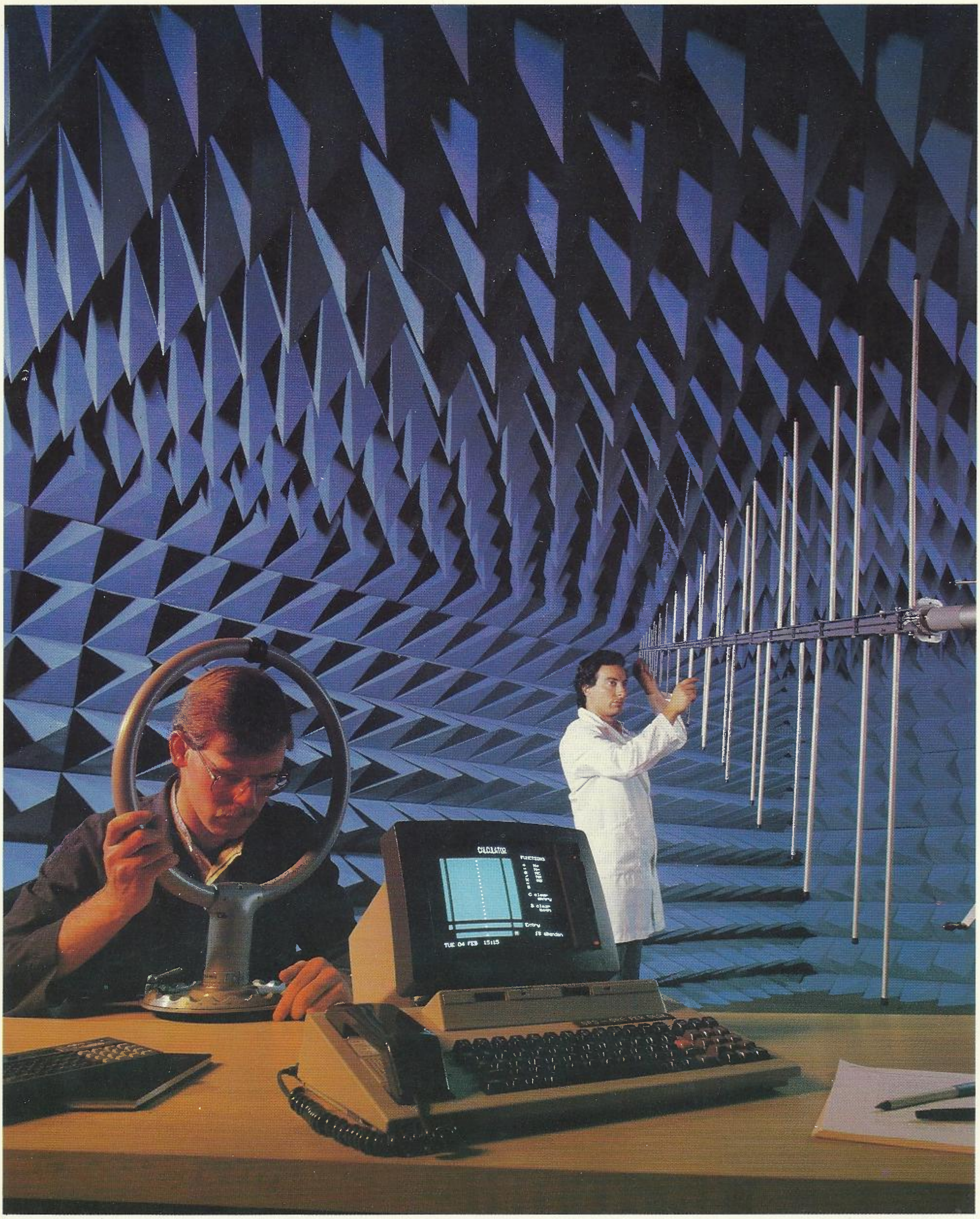
Review of Activities

1985-86



Research Laboratories

Telecom Australia

Review of Activities 1985-86

Research Laboratories, 770 Blackburn Road, Clayton Victoria 3168 Australia

Telecom Australia

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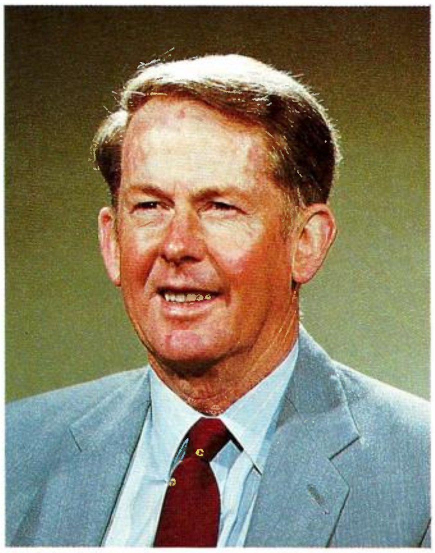
Foreword



Advances in the technologies and techniques of telecommunications are spurring worldwide activity to realise a diverse array of new telecommunications services or to provide existing services at higher standards or with greater efficiency.

These technologies and techniques are being applied by many telephone administrations to make fundamental changes to their network infrastructures, in the interests of reduced capital costs, increased efficiency of operation or technical flexibility to expand the network infrastructure. These processes are complex and evolutionary, and they are fundamental to the realisation of the Integrated Services Digital Network (ISDN).

The evolution of an Australian ISDN is a multi-facetted long term task for Telecom Australia and the Australian telecommunications industry. It requires co-ordination and co-operation in the ongoing development of competence and capabilities in new technologies and participation in the development of national and international technical standards for the effective interworking of future customer services and networks.

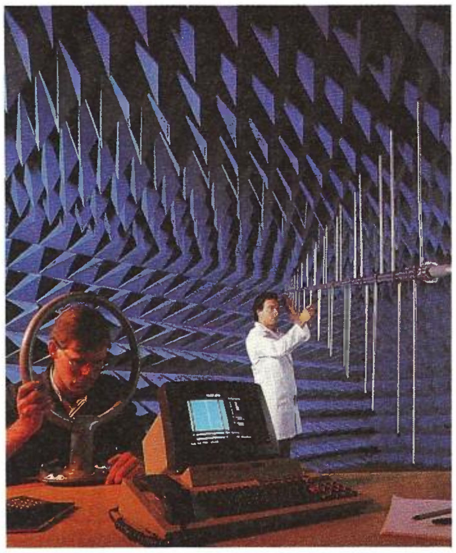
Telecom's R&D activities are one key to the successful realisation of an Australian ISDN, to provide the telecommunications services needed by the various sectors of Australian society in an effective and economic manner.

As the largest telecommunications R&D institution in Australia, Telecom's Research Laboratories are providing the technological leadership to support the development and introduction of new services and the expansion of network facilities, capabilities and extent. This Review demonstrates the depth and scope of the work being performed by the Laboratories in the fulfilment of its role to assist Telecom Australia to become the best provider of telecommunications and information services.

R. K. McKinnon

R.K. McKINNON
Chief General Manager

Our Cover



The cover photograph shows the interior of a special electromagnetically shielded chamber recently established at the Laboratories for use in the assessment of the electromagnetic compatibility (EMC) of telecommunications equipment. The walls and ceiling of the chamber are lined with electromagnetically absorbent wedges which minimise reflections of radiated signals in the chamber, replicating in the laboratory an "open field" environment. This new facility will enable precise EMC tests to be performed over frequencies ranging from 30 MHz to 10 GHz. It will provide a means for assessing and, where necessary, improving the EMC of a wide variety of existing and future telecommunications terminals and equipment, as well as for investigating and reducing bio-electromagnetic hazards.

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Telecom Australia

Telecom Australia Research Department

RESEARCH EXCELLENCE

FOR

TELECOM'S SUCCESS

MISSION STATEMENT

To provide Telecom with technological and scientific leadership, knowledge and expertise so that it can be the best provider of telecommunications and information services.

The Role of the Research Laboratories

As a Department in the Headquarters Administration of Telecom Australia, the Research Laboratories have a primary role to provide other Departments of Telecom with relevant and timely technological and scientific leadership, knowledge and expertise - to assist these Departments to fulfil their roles in relation to the planning and development of telecommunications services for the people of Australia and to the development and operation of the national telecommunications network infrastructure. In combination, the roles of all Departments are directed at the fulfilment of Telecom's Charter. In real terms, the efforts of all Departments are expressed in a myriad of projects and activities. The nature of telecommunications necessarily means that, in many projects and activities, the competent management of technology is often an important factor for success.

Under its Charter established by the Telecommunications Act 1975, 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 kept up to date and operated efficiently and economically, with charges as low as practicable.

Many of the innovations, ideas and improvements proposed for Australian telecommunications services and networks 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 environment. 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.

In meeting its responsibilities, Telecom is also aware 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 infrastructure which provides the services to the community.

Telecom's Research Laboratories are a 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 of some 500 staff, of whom approximately 200 are professional engineers and scientists and 200 are technical grade staff, the remainder being supportive staff categories.

The formal statement of the objectives of the Research Department requires it:

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

In the pursuit of these objectives, the Department is expected to:

- conduct basic and applied research in the natural sciences and engineering aimed at discovering new knowledge of telecommunications topics relevant to operations in Australia, having regard to research known to be in hand overseas or in Australia
- conduct basic and applied research in the social sciences aimed at discovering new knowledge relevant to Telecom's operations in Australia
- conduct investigations in areas of developing technology to provide expertise necessary to carry out the other functions of the Research Department

- establish and maintain specialist resources necessary to ensure that investigations and developments are conducted at an appropriate level of scientific and technical competence, and to provide and maintain, as necessary, standards of adequate accuracy for weights and measures
- encourage and, in appropriate cases, arrange research and development on telecommunications topics by industry in Australia
- encourage and support basic research on telecommunications in universities and other centres of higher learning, and encourage and support post-graduate training of engineers, scientists and others in these fields
- encourage and develop liaison channels between the Research Department and other appropriate research establishments in Australia and overseas to ensure adequate co-ordination of policies and projects, and economy in the use of professional resources.

In performing the above functions, the Department is required to collaborate with other Departments and Directorates of Telecom Australia, particularly those of the Headquarters Administration, to:

- formulate research and development programmes
- participate in the formulation and implementation of policies for the introduction of new advances in communications technology into Telecom's operations
- conduct specific investigations on aspects of systems or equipment performance and development
- define Telecom's requirements for certain new types of equipment and systems and appraise newly developed equipment offered by manufacturers
- design and develop telecommunications systems and equipment to meet Australian requirements, having regard to what is available from overseas and to the resources of local industry and of other Departments of Telecom
- provide advice on trends in science and technology of relevance to Telecom Australia.

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 R&D investigations on topics that are relevant to the Australian network, having regard to the work known to be in progress in other Australian research laboratories and in similar institutions overseas.

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.

By performing relevant R&D projects, the Laboratories seek to ensure that Telecom has available advice in fields of advanced science and technology which is necessary 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.

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 experimental development performed by the Laboratories will yield equipment directly suitable for field application.

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 1985/86.

Relationships of the Research Laboratories

Since the primary role of the Research Laboratories is directed at the fulfilment of Telecom Australia's Charter, the principal "clients" for the work outputs of the Laboratories are other Departments and Directorates of Telecom. The predominantly scientific and technical nature of the work means that most outputs from the Laboratories provide inputs to the Network Engineering and Commercial Services Departments and the Business Development Directorate at Headquarters. These Departments are responsible for the planning and development of telecommunications services and network systems, and their interactions with the Laboratories are strong and ongoing. Lesser but significant interactions occur with the Information Systems Department at Headquarters and with the Network Engineering and Commercial Services Departments of the State Administrations.

To ensure its relevance, 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. 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.

Telecom Australia recognises the variety and depth of research expertise which exists in other organisations, industry and academia. In the Australian environment, it seeks to maximise, where possible, the returns on the national investment in telecommunications R&D by collaborating with other bodies to encourage and co-ordinate R&D activities relevant to Telecom's Charter. The Research Laboratories provide a focus of Telecom's encouragement and support of extramural R&D and for other less formal R&D collaboration.

Laboratories' staff maintain working contact with their peers in the Australian telecommunications industry, Commonwealth Departments and agencies (notably, the Department of Communications, OTC (Australia), Aussat Pty. Ltd. and CSIRO) and academia. Positive interactions are established by mechanisms such as:

- R&D contracts placed with industry, CSIRO and academia
- agreements for collaboration and co-ordination of R&D on specific topics of mutual interest
- financial membership and active participation in the grant-making activities of the Australian Telecommunications and Electronics Research Board in support of post-graduate research in academia
- the dissemination of Research Laboratories Reports and similar publications of the work of the Laboratories, as official publications of Telecom and as contributions to learned journals
- the sponsorship of, or participation in, national and international Conferences, Seminars, etc.

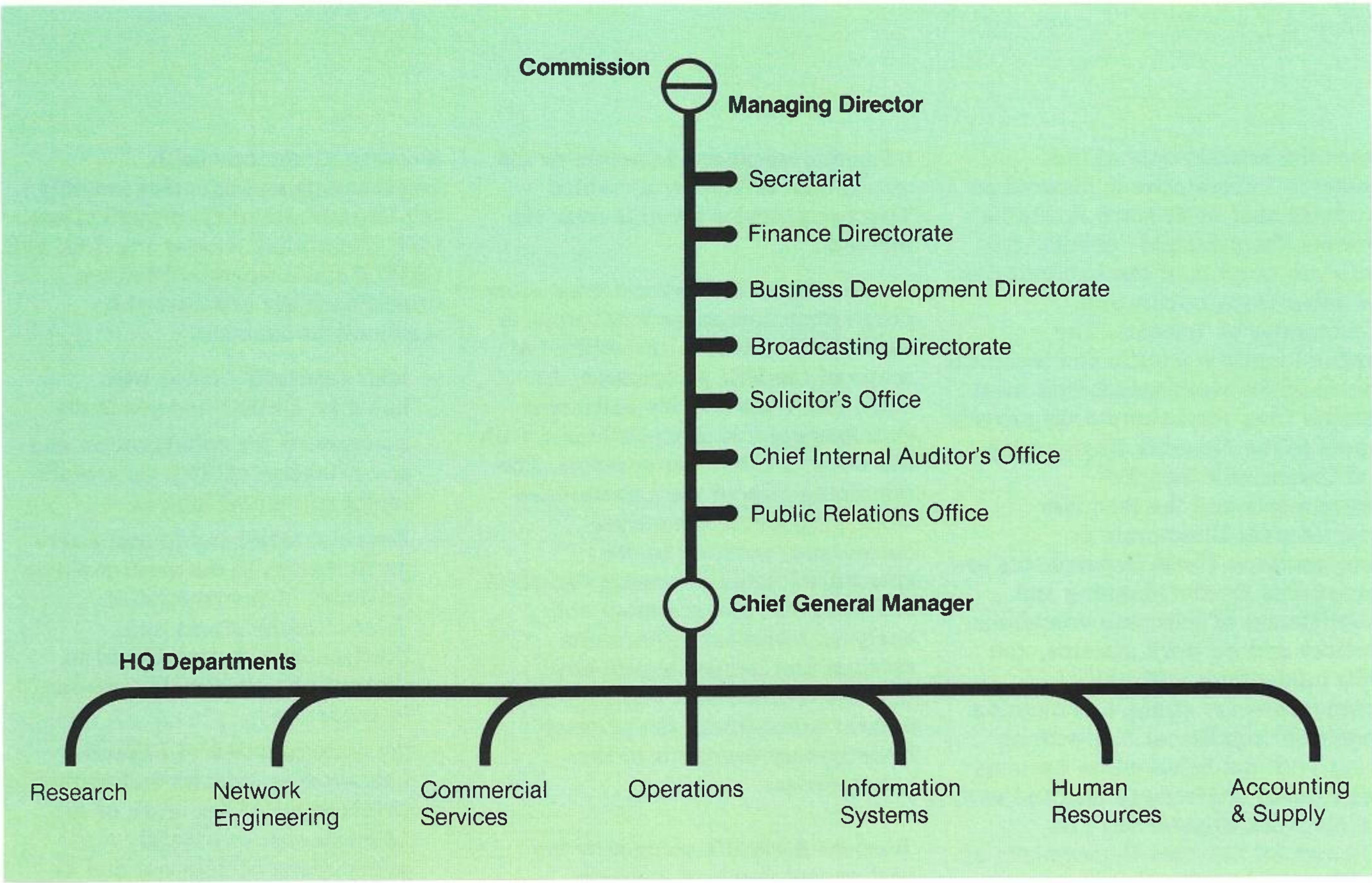
Some evidence of the extent of these activities is given in the back section of this publication.

In the evolution of more complex telecommunications services and with the increasing interactions of service-dedicated networks as the Integrated Services Digital Network (ISDN) evolves, Telecom is aware of the importance of national and international technical standards to its operations. Some of the Laboratories' projects are concerned with topics which are relevant to the development of such standards and their application. These projects provide a vehicle for Telecom's contributions to the standardisation activities of the Standards Association of Australia (SAA), the National Association of Testing Authorities of Australia (NATA), the International Telecommunication Union (ITU) and its International Consultative Committees for Telegraphy/Telephony and Radio matters (CCITT and CCIR), the International Electrotechnical Commission (IEC) and the International Organisation for Standardisation (ISO).

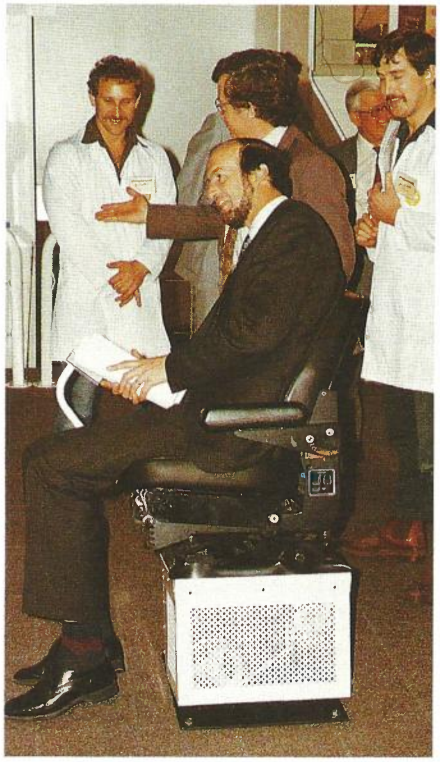
Staff of the Laboratories are also active in the work of learned institutions and participate as members of faculty and advisory boards of tertiary educational institutions.

Further evidence of the involvement of Laboratories' staff in such activities is given in the back section of this publication.

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



Items of Special Interest



Mr M.K. Ward, then Chief General Manager, talks with staff whilst putting the tractor tilt alarm to the test during the Open Days

Open Days, July 1985

For Laboratories' staff, the 1985/86 year began on a high note. After lengthy and sometimes strenuous preparations, the Laboratories became the focal point of interest for the technology minded of all ages during the first week of July 1985. The occasion, the Department's first public Open Days since 1979, attracted more than 10,000 visitors from all over Australia. For six busy days, professional, technical and clerical staff put aside their normal tasks to demonstrate and discuss the wide spectrum of working exhibits on display.

The activities of the Laboratories were demonstrated by means of a large centralised Exhibition and about 100 additional exhibits located in laboratories dispersed over the Blackburn Road campus. The Exhibition and individual exhibits were demonstrated by staff, who in turn welcomed the numerous discussions with interested visitors. Monographs were also made available at each exhibit to provide visitors with a record of items of particular interest and a Laboratories' contact for any later discussion.

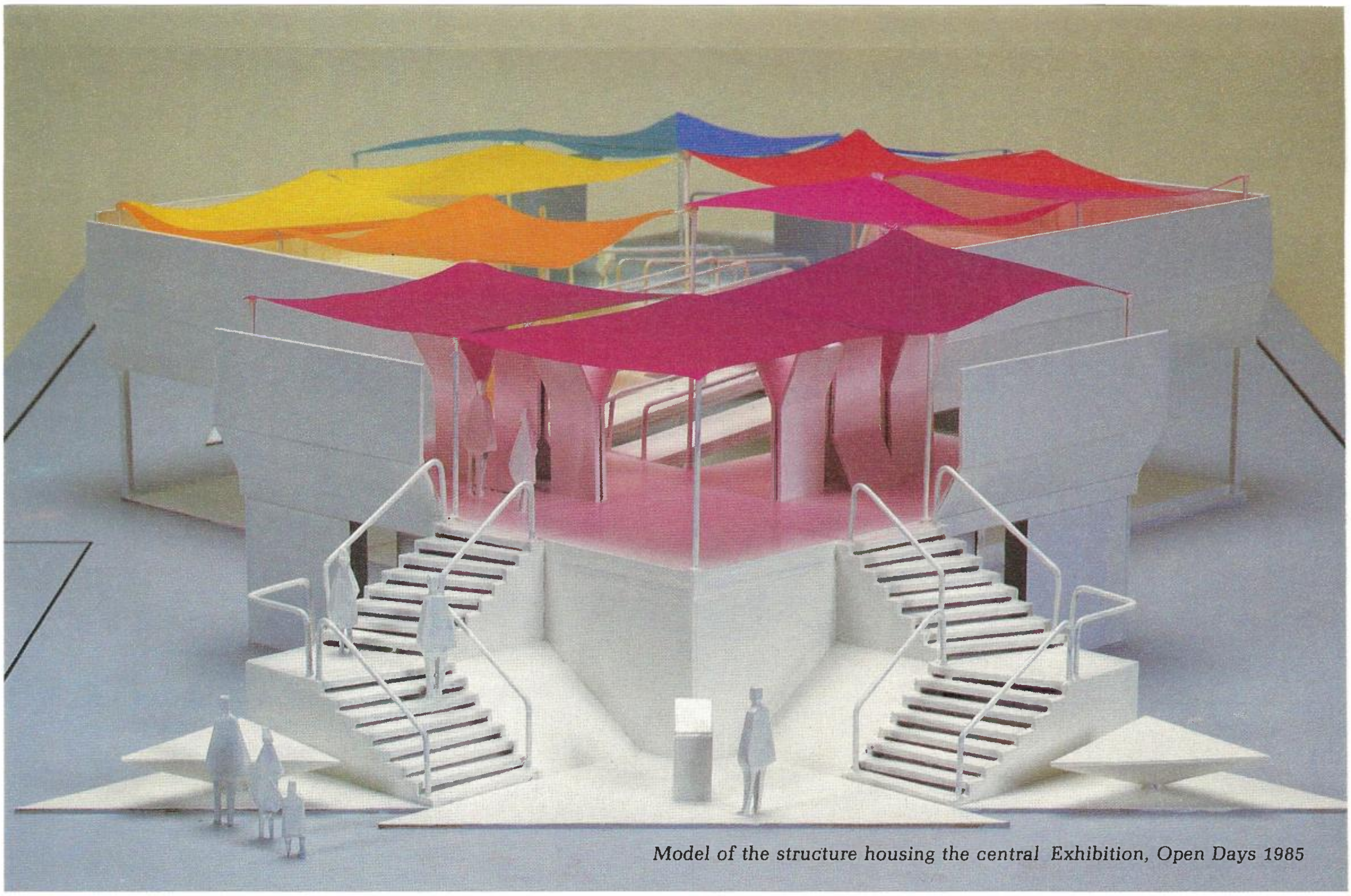
The central Exhibition provided a structured and integrated means of presenting visitors with an overview of Laboratories' activities and inviting them to inspect selected laboratory-based exhibits. The Exhibition also introduced visitors to the six major themes of Laboratories' activities under which exhibits were grouped, namely:

- Human Factors in Telecommunications
- Telematique Services
- Integrated Services Digital Network
- Optical Fibre Communications
- Satellite Communications
- Materials Science.

The central Exhibition was itself a collection of displays arranged in groups to introduce the above themes. These displays were mounted on an impressive multi-level structure. The structure itself was unique in Australian exhibition experience. It comprised four elevated platforms interconnected by a system of catwalks to partition the displays into logical groups relating to the six themes. It also provided a visitors' reception and advisory centre, together with space for relaxation and a theatrette showing videotaped film depicting some investigatory activities.

One highlight of the central Exhibition was the Laboratories' "museum" display, which comprised a number of examples of instrumentation and telecommunications equipment which were used in or were the topic of Laboratories' investigations in the 1920s, 1930s and 1940s. The museum exhibit provided a relaxing contrast to the high technology environment depicted by the exhibits relating to current activities. The individual exhibits were woven into a story which portrayed the role of the Research Laboratories in the development of communications in Australia. The highlight of the museum collection was a fully restored "Blattnerphone", an early magnetic recorder used by the Laboratories in the 1930s to record several historic shortwave broadcasts from overseas for re-transmission within Australia. The central displays included:

- an opportunity for visitors to make an interstate phone call and observe the resultant switching configuration eventuate on a large colour video image of Australia
- a working scanning electron microscope which provided photographs of enlarged images for the younger visitors



Model of the structure housing the central Exhibition, Open Days 1985

- a tilting tractor seat which demonstrated in real terms to many a startled rider the hazards faced by Telecom employees laying cable in rough terrain and the value of a safety tilt alarm designed in the Laboratories.

A fully integrated 8-track sound system complemented the central displays. The background music was composed especially for the occasion by Mr Leslie Gilbert, an accomplished Melbourne composer who specialises in the production of exhibition sound environments. In addition to the background music, localised sound on the Exhibition's platform conveyed a "collage" of material, including excerpts of informal discussions with Laboratories' staff.

The laboratory-based exhibits provided a basis for visitors from all walks of life to discuss particular projects in greater depth with Laboratories' staff demonstrators. These exhibits provided a valuable catalyst for information exchange between the staff of the Laboratories, management and staff from other Telecom Departments and Directorates, representatives of the Australian telecommunications industry, academics and students from tertiary educational institutions, staff of other research institutions and interested members of the public. During the week of Open Days, an evening session provided a special opportunity for Laboratories' staff to show their families and friends the activities of the Laboratories.

An innovative electronic directory system featuring Telecom's new Viatel videotext service provided a range of information services for visitors via terminals placed strategically throughout the Laboratories' campus.

The success of the Open Days was clearly evident to management and staff, not only of the Laboratories but also throughout Telecom. The obvious interest of visitors provided clear evidence of this success. This interest was noted among the many distinguished guests who attended the opening ceremonies on 2 July 1985, when Mr R.W. Brack, Chairman of the Australian Telecommunications Commission, formally inaugurated the Open Days and joined top management in inspections of the exhibits. Visitor interest was sustained throughout the week and provided staff with the satisfaction of being able to demonstrate their own, and Telecom Australia's, competence to continue to provide the Australian community with modern telecommunications services.

Further evidence of the success of the Open Days was the decision which resulted in the centralised Exhibition being re-established as the focal point of Telecom Australia's exhibits at the Royal Melbourne Show during September 1985.

This record would not be complete without recognising the dedicated efforts of the Laboratories' Open Days Team, led by Mr Roger Smith, Deputy Director, and the Graphic Design Team from the Network Engineering Department, led by Mr Carlton Jackson, and the valuable assistance provided by the staff of the Buildings Division of the Network Engineering Department and the Workshops of Telecom's Victorian Administration. These people were able to bring inspiration and focus to the, at times, daunting task of staging the Open Days and thence to co-ordinate the efforts of staff dispersed throughout the Laboratories to bring the event to fruition.

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 a number of such notable visits which occurred during the year.

(i) Visit by the Chairman, Commissioners and Chief General Manager, Telecom Australia

On 10 October 1985, Mr R.W. Brack, AO, Chairman of the Australian Telecommunications Commission, visited the Laboratories in the company of Ms M.A. Jackson and Mr J.C. Littlemore, Commissioners, and Mr M.K. Ward, then Chief General Manager of Telecom Australia. After being welcomed by Mr H.S. Wragge, Director, Research, and members of the Research Laboratories Council, the visitors discussed the role and work programme of the Laboratories, with reference, among other matters, to the Government Inquiry into Telecommunications R&D in Australia recently conducted by the Australian Science and Technology Council (ASTEC) and to the changing telecommunications environment in Australia. After these discussions, the visitors toured the Laboratories, inspecting project work related to:

- new glass materials and technology for optical fibre communications media
- the protection of people and plant from high voltage hazards
- thick film hybrid circuit technology
- local area networks, and
- communications protocols and services in an ISDN exchange environment, as simulated in the Laboratories by the experimental ISDN exchange project.

(ii) Visit by Mr C.C. Halton, Secretary, Department of Communications, and Commissioner of the Australian Telecommunications Commission.

On 10 April 1986, Mr C.C. Halton, newly appointed as a Commissioner of the Australian Telecommunications Commission visited the Laboratories. He was welcomed by Mr H.S. Wragge, Director, Research and, in discussion with Mr Wragge, Mr R. Smith and Dr F.J. Symons, he was given an overview of the role of the Laboratories within the Telecom Australia organisation and in the broader Australian telecommunications environment. Mr Halton then visited a number of laboratory venues, where he met and talked with staff about:-

- the experimental ISDN exchange and the associated investigations using the exchange as a test bed
- the potential future applications of fast packet switching in an ISDN
- future customer services and their terminal/network interface implications in the evolution of the ISDN
- the place of materials science in telecommunications and, in particular, the work of the Applied Science Branch in the field of polymer chemistry and reliability assessment of photovoltaic and semiconductor devices.

(iii) Visit by Members of the Telecommunications Advisory Committee

The Telecommunications Advisory Committee (TAC) is a forum of representatives of Government Departments and agencies, chaired by the Department of Communications, which discusses telecommunications issues of national importance.

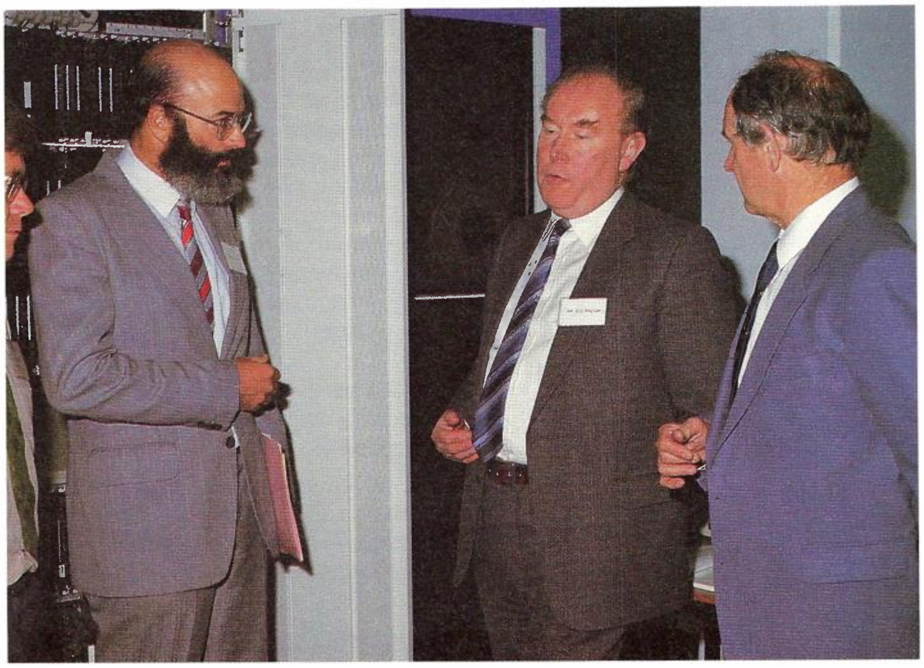
On 10 July 1985, a TAC party comprising representatives of the following Government Departments and agencies visited the Laboratories:

- Telecom Australia
- Department of Communications
- Department of Defence
- Department of Science, and
- OTC (Australia).

After being welcomed by the Director, the visitors were given a brief outline of the roles and functions of the Laboratories and then inspected and discussed the following projects and activities:

- voice synthesis techniques
- field trial of common channel signalling system No. 7

Mr C.C. Halton, Commissioner, discusses research activities relating to future services and terminals in the evolution of the ISDN with Mr H.S. Wragge and Mr P.H. Gerrand (l. to r. : Mr Gerrand, Mr Halton, Mr Wragge)



- digital radio techniques and systems
- heterodyne optical systems, and
- wideband systems.

(iv) Visits by two Delegations from the People's Republic of China

(a) On 7 October 1985, a party of scientists from the Academy of Science and Technology, People's Republic of China, visited the Laboratories. The visiting party, sponsored by Mr T. Keeble of the Institute of Engineers, Australia, comprised the following members:

- Professor Shen Yuan
  Member of Academic Division, Chinese Academy of Sciences, Member of Standing Committee, China Association for Science and Technology, and Professor and Honorary President, Beijing Institute of Aeronautics and Astronautics
- Professor Gao Lan-Qing
  Vice-Director of the Mining Department, Beijing Institute of Iron and Steel
- Mr Wen Zuning
  Deputy Director, Department of Academic Society Affairs, China Association for Science and Technology
- Mr Kang Jincheng
  Project Officer, Department of International Affairs, China Association for Science and Technology.

After discussions with the management of the Laboratories, the visiting scientists toured a number of laboratory venues for presentations and discussions on the following projects and activities:

- radio systems
- satellite systems
- solid state electronics, and
- optical technology.

(b) On 27 November 1985, the following group of Chinese research economists visited the Laboratories:

- Professor Jia-Pei Wu
  Director, Institute of Quantitative and Technical Economics (IQTE)
- Mr Bing Ma
  Deputy Secretary-General of the Economic Research Centre, State Council
- Mr Shou-Yi Zhand
  Head of Department of Economic Modelling and Associate Research Fellow, IQTE
- Mr Fang Zhow
  Deputy Head of the Department of Economic Modelling and Associate Research Fellow, IQTE
- Mr Ju-Huang He
  Staff member of the Department of Economic Modelling and Associate Research Fellow, IQTE
- Mr Shu-Cheng Liu
  Head of the Editorial Department, IQTE
- Ms Duo Qin
  Staff member of the Editorial Department and Junior Research Fellow, IQTE
- Mr Ning Su
  Staff member of the Forecasting Centre of the State Planning Commission
- Mr Dang-Zuan Pang
  Staff member of the Technical Economic Research Centre of the State Council.

Accompanying the Chinese visitors were:

- Mr D. Challen
  Chief Economist, Economic Planning Advisory Council, Canberra
- Dr K. McLaren
  Senior Lecturer, Department of Econometrics and Economics, Monash University
- Mr C. Blampied
  Melbourne University Impact Project.

The visitors discussed the roles of Telecom and the Research Laboratories with Mr F.W. Arter and then toured the Laboratories, inspecting and discussing a number of projects, including lightning protection of components, plant and equipment, and energy technology including power supply modelling.

(v) Visit by the Senate Standing Committee on Technology and the Environment

On 20 November 1985, the Senate Standing Committee on Technology and the Environment visited the Laboratories. The visitors included:

- Senator Gerry Jones
- Senator Mike Townley
- Senator David Vigor
- Ms Sasikarn Burke
- Mr Robert King, Committee Secretary.

After being welcomed by the Director and other members of the Laboratories' management team, the visitors were given a brief presentation on the Laboratories' functions and activities before touring the Laboratories to inspect and discuss project work relating to:

- optical technology
- telematic and message services
- solid state electronics, and
- time and frequency standards.

(vi) Visit by Senator Jessop

On 21 November 1985, Senator Don Jessop visited the Laboratories. After discussing the role and functions of the Laboratories, the Senator toured a number of laboratory venues to inspect the following activities:

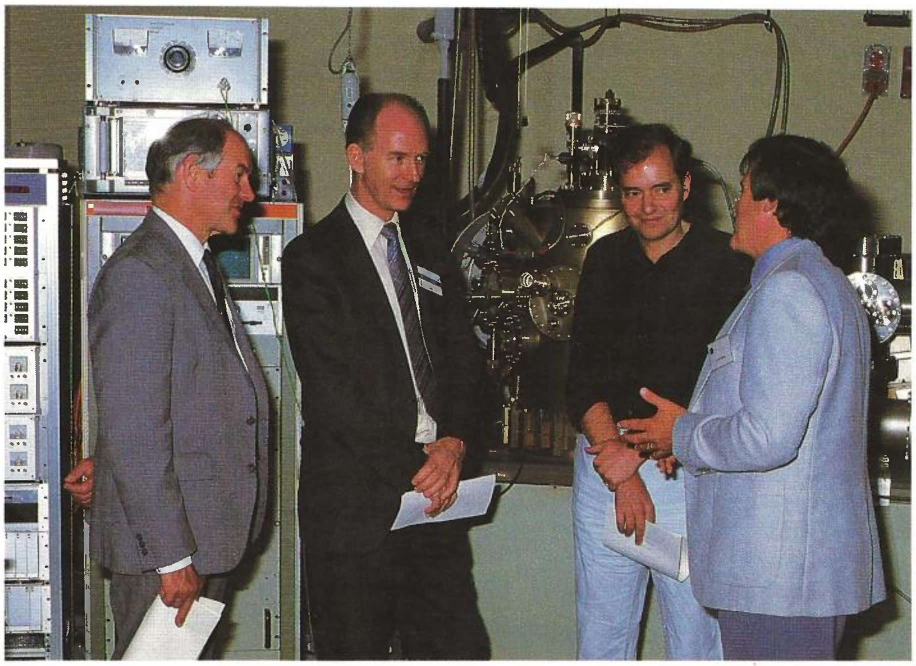
- telematic and message services
- optical technology
- solid state electronics, and
- time and frequency standards.

(vii) Visit by ASEAN Representatives

On 6 November 1985, the following four ASEAN representatives visited the Laboratories:

- Mr J.K. John
  Program Co-ordinator, National Institute of Public Administration (INTAN)
- Mrs E.B.Ramos
  Supervising Planning Officer, Program Co-ordination Division, NSTA
- Dr Roestamsjah
  Assistant to the Director for Scientific Matters, National Institute for Chemistry, Indonesian Institute of Sciences
- Mrs J. Cadoc-Reyes
  Training Assistant, Research Management Centre, College of Development Economics and Management, University of the Phillipines.

The visitors were given a presentation on the roles of Telecom and the Research Laboratories by Mr F.W. Arter



Mr W.G.T. Jones of British Telecom discusses research applications of the molecular beam epitaxy facility with Mr H.S. Wragge, and Drs G. Price and P.V.H. Sabine (l to r. : Mr Wragge, Mr Jones, Dr Price, Dr Sabine)

and then toured the Laboratories, inspecting and discussing the following projects and activities:

- molecular beam epitaxy (MBE) facilities
- fibre optics technology
- environmental testing in the laboratory
- surface characterisation techniques
- polymers in telecommunications.

(viii) Visit by Mr W.G.T. Jones, Chief Executive for Technology, British Telecom

On 17 March 1986, Mr W.G.T. Jones, Chief Executive responsible for the central R&D activities of British Telecom, visited the Laboratories whilst in Australia to present a paper to the Australian Telecommunications Users Group Conference, March 1986. During his visit, Mr Jones met senior management and staff of the Laboratories and presented them with an outline of research roles and activities in British Telecom since it was privatised. He also discussed the changing Australian telecommunications environment and future pressures and trends in telecommunications R&D.

Mr Jones then toured the Laboratories, inspecting and discussing projects related to:

- molecular beam epitaxy in semiconductor materials research
- customer access and multi-service terminal developments for ISDN
- developments in digital cellular mobile radio communications, and
- next generation packet switching techniques and networks and their likely impact on the future evolution of an ISDN.

(ix) Visit by Mr W. Rowe, State Secretary, Ministry of Posts and Telecommunications, and Colleagues from the Federal Republic of Germany

On 3 April 1986, Mr Wilhelm Rowe, State Secretary, Ministry of Posts and Telecommunications, FRG, visited the Laboratories. He was accompanied by Mr W. Freundlieb, Director (Personnel) of the Ministry and his personal aide, Mr C. Duerig. After wide ranging discussions with Mr Roger Smith, Deputy Director, Dr F.J.W. Symons and Mr F.W. Arter about Australian telecommunications and the role of Telecom Australia and its Research Laboratories, the visitors inspected and discussed projects in the laboratory relating to:

- remote area power supplies in Australian telecommunications
- telecommunications cables, and in particular, polymer materials for cable applications, in the Australian range of climatic environments.

Organisational Changes

During the past year, several changes have been made to the functional responsibilities and/or the organisational structure of the Laboratories. Some of the changes reflect changing emphasis in the activities of the Laboratories, whereas others reflect the transfer into the Laboratories of functional responsibilities previously performed by other Departments of the Headquarters Administration. The principal changes are reported in the following paragraphs.

Local Access Systems Section

In November 1985, the former Wideband Systems Section and Line and Data Systems Section of the Transmission Systems Branch were merged to form the Local Access Systems Section. With this merger, the Laboratories are better placed to carry out studies of the customer access network, which represents up to 40% of the total telecommunications network, and the physical transmission aspects of Local Area Networks (LANs).

Over the past few years, the Wideband Systems Section had built up a strong body of expertise in wideband techniques and LANs. The Line and Data Systems Section was responsible for the initial technical studies of the inter-exchange digital line transmission systems (at 2.048 Mbit/s) which became the forerunner of the digitalisation of the transmission part of the network. In more recent years, the Section studied the digitalisation of the existing customer cable distribution network, especially for the provision of ISDN Basic Access.

Now that techniques for exploiting the existing metallic cable network are close to implementation, Telecom is directing its research investigations towards the use of new optical fibre and radio media for the customer access network. Investigations of these future customer access networks are dependent on a combination of expertise not effectively achieved by the former two-Section organisation. In application of optical fibres in the future customer access network is important, since fibres are wideband transmission media capable of supporting narrowband and wideband services. Similarly, expertise in accessing techniques similar to those applied in LANs to enable many terminals to share a transmission capability are also relevant to studies of customer access networks. Hence, it was considered appropriate to combine these skills, divided between the two former Sections, into the new Local Access Systems Section. This merger of skills and resources will enhance interaction and skill transfer among the staff of the new Section.

The work of the Local Access Systems Section will initially emphasise customer access networks which are based on optical fibres, which can provide existing narrowband services at a cost comparable to the existing cable network and which have the capability to evolve to provide wideband services as required. The studies of LANs are currently concerned with the integration of video, voice and data services on LANs and the use of optical fibres as the transmission medium.

The work in the Transmission Systems Branch is now more strongly oriented towards the customer area and the studies of the Local Access Systems Section as outlined above will be complemented by work in other Sections of the Branch. In particular, the Radio Systems Section is investigating digital mobile and portable radio systems, whilst the Satellite Systems Section is investigating satellite-based customer systems, including mobile systems.

Drafting Support Section

As a result of the restructuring of the Network Engineering Department, the three drafting groups previously outposted from that Department to the Research Department were formally transferred to it late in 1985. In the process, the groups were combined into a new Section, called the Drafting Support Section, which reports to the Assistant Director, Standards and Laboratories Engineering, and is led by a Chief Draftsman as its Section Head. A total of 22 persons and positions have been added to the Standards and Laboratories Engineering Branch establishment as a result of this transfer.

The new Section will provide electrical, electronic and mechanical drafting services for the Laboratories. Examples of these services include:

- production of printed wiring board artwork, either manually or by means of a computerised drafting system
- electronic circuit diagrams and component layouts
- artwork in the form of graphs, drawings, etc. for Research Laboratories Reports, Branch Papers and other technical publications
- mechanical drawings for prototype manufacture and drawings related to laboratory accommodation, facilities and building services.

The functional statement for the new Section charges it with responsibilities for:

- the preparation and modification of drawings, incorporating associated design drafting, investigations and computations
- ensuring that the standard of engineering documentation prepared in the Research Department conforms to Telecom's policies and standards
- providing consultative services on the standard or specification of contractor-supplied engineering documentation.

Translation Unit, Headquarters Library Section

The Translation Unit was transferred from the Human Resources Department to the Research Department in November, 1985. The unit has been incorporated within the Headquarters Library Section of the Standards and Laboratories Engineering Branch and reports to the Principal Librarian. This has added a further three persons and positions to the Standards and Laboratories Engineering Branch establishment.

The Translation Unit provides translation services not only for the Headquarters Library but also for all other Departments and Directorates of the Headquarters Administration, and occasionally, for State Administrations of Telecom.

Typical translation tasks involve technical documents of various types, including items from learned journals and manuals written in other than the English language. Correspondence is also translated, together with occasional official documents (e.g. birth certificates, medical reports, qualification certificates, contract documents, etc.). Translations are undertaken by the Unit in all Western European languages and Russian. Arrangements are made by the Unit for documents in other languages to be translated by external translation service bureaux. The Translation Unit also occasionally translates or arranges translations from English to a foreign language.

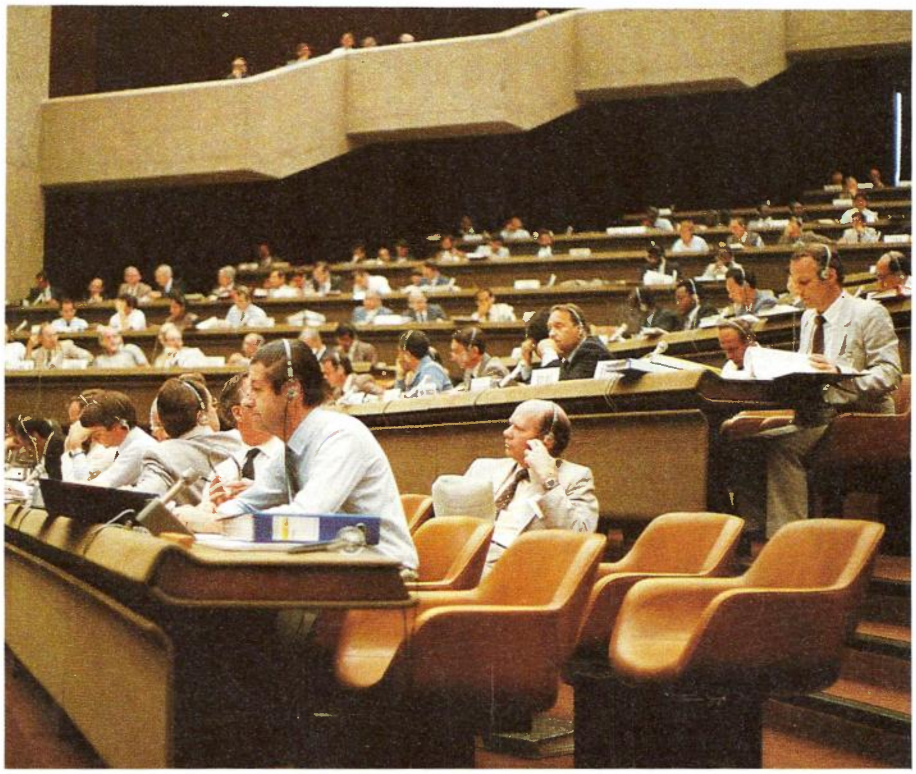
World Administrative Radio Conference on the Geostationary Satellite Orbit

During August and September 1985, representatives of 111 nations attended a World Administrative Radio Conference (WARC ORB(1)) in Geneva, to investigate means for guaranteeing that all nations will have access to the geostationary orbit (GSO) for satellite communications purposes, when required. The Conference was held in accordance with a 1979 resolution of the International Telecommunications Union (ITU) to hold such a Conference, in two sessions two years apart, to establish an equitable basis for all countries to share the GSO.

WARC ORB (1) was attended by over 900 delegates, including 14 from Australia - a reflection of the importance and far-reaching consequences of decisions to be made.Telecom Australia was represented in the Australian delegation by Mr G.F. Jenkinson of the Research Laboratories.

Australia has a large commitment to satellite communications, as evidenced by the domestic Aussat system, the significant national shareholding in the international Intelsat and Inmarsat systems, and defence systems. As well as being a shareholder in Aussat, Telecom Australia has a very large investment in its terrestrial radiocommunications network, which shares the same spectrum as some satellite systems.

The GSO is a unique orbit 36 000 km above the equator. Satellites in this orbit are synchronised with the earth's rotation and appear stationary in the sky. This is a very real advantage for communications purposes, but unfortunately, interference between adjacent satellites using the same radio frequency (RF) band limits the usable capacity of the GSO in that band. The



WARC ORB (1) in session at Geneva, with some of the Australian delegation in the foreground. (The headphones provide simultaneous interpretations of proceedings in six languages)

particular, expertise relevant to the bands available for satellite communications are also strictly limited and shared with other terrestrial communications systems. Thus, the combination of GSO and RF spectrum, the "orbit/spectrum resource", is often regarded as a limited natural resource.

Many nations, particularly the developed ones, are now making substantial use of the GSO, resulting in crowding in parts of the orbit. The newer, developing nations consequently fear that they will be unable to obtain orbital "slots" in the future. This has led to much argument between nations within the ITU over recent years. Many developing nations want an "a-priori plan" in which specific orbit/spectrum slots are reserved for each nation. As many such reservations may never be used, most developed nations strongly oppose this approach and argue that continuing advances in technology will allow more efficient use of the orbit, enabling the real needs of all countries to be met.

The 1985 Conference operated, for much of its time, with parallel sessions covering different issues. A notable feature of the Conference was the initial reluctance of many nations to come to any form of compromise position on various issues. Finally, some compromise was achieved, with agreement to develop an a-priori plan for some frequency bands, while leaving other bands to be shared by mutually agreed co-ordination procedures. A number of unresolved issues were referred for inter-sessional study by nations before the second session, WARC ORB (2), meets in 1988.

While Australia can be reasonably satisfied with the outcomes so far, much still remains to be done before and at WARC ORB (2) to protect Australia's interests. WARC ORB (1) will be recorded as one of the most difficult Conferences in ITU history.

Honour to Laboratories' Engineer, Jim Park

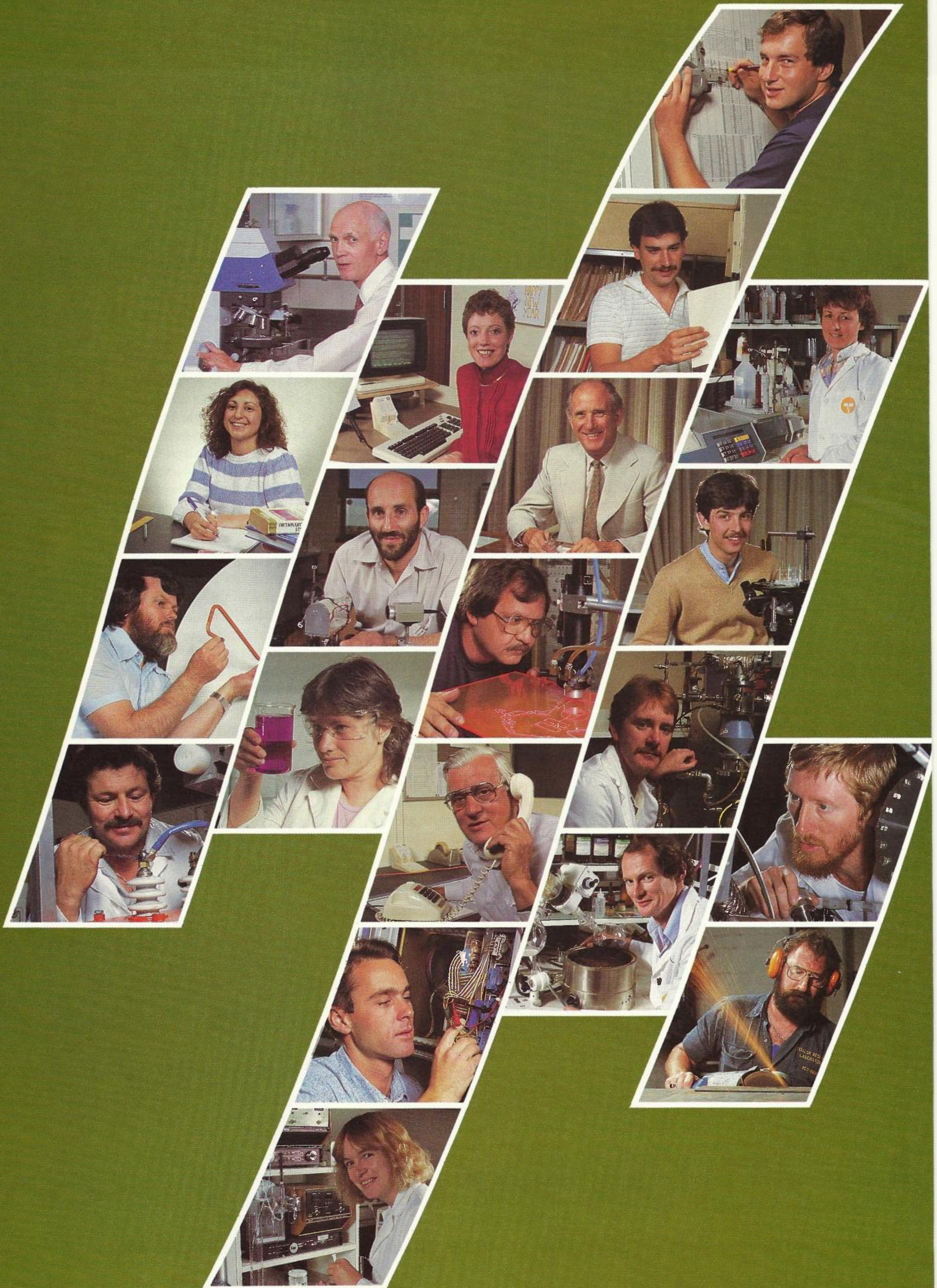
During the year, the Australian Computer Society (ACS) honoured Jim Park as its "Lecturer of the Year, 1984". The award of this honour followed Jim's presentation of a lecture entitled "The Impact of the Open Systems Interconnection Model and the Current Status of Standardisation Activities" to the New South Wales Branch of the Society in September 1984.

Jim's lecture to the ACS covered the importance of standards in data communications. In particular, Jim addressed international and national standardisation activities based on the Open Systems Interconnection Model developed by the International Organisation for Standardisation (ISO) and the Consultative Committee for Telegraphy and Telephony (CCITT) of the International Telecommunications Union (ITU). He outlined the impact of these activities on both public and private data communications networks drawing upon relevant work being performed in the Laboratories, the Standards Association of Australia (SAA) and the CCITT.

Jim is the engineer in charge of the Data Switching Section, Switching and Signalling Branch, of the Laboratories. As such, his main areas of interest include fast packet switching techniques and the performance of, and interworking between, data communications terminals and networks. At the time of the lecture, Jim was also Chairman of SAA Committee 1S/1/16/1, which is concerned with standards for computer communications. Jim continues as a Telecom representative on that Committee, and he also co-ordinates Telecom's participation in CCITT Study Group VII, which is concerned with developing and recommending international technical standards for the operation of public data communications networks.

As a result of the award, Jim has been invited to present an up-date of his lecture to the branches of the ACS in each Australian State during 1986.

Jim Park, ACS "Lecturer of the Year", 1984



A Selective Review of Current Activities

Introduction

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", a publication made 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 Branches 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.

The Human Side of Telecommunications

Much of the world's telecommunications research is concentrated on technology. Indeed, it has been this past concentration on technology that has produced existing cheap, efficient, worldwide telecommunications services. Technological research and development has now launched the world into a space of communications potential. But it is people who use telecommunications. The newest, most efficient technology is of value only if people can use it to serve their needs, easily, effectively and competitively.

Research on the human side of telecommunications was for many years confined to the human factors of telephony. Now, however, the companies who provide and market telecommunications services are increasing effort directed to non-technological research. There are two major areas for investigation, each at a different level.

At one level, a complex, highly interdependent society requires a variety of communications services and facilities, but it is not yet well understood what these are. On a quite different level, the role of the individual as one element in a diversifying range of communications processes is not well understood.

Telecom Australia, like other service providers, can choose to offer its customers a potentially huge and diverse range of new services and facilities made feasible by modern technology. However, to be successful in meeting the needs of its customers, it must understand what facilities the organisations and institutions of society will need in their continuing activities.

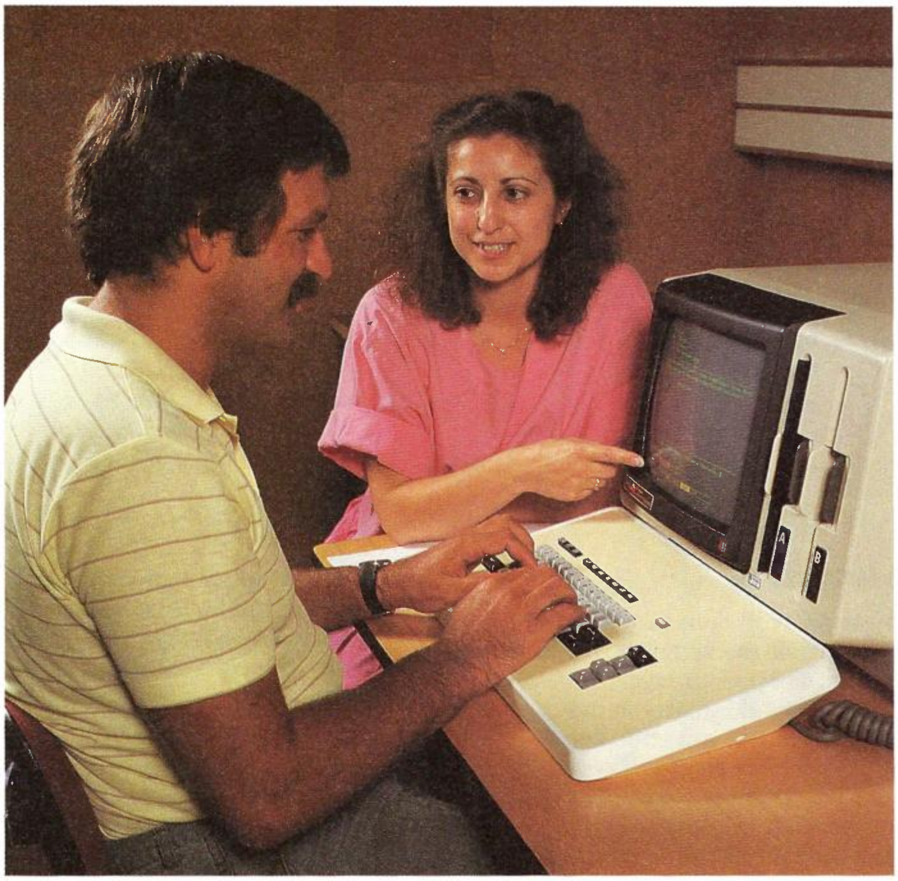
When considered at the level of the individual, telecommunications facilities that are difficult to use will not survive in the market place. New computer-based telecommunications services and facilities can be considerably more complex than earlier communications means. If they are to survive, the procedures needed to operate them must be matched to the capabilities of humans. Current human factors research in telecommunications has just such a goal.

In Telecom's Research Laboratories, a multidisciplinary group is pursuing R&D studies at both the abovementioned levels.

One team is studying organisational needs within the framework of a "Needs, Innovation and Change (NIC)" model. The model attempts to account for the effects of a diverse range of factors. For example, the perceptions of communications needs within an organisation change when new modes of communication are adopted. Consequently, new means of working are discovered and perceptions change further as decision makers become better informed about the availability and capability of new telecommunications services and facilities. Organisational style or "culture" is another factor that affects the communications facilities adopted. The NIC model also considers geographical aspects, since the spatial distribution of an organisation's establishments, suppliers and markets have important effects on its needs for telecommunications services. Current research in the Laboratories is focussed on the "cultural" effects of communication decisions and on geography.

A second team is studying human factors. In particular, the studies are concerned with how individuals gain an understanding of the operations of a computer-based telecommunications facility for services such as electronic messaging, and what that understanding is. The performance of individuals is studied while they are using telecommunications services simulated in the laboratory and where possible, in actual field use. The experimenter examines variations in learning patterns, errors made and the time taken by individuals to perform several communications tasks, while varying the amount and type of information provided. The information is provided both directly by the working facility as on-screen instruction messages or via training manuals. This research seeks to determine what makes computer-based telecommunications services and facilities most easily usable by all classes of user.

Another research programme at the individual level comes under the rubric of "artificial intelligence". Its principal theme is machine-based natural language understanding. This effort is again aimed at contributing to Telecom's goal of offering easily usable telecommunications facilities to its customers.



Subjective assessment of machine-based natural language instructions for potential application in telecommunications services

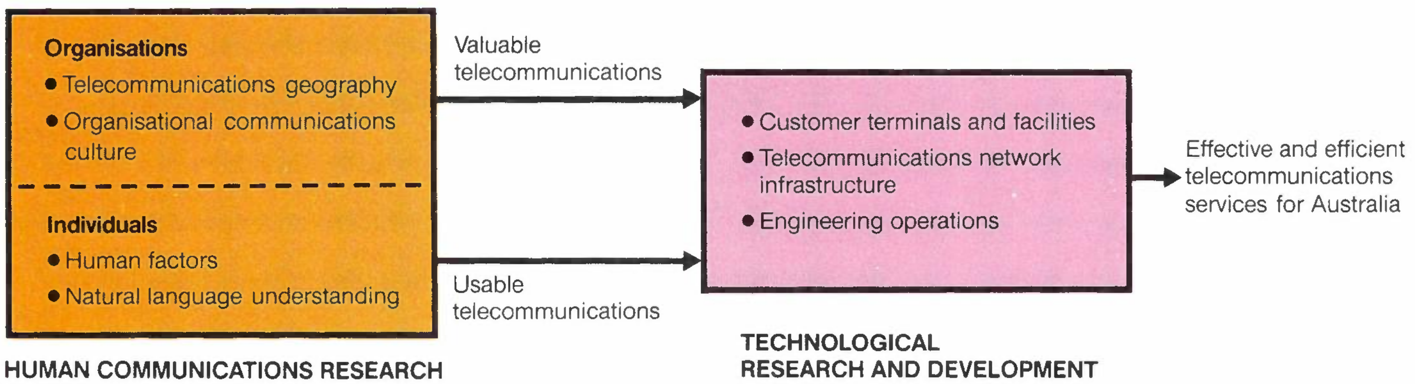
The underlying objective of both research teams is to generate a greater understanding of the needs of organisations and individuals for future telecommunications services, so that they can assist Telecom Australia to fulfil its Charter to provide telecommunications services which best meet the social, industrial and commercial needs of the people of Australia.

The Geography of Telecommunications

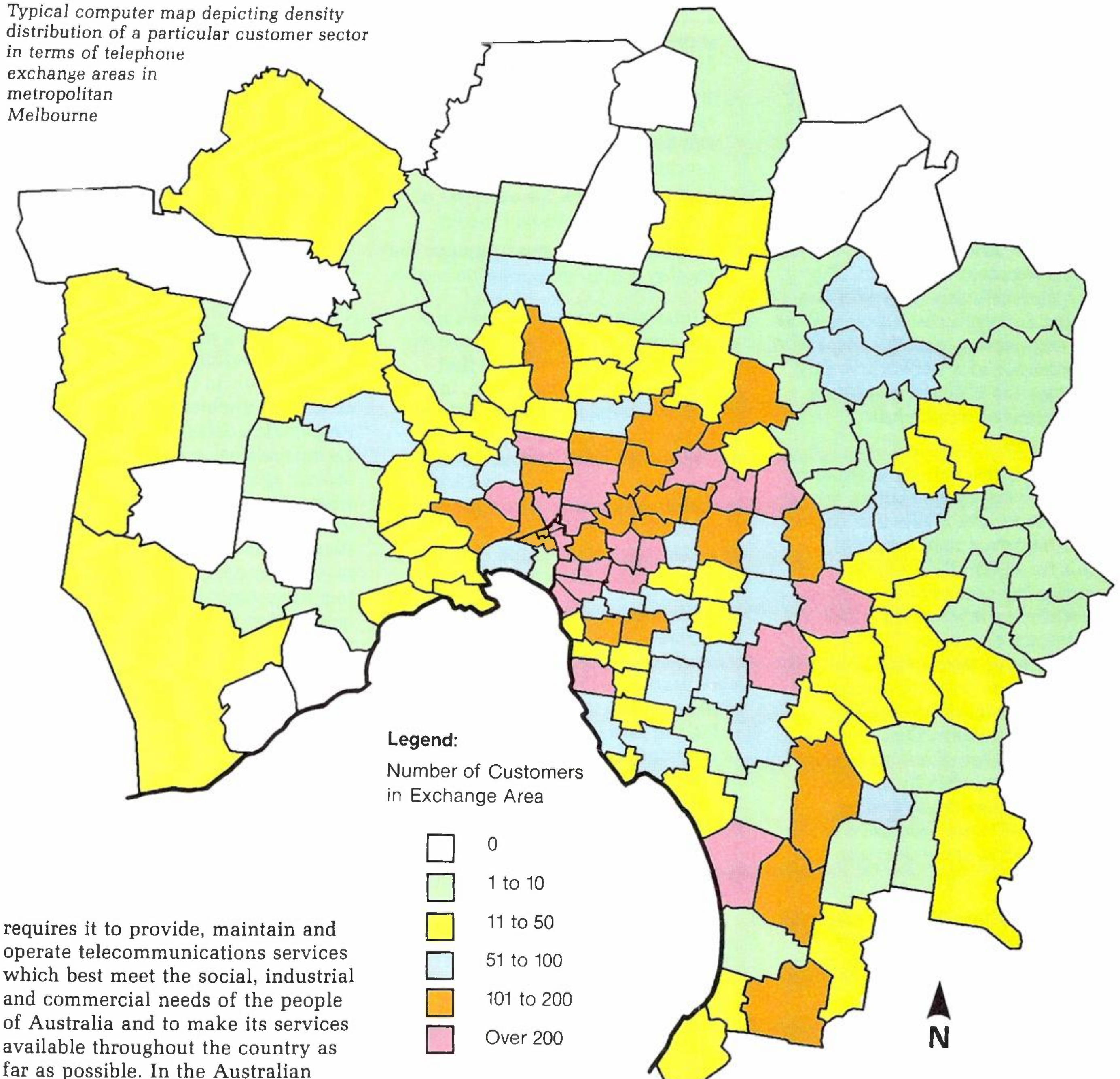
The geography of telecommunications is a relatively new field of non-technological research for Telecom. Indeed worldwide, very few geographers have carried out specific research in this field. The Research Laboratories are undertaking this research as part of a programme to understand how and why telecommunications demands arise, what information people are communicating and why, the purpose information flows serve within and between organisations, and the distribution and location of Australian organisations.

Telecom's Charter established by the Telecommunications Act 1975

The role of human communications research



Typical computer map depicting density distribution of a particular customer sector in terms of telephone exchange areas in metropolitan Melbourne



requires it to provide, maintain and operate telecommunications services which best meet the social, industrial and commercial needs of the people of Australia and to make its services available throughout the country as far as possible. In the Australian telecommunications environment, Telecom recognises that its forward planning of telecommunications services should try to anticipate future demand and social needs, and to relate these to changes in the external environment. Factors to be considered include economic growth, changes in urban and regional settlement patterns, the supply of energy and developments in other sectors, notably transport. It therefore follows that an understanding of the distribution and location of organisations, as well as their existing and likely future telecommunication needs, will help in the determination of the type and location of products and services which Telecom should concentrate on providing in the future.

The Australian telecommunications network infrastructure and the services provided to its users are the product of an existing situation, providing the starting point of any study of the geography of Australian telecommunications. In developing an assessment of telecommunications in a geographical area, the past and future development of the area can be considered as a function of the area's characteristics, implying that the telecommunications structure can be related to other structures within the area.

Within the Laboratories, initial research on telecommunications geography has concentrated on developing a technique whereby any of Telecom's data which contains telephone numbers can be mapped by computer, to provide database information for geographic zones determined by telephone exchange or business district boundaries which are already related to Telecom's operations. To date, the exchange boundaries for the Melbourne metropolitan area have been digitised and trial mapping of sample customer sectors has been carried out. The work is of a preliminary nature, the initial task being the development of computer mapping techniques.

It is anticipated that, once developed for the whole of Australia, the database will provide a powerful, cost-effective information system which will be utilised particularly for geo-informational studies, but also to provide inputs to more general strategic planning activities within Telecom.

Melbourne Network Study

Each year, Telecom Australia spends several billion dollars to develop the national network infrastructure. The development task requires the purchase and installation of switching and transmission equipment which will provide network capacity to carry the expected volume of telecommunications traffic at an adequate standard of service. The task of dimensioning networks is a specialist activity known generally as traffic engineering, and the successful dimensionsing of a network largely determines the efficient use of the funds expended on network development.

The Laboratories employ a group of traffic engineering specialists, whose function is to investigate and develop new or improved mathematical models for optimally designing and dimensioning networks at minimum cost, whilst satisfying particular performance objectives. These objectives have been established for the networks in order to provide a satisfactory level of service for Telecom's customers. Over the past decade, a number of sophisticated mathematical models for network design have been developed in Australia and these models have now been adopted in some overseas countries.

Research projects carried out by Telecom Australia in collaboration with Adelaide University over recent years have culminated in the production of a network design package based on new mathematical techniques and incorporating a number of advanced computer aids for network planners. In order to test this system, the Melbourne Telephone Network was modelled as envisaged for the year 1990. The network at that time was expected to be evolving from analogue to digital form, with some sections possibly retaining older equipment types. In the studies, 160 exchange locations were modelled; these supported nearly 900 traffic switching points interconnected by over 20 000 transmission links.

The data required for the design task was quite substantial and involved over 96 Mbytes of mass storage. The data consisted of:

- forecasts of traffic demands, which must be specified for each pair of exchanges in the network
- a set of potential routing plans, showing how traffic may be sent from one exchange to another
- a set of performance standards that specify the congestion levels that can be tolerated in the design process
- cost information for all types of transmission links and media
- module sizes for circuit groups that employ digital transmission media.

The total network design package which has been developed involves two processing phases. The first phase is an interactive phase, in which the planner prepares lists of changes to the circuit requirements, and these are submitted to the next phase. The second phase is a batch processing phase, in which automatic optimisation procedures can be invoked in addition to the interactive ones submitted from the first phase.

The Melbourne Network Study has confirmed the viability and practical value of the new network optimisation techniques for very large networks. The results show that, by using the new design package instead of conventional network design methods, cost savings of up to 10% can be achieved in the provision of inter-exchange circuits. Such savings can represent millions of dollars over a period of network development.

Effects of Propagation Delay on Telephone Users

Communications satellite links are now in use for the majority of international telephone connections and also for some remote area national telephony. Since a satellite link introduces a considerable propagation delay (500 to 600ms per round trip), the cascading of satellite links can lead to total propagation delays in a telephone connection of one second and higher. In addition, other sources of delay could result from the application of recent and emerging technologies such as digital speech interpolation, packetised voice and low bit-rate speech encoding.

The CCITT deprecates the use of more than one satellite link in a telephone connection, because long delays stimulate double-talking during which echo suppressors cannot effectively control echo. The delay itself tends to slow down the rate of information exchange, confuses users as to when they can talk without involving double-talking, and may generate an adverse opinion about a partner's responsiveness.

Although any adverse effects of echo are likely to be eliminated in the future by more effective echo control measures, the effects of delay will, of their fundamental nature, remain. In order to understand better the effects of pure delay (i.e without echo) in telephone conversations, a programme of subjective and empirical studies was undertaken by the University of Melbourne under a Telecom research contract. The studies involved both real telephone calls and laboratory simulations. Propagation delays ranged from 0 to 2.4 seconds per round trip in steps of 600ms, and echos were eliminated where practical by combinations of 4-wire working and echo cancellors. Participants in the studies were required to undertake various tasks, requiring varying degrees of information exchange. The effects of delay and other stresses were measured by perceived stress levels, heart rate, perceived performances of partners, communications task performances and changes in speaking patterns.

Overall, the results suggest that, despite the fact that increasing delays reduce communications efficiency in a task-dependent manner, telephone users are not seriously bothered by pure delay for round trip delays of up to 1.2 seconds, but their delay awareness increases rapidly with further increase of delay.

Speech Processing and Quality Assessment

Telecom Australia's networks of the future will provide new and enhanced voice services through the use of various forms of digital speech processing. Much of the existing transmission and switching of speech signals in the public network already utilises digitally encoded speech (A-law PCM-30) with a channel coding rate of 64 kbit/s.

More recently, an adaptive differential PCM coding algorithm at 32 kbit/s has been standardised internationally. It provides the capability of doubling the capacity of digital transmission trunks for speech. Even lower bit-rate encoding algorithms are in demand for applications where digital bit-rate availability or costs are at a premium.

Such applications include new generation digital satellite systems, the proposed digital mobile cellular radio system and new systems providing digital storage of speech, as in voice messaging systems.

All of the above applications are of interest to Telecom Australia. It therefore follows that the Research Laboratories should be investigating the underlying techniques for the digital coding, processing and synthesis of speech signals.

For very low bit rates, waveform encoding techniques are replaced by parametric type encoding. In addition to adding the normal quantising noise, parametric encoding may add new types of speech signal impairments, including loss of naturalness and intelligibility, and perhaps introduce significant end-to-end delays due to processing complexity. Other impairments associated with various forms of digital processing include clipping of initial sounds, clicks and the non-transmission of so-called "silences" in conversations.

Speech synthesis techniques have important applications in the areas of speech response systems and text-to-speech conversion. Available synthesis techniques can provide a wide range of qualities, from a high fidelity representation of the original spoken message to a completely synthetic sound with poor intelligibility and unnatural intonations and rhythm.

The acceptable standard of quality for digitally processed speech depends on the type of service application and customer expectations for that service. The presence of new types of impairments necessitates the adoption of new and appropriate quality evaluation tests.

The Laboratories have recently studied a range of relatively new assessment methods intended for quantifying these new speech impairments. These range from, on the one extreme, simple objective tests which provide a measure of some specific characteristic of the processing technique, to the opposite extreme of complex, time consuming, subjective tests often involving listening or conversational opinions. Between these extremes, there is a range of hybrid type tests, generally involving listeners in a comparison of some specific impairment against some reference representation.

In general, before making any assessment, it is necessary to identify the more significant impairments present, and then bearing in mind the intended application, to select the appropriate assessment technique(s). As experience is gained in the Laboratories in the use of the various assessment techniques, it is intended that a series of performance specifications with related standard test procedures will be prepared for the speech quality requirements of important service applications of digitally processed speech.

The knowledge gained from this research activity will provide Telecom with the ability to specify speech coding, processing and synthesis techniques which match the performance requirements of future services embodying these techniques.

Loudness Ratings in Telephony

For a number of years, the International Consultative Committee for Telegraphy and Telephony (CCITT) has been studying techniques and principles for using loudness ratings as an alternative to reference equivalents to specify technical standards and techniques for measuring the transmission performance of telephone instruments and telephone networks. Through relevant work performed in the Research Laboratories, Telecom Australia has actively participated in the CCITT studies.

Recent work in the Laboratories has been aimed at improving the loudness algorithm in the objective method for rating handset telephones, as well as developing the additional procedures required for headsets and handsfree loudspeaking telephones. The model on which the algorithm in CCITT Recommendation P.79 is based has been found to be adequate for all except the most extreme frequency responses tested, and it should be satisfactory for most practical cases. However, the studies concluded that the frequency weighting function of Recommendation P.79 should be modified for best results, and the optimum function (for the conditions tested) was found to be remarkably similar to that of Draft Recommendation P.XXE from which P.79 was derived. It was also found that the basic weighting function for handset telephones was adequate for headsets with insert receivers and for handsfree loudspeaking telephones, although a constant correction factor for each case should also be applied.

Carbon transmitters have presented a particular source of difficulty in the

Loudness rating of telephones in the Laboratories

application of loudness rating techniques. Their sensitivity is dependent on the signal level and can also be very dependent on their history of mechanical handling. Fortunately however, carbon transmitters are being phased out in favour of stable electronic equivalents.

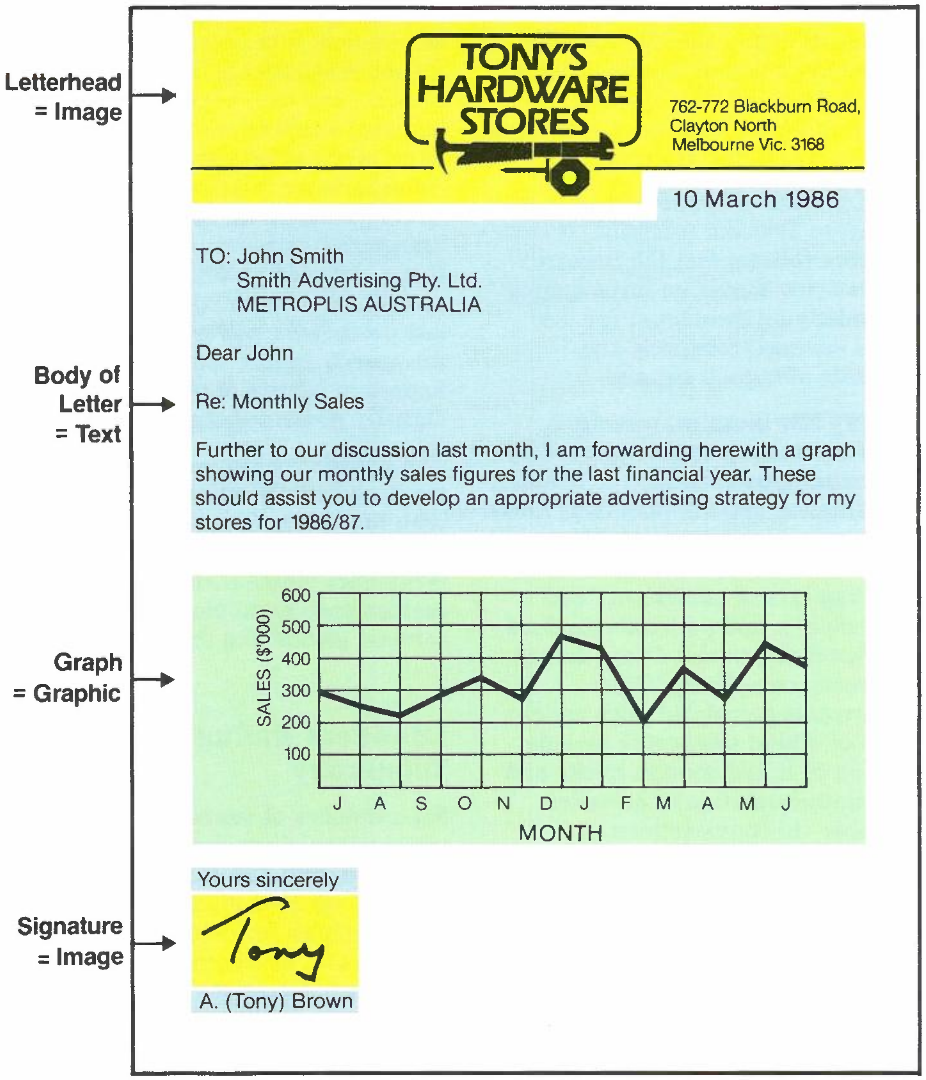
Telecom Australia is now using loudness ratings in its specifications. Consequently, objective rating systems based on the experimental system in the Laboratories are being set up elsewhere in Telecom and in private industrial companies which supply Telecom. These systems range from small portable measuring instruments with manual data collection for use in field investigations, to fully computer-controlled instrumentation systems which can also measure telephone parameters for use in network analysis programs.

Multi-mode Communications

An area of continual growth in telecommunications is in the interchange of structured items of information, often known as "documents", intended for human comprehension. Telecom currently offers several services providing this facility, each designed to serve a particular purpose and each accommodating particular types of information. The major ones are Telex and Teletex (which accommodate text data), facsimile (which accommodates photographic images) and videotex (which can accommodate a mixture of information types). The precise details of a particular document interchange facility depends on the technical standards with which it conforms.

Current services offering document interchange do not cater for all perceptibly desired electronic document transfer applications. There is a demand, especially from business, for more sophisticated document interchange services which can interchange documents similar to paper documents and which allow the recipient of a document to edit and reformat it. Such services would enable documents such as letters, contracts and reports to be interchanged electronically.

In response to the need for more sophisticated document interchange services, there is increasing research, development and standardisation



Example of a multi-mode document

activity in telecommunications administrations, the telecommunications and computer industries and standardisation bodies in the field of multi-mode documents. Multi-mode documents may contain more than one information type, or "mode". The contents of such documents may consist of a combination of text, digitised voice, image (facsimile) and graphics. A letter, for example, could consist of an image letterhead, a body of text and an image signature.

The Laboratories are currently undertaking studies aimed at determining the hardware and software requirements of multi-mode document systems. The project involves the development of an experimental system which allows users to compose, send and receive multi-mode documents. The system under development is designed to produce, and cater for, documents conforming to the Office Document Architecture (ODA) standard defined by the International Organisation for Standardisation (ISO). This standard for multi-mode documents has widespread international support and can be expected to play a significant role in electronic document interchange in the future.

Network Architecture for Value Added Network Services

In recent years, telecommunications service providers and other operators have offered a wide variety of new services over networks previously used only for voice or data traffic. Examples of these include videotex, electronic mail, electronic funds transfer and teleconferencing. In the future, this portfolio of new service offerings will continue to grow, embracing security and telemetry services, on-line electronic white and yellow pages directories, customer control of telephony options, and many more.

These new services have a common characteristic, in that they add "value" to the underlying network's capability of carrying voice or data traffic. They have become known in the international telecommunications community as Value Added Network Services (VANS), and they collectively serve to enhance significantly the value of the basic telecommunications network.

To date, VANS have tended to be added to the network through the acquisition of turnkey systems, with little reference to their eventual need to interwork with other services, to evolve in their own right or to benefit from commonality with similar services. This has tended to limit the opportunities and increase the costs of introducing new VANS.

The Laboratories have been addressing these limitations through the development of an architectural framework for VANS. New VANS require the addition to the network of certain capabilities, such as network storage or gateways or access. Considerable economies can be achieved if similarities between the basic functions are exploited. One way of accomplishing this is to develop a network architecture for VANS.

Such an architecture consists of two components:

- a functional architecture - which describes the functional capabilities required of VANS in general, their location in the network and the interconnections and access arrangements needed; and
- a protocol architecture - which specifies a hierarchy of protocols for communications between functional components.

The VANS architecture requires more work for its completion, particularly in regard to the development of an interim strategy to interconnect existing VANS systems and ones selected to meet a short-term need. However, evolution of the network towards the architecture suggested above should prove valuable in allowing new VANS to be introduced in the future.

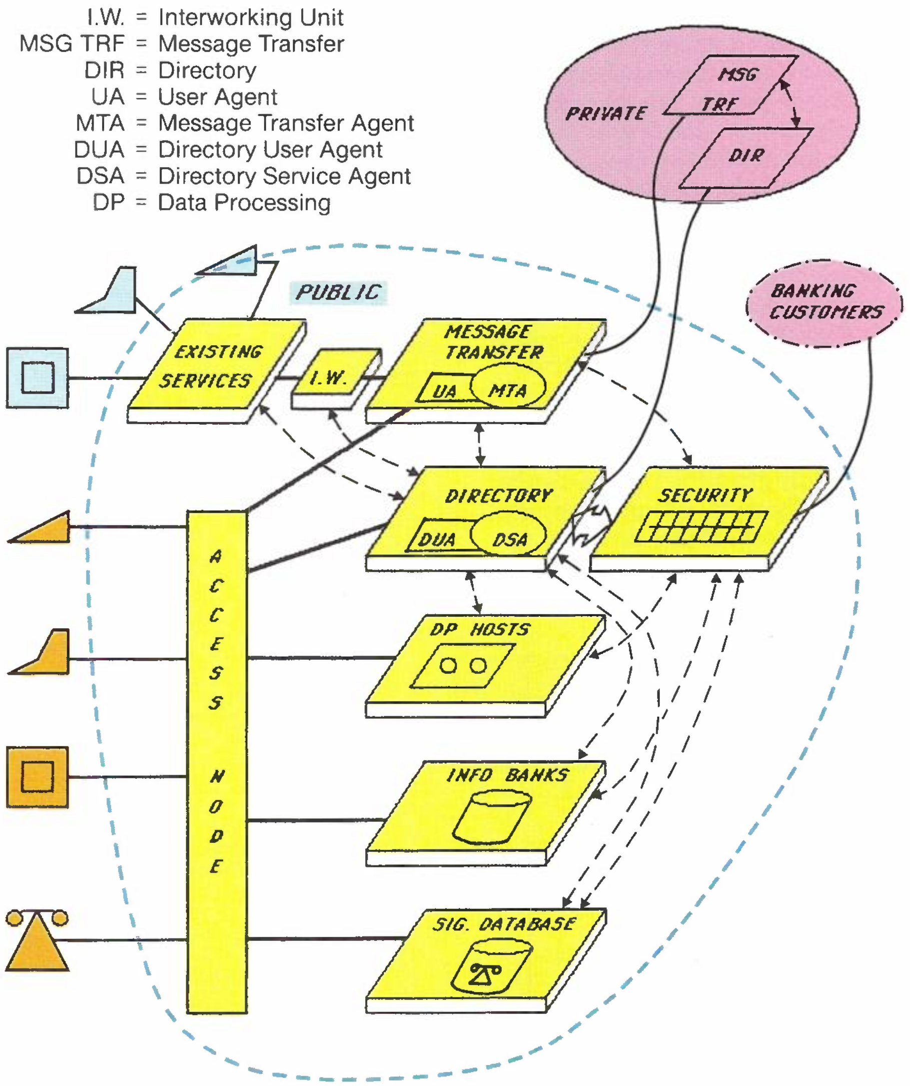
Cryptographic Algorithms for Database Security

The distributed nature of computer systems and the availability of sophisticated eavesdropping techniques make it a simple matter for unauthorised users to gain access to computer databases and to fraudulently alter sensitive or valuable information. The threat is real. Countless examples of severely disrupted databases and communications have already been reported.

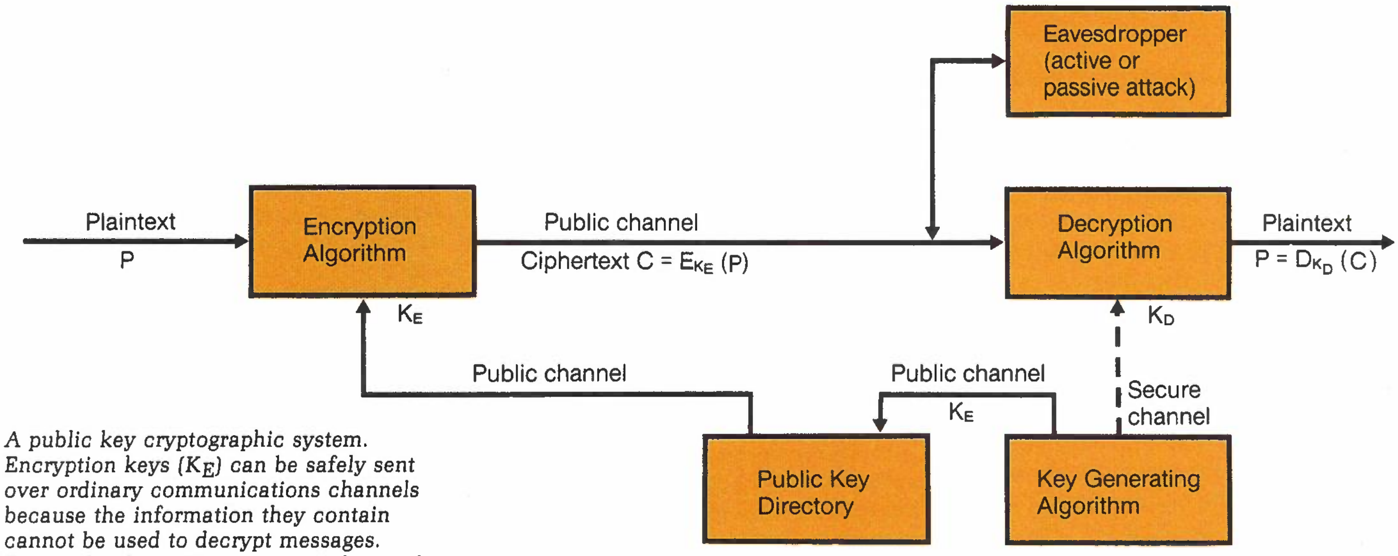
Obviously, the requirements of authorised users for both privacy and integrity in data communications are very high. To meet these requirements, a variety of cryptographic security techniques have been developed or proposed in recent years. In addition, two important classes of techniques, as well as their applications, are in the process of being standardised by the CCITT and ISO. These are known as "symmetric" and "asymmetric" cryptosystems.

Telecom Australia is interested in these developments since they will have significant impact on both existing and future networks and services. Potential areas of application include electronic funds transfer services, electronic directory services, messaging systems, mobile and satellite communications services, and a variety of services which might be provided over a future integrated services digital network (ISDN).

Symmetric or "conventional" cryptosystems employ enciphering and deciphering keys which are identical or which, if different, can be easily computed one from the other. These systems are ideal for private communications applications as long as the total number of users is kept small. However, as the number of users increases, so too does the problem of generating and securely distributing the large number of secret keys required, since, in a computer network used by N users, a total of N(N-1)/2 keys need to be distributed. Nevertheless, with appropriate though



A possible VANS architecture showing its components and their interconnections



A public key cryptographic system. Encryption keys (K_E) can be safely sent over ordinary communications channels because the information they contain cannot be used to decrypt messages. Decryption keys (K_D) are created near the decryptor and are not sent anywhere else.

rather complicated protocols, conventional cryptosystems can also be used for access control and user and data authentication, as well as key distribution applications over insecure channels.

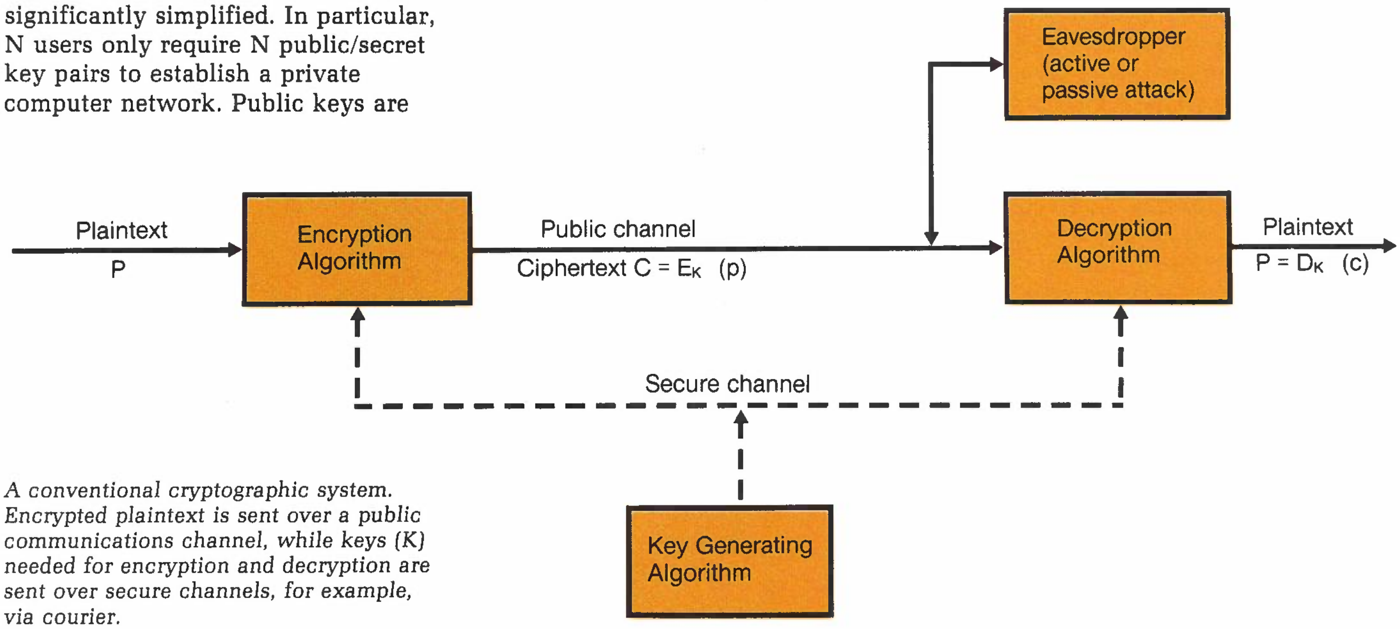
Asymmetric or "public key" cryptosystems employ two different keys. One key is for encipherment and is made public; the other key is for decipherment and is kept secret. Knowledge of one key does not imply knowledge of the other. In fact, it is extremely difficult to compute one from the other in a reasonable time. Although limited in the sense of privacy applications, these systems offer wide scope in terms of integrity and key management applications. Protocols associated with access control, authentication, digital signatures and key distribution are significantly simplified. In particular, N users only require N public/secret key pairs to establish a private computer network. Public keys are placed in a directory and anyone wishing to communicate with a given user simply looks up that user's public key and uses it to encrypt and send messages. Only the user with the corresponding secret key can decipher the message sent.

Security in Electronic Funds Transfer

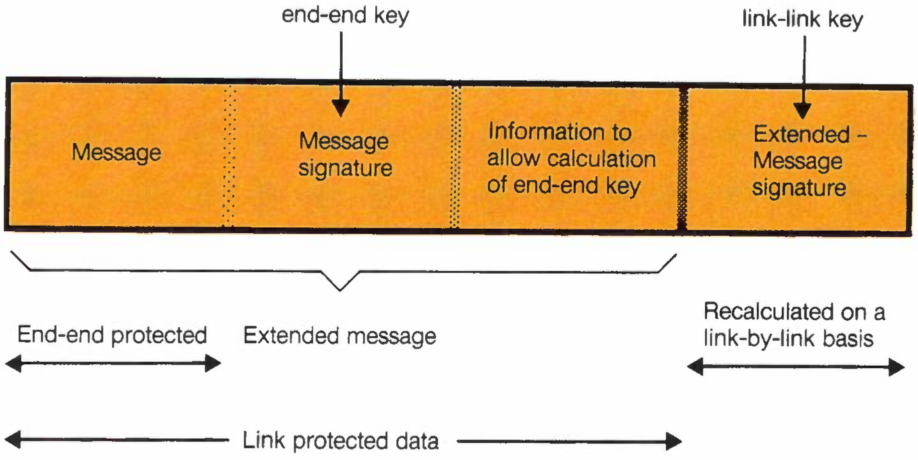
Over the last few years, a variety of trial services providing electronic funds transfer from a point of sale (EFTPOS) have been implemented by financial institutions with the assistance of Telecom Australia. Such services offer the possibilities of efficient electronic payment for goods and services, without the need for expensive cash or paper handling procedures. Essential to the success of EFTPOS services is the provision of a high level of security in the transfer of electronic messages concerning payments.

The Laboratories are currently investigating means of achieving a high level of security in communications from an insecure terminal environment for EFTPOS services application. This work has involved investigations of security procedures and techniques, as well as study and evaluation of different network security architectures.

For services such as electronic funds transfer, the integrity (or "correctness") of data transferred over the telecommunications network and the authenticated identity of each of the communicating parties are more important than the privacy aspects of the communication. These requirements can be met by



A conventional cryptographic system. Encrypted plaintext is sent over a public communications channel, while keys (K) needed for encryption and decryption are sent over secure channels, for example, via courier.



Structure of a composite signature message for secure data communications in electronic funds transfer services

cryptographic techniques, applied to generate "signatures" that are a function of the data to be transferred and secret information, or "keys", known only to the intended end systems. Wide scale implementation of a service secured in this way requires efficient but secure handling and distribution of such keys. The management of keys is made more difficult in some applications where security requires frequent changes to these keys.

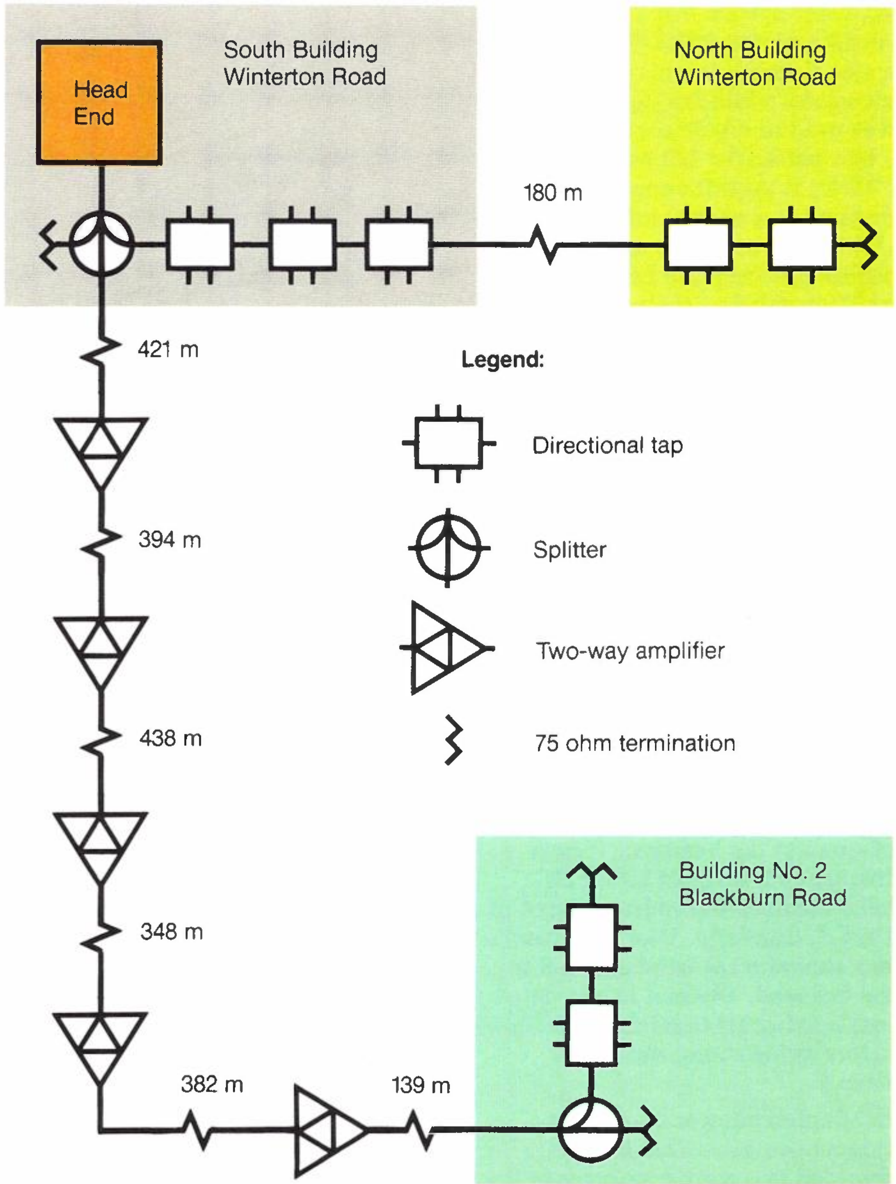
The Laboratories have been studying techniques for managing keys that can be applied on a user-to-user basis, as well as considering possibilities for service enhancement and simplification by the provision of value added services by a third party. Such techniques involve protocols for both link and end-to-end authentication techniques, and they allow functionality to be shifted from terminal systems into the support network. They offer potential advantages both in terms of reduced overall system complexity as well as substantial simplification of terminal systems. Intermediate network elements can isolate the terminal network from the host network. Thus, hosts need not necessarily know details of security keys used by all terminals, and vice versa. Careful protocol design can still provide end-to-end protection of information and protect against security or other failures in such network elements. Such techniques work by using link-specific keys to pass information between terminals and hosts that can be used by end systems to calculate end-to-end keys. If such calculation involves information which is known to both end systems but which is not transmitted or known to network elements, it is impossible for them to interfere with the integrity of the message.

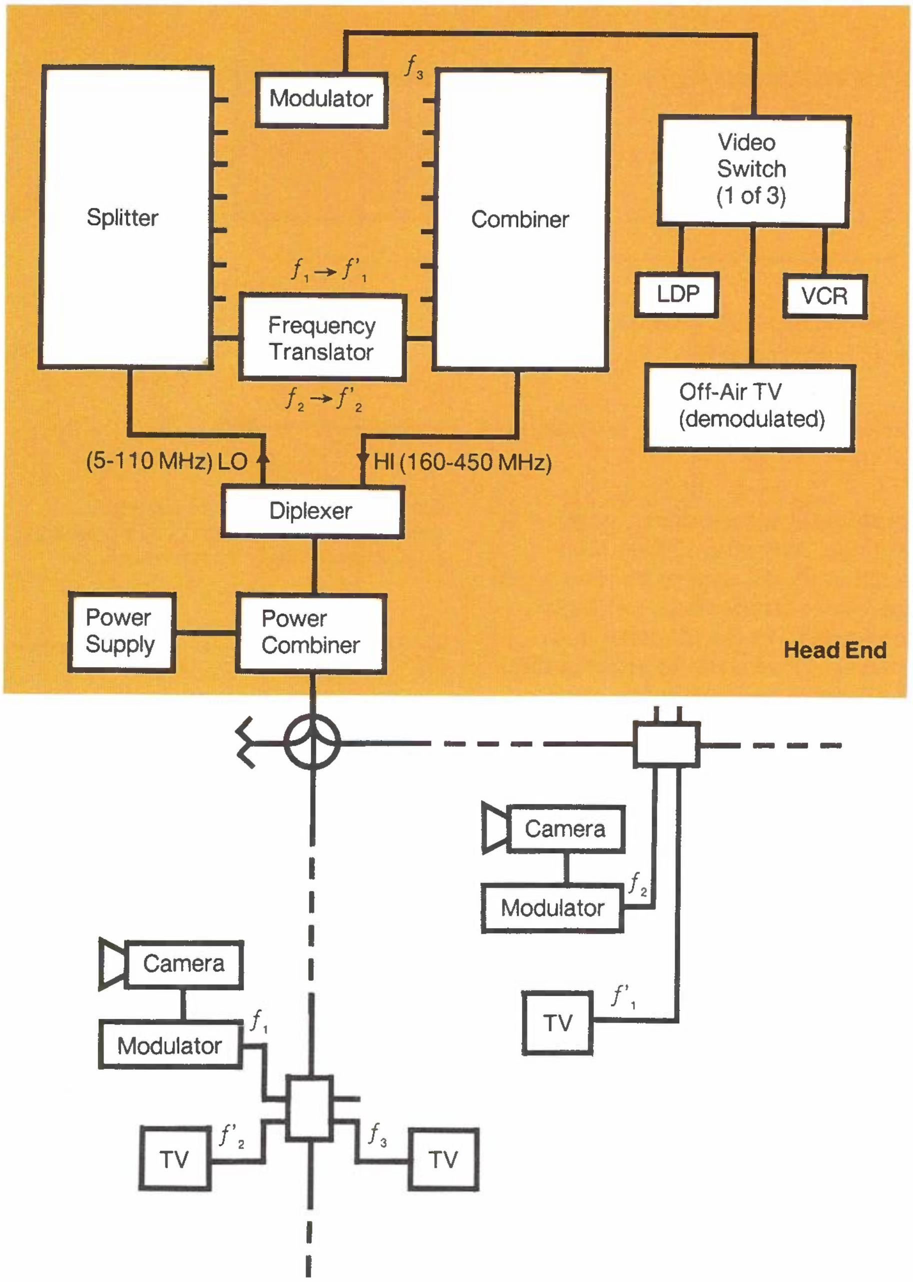
Such techniques are expected to be widely applicable for services involving large numbers of terminals in relatively insecure locations that require secure data communications with a smaller number of secured hosts.

Multi-Service Wideband Networks

As office automation proliferates, there will be a correspondingly increased demand for Telecom Australia to provide new and diverse data communications services to link devices such as personal computers, printers, databases and host computers. In addition to data communications, organisations will require wideband communications for applications such as video. One method of attaining the large

WISENET route plan





bandwidths required by such services is through the use of a broadband coaxial cable system.

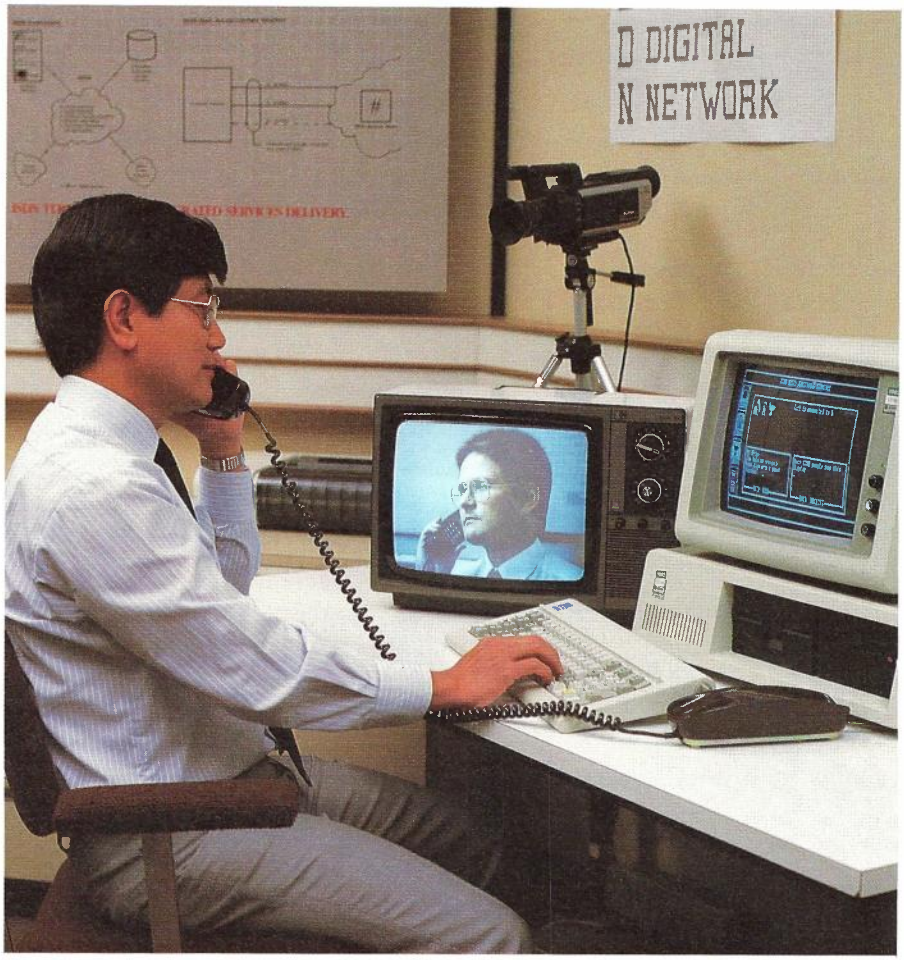
The Laboratories are investigating the transmission aspects of such wideband services. To provide a test bed and hands-on experience for the investigations, an experimental coaxial cable system has been established to link two buildings at the Laboratories' Winterton Road site and another at the Blackburn Road site, almost two kilometres away.

This network, called WISENET, is a broadband local area network (LAN) based on established coaxial cable television (CTV) technology. The single cable system has a total bandwidth of 450 MHz. To enable bi-directional transmission over this single cable, a mid-frequency-band-split is used to divide the bandwidth into two parts. The LO band (5 to 110 MHz) is used for communications from users to a central headend, and the HI band (160 to 450 MHz) is for transmissions from the headend to users. Transmission systems employed on the network use frequency division multiplexing (FDM) techniques, whereby each service occupies a different frequency channel.

The services provided on WISENET are:

- in-house video. This service is a one-way broadcast to all users. An example of this is a training video being broadcast from the headend to a number of seminar rooms.
- full-duplex video. This service allows for two-way transmissions as in a video-conference situation. User 1 transmits in a LO band channel to the headend. This is frequency translated into a HI band channel and re-transmitted to User 2. Similarly, User 2 transmits in a separate LO band channel to the headend, where it is translated into another HI band channel before being re-transmitted to User 1.
- full-duplex point-to-point data communications. This service is provided in a similar manner to the full-duplex video service, where the data communications units transmit in separate channels in the LO band to the headend, which then translates the signals into separate channels in the HI band where the receivers of the destination units can detect the signals.
- packet data communications service. This service enables full connectivity of all data communications units operating in the same channel. All units transmit in the same channel in the LO band, and all receive in the same HI band channel after the frequency translation by the headend. To enable all communications units fair access to the transmission medium, media access techniques are employed. These use a set of rules (called a protocol) for determining when each unit will access the medium. WISENET uses a Carrier Sense Multiple Access with Collision Detection (CSMA/CD) technique. By using different frequency channels in the network, it is possible to support other packet communications services employing the same or different media access techniques.

As well as providing a laboratory test-bed for investigations into the transmission aspects of wideband services, WISENET is proving to be a worthwhile vehicle for obtaining experience in the installation, operation and maintenance of wideband networks.



The experimental ISDN multi-service terminal as demonstrated during the Laboratories' Open Days

An Experimental ISDN Multi-Service Terminal

With the introduction of the Integrated Services Digital Network (ISDN) in the near future, customers will be able to have multiple services made available to them from the network by means of a single access line. These services may include voice, data, videotex (e.g. Viatel), electronic mail (e.g. Telememo), teletex, facsimile, telewriting, electronic funds transfer, credit card checking, slow-scan TV, security alarm and telemetry. From the customer's viewpoint, a most attractive feature provided by the ISDN will be his ability to activate (and de-activate) different services sequentially or simultaneously using a single common control procedure, as opposed to the different control procedures which are required for each service now provided over existing single service-dedicated networks.

A new class of terminal equipment is thus required to provide a multi-service interface between the customer and his single access line to the network.

The Laboratories are currently studying a number of aspects of this interface and the communications protocols which must be implemented across and within it to activate, supervise and de-activate the variety of possible service offerings. To provide experimental support and validation of theoretical studies, the Laboratories are developing key elements of an experimental multi-service terminal which might be used in an ISDN environment.

In the development of the experimental terminal, a modular approach has been taken in order to ensure that both communications and processing applications can be readily packaged together to meet diverse customer service requirements. The design of the terminal has been partitioned into three distinct parts, as follows:

- the user interface
- service provision and control (i.e. those protocols necessary to access value-added services)
- ISDN access and call control (i.e. protocols necessary to access the ISDN).

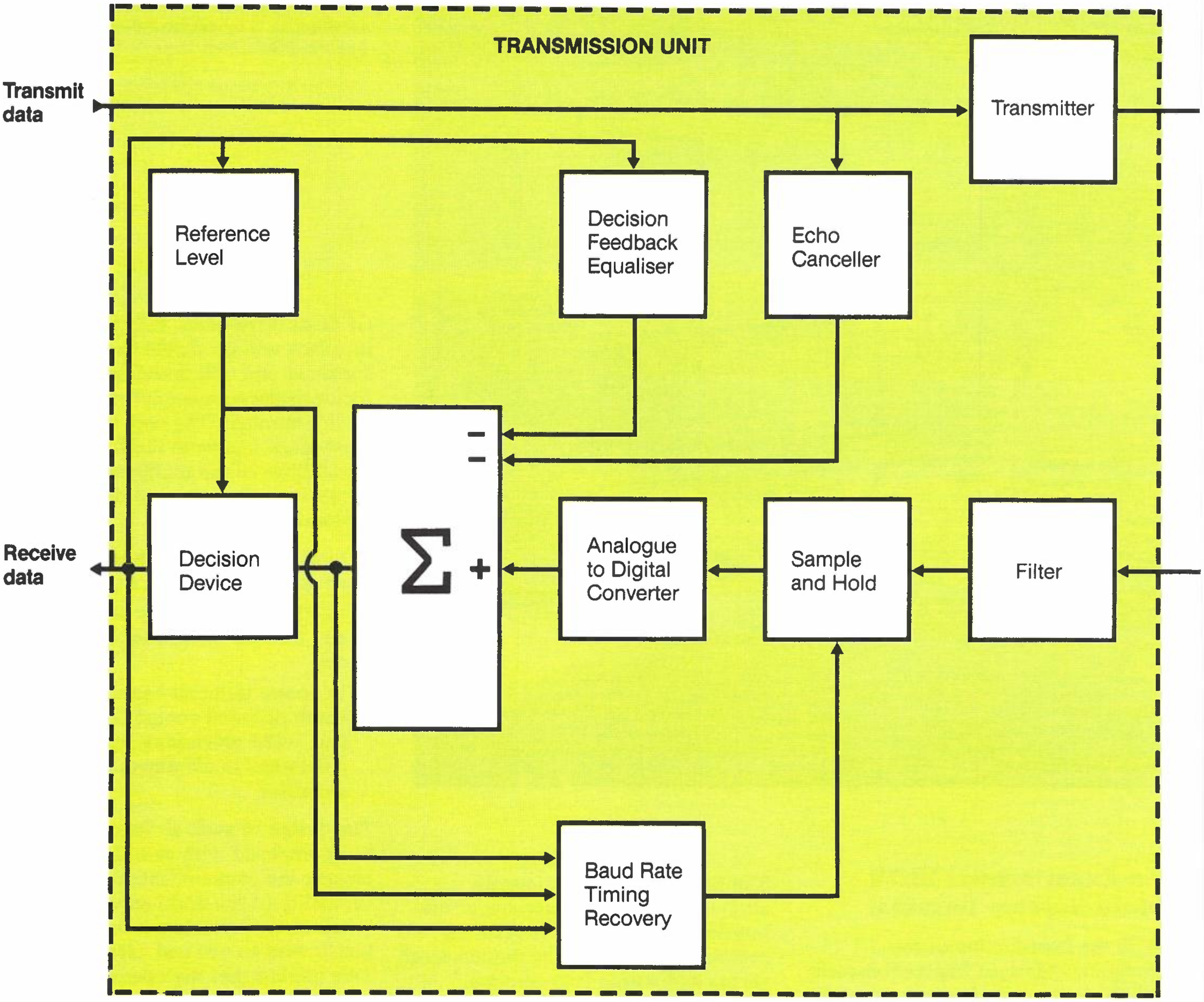
Of these three parts, only the user interface will be visible to the customer and will therefore be a key factor in the commercial success of such a terminal. The user interface must allow access to the full capabilities of the multi-service terminal, including providing the customer with abilities:

- to accept incoming calls whether or not another call is in progress
- to add supplementary services to, and remove them from, an ongoing call
- to access terminal-based and network-based computing facilities (e.g. word processing, spreadsheets, databases) to aid day-to-day office activities.

The design of such an interface must be approached with care. It must present the communications capability of the multi-service terminal to the customer in a way that is easy to use and hard to forget. This implies that the operation of the user interface should be intuitively obvious. Such a design feature is necessary to assist and encourage customers to make full use of the value-added service offerings which might be provided over the public ISDN.

A preliminary version of the user interface was developed as part of the multi-service terminal display at the recent Laboratories' Open Days. This version made extensive use of on-screen icons (i.e. small pictures representing the available services) and service control windows for each of the services demonstrated.

Judging from the interest shown in the demonstration by the general public, media and Telecom staff, ISDN terminals will represent a potentially strong new market stimulated in the 1990s by the requirements of business customers and supplemented by those of the domestic sector in the early years of the next century.



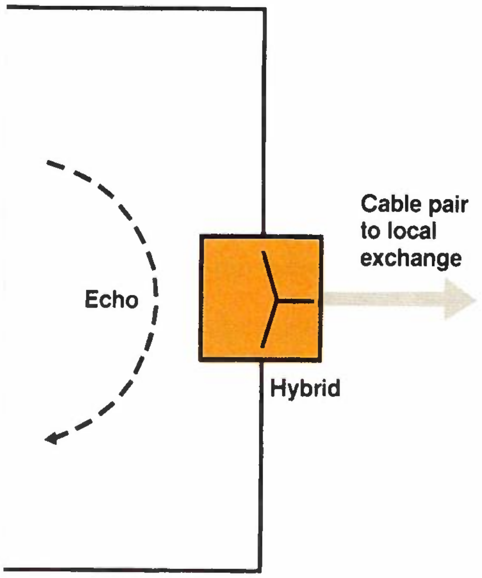
A Baud-Rate Full-Duplex Transmission Unit for ISDN Customer Access

Many telecommunications administrations around the world, including Telecom Australia, are developing integrated services digital networks (ISDNs). Such networks will provide network users (customers) with higher capacity access to the network which is capable of simultaneously providing several types of service, in a multi-service telecommunications environment. Since, like many administrations, Telecom Australia has a capital investment of about $3 billion in its copper pair cable distribution network between local exchanges and customer premises, the initial ISDN must use this network to provide basic customer access to the ISDN.

Basic customer access to the ISDN will nominally be at 144 kbit/s. This provides two 64 kbit/s channels for voice and data and one 16 kbit/s channel for low speed data and signalling. With additional framing and maintenance signal requirements, the actual information rate will be approximately 160 kbit/s. The provision of full-duplex digital transmission at 160 kbit/s over existing copper pair cables to provide ISDN customer access is a demanding problem of transmission system design. Hence, the Laboratories have been investigating a variety of transmission techniques in the quest for an optimal solution which might be applied by Telecom in its evolution of the ISDN.

Of the transmission techniques investigated, the echo cancellation technique is the most promising for basic customer access because of its relatively low bandwidth and hence superior immunity to crosstalk and impulsive noise. The echo cancellation method achieves full-duplex operation by using a hybrid for directional separation of the go and return paths. Since a compromise balance network is used in the hybrid, complete directional separation is not achieved. Instead, some of the transmitted signal "leaks" through the hybrid into its own receiver. This leakage, or echo, signal can be up to 100 times stronger than the wanted signal received from the far end of the transmission link. In order to extract the wanted, far-end signal from the unwanted echo, the hybrid is supplemented with an echo canceller. The echo canceller produces a replica of the echo at its output. This signal output is then used to subtract the echo from the receive signal path, to yield only the wanted signal transmitted from the far end of the link.

Schematic illustration of the ISDN PABX "plugged in" in an ISDN basic access environment



In practical applications of the echo cancellation technique, the transmission unit must perform a number of adaptive functions, including echo cancellation, equalisation (usually in the form of a decision feedback equaliser), adaptive reference control and timing recovery. Other functions include line coding, signal scrambling and the decision process.

To validate theoretical studies and to provide a vehicle for developing further expertise in the design of customer access systems, the Laboratories have developed a baud-rate, full-duplex transmission unit. The approach chosen was a significant advance on existing systems. Its features include baud-rate sampling, where the received signal is sampled only once in the baud interval, no special training sequences for initialisation of the unit and suitability for an all-digital implementation. In addition, it employs the Class 4 partial response line code to achieve long transmission spans. The baud-rate timing recovery method developed for the unit operates by waiting for certain special data sequences to occur. This process allows the simple but accurate estimation of the optimum sampling instant. One important aspect of the unit is that the simultaneous adaption of several adaptive loops results in significant interaction, causing substantial increases in convergence time compared with cases where individual loops operate in isolation. A method for reducing the convergence time has been devised and is the subject of a patent application.

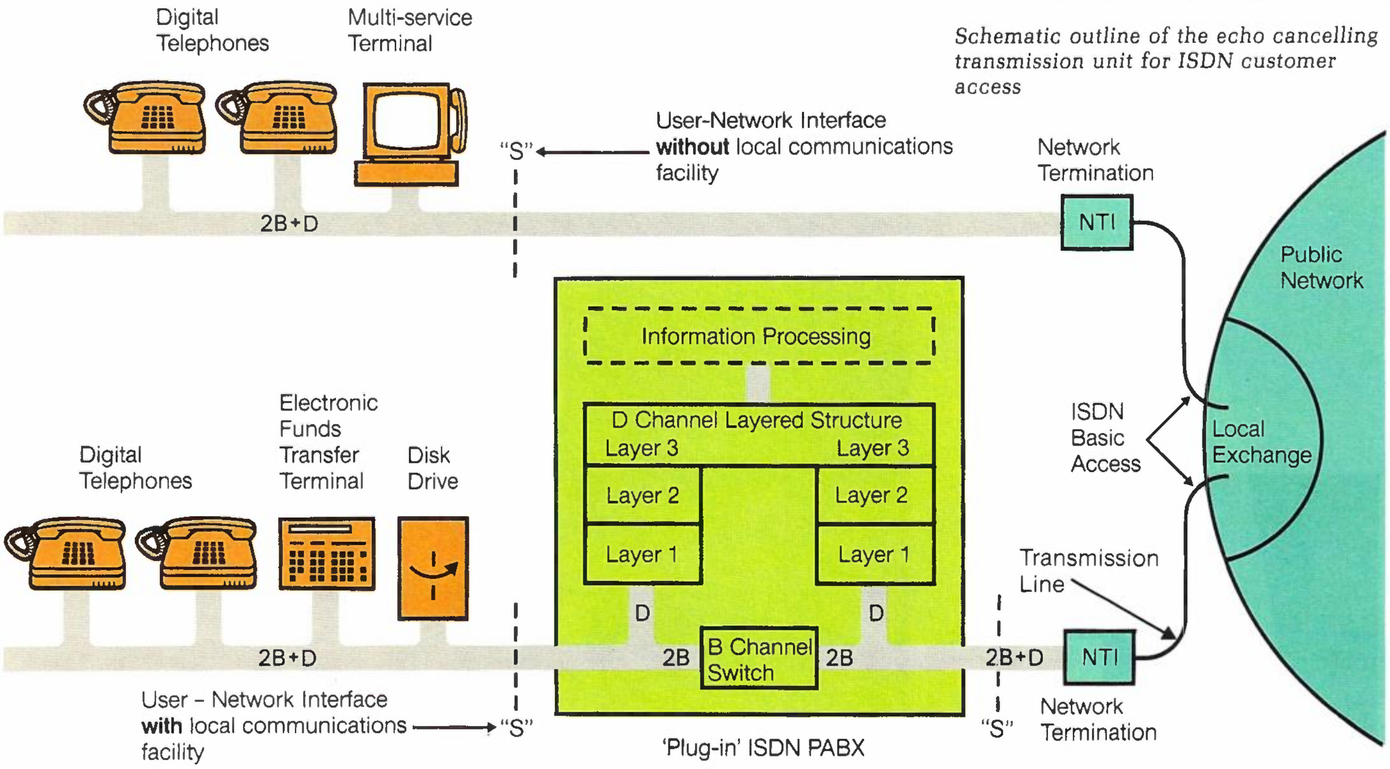
A programmable digital signal processor, based on the AMD 29000 family of byte-slice building blocks, has also been developed to test and refine the strategy adopted in the transmission unit.

Local Communications within the ISDN Basic Access Environment

At the user-network interface of the Integrated Services Digital Network (ISDN), a customer will be able to connect several terminals to the common 144 kbit/s digital bus providing him with basic access, comprising two 64 kbit/s and one 16 kbit/s (2B+D) channels, to the ISDN. However, although the terminals share a common bus, they will not be able to communicate with each other in normal circumstances without a connection being established via the local public exchange. This will attract the relevant call charge for the connection.

To avoid the involvement of the public exchange (and the charge) whilst transferring information between the customer's own terminals, a Private Automatic Branch Exchange (PABX) or a Small Business System (SBS) suited to the ISDN basic access environment must be employed. A market is foreseeable in small business and among larger domestic customers for such localised intercommunications facilities. Hence, the Laboratories have been investigating an economical means of providing such facilities and have developed a design concept for a "plug in" single-line ISDN PABX which can be inserted between the

Schematic outline of the echo cancelling transmission unit for ISDN customer access



network termination and the user-network ISDN basic access interface without any need to modify the customer's terminal equipment, the network termination or the public exchange equipment.

To date, the Laboratories have developed detailed specifications for such an ISDN PABX. As now specified, the PABX will monitor any call that a terminal tries to establish and determine whether the call must be set up by the exchange or if the call is destined for another terminal on the same basic access bus. If the call is "local", the PABX will offer the call to the destination terminal using all appropriate call control procedures. If the call is for a terminal on another basic access bus, the messages associated with the call will be relayed by the ISDN PABX to the public exchange.

The structure of the PABX has been developed and detailed Specification and Description Language (SDL) diagrams of the required protocol have been completed. The structure ensures that no changes need to be made to the existing Layer 1 and Layer 2 protocols. All of the single-line ISDN PABX functionality can be placed at Layer 3. This structure has been chosen to allow the easy inclusion of higher layer functions (e.g. word processing, local mail, voice store-and-forward) in the Network Termination (NT) and to include multiple user-network (S) interfaces on the terminal side or to allow extra B and D channels on the exchange side.

The next stage of this investigation will simulate the PABX on a computer. The simulations will test the feasibility of the system and help in the further investigation of the feasibility of the "plug in" PABX. Work already performed on the ISDN PABX has provided the basis for a CCITT contribution on the ISDN D-channel Layer 2/3 interface and for the simulation of the terminal and exchange Layer 3 interface within the Laboratories.

An Experimental Integrated Services Digital Network

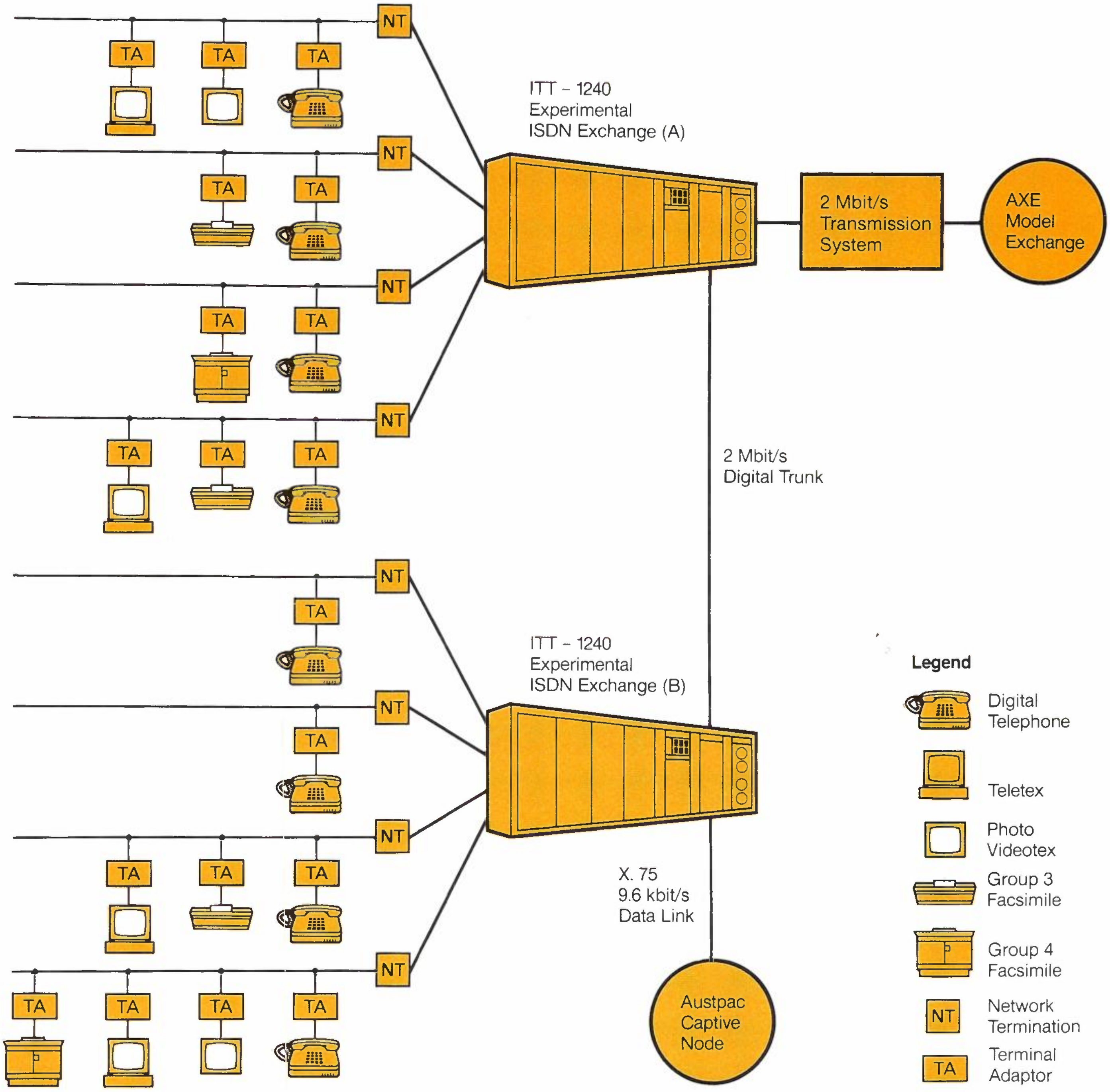
An experimental integrated service digital network (ISDN) has been established at the Laboratories as a testbed for study of ISDN services and protocols. The experimental ISDN supports a total of eight customer lines and includes all functions representative of a full-scale public ISDN, including multi-service customer access interfaces, common channel signalling and interworking to the telephone and packet switching networks.

The switching functions of the experimental ISDN are provided by two ISDN field trial versions of the ITT 1240 exchange, supplied by STC Pty. Ltd. and similar to systems used in ISDN field trials in Italy, Belgium and Spain. The exchanges provide both circuit and packet switching functions and are interconnected by a 2 Mbit/s link using Common Channel Signalling System No. 7. Inter-exchange signalling uses the CCITT-defined ISDN User Part for establishment and release of circuit-mode connections and the Class 2 Signalling Connection Control Part (SCCP) to convey packet user data between the two ISDN exchanges. Connections are also being established from the exchanges to Telecom's AXE laboratory model exchange (for telephony interworking) and to Telecom's Austpac network (for packet network interworking).

Prototype customer line transmission equipment, network termination (NT) units and representative ISDN terminal equipment have also been supplied by STC for use in the experimental ISDN testbed. The transmission equipment uses the echo cancellation technique to achieve duplex 2B+D transmission over a 2-wire customer line. The terminal equipment includes digital telephones, Group 3 facsimile terminals and teletex terminals, each adapted to the ISDN by a separate Terminal Adaptor (TA).

A photo videotex demonstration system developed by British Telecom is being studied in the experimental ISDN by Laboratories' staff as an early example of a new service

Demonstration photo videotex system using the 64 kbit/s connection capability of the ISDN testbed

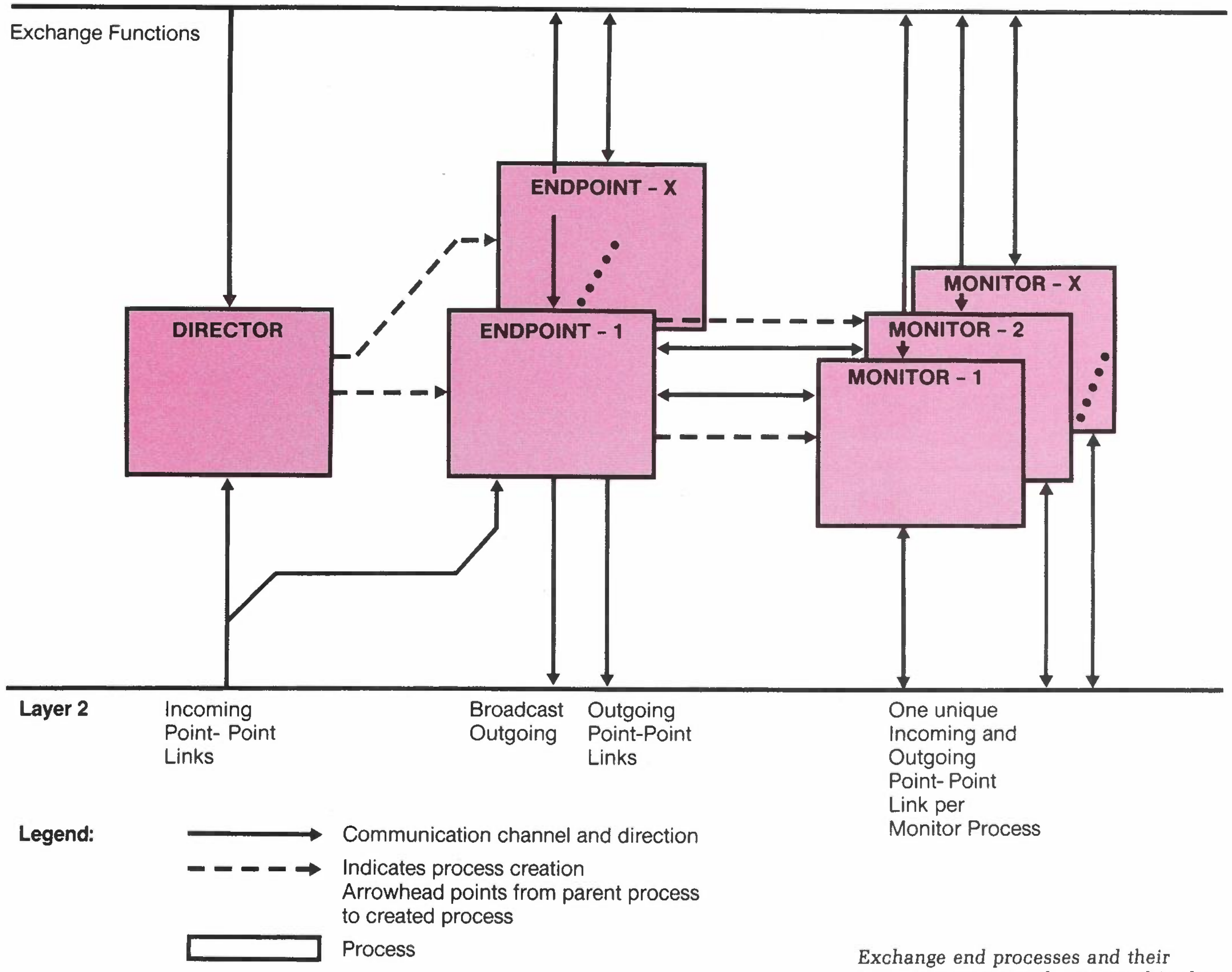


Network configuration of the experimental ISDN

utilising the 64 kbit/s connection capability of the ISDN. The photo videotex system is an enhancement of standard alpha-mosaic videotex which allows each videotex page to include full colour photographic images. The photographic images are coded in a compressed format which allows a single videotex page to be transmitted over a 64 kbit/s ISDN connection in less than 10 seconds.

A high speed (Group 4) facsimile service is also being studied with the ISDN testbed, since it is an additional example of a 64 kbit/s service which could find early use when an ISDN is introduced.

Since its installation in July 1985, the experimental ISDN testbed has been applied in an investigatory programme which complements other experimental and theoretical studies of ISDNs in hand within the Laboratories. The programme involves a combination of system operation, enhancement and testing, aimed at obtaining early experience in some critical aspects of ISDN. Dissemination of this knowledge to other parts of Telecom is being accomplished through direct consultancy (particularly to other Headquarters areas responsible for planning the introduction of an Australian ISDN), through regular progress reporting, and by demonstrations of the experimental ISDN to relevant staff groups within Telecom. Selected staff from other areas of Telecom are also participating directly in the Laboratories' investigatory programme via the engineer rotation scheme. Under the scheme, engineers are posted to the Laboratories for about six-month periods, to gain experience by participating in investigations of specific aspects of the ISDN.



Note: An endpoint process is created by a supervising director process for each call existing at the interface

Exchange end processes and their communications paths assumed in the specification of ISDN customer access signalling

ISDN Network Access Signalling Standards for Australia

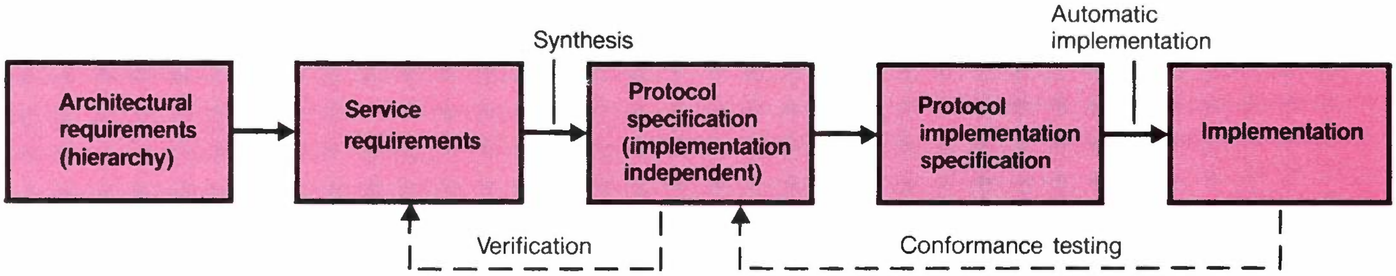
In March 1986, Telecom Australia took a major step towards the introduction of the Integrated Services Digital Network (ISDN) in Australia by releasing for review by industry its draft Australian specifications for the ISDN primary rate access interface. These specifications are firmly based on the relevant CCITT Recommendations, with appropriate selection of options and extensions for application in the Australian network. After review by industry, the specifications are scheduled for finalisation and publication by Telecom in June 1986, in preparation for offering public services in 1988.

The Laboratories, in collaboration with other Headquarters Departments, were closely involved in the definition of these access standards. Laboratories' contributions included consultancy on the technical features of ISDN interfaces and services, drafting of some textual parts of the specifications and formal description of the Layer 3 procedures using the CCITT-defined Specification and Description Language (SDL).

The interface specifications follow the layered protocol structure defined in the CCITT I series Recommendations. Contributions to the Layer 1 specifications involved a study of the maintenance requirements of Primary Rate interfaces. This study provided a basis for CCITT contributions, as well as inputs to the Australian specifications.

Due to the relative stability of the CCITT-defined ISDN Layer 2 procedures, the work on the Layer 2 specifications was largely confined to selection of national options from the CCITT Recommendations.

The Layer 3 CCITT Recommendations have not yet exhibited similar stability. At the beginning of 1986, significant parts of the Recommendations were still under discussion or had yet to be generally agreed by the CCITT. Thus, Telecom had to predict the direction that some parts of the CCITT Recommendations would take, in order to settle draft specifications by March 1986. By keeping abreast with the latest decisions and outputs of the CCITT, the Laboratories were able to make key inputs to Telecom's task of drafting its primary rate ISDN access specification, ensuring that, as far as possible, the Australian specification conforms as closely as possible to the final international standard.



A schematic protocol engineering methodology

Protocol Engineering

As advanced telecommunications and information services diversify and service-dedicated networks are required to interwork in the evolution of a multi-service ISDN environment, the protocols (or sets of rules and automated procedures) for accessing, operating and interworking terminals and networks are becoming more complex. Thus, "protocol engineering" is a field of growing importance to Telecom Australia, as well as to other telecommunications administrations and equipment manufacturers. Telecom's Research Laboratories, in particular, are actively investigating and developing methodologies, techniques and computer aids for application in the field of protocol engineering.

Protocol engineering is concerned with all aspects of the rigorous design of communications protocols. Protocol engineering covers aspects such as requirements specification, implementation-independent specifications of protocols for international standardisation, implementation-dependent specifications tailored to particular operating environments, and finally, implementations. Protocol engineering is also concerned with the transformations between these specifications. Unfortunately, no such rigorous transformations presently exist. In this situation, a validation procedure is required at each specification step to ensure that the implemented protocol conforms to requirements.

Protocol verification is the term used to describe the process of proving that an implementation-independent protocol specification provides the service defined in the requirements specification. The Research Laboratories have developed a methodology and an automated tool (PROTEAN) for the verification of protocols. PROTEAN has been used to find and eliminate errors in Telecom's T6 and P1 PCM line signalling schemes at the specification stage. It has also found errors in protocols that are being internationally standardised, such as the D-Channel ISDN single frame procedures, the Open Systems Interconnection Transport Protocols, and the Message Transfer Part of Common Channel Signalling System No. 7. The publication of these results in the CCITT and at international seminars has led to enquiries from overseas about the purchase of PROTEAN.

Current Laboratories' activities in protocol engineering aim to provide Telecom with the capability to develop correct protocol specifications for application in the development of internationally compatible services and networks in Australia. The development of protocol engineering methodologies and techniques will also allow Telecom to continue to make major contributions to the CCITT on standards for the specification and verification of protocols. Another objective is the development of methods for the rigorous conformance testing of protocol implementations, derived directly from the formal specification. Overall, Telecom's research into protocol engineering seeks to ensure that Telecom has the most advanced tools for the specification, simulation and testing of sophisticated protocols to support the introduction of modern information services.

Software Tools for the Specification of Protocol Data Units

The task of developing protocols to support communications between disparate information processing systems has been facilitated by the development of the seven-layered Reference Model for Open Systems Interconnection (OSI). The lower five layers of the Model provide facilities for the movement of data between OSI systems. The upper two layers address the description of the information to be communicated. Of these two layers, the standards for the (highest) Application Layer are concerned with the semantics or meaning of this information, while those for the (sixth) Presentation Layer handle its syntax or representation.

An application protocol is specified in terms of the transfer of Application Protocol Data Units (APDUs). The definition of the data types exchanged in these APDUs constitutes an Abstract Syntax. This Abstract Syntax identifies the nature of the information content of the APDU instances which are exchanged by application entities. An APDU-type definition is expressed in a standard notation which has a repertoire of primitive types (e.g. integer or character) and elements specifying the way in which these primitive types are combined in the APDU (e.g. choice, sequence). The emerging ISO standard Abstract Syntax Notation One (ASN.1) and the equivalent CCITT Recommendation X.409 have become popular for the specification of data types used in Open Systems Interconnection Application Layer Protocols including Message Handling and Directory Services.

The Laboratories have been studying the role of the Presentation Layer for supporting the interworking of various telematic and messaging services currently being introduced by Telecom. As part of this study, a number of software tools have been written in the C language for a Unix environment to recognise and generate instances of data types defined and encoded according to ASN.1. The benefits of using these tools include:

- easing the task of developing encoding/decoding software for protocol data units
- eliminating duplication of effort when implementing several protocols
- allowing faster development/modification of prototype protocol implementations
- increasing the reliability of resulting software.

A Multi-tasking Operating System for Communications Protocols

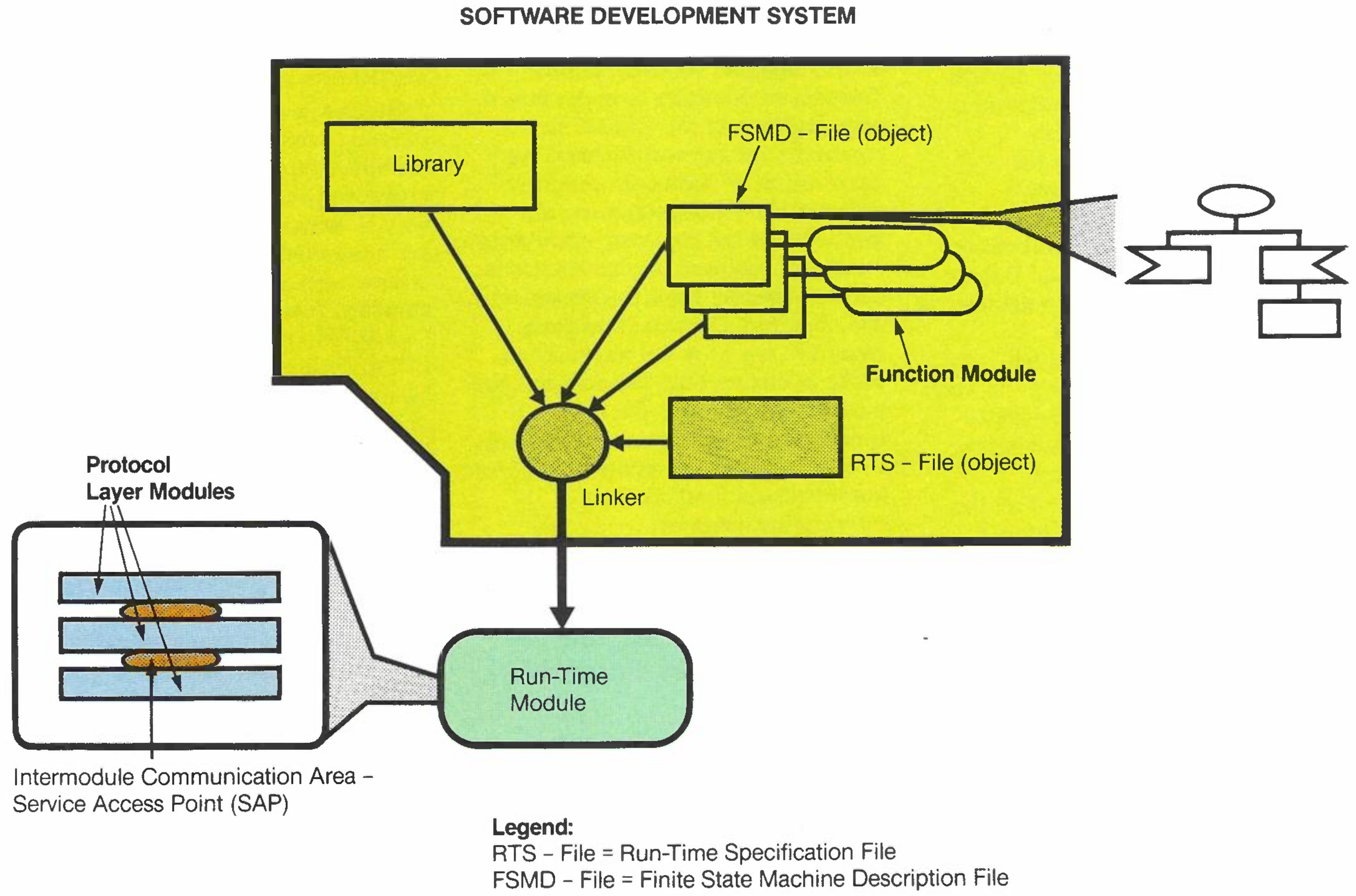
In conjunction with other projects related to the implementation of an Australian ISDN and with rapid progress in the definition of ISDN access protocols, the Laboratories have recognised a need to develop software tools and systems to assist the design and implementation of customer premises equipment (CPE) for multi-service access. In particular, a multi-tasking operating system to support the execution of concurrent and pseudo-concurrent, heterogeneous communications protocols has been developed.

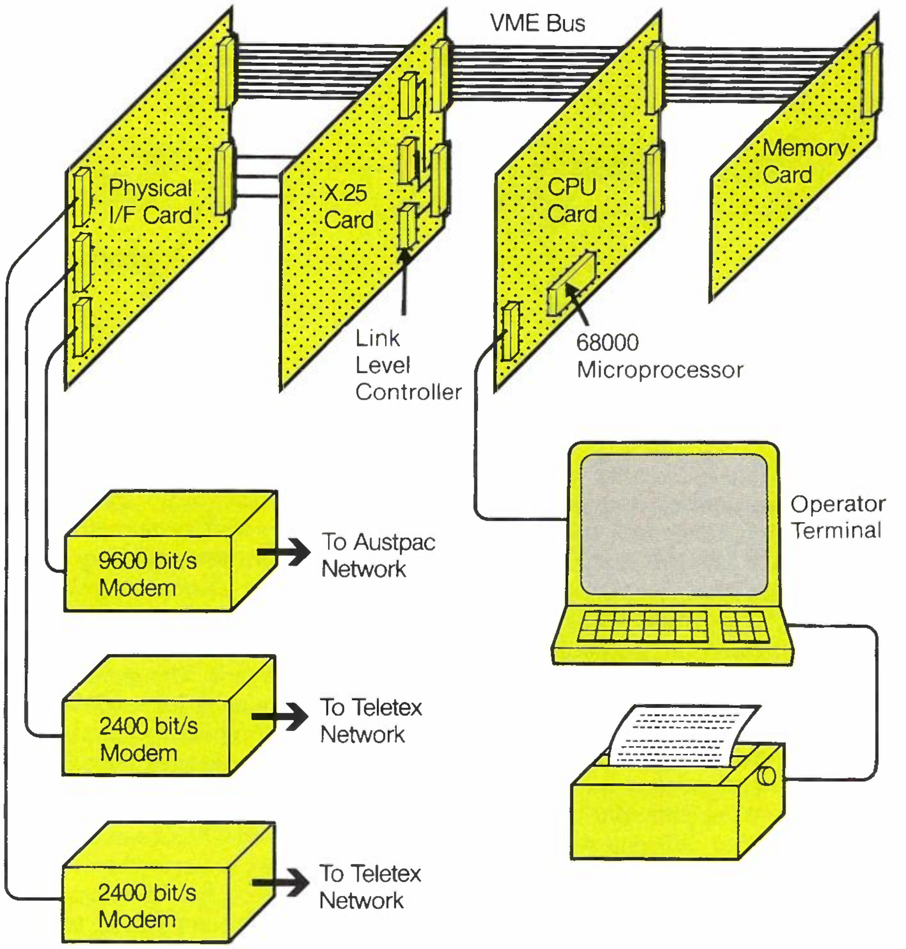
The basic representation of a protocol within the operating system is a Finite State Machine (FSM), described using the CCITT Specification and Description Language (SDL). A FSM is incorporated into the operating system as a data structure which serves as the behavioural blueprint for one group of communications processes. As a consequence, different protocol FSMs can be developed independently and integrated into the operating system by simply adding or deleting the corresponding data structures. Multiple objects of a protocol state machine can then be created and executed by the operating system during system execution time to support multi-service communications. Code sharing and process concurrency are thus established.

The operating system has been written using the programming language C, and it is interfaced to one or more target processors using assembly language. The operating system configuration supports one or more layers of protocol based on the Open Systems Interconnection (OSI) Reference Model hierarchy. Hence, it is possible to assign multiple layers of protocol to one target processor, or one protocol layer per target processor, depending on the performance requirement. Such a distributed processing capability is achieved by adopting a modular operating system design, comprising building blocks of kernel layer module data structures (LMDS) for one or more protocol layers and system task program modules. Within each layer module data structure, user-defined protocol FSMs for that layer are assembled and executed. To enhance process co-ordination and real-time application, a user-process hierarchy is established.

In addition to the basic process, time, buffer and inter-process communications management, an integrated trace and debugging facility is also provided. As a result, a high degree of flexibility and modularity for the implementation and experimentation of communications protocols for multi-service and network access is attained.

Run-time module generation in the multi-tasking operating system for communications protocols





Internal structure of the Teletex-Austpac Interworking Unit

Teletex - Austpac Interworking Unit

Increasing applications of computers throughout business, industrial and domestic communities and the associated demands for data communications facilities are both forces for the provision of more sophisticated data communications services and the interworking of networks which were originally designed as service-dedicated networks. In particular, the many aspects of office automation (word processing, electronic mail, etc) call for the development and compatible interworking of sophisticated services.

Teletex is one such service which is being introduced by Telecom Australia. It is a business communications service which allows office text machines (word processors) from different manufacturers to communicate directly with each other. The Teletex service is in effect a much more sophisticated form of the Telex service, and can be used to transfer full alphanumeric text and simple diagrams between users, with guaranteed freedom from transmission errors.

The Teletex service will be provided over two Telecom Australia networks, namely the Teletex network (which is a subset of the telephone network) and the Austpac packet switching public data network.

Currently, interworking (message transfer) between the two networks is not possible. Hence, a prototype Interworking Unit is being developed in the Laboratories to provide interworking between terminals on the Teletex network and terminals (local and international) on the Austpac network. The Interworking Unit will be used to provide a limited interworking service between Austpac network users and Teletex network users.

The Interworking Unit includes a small microcomputer consisting of a Motorola 68000 processor and associated memory. Two special purpose cards have been developed in the Laboratories to handle the X.25 communications protocol used between the Austpac network (one line) and the Teletex network (two lines). The controlling software has been written in the Pascal language. Its modular design will enable it to be used for similar interworking projects required by Telecom in the future.

The Interworking Unit performs the following functions to cope with the different characteristics of the two networks:

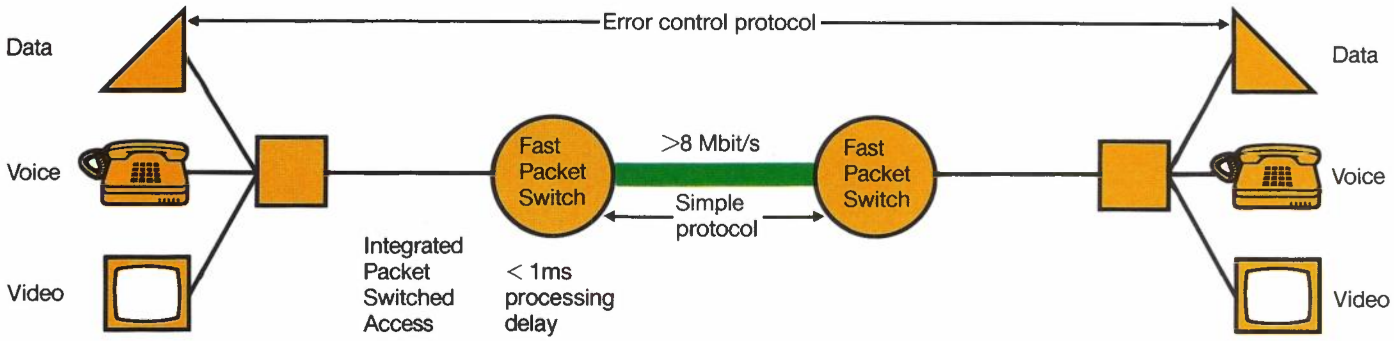
- protocol translation between the two networks
- translation of the different customer addressing schemes of the two networks
- different access line speeds of the networks
- detailed call records to enable appropriate call charges records to be applied
- checks to ensure that a customer is able to make a particular type of call.

The Interworking Unit will also provide a basis for research work on network integration studies and the formulation of suitable network development strategies.

Integrated Packet Switching

Telecom's current plans for the Integrated Services Digital Network (ISDN) are to provide customers with integrated access to separate circuit switching and packet switching networks. The circuit switching network will cater for voice and some data services, and the packet switching network will cater for data traffic only. In the near future, the use of fast packet switching will permit voice, data and video services to be provided on a single integrated network. This will provide economic advantages, but more importantly, it will increase the range and quality of services available to customers.

Rapid developments are occurring in packet switching. Switching delays are decreasing and packet throughput and trunk line speeds are increasing dramatically. Telecom's present packet switching network, Austpac, has trunk line rates of 48 kbit/s, a packet throughput per node of 3500 packets/s and node delays of 70 ms. By comparison, experimental packet switches have been reported with packet trunk rates of 12 Mbit/s, packet throughputs of one million packets per second and packet



Schematic illustration of an integrated packet switching network

processing delays less than 0.1 ms. These performance characteristics make fast packet switching suitable for voice and conference quality video services as well as for data.

Telecom is aware of the future potential of these developments and the Research Laboratories are investigating key aspects of such fast packet switching networks. The topics under study include fast packet switching architectures, integrated packet access protocols, internode packet protocols and appropriate matters for consideration in the development of national and international technical standards.

One area of study concerns the end-to-end performance of fast packet switching networks, realised by the use of advanced, fast, parallel switch architectures that can be implemented using very large scale integrated circuit technology, the use of high speed optical fibre transmission lines and the use of simpler protocols between switching nodes. Much of the complexity of currently available packet switches results from the provision of error control over each internal link. The error performance of optical fibres is sufficiently low that any additional error correction need only be provided on an end-to-end basis rather than for each link. The error performance can then be tailored to the application, such as voice, which can tolerate higher error rates than data applications. This will facilitate the integration of services.

Other studies concern the range of services which might be provided over fast packet switching networks, operating in an ISDN environment. The future ISDN will need to support a variety of information services including voice, database access (such as videotex), electronic mail, remote computing, file transfer and videophone. These services present a wide range of performance and traffic characteristics. There will also be a range of voice bit-rates in the network. Low bit-rate voice will be used in the future since it has economic advantages, particularly for voice storage, mobile services and long distance services.

Fast packet switching techniques are well suited to supporting a range of services. They are potentially very flexible, allowing different data rates on different calls, the data rate to vary during a call, simultaneous calls to multiple destinations over the same access channel, customer control of the allocation of access line bandwidth, and simpler interworking between terminals with different data rates. Fast packet switching also allows sharing of a transmission line between multiple customers while providing each one with the peak data rate. This characteristic leads to an optimum use of resources and results in both good performance and economy.

The abovementioned Laboratories' studies are expected to provide significant inputs to Telecom's evolutionary planning of the Australian ISDN.

Queueing Networks

The planning and dimensioning of modern telecommunications networks, such as Telecom's packet switching network, Austpac, and the future Integrated Services Digital Network (ISDN), requires the development of mathematical models for the offered traffics and the data flows between the communicating processors within the networks. The offered traffics are aggregations from many different types of service or terminal, each with specific performance requirements. The intra-network traffics are non-stationary, i.e. they have randomly varying intensities. The traffic emanating from a particular terminal may also be queued at the processors prior to being forwarded on to the receiving terminal, as occurs in packet switching networks. The combination of these factors calls for models of much greater complexity than the "pure chance" models of telephone traffic engineering theory.

Considerable work has been done in the Laboratories towards the implementation of mathematical techniques for the analysis of the type of queueing network problem which arises in the determination of design rules and standards for modern network performance.

A packet switching network performance program has been developed and emerging results in the theory of networks of queues have been incorporated. The data network traffic measurements which have been published recently suggest that intra-network traffic has a high variability when estimated by its coefficient of variation. Little has been published on user traffics, but the aggregation of traffic types is known to introduce correlation into the composite traffic stream. Both of these factors can be taken into account by the use of a traffic model known as the Switched Poisson Process (SPP). A special case of the SPP is the well known Interrupted Poisson Process from overflow traffic theory. The SPP can be shown to be a "Semi-Markov" process, and hence it is a tractable model for the arrival process to a queueing system.

Work is being carried out in the Laboratories on this latter aspect of the queueing problem. The objectives of the Laboratories' studies are to investigate the relationship between the sensitivity of delay and user traffic mix. The SPP also provides a set of parameters for estimation from traffic measurements, giving the basis for closer matching of performance estimation algorithms to empirical observations. To accommodate the model, future measurements of data traffics will need to take auto-correlation into account.

The Laboratories are playing a continuing consultative role in this activity.

Digital Network Synchronisation

Telecom Australia is presently extending its digital transmission and switching network all over Australia. The network will provide greater capacity and faster access for both voice and data traffic. However, to obtain the greatest efficiency from such a digital network, it is necessary to accurately control the rate at which signals are clocked around it. This can be achieved by synchronising the digital clocks controlling the digital switches, multiplexers and transmission systems throughout the network.

Synchronisation is also necessary between networks at an international level, to enable efficient transfer of signals between national networks. Relevant CCITT recommendations on network synchronisation have been agreed as international standards. These call for highly stable caesium clocks to be employed as a National Reference Clock in each national network.

The Research Laboratories have developed expertise in the operation of caesium beam frequency standards since 1969. This expertise has recently been applied in the design, construction and operation by the Laboratories of the Australian National Reference Clock (NRC). From the NRC, synchronising signals are distributed hierarchically to the National Distribution Clocks at the Exhibition and Windsor exchanges in Melbourne, and from there, to the State Main Clocks in the State capital cities. Distribution in the State networks also follows a predetermined hierarchy. This hierarchical distribution is designed to ensure the maximum reliability of synchronising signals to exchanges at all levels in the Australian national terrestrial network.

The NRC is located in the Laboratories' premises at Clayton, a suburb some 15 kilometres east of the city of Melbourne. Synchronising signals from the NRC are carried to the Exhibition exchange clock on two dedicated bearers over different routes.In the event of both synchronising paths failing, the Exhibition exchange clock automatically switches to a good quality quartz clock with frequency memory which ensures that there will be no frequency step when it is selected as the temporary reference.These back up quartz clocks have sufficiently low ageing rates to maintain adequate synchronisation of the network for several days in the unlikely event that synchronising signals from the NRC cannot be restored promptly.

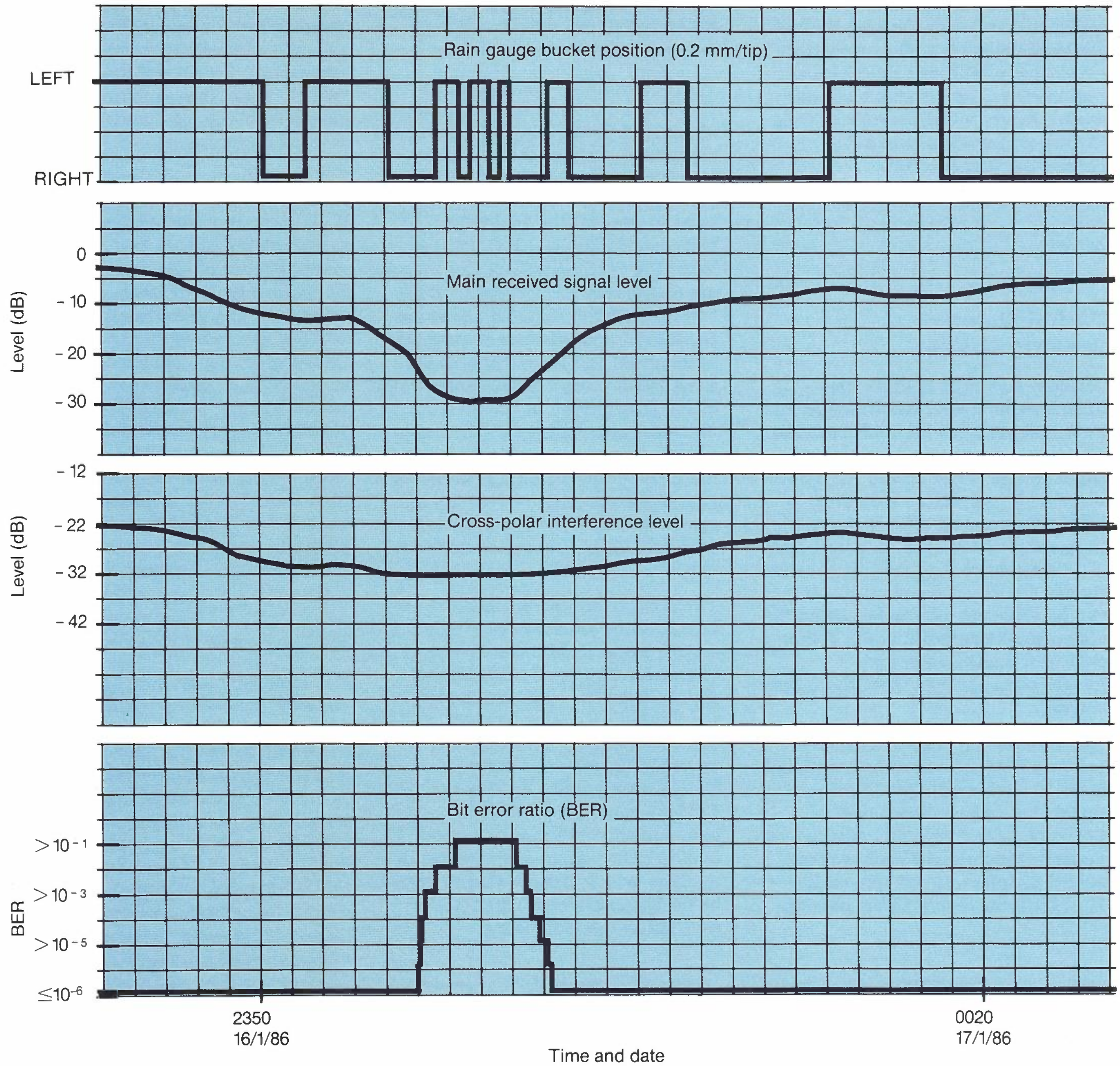
The Laboratories are also currently engaged in assessing the performance of and selecting bearers for carrying synchronising signals.The characteristics of jitter and wander on the various types of transmission systems employed in Telecom's network and fading on radio paths are being studied. The results of these studies will be used to determine which types of bearers should be selected to carry synchronising signals. Ultimately, when employed more widely in the network, optical fibre transmission systems are expected to become the preferred means of providing bearers for the synchronisation network.

Radio in the Local Network

The application of radio systems in the local network between terminal exchanges and customer premises is of current interest to Telecom. In local networks, microwave radio systems offer the advantages of rapid installation, high transmission capacity and high performance quality. They are increasingly used for PABX links, inter-exchange trunks, leased data services and TV links. Digital radio termination systems which provide a radio network for data communications amongst users are being used increasingly overseas, bypassing the established local telephone network.

Demand is such that, to avoid the possibility of mutual interference, commercial point-to-point and distribution radio systems have been developed at carrier frequencies up to 50 GHz. However, the operation of microwave radio systems above 10 GHz presents problems. In particular, they are severely attenuated by heavy rain, limiting their range to a few kilometres. This feature offsets, to some extent, the advantage offered by the signal attenuations experienced at the higher end of the frequency range by these systems, which renders them less likely to interfere with each other.

Receivers for the local radio system field experiment



A rain-induced radio system outage at 38 GHz

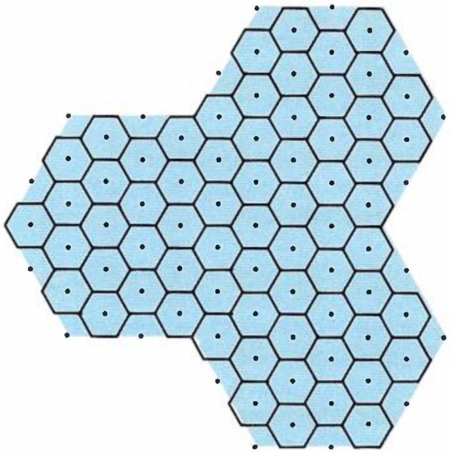
The Laboratories are pursuing theoretical and practical studies to evaluate the problem of mutual interference between systems in urban situations, and so to determine techniques for the continued use of the lower frequency bands in an effective way. Field experiments are in progress to study rain induced attenuation and cross polarisation interference in typical Australian environments. A current experiment in Sydney has been upgraded gradually to include co-polar and cross-polar receivers on two radio systems and four automatic tipping bucket rain gauges along the radio path. The performance of these systems is being remotely monitored by a data aquisition system located at the Laboratories in Melbourne.

Earlier test results suggested a significant discrepancy between measured signal attenuations and theoretical predictions. More recent measurements are being closely analysed as a check on the theoretical attenuation prediction technique and to investigate cross-polar interference prediction techniques.

Although in an early phase, these investigations are aimed at assisting Telecom to study the potential of radio system applications in the local network for a variety of purposes.

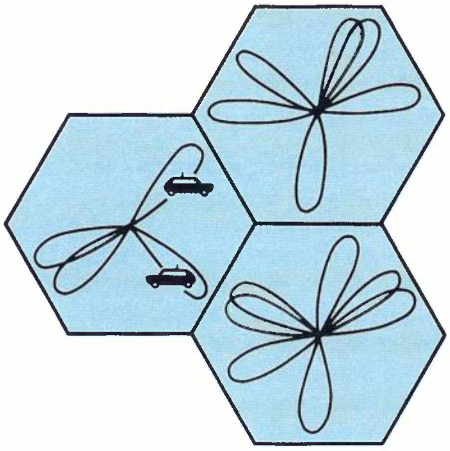
Base Station Antennas for Future Cellular Radio Systems

A current Laboratories' investigation is concerned with the assessment of the potential application of new multiple beam adaptive phased array antennas at the base stations of future high capacity mobile and personal radio telephone systems. The investigation anticipates the possible use of such antennas to replace the semi-directional or fixed sector coverage antennas used in base stations of current generation high capacity analogue cellular mobile systems and in proposed future digital systems.



(a)

All active mobiles in any cell are serviced by a single omni - directional base station antenna



(b)

Each active mobile in a cell is tracked by a separate beam of the multiple beam base station antenna

Cell plans show the comparative numbers of cells required to service a given locality with mobile services

(a) Cell plan using omni-directional base station antennas

(b) Cell plan using advanced multiple beam adaptive antennas

The new antennas would communicate with each mobile unit via a tracked narrow directive beam. Thus, the received interference from other active mobile or base stations would be very much less than that obtained with conventional broad coverage antennas. Since high capacity cellular mobile systems are designed to be interference limited, the new antennas would considerably increase the customer capacity, or equivalently the spectral efficiency, of any given cell plan. Alternatively, in any given locality, the new antennas would permit service to be provided with fewer base stations than are required in presently proposed systems.

To quantify these advantages, initial comparisons have been made for a fast frequency hopping, code division multiple access system employing full frequency re-use in every cell. Although such systems have not yet been developed, they represent one of several proposed types of future digital systems. The typical cell capacity for such a system is listed in the adjoining table, together with the relative improvement predicted if a multiple-beam adaptive base station antenna, with beam specifications as listed, is employed instead of a conventional omni-directional type. Expressed in terms of the cell plan, the use of the new antenna promises a significant reduction in the number of cells required to service a given geographical area, when compared with the number of cells required to service the same area from base stations employing omni-directional antennas, given reasonably uniform distributions of mobile customers. This reduction of the number of cells implies a corresponding reduction in the number of base stations required to service the area.

Table: Predicted Improvements using Advanced Base Station Antennas instead of Conventional Omni-Directional Antennas

Factor	Conventional Omni-Directional Antennas	Advanced Multiple Beam Adaptive Antennas
Antenna azimuthal pattern	omni-directional	each active mobile tracked by beam:- - 3 dB at ± 7.5° - 15 dB at ± 15° - 30 dB at ± 180°
Relative interference susceptibility	1.0	0.045
Capacity expressed as number of active mobiles per cell, assuming:- (a) 20 MHz one-way bandwidth (b) 32 kbit/s base band bit rate (c) Average bit error ratio 10^{-3} at full loading	33	731 (relative improvement factor 22)

The relative improvement factor cited in the adjoining table represents an ideal upper bound figure, which is based on the relative interference rejecting properties of any of the adaptive antenna beams when compared with the conventional omni-directional base station antenna. In practice, this improvement would be reduced, due to the additional overheads to set up calls with the new multiple beam adaptive antennas and to non-uniformities in the geographic distribution of active mobile stations using the code division multiple access technique assumed in the studies. The use of other multiple access techniques might regain some improvement.

The preliminary studies suggest that a significant reduction in requirements for base stations can be achieved by using the new advanced antennas. The Laboratories' investigations are therefore now turning to investigations of practical means for effectively implementing such adaptive multiple beam antennas.

A Laser Frequency Noise Model for an Optical Heterodyne FSK System

The Laboratories are currently increasing effort on research investigations of coherent optical fibre systems. These next generation systems promise very much better transmission performance than the systems which are currently being installed by Telecom. The latter systems operate simply on the basis of intensity modulation of the light source and direct detection of the received optical pulses. Coherent systems use more sophisticated modulation and detection techniques, and they offer advantages for the use of optical amplifiers in long-haul transmission systems and for optical frequency division multiplexing in, for example, advanced subscriber distribution networks.

There is a wide choice of modulation techniques that can be considered for coherent system implementation, the choice being determined largely on trade-offs between system performance and equipment complexity.

The modulation technique of frequency shift keying (FSK) and heterodyne detection, implemented with non-synchronous demodulation at the receiver, is comparatively easy to implement. In particular, it is not as demanding as other modulation techniques on obtaining narrow linewidths from the laser diodes. For this reason, several experimental FSK systems have been reported recently using distributed feedback laser diodes.

To assess the performance of heterodyne FSK systems, it is necessary to model the frequency fluctuations of the laser diode output. A large frequency fluctuation can give rise to errors in the received digital signal. Models currently reported in use have been relatively simple, assuming a Gaussian model for the laser phase and frequency fluctuations.

A more sophisticated model has been developed in the Laboratories to describe the frequency fluctuations of the laser output as a function of the laser linewidth and diode parameters. This model is based on the laser rate equations and takes account of the relaxation oscillations in the laser field. At high bit rates, such as in the Gbit/s regime, the frequency fluctuations experienced by an FSK system can be increased over those experienced at lower bit rates. The effect which this has on performance is being evaluated, with the aim of providing guidelines for the implementation of high bit rate, heterodyne FSK systems.

Composition Characterisation of Optical Fibres for Use at Mid-Infra-Red Wavelengths

One longer term aspect of the Laboratories' programme of investigations of optical fibres and systems concerns new materials and fibres which might be developed for application in the 1990s. Next generation fibres will be fabricated from non-silica glasses and operate in the 2 to 5 micrometres wavelength region. Such fibres could exhibit over ten times the transparency of present day silica fibres, promising much longer repeater spacings for equivalent transmission loss budgets.

Initial Laboratories' studies have been aimed at correlating optical properties of new glass materials with chemical and structural parameters. Composition and homogeneity have been investigated to evaluate and compare several fluoride materials, such as heavy metal fluoride glass (HMFG) and fluoride fibre samples. This has enabled the determination of an exact chemical formula of materials obtained from different sources, including information on fluctuations in the compositon of cores and claddings of the fibres.

The data was collected using an Electron Probe Micro-Analyser (EPMA) equipped with both energy dispersive and wavelength dispersive X-ray spectrometric systems (EDX and WDX respectively). The performance and analytical application of these two systems are briefly as follows.

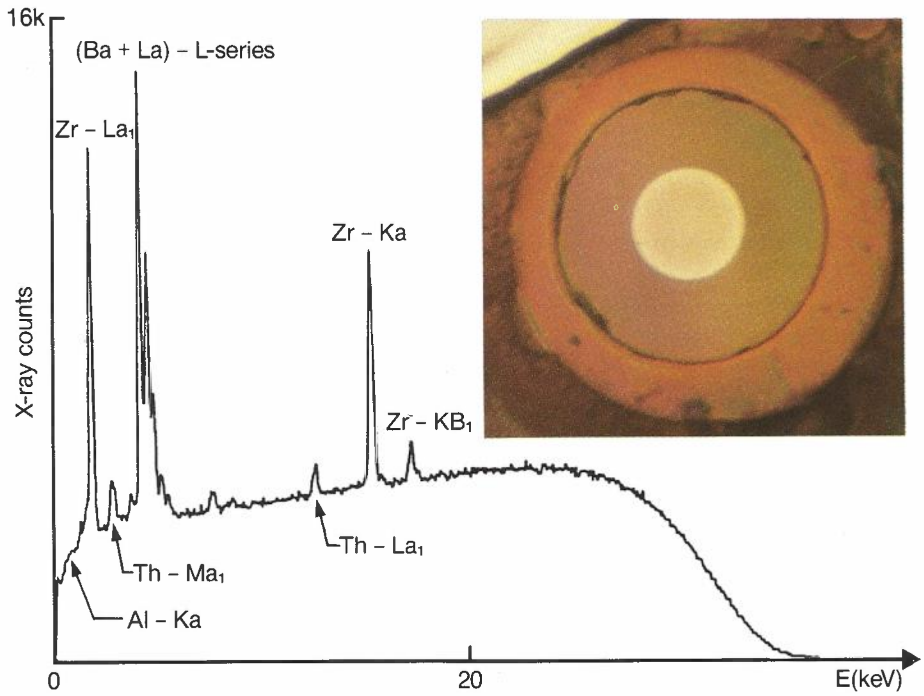
The EDX system is fully electronic. It comprises a special solid state detector, which must be held at liquid nitrogen temperatures to maintain its performance, and a multi-channel analyser which resolves X-ray energies. The EDX system has low resolution (about 150 electron volts), but it has the advantage that it enables the investigator to observe the recorded spectrum on a cathode ray tube display and store it in computer memory. No light elements of atomic number less than 11 can be detected. EDX analysis is most useful at the starting point of an analytic procedure.

On the other hand, the WDX system is partially mechanical (diffraction spectrometer) and partially electronic. It has superior energy resolution (10 electron volts), significantly higher peak-to-background ratio and has better detectability of trace elements.

For the Laboratories' studies, a computer program has been developed on a microcomputer which implements the so-called ZAF correction procedure. The program takes raw data from the X-ray spectra and determines element concentrations to better than 1 weight per cent of absolute value. However,

EDX spectrum of a multi-mode fluoride fibre

(Inset photo) Cross-section of the fibre and its polyacrylate coating



Electron probe micro-analysis system applied in characterising new glasses for optical fibres

the relative error of concentration measured at different points on one surface can be as low as 0.2 weight per cent. Pure elements are used as standards for the measurements.

The current investigation is helping to resolve a disparity which has existed for some time between the theoretically predicted loss behaviour of some materials and that observed in the laboratory. In particular, optical studies in HMFG have yielded evidence of both Rayleigh-type scattering and scattering from large particles in the glass, identified by the variation of intensity as wavelength is varied. Several reports on fluorozirconate fibres have noted non-Rayleigh-type scattering, attributed to drawing-induced growth of microcrystals. The present work is expected to reveal the physical and chemical nature of microcrystals and to produce evidence leading to crystallisation-free core and cladding compositions.

Hydrogen Ingress in Optical Fibres

About three years ago, it was reported in the literature that an unexpected increase in light attenuation had been discovered in some optical fibre cable which had been in service for a relatively short period. The cause was subsequently found to be hydrogen, which can be generated under favourable conditions from some of the materials making up the cable or introduced from an external source by electrolytic action. Molecular hydrogen diffuses some distance into most materials, including glass, since it has such a small cross-section. Hence given time, hydrogen can find its way into the very core of an optical fibre.

Since the diffused hydrogen can seriously degrade the transmission performance of optical fibres, it is important that hydrogen ingress should be minimised to maximise the service lifetime of optical fibre cable. Thus, the Laboratories have been investigating the effects of hydrogen on transmission performance, and at the same time, have examined environmental and operational factors which might increase the exposure of fibres to hydrogen.

There are several factors which may cause optical fibres to be more susceptible to loss increase in the presence of hydrogen. One of these factors is stress. This is of some concern because residual stress can be inadvertently built into an optical fibre during its manufacture, when a cable is pulled into a duct, or to a lesser extent, when it is ploughed into the ground. Consequently, an experiment was designed to test the importance of the stress factor.

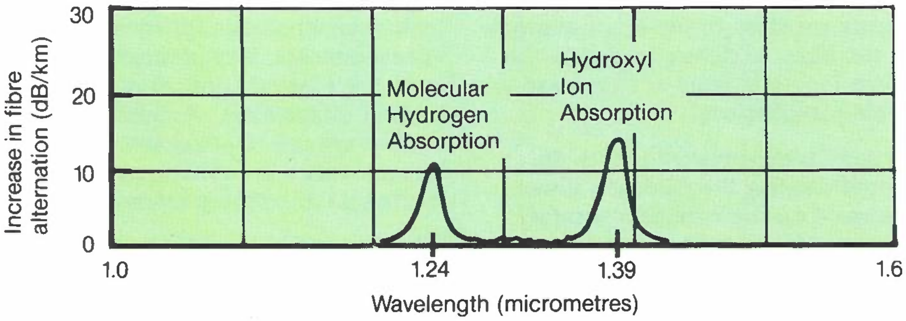
An ideal subject for testing is an optical fibre which has a known high level of stress already built in. Samples of polarisation preserving fibre (PPF), which have just such a property, were available and used in the experiments.

The testing apparatus comprised a fibre attenuation test set which could scan the wavelengths of interest, ranging from 1.0 to 1.6 micrometres. A containment vessel which held a spool of fibre could be purged with dry nitrogen or filled with hydrogen as required. The fibre was wound on a bobbin consisting of a pyrex glass cylinder with ends which mounted directly onto a fibre winding machine. The ends could be removed to allow the bobbin to be placed into the containment vessel for the experiment. Temperatures up to 100° Celsius could be attained by electrical elements located within the containment vessel adjacent to the fibre spool. This permitted accelerated ageing due to hydroxyl ion formation, known to be a principal source of attenuation increase.

When a conventional fibre was exposed to hydrogen for 10 days, attenuation increased in predictable fashion from known mechanisms. The experiment was repeated for a short length of PPF, but no dramatic additional increase in attenuation was observed.

Future experiments are planned using more refined aparatus. These will

Effects of hydrogen ingress on optical fibre transmission loss



include the use of special low-hydroxyl-ion PPF, which will enable more refined differentiation of stress effects. The results obtained to date have paved the way for the development of facilities for testing of new types of hydrogen-ingress-resistant optical fibre proposed for possible future use in the trunk network.

Lifetimes of Damaged Optical Fibres

Minute flaws which occur in the manufacture of optical fibres can significantly reduce their lifetimes as satisfactory transmission media. More serious flaws can cause fibres to break during cable hauling operations. Typically, such flaws occur during fibre drawing or subsequent handling as scratches or irregularities on the outer surface of the fibre.

Since Telecom Australia plans to use optical fibre cables widely in future extensions of its trunk and urban distribution networks, the Research Laboratories have enlisted the assistance of an Australian telecommunications manufacturer to study the effects of such flaws on the long term transmission performance of fibres.

To establish the study, Telecom awarded a research and development contract to AWA Research Laboratory Pty. Ltd. to investigate, for the first time, a wholly empirical method of lifetime prediction. The technique, pioneered by AWA, uses deliberately, but controllably, damaged fibres. Previous studies on lifetimes have used the fracture mechanics model which combines theoretical and empirical data. The essential point about the controllably damaged fibres is that, unlike normally produced fibres, the artificially damaged fibres have a far greater number, and a more even distribution, of the flaws which cause fibre failure. The effect is to give to the short lengths of fibres used in laboratory tests strengths which are close to the proof strength of the fibre, as determined over the much longer lengths of fibre used in cable manufacture.

Extensive experimental work on manufacturing the damaged fibres focussed on the variables possibly responsible for influencing the damage and hence the uniformity of flaws and strength of the fibres. The fibres were deliberately damaged in the drawing process by adding fine particles of polished aluminium oxide to the acrylate coating chamber. The level of damage was adjusted by altering the quantity of abrasive added to the acrylate coating solution. Tests showed that fibres with optimum properties should be drawn at high line speed, using low drawing tension and a pressurised coater.

The short term fatigue lifetimes of the damaged fibres were measured at various stress levels in various environments. Wiebull plots of failure probability as a function of time, rather than stress, were constructed for each case, and the slope or fatigue constant obtained. Rather than the usual 50% failure probability, the realistic level of 5% failure probability was used to generate the empirical model for lifetime predictions of prooftested optical fibres.

A number of extrapolations were used in the analysis and therefore the predictions are being used with caution. However, the water environment was more severe on the fibres than the dry environment, with extrapolations showing that, for typical stresses experienced by fibres in cables, the lifetimes should be in excess of engineering requirements.

Reference Standards for Fibre Optics

Telecom Australia is currently introducing optical fibre transmission systems into its trunk network and in an experimental local loop network in the central business area of the city of Melbourne. The use of such systems by Telecom is expected to grow rapidly in future years. The reliable and satisfactory operation of such systems depends ultimately on the accuracy with which the technical performance parameters of such systems can be measured, and in turn, the precision and repeatability of the measurements depends on the precise calibration of the measurement systems, with traceability to technical reference standards for such measurements. Key parameters to be measured include optical power, optical attenuation, wavelength and optical spectra. Optical time domain reflectometry is a measurement technique of primary interest.

The Research Laboratories have been charged with the establishment and future operation of Telecom's reference standards facility for measurements in the fibre optics field. Telecom's standards will be traceable to Australian national standards and thence to international standards.

The Research Laboratories' facility will head a hierarchy of calibration facilities throughout Telecom Australia. The Research Laboratories will calibrate working standards for calibration laboratories in the Headquarters and State Administrations, and these in turn will calibrate measurement facilities used by field operational units of Telecom. In this manner, all measurements performed throughout Telecom in the fibre optics field will be traceable to the Australian national standards and to overseas standards. This will ensure performance compatibility between new and existing equipment and also give confidence that equipment which is being returned to network operations after repair or routine maintenance will perform to specification.

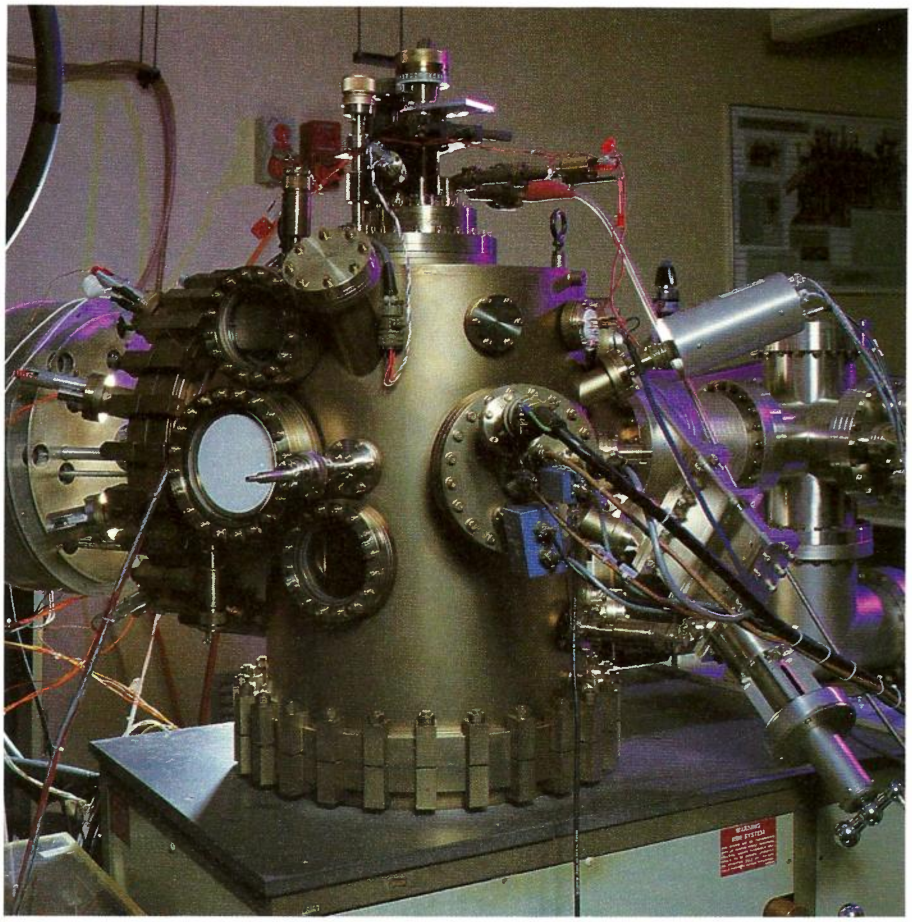
Measurement techniques are an important part of any legally traceable calibration system. This is especially so with optical fibres, since measured results can be significantly influenced by the measurement procedure. Because of this, valid and consistent measurement techniques will be developed by the Laboratories and promulgated to other Telecom calibration centres as an integral part of the Laboratories' responsibility for Telecom's reference standards.

Losses in both single-mode and multi-mode optical fibres, and the operational power levels used with them, are very small, presenting a challenging measurement task. The significance of measurement accuracy on performance is also increased by the consideration that working systems have extensive information capacity and involve long fibre lengths. System performance must therefore be specified and measured by accurately characterising systems and their elements in terms of the standards.

In the recently established reference standards facility, an electrically calibrated pyroelectric radiometer with a tuned lock-in amplifier is used as the primary standard for optical power. Its electrical calibration is referred directly to Telecom Australia's reference electrical standards, which are also maintained by the Laboratories. This radiometer, in conjunction with a series of calibrated neutral density filters, allows calibrations at all optical power levels which prevail in the optical fibre network.

Since calibrations are wavelength-dependent, it is necessary to maintain a standard of wavelength. This is achieved by intercomparisons between optical sources of known wavelength. The standards cover the three main wavelengths used in optical fibre communications. These are 0.85, 1.3 and 1.55 micrometres. Where possible, the scope of the reference standards is being expanded to cover wavelengths and conditions which might be used in the more distant future.

This comprehensive system of reference standards will assist Telecom to operate its future optical fibre transmission systems with consistently excellent performance.



High vacuum chamber of the Laboratories' molecular beam epitaxy facility

The Production of Superlattices for Opto-electronic Devices

As in other institutions performing R&D in the field of optical communications systems based on silica fibres, Telecom Australia has developed complementary research interests and facilities for the investigation of optical source and detector device materials capable of approaching the maximum fibre information rate at the ideal operating wavelength at a reasonable cost. Over recent years, the Laboratories' molecular beam epitaxy facility has been developed to provide a core facility for these research activities in the fundamental materials technologies of advanced semiconductor and opto-electronic devices. In this process, considerable expertise has been developed in the application of the facility.

Until recently, molecular beam epitaxy (MBE) growth of a range of semiconductor materials based on the gallium arsenide family of materials has produced thin film multilayer structures in which the opto-electronic properties of each layer are similar to those of the respective bulk material. It has been necessary to match the lattice constant of each layer to that of the substrate on which they are grown, to ensure attainment of the excellent structural quality required for the fabrication of devices suitable for application in optical communications systems. These constraints have severely limited the capabilities of these materials to match those of the best fibres available. In turn, this has imposed a cost penalty, since the cheapest and best understood substrate materials could not always be used.

The recent development of complex thin film structures called superlattices has resulted in the production of materials with properties which are quite different from those of bulk semiconductors. The Research Laboratories have successfully grown these structures using the powerful MBE technique. The technique allows the growth of multilayer structures in which the constituent layers may be only one or two atoms thick. Different types of superlattice structures can be grown in such a way that the properties of the resulting semiconductor material can be finely controlled by choosing layer thicknesses, composition and doping.

Strained layer superlattice (SLS) structures are one member of the family of superlattices which offer an important additional technological advantage, in that they allow a comprehensive range of semiconductor materials to be grown on a variety of substrates. These structures relax the previous constraint on lattice matching and allow the use of technologically convenient substrates for the growth of hitherto incompatible materials. The lattice matching constraint can be relaxed, since mismatched layers maintain atomic coherence in the plane of the growth, provided individual layer thicknesses are kept below critical values. The maintenance of coherence in the plane of the growth results in a compensating lattice distortion in the direction of crystal growth, and it is from this phenomenon that such structures derive their name. SLS structures are generally grown on a lattice-matched graded layer with the same average composition of the SLS, so that the strain forces in adjacent layers are alternatively compressive and tensile. This allows the growth of semiconductor structures containing up to several thousands of individual layers with the crystalline perfection required for the fabrication of state-of-the-art opto-electronic devices.

Simulation of VLSI System Architectures

As advances in integrated circuit fabrication technology allow greater chip complexities, the freedom to exploit new system architectures (i.e. the broad structure of the system) is increasing greatly. However, the time required to design these more complex ICs is escalating rapidly. In an attempt to manage complexity and minimise increasing design costs, the use of computer-aided design tools has become commonplace in the design process.

Although improvements have been significant, the recognition of deficiencies in current design approaches has prompted the Laboratories to investigate new design techniques which might allow the potential of VLSI technology to be fully realised. It is increasingly important to be able to determine and verify the optimum architecture before the detailed design begins. Logic simulators do not allow systems to be simulated at the architectural design stage, since they operate at the logic-gate or transistor level of design detail. They therefore require significantly more specification effort than is needed to verify an architecture and much more than is usually available at that stage.

To provide an effective and efficient means of simulating new VLSI architectures, the Laboratories have developed a technique that utilises the Prolog programming language. By using Prolog, system functions and architectural structure can be expressed as an executable specification that does not require logic or circuit design details. The system description may be extended to include circuit details as the structure of different sub-systems becomes defined. Unlike logic simulators, abstract or actual data values may be used in the execution of the description, and system concurrency is handled automatically. In addition to simulating the system functions, Prolog allows the system description to be interrogated to discover additional features or limitations that are implicit in the architecture.

This application of an appropriate programming language for simulation has demonstrated that many of the problems involved in designing a language specifically for hardware simulation can be avoided.

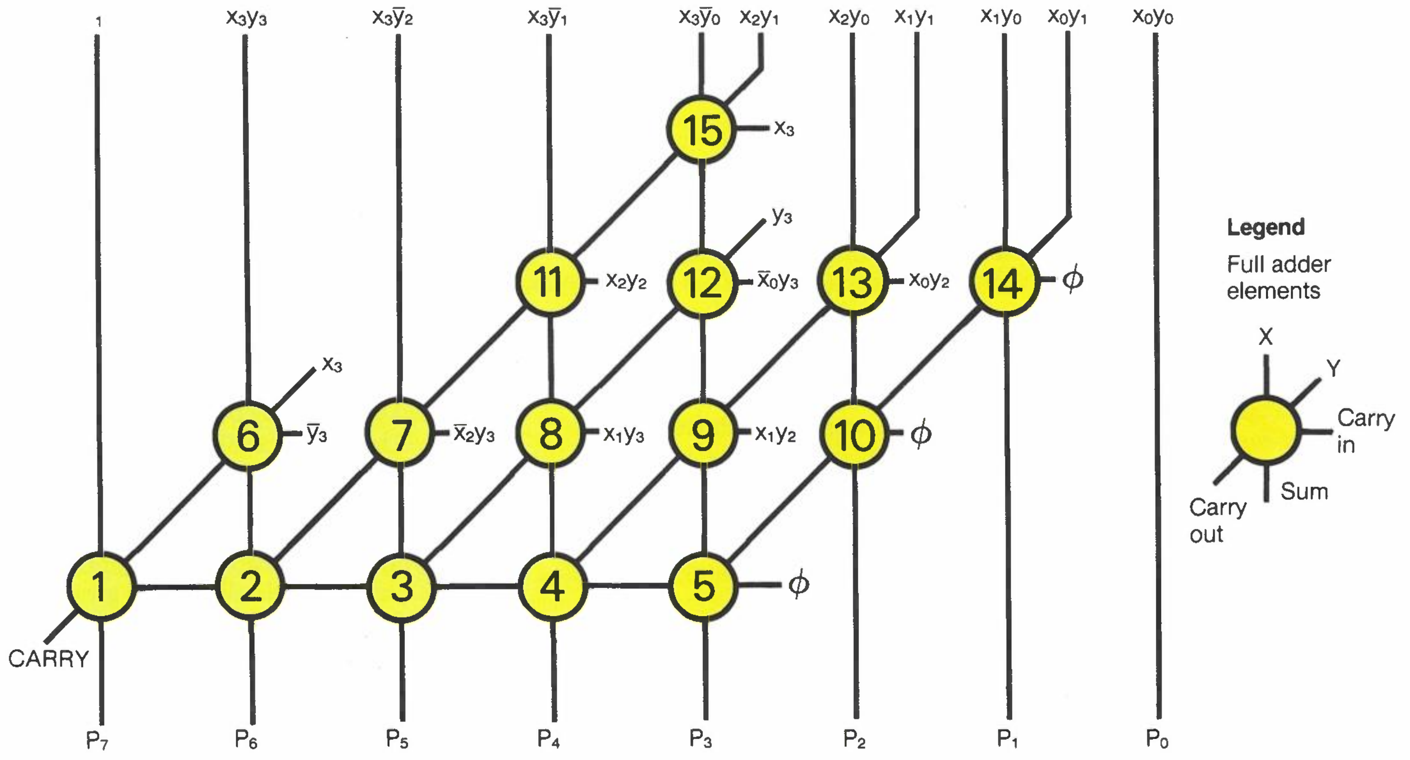
A Microprobe System for Integrated Circuit Characterisation

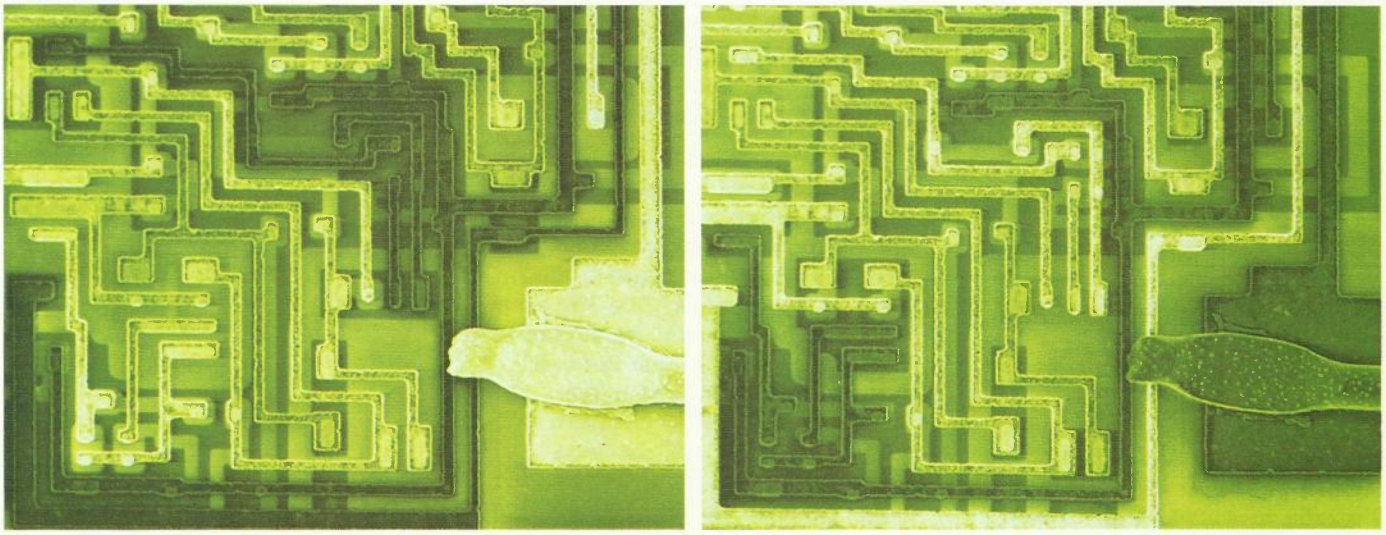
The rapid increase in the complexity of integrated circuits (ICs) has reached the stage where it is possible to fabricate one million transistors on a single piece of silicon, just 12mm square.In addition, sophisticated custom logic ICs are now finding increasing use in many applications, particularly in the tele-communications field where various specialised circuit functions are required.

Characterising and testing such complex very large scale integrated (VLSI) circuit devices during the design phase, or determining the cause of a failure, is often not possible using conventional test procedures such as mechanical microprobing.To overcome this problem, various test techniques have been devised, the most effective of these utilising an electron beam as a steerable, non-loading probe.The Research Laboratories have recently acquired such a test system which is capable of operation in several of the advanced modes required to examine complex ICs.The system is being used for failure analysis and design validation and to investigate and develop new electron beam techniques for IC analysis.

In laboratory practice, the IC to be examined is firstly decapsulated to expose the die, and then placed inside the vacuum chamber of the test system. Electrical feedthroughs allow

An example of requirements for simulating the VLSI architecture of a four-bit, two's complement multiplier





(a) (b)

Top: the Laboratories' microprobe system for IC characterisation

Bottom: Stroboscopic Voltage Contrast shows a small region of an IC operating at 10 MHz, each image being acquired by turning the electron beam on for 10^{-8} seconds

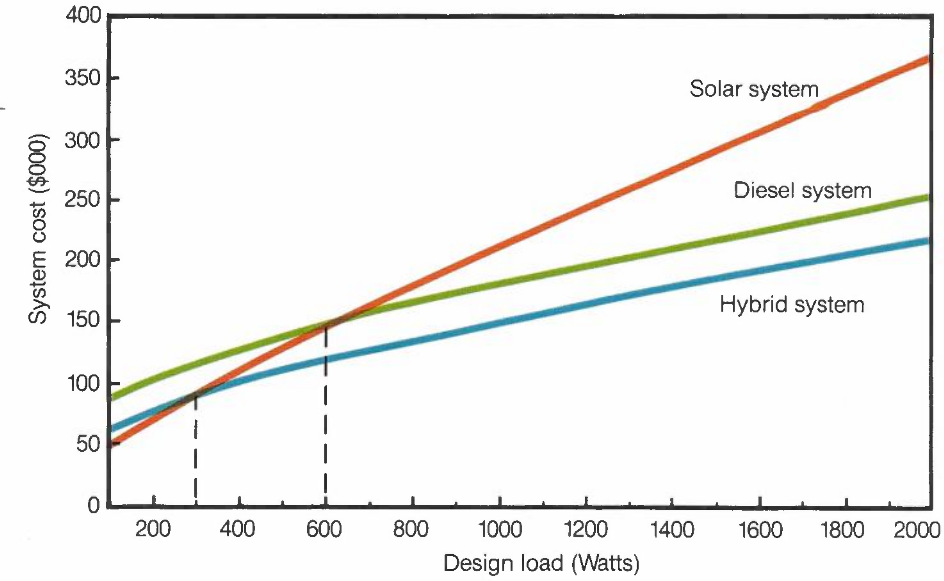
(a) shows the circuit with the input (lower right) at zero volts

(b) shows the circuit 5 x 10^{-8} seconds later, when the input has gone to +5 volts

power and other signals to be applied to the device so that normal circuit operation can continue. The interaction of the electron beam with the surface of the die results in the emission of low energy secondary electrons which can be used to generate a topographic image of the device. However, these low energy electrons are significantly influenced by the potentials present on the surface of an operating device. Regions at positive potential retard the emission of secondary electrons and appear dark in the image, while areas at zero or negative potential appear bright. This difference gives rise to the term "Voltage Contrast" and the effect provides a very useful means of IC analysis.

To examine circuits which may be operating at frequencies of hundreds of MHz, it is necessary to turn the incident electron beam on and off for short periods of time with respect to any changes which may be occurring

Comparative costs of solar, diesel and hybrid power systems for loads up to 2000W at an Alice Springs location



in the voltage levels of the circuit. This results in secondary electrons being emitted during only one small time segment of the operation of the device, with the result that the image obtained is stroboscopically "frozen" By altering the point in the cycle of circuit operation at which the electron beam is turned on, voltage changes occurring in the circuit can be observed and the propagation delay of signals through the circuit can be measured. Appropriately, this technique is known as "Stroboscopic Voltage Contrast". As well as visual observation, quantitative measurements in the form of voltage-time plots can be obtained with a voltage resolution of ± 20 millivolt and a time measurement resolution of ± 50 picosecond.

Electron-probe techniques, such as Stroboscopic Voltage Contrast, are now used in many IC research and manufacturing centres around the world. The test system acquired by the Laboratories is an indispensible tool for the examination of the advanced ICs which are now finding their way into the telecommunications network, providing essential scientific support to Telecom's use of high technology.

Hybrid Power Systems for Remote Area Telecommunications

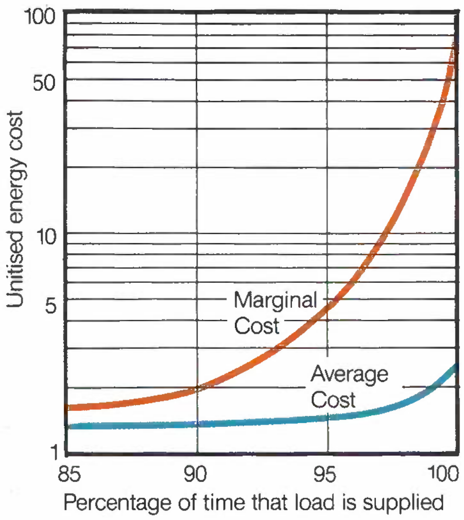
In the remoter parts of the Australian "outback" where reticulated power supplies are not available, Telecom Australia uses stand-alone power systems in a variety of network applications. The systems power equipment ranging from single customer terminals to repeater stations on major microwave radio trunk routes and, shortly, to repeaters of optical fibre trunk transmission systems. The power capacity requirements, power supply continuity and the consequent designed grade of operational service vary for different categories of application.

To date, Telecom has successfully used, alone or in various combinations, wind generators, photovoltaic solar cells, gas turbine and diesel generators and rechargeable storage batteries as remote area power sources. Recent and planned expansions of its remote area services and networks have revealed a need for Telecom to install such power sources in greater numbers and in a greater range of capacities. This increasing demand for remote power systems has called for more systematised studies of the design guidelines for such systems and of the comparative economic aspects of particular technical approaches.

To assist this work, the Laboratories have developed computer models for the computation of the costs of energy provided by single or multiple sources. The models allow the costs of different systems to be plotted as a function of load, so that the cost breakpoints between solutions involving different sources can be readily identified and the most economic system for a specific load range determined.

Studies using the models have shown that, due to vagaries in weather patterns, stand-alone systems using only solar or wind energy must be over-sized in order to provide continuous power under the most unfavourable conditions. The cost penalty for covering these infrequent circumstances is high. In a study of a stand-alone photovoltaic system located at Alice Springs in central Australia, the marginal energy cost approached $80 per kilowatt-hour.

Hybrid systems, such as those comprising a photovoltaic source



A graphical illustration of the rapid increase in the marginal costs of maintaining worst case, continuous full load power with sole reliance on a photovoltaic power system

coupled with an auxiliary diesel powered generator, offer an attractive solution for the reduction of high marginal costs over certain load ranges. The computer model can be used to optimise the proportional contribution from each source in such cases and thereby size the system components for minimum energy costs.

The model can also be used to determine the least costly option for increasing the capacity of existing stand-alone systems when, for instance, increased telecommunications traffic requires that additional channels be provided over a particular route.

An example of the application of the computer model is shown in the adjacent diagram, which depicts system costs as a function of mean system power for batteries backed by a solar system, a diesel generator system and a hybrid combination of these systems, using solar radiation data for an Alice Springs location. Below 300W capacity, the photovoltaic system is the least costly alternative. For loads ranging between 300W and 600W, the photovoltaic system is less costly than the diesel alternative but more expensive than a hybrid photovoltaic/diesel system. The hybrid system is the optimum cost alternative between 300W and 2000W. In the case depicted, the optimised hybrid system derives 95% of the required energy from the solar source and only 5% from the diesel engine. The cost savings of such a 2000W hybrid system over that of the other alternatives is typically $30 000. The hybrid system also has an added reliability advantage, in that the diesel generator is sized to carry the full load and can thus provide continuity of service in the event of failure of the photovoltaic array and/or the battery.

Standards for Examining Workplace Atmospheres

Growing community awareness that adverse conditions can have a detrimental effect on the general wellbeing of staff reached a peak with the enactment of a Federal Government Bill forming a statutory body, the National Occupational Health and Safety Commission, in 1985. Meanwhile, Telecom Australia seeks to apply the highest standards of staff safety in the many facets of its operations, improving them further through initiatives generated by Occupational Health and Safety Plans and extensive management/staff consultation. The Research Laboratories contributes scientific experience in analytical techniques to a specialist group set up by the Standards Association of Australia, Committee CH/31. This Committee is only one element of an extensive infrastructure involved in supporting occupational hygiene standardisation, both in Australia and at international levels.

Priorities for the production of Australian standard analytical methods have been set as shown in the following table:

Working Group	**Methodology**
CH/31/1	benzene; glycol ethers; n-hexane
CH/31/2 (Dusts)	inorganic fibre concentrations; respirable dusts -quartz, -fume.
CH/19 (Methods of Measurement of Air Quality)	Priority environmental pollutants- H_2S, SO_2, NO_x, O_3, CO, F−, particulates.

Telecom Australia continues to cover the immediate, specific needs of its own staff, projects and operations with the most reliable test methods and the best technology. Analytical procedures which were developed in the Laboratories are being applied in particular Telecom work environments. Recent contributions in this field include:

- analysis of diffusive organic vapour monitors, which have been used to sample industrial solvent exposure conditions in engineering areas
- mass spectrometric laboratory techniques, which have been applied to the identification, handling and disposal of polychlorinated biphenyls
- sensitive detection methods, which have been developed for possible harmful vapours from ingredients in epoxy and urethane resins.

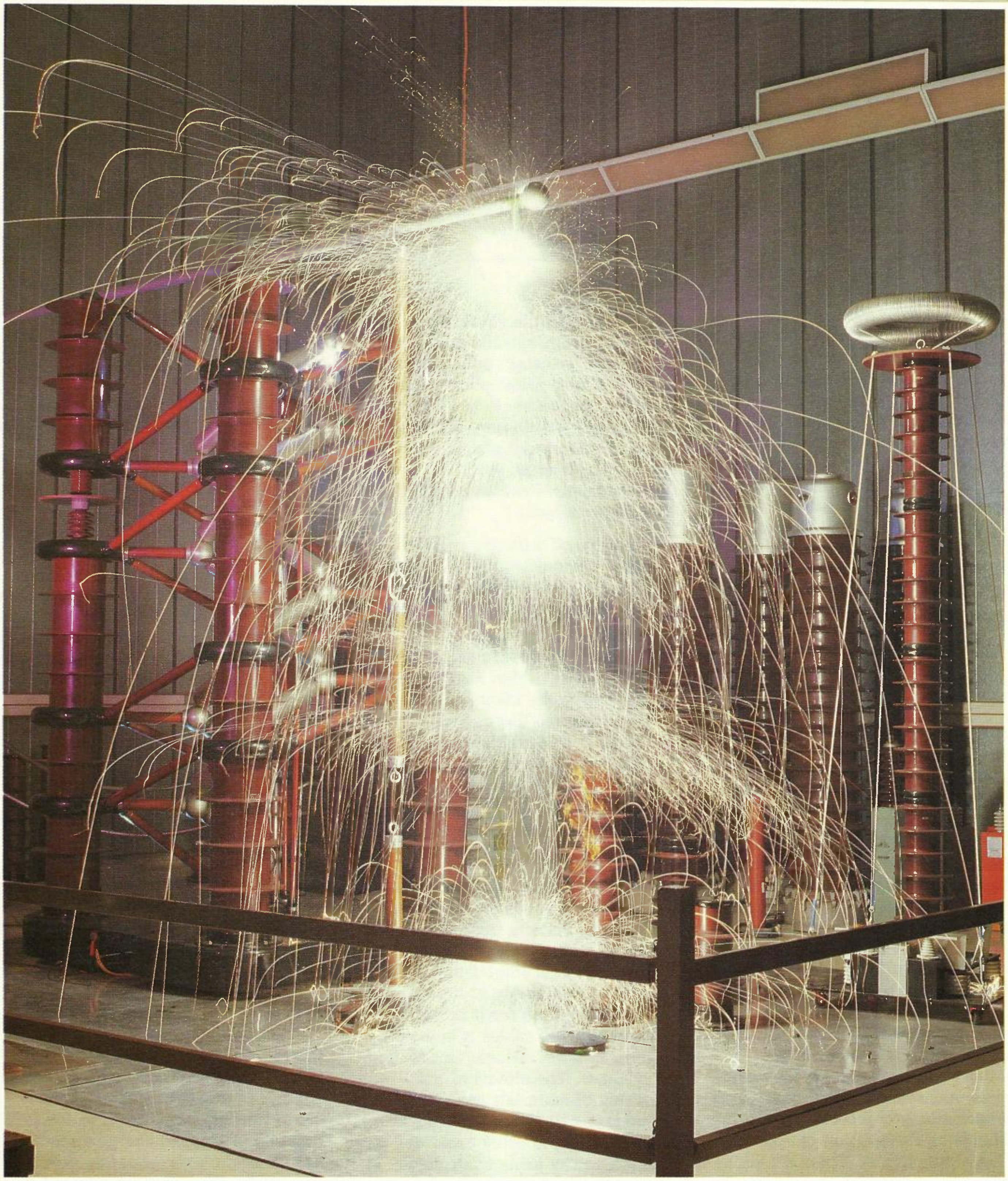
Cable pits and tunnels are now receiving attention and are being surveyed for possible workplace pollutants. Priority treatment is being given to carbon monoxide gas and automotive fuel combustion products. A special field study of the fate of the halocarbons used for leak tracing in gas-pressurised cables is being co-ordinated with Telecom Occupational Hygienists. The effects of hot working of materials used in pits and tunnels (e.g. lead wiping, soldering, shrink fitting) is being examined in the laboratory using controlled thermal degradation methods, with the resultant complex breakdown products being elucidated by mass spectrometry.

Reliability of Electrically Erasable Programmable Read Only Memories

Electrically erasable programmable read only memory (EEPROM) devices are an important class of semiconductor device used widely in modern telecommunications equipment purchased by Telecom Australia. Because of this fact, the Research Laboratories have subjected a number of types of these devices to endurance tests designed to yield data on their long term reliability and also to assess the suitability of various test methods for detecting devices likely to fail prematurely in service use.

Typically, EEPROM cells store information as a charge on the floating gate of a MOS field effect transistor. This floating gate is electrically isolated by a thermally grown insulating silicon dioxide layer with a microscopically thin (less than 200A°) tunnel oxide region above the drain or substrate to permit a transfer of charge during programming and erasure. A wearout mechanism of this type of device results from charge trapping. Thermally grown silicon dioxide contains charge traps which hold some of the charging current electrons as they tunnel through the insulator during programming. The electric field potentials used to induce charges to cross the tunnel oxide cause further charge traps to form. A build-up of trapped charge alters the cell transistor's threshold voltage, and eventually, the cell state cannot be changed and cell wearout occurs.

Floating gates are very small and the program and erase currents are in the order of nanoamperes. If the stored information is to be retained for 10 years, the leakage current must be at least 10 orders of magnitude lower than the program and erase currents.



The disintegration of a cable marker foil by a simulated lightning discharge yields a spectacular display

Therefore, the purity and thickness of the tunnel oxide determines the data retention and reprogramming qualities of the cell.

A computer controlled test system has been used in the Laboratories to program and erase batches of commercial devices. After each program and erase operation, the EEPROM's contents are verified, and at predetermined intervals, various detailed cell characteristics are measured. Marginal Voltage Analysis is used to determine the lowest supply voltage which permits correct operation, and Variable Program Pulse Width Testing is used to determine the shortest duration program pulse that correctly programs the EEPROM cells. A plot of output voltage versus supply voltage for each cell is obtained for both the programmed and erased states.

After more than 150,000 program/erase cycles, less than 1% of cells from one manufacturer have failed, while no failures have occurred among cells from others. These results are better than those predicted by the manufacturers and indicate that EEPROM chip technologies are highly reliable. Even so, testing is being continued to determine whether any correlation between anomalies and device wearout can be found.

Effects of Lightning on Optical Fibre Cables

The burying of a metallic marker foil close to underground optical fibre cables provides a possible means of subsequently locating the cable with a suitable cable detector. However, lightning strikes to the foil could damage either or both the foil and the cable, and consequently, the Laboratories have conducted tests to assess the possible effects of lightning strikes to the marker foil.

The investigations have shown that sections of the foil may be disintegrated by lightning strike currents which arc to it.It was also found that the cable itself may be damaged by the stresses generated by the disintegrating foil or by other nearby discharges generated in the soil by lightning strikes.

The maximum distance at which a strike will cause an arc discharge to the buried foil and the length of the foil subsequently destroyed depends on:

- the depth of burial of the foil
- the type of soil and its resistivity, and
- the intensity of the strike.

Simulated lightning strikes to the foil, causing its disintegration, did not cause damage to the cable when the foil was separated from the cable by an appropriate distance. However, tests at closer separations suggested that more severe strikes to the foil in the field could damage the cable at the planned field separation.

When discharges occurred very close to the cables, they caused damage attributable to mechanical, thermal and electrical stresses. The damage due to electrical stress was of particular interest because these cables did not contain any materials which are electrically conductive under normal conditions. Failure occurred because of mechanical breakage of the optical fibres, resulting from internal electrical discharges in the presence of high electric fields within voids in the cable and at interfaces between the structural and filling materials of the cable. In practice, such fields may be generated by strikes to the foil or by arc discharges in the soil or along tree roots, caused by random lightning strikes to ground in the vicinity of a cable.

The investigation is continuing in order to determine the likely frequency and severity of such damage in practice and to find ways to minimise it.

Insulation and Sheath Materials for Exchange Cables

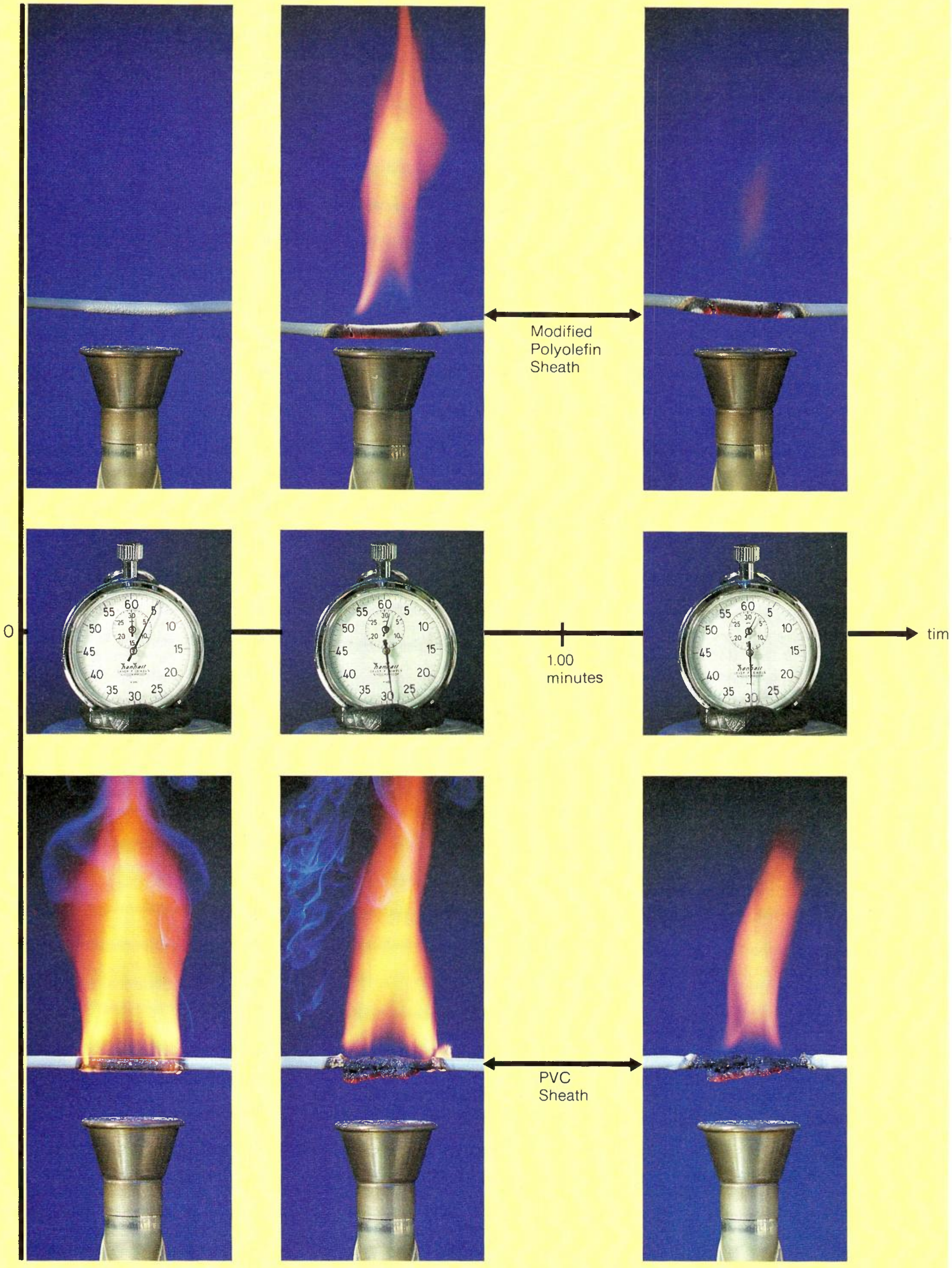
More than 30 years ago, the insulation of exchange wire was a complex PVC-textile-lacquer composite system, designed to withstand specific service applications. However, the cost of the composite-covered wire was heavily loaded by the slow application rates of textile braid and lacquer. This ultimately led to the removal of the lacquered textile covering from the insulation system. The subsequent PVC-covered wire created many difficulties in exchange and equipment wiring, such as solder iron burn and insulation cut-through. In spite of these difficulties, PVC was retained as insulation and used exclusively for the sheath, partly because it was readily available and economical, and partly because it was believed to be fire-resistant. The latter belief has since been proved incorrect. In a fire situation in which some hundreds of kilograms of insulation and sheath are consumed, the quantity of smoke, toxic and corrosive gases given off from PVC are a hazard to operators, plant, buildings and fire fighters.

Telecom Australia realised the potential problem with PVC many years ago and has since devoted significant effort to find a suitable alternative polymer. Concurrently, devastation caused by fires in telephone exchanges in Europe has triggered searches in other organisations for so-called low aggressivity polymers and compounds which, in addition to good flame retardance, are characterised by the low evolution of smoke and aggressive fumes when exposed to fire.

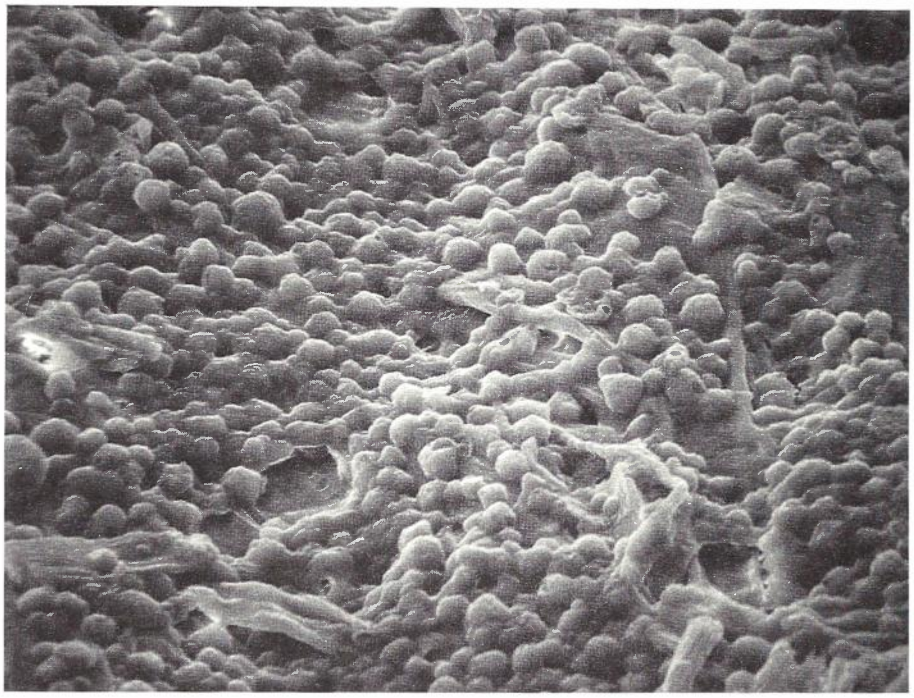
Several polymers, such as Arylet (aromatic polyester), Ultem (polyetherimide), Peek (polyetheretherketone) and Noryl (modified polythenylene oxide), meet these criteria. Telecom Australia has selected Noryl for extensive investigation because it is readily available, reasonably priced and, being unfilled, can be applied at the very low radial insulation thicknesses necessary for the wiring of equipment in modern telephone exchanges.

Initial tests by the Laboratories have shown that Noryl compound, when extruded as insulation onto unplated copper wire, deteriorates rapidly under accelerated ageing conditions.This is considered to be due to metal-catalysed, thermo-oxidative degradation of one or more of the compound's components. Research is under way in the Laboratories to correct this deficiency by the addition of appropriate stabilisers.

The approach being taken with sheath investigations differs from that for insulation in that halogen-free, flame-retardant compounds can be achieved by the incorporation of mineral fillers, such as aluminium hydroxide, into modified polyolefins. In a fire situation, the endothermic decomposition of the aluminium hydroxide acts as a heat sink, thereby removing heat which would ordinarily

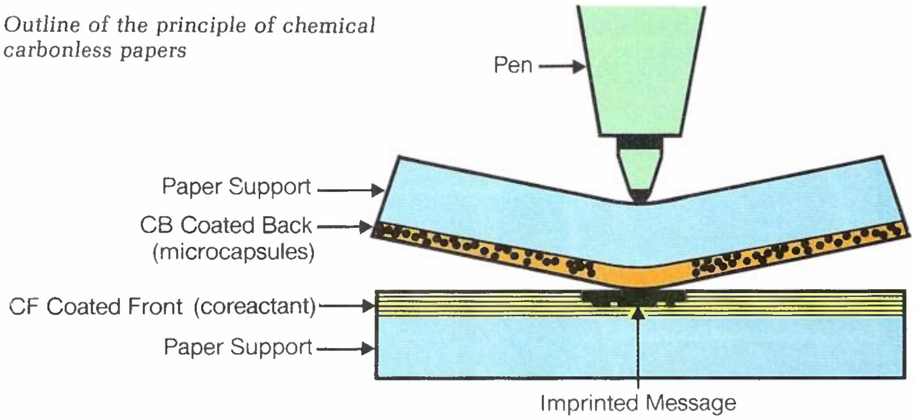


Time lapse sequence comparing flame damage to a modified polyolefin sheath with that to a PVC sheath contribute to the decomposition of the polymer. Water liberated from the decomposition of the hydroxide also serves to inhibit the access of oxygen. Loadings of aluminium hydroxide can be as high as 65%, but are more frequently around 50% in a 20% vinyl acetate modified polyethylene. Four such commercially available compounds are currently under evaluation to determine their suitability as sheath materials for cables containing Noryl-insulated wires.



Scanning electron micrograph of microcapsules on carbonless telex paper

Outline of the principle of chemical carbonless papers



Analysis of Chemical Carbonless Copy Papers

Chemical carbonless copy paper (CCCP) has been increasingly used by Telecom Australia since its introduction in the early 1950s. For many years, Telecom employed CCCP in a range of administrative documents and as continuous roll hard copy. Some CCCPs have been associated with worker complaints such as pruritus, contact urticaria and dermatitis, eye and respiratory tract irritation, fatigue and headaches. Although some manufacturers have ascribed these symptoms to mass psychosis, independent studies have confirmed that some CCCPs can adversely affect a proportion of workers.

The Laboratories have therefore initiated a research programme at the request of the Human Resources Department, with the specific objective of developing procurement specifications for CCCPs which will eliminate irritant materials.

The adjacent diagram outlines the basis of CCCP technology. The top sheet, called CB (coated back), has an underside coating of microcapsules which contain a solution of colourless dye precursor. The bottom sheet, called CF (coated front), contains a reagent (called coreactant) which reacts with the colour former to give a dye. The intermediate sheet is coated on both sides (CFB). By adding more CFB sheets, multi-ply forms with additional copies can be built up. Once pressure is applied on the top sheet, the microcapsules in all sheets are broken where pressure is applied and the solution is transferred to the next underlying sheet, forming a dye which stains the paper and leaves a permanent mark.

The crucial components of CCCP are the microcapsules, colour formers, solvents and coreactants. One colour forming substance is crystal violet lactone (CVL); another benzoyl leuco methylene blue (BLMB). The solvents used initially were polychlorinated biphenyls, but these had to be abandoned in the early 1970s due to their deleterious effects on humans and the environment. Today, solvent mixtures containing hydrocarbons, esters and chlorinated paraffins are used. The coreactants commonly encountered are acid-treated clays, phenolic resins or metal chelate complexes.

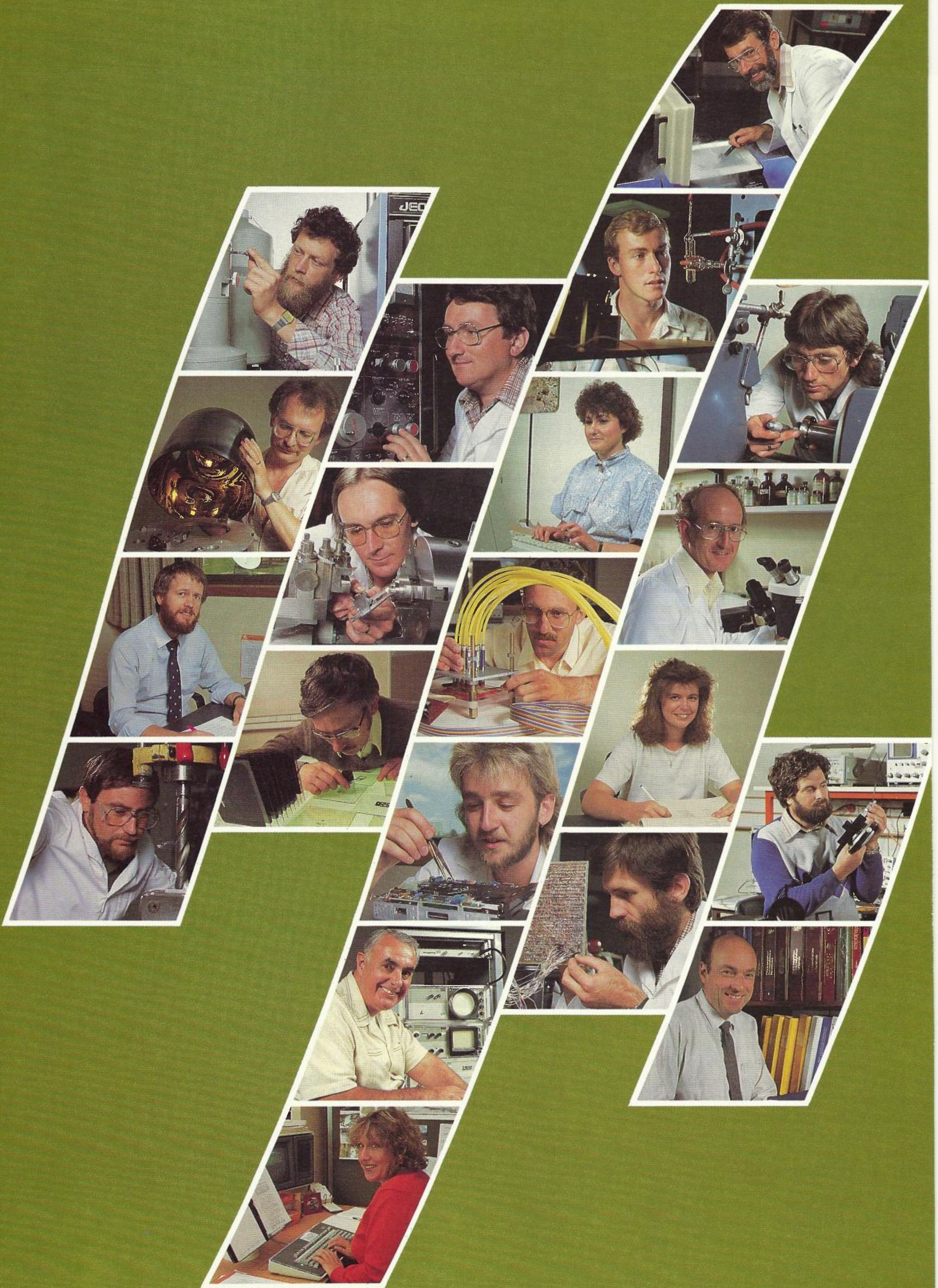
Other additives used in the coatings fall into the following categories:-

- identifying colourants and inks
- catalysts
- glues, binders, fillers and sizers
- colour enhancers
- dispersants, pH adjusters, surfactants, thickeners and lubricants
- whiteners, optical brighteners, image stabilisers, colorisation suppressors and waterproofing agents.

Residues of synthetic precursors must also be considered.

An analytical protocol is being developed by the Laboratories to reduce the field of possible irritants from several thousand to a more manageable number for any particular paper sample.

Overseas analyses of CCCP have shown that formaldehyde, some solvents, and nickel and chromium compounds as impurities can be irritants to CCCP users. Laboratories' investigations have already identified epichlorohydrin and over sixty organic chemicals, as well as compounds of seven metals, as candidates for further investigation.



Consultative Activities and Laboratory Facilities

Introduction

The Laboratories are continually developing expertise and laboratory facilities in the engineering and scientific disciplines which are somewhat special and uniquely concentrated in Telecom Australia. 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 consultations and applications of specialised laboratory facilities do not attract the same prestige as the larger-scale R&D projects, in terms of their visible contribution to major corporate decisions. Nevertheless, they are essential to 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 these activities of the Laboratories during the past year are given in the following pages.

Revision of Telecom Australia's Policy on Industrial Property

In the fulfilment of its charter and responsibilities given under the Telecommunications Act 1975, Telecom Australia engages in a range of activities which can both generate industrial property in which Telecom Australia can legitimately claim ownership rights or which can result in licensed rights being acquired by Telecom Australia to exercise industrial property owned by other parties.

The Research Laboratories have the responsibility of executing Telecom Australia's policy on industrial property matters. This work involves the provision of consultant advice and assistance to management and staff throughout Telecom in relation to the industrial property aspects of Telecom Australia's activities, together with the development, management and exploitation of Telecom Australia's industrial property portfolio.

Industrial property refers to intellectual knowledge in which rights of ownership can be established by legal process. The forms of industrial property relevant to Telecom Australia's operations are:-

- letters patent - relating to inventions of manufacturing processes or manufactured products
- registered designs - relating to the shape or appearance of products
- copyright - relating to publications, computer software and data, etc.
- trade marks - applied to telecommunication products and services offered by Telecom Australia
- confidential technical data - or proprietary know-how.

During the latter part of 1984 and early 1985, Telecom Australia's policy on matters relating to industrial property was substantially revised as a result of work undertaken by a HQ Working Party convened by the Deputy Director, Research, and including representatives of most HQ Departments and Directorates. The revision of the policy encompassed recent developments in industrial property legislation and Telecom's service, business, commercial and technical objectives in a more competitive Australian telecommunications environment. Following a comprehensive commentary phase, a revised Policy Statement was approved and presented to the Commission at its meeting of 14 August 1985.

Concurrently with the revision of the Policy Statement, a smaller Working Party produced a supplementary Industrial Property Manual to provide information and guidance to Telecom Australia's management and staff on industrial property aspects of their activities. The Manual also contains a list of contact officers throughout Telecom Australia who will provide knowledgeable access to industrial property experts in the Research Laboratories.

The revised Policy Statement and Manual provide a sound basis for Telecom Australia's activities in a future where its role and relationships with industry and other providers of telecommunications services are evolving in a more competitive, commercial climate.

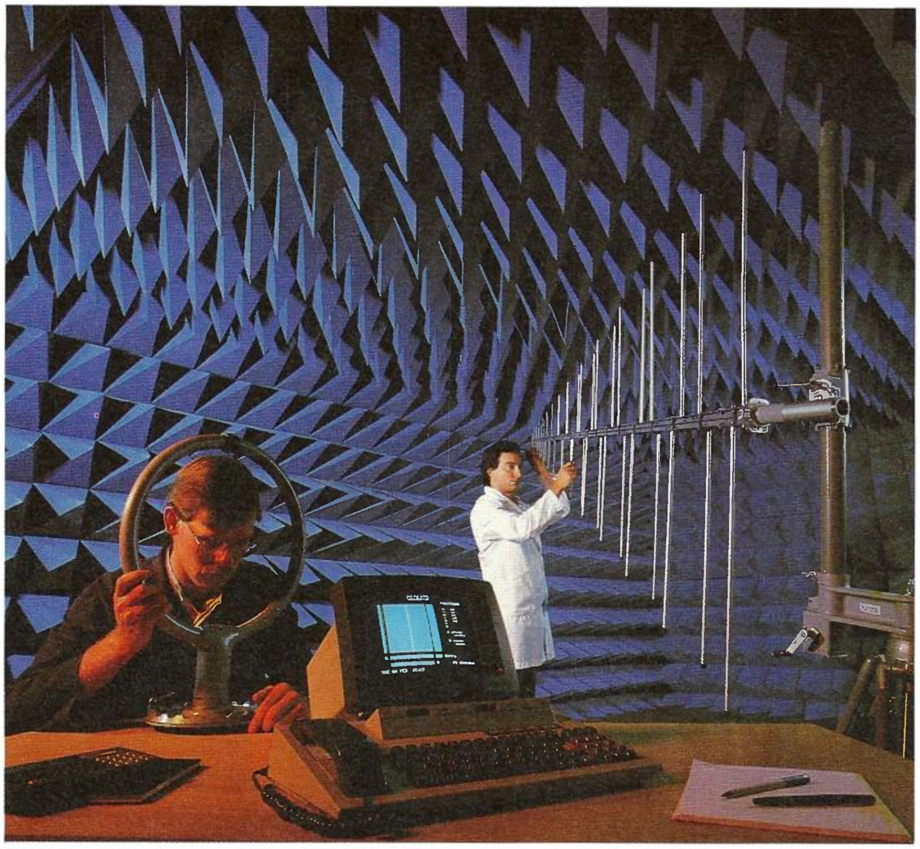
A listing of the patents and registered designs which comprise Telecom Australia's portfolio of industrial property is included in the back section of this Review.

Shielded Electromagnetic-Absorber-Lined Chamber Facility

Electromagnetic compatibility (EMC) can be described as the ability of electronic equipment or systems to function satisfactorily in their intended operational environments without suffering or causing unacceptable performance degradation due to the unintentional transmission or reception of conducted or radiated electromagnetic energy. It follows that the EMC of a wide variety of equipment is important to Telecom's network operations, particularly with the proliferation of modern equipment employing digital signal processing techniques and microelectronics technology. Unless adequate design safeguards are employed, such equipment can be a potential source of unwanted electromagnetic energy. The generally low level signals employed in such equipment also makes it susceptible to performance degradation caused by unwanted interfering electromagnetic energy generated by nearby equipment.

The Laboratories are actively pursuing a variety of R&D projects and problem-solving investigations aimed at improving the EMC of equipment employed in Telecom's networks and customer terminals.

For R&D investigations of many EMC control measures and for some investigations of bio-electromagnetic hazards, it is essential to have access to an open-field facility for experimental activity. Such a facility should represent a large open space in which the only surface which significantly reflects electromagnetic waves is conductive level ground. It is difficult to obtain such qualities in a field site in a natural geographical environment. Even if such a site is available, adverse weather conditions and the high ambient levels of electromagnetic "noise" generated by modern society limit its usefulness.



A view of the interior of the shielded electromagnetic-absorber-lined chamber facility

One method of simulating the open-field site without the above drawbacks is to construct indoors a large, six-sided, electromagnetically shielded chamber, with five of its six internal surfaces covered with electromagnetically absorbent material, leaving the metallic floor to function as a near-perfect wave-reflecting ground plane. The electromagnetic shielding keeps out the externally generated electromagnetic "noise" (and keeps in the electromagnetic radiation emitted by equipment under test), whilst the electromagnetic absorbers simulate the non-reflecting surroundings of an open-field site.

Such an electromagnetic-absorber-lined chamber (EMALC) facility has been designed and constructed at the Laboratories.

Since completion, the EMALC facility has been used for preliminary measurements of the shielding effectiveness of radio-frequency protective suits, and in the development and evaluation of techniques and fixtures for the calibration of probes and sensors used to measure the strength of electromagnetic fields. It is presently being used for the evaluation of limits for allowable levels of electromagnetic interference emitted by electronic equipment, and for the development of meters for the detection and measurement of electromagnetic radiation.

The EMALC facility offers electromagnetic shielding effectiveness of 100,000 times (100 dB) up to a frequency of 10 GHz and provides useful electromagnetic absorption qualities at frequencies down to 30 MHz. It has built-in provision for the supply of filtered single phase or three phase mains power to equipment under test. All signal and control cabling is distributed from outside the chamber to interior access points via a plenum chamber under the shielded floor (i.e. the ground plane), so that experiments in the EMALC facility can be remotely controlled without the presence of a field-disturbing operator inside the chamber.

A New Surface Analytical Facility

Telecom Australia's network infrastructure and engineering operations are becoming increasingly dependent on the use of "high technology" products manufactured from advanced materials and components by sophisticated manufacturing processes. To ensure adequate operational reliability and to solve operational problems, the Laboratories provide Telecom with in-house expertise in various fields of materials science, coupled with specialised scientific facilities which enable this expertise to be effectively applied in the reliability assessment of the wide variety of materials, components, equipment and plant employed in the network infrastructure or engineering operations. One essential ingredient for the efficient employment of this expertise is the development and operation of advanced in-house materials analysis facilities. Facilities for surface analysis are particularly important in these activities.

Recently, the Laboratories commissioned an electron spectrometer incorporating high resolution scanning auger microanalysis (SAM) and X-ray photoelectron spectroscopy (XPS). Used in combination with ion etching, these techniques enable three dimensional elemental and chemical characterisation of the surface and near-surface regions of microsamples, integrated circuits, thin films and other strategic materials employed in telecommunications. Information acquired with this instrument is essential in solving a variety of materials problems, particularly those which relate to surface properties in relation to matters such as adhesion, catalysis, corrosion, electrical contact resistance, wear and lubrication, durability, oxidation, passivation, plating epitaxy, doping and crystal growth, thermocompression bonding, solar cell materials and optical fibres.

Scanning auger microanalysis is performed by causing a focussed electron beam to scan across a solid sample to provide spatially resolved surface elemental information of monolayer sensitivity (1-5 nanometre). The atoms in the sample are excited by the electron beam and the resulting secondary electrons which are emitted from the sample surface are energy analysed to determine auger peak line positions and intensities. SAM permits fast, high sensitivity analysis of surface constituents. It provides semi-quantitative data together with some chemical bonding information. Spatial resolution is excellent, since the primary excitation beam can be focussed to a spot of approximately 0.01 micrometre in diameter. All elements except hydrogen and helium can be detected and displayed as a three-dimensional representation of their location in the sample.
X-ray photoelectron spectroscopy is performed by bombarding a solid sample with soft X-rays to provide surface chemical information of monolayer sensitivity (1-5 nanometre). Photoelectrons emitted from the surface atoms due to X-ray excitation are energy analysed to generate well defined peaks in the photoelectron energy distribution. Surface elemental composition is readily determined from the energy positions and intensities of the peaks. Detailed chemical bonding information is obtained from narrow, high resolution energy scans of selected peaks, where subtle changes in peak shape and shifts in peak energy can be related to chemical state. XPS permits detection of all elements except hydrogen, giving excellent chemical information and quantitative elemental analysis with minimal sample damage.

The new Laboratories' facility is a sophisticated mix of electronics and ultra-high vacuum (UHV) equipment. UHV is essential for optimum performance in a surface analysis instrument since adsorption resulting from poor vacuum will contaminate clean, reactive surfaces in a short time. This is particularly undesirable with specimens fractured or ion-etched in situ during more fundamental material studies.

The acquisition of this new surface analytical facility is a major supplement to the existing facilities for intramural research in the materials science field. Whilst it represents a substantial investment, it is expected to provide commensurate returns in the form of improved precision and speed with which the Research Laboratories can perform materials investigations for Telecom, which in turn will result in improvements in the quality and reliability of materials used throughout the networks and engineering operations.

Dimensioning the Common Channel Signalling Network

Common channel signalling between stored program controlled (SPC) exchanges is achieved by separating the signalling path from the speech path, so that all signalling data is carried by dedicated, large capacity signalling links. These signalling links are connected to the exchange processors (i.e. control computers) via signalling transfer points (STPs) and thus form a specialised packet switching network. This network must be correctly dimensioned in order to ensure that it performs its vital functions efficiently, whilst meeting the service standards for signalling delays.

The Laboratories have been developing a suitable dimensioning method that takes both the performance and economic factors into consideration.

For reasons of security and reliability, each signalling terminal point (SP) must be connected to at least two STPs. Since signals take a finite time to be processed at each STP, if fewer STPs are encountered by a signal, a lesser delay will be experienced. In practice, this consideration rules out the hierarchical type of network for common channel signalling, and all STPs need to be directly interconnected. The network designer's problem is to allocate SPs to STPs in such a way that, for the expected traffic dispersion, the number of multi-link connections will be minimised.

A solution to this problem has been devised in the Laboratories and a computer program has been developed that helps the designer in two ways. Firstly, it performs the traffic calculations for all A-links, B-links, SP clusters and STPs; the designer can therefore quickly and accurately calculate the effects of any allocation of SPs. Secondly, the program can be instructed to make a fully automatic best allocation of SPs to STPs for a set of criteria specified by the designer.

The program is currently being used by the Network Engineering Department for planning and dimensioning of the common channel signalling network for the integrated digital telephone network.

An Experimental Voice Signal Detector

During the year, the Laboratories developed an experimental voice signal detector, to provide a low cost device which detects the presence and level of speech signals on a subscriber's line. The detector was developed to assist the Network Engineering Department to upgrade the service assessment facility in AXE exchanges.

Service assessments typically provide statistical data on the operation of the network, based on measurements of successful call connections and signal levels on subscriber's lines. The existing AXE assessment facility generates data based only on numbers of call connections and no account is taken of signal quality. The purpose of the voice detector was to extend the measurement facilities to include signal level conditions.

Speech detection is generally complicated because signals other than speech are present in the voice frequency band. Two types of such signals are service tones and high level white noise. The voice detector distinguishes between voice and non-voice generated signals by responding to specific characteristics of speech, irrespective of language and pitch. An average of the speech level is generated over a short period of time. The acceptability of the signal is conditional on the level occurring within a preset range. A call is classified as successful only when speech is detected at an acceptable level on a subscriber's line.

The underlying requirement was for an economical design, easily incorporated into existing equipment. The experimental detector has been successfully tested on live traffic in the network.

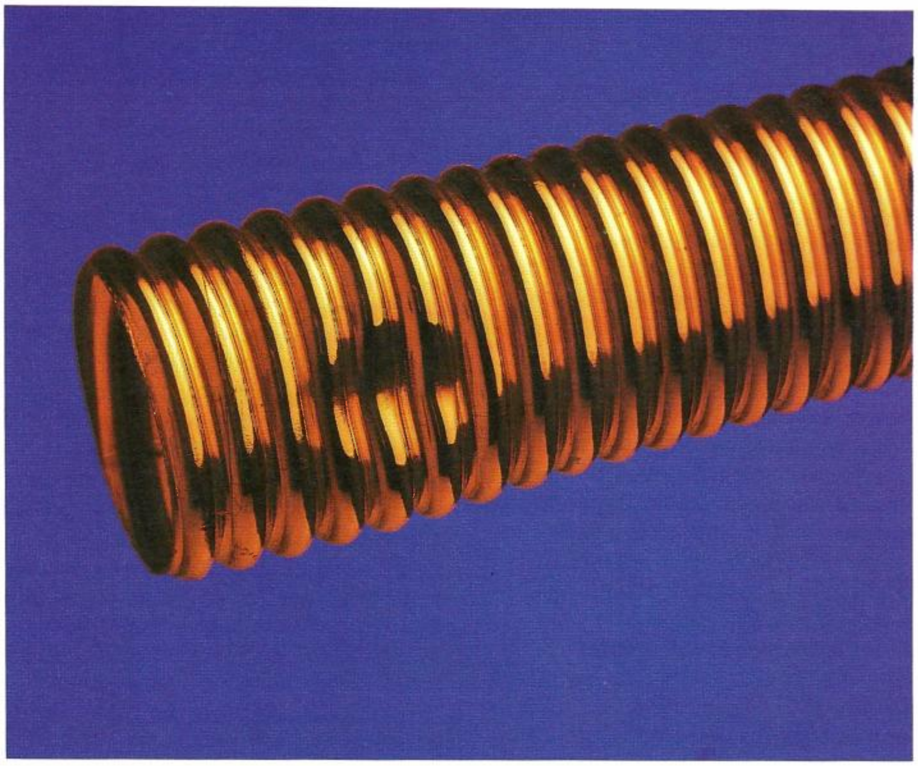
Hailstone Damage to Elliptical Waveguides

Telecom Australia is one of Australia's largest users of solar photovoltaic modules. Telecom uses these modules to power telecommunications equipment in the more remote parts of Australia, where the physical environment can sometimes be hostile to such equipment. Nevertheless, the remoteness of these equipment installations places special emphasis on obtaining excellent reliability in operational service. Since solar photovoltaic modules must be exposed to the sun in service, they particularly are also exposed to other sources of environmental stress. One such stress which they must withstand is hailstone impact.

Accordingly, in Laboratories' assessments of the reliability of solar photovoltaic modules used by Telecom Australia, one item of the suite of tests applied to modules is a "hail impact test". In this laboratory test, 25 mm diameter ice balls are projected to strike the solar module at a speed of 23 m/s (83 km/h), the ice ball's kinetic energy at impact being 2 joules.

It was with considerable interest that the Laboratories recently received samples of a hail-damaged elliptical waveguide from a repeater on the Mildura-Berri microwave route. The indentations in the waveguide were approximately 30 mm in diameter and 6 mm in depth.

It was noted that the waveguide had been damaged in its vertical run up the microwave antenna tower, a situation in which it would not be expected to be seriously damaged by hailstones falling vertically. It was therefore concluded that the damage was caused by a hailstorm associated with very strong winds, such that the horizontal component of the velocity of the hail was sufficient to cause the indentations in the waveguide.



Indentation in an elliptical waveguide caused by a hailstone

In laboratory attempts to simulate the damage with the Hail Impact Tester developed for photovoltaic module testing, negligible damage was caused to the surface of waveguide samples. Rather than modifying the existing ice ball gun to project larger ice balls, two additional hail simulation methods, namely steel balls dropped onto the waveguide from a controlled height, and steel balls indented into the waveguide using a compression test machine, were used and the results obtained from the three methods compared.

Tests performed with projected 25 mm diameter ice balls and falling 25 mm diameter steel balls showed that the ice balls needed to have about twice the energy of the steel balls to cause equivalent damage to the waveguide. This result, combined with the results of compression tests performed with 50 mm diameter steel balls, led to the conclusion that a hailstone of diameter 40-50 mm and with an energy of approximately 15 joules was responsible for the field damage.

Whether solar modules would also have been damaged during such a hailstorm will be investigated when modifications have been made to the hail test equipment, to enable it to project larger size ice balls.

Failure of Epoxy Resin Cable Hauling Eye

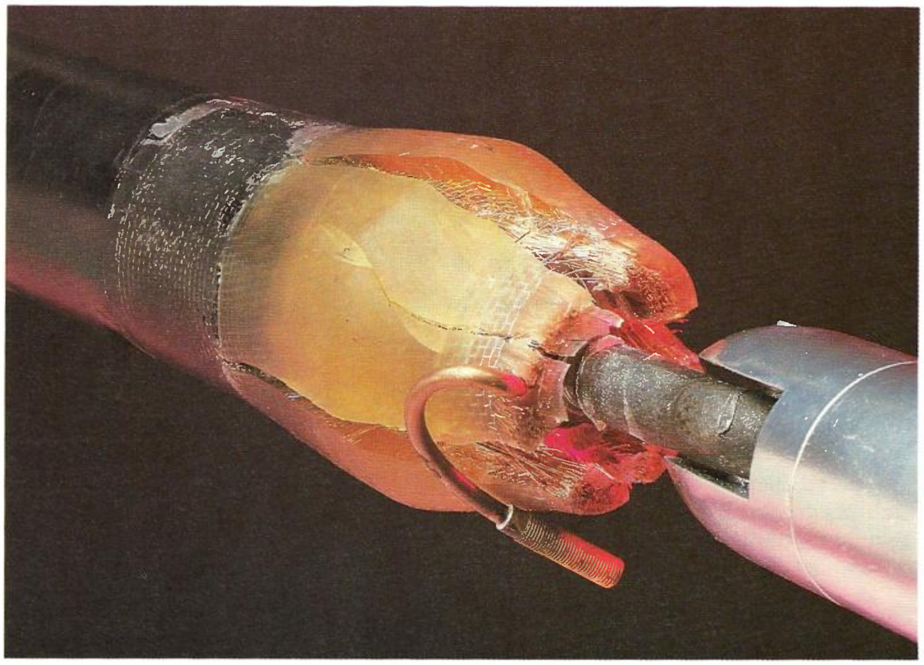
Epoxy resin cable hauling eyes were first designed by the Research Laboratories in 1959 and have been used successfully by Telecom Australia for the installation of cables of all sizes in ducts and tunnels since that time.

The strength of the hauling eye relies on the combination of a buttress-threaded steel eye-bolt moulded integrally with all parts of the cable end structure (i.e. conductors, insulation and sheath) by means of a cold-curing epoxy resin composition. Such constructions are capable of transmitting axial loads greater than 70% of the ultimate tensile strength of small size cables and of complying with the minimum axial load requirement of 77 kN for large size cable.

Failure of hauling eyes in service have been few, but one which failed during the installation of a cable in a tunnel in Sydney during 1985 was submitted to the Laboratories for examination, as its failure was considered to be due to unusual circumstances. Visual inspection showed that the method of construction was conventional, whilst tests on the epoxy resin compound and the steel eye-bolt indicated that they were both of satisfactory quality. However, multiple longitudinal score marks along the epoxy resin end and the attached cable sheath suggested that the hauling eye had been severely obstructed at a sharp bend during the cable hauling operation, placing excessive transverse tensile loads on the hauling eye.

Tests conducted in the laboratory to ascertain the effect of transverse loads were carried out by applying tensile loads to similar hauling eyes at an angle which simulated the severest bends encountered in ducts or tunnels. This necessitated the design and construction of specialised equipment for attachment to a tensile testing machine. The results obtained showed that transverse loads can reduce the tensile strength of epoxy resin hauling eyes in large size cables to about 30% of the axial strength.

Consequently, it has been recommended that practical measures be taken to ensure that circumstances are avoided in cable hauling procedures which could introduce excessive transverse hauling tensions.

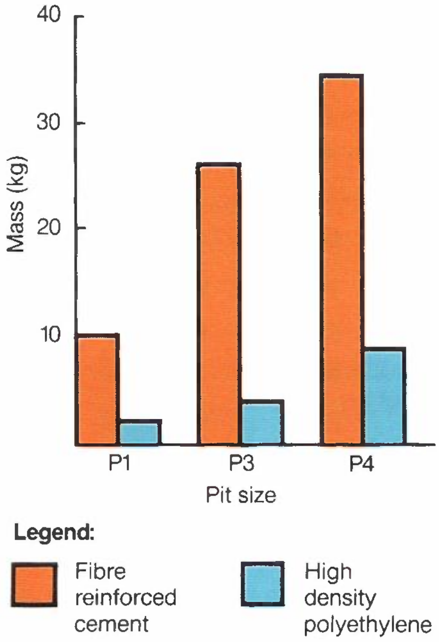


Effect of excess transverse load on an epoxy resin cable hauling eye

Polyethylene Cable Jointing Pits

For many years, the cable jointing pits used by Telecom to house and protect underground joints have been constructed from fibre-reinforced cement (FRC). Problems experienced with FRC pits, such as high breakage rates prior to installation, injuries to staff caused by handling difficulties and high transportation costs, have been attributed to the excessive weight of FRC. Consequently, the Laboratories have been involved in the choice and successful development of a polymer, as a lightweight alternative material from which pits can be constructed and successfully used in the field.

Weight comparisons for standard sized cable jointing pits made from polyethylene and fibre-reinforced cement



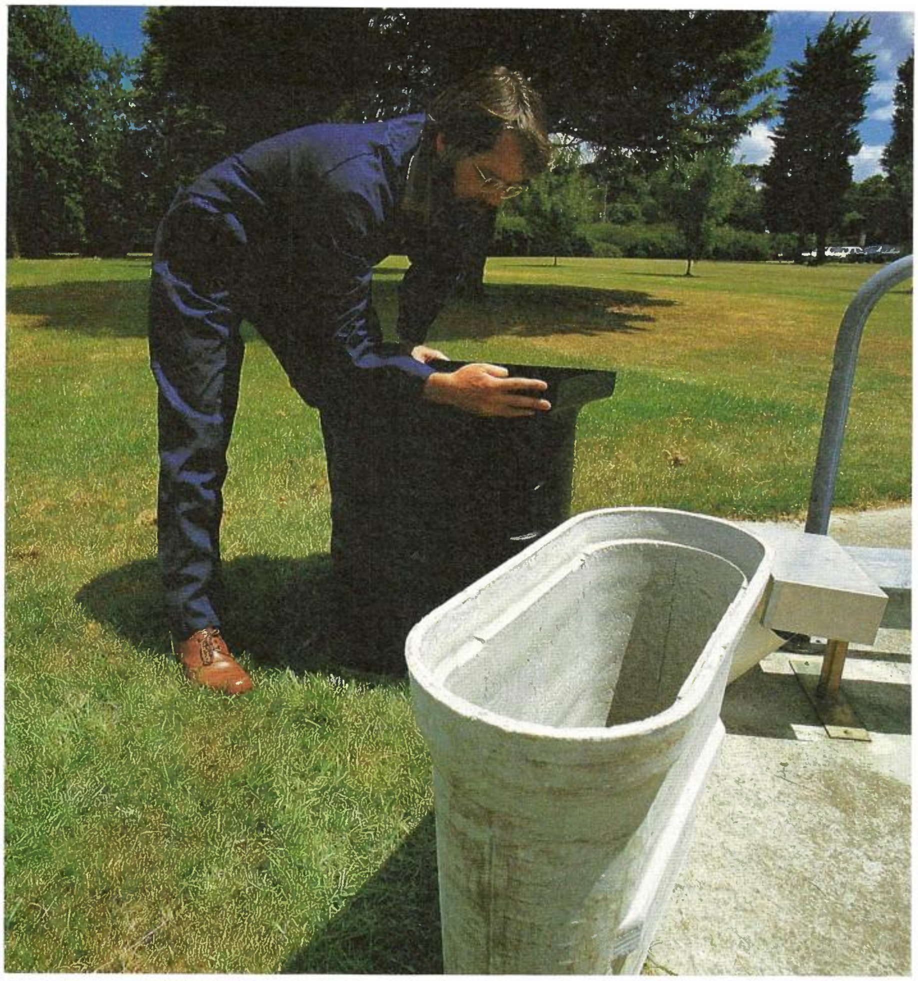
As with other equipment used in Telecom's external plant, jointing pits are required to have service lifetimes of at least 30 years and must also be capable of withstanding lengthy periods of outdoor exposure during storage prior to installation. Critical properties of polymeric materials for pit applications were therefore identified as follows:-

- high resistance to photo and thermal oxidation
- resistance to chemical attack from aqueous and non-aqueous liquids encountered in service environments
- high resistance to environmental stress cracking
- good dimensional stability and creep resistance
- good impact strength and light weight
- good moulding properties.

Several materials were evaluated in the laboratory but only high density polyethylene (HDPE) satisfied all selection criteria. Others, like glass-reinforced polyester, had excellent strength and dimensional stability but poor chemical resistance, little weight advantage, and being a thermoset, moulding properties unsuited to large production quantities. Pits produced from linear low density polyethylene by rotational moulding failed the environmental stress crack test and exhibited reduced strength due to inhomogeneity within the pit well. Soil loading and short term creep tests on polypropylene, a stiffer but lower density material than HDPE, showed that a thinner, lighter and cheaper pit could be produced from polypropylene than from HDPE. However, polypropylene was rejected on the basis of its poor resistance to photo and thermal oxidation and the inability to stabilise it adequately against degradation for the desired lifetime of the pit.

The full scale introduction of HDPE jointing pits is subject to a final evaluation of their practical suitability by field trial. Some 8000 pits in three standardised sizes are currently under evaluation throughout Telecom's network.

Should Telecom decide, after successful field trials, to use HDPE pits instead of FRC pits, savings of about $1million per annum could result. In addition, the significant weight reduction achieved by using HDPE pits should reduce the risk of injury to staff handling the pits and also reduce transportation costs.



Telecom staff find the black HDPE jointing pits easier to handle than the older white FRC pits

Polymeric Laminates as Oil Barriers for Filled Cable Sheaths

The decision to use only metal-free optical fibre cable in the Telecom network precludes the use of the conventional moisture barriered sheath with its adhering aluminium foil laminate. Since the cable will be filled with a grease-like, water repelling compound, a non-metallic barrier adjacent to the sheath is required, primarily to prevent absorbance of the oil component of the filling compound by the sheath. The same requirement exists for filled metal conductor cables installed in the urban areas, where there is no need for an expensive metal foil to double as an electrical shield.

The Laboratories have investigated a number of polymeric-type laminates from local and overseas suppliers to ascertain their oil permeation properties and laminate-to-sheath bond integrity in various environments. The results indicated that laminates with a central layer of polyamide (nylon 12), polyester (PETP) or polyvinylidene chloride (PVDC) showed the greatest resistance to oil permeation, whilst the laminates with the greatest ability to adhere to sheathing grade polyethylene after exposure in environments of air at 100°C, water at 80°C, mineral oil at 60°C and petrol at 23°C were those with polyolefin (or modified polyolefin) outer layers.

Consequently, cables with polyester or nylon oil-barriered sheaths are currently being trialled in the field to assess the performance of the laminates under actual service conditions.

Programmable Array Logic Design Techniques and Tools

A characteristic feature of microelectronics technology has been the very rapid growth in the scale and complexity of integrated circuit (IC) devices and their ability to perform more and more functions within a single integrated circuit chip. The rise in functional density has been accompanied by a decreasing cost per function. There are now a number of alternative paths that designers can take to realise a "customised circuit" These range from a fully customised IC chip to a system designed from standard components such as microprocessors and supporting IC devices.

One alternative which facilitates customised circuit design from standard off-the-shelf components is the Programmable Array Logic (PAL) family of devices. PAL devices are mass-produced, general purpose devices which can be programmed by the user to suit his particular application.

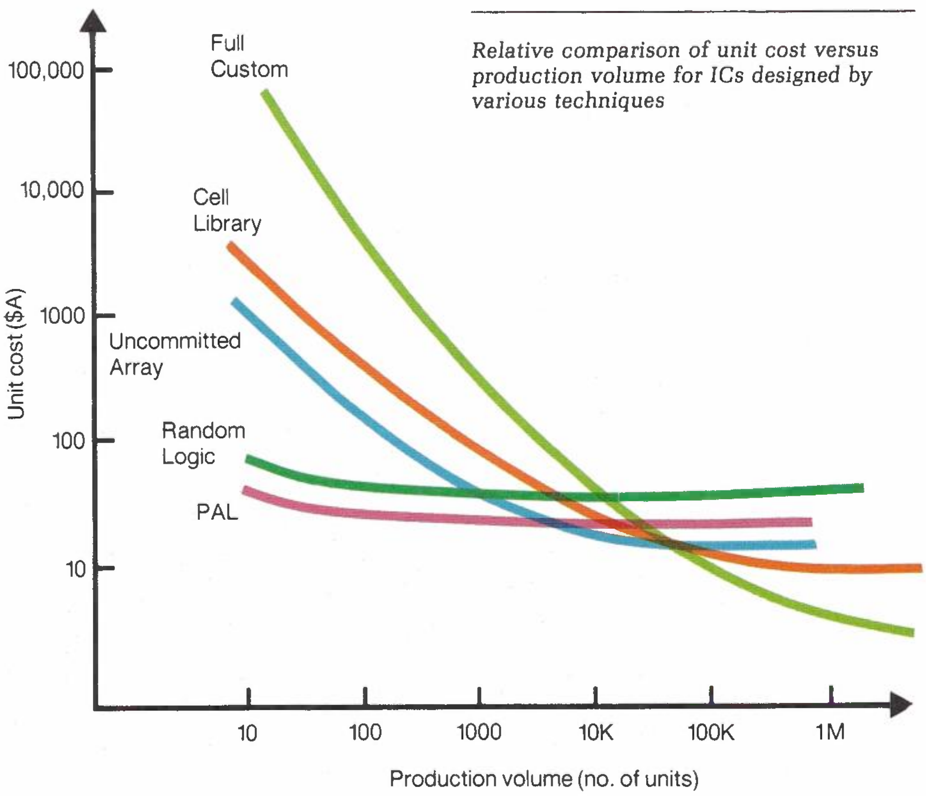
The relative cost of a PAL realisation of a logic circuit, for a given complexity, is less than other alternatives for production volumes of less than two or three thousand units. Such volumes are sufficient for the production of experimental prototypes of equipment for laboratory investigations, specialised instrumentation systems and the like. Hence, the Laboratories have been investigating PAL design techniques and tools.

The internal structure of a PAL device is such that it allows the realisation of logic functions by "blowing" selected internal fuses. The PAL design process involves translating the required logical function into Boolean expressions. A computer program can then be used to generate appropriate fuse patterns for a specific PAL device to realise the required function. The fuse pattern can then be automatically entered into a PAL programming facility which is available as an option on most popular PROM programmers.

The Research Laboratories have developed several PAL design tools and gained expertise in their use. This knowledge has been disseminated to other design groups within Telecom through design workshops conducted in various Australian States, as well as by providing consultant services to Telecom staff with a specific design task. The employment of this technique can be expected to increase the productivity of design efforts and reduce costs associated with some logic circuit design tasks within Telecom. To provide a further aid for logic circuit design using PAL, the Laboratories are developing an "Expert System" which will incorporate design methods and techniques associated with PAL applications. This is expected to further improve designer effectiveness.

An Electronic Meter Reader

A prototype circuit to perform a number of metering functions within a telephone exchange was recently designed and tested by the New South Wales State Administration of Telecom Australia. The prototype circuit used commercially available integrated circuits mounted on a printed circuit board with other components and proved that the circuit met all design requirements. However, it was too large to fit into the rack space available in the telephone exchange. Therefore, in collaboration with the NSW Administration, the Laboratories packaged the design into a smaller printed board by means of gate array technology. The reduction in board size was achieved by incorporating twelve integrated circuits of the NSW prototype into one silicon chip contained in a 40-pin dual-in-line package. This reduced the number of interconnections on the printed circuit board and thereby the number of soldered joints required, thus improving reliability.



Relative comparison of unit cost versus production volume for ICs designed by various techniques

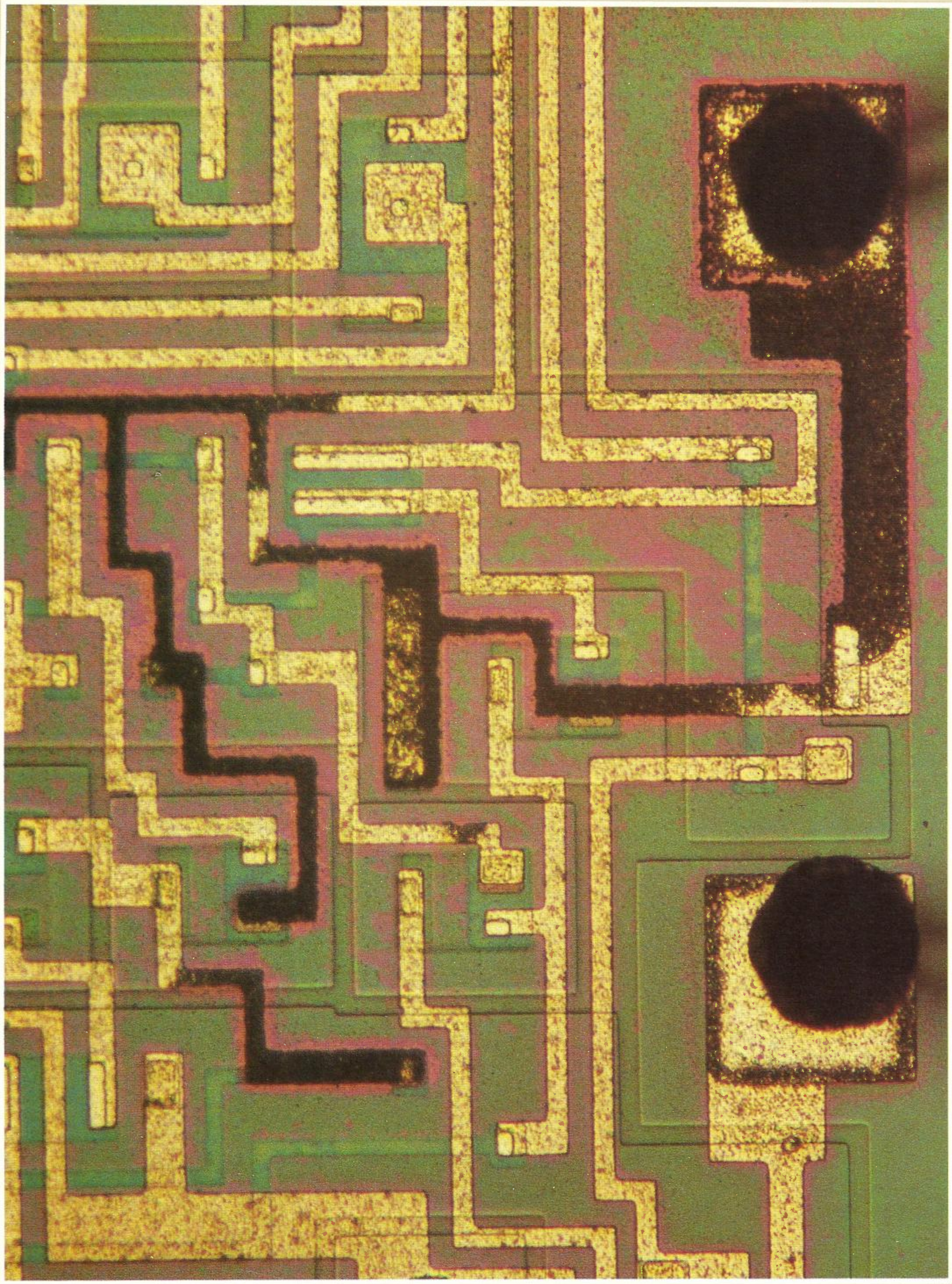
The conversion of the initial multiple IC realisation to a single gate array circuit was achieved in three stages. First, the schematic circuit was converted into an equivalent circuit using the gate array manufacturer's standard cells for standard logic functions. Next, the design was optimised in terms of minimising the number of gates and maximising performance and ease of access for test purposes. Finally, a test program was formulated to test the gate array fully, to ensure that it met its functional requirements after manufacture and packaging.

Phosphorus Glass in Integrated Circuit Encapsulation

Although plastic encapsulated semiconductor devices have been available for over two decades, it is only relatively recently that economic pressures, coupled with significant improvements in quality and reliability, have led to the acceptance and increasingly widespread use of these devices in telecommunications applications.Unfortunately, not all devices enjoy equally high reliability, as was recently demonstrated to Telecom by the failure of a significant quantity of plastic encapsulated devices of a certain type after only about three years in service in its network.These devices were sent to the Laboratories for failure analysis.

In the Laboratories, the plastic encapsulant was removed from the devices with a chemical etch which does not affect the operation of devices.The decapsulated devices were then subjected to examination in a scanning electron microscope (SEM).It was evident with this technique that portions of the aluminium metallisation on the devices had suffered a severe electrolytic corrosive attack.

It has been reported in the literature that moisture induced failures of this type will occur if the semiconductor passivation layer is cracked, contains pinholes or has a high phosphorus content.Phosphorus is added to the glass layer to reduce cracking and improve its adhesion.The optimum level of phosphorus has been experimentally determined as approximately 2% by weight.Less than this results in a decreased time to failure due to cracking and subsequent localised corrosion.More than 2% also results in a decreased



Optical micrograph of an integrated circuit element showing extensive damage to aluminium tracks caused by moisture induced corrosion time to failure due to the active role which the excess phosphorus takes in the electrolytic corrosion mechanism.

By using Energy Dispersive X-ray (EDX) analysis in conjunction with pure elemental standards and an appropriate computer program, the phosphorus content in the passivation layer of the failed devices was determined quantitatively as being approximately 6% by weight.Published data shows that phosphorus concentrations of this level are consistent with the reduced lifetimes observed in the failed devices, especially for those operating in warm, humid environments.It was thus recommended that all similar devices in the field which had not yet failed be replaced with a suitably manufactured direct replacement device.

As a result of this work, the Laboratories are now able to use the EDX analytical technique and the SEM routinely to determine quantitatively the phosphorus content in plastic encapsulated semiconductor components being evaluated for Telecom's use and thus predict the likelihood of the occurrence of reliability problems which might arise in service due to moisture induced corrosion.

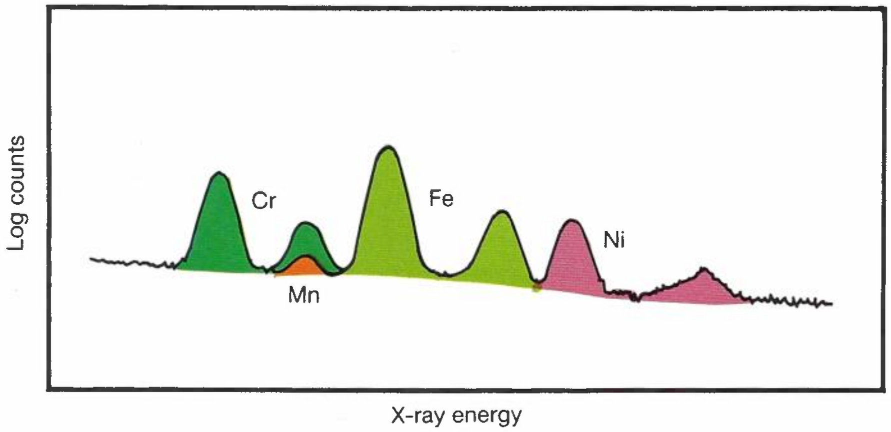
Silver Plated Edge Connectors

In the past, silver was favored as a contact material because of its high electrical conductivity. However, over the last decade, it has become less acceptable than other contact materials because it tarnishes readily and migrates between contacts across the surfaces of incorrectly chosen insulating materials. Occasionally, serious operational problems occur because of these phenomena, one such recent case involving ICEP connectors.

Failure analysis studies showed that the brass contact pins of the connectors were plated with a one micrometre thickness of gold, which in turn was covered by a two micrometre thickness of silver, finished with a very thin coating of gold. The phospor bronze female spring contact was also silver plated under a 0.1 micrometre thickness of gold.

Insertion and withdrawal of the board assembly had damaged the thin, soft gold top layers. The consequently exposed silver was able to migrate between adjacent terminals on the surface of the nylon insulating material. Energy Dispersive X-ray analysis performed with a scanning electron microscope showed the affected insulation area to contain silver, chlorine and sulphur impurities, suggesting that chloride activated flux residue accelerated the process of silver migration.

The investigation showed that the connector design was unsatisfactory, concluding that a construction with a minimum thickness of one micrometre of gold over a nickel underlay would be a more reliable and preferred finish for the base metals of the connector.



Energy Dispersive X-ray spectrum of stainless steel containing 17% chrome (Cr), 2% manganese (Mn), 11% nickel (Ni) and 68% iron (Fe)

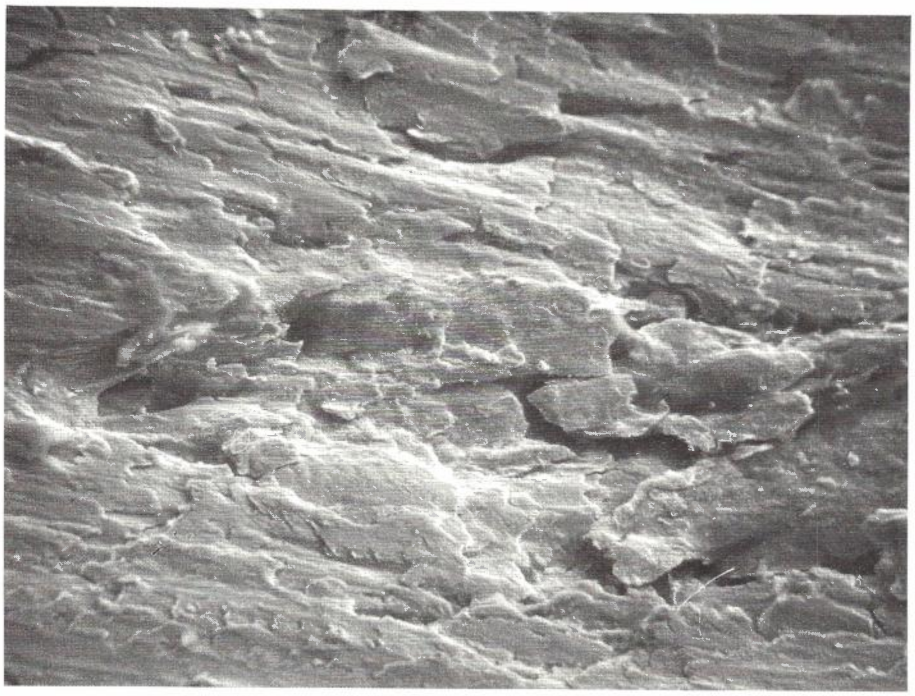
Classification of Stainless Steels

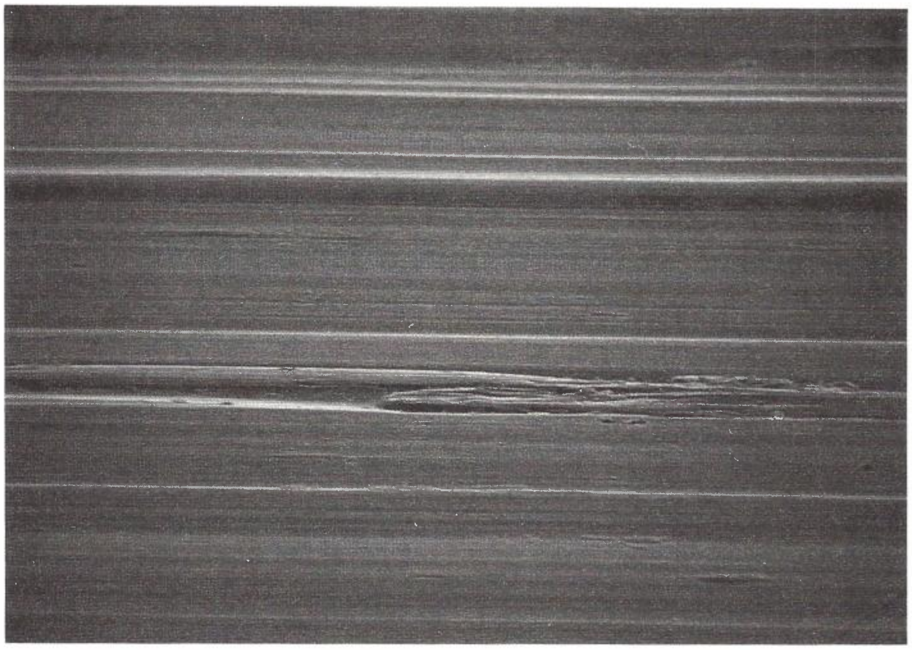
Providing a national telecommunications network involves the use of a wide variety of materials, ranging from semiconductor materials to more fundamental materials such as iron and steel. Many steel alloys have been developed over the years, but the discovery of stainless steel in 1913 paved the way for the development of the modern grades of stainless steel that are now available.

The mechanical properties and degree of corrosion resistance of any particular grade of stainless steel are primarily a function of the specific chemical composition of that steel. For example, the addition of a small percentage of molybdenum has been shown to greatly improve the corrosion resistance of stainless steel in marine environments. Hence, it is not unexpected that many different grades of stainless steel are used throughout Telecom Australia to meet the material requirements of many components, both large and small, above and below ground and under a diverse range of environmental conditions.

Unfortunately, failures sometimes happen and this is usually in the form of corrosion of the stainless steel, especially if the grade used is not suited to the particular environment concerned or unexpected environmental conditions occur. With problems of this nature, it is essential to establish whether the correct material has been used before further investigation takes place. In the past, this was time consuming using traditional chemical analysis methods and sometimes impossible when only very small components were concerned.

For several years, the Laboratories have used an Energy Dispersive X-Ray (EDX) analyser on a Scanning Electron Microscope (SEM) to assist with the identification of corrosion products on components and to try to establish the particular grade of steel used. During the past year, this analysis technique has been significantly improved by using a computer program in conjunction with pure elemental standards. It is now possible to obtain an analysis of sufficient quantitative accuracy to identify an unknown grade of stainless steel in less than one hour. The other great advantage of the EDX quantitative technique is that the material in very small items such as springs, fasteners and numerous other intricate components can now be identified.





Scanning electron micrographs showing the beneficial effect of prior laser glazing on surfaces generated during the sliding wear of cast iron (magnification X2000)

Top: Roughened nature of wear surfaces formed in the absence of laser glazing

Bottom: Smooth wear profile formed on laser-glazed surface

A recent example of the use of the technique involved a small stainless steel diaphragm in a prototype gas pressure switch being developed for Telecom. The diaphragm showed early signs of corrosion during testing and it was readily established by the application of the quantitative EDX method that the grade of stainless steel used was not suitable for the variety of operating conditions expected in service.

Surface Modification of Metals by Laser Glazing

In recent years, there has been a rapidly developing interest in the application of high powered lasers to the heat treatment of metals.The basis of such treatments is the use of the focussed laser beam as a means of transformation, melting or alloying a thin surface layer, the bulk of the underlying substrate producing a strong, self-quenching effect.The hard surface zone which results can be altered over a wide range of microstructures and composition by the laser beam with a precision unattainable by conventional techniques of heat treatment.

Investigations using the Coherent Everlase 525 Carbon Dioxide Laser located at the Laboratories have centred on the application of the technique known as laser surface melting or laser glazing.An incident beam continuously melts a small zone within the substrate, the scanning movement of the specimen in relation to the beam creating an areal coverage.The depth of the melt zone is determined by the processing parameters of beam power density, scanning velocity of the beam and thermal conductivity of the substrate. The depths obtained range typically from 50 to 500 micrometres.

The technique is particularly useful in the processing of ferrous alloys such as steels and cast iron, for which the structural changes induced by the laser produce an intense surface hardening.Work undertaken at the Laboratories has examined the response of various Fe-C alloys to laser glazing, with emphasis on the consequent effect on surface-dependent properties such as friction and wear.Under optimum conditions of processing, surfaces of Fe-3%C modified by laser glazing exhibited a finely divided structure of Cementite and Martensite phases of hardness 800HV.Such surfaces show an extreme resistance to wear, with a reduction in wear rate of between one and two orders of magnitude.Such behaviour is shown to result from a change in the operative mechanism of wear.

Laser processing is likely to become an integral part of the manufacture of many metal components, particularly load bearing, moving sections of the automotive fleet in which Telecom has a major investment. Increases in lifetime which accompany laser treatment may also promote application in components which undergo heavy abrasion, such as in digging equipment.

Laser Glazing of Plasma Sprayed Coatings

The Laboratories, in collaboration with the Materials Engineering Department of Monash University, have used the Laboratories' 600 Watt carbon dioxide laser to investigate laser glazing of plasma sprayed coatings on ferrous materials.

The plasma spraying technique is extensively used for coating deposition because of its ability to deposit a very wide range of materials (from polymers and metals to ceramics and carbides) onto various substrates. Plasma-sprayed ceramic coatings on metallic substrates are used to improve performance of machine parts operating under extremely severe conditions.

The plasma sprayed coating is formed by building up successive layers of material. Melted particles are flattened on impact on to the substrate surface and solidify to form a thin layered structure. The area of contact between individual thin layers is irregular. In some locations where the contact is poor, gaps ranging in size from 0.01 to 0.1 micrometre exist. The resultant presence of pores and intercrystalline micro-cracks is a major factor which determines the possible application of coatings. Pores which extend from the outer surface of the coating to the base onto which it is sprayed can permit the entry of corrodents, giving rise to rapid deterioration of the coating system.

Laser glazing of the coated surface was investigated as a new technique which might overcome some of the problems arising in the application of coatings by the plasma spraying technique.

The application of lasers in materials processing is relatively new. The laser has a unique ability to produce very high energy densities of the order of $10^{12} W/mm^2$ and more. This energy can be precisely controlled and scanned across a material surface to effect surface treatment. By varying the heat input and the time of contact of the laser beam with the material surface, it is possible to heat-treat, melt or even evaporate the material.

For laser glazing, very high energy densities are used in a very short time interval to melt and subsequently re-solidify the surface. The resultant microstructure is very fine-grained and, in some cases, non-crystalline.

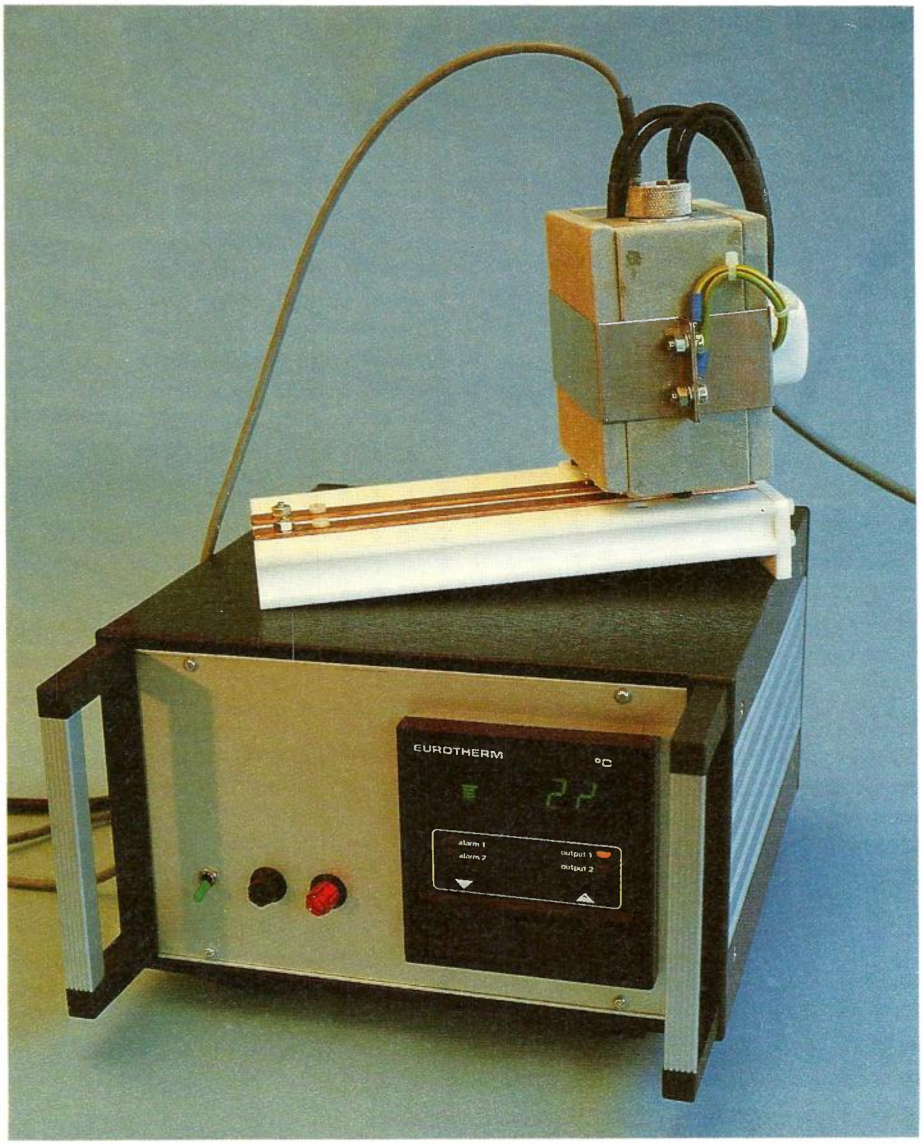
In the Laboratories/University investigations, a continuous wave carbon dioxide laser, operated at 600 Watts, was used to glaze the surface of the coatings. The specimen was mounted on a high speed turntable at a radial distance of 160 mm. At the same time, the laser beam was moved laterally across the specimen, covering the whole surface. The pass overlap was 66 percent of the beam diameter.

After glazing, the surface of the coatings was very smooth and glassy in appearance. Microscopic examination showed that bands resulting from the laser passes were present. The average size of the observed bands was equal to approximately one third of the laser beam diameter.

This preliminary study has shown that laser glazing could be applied to plasma sprayed ceramic coatings with beneficial results. In general, the process was found capable of producing smooth, pore-free surfaces and modified microstructures. The processes involved are being studied further.

A Heating Block for Precise Measurement of Dielectric Constant

The Laboratories are called upon to investigate the properties of many materials which find application in telecommunications equipment and plant. The thrust of such investigations is generally to maximise the operational reliability and lifetimes of such equipment and plant under service conditions. Necessarily, the investigations require precise measurement of key parameters which can cause material



Liquid capacitance cell in heating block, with inner cylinder of the cell removed or performance degradation in service.

One such material is the oil used in cable filling compounds, and a key parameter in assessing such oils is their dielectric constant. During the year, a specialised heating block has been designed and developed to increase the precision and repeatability of measurement of the dielectric constant of these oils.

To achieve the necessary precision, the dielectric constant must be determined at an accurately known and repeatable temperature. To achieve this objective, a liquid capacitance cell is used. The cell is embedded in a heated block which maintains a small sample of the oil under test at a constant temperature, usually 100°C. The sample dielectric oil is made to assume the shape of a thin shell between concentric metallic cylinders, with the inner cylinder insulated from the outer one. In conjunction with the main components of the heating block, the whole forms a temperature controlled capacitor, in which the oil is the dielectric. The determination of the dielectric constant is made by comparing the capacitance of the block containing the sample oil to the capacitance of the same block when filled with an oil of precisely known properties.

In the design phase, a desktop computer was employed to develop a numerical model of the heating block. This approach allowed rapid analysis and optimisation of important parameters such as heat-up time, heat soaking time and temperature stability. The numerical model employed non-steady state heat conduction analysis and finite-difference methods and included allowance for the effects of feedback control.

A liquid capacitance cell was fabricated to the specifications determined by the numerical model. Extensive trials proved that the cell exceeded its thermal specifications - a clear validation of the design approach used for the project.

An Electrical Transient Recorder

High voltage transients occurring on telecommunications distribution lines are potentially hazardous to customers, staff and equipment. The magnitude, distribution and frequency of occurrence of these transients depend on the external plant practices employed by Telecom and electrical power authorities, soil resistivity and lightning activity patterns. These factors vary significantly with locality in Australia, and transient data obtained in particular localities can assist in the design and selection of appropriate measures for installation in those localities. However, localised data cannot provide solutions which can be applied throughout Australia.

As existing instrumentation for the automatic measurement and recording of electrical waveforms is complex and too expensive to purchase in sufficient quantities to allow concurrent surveys of significant numbers of Telecom lines in several localities, the Laboratories have developed a prototype, low cost, fully automated instrument for measuring the magnitude, duration and time of occurrence of voltage or current transients appearing between conductors, or with respect to ground. The instruments will be used to conduct surveys of electrical transients on lines throughout Australia.

Previous studies showed that such an instrument should be designed to cope with the following range of inputs:

- short unipolar or oscillatory transients, with risetimes down to one microsecond, durations up to several milliseconds, and amplitudes up to 2500 volts or 250 amps (with protection against higher amplitudes)
- multiple transients separated only by milliseconds, caused by multiple stroke lightning flashes
- bursts of mains frequency
- normal Telecom line signal conditions, such as ringing voltage and exchange battery voltage.

The prototype instrument developed by the Laboratories is a modular, microprocessor-based instrument that employs analogue signal processing techniques together with software programs to analyse input waveforms. Measurements are securely stored in non-volatile memory within the instrument for later retrieval and analysis by a central computer.

Following successful laboratory tests of the lightweight, portable prototype, commercial development and manufacture of a sufficient number of units is now being arranged to allow field surveys of electrical transients to be commenced.

High Voltage Protection Modules for Telephone Apparatus

Transients with high levels of electrical energy can be induced or coupled into telecommunications lines from natural and man made sources - for example, lightning strikes and fault currents in power lines.The electrical energy present in these transients can be of sufficient magnitude to damage telephone and other equipment connected to the lines.

In areas of high risk some form of protection is usually fitted to the telephone line.The first level of protection generally comprises a three-electrode gas-filled protector which conducts current when its discharge voltage is exceeded and thus can be used to divert a significant part of the potentially hazardous energy to ground.

For more sensitive equipment, additional protection elements may be required.In such cases, a protection module which contains two or three stages of protection is employed.These modules contain various combinations of gas-filled protectors, metal oxide varistors, resistors and special zener diodes.Each of the stages in the module has a lower operating voltage, a lower power rating and a faster operating time than the preceding stage.The module is connected between the external cable and the equipment, and grounded via an earth wire.When the voltage on the line exceeds the firing voltage of the various protective elements, the potentially harmful energy is progressively conducted to ground.

The Research Laboratories are evaluating such modules to determine their effectiveness in protecting customer equipment and the manner in which they fail if they are over-stressed.The modules are tested by applying simulated lightning surges and AC power currents.It has been found that the modules provide adequate protection to equipment from all but close lightning strikes. However, the modules themselves can be damaged by surges with amplitudes and durations likely to occur in practice, and thus the ability of some modules to provide long term protection is doubtful.

As a result of the Laboratories' recommendations, one module has been modified to improve its resistance to damage from lightning strikes and further testing and design modifications are being carried out to improve its resistance to AC power surges.However, although this module now provides improved protection over that provided by a three-electrode gas-filled protector, its high cost and the fact that it can be damaged by AC power surges restricts its usefulness.

A Transportable Impulse Generator

To provide the best advice on the electrical protection of Telecom's customers, equipment and cables, the Research Laboratories must be able to produce simulated lightning surges at selected locations in the field. In this way, measurements can be made of the effects of lightning under controlled conditions. A portable impulse generator suitable for this task must be able to generate surges up to 50 kilovolts in both polarities and with various lightning-type waveshapes. For on-site measurements, the impulse generator should also be easily transportable and operate from a portable power source.

As such equipment was not available commercially, a generator meeting the abovementioned specifications was developed and constructed within the Laboratories. Various special components had to be developed. These included a motor driven sparkgap and an air-operated shorting relay to switch 50 kilovolts at 10 kiloamps. The relay also provides an additional feature, in that switching off the power causes the shorting relay to close and safely dissipate energy stored in the generator. For measurement purposes, a high voltage divider, transforming 50 kilovolts to 5 volts, was designed to match the input level of existing high voltage control circuits.

The generator will be used initially to test the protection circuitry of Telecom's new electronic AXE exchanges under "real" operating conditions. Subsequently, it will be used to measure the potential differences which occur between a telephone and metallic objects in a building when lightning strikes a telecommunications cable, the power grid or the building. These tests will enable existing protection practices to be more precisely evaluated and new techniques to be developed, to provide a safer and more reliable telecommunications service.

Optical Fibre Cable Markers

Conventional cable locators detect buried cables by the electrical detection of metals or currents flowing in metallic conductors. Such cable locators cannot be used successfully to detect the location of optical fibre cables which have no metallic elements or which, of their nature, have no electrical signals flowing in them. However, as optical fibre cables are increasingly being used in Telecom's networks, a need for a means of locating them is foreseeable, particularly for use along trunk routes in rural and remote parts of Australia where cables are directly ploughed into the ground.

Various schemes for locating optical fibres have been proposed, and the Laboratories have recently assessed some of them from the point of view of their reliability in likely service environments.

One scheme proposes that the route of the cable should be marked at intervals by unpowered radio transponders buried just above the cable, so that the transponders can be traced using hand-held detectors.

The locators are required, like the cable, to have forty year service lifetimes and thus must withstand the effects of soils that might range from being strongly acidic or alkaline to being saturated with oil or salt. In addition, they must withstand substantial compressive and shear forces during the compaction of soil over the cable, and they must also resist ant and termite attacks.

Recent Laboratories' tests have shown that commercially available transponders have sheaths of inadequate design and material.Redesign of the sheath and changing the material to nylon 12 material were advised, to safeguard against ant and termite attack and the other stresses identified above.

Another type of cable marker assessed by the Laboratories took the form of a 100 mm wide white plastic tape, to be laid with the cable and intended to alert people digging near the cable of its presence, or to assist Telecom staff to locate it. The proposed installation procedure for the tape is that it should be buried about 500 mm above the cable and run the full length of the cable. The tape bears the repeated message 'TELECOM AUSTRALIA OPTICAL FIBRE CABLE BELOW' in large black letters.The tape is formulated so that, when snagged by digging implements, it will stretch readily rather than break. Chemical and mechanical tests showed that the marker tape material was laminated linear low density polyethylene, which is highly extensible and chemically inert, and it should therefore resist all known environmental stresses present along proposed Australian optical fibre cable routes, except attack by termites and ants.

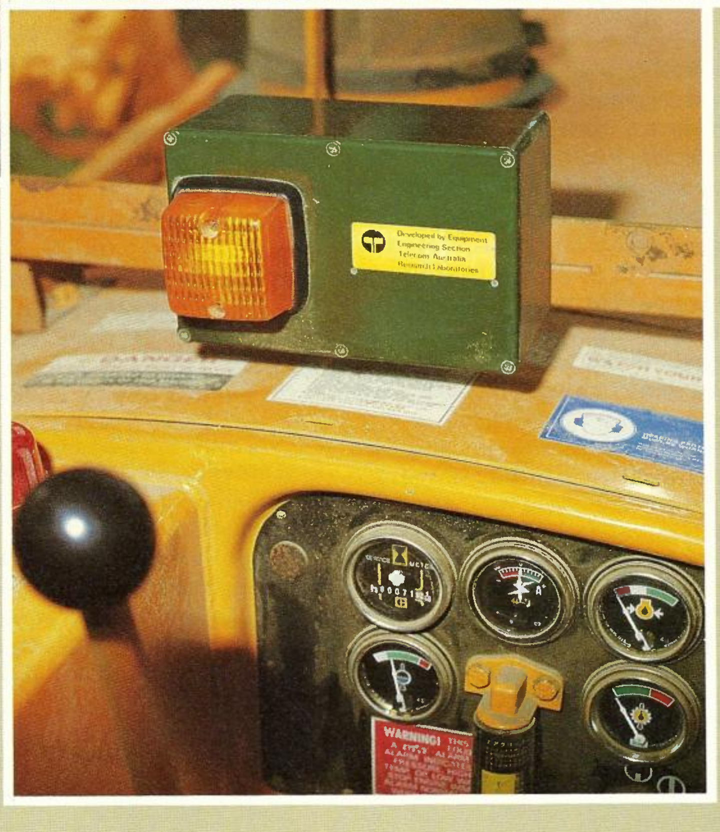
A Tractor Tilt Alarm

In cable laying activities, Telecom's cable ploughs and related mechanical aids must sometimes be operated in dangerous, rugged terrain. Although no serious accidents have yet occurred to Telecom's officers operating such equipment, Telecom has been seeking to decrease the risk of tractor rollover by installing a device on the tractor which will indicate to the operator that the tilt of the tractor is approaching a potentially hazardous angle.

Although a number of such devices are available, none fully meet the specifications considered desirable, namely that the device should:

- be rugged and weatherproof
- be simple to install and maintain
- give repeatably consistent indications of angles near the warning limits within $\pm$ 0.5°
- de-activate itself when corrective action is taken
- give visual and/or audible warnings
- be fail-safe
- be vandal-proof
- self-test when the tractor ignition switch is operated.

Telecom was aware that the Victorian Government Department of Conservation, Forests and Lands (CFL) was interested in obtaining a similar safety device for its machines. The Department advised Telecom of a sensing device which had been



A Telecom bulldozer working in rough terrain

(Inset) Tilt alarm mounted above dash in front of operator

developed out of its investigations. This device met a number, but not all, of Telecom's specifications. In particular, it suffered from false triggering of the alarm when the machine vibrations reached certain levels of amplitude.

At the request of the Network Engineering Department, the Laboratories have further developed the concept of the CFL device and have produced prototype units for field tests. The Laboratories' prototypes have improved reliability and give visual and audible warnings to the machine operator as a preset limit angle of tilt is approached. The prototypes have mechanical design features which ensure future manufacture at reasonable cost.

The tilt detection mechanism of the Laboratories' prototype comprises a disc pendulum in which a window is cut by laser machining to establish a preset "safe limit" tilt angle for a particular model of tractor or similar machine. An optical source and opto-electronic switch are coupled through the pendulum such that the switch is activated when the pendulum window is aligned with the optical path, indicating that the safe limit has been reached. Both audible and visual warnings are given by the device, which is mounted in front of the machine operator. The warnings are such that the operator will receive one or both, even when the operator is wearing ear muffs, the machine is operating noisily or the operator is not looking directly at the device.

Power for the device is drawn from the machine's battery through its ignition circuit. The device self-tests when the ignition switch is activated.

Several modes of operation of the device are being trialled in the field, namely with:-

- both visual and audible warnings set at the same angle
- an initial visual warning, followed by an audible warning five degrees later
- an initial audible warning, followed by a visual warning five degrees later
- a stepped increase in the volume of the audible warning to reduce acoustic shock, and a visual warning.

Prototype units are currently undergoing trails with Telecom cable ploughing teams in East Gippsland and Central/Western Victoria, and in the re-afforestation activities of the Department of Conservation, Forests and Lands, also in the Gippsland area.

The device was demonstrated at the Laboratories' Open Days in July 1985, and again in Telecom Australia's display booth at the Royal Melbourne Show in September 1985. The device attracted both general and rural interest, and many suggestions were received regarding more extensive applications of the device, on machines such as elevated work baskets and articulated vehicles.

Controlled flow (left) and conventional fire sprinkler heads

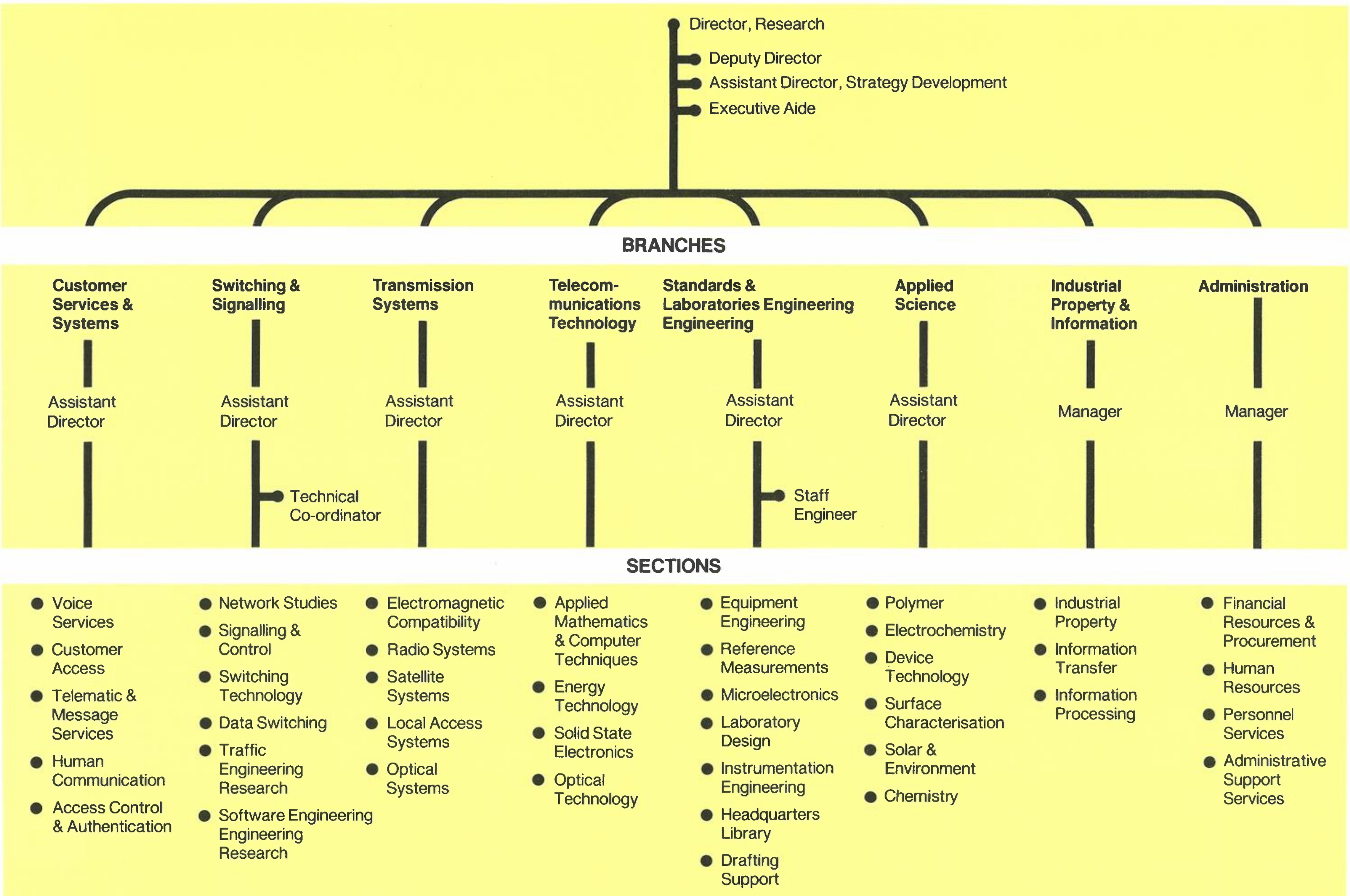
Controlling the Flow of Fire Sprinkler Heads in Telecommunications Equipment Rooms

Once triggered by a fire, the conventional fire sprinkler heads fitted to the ceilings of many buildings, including telephone exchanges, continue spraying water after the fire has been extinguished. This often causes unnecessary water damage and has prompted the commercial development of a sprinkler head that suppresses the water flow when the room temperature is below a preset threshold. Such a controlled flow system applies the water when and where it is most needed, and in the aftermath of a fire, it monitors the embers and automatically resumes spraying if a fire restarts.

Because water damage can often be more significant than damage due to localised fires in telecommunications equipment buildings, the Laboratories have recently evaluated the new controlled flow fire sprinkler heads.

It was found that, with the new heads as with conventional sprinkler heads, water flow cannot begin until the melting point (63°C) of a eutectic alloy blocking seal has been reached. With the controlled flow sprinkler head, flow is, in addition, controlled by a bimetallic strip valve on the side of the head. At 74°C, the bimetallic valve snaps open and the spray flow commences. Spraying then continues until the bimetallic valve snaps shut at 35°C. If the fire starts again, the valve sequence is repeated. It is intended that, as with conventional heads, these controlled flow heads should be replaced after an emergency is over.

The new heads are being compared with the conventional type in the laboratory, being subjected to pronounced temperature cycling whilst being monitored for leakage, a water hammer test and tests for consistency in manufacture, accuracy of temperature settings and reliability of operation. Whilst the tests have not yet been concluded, no deficiencies in the new fire sprinkler heads have been detected to date.



The Research Laboratories' Organisation

The Laboratories - Summary Information

RESEARCH EXCELLENCE
FOR
TELECOM'S SUCCESS

MISSION STATEMENT

To provide Telecom with technological and scientific leadership, knowledge and expertise so that it can be the best provider of telecommunications and information services.

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 constitute a Department of the Headquarters Administration of Telecom Australia. 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 the Director's Office, an Administrative Services Group, and thirty six scientific and engineering Sections arranged in seven Branches. The scientific and engineering Sections each possess expertise in particular areas of telecommunications engineering or science.

Professional and Senior Staff

Director: H.S. Wragge, BEE(Hons), MEngSc(Hons), MIEAust

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

Assistant Director, Strategy Development:
F.J.W. Symons, BE(Hons), PhD, DIC, MIEAust, AIEE

Executive Aide: B.F. Donovan

ADMINISTRATIVE SERVICES GROUP

Functions

* The Administrative Services Group provides administrative and clerical support to the Laboratories. This includes information and assistance on various matters relating to:
  - budgets, finance and procurement of supplies and services
  - manpower, organisation and establishment
  - staff and general personnel services, e.g. assessment of entitlements
  - administrative support services, e.g. registry, typing.

Manager, Administration: B.M. Douglas

Senior Planning Officer: T.W. Dillon

Project Officer: P.S. Dawson

Manager, Budgets and Procurement: M.A. Chirgwin

Budgets Officer: R.J. Beveridge

External Liaison Officer: T.H. Brown

Staff Services Co-ordinator: P.I. McGibbony

CUSTOMER SERVICES AND SYSTEMS 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
  - the evolving Telecom Australia 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 telecommunications 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

Senior Engineer: M.J. Flaherty, BE(Hons), PhD

Engineers:
N.H. Duong, BE(Hons), MEngSc
J.P. Goldman, Dip Rad Eng, Dip Comm Eng, GradIEAust
P.H. Newland, BE
J.S. Spicer, BE(Hons)

Senior Technical Officers:
J.B. Carroll
G.R. Leadbeater
T.R. Long

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 systems issues
* Conduct studies into the interworking of Telecom Australia's networks with customer systems and networks.

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

Principal Engineer: P.I. Mikelaitis, BE, MEngSc, MIEEE

Senior Engineer: B.J. McGlade, BE(Hons)

Engineers:
A.J. Hopson, BE(Hons)
M.J.T. Ng, BSc(Hons), PhD

Senior Technical Officers:
D.A. Drummond
P.D. Jackson

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 database 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: K.F. Barrell, BE(Hons), PhD

Principal Engineers:
E.K. Chew, BE, MEngSc, PhD, GradIEAust
R. Exner, BSc, BE(Hons), MAppSc, MIEEE
D.Q. Phiet, BE(Hons), PhD

Senior Engineers:
A.H. Al-Tarafi, BSc(Hons), PhD
R. Exner, BSc, BE(Hons), MAppSc, MIEEE
D.Q. Phiet, BE(Hons), PhD

Engineers:
M. Andrews, BE(Hons), BSc
A. Loch, BE
J.B. Nakulski, BE

Scientists: B. Smetaniuk, BSc(Hons), Dip Comp Sc, PhD

Principal Technical Officer: I.J. Moran

Senior Technical Officers:
B.W. Booth
I.C. Meggs

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 telecommunications 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 access services and facilities efficiently
* Develop models for describing user attributes and perceived needs, and for classifying telecommunications services
* Conduct studies into the needs of communities and organisations for telecommunications services.

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

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

Principal Scientist: J.B. Guy, BSc, PhD

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

Senior Research Officer: M.E. Cavill, BA(Hons), Dip TRP, MRAPI

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

Psychologists:
G. Lindgaard, BSc(Hons), SRN, MAPS, AFMAPA
J. Monaco, BSc(Hons)

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

Access Control and Authentication Section

Functions

* Provide information, advice and consultancy as defined in the Branch objectives
* Conduct theoretical and experimental research into the techniques of providing secure transport of speech signals and user data over telecommunications networks
* Conduct theoretical and experimental research into the techniques of providing secure controlled access to network-based facilities, databases, etc
* Contribute to and evaluate international standards relating to secure telecommunications.

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

Principal Engineer: N. Demytko, BSc, BE(Hons), MAdmin

Engineer: E.A. Zuk, BE, ME

Senior Technical Officer: R.I. Webster

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 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: P.H. Gerrand, BE(Hons), MEngSc, MIEAust

Technical Co-ordinator: F.R. Wylie, BE

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 Engineers:
J. Billington, BE(Hons), MEngSc, MIEEE
K.S. English, BE(Hons), MEngSc, MIEEE
M.A. Hunter, BE(Hons), MIEAust

Senior Engineer: D.M. Harsant, BE(Hons)

Engineers:
G. Foster, BE(Hons)
S.M. Jong, BE
S.A. Leask, BE(Hons)
J. Smith, BE(Hons)

Principal Technical Officer: W. McEvoy

Senior Technical Officer: R.L. Backway

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

Principal Engineers:
B.T. Dingle, Dip Elec Eng, BE(Hons)
M. Subocz, BE(Hons), MEngSc, MIEAust

Senior Engineers:
H.K. Cheong, BE(Hons), PhD
M.C. Wilbur-Ham, BE(Hons)

Engineers:
T. Batten, BE(Hons), MIEEE
N.D. Kim, BChemE(Hons), Dip DP
P. Richardson, BE(Hons)

Scientist: G.R. Wheeler, BSc(Hons), MSc

Senior Technical Officers:
H.G. Fegent
M. Schulze

Switching Technology Section

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: E.A. George, ASTC, Grad Dip Elec Comp, MIEAust

Principal Engineer: E. Tirtaatmadja, BE, MIEEE

Senior Engineers:
R.A. Palmer, BE, PhD
G.J. Scott, BSc, MAIP, MIEAust, MIEEE

Engineers:
R.J. Fone, BE(Hons)
B.W. Keck, BSc(Hons), BE(Hons), PhD
I.R. Lewis, BE(Hons)

Senior Technical Officers:
P. Ellis
L.P. Lucas

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 Engineers:
P.V. Bysouth, BE(Hons)
J.C. Ellershaw, BSc, BE(Hons), PhD, MIEEE
P.R. Hicks, BE, BSc, MEngSc
P.A. Kirton, BE(Hons), PhD, MIEEE

Senior Engineers:
G.A. Foers, BE(Hons), MIEEE
C.J. O'Neill, BE(Hons)
S.L. Sutherland, BE(Hons)

Engineers:
J.L. Burgin, BE(Hons), MIEEE
M. Littlewood, BE(Hons)

Senior Technical Officer: S.G. Ratten

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 Australia
* Recommend traffic performance standards for, and contribute to, specifications for new switching and signalling systems being considered for adoption by Telecom Australia
* Serve as a consultant for the dimensioning of special systems and networks for Telecom Australia'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, MIEAust

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

Senior Engineer: K.T. Ko, BE(Hons), MIEEE

Engineer: G. Cowle, BSc, BE(Hons)

Senior Scientist: R.A. Addie, BSc(Hons)

Scientists:
S. Choy, BSc
M. Rossiter, BSc(Hons)

Technical Officer: L.P. Lorrain

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:
P. Hui, BSc
G.P. Rochlin, BSc, MACS
E.M. Swenson, MSc, RACInson, MSc, Dip Data Proc, MAIP, MACS, MIEEE

Computer Systems Officers:
J.B. Cook, BSc(Hons), AACS, MACS
J.A. Gilmour, BAppSc
R. Liu, BSc(Hons), Dip Comp Sc, AACS
R. McNaughton, BSc, AACS

Senior Technical Officers:
P.C. Murrell
S. Dovile

TRANSMISSION SYSTEMS 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

Electromagnetic Compatibility Section

Functions

* Provide information, advice, consultancy and recommendations as defined in the Branch objectives
* Conduct research and exploratory development of techniques for achieving electromagnetic compatibility (EMC) of electronics/communications systems and equipment
* Conduct research and exploratory development of techniques for the assessment and prevention of the biological hazards of electromagnetic (non-ionizing) radiation from electonics/ communications systems and equipment
* Conduct research and exploratory development of new, advanced and novel antennas for telecommunications applications
* Investigate and develop specifications, standards and methods of measurement of incidental electromagnetic (EM) emission and susceptibility levels for electronics/ communications equipment and systems
* Investigate, evaluate and develop measurement and calibration facilities of both the indoor and outdoor types (including chambers and test ranges) for antenna, EMC and EM hazard assessments, measurements, tests and calibration applications
* Maintain and promote an awareness of EMC, EM hazards and antenna applications and implications for systems, equipment and network performance, and provide consultancy and technical advice to Telecom on a national basis.

Section Head: I.P. Macfarlane, Dip Elec Eng, BEE, MIEEE

Principal Engineers:
W.S. Davies, BE, MEngSc(Hons), PhD
S. Sastradipradja, BE, SMIREE, MIEEE, MARPS

Principal Scientist: K.H. Joyner, BSc(Hons), PhD, Dip Ed, MARPS

Senior Engineers:
S. Iskra, BE(Hons), MIEEE
E. Vinnal, BE(Hons),MIEEE

Engineer: S. Hamilton, BE(Hons)

Senior Technical Officers:
P.R. Copeland
D.M. Farr
R.J. Francis
B.C. Gilbert
S.J. Hurren

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, BE(Hons), BSc, PhD, SMIEEE, SMIREE

Principal Engineers:
F.G. Bullock, BE(Hons), GradIEAust, MIEEE
J.G. Hollow, BE(Hons), PhD, MIEEE
L.J. Millott, BE(Hons), MEngSc, SMIEEE

Senior Engineers:
I.C. Lawson, BEE
A.L. Martin, BE, GradIEAust, SMIREE

Engineer: D.J. Bakewell, BEE(Hons)

Scientist: G. Bharatula, BSc, MSc, MTech

Principal Technical Officer: R.L. Reid

Senior Technical Officers:
M.J. Durrant
J.J. Sekfy
R.N. Swinton
D.J. Thompson

Satellite Systems Section

Functions

* Provide information, advice, consultancy and recommendations as defined in the Branch objectives
* Conduct research into communications satellite technology, systems and networks
* Conduct theoretical studies, hardware development and field investigations to demonstrate the feasibility of new satellite system concepts and related networks
* Evaluate the potential applications and utilisation of such systems and networks for the transmission of existing and emerging telecommunications services
* Maintain and promote an awareness of developments in satellite communications services and networks, and provide consultancy and technical advice of strategic value
* Investigate the interworking of satellite systems and networks with other communications systems and networks.

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

Principal Engineers:
A.J. Bundrock, BE(Hons)
R.K. Flavin, BSc, MSc

Senior Engineers:
K. Balasubramanya, BE, MTech, PhD, SMIEEE
R.A. Harvey, Dip Rad Eng, BSc, MIREE

Engineer: A. Johnson, BE(Hons), MIEEE

Senior Technical Officers:
D.K. Cerchi
B.W. Thomas, BA

Local Access Systems Section

Functions

* Provide information, advice, consultancy and recommendations as defined in the Branch objectives
* Conduct research into both narrowband and wideband customer access transmission systems and networks which utilise various transmission media and possible combinations of these media, with emphasis on the use of optical bearers:
  - for local distribution between the customer and the local exchange involving:
    (i) multiple access techniques and methods for shared utilization of the transmission medium and the dynamic allocation of bearer capacity
    (ii) provision of wideband services on a widespread basis
  - for the distribution of services within the customer's premises using local area network techniques and associated contention resolution methods, taking into account:
    (i) the interworking of such systems with other parts of the transmission and switching network and the requirements of existing and emerging telecommunication services, and
    (ii) network maintenance, reliability and security protection to provide customer service integrity
* Investigate and develop appropriate performance evaluation methods and design criteria for new local access systems and networks
* Conduct experiments and participate in field trials designed to demonstrate the feasibility of new local access systems and networks.

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

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

Senior Engineers:
B.R. Clarke, BE(Hons), PhD
P.A. Evans, BE(Hons), MIEEE
M.D. Hayes, BE(Hons)

Senior Technical Officers:
L.W. Bourchier
G. Dhosi
J.L. Kelly
R. Owers
R.C. Witham
N. Wolstencroft

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 tranmission of telecommunications services in the local, junction and trunk networks
* Investigate the interworking 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, MIEEE

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

Senior Engineers:
B. Goczynski, MEngComm
K. Hinton, BE(Hons), BSc, PhD

Scientists:
J.L. Adams, BSc(Hons), PhD
M. Joyce, BSc(Hons)

Senior Technical Officers:
E.A. Dodge
J.H. Gillies
D. Temple

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.V.H. Sabine, BSc, BE(Hons), PhD

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 of, and recommend or implement as appropriate, modelling and simulation methods 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: A.J. Jennings, BE(Hons), PhD, SMIEEE, SMIREE

Principal Engineer: C.D. Rowles, BSc, BCommE, MIEEE

Senior Engineer: P.L. Nicholson, BE, MIEEE

Scientists:
A. Kowalczyk, MAppSc, PhD
J. Szymanski, MSc, PhD

Engineers:
L.A.R. Denger, ENSEMN, MIEEE, MSocFrElec

Senior Technical Officers:
R.B. Coxhill
A. Thomas

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 Australia'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 Australia's operations, particularly in remote areas.

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

Principal Engineer: D.J. Kuhn, BE(Hons), MEngSc

Scientists:
S. Goh, BSc, MSc, PhD
S. Hinckley, BSc(Hons),PhD, MIEEE, GradAIP
I. Muirhead, BSc(Hons), MEnvStud
T. Robbins, BSc(Hons), MSc, MIREE

Senior Technical Officer: E.D.S. Fall

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), PhD, FAIP, MAPS, MIEEE

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

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

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

Engineer: J.Dell, BEE(Hons)

Scientist: P. Orders, BSc(Hons), PhD, MAPS, GradAIP

Senior Technical Officers:
R. Garner
F. Gigliotti
R. Tarran

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 and passive circuit configurations of opto-electronic devices and their application in telecommunications systems.

Section Head: G.O. Stone, BE(Hons), MEngSc, PhD, MIEEE, MIREE

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

Senior Engineer: M.S. Kweitniak, BSc, MEngSc, PhD, MIEEE, MAPS, MAVS

Senior Scientist: T. Warminski, MSc, PhD, DSc

Scientists:
P.M. McNamara, BSc(Hons), MSc, PhD
Y. Ito, BE(Hons), ME

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

Principal Technical Officer: B.P. Cranston

Senior Technical Officer: P.F. Elliott

STANDARDS AND LABORATORIES ENGINEERING BRANCH

Objectives

* To ensure a sound scientific basis for all measurements made by and within Telecom Australia 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
* Provide design drafting, engineering documentation and consultative drafting services for the Research Department.

Assistant Director: G.M. Willis, FRMIT, MIEAust, SMIREE

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

Branch Administrative Officer: P. Rodoni

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, C Eng, MIMechE

Principal Engineer: P.F.J. Meggs, Dip Mech Eng, ARMIT, GradDip IM, MIEAust

Senior Engineers:
W.F. Hancock, Dip Elec Eng, MIEAust
V. Lee, BSc(ME), MSc(ME)

Engineers:
A.R. Gilchrist, Dip Mech Eng, BE(Hons), GradIEAust
R.E. Proudlock, BE

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

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 State Administrations
* Operate, maintain and calibrate Telecom Australia'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 Telecom Australia'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: R.W. Harris, BSc(Hons), BE(Hons), BComm

Principal Engineer: E. Pinczower, Dip Elec Eng, MIEAust

Senior Engineers:
R.W. Pyke, Dip Elec Eng, BE(Hons), MIEAust
B.R. Ratcliff, Dip Comm Eng, ARMIT

Engineers:
J.P. Colvin, Dip Elec Eng, BE
D.A. Latin, BE

Principal Technical Officers:
J.B. Erwin
R.H. Yates

Senior Technical Officers:
C.R. Flood
A.L. Forecast
J. Freeman

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 Engineers:
G.J. Barker, Dip Mech Eng, MIEAust
G.K. Reeves, BSc(Hons), PhD, MIEAust
H.S. Tjio, Dip Elec Eng, BE

Senior Engineer: A. Brunelli, BE, MEngSc, MIREE, MIEEE, MISHM

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

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 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, MIEAust

Engineer: R.J. Day, Dip Elec Eng, Dip Mech Eng, MIEAust

Senior Technical Officer: T.W. Crichton

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

Principal Engineer: G.C. Heinze, Dip Elec Eng, BE

Senior Engineers:
I. Dresser, BE
N.A. Leister, BE, GradIREE

Engineer: P. Standaert, BE(Hons)

Senior Technical Officers:
B.J. Churchill
P.J. Dalliston
D.R. Daws
D.C. Diamond
S.J. Heath
K.L. Rogers
D. Wilson

Headquarters Library

Functions

* Provide a comprehensive library service to all Departments and Directorates at Headquarters, including translation of foreign languages
* 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 Librarians:
M.B. McAllister, BSc(Hons), Dip Lib, ALAA
D.J. Richards, BA, Dip Lib

Librarians:
G.A. Lawson, BA, Dip Lib, ALAA
P. Millist, Dip Lib, ALAA
J.A. Smith, BA, Dip Lib, ALAA
E.M. Spicer, BA, Dip Lib
K. Sridhar, MA, Dip Lib
E.M. Tunaley, Dip Lib
G. Woods, Dip Lib

Drafting Support Section

Functions:

* Prepare and modify drawings incorporating associated design drafting, investigations and computations
* Ensure that the standard of engineering documentation prepared in the Department conforms to Telecom Australia's policies and standards
* Provide consultative services on the standard or specification of contractor supplied engineering documentation.

Section Head: M.K. Brown

Supervising Draftsmen:
A. Carratelli
A. Craig
A. Davenport

APPLIED SCIENCE BRANCH

Objectives

* Conduct scientific research, exploratory development, laboratory and field experiments, provide expert scientific advice and recommendations contributing to the establishment of design, performance and assessment criteria relating to:
  - the characteristics and properties of new materials, devices and equipment technologies for application in the telecommunications network
  - the mechanisms of degradation and service failures and the development of mitigation techniques
  - impact of the environment on personnel and plant and the development and implementation of appropriate protective measures
  - the assessment of the operational reliability of materials, components and devices
  - the evaluation and development of advanced materials, the application of emerging scientific technologies, and research into improved scientific or analytical procedures.
* Maintain liaison and exchange information with appropriate research establishments and learned institutions and participate in material and international standardisation activities.

Assistant Director: G. Flatau, Dip App Sc, FRMIT

Branch Administrative Officer: L. Roberts

Polymer Section

Functions

* Conduct exploratory research in the field of polymer science and technology
* Conduct scientific studies into the behaviour and interaction of polymer materials and additives and develop polymer systems specifically suited to the Australian environment and Telecom Australia's network
* Conduct studies into new polymeric materials or develop alternatives for existing polymers
* Devise or develop specialised test methods and analytical techniques to characterise, evaluate, and establish life expectancy and performance parameters of polymeric components
* Provide information, advice and consultancy as defined in the Branch objectives.

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

Principal Scientist: B.A. Chisholm, Dip App Chem, MSc, GradRACI, GradPRI

Senior Scientists:
D.J. Adams, Dip App Chem, GradRACI
R.J. Boast, Dip App Chem, Dip Pol Sc, GradRACI
P.R. Latoszynski, Dip App Sc, Dip Anal Chem, GradRACI

Scientists:
S. Georgiou, BAppSc, Dip Anal Chem
R.C. Wallis, BSc, PhD

Senior Technical Officer: D. Coulson

Electrochemistry Section

Functions

* Conduct exploratory research in electrochemistry including the study of corrosion and electrochemical power sources
* Conduct scientific studies related to the protection of telecommunications materials, devices and equipment against the effects of corrosion and electrochemical phenomena and develop appropriate protection methods
* Devise and develop specialised test methods and analytical techniques
* Conduct scientific investigations into the behaviour of electrochemical power sources; investigate failure modes to establish whether the faults are due to materials, construction or maintenance procedures and thereby improve operational reliability develop test facilities and methods
* Undertake fundamental investigations into surface phenomena and electro-deposition
* Provide information, advice and consultancy as defined in the Branch objectives.

Section Head: J. Der, BSc, ARACI

Scientists:
P.J. Gwynn, Dip App Chem
B.C. Eva, Dip App Sc, GradRACI

Senior Technical Officer: S. Curlis

Chemistry Section

Functions

* Conduct exploratory research into the chemical properties, composition and behaviour of materials
* Conduct scientific studies into the chemical phenomena and hazards encountered by materials, devices and equipment and advise on protective or remedial measures
* Devise or develop specialised test methods and analytical techniques
* Establish and provide specialised scientific facilities for the assessment of hazardous materials or conditions
* Provide information, advice and consultancy as defined in the Branch objectives.

Section Head: F.C. Baker, Dip App Chem, Dip Chem Eng, MAppSc, FRACI, AAIST, CChem, MRSC

Principal Scientist: T.J. Elms, Dip App Sc, Grad Dip Anal Chem, GradRACI

Scientists:
G.I. Christiansz, BSc(Hons), PhD, Dip Ed
G.N. Pain, BSc(Hons), PhD, ARACI

Senior Technical Officers:
D.A. Holding
R.R. Pierson, Dip Res Cons Stud, MAIST

Device Technology Section

Functions

* Conduct exploratory research into the reliability of electronic components and devices
* Undertake exploratory research into the properties of metals and alloys
* Conduct scientific studies into the properties and life expectancy of components, devices and assemblies and investigate causes of failure and degradation
* Conduct scientific studies into the behaviour of metal products and investigate electrical contact or interconnection systems
* Devise and develop specialised test or measurement equipment and techniques
* Research novel testing methodologies applicable to the characterisation and failure analysis of materials and components
* Provide information, advice and consultancy as defined in the Branch objectives.

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

Principal Scientist: J. Thompson, BA(Hons)

Senior Scientists:
J.R. Godfrey, Dip Met
T.J. Keogh, Dip Sec Met
T.P. Rogers, BAppSc

Scientists:
S.J. Charles, BAppSc
P.A. Galvin, Dip Sec Met
E.E. Gibbs, BSc(Hons), PhD
P.W. Leech, FRMIT, MAppSc, PhD

Senior Technical Officers:
S.G. Harper
M. Jorgensen, Dip Sec Met
I.E. Long
R.W. Rydz

Surface Characterisation Section

Functions

* Conduct exploratory research into fundamental surface-related phenomena
* Conduct scientific studies into the influence of surface characteristics on the behaviour of materials and devices
* Develop and maintain expertise in surface analysis techniques, and devise specialised facilities and novel analytical techniques
* Provide information, advice and consultancy as defined in the Branch objectives.

Section Head: J.R. Lowing, Dip Sec Met

Senior Scientist: C.G. Kelly, BAppSc, AAIP, MAXAA, MAVS

Senior Technical Officer: C.J. Ellery

Solar and Environment Section

Functions

* Conduct exploratory research into the physical properties of materials and components and their performance under environmental and high potential stresses
* Conduct scientific studies into the properties of photovoltaic solar cells and modules and their performance under various climatic conditions
* Conduct scientific studies into high potential phenomena and their effects on Telecom Australia's plant and equipment; investigate protective devices and develop measures for the protection of staff, subscribers and plant
* Conduct scientific studies into environmental factors and their effects on materials, components and equipment; measure the incidence and distribution of climatic factors
* Devise or develop specialised test methods and equipment
* Provide and maintain data acquisition and analysis facilities for the Branch
* Operate as a verifying authority and signatory in accordance with the requirements of NATA in the field of temperature and humidity measurements
* Provide information, advice and consultancy as defined in the Branch objectives.

Section Head: D. McKelvie, BSc(Hons)

Principal Scientist: A. Kruijshoop, Natlr(Delft)

Principal Engineers:
A.M. Fowler, MIEAust
I.K. Stevenson, BAppSc, Dip Elec Eng, GradAIP, GradIEAust

Senior Scientists:
E.J. Bondarenko, Dip App Phys, BAppSc, LAIP, SMIREE, FRAS, GradIEAust
G.W.G. Goode, BSc
A.J. Murfett, BSc(Hons)

Scientists:
P. Lambrineas, BSc(Hons), GradAIP, GradAXAA
D.E. Thom, BSc, Dip Ed, Dip Proc Comp Systems

Engineer: P.W. Day, BE

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

INDUSTRIAL PROPERTY AND INFORMATION BRANCH

Objectives

* Conduct studies, participate in policy formulation, contribute to specifications for and assessments of tenders, develop and operate systems, facilities and processes, and provide advice and recommendations as appropriate relating to:
  - the identification, securing and exploitation of industrial property rights relevant to the interests of Telecom Australia, including industrial property aspects of Telecom Australia's relationships with other parties
  - the management and operation of the Research Department's programme of R&D contracts and related processes for R&D collaboration with external organisations
  - technology and information transfer from the Research Department to other Departments of Telecom Australia, industry, academia and other external organisations
  - co-ordination of the participation of staff of the Department in the activities of external organisations
  - recruitment and development of professional and technical grade staff of the Research Department
  - the investigation development and operation of centralised, integrated networking computer-based facilities - in support of the Research Department's management, administration and investigatory functions
  - the formulation of the Department's work programme.

Manager: F.W. Arter, BEE, MEngSc

Administrative Officer: T.M. Walsh

Industrial Property Section

Functions

* Interpret and execute Telecom Australia's policy on industrial property and provide specialist advice and assistance to management and staff of Telecom Australia on the industrial property aspects of their activities within Telecom Australia and with external organisations
* Identify, secure and, where relevant, exploit Telecom Australia's interests in industrial property arising out of its internal activities or those with external organisations
* Co-ordinate, establish and manage the Research Department's programme of R&D contracts, collaborative research agreements and related activities
* Develop and participate in the execution of strategies for the transfer of technology developed within Telecom Australia, and in particular, the Research Department, to industry.

Section Head: O. J. Malone, BEE

Senior Engineer: P. Gretton, Dip Elec Eng

Information Transfer Section

Functions

* Develop and implement methods and programmes for the effective transfer of technical information generated within the Research Department to other Departments of Telecom Australia, and where appropriate, to external industrial organisations, R&D institutions and academia
* Co-ordinate and oversight technical publications emanating from the Research Department, including the development and operation of efficient publication processes and procedures
* Perform editorial functions and oversight approval/classification/issue procedures for technical publications of the Department
* Provide a focus for technical liaison with, and representation of Departmental activities to, external organisations and persons, including the development and operation of information retrieval services, talks, visits, displays, etc.
* Assist in the recruitment of professional and technical grade staff for the Research Department, and develop, co-ordinate and execute programmes for their technical development.

Section Head: L.N. Dalrymple, Dip Elec Eng, GradIEAust

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

Senior Technical Officers:
C.A. Block
G.C. Galey
A.M. Johnson
A.K. Mitchell

Information Processing Section

Functions

* Conduct relevant research, develop and operate integrated, networking computer-based information processing facilities for the Research Department, to provide effective, universally compatible facilities for automated office processes, management information systems, text/graphics communications, numerical/data analysis, computer simulation and control, etc., in support of the Department's management, administrative and investigatory functions
* Prepare software and hardware specifications for and co-ordinate the acquisition and commissioning of such facilities, liaising with other Departments of Telecom Australia and industry as required
* Provide consultant advice and assistance to staff of the Research Department on the application of the facilities
* Develop and co-ordinate training programmes for users of the facilities.

Section Head: P.J. Tyers, BE(Hons), BSc, MIEEE

Management Information Systems Officer: M.J. Holmes

Senior Technical Officer: W.W. Staley

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

Adams, J.L. & Johansen, E.	'Linewidth Reduction of Semiconductor Laser Diodes', 10th Australian Conference on Optical Fibre Technology, IREE, Perth, December 1985.
Adams, J.L. & Kabaila, P.V.	'A Model for Carrier Recovery, Timing Recovery and Adaptive Equalisation in High Capacity Digital Radio Systems', Australian Telecommunication Research, Vol. 19, No.1, 1985.
Addie, R.G.	'Analysis of Delays in Networks of Queues with Fluctuating Traffic', International Seminar on Computer Networking and Performance Evaluation, Kyoto, Japan, September 1985.
Addie, R.G.	'Queues with Semi-Markov Input and Service Times', 11th International Teletraffic Congress, Kyoto, Japan, September 1985.
Ayre, R.W.A., de Boer, B.T. (Network Engineering Dept.) & Shuster, R.B. (Qld State Admin.)	'Cable Design and Installation Techniques for Directly Buried Non-metallic Optical Fibre Cables', 34th International Wire and Cable Symposium, Cherry Hill, New Jersey, USA, November 1985.
Baker, F.C.	'Thermal Analysis of Foam-forming Additives', International Symposium, Polymer '85: Characterisation and Analysis of Polymers, Melbourne, February 1985.
Baker, F.C. & Elms, T.J.	'Hydrogen Emission from Optical Fibre Cabling Material', 10th Australian Conference on Optical Fibre Technology, IREE, Perth, December 1985.
Balasubramanya,K.S.	'State-Transition, Monte Carlo Simulation of Electronic Systems', IREECON 85, Melbourne, September 1985.
Barrell, K.F.	'Syntax Independence - Presentation Service', SAA Seminar: Open Systems Interconnection, Melbourne, July 1985.
Barrell, K.F. & Al Tarafi, A.H.	'The OSI Presentation Service', 1st Pan-Pacific Computer Conference, Melbourne, September 1985.
Biggar, M.J.	'Frequency Allocations and Limitations of Coaxial Cable Television and Wideband Local Networks', Journal of Electrical & Electronics Engineering, Australia, December 1985.
Billington, J.	'On Specifying Performance Aspects of Protocol Service', International Workshop on Timed Petri Nets, Turin, Italy, July 1985.

Billington, J., Wilbur-Ham, M.C. & Bearman, M.Y. (Canberra CAE)	'Automated Protocol Verification', 5th International Federation for Information Processing International Workshop on Protocol Specifications, Verification and Testing (IFIP WG6.1), Toulouse, France, June 1985.
Blackwell, D.M.	'ISDN Access Physical Layer', IREECON 85, Melbourne, September 1985.
Blakey, M. & Nuutila, P.	'Message Handling Systems - Towards an Implementation', IREECON 85, Melbourne, September 1985.
Bondarenko, E.J. & Stevenson, I.K.	'Electrical Protection of Telecommunications Equipment', IREECON 85, Melbourne, September 1985.
Brooks, A.M.	'Simulation of Digital Transmission on Narrow Band Mobile Radio Channels', IREECON 85, Melbourne, September 1985.
Bullock, F.G.	'Digital Point-to-Multipoint Radio for Business Applications', IREECON 85, Melbourne, September 1985.
Bullock, F.G.	'Echo Canceller Structures for Digital Loop Access Systems', Australian Telecommunication Research, Vol. 19, No.1, 1985.
Campbell, J.C.	'Characterisation of Laser Diode Mode Partition Noise for Single Mode Optical Fibre Communication Systems', 10th Australian Conference on Optical Fibre Technology, IREE , Perth, December 1985.
Campbell, J.C., Steel, J. & Davey, L. (Network Engineering Dept.)	'Measurement and Prediction of Digital Radio System Performance on a Long Overwater Path', Electronic Letters, Vol. 21, No. 25/26, December 1985.
Chew, E.K.	'Interworking of Local Area Networks and Public Networks', The Telecommunication Journal of Australia, Vol.34, No.3, 1984.
Chew, E.K., Chong, K.N. & McDonell, K.J. (Monash University)	'Implementation Considerations of a Name Validation Function for Distributed Directory Services', 2nd International Symposium on Computer Based Message Systems, IFIP, Washington, USA, September 1985.
Chew, E.K. & Exner, R.	'On-line Electronic Directories for Multi-service Communication Networks', IREECON 85, Melbourne, September 1985.
Clarke, B.R.	'The Time Domain Response of Minimum Phase Filters', IEEE Transactions on Circuit and System Theory, Vol. CAS-33, No.11, 1985.
Clarke, B.R. & Semple, G.J.	'Crosstalk Compatibility in the Local Loop', Australian Telecommunication Research, Vol. 19, No. 2, 1985.
Clarke, B.R., Jennings, A.J. & Webster, R.I.	'A Single Baud Rate Full Duplex Transmission Unit for ISDN Customer Access', IREECON 85, Melbourne, September 1985.
Colvin, J.P.	'Development of a Solid State Speaking Clock', The Telecommunication Journal of Australia, Vol.35, No.1, 1985.
Craick, J.	'Studies for a Multi-service Future - What Do Telecommunications Providers Need to Know?', 11th Symposium on Human Factors in Telecommunications, Cesson, Savigne, France, September 1985.
Davies, W.S., Hurren, S.J., Fall, E.D.S. & Copeland, P.R.	'Antenna Pattern Degradation due to Tower Guy Wires on Microwave Radio Systems', Proc. IEE, Vol. 132, Pt. H, No.3, June 1985
Dell, J.	'Detectors for Optical Communication Systems', 10th Australian Conference on Optical Fibre Technology, IREE, Perth, December 1985.
Demytko, N.	'Echo-Cancellation Techniques', IREECON 85, Melbourne, September 1985.
Demytko, N., Smith, B.M., Semple, G.J. & Potter, P.G.	'Transmission Considerations for ISDN Basic Access Systems', Australian Telecommunication Research, Vol. 19, No. 2, 1985.
Der, J.J.	'Batteries - Selection and Maintenance', Symposium and Exhibition: Existing Technology for Renewable Energy Resources, Department of Electrical Engineering, Capricornia Institute, Rockhampton, Queensland, September 1985.
Dingle, B.T.	'The Role of Signalling in Providing Integrated Telecommunications Services', IREECON 85, Melbourne, September 1985.
Duc, N.Q.	'ISDN Terminals and Integrated Services Delivery', IREECON 85, Melbourne, September 1985.
Duc, N.Q.	'ISDN Protocol Reference Model and Its Applications', IREECON 85, Melbourne, September 1985.
Duc, N.Q. & Chew, E.K.	'ISDN Protocol Architecture', IEEE Communications Magazine, Special Issue on Communication Protocols, Vol.23, No.3, March 1985.
Duc, N.Q. & Mikelaitis, P.I.	'ISDN: A New Multi-Service Telecommunications Environment', Professional Development Seminar, 1st Pan-Pacific Computer Conference, Melbourne, September 1985.
Ellershaw, J.C.N., Foers, G.A., Evans, P.A., Fidge, P. & Schulze, M.	'Design of an Interworking Unit', IREECON 85, Melbourne, September 1985.
English, J.C. & Vizard, J.	'An Experimental Network for Studying ISDN Protocols and Service Provision', IREECON 85, Melbourne, September 1985.
Evans, P.A.	'Implementation of Packet Assemblers/ Disassemblers', IREECON 85, Melbourne, September 1985.
Exner, R.	'Protocols for Message Handling', Australian Telecommunication Research, Vol. 19, No. 1, 1985.
Exner, R. & Chew, E.K.	'Developments in Electronic Messaging', IREECON 85, Melbourne, September 1985.

Flatau, G.	'Quality Electronic Components - IECQ Provides the Means', The Australian Standard, November 1985.
Galey, R.A.	'A Computer Based System for EPROM Reliability Assessment', Conference on Computers and Engineering, Hobart, September 1985.
Godfrey, J.R.	'Reliability Studies of Connectors and Contact Materials', NELCON 1985, Wellington, New Zealand, October 1985.
Godfrey, J.R.	'Reliability Studies of Connectors and Contact Materials', IREECON 85, Melbourne, September 1985.
Goh, S.C.	'Four Generations of Solar Cells : Prospects for the Future', Photovoltaic Systems Engineering Seminar, Swinburne Institute of Technology, Melbourne, October 1985.
Goh, S.C. & Teede, N.F.	'Amorphous Solar Cell R&D at the Telecom Research Laboratories', IREECON 85, Melbourne, September 1985.
Harris, R.J. & Berry, L.T. (University of Adelaide)	'Modular Design of a Large Metropolitan Telephone Network : A Case Study', 11th International Teletraffic Congress, Kyoto, Japan, September 1985.
Harris, R.W.	'Time and Frequency Distribution in Australia', IREE Monitor, October 1985.
Harsant, D.M.	'An Australian Multi-Project Chip', The Telecommunication Journal of Australia, Vol. 34, No. 3, 1984.
Hinckley, S.	'Photoelectro-chemical Energy Conversion and Storage', IREECON 85, Melbourne, September 1985.
Hinton, K.J.	'Quantum Physics in Optical Communications', 10th Australian Conference on Optical Fibre Technology, IREE, Perth, December 1985.
Hollow, J.G.	'Spread Spectrum - Fundamental Noise Immunity Characteristics Compared with Narrow Band Systems', IREECON 85, Melbourne, September 1985.
Horton, R. & McGregor, I.M.	'Wideband Communications Developments and Trends', IREECON 85, Melbourne, September 1985.
Ito, Y., Cranston, B.P. & Kwietniak, M.S.	'Surface Preparation of II-VI Semiconducting Crystals for Optoelectronic Devices', 3rd Conference of the Australian Optical Society, Macquarie University, August 1985.
Ja, Y.H.	'Using the Seventh Order Method to Solve the Non-Linear Coupled Wave Equations for Degenerate Two-wave and Four-wave Mixing', Applied Physics B 35, November 1984.
Ja, Y.H.	'Real-time Optical Image Differentiation by Degenerate Four-wave Mixing', Applied Physics B 36, January 1985.
Ja, Y.H.	'Degenerate Six-wave Mixing in Photoreactive $Bi_{12}GeO_{20}$ Crystals', 10th AIP Condensed Matter Physics Meeting, Wagga Wagga, NSW, February 1986.
Ja, Y.A.	'Using the Shooting Method to Solve Boundary Value Problems Involving Non-linear Coupled Wave Equations - Part 1: Degenerate Two-wave Mixing', (Author's reply to comments published), Optical and Quantum Electronics, Vol.16, 1984.
Ja, Y.H.	'Phase Conjugate Wavefront Generation with Two Object Beams in Photorefractive $Bi_{12}GeO_{20}$ Crystals', 3rd Conference of the Australian Optical Society, Macquarie University, August 1985.
Ja, Y.H.	'Intensity Dependence of Stationary Energy Transfer in Degenerate Two-wave Mixing in a Reflection Geometry with Photo-refractive Crystals', Short Communication, Optical and Quantum Electronics, Vol.17, 1985.
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7508*	Barrett, R.N.M	Use of Passive Personal Monitors for Measurement of Toxic Solvent Vapours
7553*	Scott, C.J.	The Architecture and Technology of Digital Switching ICs
7573*	Webster, R.I.	An Instrument to Characterise Impulse Noise
7608* Erratum	Goode, G.W.G. & Murfett, A.J.	Customers' Terminal Blocks & Frames: Insulation-displacing Type
7622*	Heinze, G.C. & Tjio, H.S.	An Encounter with an NMOS Multiproject Chip – The Design of a PCM Signal and Line Code Generator
7644*	Duc, N.Q. & Chew, E.K.	ISDN Protocol Reference Model and its Applications
7652	Kim, N.D.	Protocol Analysis of Signalling System No. 7, Level 3
7653*	Harsant, D.M.	Overseas Visit Report, ISSCC 83 and VLSI Design Techniques, Feb/March 1983.
7670*	Richards, D.R.	The Electromask Conversion Routine for the Gerber IDS2
7691*	Demytko, N.	Analysis of an Echo Canceller based on the Memory Compensation Technique
7704*	Semple, G.J.	The Effect of Bridged Taps on the Transmission Performance of Local Digital Reticulation Systems
7708*	Murrell, P.R.	Microstrip Circuit Design Using RT Duroid 5880
7711*	Brunelli, A.	Interconnection Technology for Microelectronics Circuits and Photovoltaic Solar Cell Fabrication Technology
7725*	Coxhill, R.B.	The Digital Network Synchronisation Field Trial – Transmission of Timing References over the Analogue Trunk Network
7730*	Chong, K.N., Nguyen, T.U., Wheeler, G.R. & Billington, J.	Specification of the Packet Level Procedure of X.25 Data Circuit Terminating Equipment using the Specification and Description Language

7732*	Duke, P.F.	Objective Measurement of Loudness Ratings
7734*	Johansen, E.	Overseas Visit Report - Long Term Developments in Optical Fibre Systems, March/April 1984
7736	Bearman, M. Wilbur-Ham, M.C. & Billington, J.	A Formal Specification of the OSI Class 0 Transport Protocol using NPNs
7738*	Murfett, A.J.	Overseas Visit Report - Solar Photovoltaic Modules, May 1984
7743	Ellery, C.J.	A Specialised Optical Fibre Bundle to Aid Semiconductor Characterisation
7746*	Coxhill, R.B.	Considerations in the Measurement of Crosstalk Noise Figure in Local Digital Reticulation Systems utilising Adaptive Cancellers
7748*	Gibbs, E.E.	The Operation and Characteristics of Some Gas Discharge Surge Protectors
7749	Pidoto, J.F.	Keypad Technologies
7750	Charles, S.J. & Rydz, R.	Component Reliability Guide - Part 1
7752*	Jenkinson, G.F.	Overseas Visit Report - Satellite Communications for the Future, June/July 1984
7753	McGlade, B.J.	Gaussian Quadrature Numerical Integration
7758*	Colvin, J.P.	A Proposed Speaking Clock Installation
7759*	Thompson, J.	Overseas Visit Report- IC Reliabiity and Failure Analysis, March/May 1984
7761*	Teede, N.F.	Overseas Visit Report - Energy Conversion and Storage Options for Telecommunications Applications, September 1984
7762	Rockliff, S.C. & Stephens, T.D.	A 4-Channel Multiplexer and a 4-Phase Divide-By-2 Clock Generator for Gbit/s Digital Transmission
7763	Cheong, H.K. & Richardson, P.J.	Signalling Traffic Handling Capacity of CCSS No.7 in the Presence of High Link Error Rates
7766*	O'Neil, C.J. Dickson, G.J. & Ford, W.S. and Hales, T. & De Chazal, P. (CSIRO)	An Open Systems Interconnection Network Service Interface Specification
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7772	Blakey, M. & Exner, R.	Review and Implementation of the OSI Session Service and Protocol
7775*	Latoszynski, P.R.	Stabiliser Losses during Manufacture of 0.4 mm Polyethylene Insulated Wire
7779	Goode, G.W.G.	Cockatoo Proof Microwave Antenna Feed Windows
7780	Wheeler, G.R.	Numerical Petri Nets - A Definition
7782*	Valk, M.J. & Leister, N.A.	Time Clock for Traffic Dispersion Equipment
7787*	Rochlin, G.P.	Overseas Visit Report - Software Engineering Trends in Europe and North America, September/October 1984
7791	Wilbur-Ham, M.C.	Numerical Petri Nets - A Guide
7792*	Kabaila, P. & Meggs, I.C.	On Feature Information for Voice & Data Type Classification in Teletraffic Measurement
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7797*	Subocz, M.	Overseas Visit Report -CCITT Meeting in Geneva and Related Visits, November 1983
7798	Ruhl, F.F.	Computer Analysis of Transmission Properties of Single-Mode Fibres
7804*	Biggar, M.J.	Improved Television Services
7821*	Kirton, P.A.	Some Trends and Developments in Computer Networking: Report on Telecom Development Award at the Information Sciences Institute.
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Notes: The reports marked * are classified as 'Telecom Australia Use Only'. In addition, six "In Confidence" reports with restricted distribution were produced.

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• Battery Standards	
- Primary Batteries	J. Der
- Secondary Batteries	J. Der
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- Zinc and Cadmium Coatings	T.J. Keogh

• Metal Industry Standards	
- Coating of Threaded Components	T.J. Keogh
- Galvanised Products	T.J. Keogh
- Electroplated and Chemical Finishes on Metals	T.J. Keogh
• Plastics Industry Standards	
- Plastics for Telecommunications Cables	H.J. Ruddell D.J. Adams
- Methods of Testing Plastics	B.A. Chisholm
- 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	D.J. Adams
• Safety Standards	
- Electronic Equipment	E. Bondarenko
- Industrial Safety Gloves	F.C. Baker
- Steel Wire Rope and Strand	T.J. Keogh
• Telecommunications and Electronics Industry Standards	
- Capacitors and Resistors	S.J. Charles
- Electro-acoustics and Recording	E.J. Koop
- Electromagnetic Interference	I.P. Macfarlane
- Environmental Testing	G. Flatau M.C. Hooper
- Hazards of Non-Ionizing Radiation	S. Sastradipradja
- Indicating and Recording Instruments	E. Pinczower
- Photovoltaic Modules	D. McKelvie
- Printed Circuit Boards	D.E. Sheridan
- Radio Communications	R.K. Flavin K.H. Joyner
- Semiconductor Devices	E.A. George G.G. Mitchell

National Association of Testing Authorities (NATA)

• Acoustic and Vibration Measurement Advisory Committee	E.J. Koop
• Assessor for Environmental Testing	M.C. Hooper
• 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	E. Pinczower J.B. Erwin

Australian Radiation Protection Society K.H. Joyner

CSIRO

• Standards Advisory Committee — G.M. Willis

Department of Resources and Energy

• Japan-Australia Collaborative Program on Remote Area Power Supplies, Committee — N.F. Teede

National Energy Research, Development and Demonstration Council

• Technical Standing Committee on Solar, Wind and Nuclear Energy — N.F. Teede

Overseas Telecommunications Commission OTC(A)

• Research & Development Board — F.W. Symons

Victorian Solar Energy Council

• Project Steering Committee — N.F. Teede

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 on Optical Fibres, Working Group 0	R.W. Ayre
• International Confederation for Thermal Analysis	F.C. Baker
• International Federation for Information Processing (Architecture and Protocols for Computer Networks)	J. Billington
• Teletraffic Engineering Training Project TETRAPRO, ITU/ITC	J. Rubas
• IEC Quality Assessment System for Electronic Components 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 portfolio includes applications for letters patent and registered designs.

PATENT APPLICATIONS AND PATENTS

Invention Title (Inventor/s)	Provisional Specification	Complete Specification	Patent No. (if granted)	Country
Self Adaptive Filter and Control Circuit (L.K. Mackechnie)		98800	3732410	USA
Tip Welding Means (E.J. Bondarenko)		4714/71	3657512	USA
Analogue Multiplier (H. Bruggemann)		855543	3629567	USA
Apparatus for Monitoring a Communications System and a Detector Therefor (J.A. Lewis)	PA1474/70	29415/71	458997	Australia
Control of Operation of a System (N.W. McLeod)	PA2035/70	31550/71 166819	466670 3745418	Australia USA
Smoke Detector (L. Gibson & D.R. Packham)		367260	3874795	USA
Method and Apparatus for Detecting the Presence of Signal Components of Predetermined Frequency in a Multi-frequency Signal (A.D. Proudfoot)		387855 178402	3882283 984068	USA Canada
Fault Monitoring Apparatus (R.W. 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
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 W. Germany W. 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 W. Germany UK Italy Holland Switzerland) Canada Japan USA

Tap Coupler for Optical Fibres (E. Johansen & E. Dodge)	PF0272/81	87251/82	544705	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	39841/85		Australia
		85306496		Europe (designating Austria Belgium France W. Germany Luxembourg Netherlands Sweden UK Italy Switzerland)
		775549		USA
		490497		Canada
		201967/85		Japan
LAN for Mixed Traffic (P.F. Frueh)	PG5956/84	44818/85		Australia
Cable Laying Apparatus (R.A. Vidler)	PG7266/84	47460/85		Australia
		778453		USA
		8523098		UK
		213532		New Zealand
		491271		Canada
Characterisation of Digital Radio Signals (A.L. Martin)	PG4999/84 PG8701/84	43227/85		Australia
		PCT/AU85/00107		PCT (designating Europe (all states) USA UK Japan Denmark Finland Norway)
		1211/85		Ireland
		543131		Spain
		481293		Canada
Conforming the Frequency Spectrum of an Output Signal to a Desired Form (B.W. Sneddon & S.G. Beadle)	PG8284/84	49251/85		Australia
Optical Distribution Systems (I.M. McGregor)	PH2612/85			Australia
Mounting Device (B.T. Burland & D.C. Hoyune)	PH3372/85			Australia
Method of Initial Synchronisation for Full Duplex Digital Transmission (A. J. Jennings & B.R. Clarke)	PH4020/85			Australia
Voice Detector Device (A.J. Taylor)	PH4244/86			Australia

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PATENT APPLICATIONS AND PATENTS

REGISTERED DESIGN APPLICATIONS AND REGISTERED DESIGNS

Design Title (Author/s)	Application No.	Design No.	Country
Housing (B.T. Burland)		87777	Australia
Table (B.T. Burland)		87679	Australia
Communications Apparatus (Design & Development Group, Telecom Australia Workshops)	8087/84		Australia
Telephone (B.T. Burland & N.E. Joseph)	1328/85		Australia
Telephone Plug (A.R. Pickering)	1327/85		Australia
Base Plate for a Telephone (D. Atkins)	1765/85		Australia
Telephone Handset (D. Atkins)	1766/86		Australia
Telephone (D. Atkins)	1767/85		Australia
Telephone (D. Atkins)	1768/85		Australia
Pipe Bushes (J.C. Wilson & D.L. Evangelista)	2259/85		Australia

Visitors to the Laboratories

The work of the Laboratories often calls for close liason with various Australian universities and other tertiary educational institutions 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 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. Some of the groups and individuals who visited the Laboratories during the year are listed below:

- Professor P. Silvester of McGill University, Canada, for consultation on computer simulation of the thermal behaviour of repeater shelters, four-wave mixing experiments and complex optical components using the finite element method.
- Professor D. Lowther of McGill University, Canada, for consultation on the numerical modelling of bio-electromagnetic hazards and antenna designs and on the design and use of computer graphics in complex geometric and material modelling studies.
- Mr C. Vernon of the New Zealand Post Office and Mr R. Prosser of Austral Standard Cables (NZ) Pty. Ltd., for discussions with senior staff on plastics insulants for telecommunications cables and optical fibre cable developments.
- Dr Ogawa, Director of KDD (Japan) Liason Office, Sydney, accompanied by Mr D. Charrett, OTC (Australia), for discussions with senior staff on new technology and future telecommunications systems.
- A delegation of senior managers of the Telephone Organisation of Thailand, comprising Messers S. Vanichseni, S. Bruminhent and S. Sresta-Sathiern, for discussions under the agreement on co-operation between the Telephone Organisation of Thailand and Telecom Australia. The purpose of this visit was to inspect and discuss various aspects of work in the areas of digital radio transmission, ISDN exchanges, photovoltaic cells and the digital radio concentrator system for rural services provision.
- Messrs G. Moore and N. Dean, of British Insulated Calander Cables (UK), accompanied by Messrs G. Dangerfield and P. Robinson, of Austral Standard Cables Ltd., for discussions on gallium arsenide lasers, optical fibres and polymers.
- Mr R. Henderson, Scientific Advisor to the RAAF, Defence Science and Technology Organisation, for discussions of research related to solid state electronics, optical technology, high voltage protection and integrated circuit reliability.
- Members of the Commonwealth Science Council Training Workshop, to see and discuss work in the fields of heat mirrors, amorphous silicon solar cells, remote area power supplies, environmental testing and photovoltaic arrays.
- Delegates and attendees from the ANZAAS Conference at Monash University, for guided tours through the Research Laboratories as part of the ANZAAS Conference programme.
- A group of about 35 Electrical/Electronics Teachers from Colleges for Technical and Further Education, the theme of the visit being "Changing Technology within the Electrical and Electronics Fields". After a brief presentation on the roles and functions of the Laboratories, the visitors toured a number of laboratory areas to inspect and discuss projects such as microelectronics, voice services and optical systems.

Overseas Visits by Laboratories' Staff

It is an important responsibility of any viable research 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:

J. Billington	J.R. Lowing
E.K. Chew	P.F. Meggs
R.P. Coutts	P.I. Mikelaitis
J.K. Craick	J.L. Park
B.P. Cranston	D.J. Richards
B.T. Dingle	P.V.H. Sabine
R. Exner	B.M. Smith
J.R. Godfrey	M. Subocz
K.J. Hinton	E.M. Swenson
G.F. Jenkinson	J. Thompson
P.C. Kemeny	R.E. Warfield

Assistance with Studies

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

The following staff have been engaged in sponsored tertiary studies or development training programmes during the past year:

- M.J. Biggar, Postgraduate Scholarship leading to Doctorate of Philosophy, Imperial College of Science and Technology, London, UK.
- R.W. Rydz, Undergraduate Scholarship, Swinburne Institute of Technology, course for the Degree of Bachelor of Engineering.
- G.C. Heinze, Development Training Programme Award, British Telecom, Martlesham, UK, and Hewlett-Packard, USA.
- A.J. Murfett, Development Training Programme Award, Japanese Government Electrotechnical Laboratory, Ibaraki, Japan.

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 Organisation (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 Australian Telecomunications and Electronics Research Board (ATERB).

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.

During 1985/86, the Research Laboratories have managed a portfolio of 14 R&D contracts with industry (total value $2.1 million) and 40 R&D contracts with other R&D institutions and academia (total value $1.8 million). The durations of the contracts vary from less than one to several years.

Total expenditures on extramural R&D by the Research Laboratories in 1985/86 will be approximately $1.5 million. Of this total, $0.25 million will be disbursed to academia via ATERB for R&D on telecommunications topics. The remainder comprises direct payments made to R&D contractors and occasional specialist consultants.

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

(i) Contracts with Industry

Research investigations of:-

- Static Fatigue in Damaged Optical Fibres
- A Low-Traffic Common Channel Signalling System No. 7 Terminal
- Services Interworking, Communications Protocols and Interfaces utilising an Experimental ISDN Exchange
- Cellular Digital Radio Transmission Systems for Mobile Services

Development of:-

- A Digital Transmission Error Performance Analyser
- A Gas Corrosion Test Facility
- A Large Weathering Chamber
- A Multiple Output ISDN Line Signal Generator
- A Dual-module Digital Cross Connect Switch
- An Optical Regenerator Test Instrument
- A Message Transfer Agent for Computer-based Messaging Systems
- An Announcing Machine for the Speaking Clock Service
- An Image Analysis System for Measurements of the Geometry of Single Mode Optical Fibres
- Software for Implementing Transport Layer Communications Protocols.

(ii) Contracts with Academia, CSIRO, etc

Research investigations of:-

- Customer Reactions to Telephone Circuit Propagation Delays
- Factors Influencing Electrical Deterioration of Plastics Spacers in Coaxial Cables
- Spectral Properties and Error Probabilities of Block Codes in Digital Transmission
- Receiver Structures for Optical Fibre Transmission Systems
- Adaptive Digital Hybrid Transmission Networks
- Effects of Bismuth Impurity Levels in Lead-Acid Batteries
- Stress Relaxation in Thermo-shrink Cable Jointing Sleeves
- Performance of Packet Switching Networks Interworking with Standardised Communications Protocols
- Application of Control Theory in Dynamic Routing of Communications Links
- Computer-aided Graphics for the Specification and Description Language (SDL) for Communications Networks and Protocols
- Fault-tolerant Microcomputer Systems
- Dimensioning Techniques for Non-hierarchical Digital Networks
- Equalisers for Digital Subscribers Loops
- Capacity of Time Division Multiple Access (TDMA) Satellite Communications Systems
- Computer-aided Design Techniques for a Digital Switch Device
- Metal-Insulator Semiconductor Structures
- A Double-ring Local Area Network
- Computer-based Graphics for Computer-aided Specification and Validation of Communications Protocols
- Fluoride Glass Systems for Mid-Infra-Red Optical Fibres
- Packaging Techniques for VLSI Circuits
- Customer Access Principles for an Integrated Services Digital Network (ISDN) Environment
- On-line Computer-based Directory Database Structures
- Integrated Voice/Data Local Area Networks
- Computer-aided Specification and Design Techniques for VLSI Circuits
- Advanced Design and Testing Techniques for VLSI Circuits
- Rules for the Automated Production of Speech from Text
- A Long Wavelength (1.55 micron) Optical Time Domain Reflectometer
- Millimetre Wave Digital Radio Systems
- Optical Phase Modulators
- Circuit Design Techniques for Optical Communications Systems
- Effects of Amplitude Inversion on Timing Extraction in the Transmission of Digital Signals
- Termite Resistance of Modified PVC Materials for Cable Sheaths
- Contours of Lightning Strike Intensities and Occurrences in Australia
- Techniques for the Thermal Modelling of Buildings
- Computer Tools Employing the Calculus of Communicating Systems for Protocol Specification and Analysis
- Optical Switch Technology
- Digital Switchblock Device Technology
- Wideband Switching in the Optical Domain.

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

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