manipulated within the network. Examples of the latter include digitised voice coding/decoding, data compression, data encryption, protocol conversion, etc.

Control information flows relate to signalling information required to control a network connection (e.g., establishing and clearing down); to control the use of an already established network connection (e.g., change of service characteristics or communication modes during a call, such as alternate voice/test, without changing the logical or physical connection); and to provide both above control functions (as in a multi-point conference call with change in communication modes). It is noted that the last two features are not yet defined in the OSI Reference Model.

The ISDN Protocol Reference Model therefore consists of two logical protocol planes corresponding to User and Control information flows. Interactions between the two planes may also take place in some situations.

The accompanying figure illustrates an application of the Model, dealing with ISDN circuit-switched connections. ISDN user-network call control signalling is represented by the lower three layers in the Control plane. However, the layering of CCSS No. 7 in terms of the OSI Reference Model has not yet been resolved and is under further study within CCITT. In the User plane, the Physical Layer (Layer 1) is used to model the fully-established circuit-switched connection of the exchanges involved, allowing physical information flow between the communicating terminal equipments. Peer-to-peer protocols may take place in the other six layers on an end-to-end basis.

The Research Laboratories have actively contributed to the development of the above ISDN Protocol Reference Model. This participation took the forms of written CCITT contributions and drafting group chairmanship at CCITT Study Group XVIII ISDN meetings. In view of the excellent progress made so far, it is hoped that the Model will be finalised as a new CCITT 1984 Recommendation.

Protocol Studies for Application-oriented Services

Telecommunication services, particularly the newer ones which involve communication over public data networks, can be classified into two categories, namely:

- Transportation-oriented (TO) services, and
- Application-oriented (AO) services.

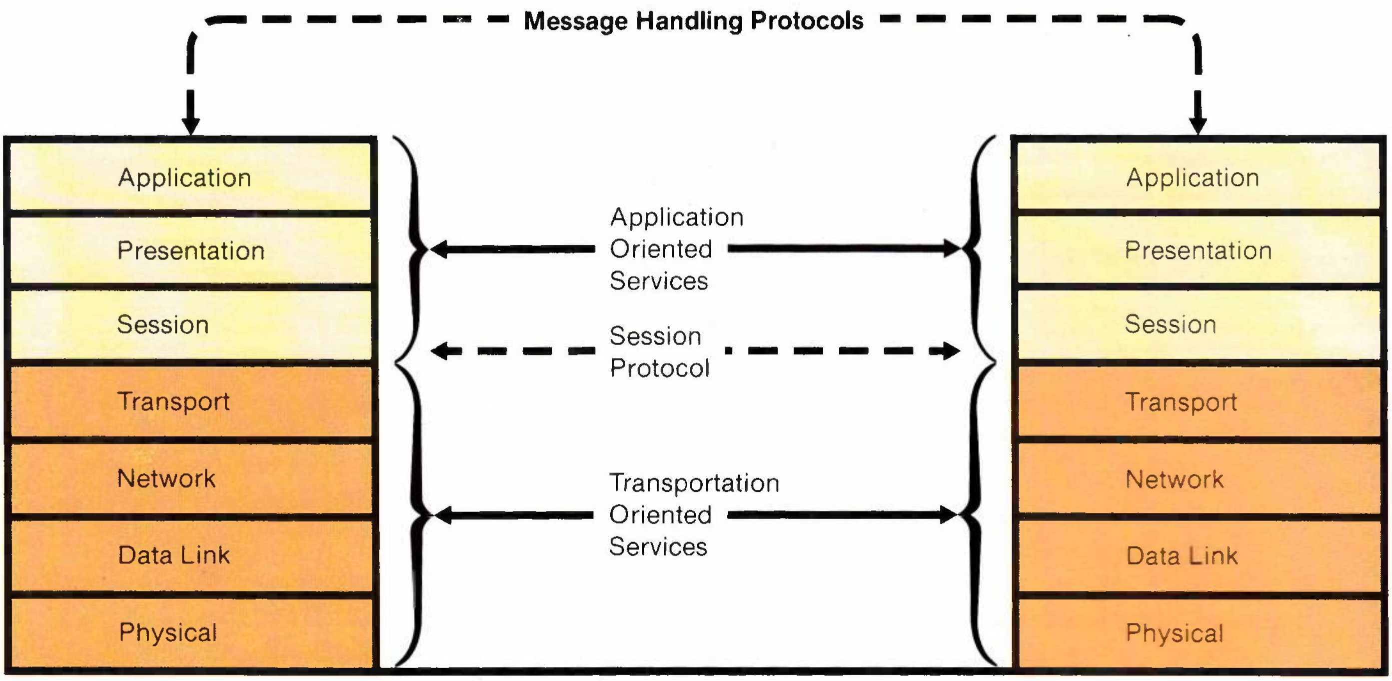
Transportation-oriented services provide a basic means of transferring information between end-users; an example is Telecom Australia's packet switched data service, AUSTPAC. Application-oriented services directly serve the end-user in his information processing application; an example is an on-line electronic directory service which allows users to obtain directory information from a data base.

The relationship between AO and TO services is clearly seen in the CCITT/ISO Open Systems Interconnection (OSI) Reference Model. AO services make use of communication protocols in the upper three layers of the model, and use an underlying TO service to carry these protocols.

The protocols necessary to support AO services are only now being standardised by the CCITT and the ISO. Given their importance in making possible future services, Telecom is monitoring and contributing to these international developments. The Laboratories are playing a leading role within Telecom in this field of activity, actively participating in the CCITT's standardisation processes by making technical contributions and attending local and international meetings.

An important aspect of this work is the implementation and testing of protocols while they are still in the form of draft standards. This approach assists a detailed understanding of an evolving protocol and identifies any weaknesses in the protocol or its specification. With such purposes in mind, the Laboratories have recently completed an implementation of the Session Protocol, which manages the "turn" in a dialogue between two Application processes and assists its users in correctly re-synchronising following an error or abnormal situation. Several contributions on the Session Layer have been made to the ISO through this programme of work.

The Laboratories' attention has now turned to the emerging protocols that will support a Message Handling Service. These protocols are special-purpose Application Layer protocols that will permit the establishment of a store-and-forward service for the exchange of messages, whether text, image or voice, or a mixture of these. Message Handling (MH) will embrace traditional telematic services such as telex, teletex and facsimile, as well as computer-based message systems (electronic mail).



Transport-oriented and Application-oriented services depicted in terms of the seven layers of the OSI Reference Model

The Laboratories have been closely following the work of the CCITT to define draft protocols and have underway several projects to permit the establishment of an experimental MH service.

Some of the project work has been contracted to local industry, and the resultant interaction between the Laboratories and industry should produce mutual benefits in the development of awareness and expertise in this emerging field, which will assist future specification and design of AO service implementations in general and of messaging systems in particular.

The Laboratories' experimental message handling system will be applied to studies of the many unresolved questions concerning the operation of such systems. The work will provide grounds for further contributions by Telecom Australia to the CCITT's standardisation activities. It will also assist Telecom's Commercial Services Department to plan for new services and network developments which are related to message handling.

Graphics for Protocol Analysis

Communications equipment is becoming more complex as new facilities are being introduced. Consequently, the complexity and sophistication of signalling schemes and data protocols is increasing.

Within the Research Laboratories, a methodology has been developed which can be used to specify, analyse and verify the operation of communication protocols. This methodology uses Numerical Petri Nets (NPNs), a generalisation of Petri Nets, to formally model the protocols.

PROTEAN, a PROTocol Emulation and ANalysis computer aid, has been designed to automate parts of this methodology. Sub-system NPNs can be entered into PROTEAN. These are then linked together to form a total system. Given an initial condition, PROTEAN then generates the relevant reachability set and computation flow graph (CFG). The reachability set is the set of all possible states of the system from the given initial condition, and the CFG is the relationship between these states. PROTEAN can then detect any loops and deadlocks in the protocol's operation.

Previously, all input and output of PROTEAN was textual. This has recently been enhanced by graphics developed by the Computer Science Department of the University of Melbourne. These graphics, designed for use on a simple graphics terminal and an inexpensive printer, provide three main facilities for displaying:

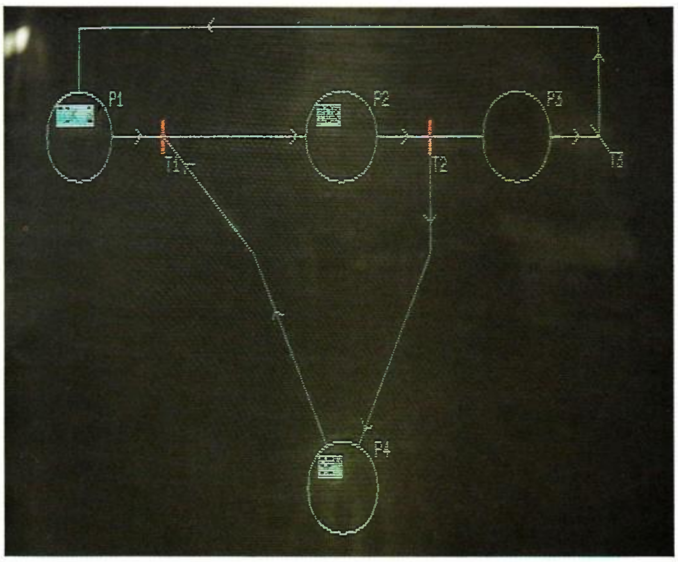
- an unmarked NPN
- the CFG, and

- a marked NPN.

Displaying the NPN allows the user to design the NPN on-line, using the computer as a drafting aid. Once drawn, the NPN is ready for analysis. The execution of the NPN can be shown, with the distribution of tokens and enabled transitions clearly visible. Once PROTEAN has executed an NPN, the CFG can be drawn.

Before the graphics facility was introduced, most CFGs were too large to draw by hand and thus were seldom drawn. With the availability of the graphics facility, all CFGs can be viewed, and all deadlocks and loops in the CFG can be highlighted. Thus, the new graphic facilities significantly enhance the capabilities of the PROTEAN package as a tool for protocol verification and analysis.

Graphics workstation for protocol analysis



Computation flow graph generated by PROTEAN)

Traffic Control Studies

The Australian telephone network operated by Telecom Australia is evolving into an integrated digital network, with computer controlled digital exchanges and high speed common channel signalling. Telecom's packet switched data network, AUSTPAC, utilises microprocessor-based hardware and thus also operates under program control. Both networks, therefore, have the potential for centralised network management.

The objectives of network management are to maximise traffic throughput and maintain communications at all times. These objectives are best achieved by continuous monitoring of network status and performance, and by applying appropriate traffic control measures when required. These control measures are generally classified as either "protective" or "expansive", depending on whether they serve to protect switching machines from overloads or to utilise lightly loaded parts of the network more effectively. Dynamic, or adaptive, routing is one expansive technique that has become practicable with the advent of computer controlled exchanges and common channel signalling.

To assist the planning of network management facilities for Australian public telecommunications networks, studies of traffic control techniques and optimal strategies are being undertaken in the Laboratories. To investigate the effectiveness of dynamic routing and other traffic control strategies, a comprehensive network simulation program is being developed. At the same time, the use of the CCITT Common Channel Signalling System No. 7 for transmission of traffic control signals and the management of the No. 7 signalling network itself is also being investigated.

To resolve some of the fundamental questions involved in the application of traffic control techniques in telecommunications networks, a research contract has been let to the University of Newcastle. The University's investigators will survey the problems and opportunities in this area and thence identify and define ways in which techniques drawn from the field of Optimal Control can be applied to the dynamic management of telecommunications networks.

SDL Specification of ISDN Customer Access and Network Signalling Protocols

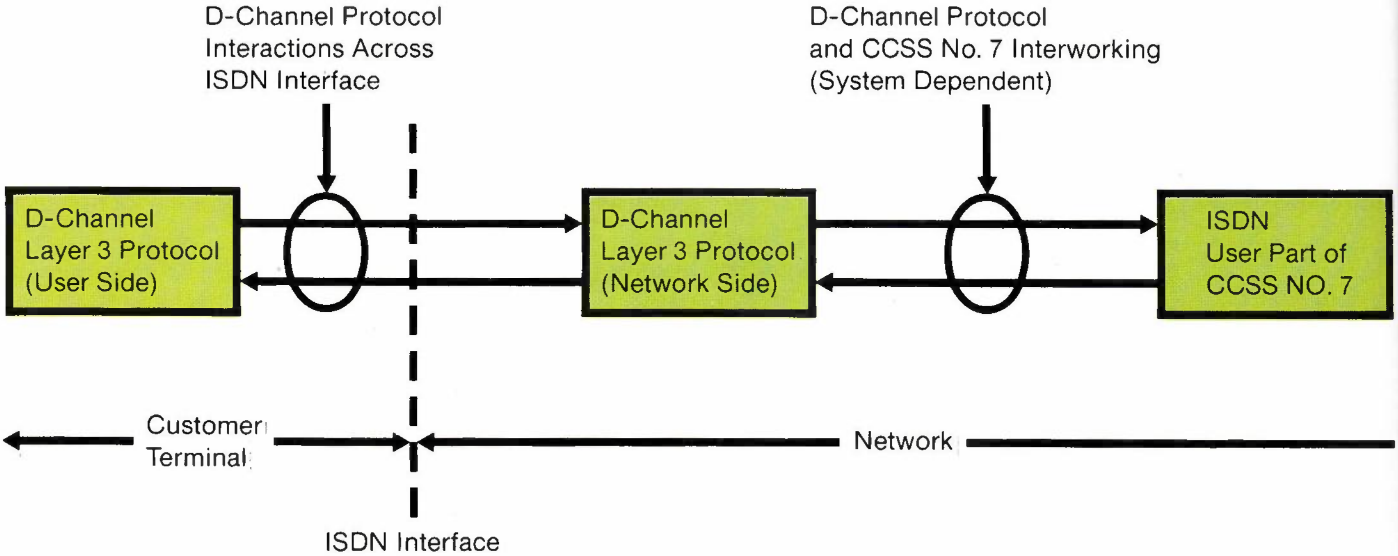
In continuing studies of Integrated Services Digital Network (ISDN) principles and standards, the Laboratories have been investigating the Recommendations for ISDN customer access and network signalling protocols proposed by the CCITT. These standards constitute a key feature of the ISDN concept in the early development of digital telecommunications networks to support a wide range of services.

An important aspect of this development is the provision of a small set of common or integrated access structures between the customer's premises and the network to carry multiple voice and non-voice services. One such interface which has received urgent consideration by the CCITT is the so-called ISDN Basic Access structure comprising two 64 kbit/s B-channels and one 16 kbit/s D-channel. These full-duplex channels will be derived on an ordinary subscriber cable pair. The B-channels provide transparent circuit-switched connections between customer terminals and the local exchange, whereas the D-channel is primarily used to convey signalling information to control the B-channels. In the future, other information such as packetised data and telemetry may also be multiplexed with the signalling information in the D-channel. The above separate access signalling channel concept is an extension of the technique used in the Common Channel Signalling System No. 7 (CCSS7) for signalling within the network.

During 1983, the Laboratories have contributed to the development of ISDN protocol standards. These contributions fall into the areas of the ISDN Layer 3 Customer Access Signalling Protocol (commonly known as D-channel Layer 3 Protocol) and the ISDN User Part of CCSS7. In particular, they relate to the graphical description of these protocols using the CCITT Specification and Description Language (SDL).

In contrast to natural language (e.g. English) description, SDL allows signalling procedures and protocols to be less ambiguously described. CCITT Working Party XI/2 (CCSS7) has for some years been using SDL to describe various aspects of CCSS7. However, it was not until April 1983 (following a CCITT contribution from the Research Laboratories using SDL for the description of the D-Channel Layer 3 Protocol) that SDL was used by CCITT Working Party XI/6 (Digital Subscriber Line Signalling). Further contributions were subsequently submitted by the Laboratories and SDL is now a recognized method to describe ISDN access protocols. From developments at recent meetings, it seems likely that an SDL description will be incorporated in the CCITT 1984 Recommendation for the ISDN Layer 3 access protocol.

The Laboratories have also contributed to the SDL description of the Call Control Procedures of the ISDN User Part of CCSS7. It is hoped that this too will be incorporated in the relevant CCITT 1984 Recommendation.



Conceptual overview of interworking between ISDN D-Channel Layer 3 Access Protocol and ISDN User Part of Common Channel Signalling System No. 7.

Access from a Packet Switched Network to a Telephone Network

Currently, it is possible for a character mode data terminal to gain access to Telecom's packet switched network, AUSTPAC, from the telephone network. However, outgoing access from the packet switched network (PSN) to the telephone network is not possible on a switched basis. The major difficulties in establishing a call in this direction are:

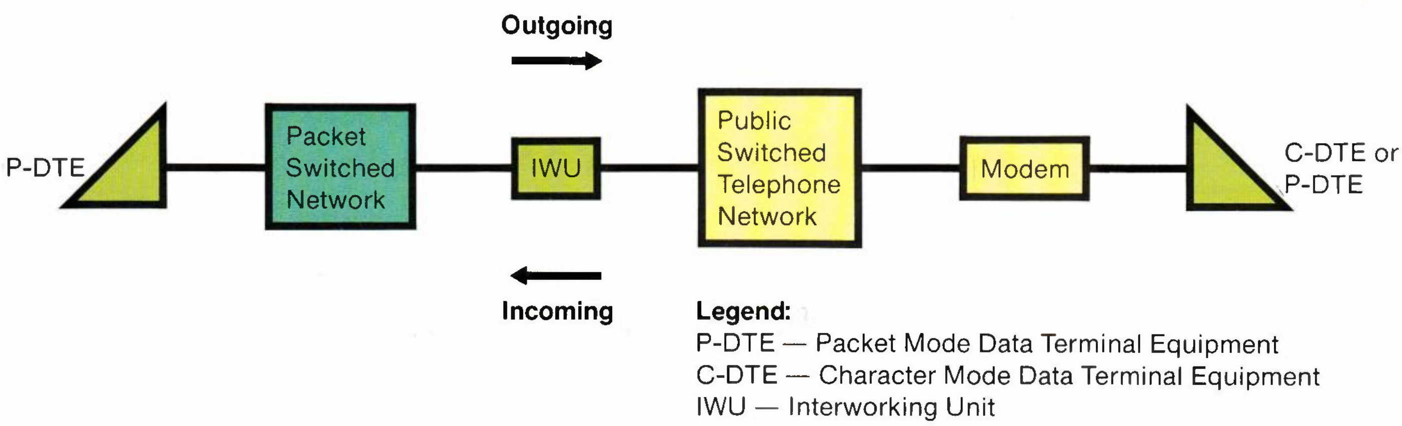
- addressing the called terminal on the telephone network
- determining the transmission profile of the called terminal
- designing the interworking unit required between the two networks
- charging.

Three methods of carrying the telephone number address through the PSN have been identified. The first makes use of a provision within the public packet switched network addressing scheme, X.121, whereby a telephone number can replace the normal data network address if it is preceded by a special reserved digit. The second addressing technique involves treating the entire public telephone network as a separate data network with its own data network address. The third approach is to provide each terminal on the telephone network with a PSN address so that it in fact becomes a terminal on the PSN as well. The last approach requires all telephone network terminals wishing to be accessible from the PSN to be registered with the PSN.

Another area of difficulty concerns the determination of the terminal's transmission profile. This identifies the type of connection required by the terminal on the telephone network. Parameters of importance include the data rate, the line code, whether full or half duplex is to be used, the type of terminal and the protocols it uses. Options for determining this information are:

- to register the transmission profile of each terminal with the PSN
- for the calling party on the PSN to provide the terminal profile at call set-up
- for the interworking unit to negotiate with the called terminal to determine its profile during call set-up.

The adoption of each of these methods presents some problems and all are currently under study by the Laboratories, in collaboration with the Packet Switching Network Group of the Headquarters Commercial Services Department. The studies are intended to identify the optimum method for application in the Australian telecommunication networks and to pursue its standardisation by the CCITT. Related work is also being performed in the Laboratories to develop and construct a prototype of an interworking unit between the packet switched and telephone networks.



Elements involved in interworking between the packet switched network and the switched telephone network

Network Service Interface Specification

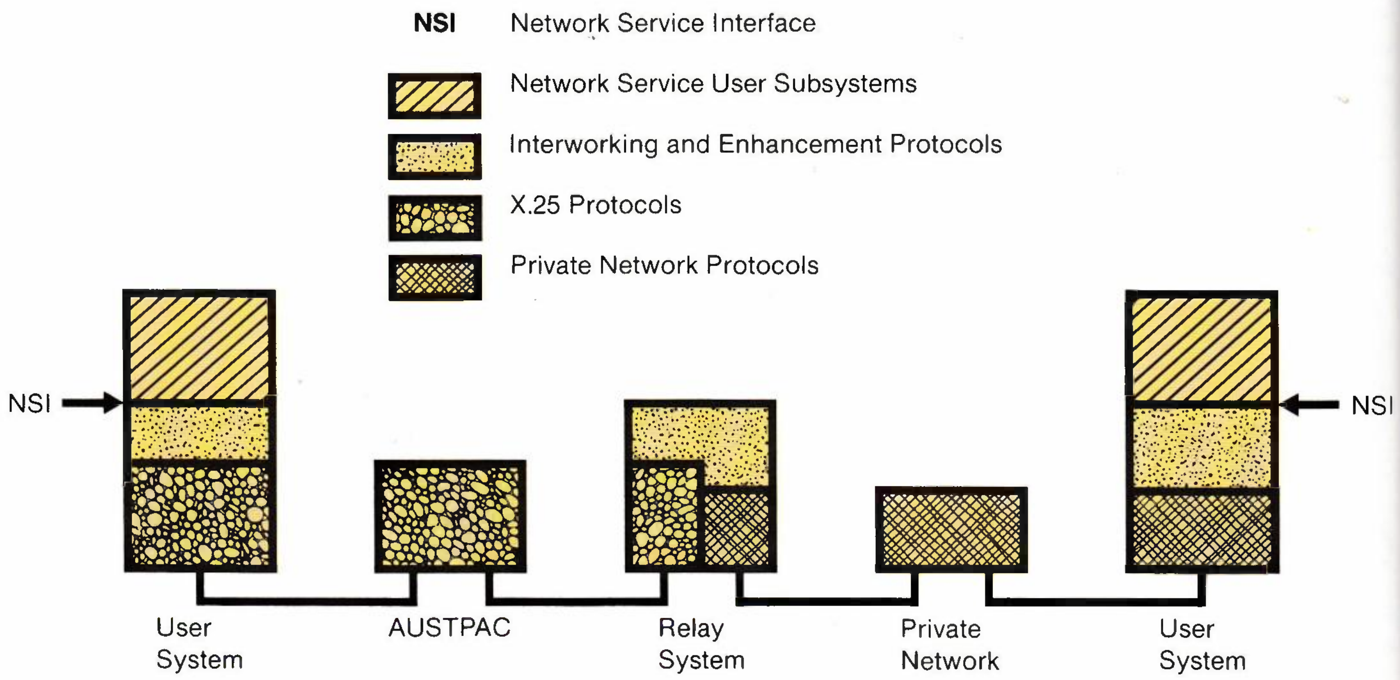
The International Organisation for Standardisation (ISO) and the International Telegraph and Telephone Consultative Committee (CCITT) are developing standards to facilitate communication between different types of information processing systems. The key standard developed for this purpose is the Open Systems Interconnection (OSI) Reference Model, which provides a framework to facilitate the specification of protocols to support such communications. The OSI standards do not attempt to specify how any communications hardware or software systems using the OSI protocols should be implemented. The standards therefore provide little direct assistance in solving problems of interfacing communications hardware or software modules from different sources. Such modules can be associated with particular underlying sub-networks such as AUSTPAC, a private network or more particular applications.

The Research Laboratories and the CSIRO Division of Computing Research are both involved with the development of OSI-oriented communications software. Through a collaborative research agreement, the two organisations exchange such software for use in integrated systems. A requirement exists for common general-purpose interface specifications, compatible with OSI, for use within and between the two organisations and other interested parties.

The most important interface required initially was recognized as being one similar in function to the OSI Network Service, the most basic service that provides communication between users across one or more sub-networks. Such an interface would allow various Network Service user modules to be readily combined with various sub-network-specific modules.

A joint Laboratories/Division of Computing Research project is therefore being undertaken to design a common Network Service interface specification, consistent with the OSI Network Service Definition. The interface will allow transfer of data between Telecom, CSIRO and other participants in a consistent manner, independent of the characteristics of the particular data communication networks being used (e.g. AUSTPAC, CSIRONET, or private networks).

To ensure that the interface is valid and that its specification is complete and unambiguous, formal descriptions of the interface behaviour were developed at an early stage. The formal descriptions were developed using two different techniques, the CCITT Specification and Description Language and Numerical Petri Nets. The Numerical Petri Net description was tested using the Laboratories' computer-based protocol analysis system, PROTEAN. This detected some faults in the specification, which were easily rectified.



Relationship between Network Service interfaces and an AUSTPAC - Private Network interworking scheme

Experimental Digital System

Currently, the CCITT is actively specifying standards for future telecommunication networks and services, specifically the Integrated Services Digital Network (ISDN). Planning of future network developments in Australia will be very much influenced by the resulting CCITT Recommendations. Telecom has been involved in this specification process by actively contributing to CCITT meetings and discussions. Particular attention is being paid to the capabilities of the ISDN local exchange which will have additional features not provided by exchanges within the digital telephone network.

The Laboratories have undertaken the development of a small experimental digital switching system. The system, called the Experimental Digital System (EDS), will be a framework only, comprising the major architectural features of a modern switching system, designed and developed using the latest available technology and concepts. It is not intended to be a fully functional exchange, but rather an experimental tool to be used to study the impact of technology on future switching systems. The EDS project is intended to serve a number of aims, all of which are directed at gaining practical knowledge of ISDN implementations. Although the EDS will not attempt to implement a full ISDN exchange, the project will enable the realization of ISDN recommendations, concepts and ideas. This is intended to lead to a greater understanding of the practical problems to be faced in ISDN developments and to more informed debate on these problems within Telecom.

The ISDN will rely to a large extent on Very Large Scale Integrated (VLSI) circuit devices to perform functions which previously were not practically or economically possible. In this context, the EDS will facilitate active investigation and evaluation of the application to telecommunication systems of new technological developments such as VLSI design techniques and complex telecommunication integrated circuit devices, sub-systems and systems.

In the last year, activity on this project has been centred around the architectural design of the EDS, with the objective of ensuring that it will be versatile enough to meet its varied objectives.

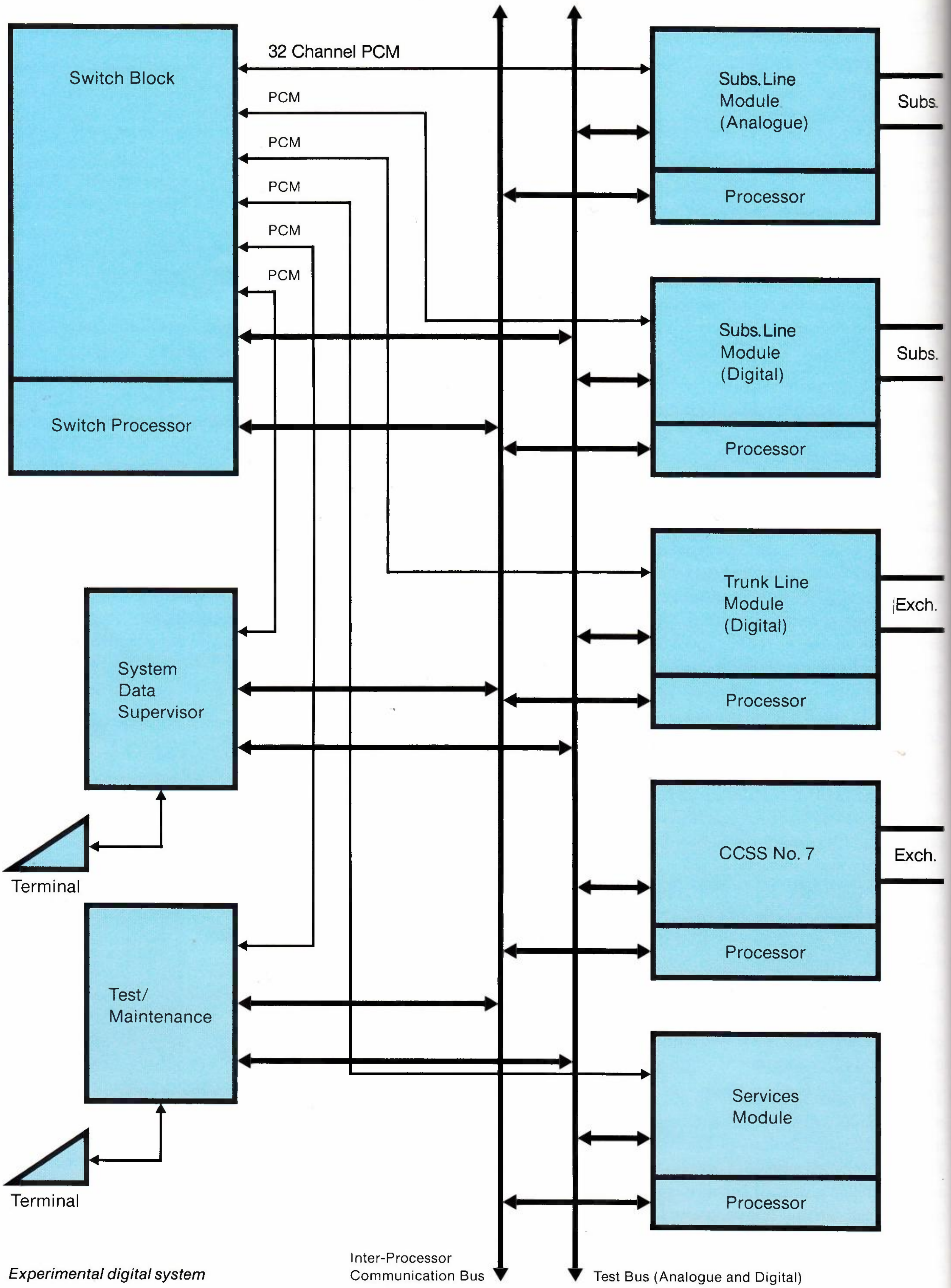
The EDS is made up of a number of modules, each with its own processor which facilitates module control as well as inter-module communication. The control function of the EDS is distributed among all processors. For example, a subscriber-line processor supervises the setting up of an outgoing call; a trunk-line processor supervises the connection of an incoming call; and the digital-switch processor controls the operations of the switch-block.

Each module is sufficiently self-contained so that system expansions can be achieved relatively easily by adding appropriate modules. The modularity principle is not restricted to processor modules, but is extended to all other modules and sub-modules of the EDS. This will allow future modifications and changes to be made to any part of the system, with little consequence to other modules. Each module of the EDS can access common resources (such as the system data base or the digital signal processing facilities) by first establishing a communication link to the processor controlling the required module. Once access is allowed, a data link to the required device can be established.

During last year, an analogue subscriber interface module, a digital switch module, a digital signal generation/detection module and the system-data module have been designed and tested. The signalling scheme used over the subscriber lines is the Dual Tone Multi-Frequency (DTMF) scheme. Modularity of the system should allow subsequent module additions, such that the system will be capable of providing varied facilities with diverse requirements.

A digital trunk module will be designed next. It will use the CCITT Common Channel Signalling System No. 7 to signal to other exchanges. Other modules which will be added subsequently include a multi-services digital subscriber interface module and its associated information handling modules.

(See diagram over)
Schematic outline of the experimental digital system



Experimental digital system

Digital Network Dimensioning Studies

Telephone networks in Australia are hierarchically structured and employ alternative routing. This means that, for most calls, there is more than one path between the call's origin and its destination. Calls are first offered to the most direct (and economical) route. If this is congested, the call is offered to the next most direct route, and so on until either the call succeeds in reaching its destination or there are no further routes available to the desired destination. Such networks can often be quite large and complex, and this requires that great care must be exercised in determining the number of circuits between pairs of exchanges in the network. The process of computing the circuit requirements is usually referred to as "dimensioning".

Traditional methods for network design involved dimensioning the outgoing routes of individual exchanges to carry their originating traffic at minimum cost. Unfortunately, this method does not necessarily lead to a minimum-cost total network design.

Work carried out by Telecom Australia in collaboration with Adelaide University over recent years has resulted in the development of new methods for total network design. These techniques are based on mathematical programming models, and they design alternative routing networks to a minimum network cost criterion subject to user-specified end-to-end grades of service. As the design grade of service standards for Australian telecommunications networks are given in terms of overall end-to-end congestion probabilities, the new models are ideally suited to satisfy these standards. In addition, these methods lead to substantial cost savings over conventional design methods, whilst still satisfying the specified network grades of service.

Studies involving the practical realisation of the new design methods on smaller networks have been continuing for some time. Recently, with the support of Headquarters and Victorian Engineering Departments, one of these methods has been applied to the design of the future Melbourne metropolitan network. The Research Laboratories, in conjunction with Dr. L. Berry of the Adelaide University, undertook this major project to optimally dimension this network and to compare the results with those obtained with more conventional planning methods.

The project involved three major phases, as follows:

(i) A theoretical study to extend the methodology of the optimisation process to general hierarchical networks and to develop a technique for determining which type of transmission media is most economical for each individual route in the network. Included in this study was the need to develop a procedure for efficiently listing the available paths between every origin-destination pair in the network.

(ii) Development of software and special computer techniques in order to accommodate networks consisting of up to 1000 separate switching stages.

(iii) Optimisation of the network for end-to-end grades of service which have been previously determined from a network dimensioned by traditional methods. These grades of service were selected in order to carry out an exact comparison between the two network designs.

The first two phases of the project were completed in 1983 and the last phase early in 1984. At the conclusion of this final phase, a review of the results was commenced to assess the overall performance of the software and the savings in network and computing costs possible through the use of the new techniques. The review is continuing.

Crosstalk and Impulsive Noise Limitations of Local Digital Transmission Systems for the ISDN

Customer access to an ISDN requires digital transmission to the local exchange. Economic constraints determine that the single twisted pair of wires presently used for the telephone service should be generally used to carry the digital signals in both directions. Two transmission techniques which could efficiently provide this full-duplex digital access at possible rates from 80 to 192 kbit/s are the burst mode or Time Compression Multiplex (TCM) and the Echo Cancelling Hybrid (ECH) techniques.

An ISDN cannot be implemented quickly. In the early stages of ISDN implementation, only a limited number of customers will have ISDN access, and a major source of interference to the associated digital systems will arise from the existing plant in the local network. In particular, a significant source of interference will be the impulsive noise produced by decadic signalling for analogue telephone services on nearby pairs. In the longer term when the ISDN is widely established, the loop access performance may be limited by crosstalk interference from large numbers of other digital access systems.

The Laboratories are currently studying the susceptibility of these systems to impulsive noise and crosstalk. The relative merits of various proposed systems are being assessed in terms of the maximum achievable line lengths over which the maximum percentage of subscribers could be provided service with adequate transmission performance without signal regeneration. Preliminary studies have been based on the commonly occurring

0.4 mm diameter copper pair cable, which has pairs grouped in 10-pair units.

For the preliminary crosstalk studies, the cable is assumed to be uniform and the effects of bridged taps and wire gauge changes on the crosstalk path are ignored. However, the reduction in noise margin produced by bridged taps has been quantified in other studies and this aspect will be included in the studies where appropriate.

The studies are also based on ideal implementations of the receivers in the proposed systems. However, a 6dB margin has been included to account for practical limitations such as inter-symbol interference and imperfections in the clock extraction process. The particular line codes considered have transmit pulses consisting of rectangular segments, each of which is equalised to a 100% raised cosine shape in the receiver. With the echo cancelling hybrid, it is assumed that complete echo cancellation occurs. In the burst mode system, the two directions are assumed to transmit alternately at three times the required access rate, with a guard time to separate the bursts in each direction.

Crosstalk interference may occur via near-end or far-end crosstalk (NEXT or FEXT) paths. With burst mode systems, synchronisation of the bursts at the local exchange effectively eliminates the effect of NEXT. If a fixed transmit level is used with each system, the worst case FEXT interference occurs when all disturbers are at about 4dB from the exchange. Furthermore, if the FEXT disturbers are much more than 4dB from the disturbed system, FEXT does not cause a significant limitation to burst mode systems. However, since the worst case conditions may occur, the FEXT burst mode limits given in the accompanying Table apply to this case. For both NEXT and FEXT studies, nine disturbers are assumed to occur within the 10-pair unit of the cable; this corresponds to the unit being fully utilised for ISDN access. Because the crosstalk paths are described statistically, the designer can only satisfy a statistical criterion. In this case, 99% of maximal length systems should satisfy the transmission performance objective, which is chosen to be a long-term bit-error of 10^{-7}.

Abrupt 50 volt steps to line, which occur during decadic dialling from the analogue subscribers' telephones, are coupled through the NEXT path as impulsive noise into nearby pairs in the cable. It is assumed that these steps occur at an average rate of about 35 per call.
The distribution of the telephony traffic over the analogue subscriber lines is described statistically, with the mean of 2 calls per hour corresponding to a busy urban area. The worst case of nine within-unit analogue subscriber lines, with the telephones at the same location as the digital subscriber, is considered. The cable crosstalk data used in the impulsive noise and crosstalk analyses is given in the Table and was based on measurements from a sample of 0.4 mm cable. The statistical design criterion used for impulsive noise is the same as the one used for crosstalk interference.

The Laboratories have developed separate computer simulations based on published theoretical models for both crosstalk and impulsive noise. These iterate the line length to obtain the maximum length system which just satisfies the design objective. The maximum length on 0.4 mm cable for several line codes, two access rates and the two access techniques are tabulated. These results indicate that impulsive noise is the limiting factor for TCM systems, and that NEXT is usually limiting for ECH systems.
The results also show that, in an impulsive noise environment, ideal ECH systems allow longer line lengths than TCM systems, and that the choice of line code has a significant influence on the achievable distance. However, in an all-digital network of the future, impulsive noise from signalling events would not exist and crosstalk would be the main source of interference. In this case,

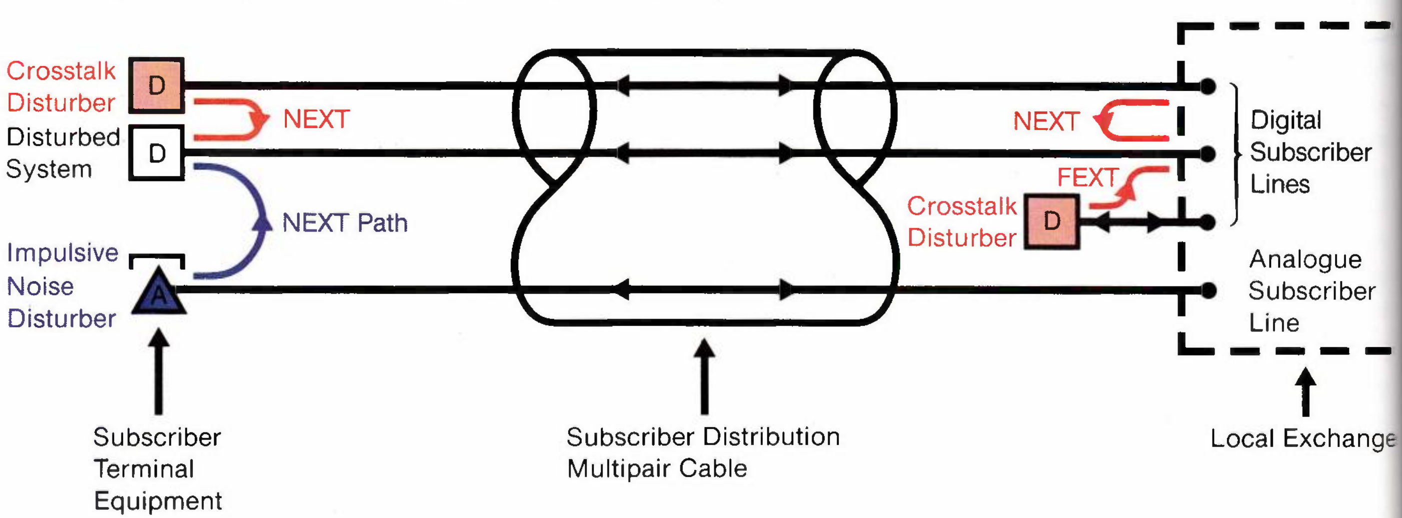


Illustration of crosstalk and impulsive noise interference paths synchronised TCM systems (with transmit signal level adjustment to eliminate the worst-case FEXT) would permit greater transmission spans than ECH systems.

The studies to compare the performance of ECH and TCM systems have so far only been based on their sensitivity to impulsive noise and crosstalk interference. Other factors such as the effect of bridged taps, the feasibility of VLSI implementation, and the degree of receiver equalisation and echo cancellation which can be realised with batch production have also to be taken into account when assessing possible systems for ISDN access in the Australian subscriber network.

ACCESS RATE (kbit/s)	ACCESS TECHNIQUES	LINE CODE	LINE LENGTH LIMIT (km) DUE TO: NEXT	FEXT (Worst Case)	IMPULSIVE NOISE
80	ECH	4B3T	5.74	6.40	5.48
		AMI	5.02	6.05	5.10
		WAL1	4.08	5.61	4.35
	TCM	4B3T	-	5.18	3.63
		AMI	-	4.85	3.34
		WAL1	-	4.48	2.29
144	ECH	4B3T	4.45	5.73	4.40
		AMI	3.90	5.40	4.07
		WAL1	3.18	5.00	3.60
	TCM	4B3T	-	4.56	2.93
		AMI	-	4.24	2.69
		WAL1	-	3.89	2:20

Table showing maximum line lengths on 0.4 mm cable for several system proposals

CROSSTALK	MEAN VALUE (dB)	STANDARD DEVIATION (dB)
NEXTA @ 100 kHz	76.2	8.0
FEXTR @ 100 kHz and 1000 m	74.8	6.2

Table showing within-unit crosstalk cable data used in the Laboratories' analyses

A New Method for Timing Recovery in Digital Transmission

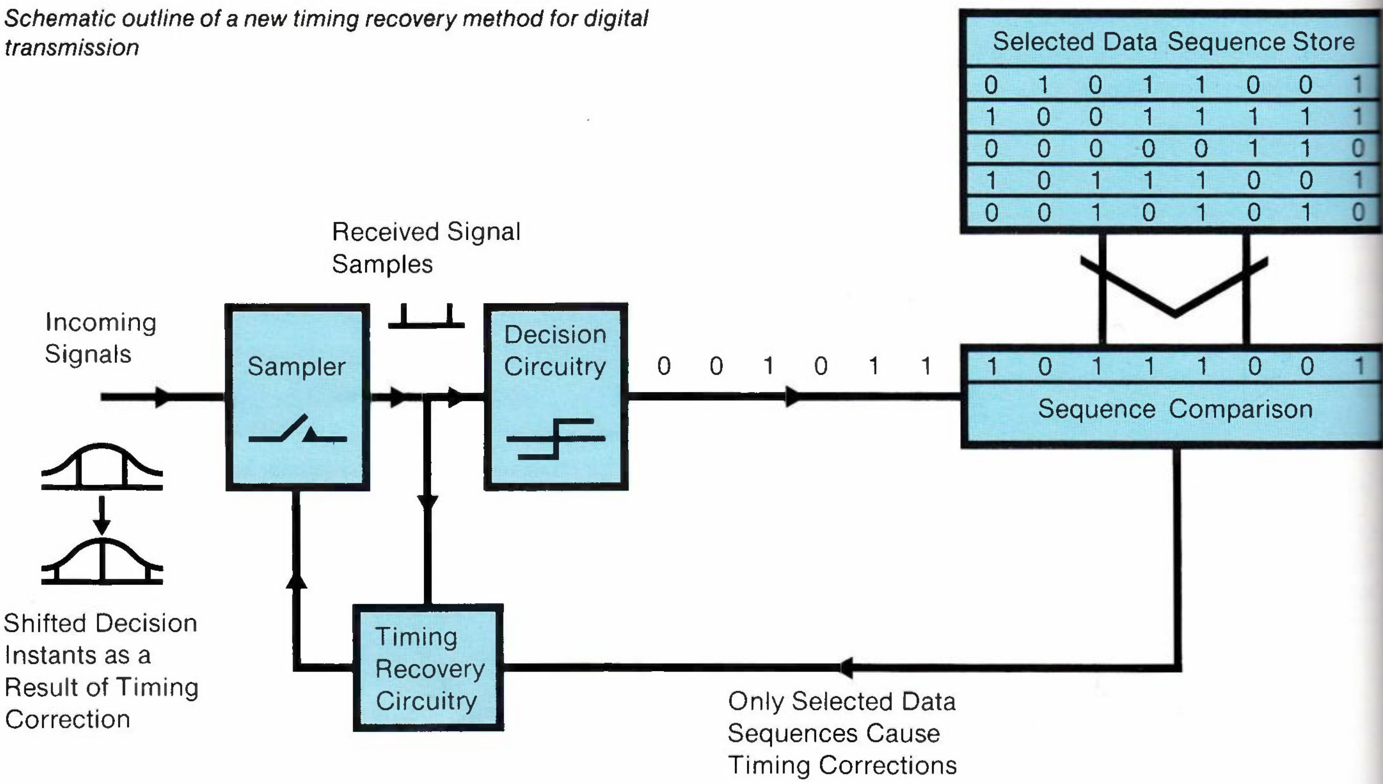
A receiver for digital transmission requires some means of synchronisation with the incoming data signal. This timing recovery circuitry must extract the timing information contained within the data signal and adjust the timing of the decision circuitry in the receiver to ensure that decisions are taken close to the correct instants, to give greatest margin against noise-induced bit errors.

Typically, the timing recovery is performed by operations on the received signal requiring precision components such as phase-locked loop or narrow bandwidth bandpass filters. These components can be quite expensive, and since they involve analogue signal operations, they are quite difficult to integrate on the same chip as digital logic circuitry. Current developments in transmission equipment make it highly desirable that a replacement for these analogue components should be found. In many cases, timing recovery is the last obstacle to a fully integrated digital receiver. For example, in digital customer access, a single chip digital logic implementation of the customer access equipment is most desirable.

The Laboratories have recently investigated a new timing recovery method using only digital logic circuitry to implement the timing recovery function. It is applicable to many digital transmission systems (metallic or optical fibre cable and radio) since it relies only on fundamental properties of digital transmission systems. Given the signal samples at the receiver and the subsequent decisions on these samples, the timing recovery method forms an estimate of channel characteristics. By comparing this estimate with known constant characteristics of the channel (e.g. leading edge zero-crossings in the pulse response), the timing recovery method adjusts the timing according to this estimate. The method relies on the fact that certain data sequences more readily provide information concerning the channel characteristics.
In restricting the timing recovery operation to consider only these data sequences, reliable timing adjustment is obtained. So, in practice, the timing recovery waits for an occurrence of a certain data sequence and then rapidly adjusts the timing.

In operation, the timing instant may initially be placed such that there are many decision errors in detecting the data sequence, if the timing is initially far from the correct instant. This is a situation where correct decisions are required for correct timing, which in turn can only be made with correct timing. At first sight, it may appear that a situation is thereby presented from which the method may not recover. However, extensive analysis in the laboratory has shown that the method will always recover rapidly from this situation.

Schematic outline of a new timing recovery method for digital transmission



Interfacing Analogue Subscriber Lines with the IDN

The application of modern technology to the interface between analogue subscriber lines and the Integrated Digital Network (IDN) promises to yield a more versatile, smaller and less expensive arrangement than at present, with the potential for improved performance.
This interface must provide protection of the more delicate exchange equipment against unwanted voltages on the subscriber lines and must provide for power feeding to the telephone. Hence, it is divided into two parts, namely a high power, robust part which connects directly to the subscriber line, and a less robust, more complex part which performs most of the signal processing required to connect the subscriber to the IDN.

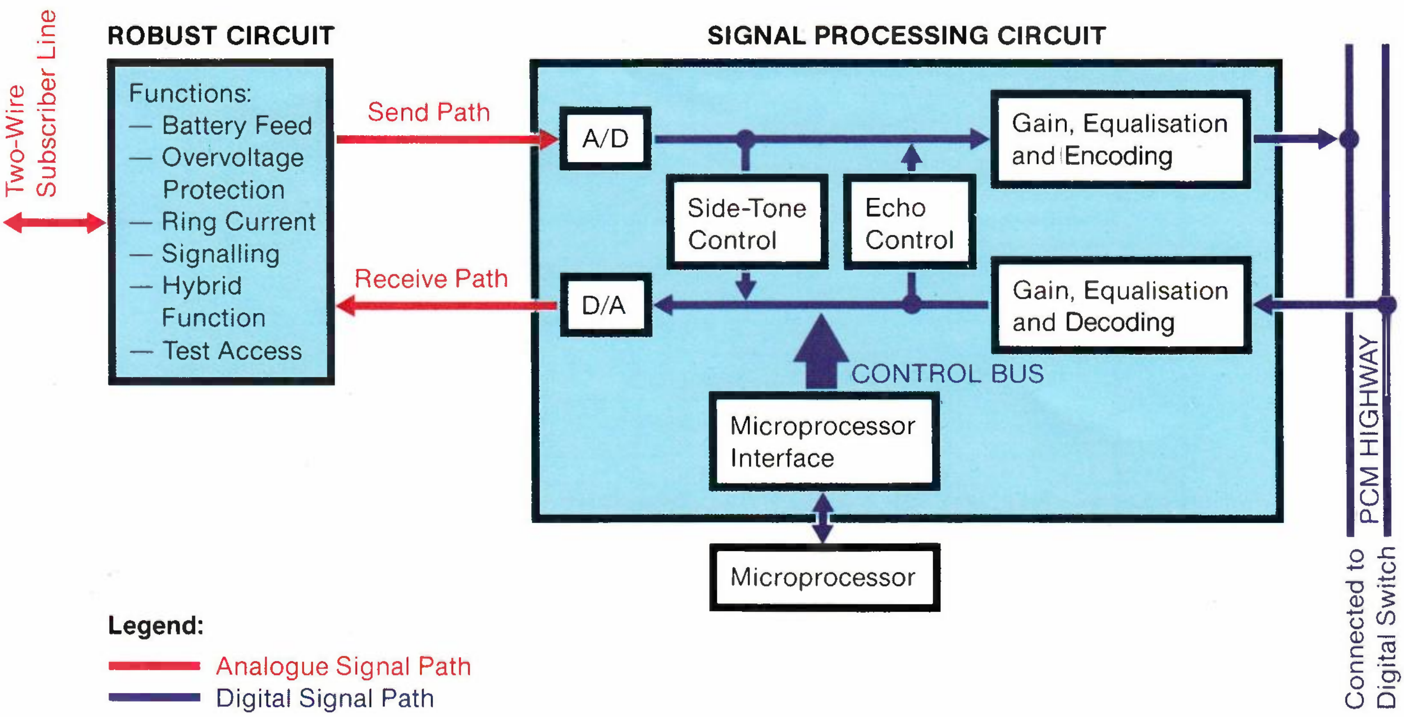
The Research Laboratories are actively investigating solutions to this interface problem. One solution is to perform the functions of echo and sidetone improvement, gain and equalization for both send and receive directions, as well as the encoding and decoding functions, in the signal processing circuit. All other functions, including the hybrid function (splitting the subscriber's signals into the send and receive paths) are carried out in the more robust circuit.

One currently available signal processing circuit uses digital techniques to perform the functions outlined above. It is a complex Very Large Scale Integrated (VLSI) circuit with on-chip analogue-to-digital (A/D) and digital-to-analogue (D/A) converters, as well as a microprocessor interface for controlling the device. Since the signal processing functions are performed using digital filters, it is possible to alter their response by changing their co-efficients under software control. This is equivalent to changing the hardware components in an analogue circuit.

A test-bed facility has been developed in the Laboratories to investigate this signal processing device. The facility involves both complex hardware and software.

The hardware includes clock circuits, digital interfaces to the PCM highway, analogue interfaces to the subscriber line, and complex control circuits for the interface between the signal processing device and the microcomputer used for software control of the device. This control circuitry performs the required protocol and transmission rate conversions between the microcomputer and the device.

The software required to control the signal processing device is written on the microcomputer, which transmits information to the device through the control circuitry. The software allows the operator to enter commands in a high-level language. It then converts them into the required object code for the device. Syntax checking routines are also contained in the software to ensure that the commands entered by the operator are of the correct format. The microcomputer controls associated measuring instruments and records the measurements for analysis. Optimisation routines are also included to enhance the



Schematic diagram of interface for an analogue subscriber line with the IDN

performance of the signal processing device by finding the optimum coefficients for the digital filters.

Initial experiments have revealed that, although the signal processing circuit would provide a very compact and versatile interface, the echo control is barely adequate for the Australian network. Further work is being undertaken to validate this initial conclusion.

Customer Wideband Radio Systems for Urban Applications

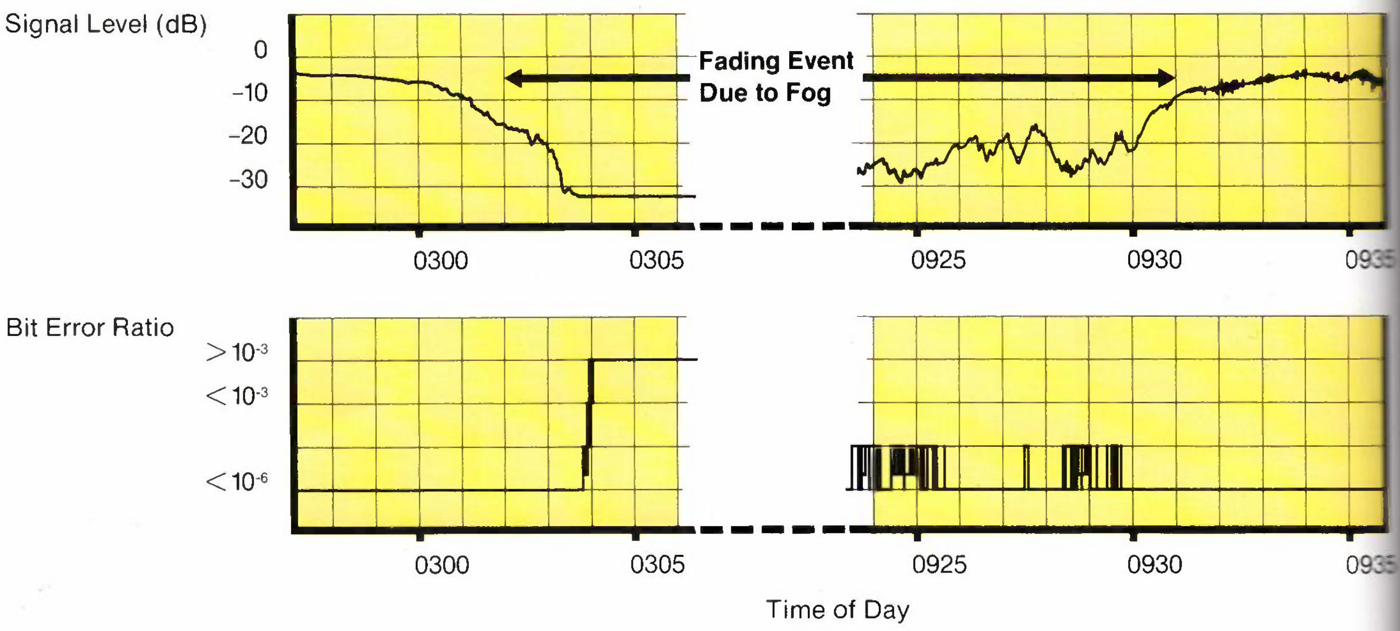
Low-cost microwave radio and through-atmosphere optical transmission systems have a number of potential applications in urban environments to provide a variety of customer services. For this reason, millimetre and centimetre wave radio systems and infra-red atmospheric optical systems are currently being assessed in the Laboratories.

Infra-red optical systems are suitable for short range (typically less than 1 km) point-to-point services, while millimetre or centimetre wave radio systems are being used or developed for longer range (typically from 1 to 40 km) point-to-point or point-to-multipoint services. The systems can be used to provide a variety of wideband services, such as digital links for voice and data, and video links for monitoring, surveillance or video-conferencing facilities. Although optical systems have shorter range capabilities than radio links, their cost is lower since waveguide components are not required. Thus, optical systems promise to find considerable application to link data processing equipment and video monitors over short distances within industrial sites, university campuses, etc.

There are many advantages in implementing wideband, urban services using millimetre wave, centimetre wave and atmospheric optical systems. The systems are small and lightweight and are designed to be mounted on poles or directly on existing rooftops. Systems can even be mounted within buildings for through-window operation. The equipment can be rapidly installed, presenting convenient communications at temporary sites or in situations where cables are inconvenient or too costly. Considerable flexibility is also gained to remove or re-configure links to suit customer requirements. In addition, the narrow beamwidths obtainable with small antennas at the wavelengths involved allow services to be provided to large numbers of customers within a relatively small urban area. Atmospheric optical links have the added advantage of not being affected by radio frequency interference, so that they can also provide transmission of wideband signals in environments which are either too hazardous or electrically noisy for the use of cable or radio systems.

Since relatively little information is available on the various factors which effect the performance of these systems, the Laboratories are conducting a number of relevant investigations which include:

- a millimetre and centimetre wave point-to-point system field experiment, conducted in conjunction with Telecom's New South Wales State Administration. This experiment is designed to assess the consequences of propagation effects (particularly rain attenuation and



Recorded fading event for atmospheric optical system operated in fog

building reflections) on the performance of point-to-point systems using commercially available equipment operating at both 13 GHz and 40 GHz.

- numerical studies to assess limitations imposed by mutual interference on achievable system densities for point-to-point links in a given urban environment and to study building obstruction and reflection effects on cellular point-to-point multipoint systems.
- an infra-red field experiment, designed to assess the performance of atmospheric optical systems under a variety of weather conditions. The link, set up using commercially available equipment, has been monitored since June 1983, during which time fog and rain fades, scintillation, and even interruption of transmission by the presence of a smoke plume have been recorded.

With the information gained from these various experiments, the Laboratories expect to assist Telecom's planners and designers to utilise effectively the many advantages offered by these new systems.

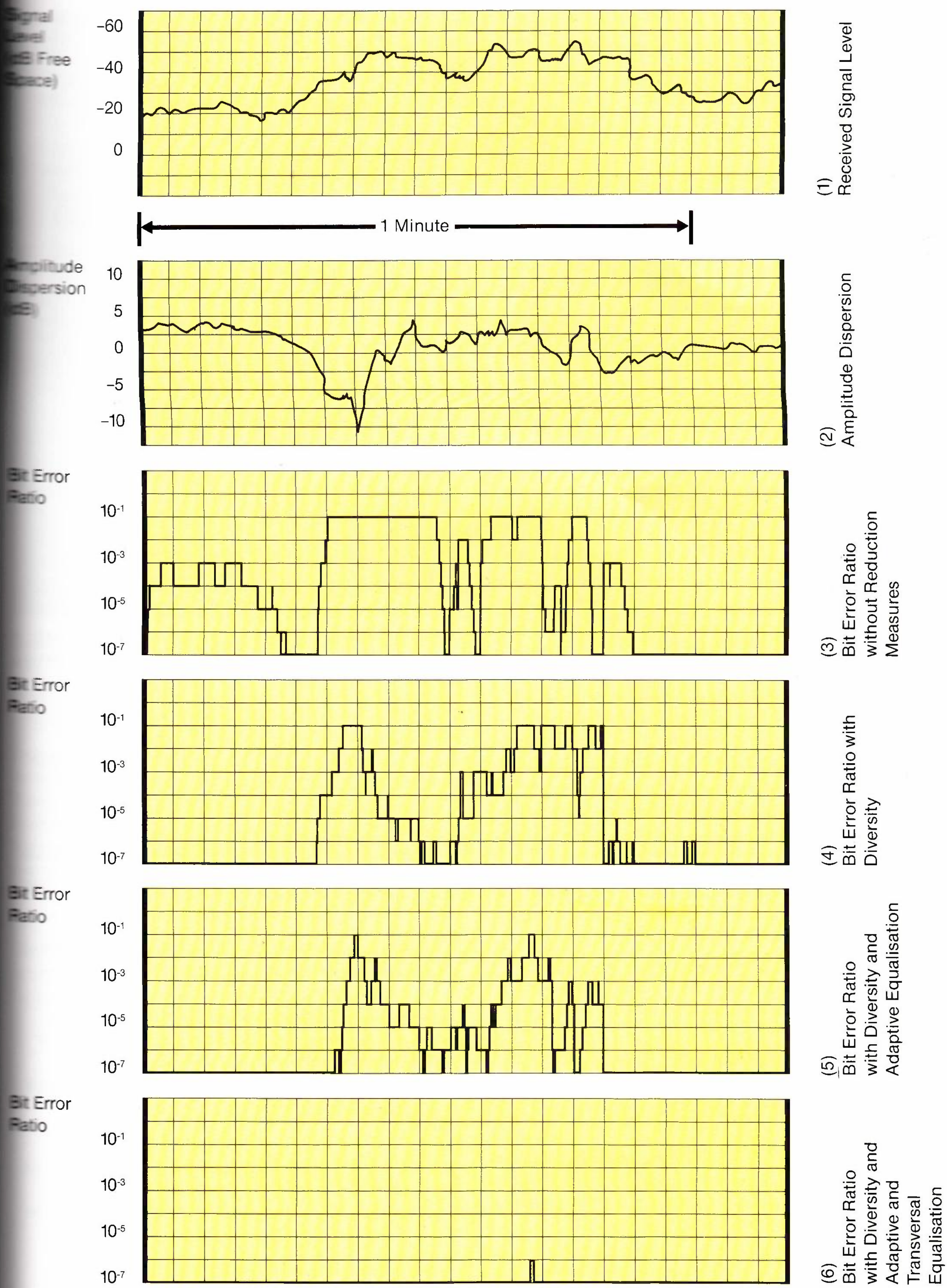
Field Investigations of a Digital Microwave Radio System

To assist the planning and specification of Australia's projected requirements for digital transmission facilities between the major urban areas of Australia, the Laboratories have been or are investigating different types of transmission system which utilise terrestrial radio, optical fibre cables, metallic cables or satellites for possible application to provide inter-urban digital links. In one aspect of these investigations, a field experiment was established early in 1982 to evaluate a 16-state quadrature amplitude modulated (16-QAM) digital radio system operating at a transmission bit rate of 140 Mbit/s in the 6.7 GHz microwave radio band. A path of 61.5 km near Ararat in Western Victoria was used and all performance data gathered was transmitted to the Laboratories for recording on magnetic tape and later analysis.

Comprehensive measurements were carried out on the experimental system to establish how it performed during periods of signal fading. It was found that the only cause of errors in the output bit stream during fading was so-called "frequency selective multipath fading".

To reduce errors caused by multipath fading, an adaptive amplitude equaliser, a transversal equaliser and space diversity combining were applied experimentally in various combinations. To help characterise the multipath fading, special receivers were designed and constructed to measure amplitude distortion in the received signal.

(See diagram opposite)
Field records showing effects of fading and amplitude dispersion on bit error ratios of digital radio signals and improvements due to combining and equalising


Free
-60
-40
-20
0
1 Minute
(1) Received Signal Level
Dispersion
10
5
0
-5
-10
(2) Amplitude Dispersion
Error
10-1
10-3
10-5
10-7
(3) Bit Error Ratio without Reduction Measures
Error
Ratio
10-1
10-3
10-5
10-7
(4) Bit Error Ratio with Diversity
Error
10-1
10-3
10-5
10-7
(5) Bit Error Ratio with Diversity and Adaptive Equalisation
Error
10-1
10-3
10-5
10-7
(6) Bit Error Ratio with Diversity and Adaptive and Transversal Equalisation

In a working system, all channels in the allocated band may be used and consequently, it is possible for systems operating on adjacent channels to interfere with each other. Normally, adjacent channels operate on opposite polarisations of the antenna, which is sufficient to reduce this adjacent channel interference to a negligible level. However, during multipath fading, the isolation due to the use of opposite polarisations can be severely degraded and channels operating adjacent to one another can cause mutual interference, resulting in additional errors in the output bit stream.

In the experiments, adjacent channel interference was also investigated by operating a digital system in a channel adjacent to the measured channel. Further, because of the possibility of adjacent channel interference between digital and analogue microwave radio systems, an analogue radio system was operated on the other side of the measured channel.

Telecom Australia plans to install digital microwave systems on the same routes as existing analogue microwave systems. In order to minimise the cost of new digital microwave radio systems, a performance prediction technique has been developed by the Laboratories. Input data for this performance prediction technique comprises propagation data which can be obtained from existing analogue microwave systems. To establish the technique, field measurements were made on the experimental path of the current 6.7 GHz analogue system. Comparisons of the measured and predicted results subsequently verified the performance prediction technique. The technique is now being used to design digital systems to be overlaid on existing analogue routes. In the absence of field data from analogue microwave systems, empirical formulae can be used to obtain estimates of the parameters required for the performance prediction.

Another element necessary for the application of the performance prediction technique is a parameter which characterises the particular digital radio system of interest. This parameter is called the "system signature" and is obtained by using a two-ray fading simulator. The fading simulator is connected between the transmitter and the receiver, whereby the amplitude and delay of a second arm of the simulator, relative to the first arm, are adjusted to several positions to obtain a particular bit error ratio at the output of the system. The system signature thus obtained is evaluated to give a characteristic value for the system under test. This value is then used in performance prediction for system design purposes.

Coupling between Co-sited Antennas

The co-siting of a number of radio services where the antennas are located close to each other has potential to create interference between the radio systems. This aspect of inter-system interference is becoming an increasingly serious problem as older systems are upgraded either by increasing system capacity or the number of systems utilising existing antenna towers.

Interference due to antenna inter-coupling commonly occurs at terrestrial radiocommunication terminals, particularly at node points, where larger numbers of antennas servicing parallel or adjacent routes are situated very close to each other. The coupling between these co-sited antennas influences the achievable quality of the various radio services. Coupling can take place between antennas installed on the same tower or on different towers close to each other. It can also occur between antennas of different types and configurations.

The amount of antenna inter-coupling can also determine the extent to which a system's frequency can be utilised. In the case of adjacent antennas servicing parallel routes and operating in the same frequency bands, the wanted to unwanted signal ratio criterion is often difficult to achieve because of the presence of inter-coupling interference. In such situations, maximum isolation or minimum inter-coupling between antennas will lead to better spectrum utilisation.

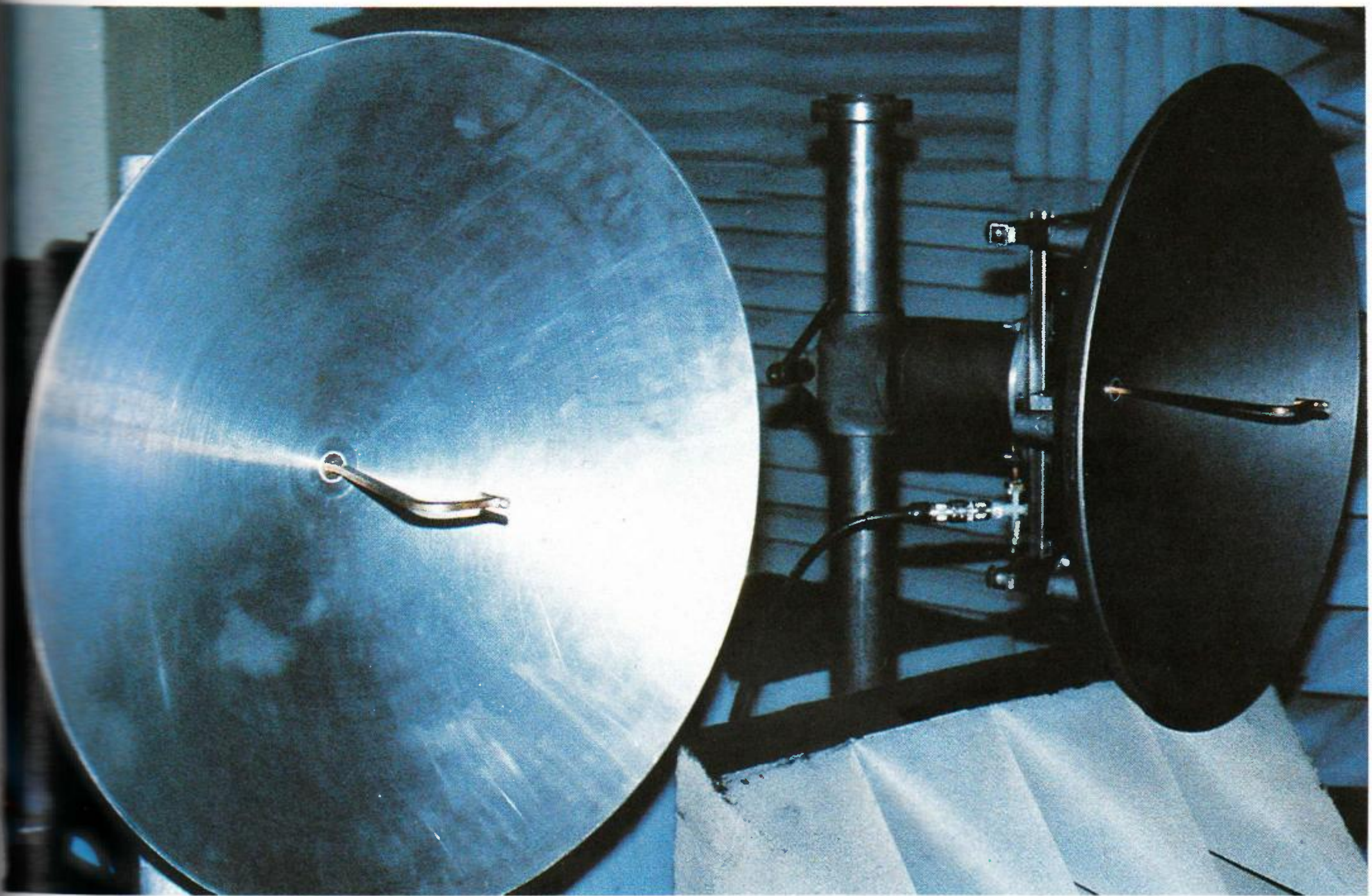
To establish design rules for the co-siting of antennas, the Laboratories have conducted both theoretical and experimental investigations with the following objectives:

- the formulation of a simplified method which accurately predicts antenna inter-coupling, and
- the development of "clearance criteria" for use by system designers when co-siting a number of antennas.

The investigations were conducted at microwave and VHF frequencies.

In the microwave investigations, the theoretical analysis involved the use of an extended form of the geometrical theory of diffraction. Verification of the results of the theoretical investigations on microwave communication antennas was then sought by conducting experiments at 36 GHz on scale-models of typical parabolic reflector radiocommunication antennas with aperture diameters of 75 wavelengths.

For the VHF investigations, the case selected for study from the number of possible types and configurations was that of two six-element VHF Yagi antennas aimed in the same direction. The antennas were initially assumed to be in free space, though subsequently the effect of a tower



Experimental investigation of coupling between co-sited model antennas in the RF anechoic laboratory

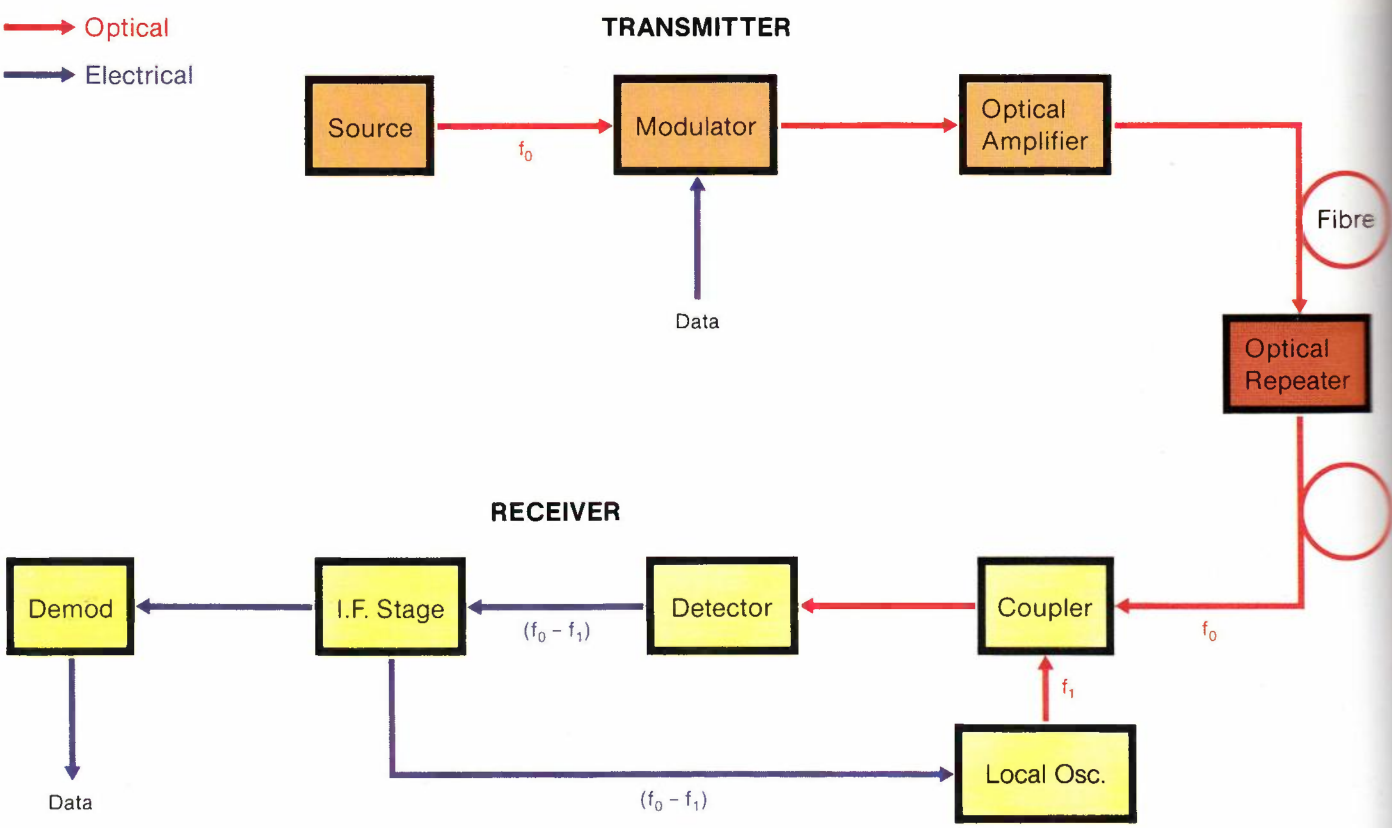
member or support structure was given limited consideration.

By assuming three different configurations for the antennas about their boresights, the H-plane, E-plane and X-polar isolations with separation were obtained. Special consideration was given to separations less than five wavelengths. For example, at a separation of two wavelengths, the E-plane and H-plane isolations in free space for the particular antennas analysed were 30 dB and 56 dB respectively.

The theoretical models developed to predict the level of inter-coupling were subsequently verified experimentally for both VHF and microwave antennas.

Optical Communication Systems for the 1990s

Multi-mode optical fibre communication systems are currently being installed in the Telecom Australia network for short haul applications in urban networks and as tails for radio systems. The next generation of optical systems, utilising single-mode optical fibres, are at present undergoing field investigation for application in the long haul network, with expected application by the end of this decade. Such systems are expected to offer repeater spans in excess of 30 km for information rates of 140 Mbit/s (the equivalent of 1920 voice circuits) and the capability of being re-designed for operation at higher bit rates such as 565 Mbit/s (7680 voice circuits). However, for the 1990s, an ever increasing demand is anticipated for greater capacity for the provision of wideband services, television transmission and data, voice and teleconferencing services. Existing techniques to meet this demand include the operation of single-mode systems at increasingly higher bit rates and the use of conventional wavelength division multiplexing techniques. The next significant new development in optical fibre systems is expected to be the application of heterodyne/coherent techniques, as such systems are predicted to offer larger information capacities as well as larger repeater spacings than those offered by existing single-mode systems.



Schematic diagram of a heterodyne/coherent optical system

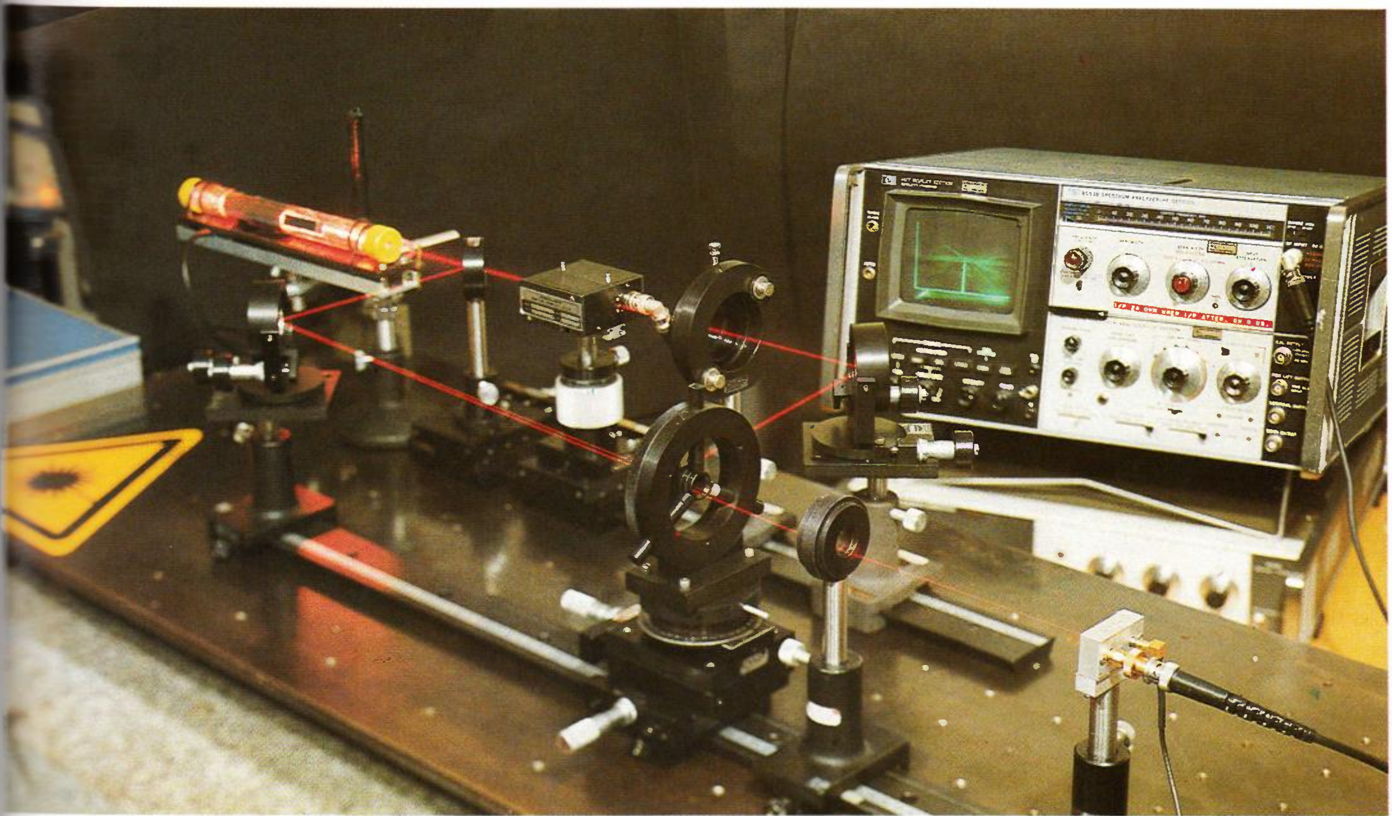
During the past year, investigations have been undertaken in the Laboratories to develop knowledge of the techniques used in the realisation of optical heterodyne systems, in anticipation of their future application in the Telecom Australia network.

The practical realisation of a heterodyne optical system is dependent on the development of several key components. One such crucial component is a stable laser oscillator for use in both transmitter and receiver. The laser emission frequency, which is of the order of 300 THz (i.e. 3×10^{14} Hz), must have a stability of the order of 1 MHz with an extremely narrow spectral line-width (less than 100 kHz). Semiconductor laser diodes can be configured to meet these specifications by using sophisticated temperature and current control and optical feedback methods, but considerable research and development effort is required before they can be considered practical sources.

At the receiver, the incoming optical signal is mixed (or heterodyned) with an optical local oscillator signal and then detected, to produce an electrical intermediate frequency signal which is demodulated using conventional techniques. Provided that the local oscillator power is sufficiently large, quantum noise limited detection is attained. This offers a significant improvement in receiver sensitivity over the direct detection technique used in current optical fibre systems. For a system operating at 565 Mbit/s, this improvement in receiver sensitivity can be 15 to 20 dB, depending on the modulation scheme employed. Such an improvement allows repeater spacings in excess of 50 km.

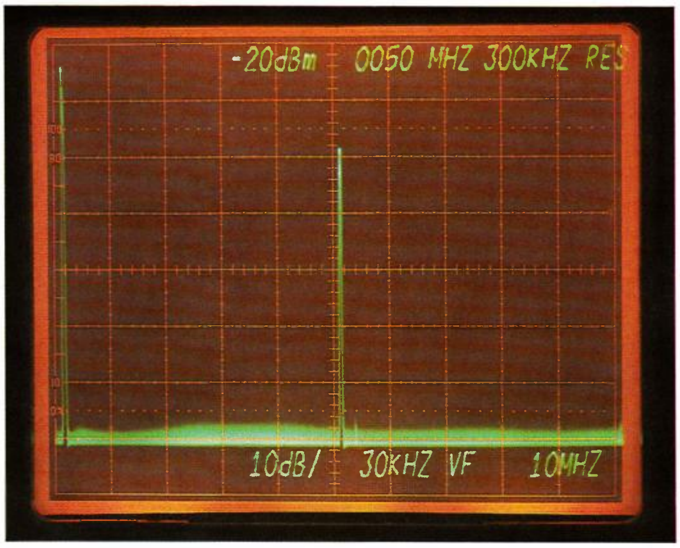
Other technological and system design aspects are also being investigated in the Laboratories. These include measurement techniques to characterise the optical source and local oscillator, evaluation of the ease of implementation of possible modulation schemes, characterisation of system noise sources and modelling of complete systems. These investigations will extend to studies of homodyne systems.

The capacity of heterodyne/coherent systems will be significantly greater than current single-mode systems because wavelength division multiplexing techniques can be more effectively employed. This results from the stringent requirements on the optical source and local oscillator. The channel spacings of the optical sources can be dramatically reduced to enable more complete utilisation of the optimum transmission characteristics of the optical fibre. Heterodyne systems offer an additional advantage arising from the possible application of laser amplifiers as both transmitter power amplifiers and as optical on-line repeaters to enable large terminal-to-terminal spans. The spontaneous emission noise generated within the laser amplifier, which limits the application in conventional systems, is filtered out by the highly selective heterodyne technique.



A self-heterodyning technique in use to measure laser line width

The anticipated information explosion of the 1990s will place considerable pressure on all telecommunications media. The technique of heterodyne/coherent optical systems is expected to play a vital role in helping to satisfy the demand for transmission capacity, provided the problems in many exciting technological areas can be solved.



Enlarged view of the screen shown above

Optical Fibre Wideband Distribution Networks

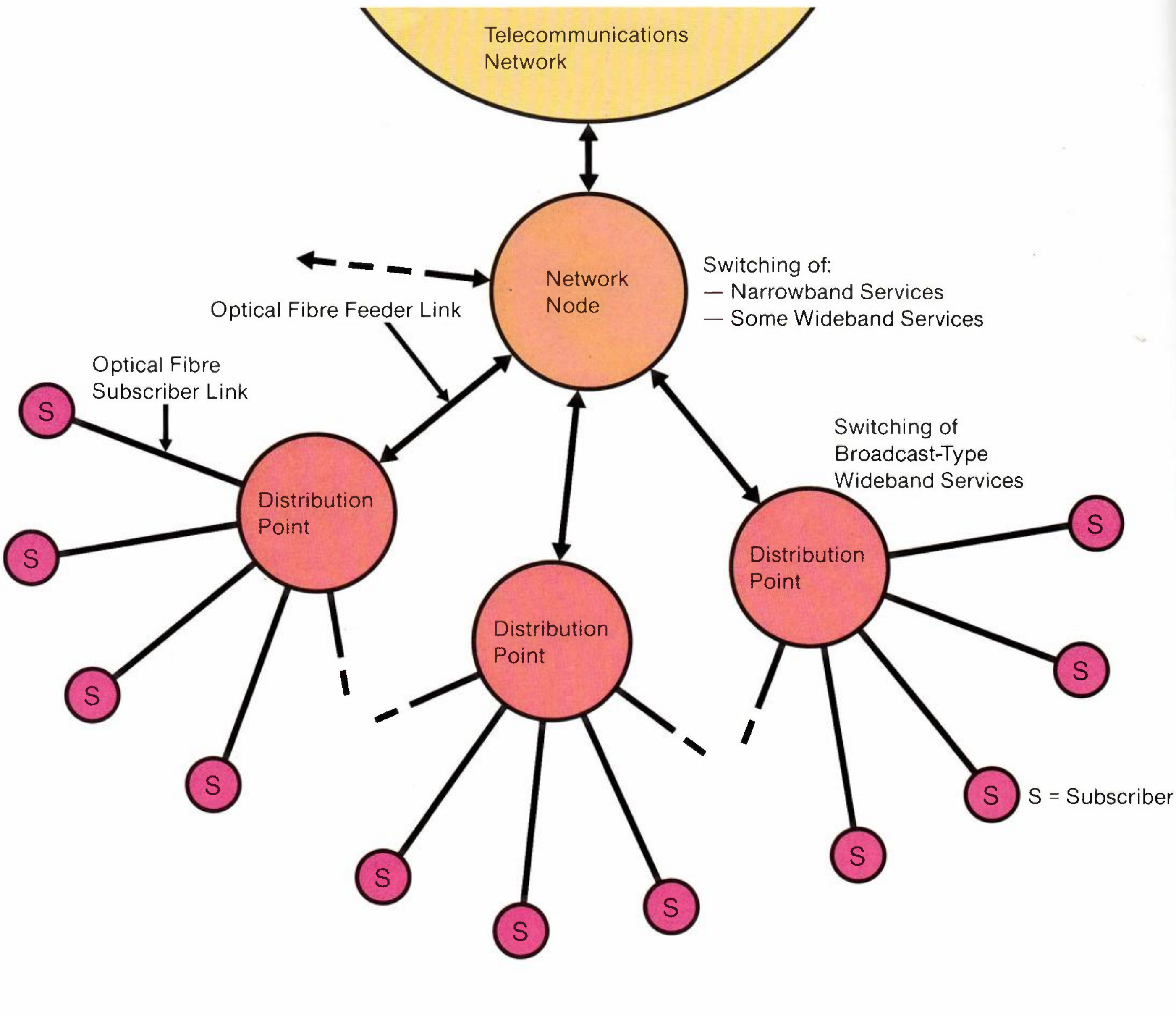
Optical communications technology promises to provide a more attractive alternative for the distribution of wideband services in local subscriber networks than those provided by copper pair or coaxial cable technology. The Laboratories are therefore investigating the potential application of optical fibres in the subscriber distribution portion of the Australian telecommunications network.

The investigation has so far concentrated on the integrated reticulation of narrowband and wideband services, in anticipation of the likelihood that the first widescale implementations of such optical networks will occur perhaps ten years hence. The use of optical fibres to provide transmission capacity between a local exchange and a remote switching stage or concentrator has not yet been studied, although these applications are foreseen in a shorter timescale with the introduction of narrowband digital services.

The narrowband service considered is a full duplex 192 kbit/s facility, as proposed in the CCITT basic integrated services digital network (ISDN) access structure. The wideband services may include video and high-quality audio programmes, high speed data, video conferencing and videophone.

The studies have concluded that the most appropriate network topology is a star structure in which a separate optical fibre link would be provided to each subscriber from a distribution point typically serving a few hundred subscribers in an urban environment. This approach significantly reduces the amount of distribution cable required, since subscriber link lengths will usually be less than 0.5 km. A number of distribution points would be connected in a star network configuration to a larger network node, where functions such as traffic routing, network control and monitoring would be carried out.

Star topology envisaged for an optical fibre wideband distribution network



This network structure offers the advantages of handling a range of wideband services easily and providing flexibility for network growth or changes in service needs.

Wideband services present different requirements for transmission capacity for the optical subscriber link. Broadcast-type services such as video and audio programmes need a large, one-way transmission capacity downstream to each subscriber, with only low bit-rate signals to be transmitted upstream from the subscriber for programme selection at the distribution point. However, a videophone service requires a large transmission capacity in both transmission directions.

The Laboratories' studies indicate that an all-digital network is preferable in the long term. While present costs favour analogue intensity or frequency modulation techniques for wideband services such as video, the cost differences with digital transmission alternatives (such as differential pulse code modulation) are expected to change significantly in the next few years.

Since wideband switching of digital signals requires an array of logic gates operating at high speeds, further technological development is needed in this area to reduce device cost and power consumption. This is especially true if a videophone service is to be provided, introducing a requirement for two-way wideband switching in contrast with one-way switching needed for broadcast-type wideband services.

The Laboratories' studies support the consideration of optical fibre systems as a viable means of providing wideband subscriber facilities in the future. Activity is therefore continuing to assist the development of suitable strategies for the evolution and implementation of such networks.

Characterisation of Single-mode Optical Fibres

The Research Laboratories have recently developed methods to characterise the transmission performance of single-mode optical fibres. The characterisation methods are an important element in the specification of fibres and fibre systems to be introduced into the Australian telecommunications network. The transmission parameters of single-mode fibres which have been identified as important to specify include:

- the attenuation of the cabled fibre
- the effective cut-off wavelength
- a mode field diameter
- a geometrical description of the cladding and its relation to the mode field location, and
- the dispersion or bandwidth.

A major part of this work has involved the development of measurement techniques for the effective cut-off wavelength and the mode field diameter. The effective cut-off wavelength is defined as the wavelength above which only a single electromagnetic mode is measured as propagating in the optical fibre. The mode field diameter is a measure of the width in microns of the field that propagates in the fibre at its operating wavelength. These parameters can be used to estimate transmission performance such as the bending and splicing losses of the fibre.

Three measurement techniques have been experimentally evaluated for the effective cut-off wavelength. The favoured technique depends on measuring the variation in bending loss of the fibre with wavelength. This technique is simple, achieves good repeatability of measured results and can be readily incorporated into the system for measuring fibre attenuation.

A number of proposed definitions for the mode field diameter have been compared theoretically in the Laboratories' studies. From this comparison, three definitions and their associated measurement techniques have been experimentally investigated. The favoured measurement technique is based on the far-field optical power distribution of the single-mode fibre. This measurement is straightforward and easy to perform, and the repeatability of the measured results does not depend significantly on the preparation of the fibre end.

The fibre geometry is measured by digital processing of a TV image of the fibre endface. The concentricity error between the mode field centre and the cladding centre is measured by launching light into the fibre to establish the mode field location. Parameters such as the cladding diameter and non-circularity are also determined.

(See photograph over)

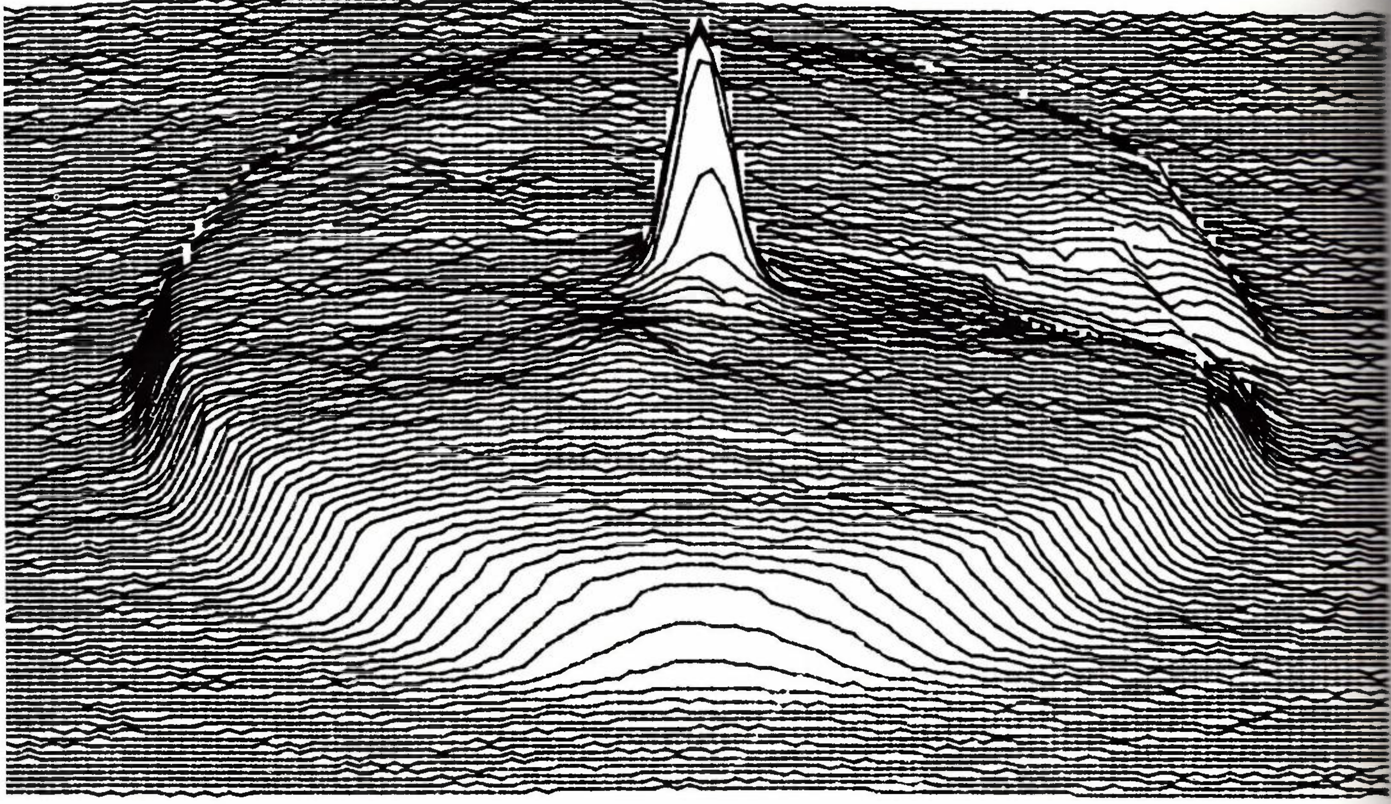


Image of a single-mode fibre endface used to determine the concentricity error of the mode field

Single-mode Optical Fibre Field Trial

Single-mode optical fibres offer very high bandwidths together with very low losses and, in comparison with other media, are reasonably priced. Single-mode optical fibre transmission systems therefore offer high transmission capacities and long repeater spacings. These systems are attractive for application in the trunk network and on selected, high traffic routes in the junction network.

During the past year, Telecom Australia established a field trial application of single-mode optical fibres in which the Headquarters Engineering Department, the Research Laboratories and the Victorian State Administration are participating. The lessons learned from this trial will enable Telecom to proceed confidently with a full-scale installation on a major trunk route when the need arises, to gain advantage from the timely introduction of this new technology.

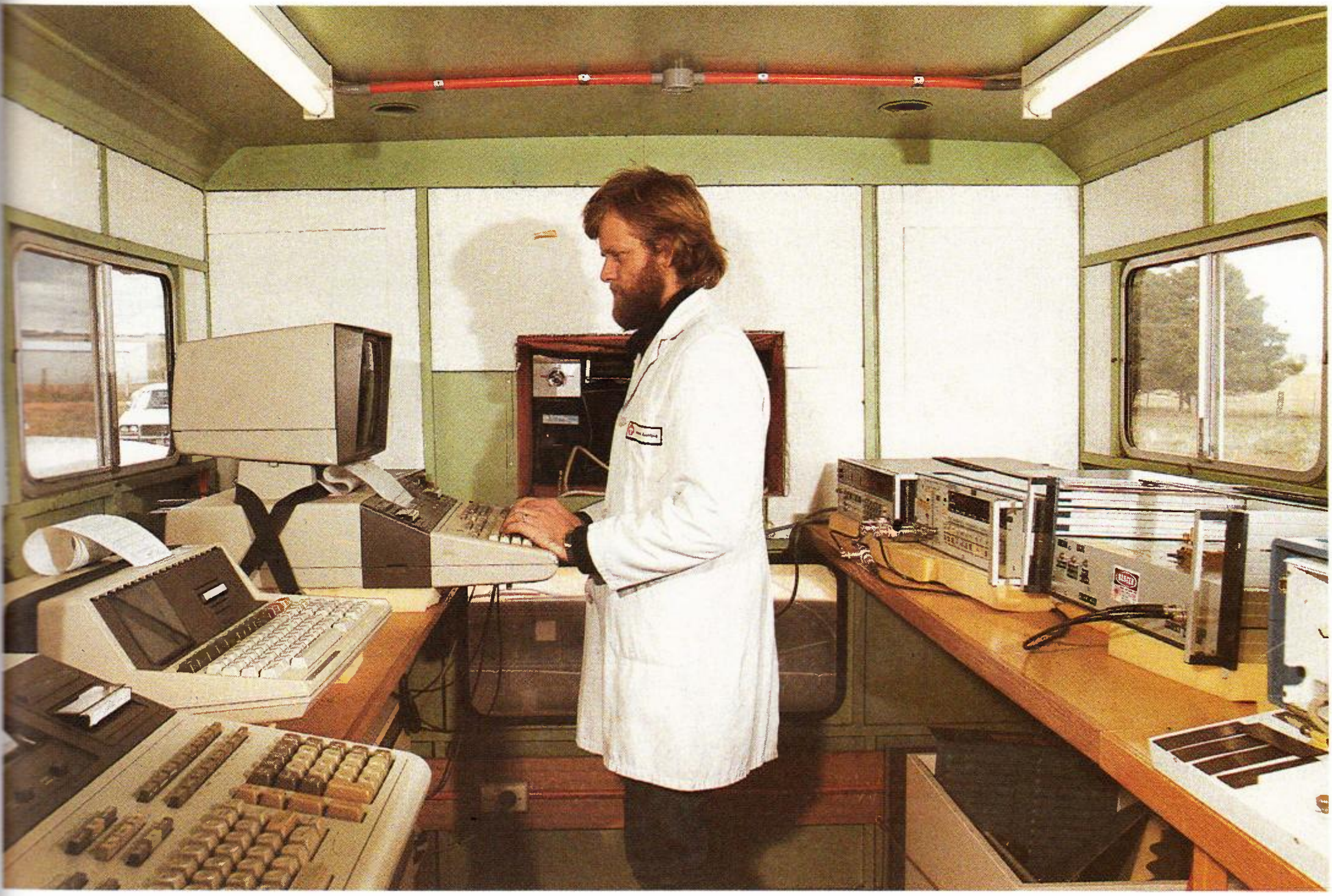
The trial involves the installation of optical fibre cable along a 76 km route between Melton and Ballarat, to the west of Melbourne. The cable will be equipped with transmission systems operating at both 140 Mbit/s and 565 Mbit/s for the trial. The performance of both the cable and transmission equipment will be monitored, and the cable is expected to commence carrying live traffic early in 1986.

Most of the field trial cable route is in rural areas, and the cable is being installed by using ploughing techniques similar to those used with conventional metallic cables.

The susceptibility of fibres to failure through static fatigue when exposed to small strain levels for long periods of time prompted a review of ploughing techniques for such cables before the trial commenced. A modified technique has been developed to minimise the stresses applied to the cable during the ploughing-in operations and it is being evaluated in a series of trials in the field.

By using specially developed equipment housed in a transmission test van equipped as a mobile laboratory, Laboratories' staff measure the strain imposed on the cable throughout the duration of each installation. Measurements to date have shown that optical fibre cables can be satisfactorily installed using this direct ploughing technique, and a number of criteria for selecting cables most suited to this application have been established for application in future routine plant installation activities.

(See photographs opposite)
Mobile laboratory for optical fibre strain measurement during ploughing operations (Top)
Ploughing of optical fibre cable in the field trial (Bottom)



Real-time Optical Image Processing

The growing role being played by optical fibres in modern telecommunications networks means that an increasing volume of information is being transmitted at optical frequencies. Thus, there is a need to develop new devices and techniques for faster processing of optical signals to complement advances in the transmission field.

The Laboratories are investigating methods for real-time optical image processing. One promising approach under study is Four Wave Mixing (FWM) in a photo-refractive crystal. The refractive index of a photo-refractive crystal can be modified by a sufficiently intense incident light beam, which creates a means for the optical storage and retrieval of information similar to conventional holograms. In the FWM experiment, an object beam and a reference beam from an argon ion laser are arranged to intersect within the crystal, thus establishing a phase hologram through the photo-refractive effect. A third beam is introduced by using a mirror to reflect the reference beam back through the crystal. The reflected beam is diffracted by the stored hologram, resulting in the generation of a fourth beam. This fourth beam has unique phase-conjugate properties in that its direction of propagation and phase distribution are the exact opposite of the object beam. It can thus be regarded as a time-reversed replica of the object beam.

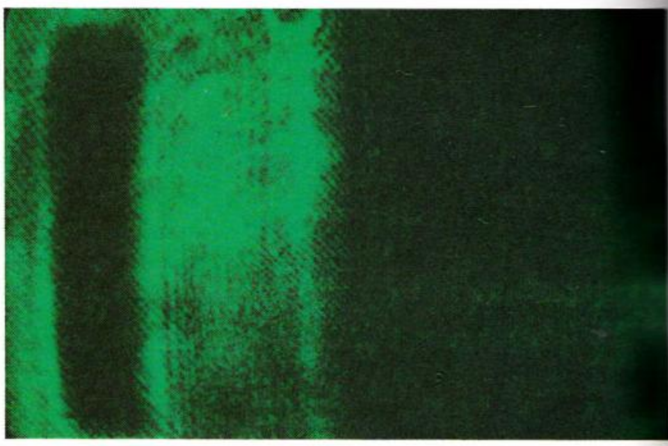
To perform image processing, the original images are placed at selected points in the beams and the resultant processed image appears in the fourth beam. Real-time operations that have been demonstrated in this way include image subtraction, image division and image de-blurring. The two latter techniques exploit the non-linear characteristics of the FWM process. On the other hand, image subtraction is carried out in the linear region, where the intensity of the output beam is proportional to that of the incident object beam.

Image subtraction is achieved by two consecutive steps which take advantage of the fact that FWM provides simultaneous image recording and reconstruction.
The first step is to record an image of object A. In the second step, the phase of the reference beam is shifted by 180° and an image of object B is recorded. (This phase shift, which ensures that the phase of image B is opposite to that of image A, can be introduced simply by changing the optical path distance by one half wavelength). The response and erasure times of holographic recording in photo-refractive crystals can be made relatively slow, so that these two images co-exist for a period. During this time of co-existence, interference of the two images produces a resultant image depicting B subtracted from A. When one of the objects, say B, is a beam of uniform cross-sectional intensity, the same procedure yields image contrast reversion of A.

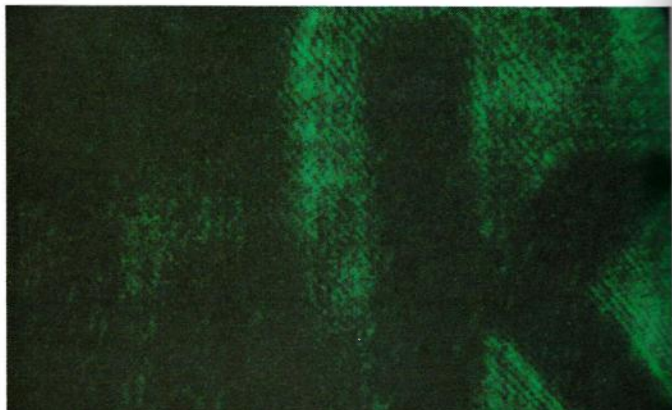
Studies indicate that these new techniques have potential applications in the development of opto-electronic or all-optical devices that will allow more efficient processing, switching and manipulation of optical signals.

(a)

(b)



(c)



Photographs depicting experimental results of real-time image subtraction:
(a) the first image
(b) the second image
(c) the subtraction of (a) and (b)

Versatile Digital Image Processing System

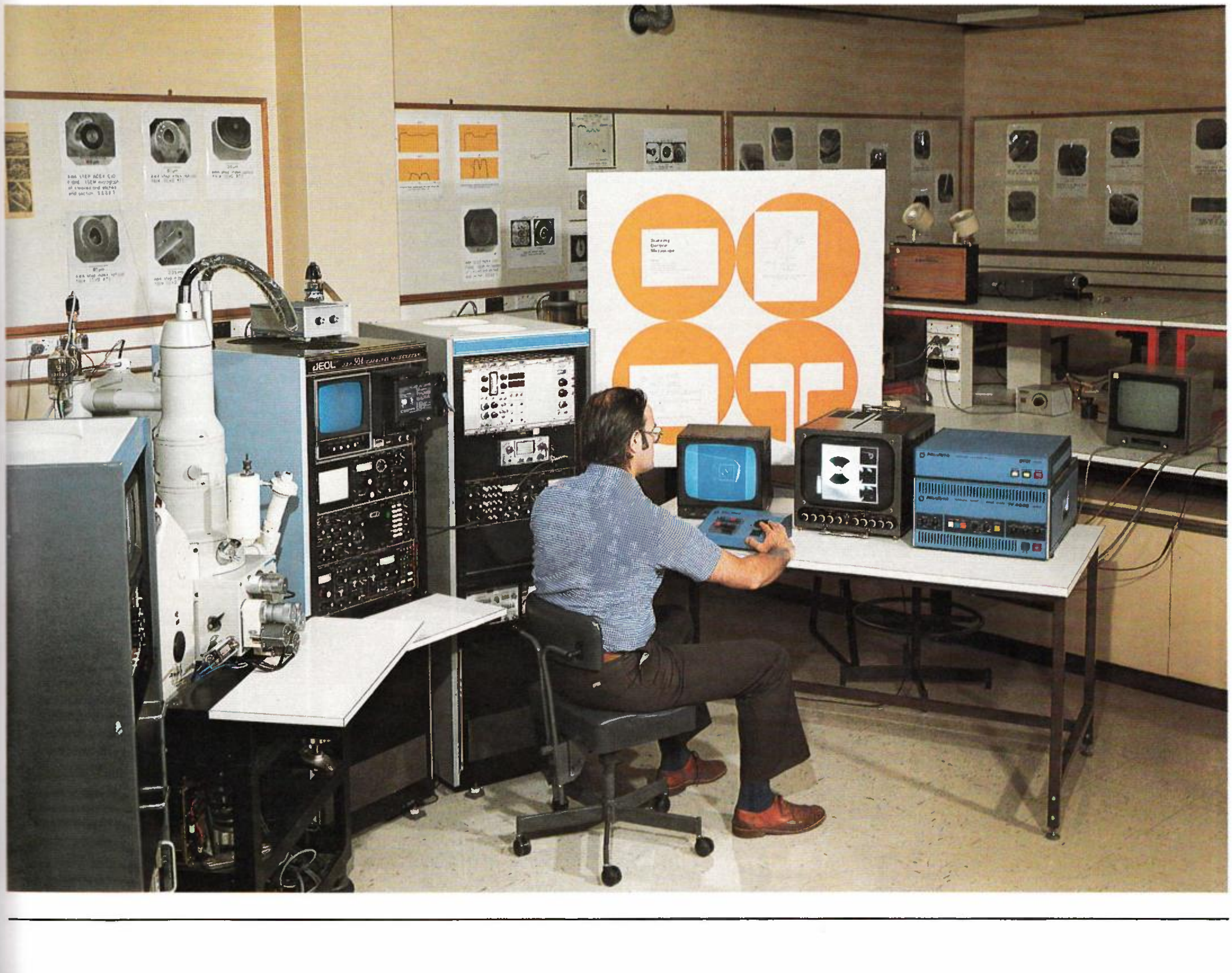
Through a research and development contract, the Laboratories have enlisted the support of local industry to develop a versatile and efficient digital image processing system.

At the heart of the system is a video signal temporal filter and high resolution image store (512 by 512 pixels of 256 level grey scale). A computer transfer module (CTM) provides access to the image store via industrial standard interfaces, including RS 232 (up to 19.2 kbaud) and the IEEE-488 standard instrument bus. A key feature of the system is a remote controller module (RCM) permitting the operator to be in close proximity to the displayed image whilst directly interacting with the image store. The RCM features a tracking ball which allows a rectangular window of any size and position within the displayed image area to be defined and highlighted on the display screen. By using the CTM and RCM in conjunction, a windowed area may be transferred from one image store to another or between an image store and a computer. In this way, all or part of an image may be quantitatively processed and/or stored on disk for later retrieval and display.

As a bonus, the temporal filter part of the system provides a noise reduction capability for the incoming video signal, a feature which is especially useful in conjunction with a scanning electron microscope (SEM). High magnification of a SEM image requires a low electron beam current for best resolution. Under such operating conditions, amplifier noise intrudes, thus limiting the efficacy of the TV scan mode of the SEM. The temporal filter and image store can be used in two ways under these circumstances. Firstly, it may be used in a "tracking mode" to improve picture quality whilst locating and focussing the subject. In this mode, a trade-off exists between a noise-reduced image and the ability to follow movement. Secondly, the image processing system provides a means for obtaining a very high quality signal-averaged display. Photographs are therefore only required as a final record, either from the displayed image directly or using the conventional slow scan mode of the SEM.

The new equipment is currently being used with the SEM to examine optical materials and components, and in the quantitative measurement of optical images for fibre and opto-electronic device studies. One sample under

Digital image processing system in use with the Laboratories' scanning electron microscope



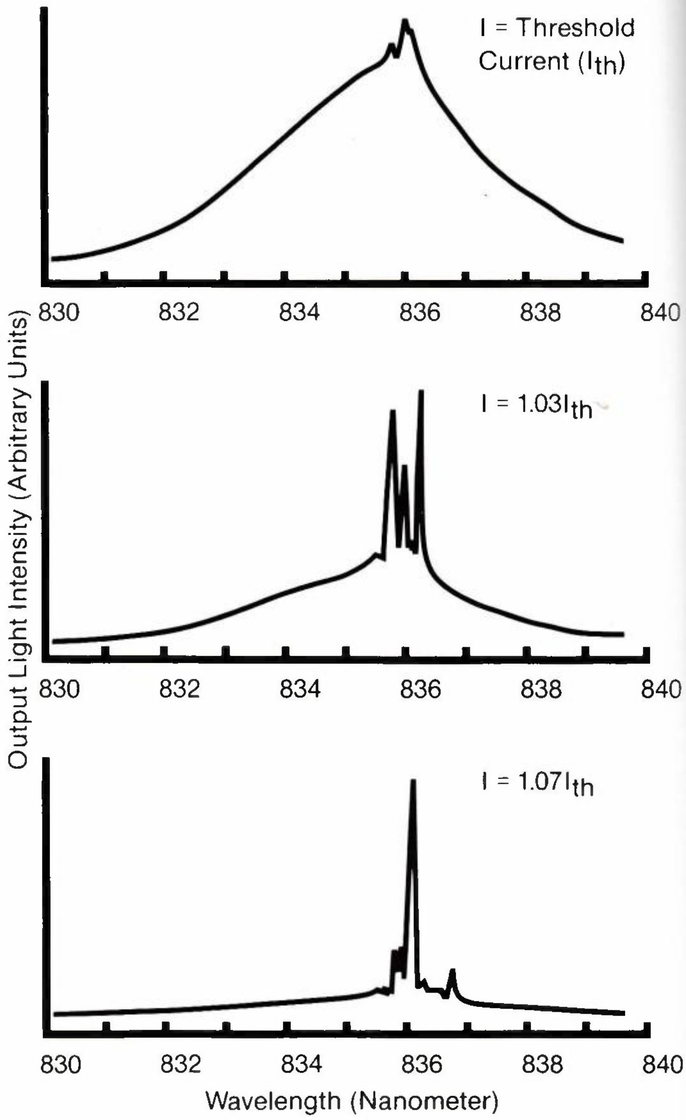
investigation is a short section of state-of-the-art wide bandwidth optical fibre which has undergone a complex manufacturing process to modify its symmetry in a prescribed manner. This process involves the addition of two zones, one on each side of the central information-carrying core region of the fibre, which induce stress in the core region. Such modification permits greater control of the way light propagates down an optical fibre. Controlled chemical etching allows the various regions of the fibre cross-section to be seen under the SEM. The core region image only becomes visible after relatively long etch times. By using the image processing system, the core region image can be superimposed on an earlier image of the fibre to yield a composite picture of the modified fibre cross section.

Right hand screen of image processing system shows composite picture of polarisation-preserving fibre after various stages of etching

Fabrication and Performance of a Gallium Arsenide Laser Diode

The introduction of high capacity optical fibre transmission systems into the telecommunications network depends, among other factors, on the development of suitable light sources capable of being modulated at very high speeds. The device most suited to this role has proved to be the semiconductor laser diode, which is fabricated from various semiconductor alloys based on gallium, arsenic, aluminium, indium and phosphorus. The semiconductor alloy used determines the operating wavelength of the laser.

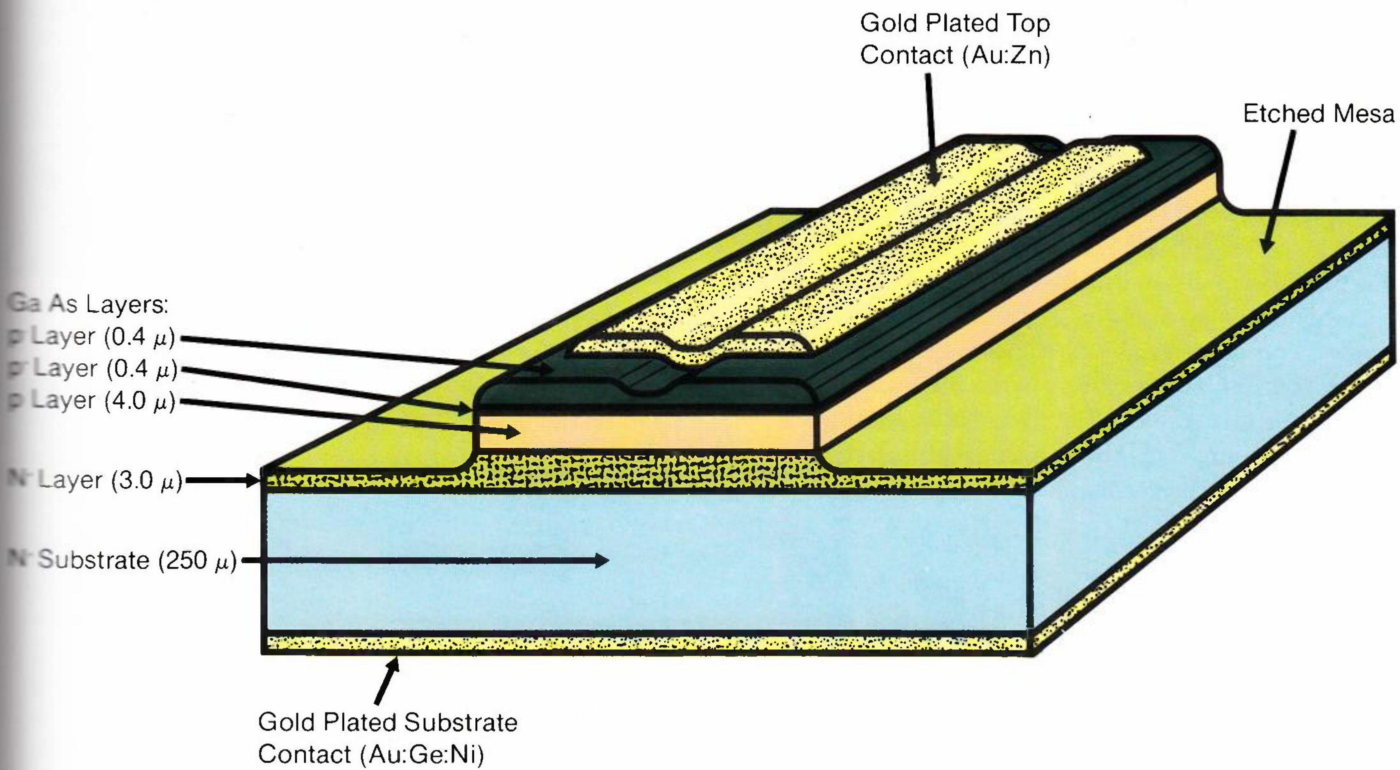
To develop expertise in this area of telecommunications technology, the Laboratories are using their Molecular Beam Epitaxy (MBE) system to grow semiconductor wafers using these elements. Selected wafers are being further processed into semiconductor devices, including laser diodes. Recently, gallium arsenide (GaAs) wafers with four layers of GaAs, each layer having a different



Output light intensity spectra of a GaAs laser diode thickness and doping density, were grown in the MBE system and processed into GaAs laser diodes in the following way:

- photo-lithographic techniques were used to define an opening in the top GaAs layer for an ohmic contact to the underlying p^+ layer. This was accomplished by developing away selected areas of a protective photoresist film and etching the exposed GaAs.
- photo-lithographic techniques were also used to define the top ohmic contact metallization pattern of vacuum evaporated gold and zinc. The substrate ohmic contact consisted of gold, germanium and nickel; both contacts were gold plated to improve their conductivity.
- the overall mesa structure of the laser diode was then formed by chemically etching the wafer down to the n^+ substrate. Photoresist protected the areas that were not to be etched.
- the wafer was cleaved into individual diodes. Care had to be taken when cleaving the wafer at right angles to the etched mesas as these cleaved surfaces form the mirrors of the Fabry-Perot cavity necessary for lasing action.
- individual diodes were mounted and electrically bonded to an alumina substrate.

The mounted diodes were cooled to a temperature of 77°K and their light spectra (wavelength and intensity) were recorded as a function of current. The measured data showed that the diodes lased successfully at a threshold current of 10^4 amp/cm^2 with a wavelength of 836 nm.



Cross section of a GaAs laser diode

Reverse Engineering of Integrated Circuits

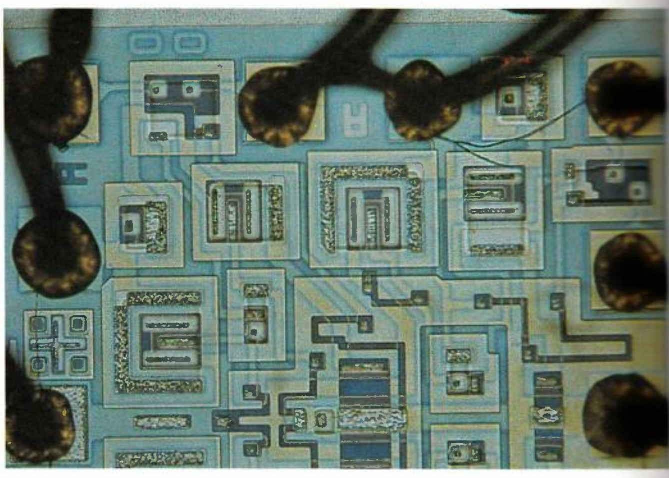
A wide range of integrated circuit technologies is currently in use in telecommunications equipment and, when failures occur, it is essential to discover the reason in order that any necessary corrective measures may be taken. Such integrated circuits (ICs) may fail in a number of different ways and the process of taking the circuit apart one layer at a time, to discover how it was designed and fabricated, is an essential pre-requisite for failure analysis. Technology is advancing continuously and individual failure analysis and reverse engineering techniques may have to be varied in particular cases, but there are many common features in the process.

The first step is to expose the chip in an undamaged condition so that it may be examined. ICs in ceramic packages may be opened by applying mechanical pressure if they are of the frit-seal type or de-soldered if of the lidded type. For plastic packaged ICs, the encapsulant, which usually consists of a thermosetting mixture of resin and glass, is selectively removed from over the chip by applying hot fuming nitric acid. With care, this strong chemical treatment does not damage the IC and enables it to be inspected optically. The chip at this stage appears to have a uniform colour, usually green or light brown when viewed under a vertically illuminated microscope, with components delineated by dark lines on the surface. A colour contrast between layers in the circuit, which allows positive identification of all individual features, may be obtained by removing the one micron thick glass passivation layer protecting the surface of the chip.

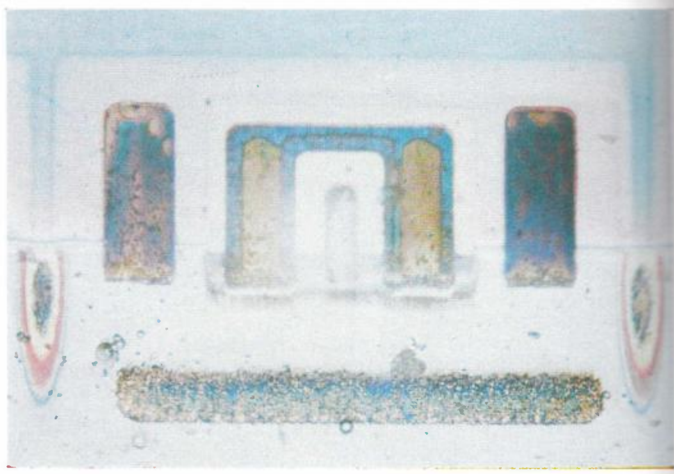
This layer is removed using buffered hydrofluoric acid, and etching is continued until the top metallisation layer is exposed. The features formed during each processing stage now have different colours because of interference effects occurring in the different thicknesses of transparent silicon dioxide covering them, and consequently, each can be distinguished and identified. Thus, in a simple bipolar integrated circuit, the isolation, transistor collectors, transistor bases and resistors formed by base diffusion, and transistor emitters may be identified and components electrically characterised by microprobing to the exposed metal interconnection layer on the surface of the chip. In addition, sensitive electrical measurements can be used in conjunction with mathematical models to obtain details of the diffusion processes used to form components in the silicon substrate. Information on the vertical structure of the device may be obtained using a sectioning technique known as lapping and staining.

In the latter method, vertical distances are amplified by mounting the chip, after removal from its package and careful preparation, on a glass block and lapping it away at a shallow angle using an abrasive paste. A suitable preferential etch or stain is then applied to the chip. This causes the p-type layers to be differentiated from the n-type layers. Vertical junction depths and important features such as transistor base width may then be measured directly with an optical microscope.

By applying these step-by-step analytical processes, a remarkably complete dossier of information concerning the design, processing, quality control, etc. of the device can be collated. Such a dossier can be used as an aid in maintaining a high standard of reliability in ICs, as is required in telecommunications equipment applications.



TTL device after removal of the glass passivation and metallisation, showing contrasting oxide colours



Lapped and stained section of a transistor on a TTL integrated circuit, showing base, emitter and isolation diffused regions

Protection of the Telecommunications Environment

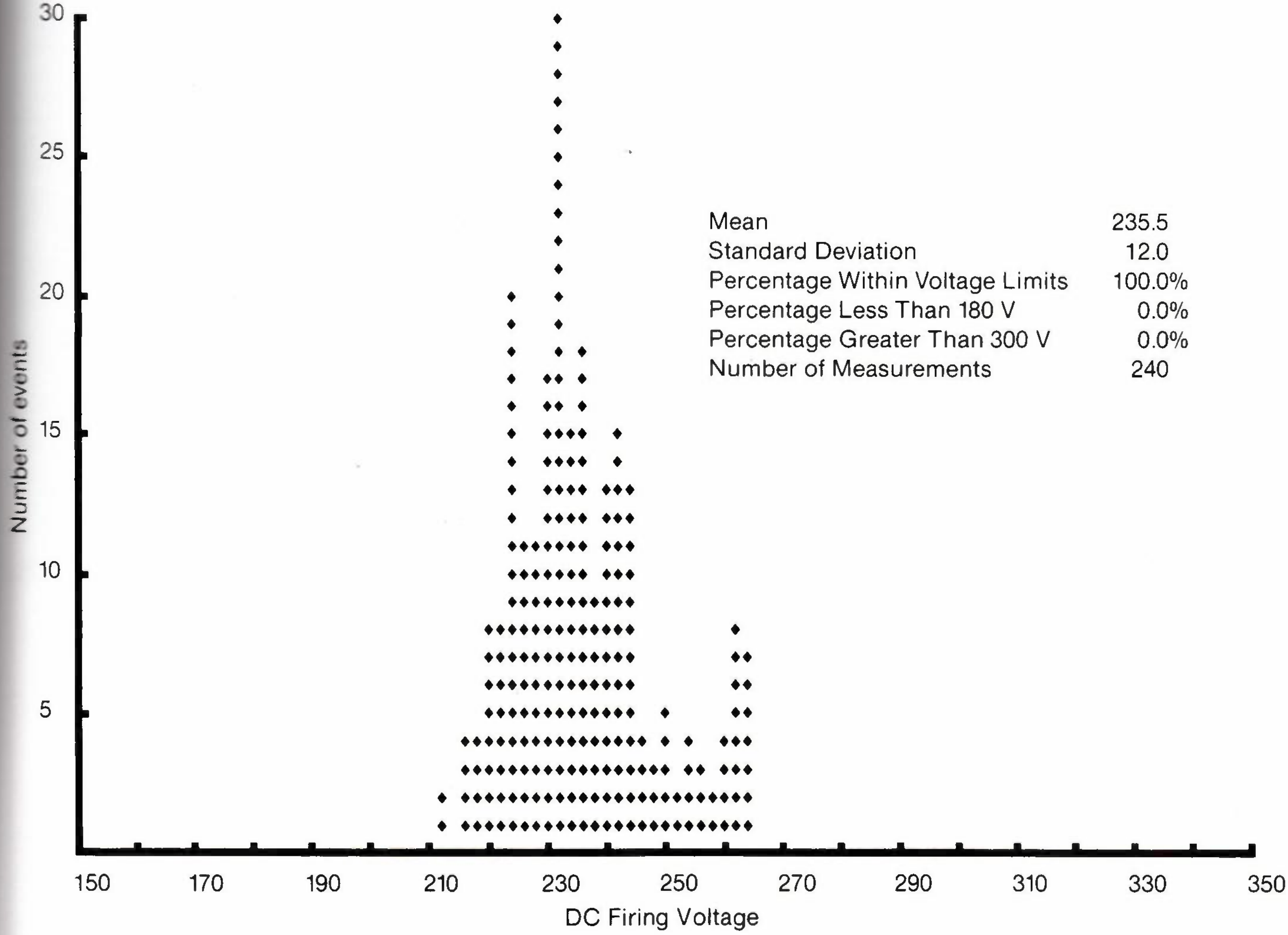
Prior to the introduction of solid state devices into telecommunications networks, the electromechanical devices generally employed enjoyed a relatively high immunity from damage due to electrical surges. However, solid state devices have greatly decreased immunity and it is apparent that, as solid state devices are increasingly used in a wide variety of plant systems, protection devices must be fitted to the network to maintain the desired level of reliability.

The source of electrical surges may be either lightning discharges or power faults. The surges can enter the network by either inductive, conductive or direct means. The modes of failure caused by the surges include physical damage to telecommunications equipment and corruption of digital signals either stored in or being transmitted over the network.

Protection from electrical surges is achieved by installing devices designed to either limit the surge voltage or divert the surge. These devices include gas-filled protectors, metal oxide varistors (MOV) and transorbs. The gas-filled protector is the most commonly used device. It consists of either two or three electrodes sealed inside a glass or ceramic body with a low pressure inert gas, usually argon. These devices are designed to exhibit an electrical breakdown at a fixed, repeatable voltage level, so diverting surges with an amplitude in excess of the breakdown voltage away from the network.

To ensure that gas-filled protectors used by Telecom exhibit the characteristics claimed by their manufacturers, and to aid investigation of the fundamental operation of protectors, tests are being performed in the Laboratories on gas-filled protectors, using a semi-automatic tester built in the Laboratories. The tester selects the protector device to be tested from a bank of ten, sets the firing conditions (DC, with an applied voltage gradient of 1kV/s; or impulse, with a gradient of 1kV/μs), selects the polarity, records the breakdown or firing voltage, and then selects the next device to be tested. All data obtained and the test conditions are recorded for subsequent computer analysis. To ensure that the tester is working correctly, the firing voltage of a solid state circuit simulating a protector is also measured at the start and end of each test run.

Distribution of DC firing voltages of one type of 3-electrode button-type protector



A range of types of protector devices

In addition to conducting the standard range of tests, a more general investigation has also been commenced in the Laboratories, primarily to identify critical parameters of a protector and assess the effect of both artificial and natural ageing on these parameters. Natural ageing is being achieved by means of field exposure in the Darwin area, which has one of the highest lightning strike rates in Australia. The investigation involves the comparison of batches of protectors which have been subjected to field exposure, long term storage or laboratory tests.

It is expected that this work will enable more accurate prediction of the reliability and life of gas-filled protectors. This knowledge should assist the formulation of Telecom's protection policy, which in turn will produce an increase in network reliability and a consequent decrease in the cost of maintaining the network.

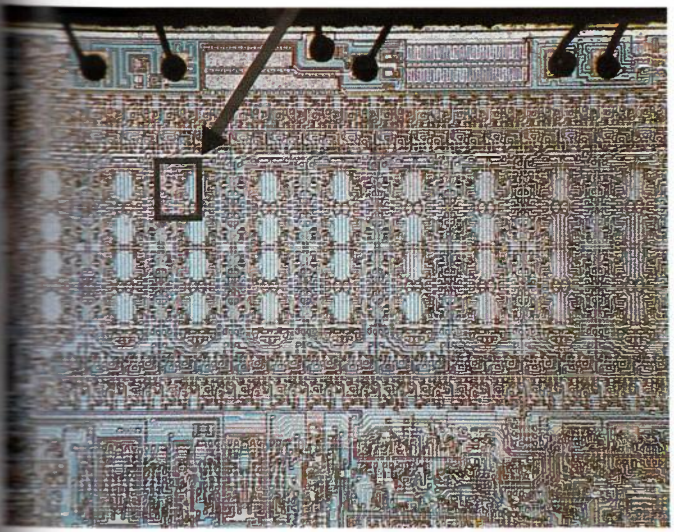
An Unusual Failure of a Telephone Dialler Chip

When chip failures are recorded early in the life of a new product, it is essential to analyse the failures to determine whether they are of significance for the reliability of the product. A recent interesting case study of this type involved the dialler integrated circuit (IC) in a new telephone which displayed an unusual fault.

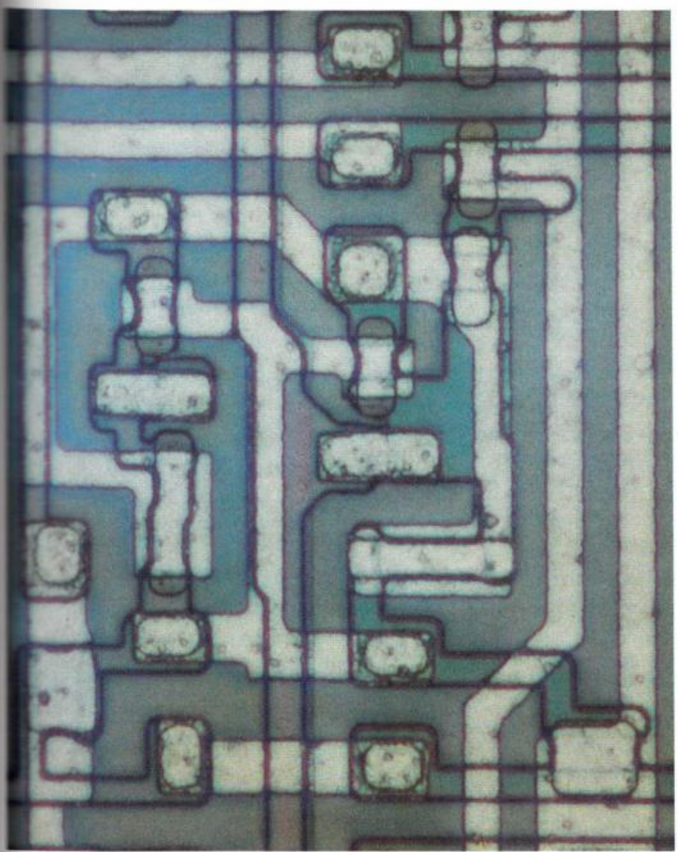
In the case study, the fifth digit dialled was incremented if it was a 1, 4 or 7; otherwise the telephone worked normally. The fault was traced to the dialler chip itself, and by a process of reverse engineering, the IC was disassembled down to the metallisation level while remaining in a working condition. The IC was found to be fabricated in metal gate CMOS, a technology which is relatively easy to read, and a circuit diagram of the relevant part of the circuit was obtained from optical inspection under a powerful microscope. It was determined that the dialled digits are stored in the form of a 4-bit parallel code in an 18 x 4 array, consisting of static memory cells of 8 transistors each with sequential Write and Read operations controlled by pulses propagating along associated shift registers. It seemed likely that the fault was located in a single cell, but as no visible defect was observable, it was necessary to obtain precise internal timing information and to determine the 4-bit code used to store the dialled digits. All of this information was obtained whilst the circuit was in operation by making electrical contacts to the 0.006 mm wide aluminium tracks on the surface of the chip using a microprobe station.

With this information, it was possible to conjecture exactly which of the 72 memory cells could cause the observed fault, and again with the microprobe, to prove that the cell was indeed faulty by electrically testing it. The cell was unable to store the correct bit level due to internal leakage in one of its 8 transistors. The position of the faulty bit and nature of the code used caused only the numbers 1, 4 and 7 to be affected. The other numbers were correct or could be interpreted without the fourth bit.

It was concluded that this example of a chip containing a random manufacturing fault which "escaped" from the production testing screen was unlikely to be indicative of a future reliability problem, which could otherwise have been the case if a subtle design weakness had been found.



...eral view of the dialler chip showing the location of the ...ty memory cell



(INSET: Dialler chip 8-transistor memory cell)

A Flexible Automatic Plating System for Plated-through-hole Printed Circuit Boards

Since the late 1960s, the Laboratories have been fabricating prototype plated-through-hole (PTH) printed boards for use in the development of a wide variety of experimental circuits. Since then, the demand for printed boards has steadily climbed in quantity, quality and circuit complexity. To meet the Laboratories' prototype production throughput and quality requirements more efficiently, an R&D project was undertaken in 1981 to automate the PTH plating line. To cater for a wide variety of circuit designs and complexities, operational flexibility was considered a prime requirement of the automated plating line, particularly at its VDU interface with the operator.

In 1981, the technical specifications for the automated plating line were completed and formed the basis of Telecom's call for tenders from industry to undertake the project. After assessment of tenders, a contract was placed with Lawrence Smith and Canning Pty. Ltd. for the design, development, installation and commissioning of the automated plating line at the Laboratories. The project was completed in September 1983 and was accepted after comprehensive testing by Laboratories' engineering staff.

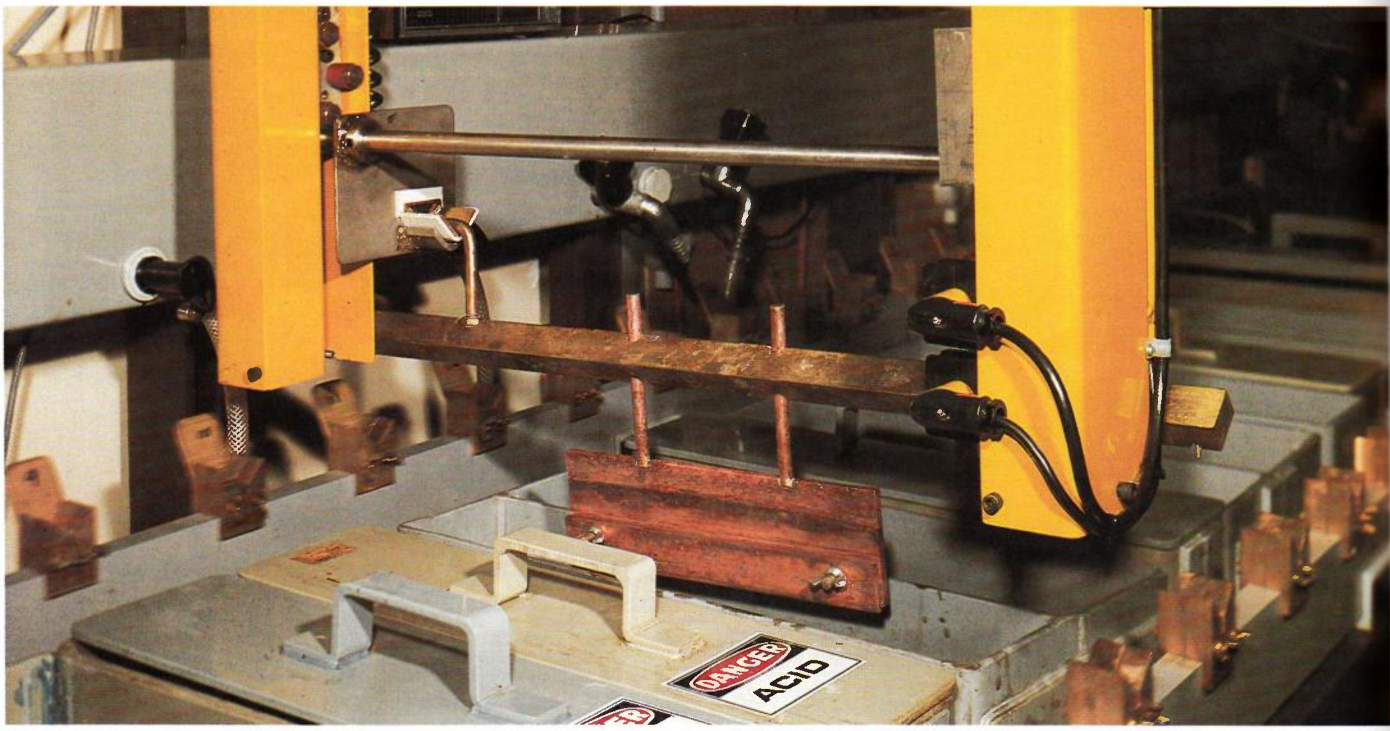
The plating line utilises a dedicated laboratory computer to control simultaneously the operation of cranes which lift, lower and transport boards from tank to tank in the line, plating currents, bath temperatures, and bath agitation.

In the control system, either a HP9835 or HP9845 desk-top computer can act as the controller and interface to a HP6940B multi-programmer. This multi-programmer provides the essential interface between digital computer commands and the analogue elements of the plating line to: activate relays, sense the start and completion of events, measure voltages, and control the plating rectifiers, crane hoists, crane traverse motors and bath agitation motors. All heated bath temperatures are continuously scanned by the system, which provides a warning when any bath is out of the allowed temperature range. For safety purposes, a completely separate liquid level detection system is interlocked with all heated tanks such that all power to the heaters is removed if any bath liquid level falls below a given minimum. Also, a very loud alarm (only resettable by human intervention) signals to the operators the existence of such a fault condition.

The throughput of the automated plating line is 19 complete (panel and pattern plated) PTH printed boards per 10-hour day.

The benefits gained by the Laboratories from this R&D project include the following:

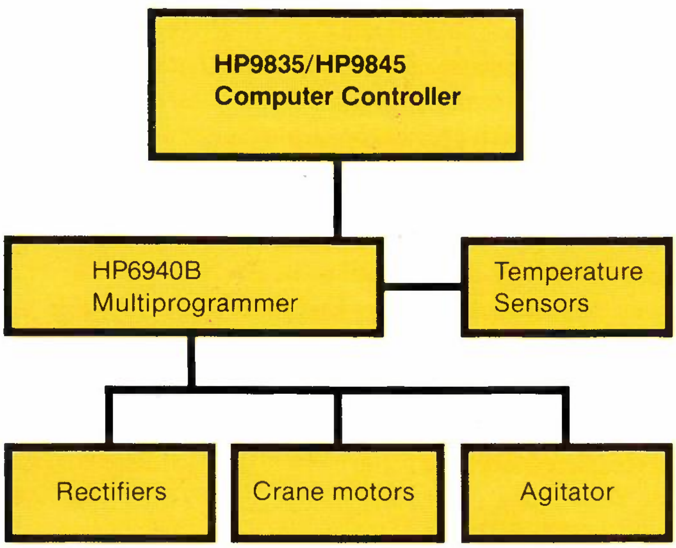
- The board throughput has substantially increased over the earlier manual system.



Crane lifting a board from a plating bath to transport it to and place it into another bath in the automated plating line

- The quality of finished boards shows a consistent improvement.
- Plating line supervision has been reduced to a minimum.
- No operator is required for manual processing.
- The job has become more satisfying to staff.
- The project has been beneficial both to the Laboratories and to the contractor.

The automated plating line has now taken over from manual procedures used in the past for the low-volume production of prototype PTH boards required in the pursuit of a wide range of Laboratories' investigatory projects.



Main elements of the control system of the automated plating line

Ion Exchange Chromatography

Ion exchange chromatography (IEC) is a chemical analysis technique which is readily able to separate complex mixtures of either negative ions (anions) or positive ions (cations) in solution. Both anionic IEC and cationic IEC are applied in the Laboratories to a range of tasks involving chemical analysis. One important determination is that of trace levels of electrochemically destructive ionic species found in malfunctioning telepower batteries.
The technique is also applied in the accurate measurement of chloride, sulphate, carbonate and bicarbonate ions in soil surveys for site works along radiocommunication routes, and in quality control and defective material investigations for consumable items such as detergents, insecticides, soaps, repellents and disinfectants.

The IEC method requires a solvent (eluent) to be pumped under high pressure through a stainless steel column (100-250 mm long and 2-5 mm in diameter) containing small regular particles of ion exchange resin. The sample solution (typically, 10-100 microlitres) containing the ionic species to be separated is injected as a discrete "plug" through an in-line valve system at the head of the column.

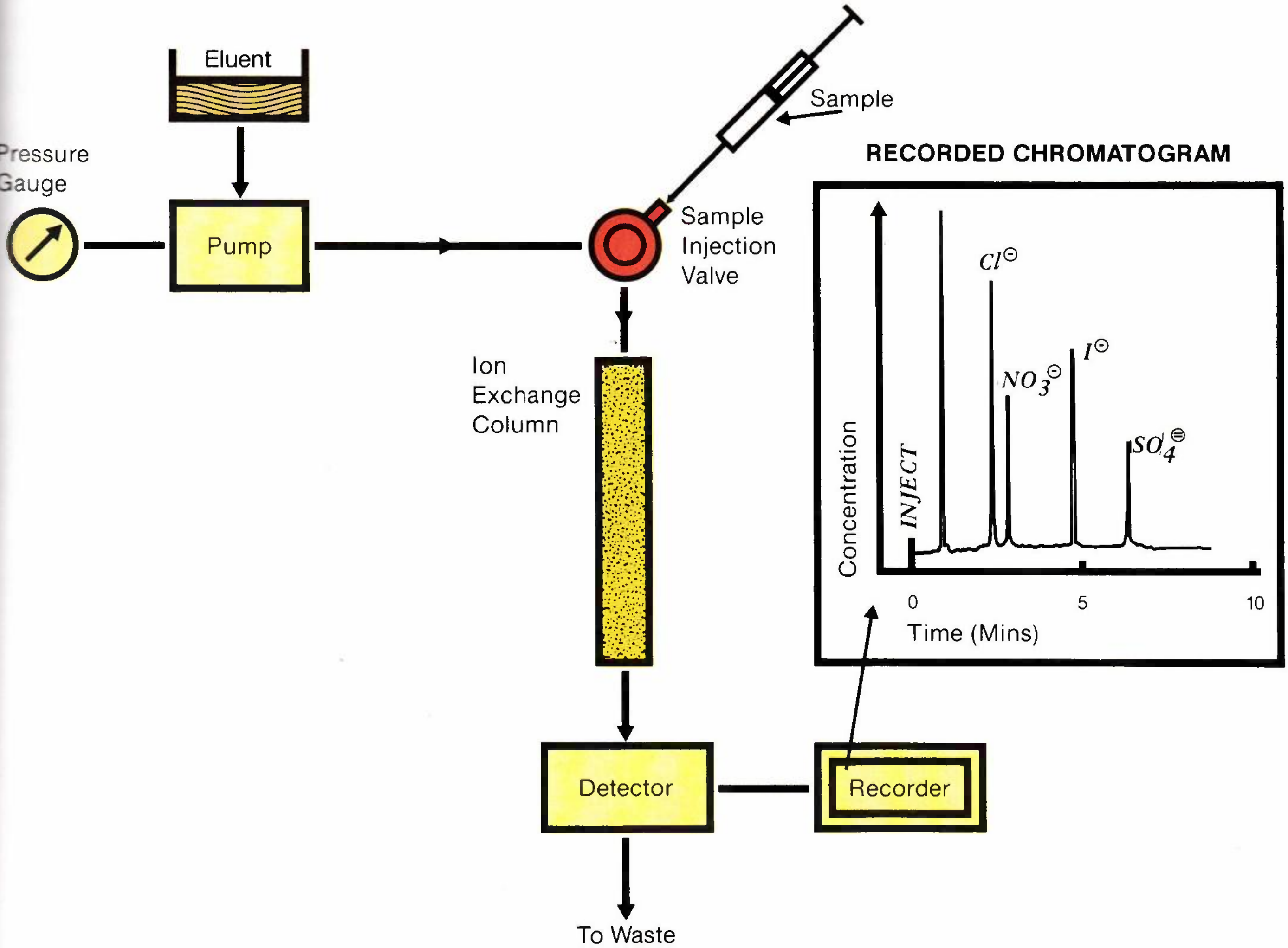
The separation, which is performed in the ion exchange column, can be understood from a consideration of the equilibrium reaction between two salts (RA and MX) in solution, as follows:

$$R^+ A^- + M^+ X^- = R^+ X^- + M^+ A^-$$

The anionic species, X^-, can "exchange" with another anionic species, A^-, in a reversible manner. The equilibrium constant for this reaction varies according to the affinity of X^- for the species R^+. In IEC, the species $R^+ A^-$ is not in the eluent solution but is held by chemical bonding to the ion exchange material contained within the column. This material is usually in the form of spherical resin or porous silica particles ranging in diameter from approximately 5 to 50 microns, and it is selected according to the ionic species to be separated. For example, in anionic IEC, the bonded phase or species R^+A^- is typically a tetra alkylammonium cation together with a suitable counter anion (typically hydroxyl or carbonate). The counter anion is also contained in excess in the eluent. Thus, a mixture of other anions can be separated on the basis of their characteristic ion exchange reactions. The degree of separation reflects the relative affinities of each anion for the bonded phase.

Put simply, each discrete ionic species travels at a different rate when pumped down the column. This results in the progressive separation of a mixture of different species, such that they arrive at the detector at different times. A sensitive flow-through detector of the spectrophotometric, electrochemical or conductivity type senses each species as it emerges from the column, and its concentration is measured relative to those of other species in the sample. The data may be recorded in analogue form on a chart recorder or fed into a computer-based analysis system. Quantitative analysis is performed by detector signal strength comparison, using solutions of known concentration.

IEC is faster, more convenient and has a greater separating ability than classical wet chemical methods. It will undoubtedly find even wider application in the Laboratories in future projects requiring the application of chemical analysis techniques to identify the components of mixtures and their concentrations.



Schematic outline of an ion exchange chromatography system (INSET: Chromatogram of a separated mixture of four anions)

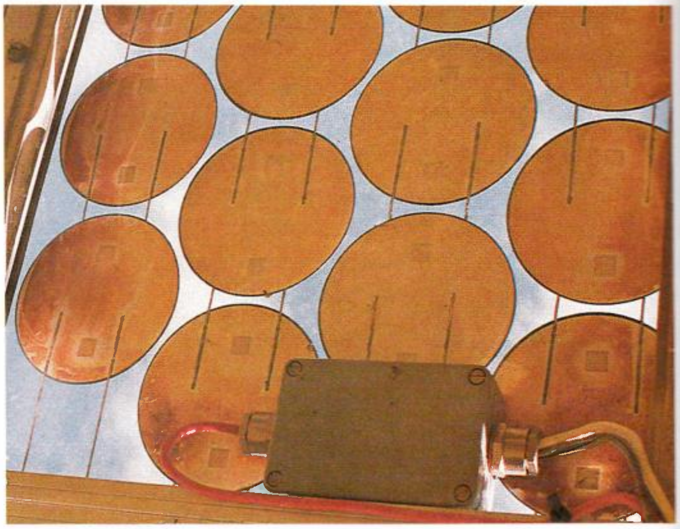
Photovoltaic Module Evaluation

The establishment of the Laboratories' photovoltaic module evaluation facilities, which have been funded in part since 1980/81 by a National Energy Research, Development and Demonstration Council (NERDDC) Grant, has continued during 1983/84 with the installation of a seaside exposure site at North Head near the city of Sydney, and with the development and commissioning of additional test and measurement facilities in the Laboratories.

Data on solar cell panel module performance and climatic conditions is now being collected from sites in four different climatic environments in Australia. Samples of four Japanese and two Australian-sourced module types are exposed at each site. Although no significant change in the electrical performance of any modules has been detected yet at any site, modules have begun to deteriorate physically. Effects such as delamination of the encapsulant from the glass and cells and yellowing of the encapsulant can be seen in some modules at the older established sites.

Accelerated environmental and mechanical tests are being conducted in the Laboratories on the same types of modules as those exposed at the field sites. These latter tests have identified marked changes in the electrical performance of particular modules. Failure analysis of the affected modules has revealed some poor design features and manufacturing errors, such as inflexible interconnects, incomplete solder coating of cell back-surfaces, dry solder joints to cells, and insufficient insulation between module frames and their cells or terminals.

Concurrently with these evaluation activities, work is continuing to widen the scope of the Laboratories' photovoltaic measurement facilities. Equipment to measure the spectral response of photovoltaic cells and the spectral irradiance distribution of light sources has been commissioned and methods established to measure cell shunt resistance and the temperature coefficients of cell output current and voltage. These facilities are being applied in the Laboratories' programme to evaluate the reliability of solar cell panel modules in the range of field environments which are typically met in Australia.



(See photograph above right)
Solar cell module at Innisfail site showing evidence of moisture ingress from the edges causing discolouration of silver backing on the cells

Simulation of Hailstone Strikes on Solar Modules

Over the last three years, the Laboratories have been developing test facilities and applying them to the evaluation of the performance and reliability of solar cell panels (modules) under actual and simulated environmental conditions which are relevant to the field application of the panels anywhere in Australia. Among the sequence of tests to which panels are subjected are those which relate to the evaluation of the mechanical and structural properties of the panels. One such test is intended to simulate the impact loadings caused by hailstones striking the panels at critical points.

To facilitate and standardise the latter test, a hailstone test rig was designed and constructed in the Laboratories. The rig provides for "hailstones" of standardised size to be projected with measurable velocity and direction at a selected point on the solar cell panel under test.

The hailstone test rig comprises a holding frame to which the solar cell panel module is fixed, a moveable hailstone "gun" powered by compressed air, a hailstone velocity measuring system and an electronic triggering facility.

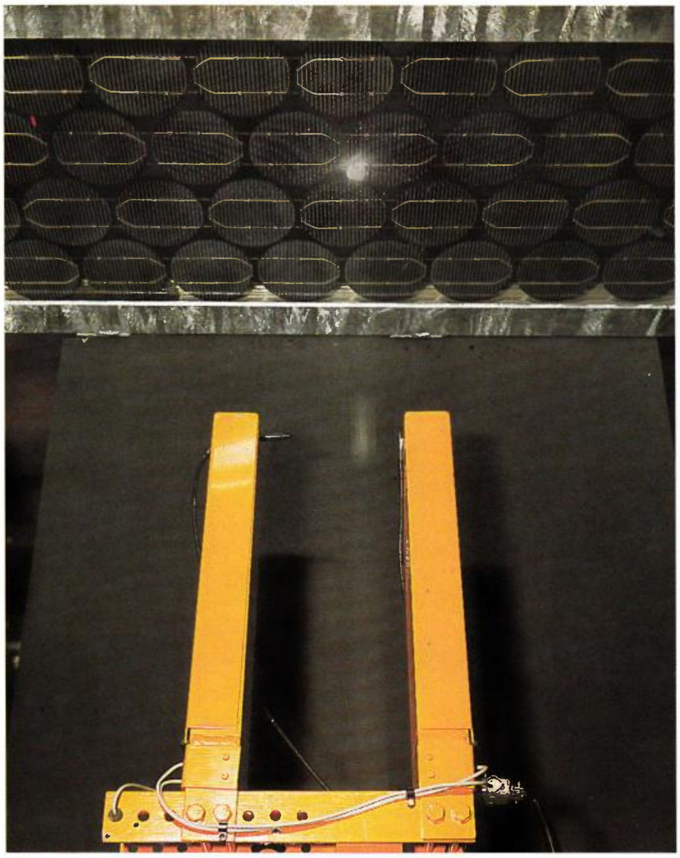
After consideration of the various forms of hailstones that might strike a panel module in field locations and to provide a transferable and repeatable reference, it was decided to use frozen water projectiles and a "gun" barrel diameter of 25 mm. This diameter allows comparison with overseas investigations and covers the largest verified size of hailstones commonly encountered throughout Australia.

To accommodate the range of solar cell panel modules on the hailstone test rig for evaluation, the modules are positioned horizontally in an adjustable holding frame and clamped using their designed mounting methods. Panels are mounted one at a time and face down, with the desired point of impact positioned perpendicular to and above the muzzle of the gun barrel.

The pneumatic gun consists of compressed air reservoir, pressure control devices, a one metre detachable barrel and mountings for the hailstone velocity measuring system. The latter system is capable of measuring velocities between 8m/s (29 km/h) and 99.9 m/s (360 km/h).

In operation, the barrel is aligned to a designated target area on the module using a spotlight mounted in the barrel. The reservoir is charged to 25kPa and the control system set. A moulded 26mm diameter ice-ball is placed on the muzzle of the gun barrel where it melts to the 25mm bore. This ensures consistency in projectile shape and seal. As the free-falling ice-ball drops to the lower end of the barrel, it passes an infra-red triggering sensor which arms the velocity measuring system and opens a solenoid valve to fire the hailstone projectile.

After leaving the muzzle, the projectile passes through two infra-red sensor arrays in the detector head of the velocity measuring system before impacting on the module surface. A digital readout of the velocity just prior to impact is given in metres per second. The required test velocity is 25m/s, and impact velocity can be varied by varying the pressure of air in the reservoir.



(See photograph above right)
Laboratory test rig for simulating hailstone strikes on solar cell panel modules
(See photograph right)
A hailstone projectile impacting on module surface

Ageing Studies of Plastics for Telecommunications Applications

Like many overseas telecommunications administrations, Telecom Australia has used plastics materials in its networks for many years. Current estimates are that, each year, Telecom Australia consumes in excess of 20 000 tonnes of plastics raw materials and spends about $100 million on plastics sheathed and insulated cables.

The successful use of plastics in external telecommunications applications in Australia depends heavily on their ability to resist the harsh and varied climatic conditions encountered, often for periods exceeding forty years. To ensure successful service lifetimes of plastics, the Laboratories devote considerable effort to the selection of appropriate plastics compounds and to the determination of laboratory testing procedures to predict service lifetimes with reliability. As an adjunct to this work, data must be obtained by placing materials and components outdoors, so that the combined influences of temperature, solar radiation and moisture can be studied in the anticipated service conditions or in a "worst-case" environment.

Ageing studies are currently being conducted by the Laboratories at three exposure sites. One is the internationally recognised hot/dry site at Cloncurry, Northern Queensland, which represents a "worst-case" location for temperature and solar radiation interactions. The second is on Mt. Barrow, Tasmania, for a realistic appraisal of moisture, wind and freezing/thawing effects. The third is in the grounds of the Research Laboratories at Clayton, Victoria, and this provides an easily accessible site which is representative of a moderate temperature and ultraviolet (UV) environment.

At Cloncurry, wire insulated with more than 30 different stabilised polyethylenes are being aged in standard above-ground jointing posts. In conjunction with laboratory ageing experiments, this field exposure trial seeks to establish a realistic means of predicting whether plastics insulation will be reliable in service over the desired lifetime of 40 years in Australia's harsh climate. In addition, the trial is aimed to identify early warning signs of any inadequacies in the plastics insulation now in use in Telecom's cable network.

Panels made from a fibreglass/polyurethane sandwich laminate were used in 1982/83 to construct a radome to protect television and FM antennas mounted on a tower at Mt. Wellington in southern Tasmania from a build-up of ice and snow. The high velocity winds and unique freeze/thaw temperature cycles encountered on Mt. Wellington placed special demands on the materials selected for the radome. Previous experience at Mt. Barrow in Northern Tasmania indicated that glass-reinforced polyester outer skins with a polyurethane foam core had performed satisfactorily over an 18-year period. Alternative sandwich core materials of end grain balsa wood and polyvinyl chloride foam, claimed to have superior properties to polyurethane, were rejected for the Mt. Wellington radome due to a lack of sufficient technical or experimental supporting data. However, these alternative panel materials are now being exposed on Mt. Barrow in a programme designed to last for at least a decade.

At the Clayton site, exposure trials of transparent plastics and safety helmets are underway.

Transparent plastics are used often in outdoor environments and must therefore withstand UV degradation. Since, in many instances, manufacturers are unable to provide adequate life expectancy data, the gathering of some primary data is one objective of the trials at the Clayton site. Trends have been observed after only two years of the anticipated 5-year programme. For example, the standard uncoated polycarbonates are already showing signs of degradation, as evidenced by losses in physical properties and changed appearance. The coated, scratch-resistant grades of polycarbonates and, unexpectedly, some acrylics are withstanding these environmental conditions much better.

The industrial safety helmets compulsorily worn by Telecom officers in the field are manufactured from a number of different types of plastics materials. When new, the helmets satisfy Australian Standard Specification 1801-1981 to ensure adequate head protection, but the working life of helmets worn outdoors and the comparative rate of deterioration of the different plastics used has never before been comprehensively studied in Australia. The Laboratories' exposure programme, which is in its fifth and final year, has confirmed the suitability of two materials for this application and provided a reliable data base from which to estimate service lifetimes and establish a helmet replacement policy.

Stabilising System for Polyethylene Insulation

In 1980, a dramatic increase in the reported incidence of faults in polyethylene insulated wires from cables in above-ground jointing enclosures initiated an intensive investigation to ascertain the cause of failure and to develop materials and practices which would mitigate against the problem in the future. Based on results obtained from field surveys and laboratory studies, it was concluded that failure of the solid polyethylene insulation occurred only in cables manufactured between 1965 to 1974 and was due to thermo-oxidation as a consequence of antioxidant depletion.

Factors which contributed to depletion of the antioxidant were identified as:

- low initial antioxidant levels in the polyethylene raw material
- antioxidant losses during processing (as high as 50%, depending on processing conditions)
- interaction between antioxidant and metal-based pigments - with higher failure rates for white and grey insulated wires attributable to higher levels of titanium dioxide pigment being associated with these colours
- migration of antioxidant to the surface of the insulation, rather than remaining dispersed throughout the polymer - a function of the solubility and diffusion of the antioxidant in the polymer matrix and of temperature
- high temperatures inside joint enclosures, influencing solubility and the thermo-oxidation reaction rate.

As a consequence of the Laboratories' investigations, the following wide ranging recommendations were made:

- to use a stabiliser system comprising both a primary antioxidant and a metal deactivator
- to specify stabiliser levels 'on wire', that is, after extrusion (to account for processing losses)
- to avoid antioxidant interaction with other additives such as metal-based pigments by minimising or excluding their use
- to use stabilisers with high solubility, and hence low migration loss, over the range of temperatures encountered in service
- to design cooler joint enclosures.

These findings formed the basis of two papers presented at international conferences in the UK and USA.

Implementation of these recommendations by Telecom has involved the formulation and evaluation of alternative stabiliser systems for use in both solid and cellular insulation. Several primary antioxidants were selected on the basis of their high solubility in low density polyethylene (LDPE) plaques, providing low migration losses over the temperature range from 23° to 100°C.

Thirty-two polyethylene compounds were then formulated using these antioxidants in conjunction with a secondary antioxidant, two metal deactivators and medium density polyethylene (MDPE) from two Australian manufacturers. These compounds were extruded onto 0.64 mm diameter copper wire and then subjected to accelerated thermal ageing in the laboratory, since testing the stabiliser system in MDPE insulation on wire is more akin to real life than testing LDPE plaques. The performance of the various compounds was monitored by measurement of stabiliser losses and changes in physical and electrical properties, as a function of time and temperature.

Definitive answers will take some time to emerge, but on the basis of early data, an interim stabiliser formulation has been recommended for solid, MDPE insulation, aimed at achieving a 40-year life at an effective service temperature of 40°C. MDPE compounds containing this stabiliser system will be introduced into Telecom's cables in 1984. Although an interim formulation, the stabiliser types chosen are firm. The concentrations, however, may be varied as a result of the outcome of present work.

The replacement of paper insulated air-core cable with cellular polyethylene insulated cable has dramatically increased the use of this material throughout the network. Cellular polyethylene differs from solid polyethylene in that the raw material is a high density polyethylene (HDPE) incorporating a chemical blowing agent.
The solubility of stabilisers in HDPE differs from that in MDPE, and losses of stabiliser by reaction with the blowing agent during extrusion can be around 30% compared with 10%-15% for the same polymer without a blowing agent. Additional loss can also be expected from cellular polyethylene in a filled cable by contact with the filling compound.

A testing programme similar to that for solid MDPE insulation has been developed in the Laboratories for cellular HDPE insulation, involving 43 different experimental HDPE compounds. It will be some time before complete data is derived from this study, but on the basis of existing knowledge, an interim stabiliser system has been recommended for cellular HDPE insulation.

CONSULTATIVE ACTIVITIES

The Laboratories are continually developing expertise and laboratory facilities in the engineering and scientific disciplines which are somewhat special and uniquely concentrated in Telecom. As can be seen from the earlier sections of this Review, these are necessary for the pursuit of the major technical and scientific research projects which cover the whole range of advanced materials, components, equipment and systems which make up the network by which Telecom provides Australia's national telecommunications services.

In addition to performing larger project-scale research investigations in an on-going work programme, the staff of the Laboratories are often called upon by other Departments of Telecom to give ad hoc consultant advice and assistance on problems which arise in their day-to-day activities and which can be quickly and effectively solved by such calls. Such assistance provided by the Laboratories ranges from advice on the design and specification of equipment; to assessments of the reliability of materials and components; to evaluations of the effects of particular manufacturing process technologies on equipment performance and reliability; or to assessments of the likely causes and effects of problems arising in field operations through component or equipment failures, through the adoption of particular operational practices or as the result of accidents or equipment malfunctions.

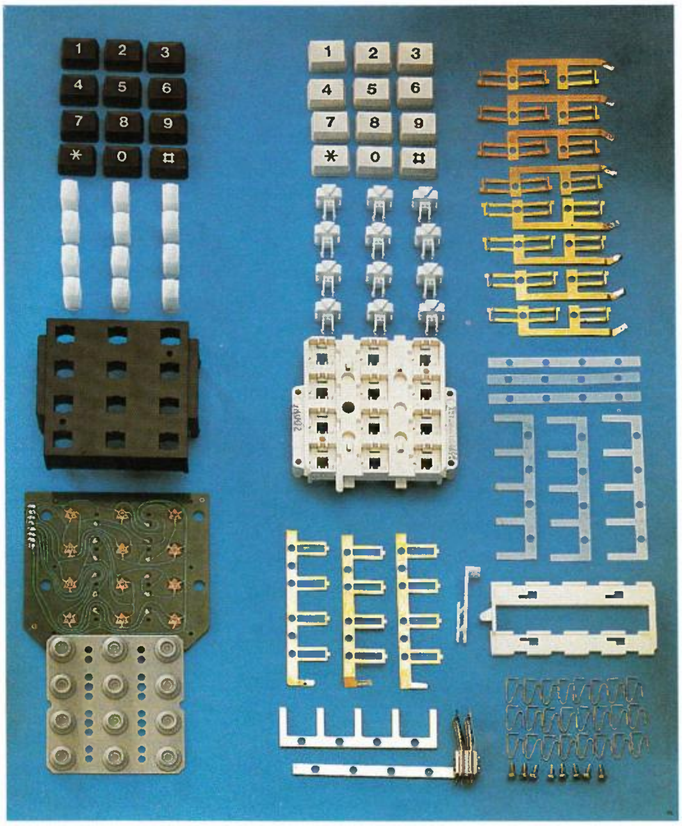
These smaller scale tasks do not attract the same prestige as the larger-scale R&D projects, in terms of their contribution to major corporate decisions. Nevertheless, they are regarded as an essential part of the Laboratories' role to provide cost-effective and speedy assistance, where possible, to other Departments of Telecom – to avoid or solve minor, but often costly, problems arising in the operation of a large telecommunications network.
Brief details of some of the consultative activities of the Laboratories during the past year are given in the following pages.

Evaluation of Telephone Keypads

Since the introduction of the Touchfone 10 telephone, all new telephone designs introduced by Telecom have incorporated push button keypad dialling. These have included Telecom's new range of premium telephones (i.e. the Digitel, Flip-Phone and Touch-A-Matic models), the Commander series of small business systems and the new coin telephone (the Gold Phone). As a result of their role in assessing the reliability of new telephones, the Laboratories have maintained an active interest in keypad technologies and have developed a range of tests and specialised life testing equipment for providing critical evaluations of new telephone keypad designs.

Early keypad designs required off-normal contacts in addition to the set of metal spring contacts used to uniquely define each button. These designs were mechanically complex, with failures commonly resulting from metal fatigue. None of the early designs evaluated by the Laboratories possessed mechanical lifetimes much in excess of 200 000 operations per button. They have now been superseded by mechanically simpler and more reliable designs, most of which employ a "collapsible dome" structure. This has resulted in extended mechanical life, lower operating forces and improved tactile feedback to the user.

Typical of a modern keypad employing membrane switch technology is that used in the Mark III Touchfone. The keypad comprises a one-piece moulded rubber mat with pads of conductive rubber vulcanized onto raised dome areas above the contact points. The mat is placed against a printed wiring board so that the domes collapse onto printed circuit contact pads when a button is pressed. Measurements of the contact resistances of these keypads range from 10 to 100 ohms, depending on the applied force. This resistance is significantly higher than that obtainable from metal contacts (typically 0.1 ohm), but the MOS semiconductor devices now used for keypad encoding tolerate contact resistances of almost 100 000 ohms before a switch closure is not detected. A number of telephones containing rubber membrane keypads have been life tested in the Laboratories for one million operations per button without failure.



The MKIII and MKI versions of the Touchfone keypad highlight the differences between early and recent keypad design

In compact telephone designs requiring a thin keypad, conductive ink tracks printed onto plastic films are used to construct membrane keypads only a few millimetres thick. Laboratories' tests have shown that these will not usually withstand as much usage as the rubber dome type, but lifetimes sufficient for domestic applications are achievable.

A New Motorway Emergency Telephone

A new motorway emergency telephone, designed by the New South Wales Administration of Telecom Australia for connection to its network, has been proposed for more general use. Previous emergency telephones installed along motorways have used separate private lines.
The new emergency telephone is more flexible; it uses a button-operated automatic dialler to connect the user to the emergency service and automatically registers the calling location. It is housed in a 2m tall aluminium enclosure which has been designed to be fixed by bolts to the pavement at the edge of the motorway.

The Laboratories were requested to assess the suitability of the telephone and its housing for operation in the outdoor environment.

As part of the assessment, temperatures which might be experienced by the telephone in an operational environment were gauged by monitoring temperatures, throughout one summer, of a prototype unit installed at an unshaded site. Temperatures at three points within the enclosure were recorded, together with the ambient temperature. These confirmed that, in this respect, the unit was satisfactory. The maximum internal temperature recorded was 46°C and the maximum excess of internal temperature above ambient was 20°C. With an upper working limit of 85°C, the most temperature-sensitive components of the telephone were considered adequately protected in this regard.

Further tests showed the enclosure to be rain-proof, but recommendations were made to improve the protection of the telephone components against the effects of high humidity, condensation and the ingress of small insects.

The design evaluation showed a need for improvements to provide for more adequate earthing of the enclosure to discharge lightning potentials and for a high-current conductor to connect the metallic parts of the removable fibreglass telephone support to the aluminium enclosure. The latter provision was considered necessary to ensure an adequate low resistance path existed for any large lightning currents which might occur in the outdoor environment.

The tests concluded that, with the recommended design improvements, the new emergency motorway telephone will provide safe and reliable service in its unusual environment.

(See photograph above right)
Prototype motorway emergency telephone

Teleconferencing Handbook.

Teleconferencing, the use of telecommunications to support communication between three or more people separated by distance, has been under study in the Research Laboratories for a number of years.

Recently, as part of an ongoing policy of transferring technology to user areas, the Laboratories made a major contribution to the preparation of a handbook on teleconferencing which would assist Telecom staff with queries from business customers on their teleconferencing requirements and the most efficient methods of satisfying these requirements.

The handbook covers both audio and video teleconferencing and includes details of enhancements and arrangements which improve communication effectiveness. The handbook is structured in order to satisfy differing requirements for technical information. This allows, for example, the particular teleconferencing application best suited to the customer's needs to be first determined, then the technique which best fits that application, and finally at the most complex level, the details of equipment necessary to realise the chosen technique. Several complete teleconferencing "packages" are also described in appendices which illustrate solutions to particular requirements in detail.

Teleconferencing for Staff Training

During the year, the Research Laboratories assisted the Commercial Services Department, Headquarters, and the Commercial Department, New South Wales, in the conduct of a trial to investigate the potential application of teleconferencing in staff training.

The trial was conducted in Sydney during February 1983. Two groups of Service Advisory staff undertook a product training course for the new Commander T105 telephone via a teleconference system, while a third group undertook the course face-to-face. The trial's objectives were to assess the effectiveness of teleconferencing for training in comparison with that of the traditional classroom approach.

The Research Laboratories assisted the planning of the trial by providing advice on:

- teleconferencing equipment
- the adaptation of course material and teaching style to suit teleconferencing, and
- evaluation procedures.

The equipment chosen for the trial was the Small Group Terminal designed in the Laboratories. The Staff Development Section, after consultation with Research Laboratories, partially re-designed the Commander T105 course and briefed the Training Officer who instructed all three groups.

The Laboratories took responsibility for planning the course evaluation, which comprised:

- two questionnaires completed by course participants (one before and one after training), designed to assess their attitudes to the course
- a short questionnaire filled out by supervisors of the participants taking the teleconferencing courses, seeking the supervisor's opinion about advantages and disadvantages of this form of training
- observation of a teleconference training session
- an interview with the Training Officer after he had given all three courses, and
- a quiz to test all trainees' product knowledge, administered at the end of the course and again one month later.

The trial showed that teleconferencing has some potential for removing the difficulties presented by distance in staff training, particularly where the staff to be trained are geographically dispersed in relatively small groups over a number of locations.

Third Generation PABX Consultancy

Telecom Australia recently undertook a major communications assessment project for a large municipal government body. The task involved the assessment of requirements for data, electronic mail, teletex, facsimile and word processing facilities as well as intelligent work stations which would operate with an integrated voice and data digital PABX.

The project team comprised staff from the Research and Commercial Services Departments at Headquarters and from the Commercial Department of Telecom's Victorian State Administration.

Proposals were prepared by the Research Laboratories on the problems of integrated voice and data terminals working within a central office; data communication between a central PABX/data processing centre and remote depot sites; the applicability of local area networking to central office data communications; image, text and document transfer between the central office and remote sites; and the communication aspects of word processor systems.

This work also provided a supplementary input on non-voice service aspects of Telecom's third generation PABX implementation programme. Furthermore, it provided valuable experience in support of Laboratories' studies related to new business communications services and systems.

LEOPARD System Response Time Measurement

The LEOPARD system provides Telecom with on line access to subscriber service records, for real time reporting and allocation to repairers of service faults. To assess the performance of this system, especially while it is in its introductory phase, it was decided to measure system "response times".

To facilitate these measurements, the Laboratories designed and constructed a microprocessor-controlled unit which automatically measures and records the system's response times with the desired accuracy. The unit is self-contained, transportable and easily connected to a system terminal. For installation, it simply requires the following connections:

- 240 volt mains power,
- RS232 connection to the rear of the terminal, and
- data connection to the keyboard.

Once the unit is connected, its activation only requires that the terminal address be dialled up on the front panel and the RESET button pressed. As soon as a message is sent from the terminal, the keyboard interface circuitry recognises that the SEND key has been depressed and initiates a routine to measure the response times.
This information is then entered into the display and also stored onto a micro-cassette ready for subsequent processing and evaluation.

In the past, the response times have been measured manually by using a stopwatch and the information recorded on a sheet of paper. The shortcomings of this method included:

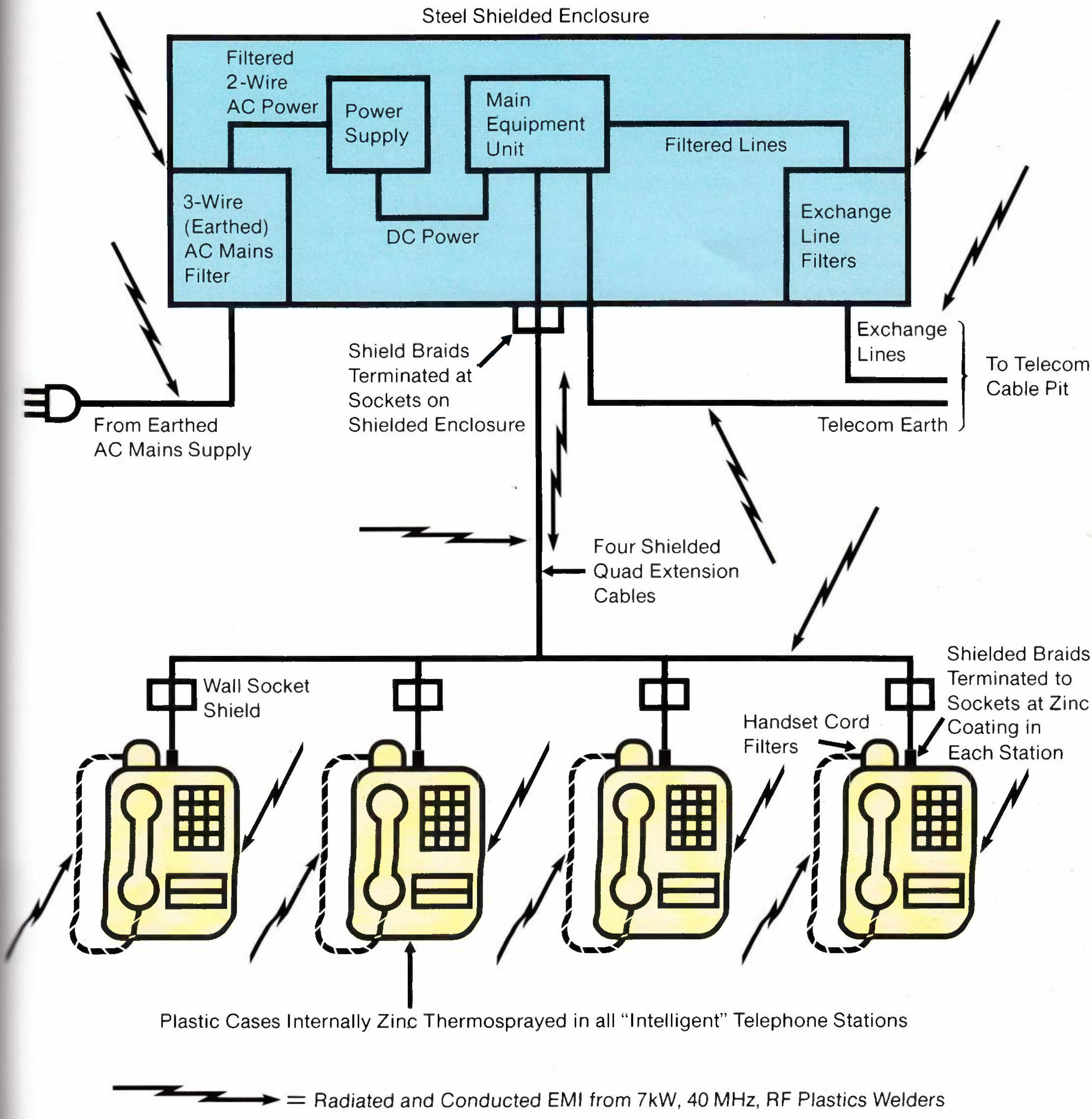
- inaccurate readings,
- sample number too small,
- readings only taken for the assumed peak periods, and
- time consuming measurement and analysis procedures.

With the new unit operating at a terminal, response times can be continually measured and recorded along with the message code and time of day. The analysis of the recorded information by a central computer provides statistics suitable for assessing the response times of the LEOPARD system, thereby providing an objective measure of its efficiency.

Protection of a Small Business System against High Level Electromagnetic Interference

The problems presented by electromagnetic interference (EMI) to new generation, semiconductor-based, subscribers equipments can sometimes be manifested in extreme forms. An example, which unfortunately is not the only one of its kind, is the case where a Small Business System(SBS) may be required to function in a factory and office complex where the manufacturing process involves the use of radio frequency (RF) dielectric heaters or plastics welders operating at RF power levels of several kilowatts or more. The resulting leakage of conducted and radiated RF power, when coupled into the AC mains power supply, the telephone extension cabling and exchange lines, the centralised microprocessor-controlled equipment and the microprocessor-controlled "intelligent" telephone stations of the SBS, can cause continuous malfunctioning and even destruction of some components of the SBS.

EMI-hardening of a Small Business System



For one such extreme case, the Laboratories recently devised electromagnetic shielding and lossy-filtering techniques to EMI-harden a complete SBS. The level of EMI immunity obtained by these techniques has been sufficient to enable the modified SBS to function successfully in a factory environment where EMI far field and near field electric and magnetic field strengths of greater than 100 v/m and 1 A/m respectively have been measured.

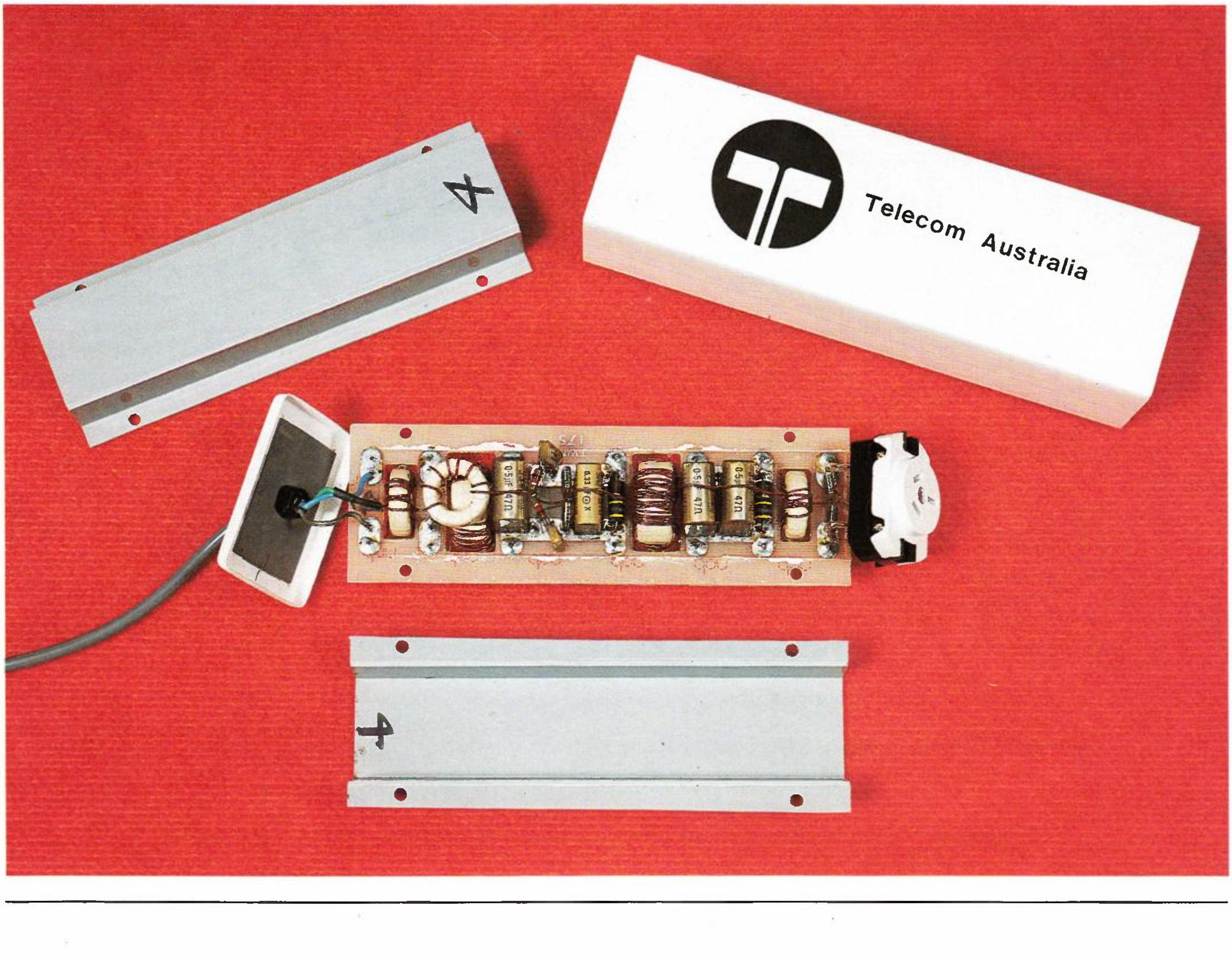
During installation and commissioning of the modified SBS, the Laboratories' modifications were demonstrated and explained to local maintenance staff and some of the maintenance difficulties that they might experience in the future were indicated. In particular, it was made quite clear that no maintenance work should be carried out on the system at times when RF welders were in operation, since human contact with uninsulated sections of the system shielding for maintenance purposes, when the abovementioned high level electromagnetic fields are being generated, could cause radio frequency burns to the skin. In addition, when the external shielding panels of the SBS equipment are removed during maintenance, the same high level fields can gain entry to the system and thence damage circuit components, particularly semiconductor devices.

Power Mains Line Filter for Protection of Equipment against Conducted Electromagnetic Interference

Many devices and appliances operating from AC mains power lines produce fast, high energy transient voltage and current surges. Electric drills, arc welders of all types and electric typewriters are some of the culprits in this respect. The proper functioning of small computers, desk-top calculators, PABXs, and Small Business Systems (SBS) and many other types of AC mains operated "intelligent" equipment items can be adversely affected, and sometimes even damaged, by mains-borne transients.

When such equipment has not been provided with sufficient internal protection against conducted electrical interference, it is often possible to provide external protection in the form of a filter incorporated in the AC line cord to the equipment. Because such an electrical filter is "floating" in an electromagnetic sense, rather than being electrically referenced intimately to the equipment it is to protect, there are definite limits to the amount of protection that may be provided in this way. However, by

AC mains power line filter (exploded view)



having regard to these limits and by devising appropriate lossy-filter techniques with selection of components and materials, the Laboratories have designed and developed a "floating" 3-wire AC mains line filter. The filter is applied between the mains power outlet and the equipment to be protected from mains-borne interference.

From the design information, some prototype filter units have been production-engineered and manufactured in Telecom's Workshops in Melbourne. A number of the filter units are being field-trialled at SBS installations where AC mains-borne interference is the known or suspected cause of system malfunctions. From the very small number of filter units so far in the field, trial results indicate that on the order of 30% of mains conducted interference problems can be solved by the use of the filters. However, the filters cannot be effective in situations where the original mains-conducted interference is also radiatively transferred to signal and extension lines of the equipment to be protected. In these latter cases, additional protective measures must be applied to screen out such radiation.

Effect of Organic Acid Impurity in Stationary Batteries

During the past two years, severe positive plate corrosion has been observed in some new exchange battery banks. The corrosion was first observed in Queensland but it soon became apparent that the problem was more widespread.

The particular type of corrosion occurred only in selected batches of new batteries. In some cells, the corrosion process had consumed a large part of the positive grid material, and in a number of instances, the battery cases had cracked because of excessive pressure created by the voluminous corrosion products formed between the plates. The resulting spillage of sulphuric acid caused further damage around the cells, on the floor of the battery room and in cable ducts.

Microscopic examination of cross-sections of the affected positive grids revealed the presence of tetragonal lead monoxide formation between the lead-lead dioxide interface. Further laboratory investigation determined the

Lead-acid battery plates showing contamination damage due to organic acid impurity in the electrolyte

cause of this as contamination of the electrolyte with organic acid.

To establish the extent of this contamination problem, it was necessary to evaluate several analytical methods and identify the one which was suitable for the accurate and reliable quantitative determination of organic acid.

The reduction of iodate by acid and the subsequent iodometric titration used by some laboratories was considered only semi-quantitative. This method requires the complete separation of the sulphuric and organic acids at the distillation stage, which is very difficult.

A second method examined required the refluxing of the distillate using barium carbonate in excess. As the sulphate precipitates in the barium carbonate slurry, the distillation can be carried out quantitatively for all volatile organic acids. This method demands very careful control, as it is essential to have reproducible equilibrium conditions between the carbon dioxide, carbonate and sulphate ions in saturated solutions. After some effort, it was demonstrated that the accuracy and reproducibility of this method was unacceptable.

The analytical technique finally adopted for the determination of volatile organic acids in a large excess of sulphuric acid was partial separation by distillation to 220°C, followed by a non-aqueous titration using 0.01 molar potassium hydroxide in iso-propyl alcohol. The sample also had a large excess (4:1) of carefully neutralised iso-propyl alcohol. A small amount of sulphuric acid can be present through being carried over in the distillation. A known aliquot of the distillate is neutralised to about pH4 and then titrated to pH13. A first inflexion point occurs around pH 5-6 and is due to the sulphuric acid and any other strong mineral acids present. A second inflexion point around pH10 indicates neutralisation of the much weaker organic acid. The difference between the two hydrogen ion activities is very pronounced.

The results obtained with the adopted method were accurate and reproducible. The source of the organic acid contamination was traced back to some of the stages of battery manufacture, resulting in corrective action being subsequently taken. Determination of the degree and extent of contamination proceeded with the analysis of a large number of samples. This allowed affected cells to be identified and remedial action to be taken to minimise the losses in battery service lifetimes and consequent interruptions to service.

Reduction of Explosion Hazards at Stationary Battery Installations

The space above the electrolyte in rechargeable batteries, particularly towards the end of the charging half cycle, is filled with a very explosive hydrogen-oxygen mixture. A certain amount of hydrogen evolution can occur at a very low rate even on float service, especially if the battery is old and has a partially poisoned negative plate surface.

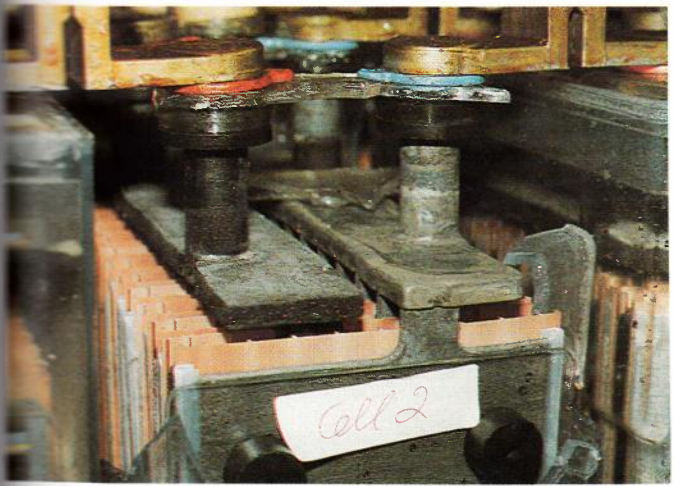
As a protective measure, the cells in Telecom's stationary batteries are fitted with a specially designed anti-explosion vent. Any gas mixture accumulating above the electrolyte can diffuse out of the cell through the fine pores of the vent frit, but external flame cannot penetrate into the cell to produce an explosion. Although the hydrogen gas concentration inside the cell may exceed the lower explosive limit (LEL) of 4% hydrogen quite frequently, the diffused gas concentration outside the cell is seldom above the LEL, even during charging. This is due to the high mobility of the light hydrogen molecule.

To further reduce the possibility of explosion, an exhaust fan is provided, usually at ceiling height, to ensure a continuous, unidirectional air movement from the battery room to outside atmosphere. Even so, it is not advisable to work near the battery with spark-producing tools, particularly when a boost charge is in progress. Unlikely though it may be, if a flame front was to penetrate through the anti-explosion vent and into a cell, the consequences could be extremely unpredictable.

A recent Laboratories' investigation of a battery explosion showed that one of the causes was a faulty anti-explosion vent. As assembled, the vent could not have prevented flame propagation. Further investigation also disclosed that this particular vent fault was not an isolated occurrence, and hence, the unreliable vents were replaced urgently.

One reason for the failure to detect the faulty vents during the production phase was an unsatisfactory testing method used to assess quality. Both production and quality control processes have subsequently been improved considerably, and a new, accurate and more reliable test method is being established as an Australian Standard. With these remedial actions, the already very low risk of battery explosion will be further reduced.

(See photograph above right)
Exploded cell in the battery bank



Rhenium as an Open Relay Contact Material

Samples of rhenium contacts from open relays in switching equipment have been submitted for Laboratories' examination from the field in a "burnt" condition after as little as six weeks in service. Typically, the affected contacts are covered with a black, sticky deposit. Laboratory tests have shown that, although some contamination was present initially, the fundamental cause of the problem is a susceptibility of rhenium to corrode in the presence of both high humidity and applied voltage.

In the laboratory tests, sets of contacts switching a normal load in the appropriate relay circuit deteriorated rapidly when placed in an environment of 40° C and 95% relative humidity. Within a few days, the positive contacts were eaten away. The corrosion products were hygroscopic and once deterioration commenced, high humidity levels were not needed to maintain it. Without load voltage or high humidity applied, there was little deterioriation.

The fundamental nobility of rhenium appears to reveal the cause of this problem. Rhenium is ranked 20th in thermodynamic (or theoretical) nobility. However, when its practical nobility is assessed by taking into account its stability in water, the effects of passivation, etc., its rating drops markedly. In practical terms, it will corrode in solutions of a wide pH range. In the presence of moisture, arcing and chlorine contamination, the production of the black rhenium dioxide and its deposition on the negative contact is consistent with rhenium's known chemical properties.

As a result of the Laboratories' investigation, it was recommended that the use of rhenium in this application should be discontinued and that an alternative recognised heavy duty electrical contact material such as platinum, rhodium or silver-cadmium oxide alloy should be substituted. The susceptibility of these materials to corrosion is much lower.

Replacement of Asbestos Fibre by Cellulose in Cable Pits

Asbestos fibre reinforced cement has been used for many years as the construction material for cable pits. Because of growing concern over possible health risks involved with asbestos fibre, Telecom has been seeking a suitable alternative reinforcing fibre since about 1980.

Cellulose fibres have been used as a partial replacement for asbestos fibres in some cement-based products since the early 1960s. Hence, complete replacement of asbestos with cellulose fibre was considered a possibility warranting more detailed investigation, before examination of other alternatives like glass or nylon reinforcements with cement or polyester binders.

It was known that the Division of Chemical Technology of CSIRO was investigating the use of wood (cellulose) fibres as reinforcement in structural composite materials and had found that, although wood fibres have relatively poor mechanical properties compared with synthetic fibres, their low density, low cost and low energy demand during manufacture make them attractive as reinforcement for cement matrix composites. CSIRO had found it necessary, however, to be selective in the type of pulping process used to remove the fibres from the wood and also to improve the affinity between the cellulosic surfaces and cement particles by the introduction of coupling agents, in order to optimise the mechanical properties of the composite.

Subsequently, a number of small-sized cable pits were manufactured by an injection moulding process, using a cement slurry containing only cellulose fibre as the reinforcement. These pits were subjected to a number of tests by Telecom's Laboratories, the results of which indicated that the cellulose reinforced cement composite compared favourably with asbestos reinforced cement. Based on this work, Telecom has decided to adopt cellulose reinforced cement for injection moulded pit production, which currently covers the four smallest sizes. Extension of the material and process to the production of larger size pits is still under examination.

An Alternative Coating for Underground Plant

With the discovery and widespread use of natural gas in Australia, the production of coal gas ceased and, along with it, the production of some very useful by-products from the gas retorts. One such product is coal tar pitch which, with the addition of 35-40% finely ground talc, gave an economical, tough, abrasion resistant coating for the protection of manhole covers and frames. The article to be coated was heated to a sufficiently high temperature to become thoroughly dry, and then immersed for at least ten minutes in a bath containing the mixture of molten coal tar pitch and talc. The resultant thick adherent coating which resulted gave excellent corrosion protection to the cast iron covers and frames. As soon as the coated article was cool, it could be handled without causing damage to the coating.

A number of possible substitutes for coal tar pitch have been considered by the Laboratories in collaboration with the Engineering Department. Those based on bituminous residues dissolved in a petroleum solvent, such as mineral turpentine, were considered one possible replacement. This type of material is intended for cold application by dipping and relies on the evaporation of the solvent to dry. However, these alternatives were found to be unsatisfactory because they formed soft, relatively thin films that were easily damaged and gave poor corrosion protection. If several coats were applied, the corrosion protective properties improved, but the softness of the coating was considered a severe drawback, as was the time taken to carry out the coating and drying operation. These bituminous coatings were rejected as being inferior to the coal tar derivatives.

Consideration was then given to a coal tar enamel which is used as an internal coating for water mains. It is a blend of coal tar pitch and tar oil, both being derived from coke oven residues. Coal dust and ground talc is also added. Although this material was found to be basically satisfactory, as it forms a thick, hard film giving excellent corrosion protection to cast iron, it was found to be too brittle for Telecom Australia's applications.

Further Laboratories' investigations showed that blends of this coal tar enamel and varying proportions of tar oil produced tough films with improved flexibility. Consequently, co-operative work between Telecom and a local manufacturer of coal tar enamels has produced test batches of the enamel modified with tar oil. Field trials indicate that some useful coatings have been formulated and that, when needed, a substitute coating will be available to meet Telecom's requirements for this rather mundane, yet important product.

Surface Preparation of Galvanised Steel for Painting

The painting of galvanised steel structures such as radio transmission towers and masts is undertaken either for corrosion protection or to render them more readily visible to aircraft. Sometimes both reasons apply. As the field painting of a large tower can cost in the order of a quarter of a million dollars, methods of extending the service life of such a structure have been the subject of laboratory investigations.

Investigations of paint failures on galvanised structures have shown that the most common mode of failure is separation between the priming coat and the galvanised surface. It has been a common practice in specifying paint systems for galvanised steel to stipulate that the galvanised surface should be lightly abrasive blasted to remove the metallic sheen, any passivating coating and any corrosion product that may be present, in order to enhance the adhesion of the paint system to the galvanised surface.

Sand is a commonly used abrasive since it is a cheap and an effective medium, but because of the danger of silicosis, other less hazardous abrasives are now being specified. An investigation has commenced to determine the performance of alternatives such as ilmenite, copper slag, iron grit and shot for abrasive blasting of galvanised surfaces. Ilmenite is a very hard mineral containing iron and titanium oxides. Copper slag is a waste, glass-like material obtained from the smelting of copper ores. Both are reduced to the particle size of beach sand for use as abrasives.

A preliminary low magnification inspection of an untreated galvanised surface showed it to be rather rough, but with typical metallic sheen. Inspection after blasting with the selected media revealed that the ilmenite and copper slag left the surface with a matte and clean finish, whereas the shot and grit left a surface that was not totally clean. Accordingly, only ilmenite and copper slag were used for surface preparation of galvanised surfaces prior to painting in further laboratory studies.

Due to the corrosion protection afforded to steel by galvanising, any abrasive preparation of the surface to improve paint adhesion must remove a minimum of zinc. Blasting the surface with either ilmenite or copper slag generally removed less than 1% of the mass of zinc on the steel surface.

After preparation, the galvanised surfaces were painted with heavy duty paint systems and then the whole system of galvanised steel and paint was subjected to a number of tests. Some accelerated laboratory tests have been carried out on these systems, but the most reliable and realistic tests are time consuming, outdoor exposure trials in an aggressive environment. In this context, painted galvanised steel panels, some abrasive blasted and others with no surface pre-treatment other than solvent degreasing, are being exposed at a seaside location at Port Melbourne. It is anticipated that these samples will need to be exposed for several years before any firm conclusions about extended service life can be made.

Improved Earth Digging Equipment

In its cable laying activities, Telecom Australia is a major Australian purchaser of excavation tooling, particularly in the form of such items as pneumatic chisels and chain trench digging teeth. Experience over recent years has suggested that these items perform to a less than adequate degree, with failures resulting from both rapid wear and breakage. Laboratories' investigations have concluded that these shortcomings result from the use of both steels and manufacturing processes that are not optimal.

For example, in the case of pneumatic chisels, tools are manufactured from high carbon unalloyed steels. These steels are relatively inexpensive but they do not afford a high degree of toughness, and several serious accidents have occurred when tools made from this material have broken in service. A specification has therefore been developed for these tools to be manufactured from a low alloy, shock resistant steel and it is expected that, after completion of satisfactory field trials of tools produced to this specification by an Australian manufacturer, the improved tools will be placed in service.

A new specification is being prepared for chain trench digging teeth. The specification is expected to extend the working lifetimes of teeth in Telecom's external plant operations. The specification is based not only on an alternative steel and a specific heat treatment, but also includes details for hardfacing the cutting edges of the teeth. The latter specifies the grade of hardfacing metal, its method of application and the required metallurgical properties. It is expected that the adoption of the new specification by Telecom will result in savings through increased tool lifetimes in service.

Biological Effects of Electromagnetic Radiation

Rapid progress in technology has caused widespread and increasing application of radio frequency (RF) energy in our day-to-day lives. Communication, broadcasting, radar and navigational systems, medical instrumentation as well as consumer items such as microwave ovens and CB radios are some of the most popular applications. RF radiation mechanisms are extensively employed in or could be by-products of the numerous services provided by Telecom, and these can potentially cause biological effects which may be harmful.

One of the responsibilities of the Research Laboratories is to maintain a knowledge base on the biological effects of electromagnetic radiation and to develop design practices by taking into account the best available information.

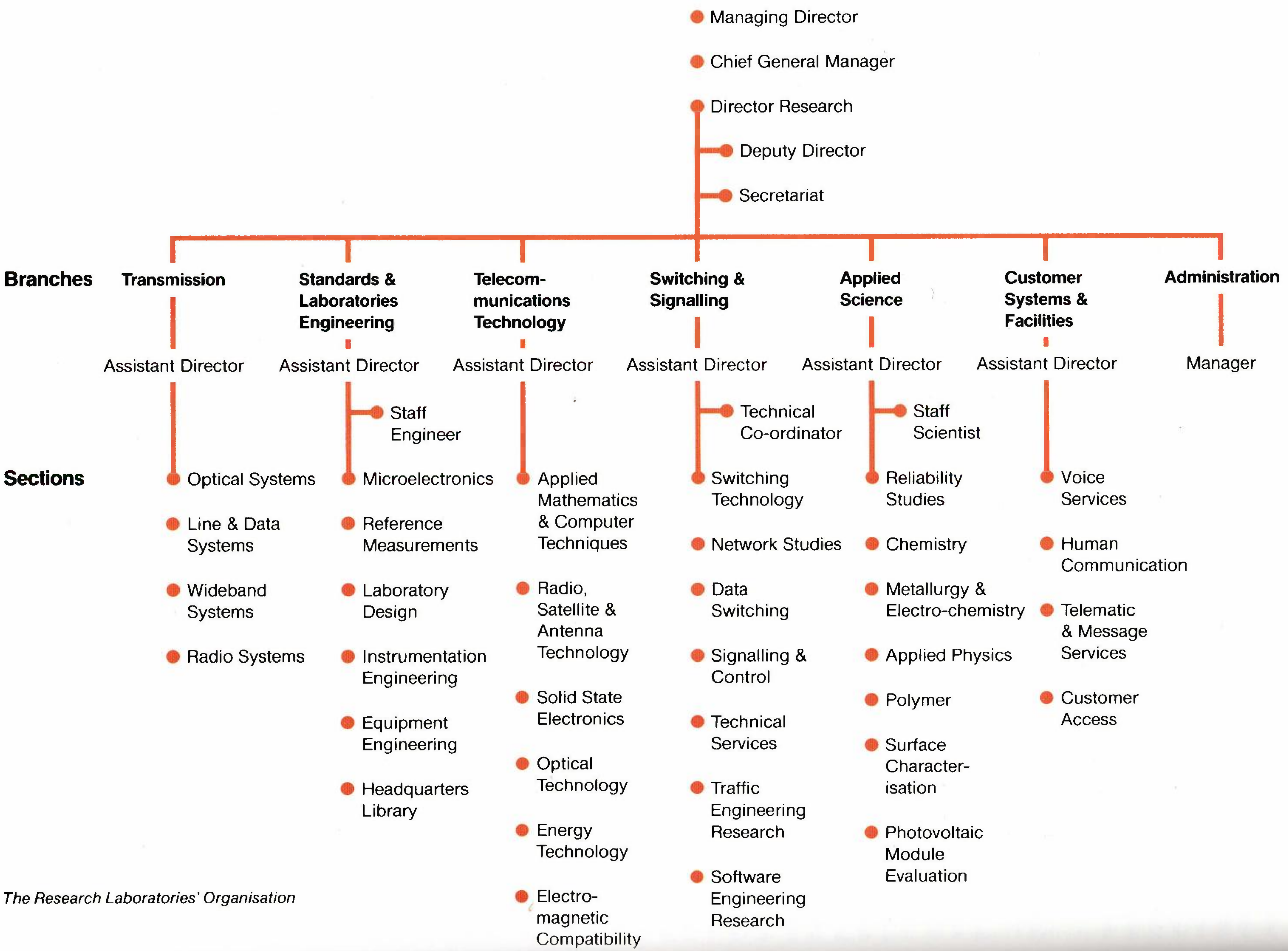
To investigate means of protecting people against possible harmful effects of RF radiation, Telecom has established, with the active participation of the Research Laboratories, an R&D programme. The main objectives of the programme are the development of RF field measurement techniques and thence protective measures against over-exposure, by obtaining better understanding of the health effects of over-exposure and educating Telecom staff appropriately.

From October 1983 till April 1984, Dr. Maria A Stuchly of the Canadian Department of Health and Welfare, worked in the Laboratories as a visiting consultant and provided advice on the biological effects of electromagnetic radiation. With her assistance, workshop sessions were conducted with the Headquarters' Electromagnetic Radiation Working Group, which is responsible for the formulation of safe practices in Telecom for working in RF radiation areas. Regular consultations were also held with the Headquarters' Occupational Health and Safety Unit.

A protocol for conducting RF field surveys in Telecom establishments and the evaluation of RF exposure has been developed.

With the assistance of two engineers from the Research Department and the Broadcasting Directorate, Dr. Stuchly also conducted five two-day training courses in the mainland capital cities for staff involved in RF radiation safety surveys. These courses were also attended by representatives from several external organisations, including the State Departments of Health and the Department of Communication.

Lectures on the biological effects of electromagnetic radiation and radiation from VDU terminals were also held in each State. These lectures were attended by managerial and senior staff of Telecom and representatives of other organisations with interest in these subjects.



The Research Laboratories' Organisation

THE LABORATORIES—SUMMARY INFORMATION

OVERALL OBJECTIVES OF THE LABORATORIES

- Maintain a position at the forefront of knowledge in communications science and technology, in order to provide expert participation in the formulation and implementation of policies for the introduction of advances in science and engineering of relevance to Telecom Australia.
- Conduct specific development and design projects and scientific and engineering investigations related to telecommunications problems.

ORGANISATION

The Research Laboratories are a Department at Headquarters. The Director, Research, heads the Laboratories' organisation. He is responsible to the Chief General Manager, who in turn is responsible to the Managing Director of Telecom Australia. The Laboratories comprise a Secretariat attached to the Director's Office, an Administrative Services Group, and thirty-four scientific and engineering Sections/Groups arranged in six Branches. The scientific and engineering Sections/Groups each possess expertise in particular areas of the telecommunications engineering or science.

PROFESSIONAL AND SENIOR STAFF

The names given below are those of the actual occupants of the positions (appointed or acting) at 31 May 1984.

Director: E.F. Sandbach, AM, BA, BSc, FTS

Deputy Director: R. Smith, BE(Hons), ME, MIEE, SMIREE

Secretariat

Functions
Provide executive assistance to the Director, Research, in the management of the Research Department, in matters relating to:

- corporate planning and work programming
- technical information services and external relationships
- staff development
- industrial property.

Head, Secretariat: F.W. Arter, BEE, MEngSc

Senior Engineers:
L.N. Dalrymple, Dip Elec Eng, Grad IE Aust
O.J. Malone, BEE

Engineer: G.R.G. Smart, Dip Rad Eng, ARMIT, MIREE, MTV Soc Aust

Executive Officer: A.B. Conroy

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

Administrative Services Group

Functions
The Administrative Services Section provides administrative and clerical support to the Laboratories.

This includes information and advice on various matters relating to:

- manpower, organisation and establishment
- budgets, finance and supply and procurement of supplies and services
- staff, industrial and general personnel services, e.g. registry and typing.

Manager, Administration: B.M. Douglas

Senior Planning Officer: T.W. Dillon

Project Officer: B.F. Donovan

Budgets Officer: R.J. Beveridge

Staff Services Co-ordinator: G.N. Galvin

Transmission Branch

Objectives
In the field of transmission, conduct research, exploratory developments, system applications and field experiments, contribute to specifications, assist in the assessment of tenders and provide advice and recommendations as appropriate relating to:
- the technical aspects of signal transmission within the Telecom Australia network
- new transmission systems, and systems which are extensions of present techniques, with particular reference to their integration into the existing network
- mutual compatibility of the various services and systems within the network
- sensitivity studies.

Assistant Director: A.J. Gibbs, BE(Hons), PhD, SMIEEE, SMIREE

Branch Administrative Officer: K.J. Sexton

Radio Systems Section

Functions
- Provide information, advice, consultancy and recommendations as defined in the Branch objectives
- Conduct research into transmission systems which utilise radio bearers
- Investigate the interworking of such systems with other parts of the transmission and switching network
- Investigate and develop appropriate bearer and system testing methods
- Develop appropriate systems and testing apparatus which are not otherwise available.

Section Head: R.P. Coutts, BSc, BE(Hons), PhD, MIEEE

Principal Engineers:
W.S. Davies, BE, MEngSc(Hons), PhD
L.J. Millott, BE(Hons), MEngSc, MIEEE

Senior Engineers:
I.C. Lawson, BEE
A.L. Martin, BE, Grad IE Aust, SMIREE

Engineer: A.M. Brooks, BEE(Hons)

Scientist: J.L. Adams, BSc(Hons), PhD

Senior Technical Officers:
M.J. Durrant
R.L. Reid
J.J. Sekfy
D.J. Thompson

Line and Data Systems Section

Functions
- Provide information, advice, consultancy and recommendations as defined in the Branch objectives
- Conduct research into transmission systems which utilise metallic bearers
- Conduct research in modulation and multiplexing techniques and applications
- Conduct research into methods of data transmission with particular reference to Datel type services and to dedicated data networks
- Investigate the interworking of such systems with other parts of the transmission and switching network
- Investigate and develop appropriate metallic bearer and system testing methods
- Conduct exploratory development of appropriate systems and testing apparatus which are not otherwise available.

Section Head: B.M. Smith, BE(Hons), PhD, MIEEE

Principal Engineers:
P.G. Potter, BE(Hons), PhD
G.J. Semple, BE(Hons), MEngSc

Senior Engineers:
N. Demytko, BE(Hons), BSc, MAdmin
A.J. Jennings, BE(Hons), MEngSc, MIEEE

Engineer: B.R. Clarke, BE(Hons)

Senior Technical Officers:
L.W. Bourchier
R.B. Coxhill
J.L. Kelly
R.I. Webster

Optical Systems Section

Functions
- Provide information, advice, consultancy and recommendations as defined in the Branch objectives
- Conduct research and exploratory development into the transmission characteristics of optical media
- Conduct research into transmission systems which utilise optical media
- Evaluate the potential applications and utilisation of systems using such media for the transmission of telecommunications services in the local, junction and trunk networks
- Investigate the inter-working of such systems with other parts of the transmission and switching network
- Develop and advise on new techniques for the measurement of transmission properties and characterisation of optical systems
- Maintain an awareness of and evaluate and advise on emerging techniques relating to optical systems transmission.

Section Head: R.W.A. Ayre, BE(Hons), BSc(Hons),MEngSc

Principal Engineers:
E. Johansen, BE(Hons), PhD, SMIREE
G. Nicholson, BE(Hons), MEngSc, MIEEE

Senior Engineers:
J.C. Campbell, BE, MEngSc, MIEEE
T.D. Stephens, BE(Hons), MEngSc

Senior Technical Officers:
J.B. Carroll
J.H. Gillies
S.G. Ratten

Wideband Systems Section

Functions

- Provide information, advice, consultancy and recommendations as defined in the Branch objectives
- Conduct research into wideband networks which employ metallic, optical and radio media and systems
- Study and assess access techniques appropriate to wideband media
- Evaluate the potential applications and utilisation of wideband networks for the carriage of existing and emerging telecommunications services
- Maintain and promote an awareness of wideband network developments, and provide consultancy and technical advice of strategic value
- Investigate the interworking of wideband networks with existing and other communication networks
- Conduct experiments, and participate in field trials designed to demonstrate the feasibility of wideband network applications.

Section Head: R.Horton, BSc(Hons), PhD, AMIEE, FIREE

Principal Engineers:
I.M. McGregor, BE(Hons), MEngSc, PhD
A.Y.C. Quan, BE(Hons), ME, AMIEE

Senior Engineers:
F.G. Bullock, BE(Hons)
M.D. Hayes, BE(Hons)
J.G. Hollow, BE(Hons), PhD, MIREE

Engineer: M.J. Biggar, BE(Hons)

Senior Technical Officers:
G. Dhosi
D.A. Jewell
R. Owers

Standards and Laboratories Engineering Branch

Objectives
To ensure a sound scientific basis for all measurements made by and within the Australian Telecommunications Commission by arranging traceability of accuracy of measurement of fundamental engineering and physical quantities to the Australian National Standards.

Conduct studies, exploratory development and field experiments, contribute to specifications and provide advice and recommendations as appropriate relating to:

- development and application of standards of electrical quantity, time and frequency within the field of telecommunications
- telecommunication instrumentation and equipment engineering practices
- development and application of microelectronics components.

Provide a mechanical, electrical and/or electronic equipment development facility for Telecom Australia.

Provide a laboratory design and instrumentation facility for the Research Department.

Provide a comprehensive library service to all Departments and Directorates at Headquarters.

Assistant Director: G.M. Willis, FRMIT, MIE Aust, SMIREE

Staff Engineer: A.J. Stevens, BE, MIEE, MIEEE

Branch Administrative Officer: T.H. Brown

Reference Measurements Section

Functions

- Plan and oversight the implementation, operation and further development of a system of engineering references and calibration facilities for Headquarters and all States
- Operate, maintain and calibrate the Commission's central engineering references in terms of the Australian National Standards of Measurement
- Develop improved engineering references, calibration and measuring techniques and procedures to meet the Commission's developing technology and operational needs
- Develop special techniques, systems and equipment for the application of measurement technology to the solution of engineering plant problems
- Operate as a Verifying Authority and Signatory in accordance with the requirements of the National Standards Commission and the National Association of Testing Authorities
- Liaise with other sections of Telecom Australia to ensure that all standards of reference have an appropriate authenticity of calibration as required by the Weights and Measures Act
- Liaise with other national and international measurement laboratories and authorities, particularly the International Telecommunications Union, Union Radio Scientific Internationale, the Standards Association of Australia and the National Association of Testing Authorities.

Section Head: J.M. Warner, BSc, MIEE

Principal Engineer: R.L. Trainor, BSc

Senior Engineers:
R.W. Harris, BSc(Hons), BE(Hons), BComm
E. Pinczower, Dip Elec Eng, MIE Aust

Engineers:
J.P. Colvin, Dip Elec Eng, BE
D.A. Latin, BE
R.W. Pyke, Dip Elec Eng, BE(Hons), MIE Aust
B.R. Ratcliff, Dip Comm Eng
P. Standaert, BE(Hons)

Senior Technical Officers:
J.B. Erwin
C.R. Flood
A.L. Forecast
J. Freeman
R.H. Yates

Laboratory Design Section

Functions

- Plan and specify, in conjunction with other Telecom Australia staff, accommodation requirements of the Department in future and existing buildings; liaise with construction authorities and contractors as appropriate; plan and co-ordinate the occupation of new accommodation
- Maintain special laboratory buildings, fittings, services and facilities; liaise with Buildings Sub-Division to arrange all buildings and building services, repairs and maintenance required within the Department
- Co-ordinate all safety, security, and fire protection matters within the Department.

Section Head: D.S. Geldard, MIEE, MIE Aust

Engineer: R.J. Day, Dip Elec Eng, Dip Mech Eng, MIE Aust

Senior Technical Officer: J.T. Blake

Instrumentation Engineering Section

Functions

- Study instrumentation trends relevant to present and future Telecom Australia applications; design and develop novel instrumentation systems for specific Telecom Australia needs which cannot be obtained from commercial sources
- Develop and maintain facilities, including calibration standards, required for the calibration and maintenance of advanced laboratory test equipment and apply these facilities to ensure the high standard of performance required of the Research Department's instrumentation
- Conduct the procurement programme for all new equipment for the Department, including preparation of technical specifications, tender evaluations and technical reports; perform acceptance testing of new equipment.

Section Head: A.M. Collins, BSc

Senior Engineers:
G.C. Heinze, Dip Elec Eng, BE
F.R. Wylie, BE, MIEEE

Engineers:
I. Dresser, BE
N.A. Leister, BE, Grad IREE

Senior Technical Officers:
S.P. Curlis
P.J. Dalliston
D.R. Daws
P.S. Dawson
D.C. Diamond
B.K. Eley
K.L. Rogers

Headquarters Library

Functions

- Provide a comprehensive library service to all Departments and Directorates at Headquarters
- Co-operate with State Administrations and provide consultative services in regard to common standards and systems.

Principal Librarian: H.V. Rodd, BA, Dip Lib

Senior Librarian: D.J. Richards, BA, Dip Lib

Librarians:
G. Chua, B App Sc, ALAA
G A. Lawson, BA, Dip Lib, ALAA
M.B. McAllister, BSc(Hons), Dip Lib, ALAA
P. Millist, Dip Lib, ALAA
J.A. Smith, BA, Dip Lib, ALAA
E.M. Spicer, BA, Dip Lib
B.A. Wilson, BA, LLB, Dip Lib

Equipment Engineering Section

Functions

- Conduct research into the application of new materials, components, fabrication and assembly techniques applicable to the design and construction of mechanical, electrical and electronic equipment and tools required within the Research Department and elsewhere in Telecom Australia
- Provide for Telecom Australia a specialist design facility, including mechanical and electromechanical engineering design of the hardware aspects of telecommunications models; arrange for production of these designs within Telecom Australia or industry or, when necessary, within the Section; establish specification criteria for performance and quality, and the necessary measuring equipment, and employ these to ensure adequate performance of the items produced
- Oversight the on-the-job training of apprentice artisans and trainee technical staff in the mechanical engineering field for the Research Department.

Section Head: F. Wolstencroft, CEng, MI Mech E

Senior Engineer: P.F.J. Meggs, Dip Mech Eng, ARMIT, Dip IM, MIE Aust

Engineers:
A.R. Gilchrist, Dip Mech Eng, BE(Hons), Grad IE Aust
W.F. Hancock, Dip Elec Eng, MIE Aust
R. Proudlock, BE

Senior Technical Officers:
J.D. Kisby
D.J. McMillan
W.L. Reiners

Microelectronics Section

Functions

- Conduct research studies into the design and physical realisation of electronic circuitry, in particular that involving miniature and microminiature techniques and components, and into interconnection and mounting of these circuits
- Provide in-house facilities for the production of prototype microelectronic circuits in experimental quantities; specify and develop test criteria and techniques for the control of quality and reliability of these circuits.

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

Principal Engineer: G.J. Barker, Dip Mech Eng, MIE Aust

Senior Engineers:
G.K. Reeves, BSc(Hons), PhD, MIE Aust
H.S. Tjio, BE, Dip Elec Eng

Engineers:
A. Brunelli, BE, MEngSc, MIREE, MIEEE, MISHM
J.L. Chester, BE(Hons), MEngSc
D.R. Richards, BE, MIEEE
S.C. Rockliff, BE(Hons), BSc

Scientist: Z. Slavik, Dip Eng, ARACI

Senior Technical Officers:
G. Brinson
M. Crarey
G. Longridge

Telecommunications Technology Branch

Objectives
Conduct studies, exploratory development and field experiments, provide advice and recommendations, and contribute to equipment specification and assessment relating to:
- the application of newly emerging, extended or improved technologies in telecommunications engineering
- the characteristics and properties of new devices, circuits and techniques in communications applications
- the impact and compatibility of new technology and new applications of existing technology with those already in the Telecom Australia network
- the forecasting and evaluation of developing trends in telecommunications technology particularly suitable for application in Australia.

Maintain and develop liaison with appropriate research establishments in Australia and overseas to provide information and advice on emerging technologies of interest to Telecom Australia.

Assistant Director: P.H. Gerrand, BEng(Hons), MEngSc, MIE Aust, MACS

Branch Administrative Officer: C.J. Chippindall

Applied Mathematics & Computer Techniques Section

Functions
- Provide information, advice and consultancy as defined in the Branch objectives
- Investigate and make recommendations on methods of mathematical analysis and their application to problem solving in telecommunications engineering
- Conduct fundamental studies on, and recommend or implement as appropriate, modelling and simulation methods, as applicable to telecommunications systems and techniques, and related activities
- Investigate and recommend or implement computing techniques and facilities including hardware and software to meet special needs within Telecom Australia.

Section Head: J.V. Murphy, BE(Hons), BA

Principal Engineer: P.J. Tyers, BE(Hons), BSc, MIEEE

Senior Engineers:
P.V. Kabaila, BSc, BE(Hons), PhD
C.D. Rowles, BSc, BE, BCommE, MIEEE

Engineer: L.A.R. Denger, ENSEMN, MIEEE, MSoc Fr de Elec

Senior Technical Officers:
D. Drummond
I.J. Moran

Electromagnetic Compatibility Group

Functions
- Provide information, advice and consultancy as defined in the Branch objectives
- Investigate interference effects of conducted and radiated electromagnetic fields and waves on telecommunications equipment and make recommendations on electromagnetic compatibility as appropriate.

Group Leader: I.P. Macfarlane, Dip Elec Eng, BE, ARMTC, MIEEE

Engineer: S. Iskra, BE(Hons), MIEEE

Senior Technical Officers:
D.M. Farr
B.C. Gilbert

Radio, Satellite & Antenna Technology Section

Functions
- Provide information, advice and consultancy as defined in the Branch objectives
- Conduct research into, and advise on, applications of communications satellite technology in Australia by technique studies, hardware development and experimentation
- Conduct research and exploratory development in the field of freely propagated electromagnetic waves, including the study of antennas for launching and receiving electromagnetic radiation, and make recommendations in relation to the performance and design characteristics of radio communication systems.

Section Head: G.F. Jenkinson, BSc, SMIREE

Principal Engineers:
R.K. Flavin, BSc, MSc
S. Sastradipradja, BE, SMIREE

Senior Engineers:
A.J. Bundrock, BE(Hons)
R.A. Harvey, Dip Rad Eng, BSc, MIREE

Engineers:
P.R. Murrell, BE
E. Vinnal, BE(Hons)

Senior Technical Officers:
D.K. Cerchi
R.J. Francis
S.J. Hurren
B.W. Thomas, BA

Solid State Electronics Section

Functions
- Provide information, advice and consultancy as defined in the Branch objectives
- Undertake fundamental investigations into solid state electronics, including the exploratory development and fabrication of devices and circuit elements which have functions based on the exploitation of special material properties
- Develop and provide specialised facilities in the field of solid state electronic materials and devices arising from the above.

Section Head: G.L. Price, BSc(Hons), DPhil, FAIP, MAPS, MIEEE

Principal Scientist: P.C. Kemeny, BSc(Hons), PhD, Grad APS

Senior Engineer: J. Hubregtse, Dip Comm Eng, MIREE

Senior Scientist: B.J. Linard, BSc(Hons), PhD, Grad AIP

Scientist: B.F. Usher, BSc(Hons), Dip Ed, PhD, MAIP

Senior Technical Officers:
R. Garner
F. Gigliotti

Energy Technology Section

Functions

- Provide information, advice and consultancy as defined in the Branch objectives
- Undertake fundamental investigations into energy, its sources, conversion, storage, utilisation and conservation, including electrical and thermal forms for both stationary and mobile applications
- Evaluate and make recommendations on the potential impact of changing energy technology on Telecom's operations
- Undertake the design, exploratory development and experimental assessment of new devices and techniques for power generation and cooling, and make recommendations on their application in Telecom's operations, particularly in remote areas.

Section Head: N.F. Teede, BE(Hons), PhD, Dip Mgt

Senior Engineers:
N.F. Fourikis, Dip Rad Eng, MSc, ARMIT
D.J. Kuhn, BE(Hons), MEngSc

Scientists:
S. Goh, BSc, MSc, PhD
S. Hinckley, BSc(Hons)

Senior Technical Officer: E.D.S. Fall

Optical Technology Section

Functions

- Provide information, advice and consultancy as defined in the Branch objectives
- Undertake fundamental investigations into the generation, amplification, modulation, detection and waveguiding of coherent electromagnetic radiation having submillimetre or shorter wavelengths, and into techniques or phenomena which can effect the propagation characteristics of such radiation
- Investigate and advise on active passive circuit configuration of opto-electronic devices and their application in telecommunication systems.

Section Head: P.V.H. Sabine, BSc, BE(Hons), PhD

Principal Engineers:
Y.H. Ja, BE, PhD, MAOS
G.E. Rosman, BEE, ME

Senior Engineers:
M. Kwietniak, BSc, MEngSc, PhD, MIEEE, MAPS
G.O. Stone, BE(Hons), MEngSc, PhD, MIEEE, MIREE

Engineer: A.M. Duncan, BSc, BE(Hons)

Senior Technical Officers:
B.P. Cranston
P.F. Elliott

Switching and Signalling Branch

Objectives

In the fields of switching and signalling, conduct studies, exploratory development and field experiments, contribute to specifications and provide advice and recommendations as appropriate relating to:

- technical aspects of switching and signalling within the Telecom Australia network
- new switching and signalling systems which use extensions of present techniques, or new techniques with particular reference to their integration into the existing network
- compatibility of switching and signalling systems
- cost sensitivity studies
- traffic engineering.

Assistant Director: F.J.W. Symons, BE(Hons), PhD, DIC, MIE Aust, AIEE

Technical Co-ordinator: J.L. Snare, BE(Hons), MEngSc

Branch Administrative Officer: S.J. Chalk

Network Studies 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 future systems in relation to network needs
- Provide specialist consultative advice and assistance in relation to the progressive integration of new switching systems into Telecom Australia's networks
- Examine requirements for switching and signalling systems in future environments and conduct feasibility studies of possible approaches.

Section Head: R.J. Vizard, Dip Elec Eng, BEE

Principal Engineer: M.A. Hunter, BE(Hons), MIE Aust

Senior Engineers:
J. Billington, BE(Hons), MEngSc, MIEEE
K.S. English, BE(Hons), MEngSc, MIEEE

Engineers:
N.D. Kim, BChemE(Hons), Dip Data Proc
U.T. Nguyen, BEE, PhD
M.C. Wilbur-Ham, BE(Hons)

Research Officer: G.R. Wheeler, BSc(Hons), MSc

Signalling and Control Section

Functions

- Study the characteristics and potential of new approaches in the field of control and signalling
- Develop models to validate theoretical studies of new control signalling systems and techniques
- Conduct field trials to assess the performance of new approaches and techniques in the field of control and signalling
- Provide specialist consultative advice in matters pertaining to control and signalling.

Section Head: M. Subocz, BE, MIE Aust

Principal Engineer: B.T. Dingle, Dip Elec Eng, BE(Hons)

Senior Engineers:
P.R. Hicks, BE, BSc, MEngSc
G.K. Millsteed, Dip Elec Eng, BE(Hons)

Engineer: H.K. Cheong, BE(Hons), PhD

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

Research Officer: I.P.W. Chin, BSc(Hons), AIEE

Data Switching Section

Functions

- Provide specialist advice, consultation, information and recommendations in relation to data switching systems, networks and techniques
- Maintain an awareness of, and evaluate and advise on the characteristics and potential of new approaches in the field of data switching systems, networks and techniques and their impact on existing networks
- Develop models to validate theoretical studies of new data switching systems, networks and techniques
- Contribute to the development of standards for data communication networks and participate in their use and application
- Investigate and advise on the interworking of data switching networks with other networks.

Section Head: J.L. Park, BE(Hons), MEngSc, SMIEEE

Principal Engineer: G.J. Champion, BE

Senior Engineers:
G.J. Dickson, BE(Hons), MEngSc, MIEEE
J.C.N. Ellershaw, BSc, BE(Hons), PhD, MIEEE
C.J. O'Neill, BE(Hons)

Engineers:
P.A. Evans, BE(Hons)
G.A. Foers, BE(Hons)
K.T. Ko, BE(Hons), MIEEE
G.S. Ong, BE(Hons), BSc

Traffic Engineering Research Section

Functions

- Serve as a national reference authority for traffic engineering theory and education
- Investigate the traffic characteristics and traffic capacity of new switching and signalling systems adopted or being considered for adoption by Telecom
- Recommend traffic performance standards for and contribute to specifications for new switching and signalling systems being considered for adoption by Telecom
- Serve as a consultant for the dimensioning of special systems and networks for Telecom's larger customers
- Maintain a constant review of world developments in traffic theory and its application to telecommunications networks.

Section Head: J. Rubas, Dip Rad Eng, ARMTC, MIE Aust

Senior Engineers:
R.J. Harris, BSc(Hons), PhD
R.E. Warfield, BE(Hons), PhD

Engineer: A. Hopson, BE(Hons)

Senior Research Officer: M. Rossiter, BSc(Hons)

Research Officer: S. Choy, BSc

Technical Services Section

Functions

- Provide field and laboratory planning, provisioning, investigational, developmental, production, testing and evaluation support for Branch activities
- Install, operate and maintain equipment in field experiments.

Section Head: W. McEvoy, AAIM

Senior Technical Officers:
R.L. Backway
S. Dovile
P. Ellis
H.G. Fegent
L.P. Lucas
P.C. Murrell
M. Schultz
B.J. Wilson

Software Engineering Research Section

Functions

- Conduct research and investigations and develop new techniques in fundamental areas of the application of computer systems to telephony and data switching and signalling
- Study the characteristics and potential of new approaches in the field of SPC programming and software technology
- Participate in the design and assessment of laboratory and field trials of new switching and signalling systems using novel software engineering and programming techniques
- Provide an SPC system programming and software specification, analysis, design, production and testing capability for the Switching and Signalling Branch
- Make recommendations concerning the provision of the Branch processor complex, provide a comprehensive software support capability, and co-ordinate the day to day operation of the Branch processor complex
- Provide specialist consultative advice and assistance in relation to the progressive integration of new SPC programming and software technology into the network.

Section Head: R.H. Haylock, MACS

Senior Computer Systems Officers:
R. Liu, BSc(Hons), Dip Comp Sc, AACS
G.P. Rochlin, BSc, MACS
E.M. Swenson, MSc, Dip Data Proc, MAIP, MACS

Computer Systems Officers:
J.B. Cook, BSc(Hons), AACS
C. Fidge, B App Sc
J.A. Gilmour, B App Sc
D.M. Heagerty, B.Tech(Hons)
B. Nigli, BSc
H. Stein, Diplom-Informatiker

Switching Technology

Functions

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

Section Head: R.A. Court, BE(Hons), BSc, MEngSc, SMIEEE, SMIREE

Senior Engineers:
D.M. Harsant, BE(Hons)
E. Tirtaatmadja, BE, MIEEE

Engineers:
B.W. Keck, BSc(Hons), BE(Hons) PhD
R.A. Palmer, BE, PhD

Scientist: C.J. Scott, B App Sc, Grad AIP

Applied Science Branch

Objectives

Conduct studies, exploratory development and field experiments, contribute to specifications, assist in the assessment of tenders and provide advice and recommendations, as appropriate, relating to:

- the properties of materials, components and equipment
- the causes of degradation and failure, and the establishment of remedial measures
- the influence of the environment on staff and plant and the required protective measures
- the development and application of new materials and of new scientific test methods
- the reliability of components and devices
- participation in committees, conferences, etc., both national and international, and liaison with universities and research organisations.

Assistant Director: R.D. Slade, Dip Met, MIM, FIM, MAIMF

Staff Scientist: G. Flatau, Dip App Sc, FRMIT

Principal Engineer: A.M. Fowler, MIE Aust

Branch Administrative Officer: M.A. Chirgwin

Surface Characterisation Group

Group Leader: J.R. Lowing, Dip Sec Met

Scientist: C.G. Kelly, B App Sc, AAIP, MAXAA, MAXS

Solar Module Evaluation Group

Group Leader: D. McKelvie, BSc(Hons)

Senior Scientist: A.J. Murfett, BSc(Hons)

Senior Technical Officer: R.R. Leschinski

Reliability Studies Section

Functions

- Provide information, advice and consultancy as defined in the Branch objectives
- Conduct exploratory research and investigation into the reliability of components, devices and assemblies to the depth necessary to enable this scientific knowledge to be applied to the solution of Telecom Australia's problems
- Conduct scientific studies into the causes of failure or degradation of components, devices and assemblies
- Conduct research leading to the statistical prediction of the life expectancy of components, devices and assemblies
- Design and develop specialised test equipment
- Develop special analytical techniques for failure analysis
- Conduct scientific studies into the properties of materials and components.

Section Head: G.G. Mitchell, BSc(Hons), MSc

Senior Scientist: J. Thompson, BA(Hons)

Scientists:
S.J. Charles, B App Sc
J.R. Godfrey, Dip Met
P. McNamara, BSc, BSc(Hons), MSc, PhD
T.P. Rogers, B App Sc

Senior Technical Officers:
R.A. Galey
J.M.F. Pidoto
R.W. Rydz

Metallurgy and Electro-Chemistry Section

Functions

- Provide information, advice and consultancy as defined in the Branch objectives
- Conduct exploratory research and investigation in the fields of metallurgy and electro-chemistry to the depth necessary to enable this scientific knowledge to be applied to the solution of Telecom Australia's problems
- Perform scientific studies involving electrochemical phenomena in the fields of corrosion and electrical power sources
- Conduct scientific studies into the properties of metals and alloys and their application
- Develop appropriate test methods and specialised equipment as required
- Conduct research into surface phenomena and electro-deposition; develop practices for the satisfactory protection of equipment and plant.

Section Head: K.G. Mottram, Dip Met Eng

Senior Scientist (Metallurgy Group): T.J. Keogh, Dip Sec Met

Senior Scientist (Electro-Chemistry Group): J.J. Der, BSc, ARACI

Scientists:
P.A. Galvin, Dip Sec Met
P.J. Gwynn, Dip App Chem

Senior Technical Officers:
F.M. Hamilton
G.C. Healey
M. Jorgensen

Chemistry Section

Functions

- Provide information, advice and consultancy as defined in the Branch objectives
- Conduct exploratory research and investigations in the field of chemistry to the depth necessary to enable this scientific knowledge to be applied to the solution of Telecom Australia's problems
- Conduct scientific studies into chemical phenomena and hazards
- Develop specialised techniques and equipment for the analysis of materials
- 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 material and consumer products.

Section Head: F.C. Baker, Dip App Chem, Dip Chem Eng, ARACI, AAIST, C Chem, MRSC

Senior Scientist: R.N.M. Barrett, BSc(Hons), C Chem, MRSC

Scientists:
T.J. Elms, Dip App Sc, Dip Anal Chem, Grad RACI
P.W. George, Dip App Sc, Grad RACI
F.M. Petchell, Dip App Chem, ARACI

Senior Technical Officer: R.R. Pierson, Dip Res Cons Stud, MAIST

Polymer Section

Functions
- Provide information, advice and consultancy as defined in the Branch objectives
- Conduct exploratory research and investigation in the chemistry and application of polymeric and associated materials to the depth necessary to enable this scientific knowledge to be applied to the solution of Telecom Australia's problems
- Carry out scientific studies of the properties of polymeric materials and develop methods for their application
- Develop polymer materials with special properties for particular applications as required
- Develop appropriate test methods and specialised equipment as required.

Section Head: H.J. Ruddell, Dip App Chem, FPIA, ARACI

Senior Scientists:
D.J. Adams, Dip App Chem, Grad RACI
B.A. Chisholm, Dip App Chem, MSc, Grad RACI, Grad PRI

Scientists:
R.J. Boast, Dip App Chem, Dip Pol Sc, Grad RACI
G.I. Christiansz, BSc(Hons), Dip Ed, PhD
S.J. Foulks, BSc(Hons), PhD
S. Georgiou, B App Sc, Dip Anal Chem
P.R. Latoszynski, Dip App Sc, Dip Anal Chem, Grad RACI

Senior Technical Officer: D. Coulson

Applied Physics Section

Functions
- Provide information, advice and consultancy as defined in the Branch objectives
- Conduct exploratory research and investigation in the field of physics to the depth necessary to enable this scientific knowledge to be applied to the solution of Telecom Australia's problems
- Conduct scientific studies into the physical properties of materials and components
- Conduct research into the effects of the natural and man-made environment on staff and plant; devise means of protection from any deleterious influences
- Conduct research into high voltage phenomena and its effect on staff and plant; devise protection methods as appropriate
- Design and develop specialised testing and measuring equipment as required.

Section Head: I.A. Dew, BSc, MSc

Senior Engineer: I.K. Stevenson, B App Sc, Dip Elec Eng, Grad AIP, Grad IE Aust

Senior Scientists:
E.J. Bondarenko, Dip App Phys, B App Sc, LAIP, SMIREE, FRAS
G.W.G. Goode, BSc

Scientists:
E. Gibbs, BSc(Hons)
D.E. Thom, BSc, Dip Ed, Dip Proc Comp Systems

Engineer: P.W. Day, BE

Senior Technical Officers:
M.C. Hooper
S.R. McAllister
I.M. Tippett

Customer Systems and Facilities Branch

Objectives
In the field of customer services and systems, conduct research, exploratory development and field experiments, contribute to specifications, assist in the assessment of tenders, and provide other advice and recommendations as appropriate relating to:
- user needs for telecommunication services, considering both human and technical aspects
- for the evolving Telecom network, the application of network-based facilities to support customer requirements including service combination and interworking
- technical and human aspects relating to efficient network and service access procedures, and end-to-end performance criteria
- structured techniques for modelling telecommunication services.

Assistant Director: R.J. Morgan, BSc(Hons), PhD

Branch Administrative Officer: H.Merrick

Voice Services Section

Functions
- Provide information, advice and consultancy as defined in Branch objectives
- Conduct theoretical and experimental research into techniques relating to the generation, synthesis, transmission, reception, recognition, measurement and characterisation of speech signals for telecommunication services
- Develop quality assessment techniques and associated reference standards for services incorporating speech processing, and make recommendations on their performance criteria
- Conduct investigations into audio frequency acoustic signal propagation and noise in relation to the provision of voice communications services.

Section Head: E.J.Koop, Dip Elec Eng, BE, MAAS

Principal Engineers:
P.F. Duke, Dip Maths, BTech
R.A. Seidl, BE(Hons), PhD

Engineers:
N.H. Duong, BE
J.P. Goldman, Dip Rad Eng, Dip Comm Eng, Grad IE Aust
P.L. Nicholson, BE, MIEEE
P. Nuutila, MSc
J.S. Spicer, BE(Hons)

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

Customer Access Section

Functions
- Provide information, advice and consultancy as defined in the Branch objectives
- Conduct theoretical and experimental research into the techniques of providing customer access to a multiservice telecommunication environment, including Integrated Services Digital Networks (ISDNs)
- Evaluate emerging international standards on ISDN customer access and related customer system issues
- Conduct studies into the interworking of Telecom's networks with customer systems and networks.

Section Head: N.Q. Duc, BE(Hons), PhD, SMIREE, MIEEE

Senior Engineers:
D.M. Blackwell, BE
P.I. Mikelaitis, BE, MEngSc, MIEEE

Engineer: B. McGlade, BE(Hons)

Telematic and Message Services Section

Functions

- Provide information, advice and consultancy as defined in the Branch objectives
- Conduct theoretical and experimental research into message based services
  Conduct theoretical and experimental research into interactive data base services, including electronic directory services
- Conduct theoretical and experimental research into interworking between these service types
- Develop structured models of telematic and message based service types.

Section Head: P.S. Jones, BE, MEngSc

Principal Engineers:
K.F. Barrell, BE(Hons), PhD
E.K. Chew, BE, MEngSc, PhD, Grad IE Aust

Senior Engineers:
R. Exner, BSc, BE(Hons), M App Sc, MIEEE
D.Q. Phiet, BE(Hons), PhD

Engineers:
A.H. Al Tarafi, BSc(Hons), PhD
M. Blakey, BE(Hons), MEngSc

Senior Technical Officers:
B.W. Booth
P.D. Jackson
A.M. McDonald

Human Communication Section

Functions

- Provide information, advice and consultancy as defined in the Branch objectives
- Undertake theoretical and experimental research into the processes of human communication over telecommunication networks, including user perceived end-to-end performance
- Conduct theoretical and experimental research into the human and related technical aspects of the procedures required to efficiently access services and facilities
- Develop models for describing user attributes and perceived needs, and for classifying telecommunication services
- Conduct studies into the needs of communities and organisations for telecommunication services.

Section Head: G.D.S.W. Clark, BEE(Hons), MSc, MIE Aust

Principal Engineer: J.K. Craick, BE(Hons), BSc

Senior Engineer: A.R. Jenkins, Dip Comm Eng, ARMIT

Engineer: P.H. Newland, BE

Senior Psychologist: L. Perry, BA(Hons), MAPS

Psychologist: S. Lindgaard, BSc(Hons)

Senior Technical Officers:
A.H. Borg
D.R. Potter

PAPERS, LECTURES, TALKS AND REPORTS

Research Laboratories Reports are the vehicles by which the results of research studies and investigations, development projects and other specialised tasks undertaken in the Laboratories are officially documented. The staff of the Laboratories also contribute papers to Australian and overseas scientific and technical journals and present papers to learned societies both in Australia and overseas. This list shows the papers, lectures, talks and reports presented or published during the last 12 months.

Papers

Albertson, L.A. & Perry, L.	"Configuration or Channel? A Challenge to the Type Allocation Model as a Basis for Teleconferencing Research and Design", 10th International Symposium on Human Factors in Telecommunications, Helsinki, Finland, June 1983.
Baker, F.C.	"Preparative Uses of RF Plasmas for Analysis", Seventh Australian Symposium on Analytical Chemistry, University of Adelaide, August 1983.
Baker, F.C., Elms, T.J. & Eva, B.C.	"Prediction of Additive Losses from Plastics by Thermo-gravimetry", Seventh Australian Symposium on Analytical Chemistry, University of Adelaide, August 1983.
Barrell, K.F.	"The Graphical Kernel System - A Replacement Core", First Australian Conference on Computer Graphics, NSW Institute of Technology, Sydney, August 1983.
Billington, J.	"Abstract Specification of the ISO Transport Service Definition Using Labelled Numerical Petri Nets", 3rd International Workshop on Protocol Specification, Testing and Verification, Zurich, May-June 1983.
Billington, J.	"Specification and Analysis of the ISO Transport Service Definition, DIS 8072", 4th European Workshop on Applications and Theory of Petri Nets, Toulouse, France, September 1983.
Billington, J. & Wilbur-Ham, M.C.	"A Petri Net Based Protocol Emulation and Analysis Tool", 4th European Workshop on Applications and Theory of Petri Nets, Toulouse, France, September 1983.
Billington, J.	"Abstract Specification of the ISO Transport Service Definition using Labelled Numerical Petri Nets", SDL Newsletter No. 6, January 1984.
Bondarenko, E.J. & Clark, R.A. (Engineering Department)	"Hazards to Occupants in Buildings from Potential Differences Caused by Lighting", SAA Seminar on AS1768-1983, Lightning Protection, Melbourne, November 1983.
Brunelli, A., Rowles, C.R. & Reeves, G.K.	"Screen Printed Contacts to Silicon Solar Cells", IREE Convention, Sydney, September 1983.
Brunelli, A.	"A Flexible Automatic Plating System for Prototype Plated-through-Hole (PTH) Printed Boards", Internepcon 1983, Brighton, England, October 1983.
Campbell, J.C.	"Digital Radio Outage Prediction with Space Diversity", Electronics Letters, Vol. 19, No. 23, November 1983.
Chew, E.K.	"Interconnection of Local Area Networks and Public Networks", 1983 Australian Computer Engineering Symposium-1, University of Newcastle, New South Wales, August 1983.
Chew, E.K. & Subocz, M.	"An Introduction to the CCITT No. 7 Common Channel Signalling System", The Journal of Electrical and Electronics Engineering, Australia, Vol. 3, No. 3, September 1983.
Chew, E.K.	"Principles of Network Interworking", IREE Convention, Sydney, September 1983.
Chew, E.K. & Duc, N.Q.	"ISDN Customer Access", IREE Convention, Sydney, September 1983.
Chew, E.K.	"Internetworking : Local Area Networks and Public Networks", 10th Australian Computer Conference, Melbourne, September 1983.
Chin, I.P.W.	"The Australia Japan Field Trial of CCITT No. 7 Signalling System", Telecommunication Journal of Australia, Vol. 33, No. 3, 1983.
Craick, J.K.	"An Overview: Non-Technological Studies for a Multiservice Future", Deakin University, Geelong, November 1983.
Davies, W.S. & Wende, D.	"Urban Atmospheric Communication Systems at Centimetre and Shorter Wavelengths", IREE Convention, Sydney, September 1983.

Denger, L.A. & Tyers, P.J.	"A Study of Optimisation in ARQ Satellite Circuits", IREE Convention, Sydney, September 1983.
Der, J.J. & Gwynn, P.J.	"Evaluation of the Determination of Soldering Flux Resistance using Rectangular and Circular Test Cells", Brazing and Soldering, No. 5, Autumn 1983.
Dew, I.A. & Thom, D.	"Control and Monitoring of an Environmental Chamber-Complex", Conference on Computers and Engineering 1983, Sydney, August/September 1983.
Dickson, G.J.	"Open Systems Interconnection Network Layer", Technical Meetings, IREE Adelaide Group, Adelaide, July 1983.
Duc, N.Q. & Chew, E.K.	"Trends Towards Integrated Service Digital Networks", 10th Australian Computer Conference, Melbourne, September, 1983.
Duc, N.Q. & Chew, E.K.	"ISDN - A Unified Approach to Telecommunications", IREE Convention, Sydney, September 1983.
Ellershaw, J.C. & Park, J.L.	"Data Communications", Australian Computer Education Conference, Latrobe University, May 1983.
Ellershaw, J.C.	"Methods of Interworking Between Private and Public Data Networks", IREE Convention, Sydney, September 1983.
English, K.S. & Vizard, R.J.	"Multiservice Switching in the ISDN", IREE Convention, Sydney, September 1983.
Flavin, R.K. & Murrell, P.R.	"Low Cost Microwave Component Design", IREE Convention, Sydney, September 1983.
Frueh, P.F.	"Image Messaging for Business Applications", 1st Australasian Conference on Computer Graphics 1983, NSW Institute of Technology, Sydney, August/September 1983.
Gerrand, P.H. & Symons, F.J.W.	"Current Status of the ISO/CCITT Reference Model for Open Systems Interconnection and its Associated Protocols and Services", Telecommunication Journal of Australia, Vol. 33, No. 1, 1983.
Gerrand, P.H.	"An Overview of the Uses of Computer Control in Telecom Switching Systems: Current Status and Future Directions", 1983 Australian Computer Engineering Symposium-1, University of Newcastle, New South Wales, August 1983.
Gibbs, A.J. Smith, B.M. & Campbell, J.C.	"The Cyclostationary Nature of Crosstalk Interference from Digital Signals in Multipair Cable - Part I : Fundamentals", IEEE Transactions on Communications, Vol. COM-31, No. 5, 1983.
Gibbs, A.J. Smith, B.M. & Campbell, J.C.	"The Cyclostationary Nature of Crosstalk Interference from Digital Signals in Multipair Cable - Part II : Applications and Further Results", IEEE Transactions on Communications, Vol. COM-31, No. 5, 1983.
Hand, T.J.	"A Hail Gun Velocity Measuring System", IREE Convention, Sydney, September 1983.
Harris, R.J.	"Comparison of Network Dimensioning Models", 10th International Teletraffic Congress, Montreal, June 1983.
Ja, Y.H.	"Using the Shooting Method to Solve the Nonlinear Coupled-Wave Equation in Degenerate Four-Wave Mixing", The International Conference on Laser 1983, Guangzhov, Guangdong Province, China, September 1983.
Ja, Y.H.	"Using the Shooting Method to Solve Boundary-value Problems Involving Nonlinear Coupled-Wave Equations, Part 1: Degenerate Two-Wave Mixing", Optical and Quantum Electronics, 15, September 1983.
Ja, Y.H.	"Using the Shooting Method to Solve Boundary-value Problems Involving Nonlinear Coupled-Wave Equations, Part 2: Degenerate Four-Wave Mixing", Optical and Quantum Electronics, 15, September 1983.
Ja, Y.H.	"Numerical Study of Energy Transfer Between a Beam and its Internal Reflection Component in a Non-Linear Medium", Applied Physics B, January 1984.
Ja, Y.H.	"Real-time Image De-blurring using Four-Wave Mixing", Optical and Quantum Electronics, 15, September 1983.
Ja, Y.H.	"On the Approximate Formulae and the Exact Method to Compute Wave Front Reflectivity in Degenerate Four-Wave Mixing", Applied Physics B, February 1984.
Jennings, A.J.	"Switched-Capacitor Equaliser Structures for a Digital Telephone" Australian Telecommunication Research, Vol. 17, No. 2, 1983.
Jennings, A.J.	"Switched-Capacitor Equaliser Structures", IREE Convention, Sydney, September 1983.

Kirton, P.A.	"The Data Communications Transport Service and Protocols", Telecommunication Journal of Australia, Vol. 33, No. 3, 1983.
Ko, K.T.	"Review of Multiple Access Protocols for Satellite Data Communication", IREE Convention, Sydney, September 1983.
Lowing, J. & Kelly, C.G.	"Introduction to Secondary Iron Mass Spectrometry", The Fifth Australasian School and Conference on X-Ray Analysis, Melbourne, May 1983.
McGlade, B.J. & Ellershaw, J.C.	"Co-Channel Interference in a Digital Radio Concentrator System", IREE Convention, Sydney, September 1983.
McKelvie, D.	"Evaluation of Photovoltaic Modules for Use in Australian Conditions", NERDDC Workshop on Remote Area Power Supply, Canberra, May 1983.
Martin, A.L., Coutts, R.P. & Campbell, J.C.	"Results of a 16 QAM, 140 Mbit/s Digital Radio Field Experiment", International Communication Conference, Boston, USA, July 1983.
Martin, A.L., Coutts, R.P. & Campbell, J.C.	"140 Mbit/s Digital Radio Field Experiment", IREE Convention, Sydney, September 1983.
Millott, L.J.	"The Effect of Channel Filtering on Data Transmission Employing Class 4 Partial Response Coding and SSB Modulation", Archiv fur Elektronik und Ubertragungs Technik, Electronics and Communication, Band 35, Heft 11, November 1981.
Mottram, K.G. & de Boer, B.T. (Engineering Department)	"Use of Plain Copper Conductors in Lieu of Tinned-Copper for Internal Cables", The 32nd International Wire & Cable Symposium, New Jersey, USA, November 1983.
Murphy, J.V.	"Determination of Minimum-cost Interference Between Services Sharing the Same Frequency Band", Annales des Telecommunications, Vol 37, Nos. 9-10, September/October 1982.
Murphy J.V.	"Interference to Satellite Earth Stations Due to Scatter of Terrestrial Transmission by Aircraft", Australian Telecommunication Research, Vol. 17, No. 1, 1983.
Nicholson, G.	"Modulation Techniques for Cable Television Distributed on Optical Fibres" Australian Telecommunication Research, Vol. 17, No. 2, 1983.
O'Neill, C.J. & Billington, J.,	"Proposed Abstract Specification of the Network Service Definition", SDL Newsletter No. 6, January 1984.
Perry, L.	"Teleconferencing Research at Telecom Australia", Media Information Australia, No. 28, May 1983.
Reeves, G.K. & Harrison, H.B. (RMIT)	"Polysilicon-Silicon Contacts for VLSI Applications", IREE Convention, Sydney, September 1983.
Reeves, G.K. & Harrison, H.B. (RMIT)	"Specific Contact Resistance Measurements on Multi-Layer Interconnect Structures", Materials Research Society Symposium, Boston, USA, November 1983.
Reeves, G.K. & Harrison, H.B. (RMIT)	"Low Ohmicity Contacts to Scaled Silicon Devices", Journal of Electrical and Electronic Engineering Australia, Vol. 3, No. 4, December 1983.
Reeves, G.K. & Harrison, H.B. (RMIT)	"Ohmic Contacts Formed on Single and Poly-crystalline Silicon using Ion Implantation and Low Temperature Annealing", IEEE Electronic Development Letters, Vol. EDL-5, No. 2, February 1984.
Rubas, J.	"Another Approach to Estimation of Traffic Load", 10th International Teletraffic Congress, Montreal, Canada, June 1983.
Ruddell, H.J. & Board, B.L.	"Investigation of Premature Depletion of Stabilisers from Solid Polyethylene Insulation", Telecommunication Journal of Australia, Vol. 33, No. 2, 1983.
Ruddell, H.J., Adams, D.J., Latoszynski, P. & de Boer, B.T. (Engineering Department)	"Behaviour of Four Non-Migratory Antioxidants in Solid Polyethylene Insulation", The 32nd International Wire & Cable Symposium, New Jersey, USA, November 1983.

Sastradipradja, S. & Lobert, W.	"Inter-Coupling between Co-sited Antennas", IREE Convention, Sydney, September 1983.
Seidl, R.A.	"A Tutorial Paper on Medium Bit Rate Speech Coding Techniques", Australian Telecommunication Research, Vol. 17, No. 1, 1983.
Smith, R. & Millott, L.J.	"Synchronisation and Slip Performance in a Digital Network", The Radio and Electronic Engineer, February 1984.
Snare, J.L.	"An Introduction to the CCITT Recommendation X.25", Telecommunication Journal of Australia, Vol. 33, No. 2, 1983.
Snare, J.L., Dickson, G.J. & O'Neill, C.J.	"Use of Public X.25 Services to Support the OSI Network Service", IREE Convention, Sydney, September 1983.
Symons, F.J.W.	"Organisation of the International Data Communications Standards Seminar", Telecommunication Journal of Australia, Vol. 16, No. 3, 1982.
Symons, F.J.W	"Overview of Developments in the Key Features of Public Telecommunication Networks and Their Relevance to the Seminar", International Standards for Digital Telecommunications Networks Seminar, Melbourne, May 1983.
Symons, F.J.W. & Park, J.L.	"The Role of Computer Engineering in Switching and Signalling Investigations in the Telecom Australia Research Laboratories", 1983 Australian Computer Engineering Symposium-1, Newcastle University, August 1983.
Thompson, J. & Galey, R.A.	"Electromigration Failure Rate Measurements on Standard Integrated Circuits", IREE Convention, Sydney, September 1983.
Thompson, J., Rogers, T. & Galey, R.A.	"Non-Destructive Internal Characterisation of CMOS Integrated Circuits as a Reliability Analysis Tool", IREE Convention, Sydney, September 1983.
Thompson, J., Rogers, T. & Galey, R.A.	"A Non-Destructive Method of Monitoring Internal Parameter Drifts in CMOS Integrated Circuits", Australian Telecommunication Research, Vol. 17, No. 2, 1983.
Thompson, J.	"Semi-Conductor Physics - An Introduction", Book Review, Telecommunication Journal of Australia, Vol. 33, No. 3, 1983.
Warfield, R.E. & Foers, G.A.	"Application of Bayesian Methods to Teletraffic Measurement and Dimensioning", 10th International Teletraffic Congress, Montreal, Canada, June 1983.
Wheeler, G.R., Symons, F.J.W. & Billington, J.	"Description of Numerical Petri Nets", SDL Newsletter No. 6, January 1984.
Wilbur-Ham,M.C. & Billington, J.	"A Protocol Emulation and Analysis Tool", IREE Convention, Sydney, September 1983.
Wragge, H.S.	"Effective Management of Multi-disciplinary Teams", Conference on Engineering Management, Brisbane, July 1983.
Wragge,H.S.	"Recent Advances in Interpersonal Communication Technology", Communication and Government Conference, Canberra College of Advanced Education, Canberra, July 1983.

Lectures and Talks

Ayre, R.W.A.	"Measurement of Longitudinal Strain Imposed on Optical Fibre Cables During Installation", 8th Optical Communications Workshop, Adelaide University, December 1983.
Barrell, K.F.	"Current Developments in International Standards for Computer Graphics", ADP Branch of Bureau of Meteorology, October 1983.
Billington, J.	"Example of Verification", Communication and Networks Lecture, Monash University, July 1983.
Billington, J.	"NPN-Example of Specification", Communication and Networks Lecture, Monash University, July 1983.
Billington, J.	"Petri Nets/NPNs", Communication and Networks Lecture, Monash University, July 1983.
Billington, J.	"Transport Service", Communications and Networks Lecture, Monash University, June 1983.
Chew, E.K.	"Overview of ISO Reference Model", Communication and Networks Lecture, Monash University, June 1983.
Chew, E.K.	"Principles of Network Interworking", Local Area Networks Seminar, Warren Centre, Sydney University, October 1983.
Coutts, R.P.	"Digital Radio", IREE Melbourne Division, Melbourne, November 1983.
Craick, J.K.	"Human Factors in Office Automation", Audit of Office Automation Strategies, Research Forum, Deakin University, Geelong, February 1984.
Ellershaw, J.C.	"Interworking Between Networks", Communication and Networks Lecture, Monash University, June 1983.
Ellershaw, J.C.	"Local Area Networks (LANs)", Communication and Networks Lecture, Monash University, July 1983.
Ellershaw, J.C.	"Telecom Datacommunication Services", Communication and Networks Lecture, Monash University, August 1983.
English, K.S. & Vizard, R.J.	"Overview of ISDN", Seminar to AWA, Switching Division, Sydney, March 1983.
Flatau, G.	"The Role of the Material Scientist in Telecom", Telecommunication Society of Australia, Western Australia, November 1983.
Frueh, P.F.	"Current Technology and Techniques", Local Area Networks Seminar, Warren Centre, Sydney University, October 1983.
Godfrey, J.R.	"Accelerated Industrial Atmosphere Testing", Australian Institute of Metal Finishing Seminar, National Science Centre, Melbourne, May 1983.
Horton, R.	"Digital Radio", Telecommunication Society of Australia, Geelong, July 1983.
Johansen, E.& McGlade, B.J.	"Research into Optical Heterodyne Systems at Telecom Australia", 8th Optical Communications Workshop, Adelaide University, December 1983.
Kemeny, P.C., Reeves, G.K. & Hubregtse, J.	"GaAs Laser Diodes Grown by Molecular Beam Epitaxy", 3rd International Laser Conference, Monash University, August 1983.
Kemeny, P.C.	"Progress in MBE Growth and Fabrication of III-V Laser Diodes", First Conference of the Australian Optical Society, Optics in Australia, Sydney, May 1983.
Kemeny, P.C.	"III-V Laser Diodes Grown by Molecular Beam Epitaxy", 8th Optical Communications Workshop, Adelaide University, December 1983.
Latoszynski, P.	"Chromatographic Analysis of Polymeric Materials", Moorabbin TAFE College, August 1983.
McKelvie, D.	"Evaluation of Photovoltaic Modules for Use in Australian Conditions", NERDDC Workshop on Remote Area Power Supply, Canberra, May 1983.
Morgan, R.J., Jones, P.S., Frueh, P.F. & Duc, N.Q.	"Towards the Standardisation of End-user Telecommunication Services", First National Telecommunications Exhibition and Conference, Melbourne, March 1984.
Nicholson, G.	"A Mode Spot Size for Single-Mode Optical Fibre", 8th Optical Communications Workshop, Adelaide University, December 1983.

Reeves, G.K. & Harrison, H.B., Williams, J.S. (RMIT)	"The '1.25 Micron Discontinuity': A Technological Challenge for MOS VLSI", Creating Integrated Systems Conference, Silicon Workshop 1983, IREE Adelaide Division and IE Australia, May 1983.
Reeves, G.K. & Harrison H.B., Sai-Halasz, G. (RMIT)	"Layer to Layer Interconnections in VLSI Circuits, Models and Measurement Considerations", IEEE Workshop VLSI Test Structures, San Diego, USA, February 1984.
Rosman, G.E.	"Non-Linear Effects in Optical Fibres", Staff and Students, University of Western Australia, Perth, October 1983.
Rosman, G.E.	"Four-Photon Spectra from Communications Fibres", 3rd International Laser Conference, Monash University, August 1983.
Rosman, G.E.	"Interpretation of Four Photon Spectra from Optical Fibres", 8th Optical Communications Workshop, Adelaide University, December 1983.
Rosman, G.E.	"Measurement of Group Velocities of Modes in Curved Fibres", Australian National University, Canberra Institute of Advanced Studies, February 1984.
Ruddell, H.J.	"Premature Depletion of Stabilisers from Solid Polyethylene Insulation", Royal Australian Chemical Institute 14th Australian Polymer Symposium, Ballarat, Victoria, February 1984.
Sabine, P.V.H., Ja, Y.H., Linard, B.J., Price, G.L., Kemeny, P.C.& Rosman, G.E.	"Optical Device and Quantum Electronic Research in Telecom Australia", First Conference of The Australian Optical Society, Optics in Australia, Sydney, May 1983.
Sabine, P.V.H. & Rosman, G.E.	"Mid-Infra-Red Communication Fibres and Devices", 3rd International Laser Conference, Monash University, August 1983.
Sabine, P.V.H. & Rosman, G.E.	"Fibre and Devices for Mid-Infra-Red (2-10 μm) Communications Systems", 8th Optical Communication Workshop, Adelaide University, December 1983.
Sandbach, E.F.	"University-Industry Interaction", Electrical Engineering Foundation Workshop, Sydney University, April 1984.
Skopakow, P.	"Measurement of the Cutoff Wavelength of Single-Mode Optical Fibre", 8th Australian Optical Communications Workshop, Adelaide University, December 1983.
Snare, J.L.	"X.25 Implementation", Communications and Networking Lecture, Monash University, June 1983.
Stephens, T.D. & Gibbs, A.J.	"Characterisation of Optical Line Transmission Equipment", 8th Optical Communications Workshop, Adelaide University, December 1983.
Stevens, A.J.	"Experience with HP86A", Hewlett-Packard Desk Top Computers User Group, CSIRO, Syndal, September 1983.
Stone, G.O.	"Analysing Optical Components having Irregular or Nonlinear Material and Geometric Properties", 8th Optical Communication Workshop, Adelaide University, December 1983.
Symons, F.J.W.	"Some Fault Tolerant Aspects of Stored Program Controlled Exchanges and Networks", 2nd National Workshop on Fault Tolerant Computer Systems, Monash University, February 1984.
Wheeler, G.R.	"Introduction to Net Theory", Communication and Networks Lecture, Monash University, July 1983.
Wilbur-Ham, M.C.	"The Open Systems Interconnection Transport Protocol Specifications", Lecture, Monash University, July 1983.

Reports

Report No.	Author(s)	Title
7043*	A. Brunelli	Standard and Design Guide of Layout for Prototype Printed Boards in the Research Laboratories
7414*	E. Tirtaatmadja	A Universal Data Capture Unit (UDCU) for Field Experiments
7417* Addendum 1	F.M. Petchell	Exposure Trials of Paint Systems on Galvanised Steel
7429*	J.B. Carroll	A Computer Controlled Optical TDR Measurement System
7431	N.D. Kim, P. Gerrand, J. Sheard & A. McDonald	User's Manual for CADDIE, a Visual Interactive Graphics System for the Specification of New Telecommunications Facility Requirements
7480	M.A. Hunter & R.J. Vizard	IST/RSU Project - Project Overview
7483*	M.A. Hunter	IST/RSU Project - Equipment Practices
7489*	R. Proudlock	Power Supplies for a Sputter Etch System
7519*	I.C. Lawson & P.R. Hicks	A Self Contained Mobile Field Strength Receiver for use at VHF & UHF: General Description and Operating Notes
7527*	W.L. Reiners	Development of a Variable Height VDU Work Station
7538	R.W.A. Ayre	Laser Safety Considerations in Optical Fibre Communications
7546*	J. Thompson	The Feasibility of Using Standard Devices to Determine the Electromigration Susceptibility of Integrated Circuits
7550* Addendum 1	J.F. Pidoto	An Evaluation of Miniature DIP Switches
7555	G.R. Wheeler & J.L. Snare	The Link Access Procedure-LAPB of X.25 Specified by a Language based on SDL
7564*	G.K. Reeves & F. Gigliotti	Thick Film Design Guidelines
7574*	L.J. Millott & R.I. Webster	Analysis and Interpretation of Impulse Noise Measurements
7576*	H.J. Ruddell & L.G. Powell	Examination of Six Japanese Materials as Interlayer Compounds for Plastic Jacketed Cables
7578*	B.J. McGlade	Simulation of Frequency Selective Fading
7585*	G.N. George, P.R. Hicks & R. Witham	Multiplex Switch for Network Synchronisation Field Experiment
7586*	R.J. Boast	Nozzle Mixing Systems for Epoxy Resin Field Packs
7587	J.R. Grimwade	User Acceptability of the Convenor-Controlled Conference Bridge, Mark 1
7588*	G. Jones	A Specification of the AUSTPAC X.25 Link Level
7590*	G.J. Semple	The Effect of Bridged Taps on the Transmission Performance of the Baseband Digital Data Modems used in the Digital Data Network
7591	E. Tirtaatmadja	Programmable Array Logic Design Techniques
7593*	G.C. Healey & T.S. Hand	Thermal Protection for Equipment Cooled by Recirculated Water

7594	I.P.W. Chin	Graphical Description of the Associations Both Defined and Undefined between Two Terms used in the ISO OSI Reference Model (DIS 7498)
7595*	W.F. Hancock & Ho Kong Mah	Accidental Detachment of Flexible Hoses from Insert Fittings
7596*	G.K. Millsteed	Availability Design of Common Channel Signalling Systems
7597*	R.K. Flavin	Microwave Communication Technology and Rain Attenuation Modelling: Overseas Visit Report
7598	I.P.W. Chin	Glossary for Information Processing Systems - Open Systems Interconnection - Basic Reference Model
7604*	J.R. Godfrey	Overseas Visit - September/October 1982
7605	J.B. Cook	General Exchange Simulator
7606	N.R. Smart	Development of a High Resolution Low Energy Electron Spectrometer
7607	K.S. English	CCITT Standardisation of ISDN - A Status Report
7611*	R.J. Boast	Comparison of Polymers for Telephones - Stage 2
7612*	K.F. Barrell & P.J. Turner	A TACONET Facility for Contouring Functions of Two Variables
7613	A.J. Bundrock & J.V. Murphy	A Broadband 11 GHz Radio Propagation Experiment
7614*	B.J. McGlade	Digital Radio Concentrator System Interference Studies - Programming Aspects
7616*	M. Subocz	Overseas Visit - November-December 1982 - CCITT SG XI Meeting - Geneva & Related BTM and KDD Visits
7617*	P.R. Hicks	Software Design Considerations for the Network Synchronization Field Experiment Measurement System
7618	D.M. Harsant	A Guide to the Use of CMOS Technology
7619*	J.C. Ellershaw	Co-Channel Interference in a Digital Radio Concentrator System
7620*	K.G. Mottram & J. McNally (Engineering Department)	Fractures in Large Telephone Exchange Battery Jars
7625*	J.S. Spicer	A Survey of Wander and Jitter on Synchronisation Links
7627*	J.L. Park	Overseas Visit Report - CCITT Study Group VII Meeting and Special Rapporteurs Meeting, November-December 1982
7628*	A.J. Gibbs	Single Mode Optical Fibre Systems - Overseas Visit, 9/9/82 to 13/10/82
7630*	K.F. Barrell & R.A. Palmer	Graphical Data Input Using the Tektronix 4953 Tablet
7631*	W. Lobert	Measurements of Dielectric Properties of Solids at Microwave Frequencies, Part 1: Cavity Resonator Method
7635	E.V. Jones	A Phasor View of Pulse Sequences Properties and Application to Clock Extraction
7636*	R.W.A. Ayre	Optical Communication Research in Japan - A Review - Overseas Visit Report
7637*	L. Perry	A Field Study of Audio Teleconferencing for Education in Rural Areas
7638	G. Nicholson	Mode Spot Size for Characterising Single-Mode Optical Fibre
7640*	W.E. Metzenthen	Message Handling
7645*	N.Q. Duc	ISDN Aspects of CCITT Study Group XVIII Meeting, Geneva, June-July 1983
7646*	J.S. Spicer	Measurement System and Data Logger for the Network Synchronisation Field Experiment

7648	G.R. Wheeler K.S. English & I.P.W Chin	Specification of the Link Access Procedure of X.25 Using the Specification and Description Language
7654	E.V. Jones & L.W. Bourchier	Pulse Transmission on Pair Cable - the Control of Intersymbol Interference
7655*	G.W.G. Goode	Heat Shrink End Caps for Pressurized Cables
7656*	R.I. Webster & G.J. Semple	The Effect of Bridged Taps on the Transmission Characteristics of Pair Cable
7659*	P.F. Frueh	Integrated PABXs and Local Area Networks - Overseas Visit Report - April-May 1983
7661	G.J. Dickson	Overseas Visit Report - CCITT Working Party Meetings - June 1983
7665	G. Nicholson	Far Field Measurement of the Mode Spot Size
7672	J.C. Ellershaw & J.L. Snare	Addressing Aspects of Interworking Between Private and Public Data Networks
7673	D.B. Keogh (Guest Worker)	An HDB3 Encoder Realized Using a Programmable Array Logic Device
7674	D.B. Keogh (Guest Worker)	A Modular Logic Cell for Pseudo-Random Sequence Generation
7678*	E.J. Bondarenko & D.R. Kelso	Overvoltage Tests on AXE Exchange, Lyndhurst, Victoria
7679*	H.V. Rodd	Information Technology: Report of an Overseas Visit
7697	H.E. Green (Guest Worker)	Calculation of the Specular Ground Ray on a Certain Class of Terrestrial, Point-to-Point, Microwave Communications Links
7702*	H.J. Ruddell	Report on European Visits during September/October 1983.

Note: The reports marked * are classified as "Telecom Australia Use Only".
In addition, three "In Confidence" reports with restricted 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)

Technical and Further Education Board, Victoria
Science Laboratory Standing Committee — F.C. Baker
Applied Science Joint Standing Committee — F.C. Baker

University of Melbourne
External Member - Faculty of Engineering — E.F. Sandbach

Monash University
Research Associate - Department of Electrical Engineering — P.H. Gerrand

Footscray Institute of Technology
Course Advisory Committee — G.F. Jenkinson

Chisholm Institute of Technology
Course Advisory Committee — R.J. Morgan

Royal Melbourne Institute of Technology
Communication and Electronic Engineering Course Advisory Committee — P.H. Gerrand
Industrial Fellow — P.H. Gerrand

National & State Professional Bodies

Australian National Committee for Radio Science — W.J. Williamson

Radio Research Board — E.F. Sandbach

Australian Computer Research Board — F.J.W. Symons

Victorian CSIRO State Committee — E.F. Sandbach

The Institution of Radio and Electronics Engineers, Australia
Publications Board — R. Horton
Melbourne Committee — R. Horton

Telecommunication Society of Australia
Council of Control — E.A. George, G.F. Jenkinson

Board of Editors: "Australian Telecommunication Research" — G.F. Jenkinson, J. Billington, G.D.S.W. Clark, G. Flatau, P.H. Gerrand, A.J. Gibbs, M.A. Hunter, D.J. Kuhn, I.P. Macfarlane, G.K. Reeves, H.V. Rodd

Board of Editors: "Telecommunication Journal of Australia" — A.J. Jennings

Institute of Electrical and Electronic Engineers
Victorian Sub-Section Committee — R.A. Court, R.P. Coutts, A.J. Gibbs
Secretary/Treasurer Region 10 — A.J. Gibbs

University of Queensland
Microwave Technology Development Centre — W.J. Williamson
Systems Research Institute of Australia — W.J. Williamson

Standards Association of Australia (SAA)
Council — E.F. Sandbach
Executive Board of Council — E.F. Sandbach
Telecommunications and Electronics Standards Board and Executive — G. Flatau, E.F. Sandbach

Australian Electrotechnical Committee — G. Flatau, E.F. Sandbach

- Reliability of Components and Equipment — G. Flatau
- IEC Quality Assurance Scheme for Electronic Components — G. Flatau, E.F. Sandbach

Acoustic Standards Committee — E.J. Koop
Plastics Industry Standards Board — R.D. Slade
Co-ordinating Committee on Fire Tests — F.C. Baker
Metals Standard Board — R.D. Slade

Technical Committees
Acoustic Standards
- Instrumentation and Techniques for Measurement of Sound — E.J. Koop

Chemical Industry Standards
- Adhesives — F.C. Baker
- Heavy Duty Paints — F.C. Baker

Computers and Information Processing Standards
- Data Communications — J.L. Snare
- Open Systems Interconnection — J.L. Park

Electrical Industry Standards	
• Plastics	G.W.G. Goode
• Lightning Protection	E.J. Bondarenko
• Indicating and Recording Instruments	J.M. Warner
• Electrical Insulating Materials	G. Flatau
• Electrolytes	F.C. Baker
• Control of Undesirable Static Charges	G.W.G. Goode
• Copper & Copper Alloys	K.G. Mottram
• Electrical Accessories	E.J. Bondarenko
Mechanical Engineering Industry Standards	
• Engineers Hand Tools	P.F.J. Meggs
• Solders	K.G. Mottram
• Vibration & Shock Measurement & Testing	I.A. Dew
• Fasteners	F. Wolstencroft
Metal Industry Standards	
• Coating of Threaded Components	R.D. Slade
• Galvanised Products	R.D. Slade
• Electroplated and Chemical Finishes on Metals	R.D. Slade
• Bi-metallic Corrosion	R.F. May
Plastics Industry Standards	
• Plastics for Telecommunication Cables	H.J. Ruddell D.J. Adams
• Methods of Testing Plastics	G. Flatau
• Outdoor Weathering of Plastics	G.W.G. Goode
• Flammability of Plastics	D.J. Adams
• ISOTC 61 Plastics Advisory Committee	B.A. Chisholm D.J. Adams
• Safety Helmets	R.J. Boast
• Fuel Containers	H.J. Ruddell
Safety Standards	
• Industrial Safety Gloves	F.C. Baker
• Steel Wire Rope and Strand	T.J. Keogh
Telecommunications and Electronics Industry Standards	
• Capacitors and Resistors	G. Flatau S.J. Charles
• Printed Circuits	D.E. Sheridan
• Wires and Cables	G. Flatau
• Semiconductors	I.P. Macfarlane
• Environmental Testing	G. Flatau
• Electro-Acoustics and Recording	E.J. Koop
• Hazards of Non-Ionizing Radiation	S. Sastradipradja
Victorian Solar Energy Council	
• Project Steering Committee	N.F. Teede

National Association of Testing Authorities (NATA)

Electrical Registration Advisory Committee	E.F. Sandbach J.M. Warner
Assessor for Environmental Testing	G. Flatau
Assessor for Laboratories Engaged in Testing Plastics	B.A. Chisholm
Assessor for Laboratories Engaged in Acoustical Testing	E.J. Koop
Assessor for Laboratories Engaged in Electrical Testing	J.M. Warner E. Pinczower J.B. Erwin

Overseas Telecommunications Commission

• OTC(A) Research & Development Board	F.J.W. Symons

International Bodies

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

- The International Telegraph and Telephone Consultative Committee (CCITT)
- The International Radio Consultative Committee (CCIR)
- The Australian and New Zealand Association for the Advancement of Science (ANZAAS)
- The Bureau International de l'Heure (BIH)
- The International Electro-Technical Commission (IEC)
- The International Standards Organisation (ISO)
- The International Federation of Documentation, Committee for Asia and Oceania (FID/CAO).

In particular, staff of the Research Laboratories held offices in the following International Bodies during the year:

• IEC Joint Co-ordination Group -Optical Fibres, Working Group 4	A.J. Gibbs
• International Confederation for Thermal Analysis	F.C. Baker
• Teletraffic Engineering Training Project TETRAPRO, ITU/ITC	J. Rubas
• Special Rapporteur, CCITT SG XVIII	R. Smith
• IEC Quality Assessment System for Electronic Component Certification Management Committee	G. Flatau
• Special Rapporteur, CCITT SG VII/39	G.J. Dickson
• Special Rapporteur, CCITT SG XI/14	M. Subocz

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 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

	PATENT APPLICATION NUMBERS			
Invention Title (Inventor/s)	**Provisional Specification**	**Complete Specification**	**Patent No. (if granted)**	**Country**
Method and Apparatus for Testing Subscribers' Telephone Instruments in situ under Service Conditions (J.F.M. Bryant & R.W. Kett)		233699	3261926	USA
Self Adaptive Filter and Control Circuit (L.K. Mackechnie)	65671/69	23649/70 98800	448805 3732410	Australia USA
Tip Welding Means (E.J. Bondarenko)	49395/70	10361/70 4714/71	455004 3657512	Australia USA
Analogue Multiplier (H. Bruggemann)	43033/68	43033/68 855543	414207 3629567	Australia USA
Apparatus for Routing Discrete Telecommunication Signals (A. Domjan)	61428/69	19808/70	448958	Australia
Apparatus for Monitoring a Communications System and a Detector Therefor (J.A. Lewis)	PA1474/70	29415/71	458997	Australia
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 166819	466670 3745418	Australia USA
Apparatus for Use in Feeding Alternating Electric Current to a Load and an Antenna including such Apparatus (R.P. Tolmie)	PA7174/71	49340/72	484853	Australia
Smoke Detector (L. Gibson & D.R. Packham)	PA9230/72	56513/73 367260	482860 3874795	Australia USA
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 178402	480006 3882283 984068	Australia USA Canada
Nephelometer with Laser Source (L. Davidovits)	PC4286/75	20511/76	507518	Australia
Tamperproof Telephone Apparatus (C.M. Hamilton & J.A. MacCaskill)	PC5285/76	23264/77	502780	Australia
Fault Monitoring Apparatus (R.W.A. Ayre)		17251/76	504585	Australia
Optical Waveguides and a Method of Manufacture Therefor (P.V.H. Sabine & P.S. Francis)	PC4499/76	21232/77	507723	Australia
Method and Apparatus for Reducing Phase Jitter in an Electrical Signal (K. Webb)		24926/77	510034	Australia
Programmable Digital Gain Control System for PCM Signals (A.M. Fowler)	PD3192/78	43735/79	519441	Australia
Transversal Filter (K.S. English)	PD7273/79	54367/80 109589/80 00263/80	532103 4340875	Australia USA Japan

Fibre Optic Termination (P.V.H. Sabine)	PD6157/78	50841/79 P2938649 G79271195 126329/79 266321	521528 4381882	Australia Germany Germany Japan USA
Noise Assessment of PCM Regenerators (A.J. Gibbs)	PD6790/78	52160/79 793025727 339841 148305/79 093228	525766 0012515 1134915 4300233	Australia Europe (designating France Germany Britain Italy Holland Switzerland) Canada Japan USA
Tap Coupler for Optical Fibres (E. Johansen & E. Dodge)	PF0272/81	87251/82		Australia
Hydrometer (F. Bodi)	PF1183/81	89297/82		Australia
Apparatus and Method of Cable Hauling (J. Alcorn)	PF5293/82	17465/83		Australia
Method and Apparatus for Testing Bells and other Electrically Actuated Devices (B. Sneddon)	PF5557/82	17570/83		Australia
Etching (Z. Slavik)	PF7347/82	22712/83		Australia
Instant Speaker Algorithm for Digital Conference Bridge (D.Q. Phiet)	PG4037/84			Australia

VISITORS TO THE LABORATORIES

The work of the Laboratories often calls for close liaison with various Australian universities and other tertiary institutes and with the research establishments of government departments, statutory authorities and private industry. Reciprocal visits are made by the staff of the Laboratories to these and other establishments for mutual participation in discussions, symposia and lectures. In some instances, visitors with expertise in particular fields contribute more directly to the work of the Laboratories as consultants.

The Laboratories' activities are also demonstrated to specialist and non-specialist groups from industry, professional societies, government departments and academia. This is achieved through arranged discussions, inspection tours and demonstrations 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, academia, 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 sponsored by an international organisation and the visit to the Laboratories is a part of a more extensive visit programme within Telecom Australia.

Some of the groups and individuals who visited the Laboratories during the year are listed below:

- Mr R. Mere, Assistant Secretary, Communications Development Division, Department of Communications and Mr K. Barnes, Chief Planning Engineer, Headquarters Engineering Department, Telecom Australia, for general discussion of the Laboratories' activities and inspection of a number of projects in the areas of microelectronics, optical, digital radio and wideband transmission systems, voice and data switching systems, and customer access aspects of new services and networks.
- Professor A.R. Billings, Head of the Department of Electrical and Electronic Engineering, University of Western Australia, Professor A.E. Karbowiak, Head of the Department of Communications, University of New South Wales, and Dr. R.H. Frater, Chief of the CSIRO Division of Radiophysics visited the Laboratories at the invitation of the Director, Research, after attending the annual Radio Research Board meeting in Melbourne. The visitors had general discussions with the Laboratories' management and visited areas related to their interests to discuss projects related to satellite and antenna developments, optical systems technology, solid state electronics and microelectronics.
- Professor J. Bennett, of the Department of Computer Science, University of Sydney, and Mr G. Barlow, Deputy Chief Defence Scientist, Department of Defence, visited the Laboratories after attending the annual Australian Computer Research Board and Radio Research Board meetings in Melbourne. After discussions with the Laboratories' management, the visitors toured the Laboratories to see and discuss work in the fields of digital radio systems, circuit and packet switching for telephony and data, and satellite transmission.
- Dr. F.C. Yuastavino, of the University des Sciences et Techniques du Languedoc, France, visited the Laboratories whilst on sabbatical leave from the Laboratorium Elektronika dans Komponen ITB Bandunk, Indonesia.
- Mr Qi-lu Zhu, a visiting scholar from the Ministry of Posts and Telecommunications of China, held discussions with staff of the Customer Access, Human Communication, Business Communication, Voice Services, Data Switching, and Signalling and Control Sections during his visit to the Laboratories.
- Members of the Steering Committee for the Philips Photovoltaic Cell Project, namely, Messrs J. Taylor and P. Zerleney of the Department of Science and Technology, Messrs D. Edwards of the Australian Industrial R&D Incentives Board, Mr A. Smart of the National Energy Research, Development and Demonstration Council, Messrs J. Ward, J. Telfer and W. McCormick of Philips Industries, and Dr. M. Kenny of CSIRO visited the Laboratories for discussions related to the Laboratories' work to evaluate the reliability of solar cell panel modules and to inspect the Laboratories' facilities for the design and experimental fabrication of thick and thin film microelectronics devices and of advanced semiconductor materials and devices.
- Professor J. Lamb, of the Department of Electronics and Electrical Engineering, the University of Glasgow, Scotland, visited the Laboratories and presented a talk on "Progress Towards Integrated Optics". He then held detailed discussions with the Laboratories' staff working in the fields of molecular beam epitaxy and semiconductor materials research, non-linear optics and optical device research.
- Twenty delegates from the Third International Laser Conference (Australia) visited the Laboratories' Solid State Electronics Section, where they inspected the molecular beam epitaxy facilities and held discussions on four-wave optical mixing in photorefractive crystals and non-linear interactions in single-mode optical fibres.
- Mr Shinji Sugai, Manager of the Measuring Instruments Division of Anritsu, Japan, accompanied by Mr D.M. Lawrence, Manager, Measuring Instruments, STC Pty. Ltd., Melbourne, visited the Laboratories for discussions and inspection of the Laboratories' reference measurements and instrumentation facilities.
- Mr B. Bernau and a party of engineers from the Government Aircraft Factory, Department of Defence Support, visited the Instrumentation Engineering, Microelectronics and Equipment Engineering Sections to inspect and discuss advanced facilities for the fabrication and production of electronic and communications equipment.
- Dr. W.A. Barlow, Research and Technology Manager, Imperial Chemical Industries Pty. Ltd., UK, accompanied by Mr R.W. Moses, Manager, New Business Development Planning and Development, ICI Australia Pty. Ltd., visited the Laboratories for discussions with the Director, Research, and staff on aspects of research work being performed in the fields of optical fibres, cable materials, connectors and microelectronic technology and components.
- Dr. R. Wetton of the Loughborough University of Technology, UK, visited the Laboratories for discussions with the Assistant Director and senior scientists of the Applied Science Branch on topics of mutual interest in the areas of polymer science and analytical chemistry, and to obtain a general overview of the Laboratories' related facilities.
- Ms L.C. Brady, Director (Financial Systems) of Pacific Bell (USA) and Messrs. M.J. Perry, Vice-President (Marketing), D.W. Mitchell, Vice-President (Operations) and D.R. Sanders, Director (Operations) of Pacific Telesis International (USA) visited the Research Department whilst on an introductory visit to Telecom Headquarters, for discussions with the Director and staff on the role, work programme and facilities of the Laboratories.

OVERSEAS VISITS BY LABORATORIES' STAFF

It is an important responsibility of any viable organisation to keep abreast with developments and changes in particular fields of interest. To this end, the Laboratories arrange an annual programme of overseas visits through which members of staff are enabled to interchange experience, technical knowledge, opinions and ideas with research personnel of other organisations. The visits are normally to other telecommunications 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:

R.N. Barrett	P.S. Jones
A. Brunelli	B.J. Linard
E.K. Chew	J.R. Lowing
R.P. Coutts	G.K. Reeves
W.S. Davies	H.J. Ruddell
G.J. Dickson	R. Smith
K.S. English	J.L. Snare
P.F. Frueh	M. Subocz
Y.H. Ja	J. Thompson
E. Johansen	

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 post-graduate 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 staff have been encouraged to engage in post-graduate studies:

- P.A. Kirton, Development Training Programme Award, Information Science Institute, University of Southern California, USA
- R.G. Addie, full-time Study Leave without pay, Department of Mathematics, Monash University, research studies leading to the Degree of Doctor of Philosophy
- G.C. Heinze, Development Training Programme Award, British Telecom, Martlesham, UK, and Hewlett-Packard, USA.

The following staff members have been given an award to enable them to pursue full-time undergraduate study:

- H.A.J. Meijerink, Undergraduate Scholarship, Royal Melbourne Institute of Technology, course for the Degree of Bachelor of Computer Science
- R.W. Rydz, Undergraduate Scholarship, Swinburne Institute of Technology, course for the Degree of Bachelor of Engineering.

SPONSORED EXTERNAL RESEARCH AND DEVELOPMENT

Telecom Australia is aware of the external R&D capabilities in telecommunications science and technology which exist in local industry, in academia and in specialised Australian research institutions such as the Commonwealth Scientific and Industrial Research Organization (CSIRO).

Recognising the mutual benefits of co-operative effort, it actively supports pertinent projects in these organisations through formal contracts and agreements and through its participation in the activities of bodies such as the Radio Research Board and the Australian Computer Research Board.

The Research Laboratories act as one channel for the provision of such support by Telecom, in particular, for research studies on telecommunications topics having potential application in the longer term development of the telecommunications network. The Laboratories also contract out development projects in specialised fields to meet an instrumentation or similar technical need which cannot be met from the usual sources of supply.

Current R&D contracts administered by the Laboratories concern the study topics or developmental projects listed below:

- Manufacturing Processes for Optical Fibres and Optical Fibre Cables
- Index Profiling of Single Mode Optical Fibres
- An Optical Fibre Strain Measurement System
- Transmission Performance of Single and Multi-mode Optical Fibres
- Modulation Characteristics of Laser Diodes
- An Optical Parametric Amplifier
- Static Fatigue in Optical Fibres
- A Multi-purpose Drawing Machine for Mid-IR Optical Fibres
- Receiver Structures for Optical Systems
- Coherent Optical Fibre Communications
- A Speech Level Measurement System
- Correlation between the Physical Properties of Plastics and their Resistance to Termite Attack
- Automated Generation of Chill Codes from Call State Transition Diagrams and Other Pictorial Data
- Fault-tolerant Microcomputer Systems for Telecommunications Applications
- Optimal Dimensioning of Circuit Switched Digital Networks
- A Digital Transmission Error Performance Analysis System
- Microwave Solid State Amplifiers for Satellite Communications
- Modelling and Analysis of Electric Field Strength and Noise
- Distributions in Mobile Radio Communications
- Techniques for Full Duplex Digital Communications on Subscriber Lines
- Lightning Detection Apparatus
- Electrical Parameters of Lightning Surges Induced in Telephone Lines
- Interference Effects in Digital Radio Systems
- Gas Exposure and Weathering Chambers
- Early Indicators of Electrical Deterioration of Polyethylene Spacers in Coaxial Cable
- Techniques for Group Delay and Attenuation Measurement
- Simulation of Numerical Petri Nets using Data-driven Computer Architectures
- Rules for the Production of Speech from Text
- Automated Systems for the Verification of Communications Protocols
- Teleconferencing Diffusion Studies
- Customer Reaction to Telephone Circuit Delay
- Spectral Properties and Error Probabilities of Block Codes
  A Multiple Output ISDN Line Signal Generator and Switch
- An Adaptive Digital Hybrid for Data Transmission on a Subscriber Loop
- A Solid State Refractometer
- An Optical Time Domain Reflectometer
- VLSI Impacts on Telecommunications Equipment Design
- Stability Properties of Transmultiplexers
- Bismuth Impurities in Stationary Lead-acid Batteries
- Stress Relaxation of Thermoshrinkable Polyethylene Sleeves for Jointing Moisture Barrier Cable
- Interworking of Packet Switched Networks using Standard Protocols
- Control Theory applied to Dynamic Routing and Telecommunications Traffic Control
- Dimensioning Techniques for Non-hierarchical Digital Networks
- ISDN Customer Access Protocol Architectures
- Effects of Metal-framed Spectacles on Electromagnetic Radiation Levels near the Human Eye
- "Equivalent Temperatures" in Above-ground Cable Jointing Enclosures
- Software Engineering for Solar Module Performance Analysis
- Computer-aided Graphics System for SDL-based Specification of Switching Systems.

In addition, the Laboratories occasionally participate in joint projects with other national and international bodies such as the Overseas Telecommunications Commission (Australia), the CSIRO, international standardisation bodies such as the CCITT and CCIR, and overseas telecommunications administrations.

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