Research Laboratories' Review of Activities 1984-85

Telecom Australia

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Review of Activities 1984-85

Research Laboratories, 770 Blackburn Road, Clayton, Victoria 3168 Australia

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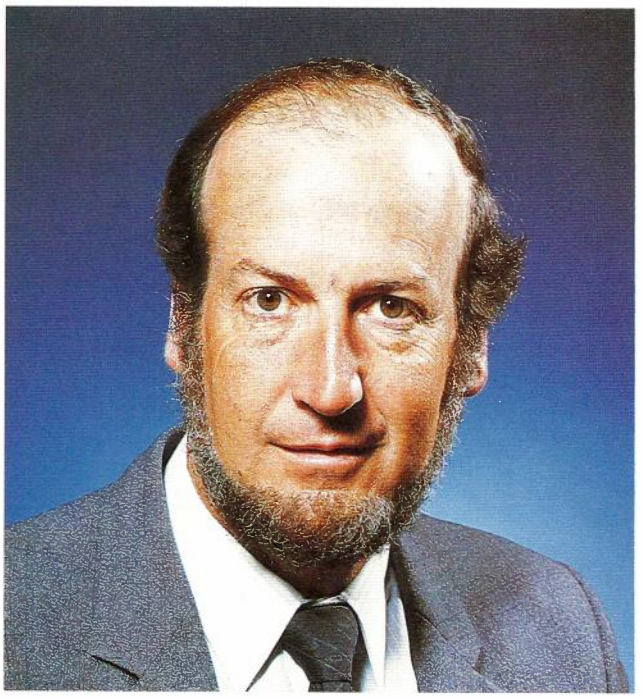
Foreword

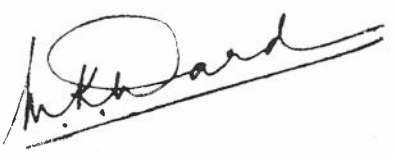


With its geographical separation from the world centres of telecommunications R&D, Telecom Australia is aware of its need to conduct in-house research and development projects to investigate advances in telecommunications techniques and technology, selected on the basis of their relevance to the Australian telecommunications environment. In doing so, Telecom is able to develop and maintain an independent competence to plan, specify and provide new and improved customer services and to develop the Australian national network infrastructure - making effective and timely use of new products of the world telecommunications industry to provide world standard telecommunications services to the people of Australia at minimum cost.

We are living in times of rapid and major advances in the technology and techniques of telecommunications and computer services. These advances are founded on microelectronic devices, optical fibre cables, distributed computer control of networking systems, and digital switching and transmission. Telecom's limited R&D resources do not permit comprehensive coverage of all advances in these areas. However, by careful project selection, Telecom's Research Laboratories seek to develop technical knowledge of key advances relevant to Telecom Australia's corporate plans, and thereby to provide timely technical advice to the other Departments of Telecom which are charged with the responsibility for planning, implementing and operating new customer services or network developments.

The work of the Laboratories also provides a basis for some of Telecom Australia's contributions to the studies of international organisations engaged in the development of telecommunications standards. These include the Committees of the International Telecommunications Union (ITU) and the International Standards Organisation (ISO).

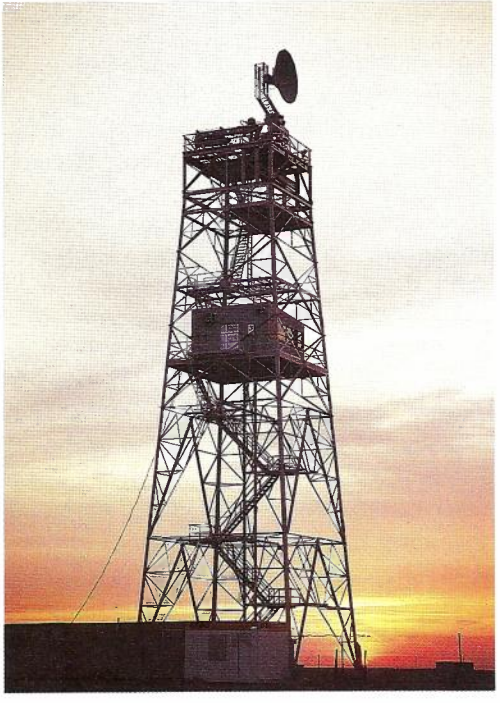
This review of the activities being undertaken by Telecom's Research Laboratories in 1984/85 is intended to illustrate the scope and purpose of Telecom's R&D programme. It demonstrates Telecom Australia's commitment to stay abreast of and, where possible, to contribute to world developments in telecommunications.



M.K. WARD

CHIEF GENERAL MANAGER

Our Cover



The cover photograph shows the receiver site antenna tower silhouetted against the setting sun at Telecom Australia's new antenna test range at Caldermeade, Victoria. The antenna under test is mounted on a rotatable platform at the top of the tower. The platform is controlled from the measurement cabin half way up the tower. The cabin also houses computer-controlled equipment for measuring and analysing signals received from the distant, calibrated source antenna.

Contents

The Role of The Research Laboratories

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

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

The Research Department, known as the Telecom Australia Research Laboratories, is the focal point for much of Telecom's research and development effort. The Laboratories began in 1923 as a Section in the Headquarters Administration of the then Postmaster-General's Department, having been established to provide specialist technical advice to the Chief Engineer on "the latest discoveries, inventions and developments in electrical communications and their promising and likely benefits to the Department's telephone and telegraph services".

Today, the Laboratories are a Department in the Headquarters Administration of Telecom, and the Director, Research, is directly responsible to the Chief General Manager.

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

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

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

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

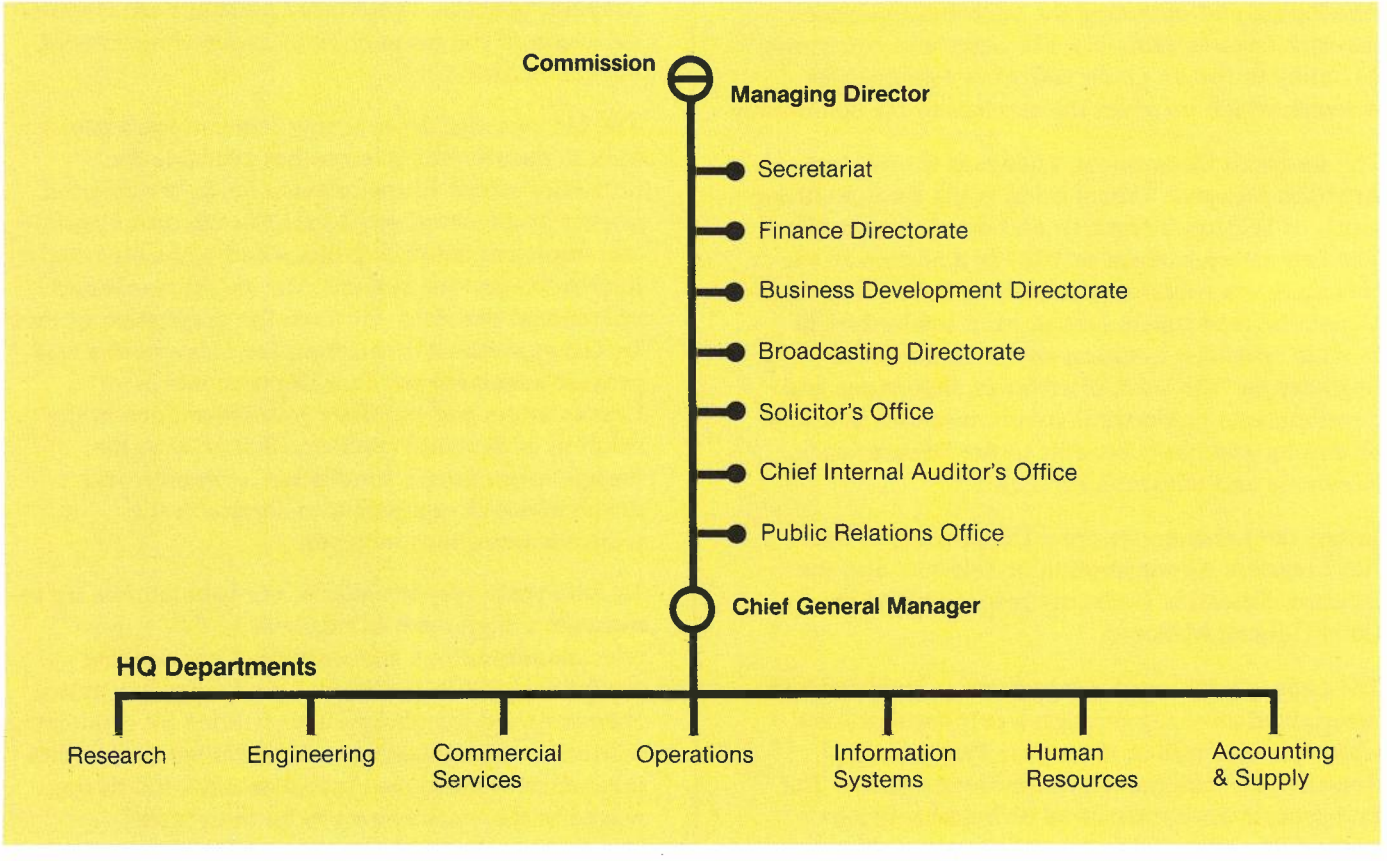
Many of the innovations, ideas and improvements proposed for the Australian network originate overseas. However, it is necessary for Telecom to have advance knowledge of these developments so that they can be evaluated soundly on social, economic and technical grounds, before they are accepted or adapted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

Most of the projects undertaken by the Laboratories, rather than being directed at manufacturing or production specifications, find their ultimate expression in the performance requirements incorporated in procurement specifications for the systems and equipment which are bought by Telecom from the international telecommunications industry. Other work is expressed in the assessment of materials, components and assembly practices used by suppliers in equipment tendered against Telecom procurement specifications. Occasionally, a project is carried to production when it is evident that the initial, experimental development performed by the Laboratories will yield equipment directly suitable for field application.

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

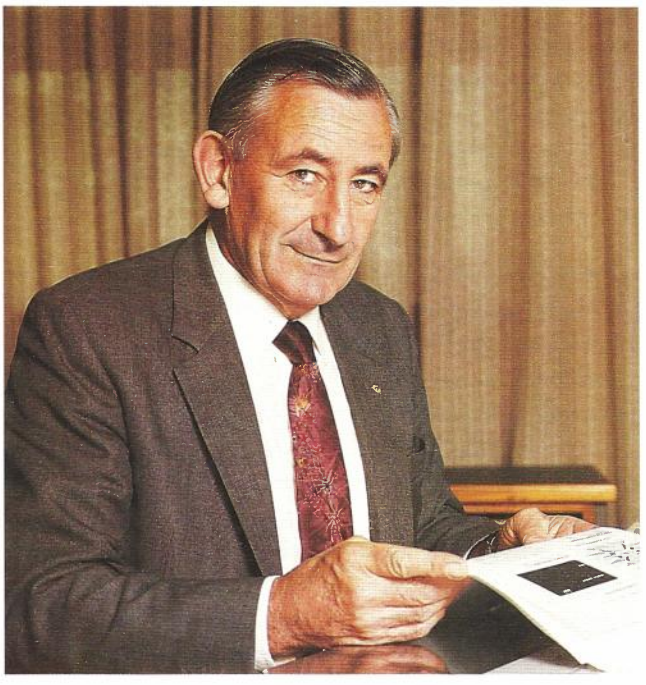
Telecom, through its Research Laboratories, recognises the great variety and depth of research talent which exists in centres of higher learning and in industry in Australia. The Laboratories encourage these other research organisations to undertake specific projects of interest to Telecom and act as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

The role of the Research Laboratories remains basically the same as it was when they were first established. In essence, their basic function is to develop knowledge and skills in the advancing areas of telecommunications science and technology to assist Telecom to decide when, and to what extent, new technology is to be harnessed to provide new or improved customer services and systems. In the selection of activities reported in the following pages, this edition of the Review of Activities of the Research Laboratories illustrates the ways in which the Laboratories have sought to fulfil their role during 1984/85.



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

Items of Special Interest



Edward F. Sandbach, AM, BA, BSc, FIE Aust., FTS

Edward F. Sandbach, AM, BA, BSc, FIE Aust., FTS, Retires

On 23 January 1985, Ed Sandbach retired from the position of Director, Research, after a lifetime and distinguished career in telecommunications. Throughout his career, Ed's professional and thorough approach has been a common hallmark of his many contributions to the advancement of telecommunications, both in Australia and in international forums where Ed represented Australian interests.

Ed joined the then Postmaster General's (PMG) Department as a Clerk in 1941. Subsequently graduating as a Bachelor of Science with honours in Physics and Radiophysics from Melbourne University, he joined the Radio Section of the Department's Research Laboratories as an acting Engineer in 1943, where he participated in early investigations of time division multiplexed, pulse operated microwave radio systems. Following a period of further study as a Cadet Engineer, Ed gained his Bachelor of Arts degree from Melbourne University, majoring in mathematics, before he re-joined the Laboratories as an Engineer engaged on VHF and UHF multi-channel radio system developments.

In 1948, Ed was placed in charge of the Time and Frequency Standards Division of the Laboratories. Over the next 15 years, he was responsible for a number of important developments of the PMG Department's reference frequency standards and associated equipment facilities. These developments included the design and commissioning of new standards built around high precision 100 kHz ring crystals, the introduction of the Speaking Clock Service, the development of VLF phase tracking techniques for precise inter-continental frequency comparisons, experiments with an ammonia MASER, the introduction of standard frequency and time broadcasts from Radio Australia's site at Lyndhurst, Victoria, and early investigations of caesium atomic clocks offering a hundredfold improvement in their frequency stability.

During 1964, Mr Sandbach was promoted to the position of Assistant Director-General in charge of the Apparatus and Services Branch of the Laboratories. In this position, he was responsible for the Laboratories' functions relating to the physical sciences, reference standards and laboratory services and facilities. In a later re-organisation of the Laboratories, the Branch was re-named the Applied Science and Laboratory Services Branch. Whilst in this position, Ed played a key role in the re-establishment of the Laboratories in new, much-improved buildings at Clayton.

During 1967, Ed completed the advanced management course at the Australian Administrative Staff College.

With further growth and re-organisation of the Laboratories, the physical sciences functions were separated and given Branch status, and Mr Sandbach continued to fulfil the responsibilities of Assistant Director, Standards and Laboratories Engineering, until mid-1975, when the PMG's Department was dissolved and the Australian Telecommunications Commission (less formally known as Telecom Australia) was established on 1 July 1975. On this date, Ed succeeded to the position of Director, Research, responsible to the Chief General Manager for all R&D functions performed by the Research Department of the newly formed Commission. Mr Sandbach occupied this position until he retired.

During his career, Ed has made significant contributions not only to the operations of the PMG's Department and Telecom Australia in the development of the Australian national telecommunications network but also to the operations of national and international standards organisations, research organisations and academia.

With the development of satellite communication techniques, Ed, in conjunction with the late Mr E.R. Craig, was extensively involved in the activities of CCIR Study Group IV (Space Systems and Radio Astronomy) from 1962. For several years, he joined with personnel of OTC (Australia) to represent Australia at Intelsat Conferences. He led the Australian delegations to CCIR Plenary Assemblies in 1966, 1970 and 1974. He participated in the ITU Administrative Space Conferences in 1963 and 1971, and the Plenipotentiary Conferences in 1973 and 1982.

For many years, Mr Sandbach has contributed to the activities of several technical committees of the Standards Association of Australia (SAA). Over the last decade, he was Telecom Australia's representative on the Council and more recently, the Executive Board of the Council of the SAA. He was also a member, and recently Chairman, of the SAA Telecommunications and Electronics Standards Board and its Executive, and of the Australian Electrotechnical Committee of SAA. Another position related to measurement activities recently held by Mr Sandbach included chairmanship of the Electrical Registration Advisory Committee of the National Association of Testing Authorities (NATA).

Mr Sandbach was Telecom Australia's representative on the Radio Research Board, chairing the Board from 1981 to 1984. He is currently a member of the Victorian State Committee of CSIRO and a Fellow of the Australian Academy of Technological Sciences.

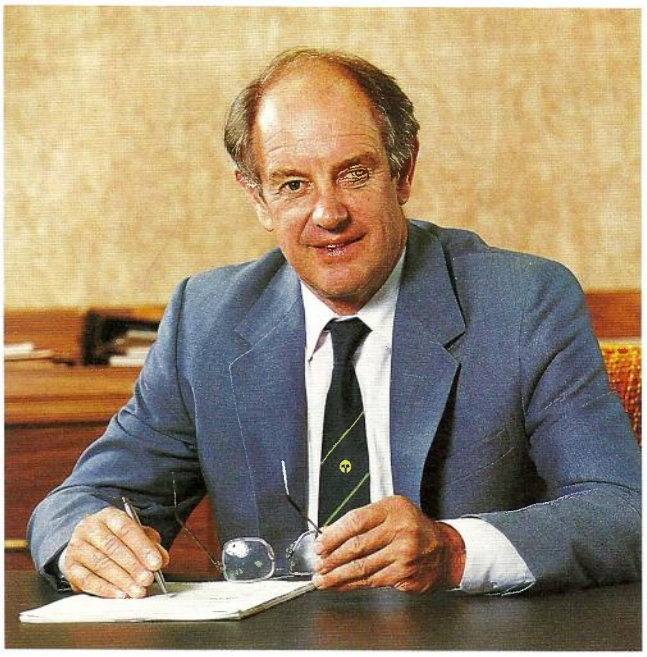
In 1981, Ed's distinguished career in the service of the Australian public was recognised by an award in the Queen's Birthday honours, whereby he was admitted to membership of the Order of Australia (General Division).

New Head of the Laboratories - Harry S. Wragge, BEE(Hons), MEngSc(Hons), MIE Aust.

Mr. Harry Wragge was promoted to the position of Director, Research, following the retirement of Mr Ed Sandbach in January 1985. Harry's previous office was that of Assistant Director in the Business Development Directorate at Headquarters, a post which he held for about two years. However, Harry is no stranger to the Laboratories, having spent most of his professional career as a member of the staff of the Laboratories - from 1955 to 1981.

Harry joined the Research Laboratories of the then Postmaster General's (PMG) Department in 1955 after completing a 5-year Departmental Cadetship during which he obtained the degrees of Bachelor of Electrical Engineering (First Class Honours) and Master of Engineering Science (Honours) from Melbourne University.

In 1956, Mr. Wragge was promoted to the position of Divisional Engineer (later classified Engineer Class 3) in charge of the VF Transmission, Switching and Signalling Division of the Laboratories; he occupied this position until 1963. In this period, he was concerned with the first applications of transistors in network systems and equipment, including the development of an experimental, all-electronic PABX about 1960. Harry led the development of the Laboratories' research activities in the switching and signalling field until 1979, earning successive promotions up to Assistant Director-General, Switching and Signalling, in 1972. When Telecom Australia was formed in 1975, Harry continued this work in the re-named office of Assistant Director, Switching and Signalling. This era saw a significant growth in research and experimental development on switching and signalling topics in the Laboratories, and as a result, an increase in Telecom's participation in the activities of relevant CCITT Study Groups. Notable achievements of this period under Harry's leadership include the development of an experimental, all-electronic, stored program controlled (SPC) tandem exchange which utilised digital techniques to integrate switching and transmission (IST) functions. This experimental development was a notable "first" for Australia and was among the first in the world. This SPC/IST exchange provided a test bed for early studies and the development of expertise within PMG/Telecom in the fields of SPC techniques, digital switching and transmission techniques and the emerging logic/memory device technologies. Studies of processor loading and exchange traffic capacity were performed with the aid of this "test bed", and this work enabled



◁ *Harry S. Wragge, BEE(Hons), MEngSc(Hons), MIE Aust.*

Australia to join in international trials of the CCITT No 6 Common Channel Signalling System in the early 1970s. Following laboratory trials, the IST tandem exchange was placed on field trial, in August 1974, in service in the Melbourne telephone network, using PCM transmission systems for network interfacing. The exchange successfully and reliably carried live traffic for the 4-year period of the trial and also provided a basis for further investigations of remotely controlled switching stages and of exchange management and maintenance practices relevant to the new SPC control techniques. The knowledge gained during this era assisted Telecom's planning studies which were ultimately expressed in the decision to move from crossbar exchange technology to SPC digital technology in the latter half of the 1970s. Research studies on the new topic of data switching techniques followed on as a natural extension of the work on telephone switching, developed under Mr. Wragge's leadership.

In July 1979, following a re-organisation of the Laboratories, Harry moved to a new field of customer-services-oriented research, taking up the office of Assistant Director in charge of the newly established Customer Systems and Facilities Branch. In this position, Harry led the development of an extended programme of research activity into new types of services, which were becoming realisable with new technologies. This work anticipated the demands which were emerging from the needs of business for computer-based services, and which would impact strongly on Telecom's planning studies and future actions to implement the integrated services digital network (ISDN) concept in Australia. This work engaged the attention of both engineers and applied scientists, and also of social scientists, reflecting the growing concern of Telecom to ascertain the social and business needs of its customers in a future of service diversification and multi-service networks.

Throughout his period as a member of Laboratories' staff, Harry has been involved in the activities of the CCITT. In particular, from 1976 to 1980, he was Vice-Chairman of the CCITT Study Group which was concerned with the development of standards for digital networks.

In November 1981, Harry was seconded to assist the Director, Business Development, in the presentation of Telecom Australia's case to the Inquiry commissioned by the Government (better known as the Davidson Inquiry) into Telecommunications in Australia. In May 1985, following the publication of the Inquiry Report and the clarification of Telecom's role by the Government, Mr Wragge was promoted to the position of an Assistant Director in the Business Development Directorate, where he was concerned with strategic business studies and the formulation of Telecom's strategies relating to the interconnection of private networks, industry relationships and charging principles.

Throughout his professional career, Mr Wragge has been an active member of the Institution of Engineers (Australia) and of the Telecommunication Society of Australia. He was chairman of the Institution's National Committee on Electronics and Communications from 1976 to 1979 and a member of the Board of the Institution's College of Electrical Engineering from 1969 to 1978. Harry has not only contributed papers to the publications of the Telecommunication Society but served as a foundation member of the Editorial Board of "Australian Telecommunication Research" from 1968 to 1982.

Harry's personal interests include sailing and also yachting administration. He was Commodore of the Frankston Yacht Club from 1978 to 1981 and is currently Junior Vice-President of the Victorian Yachting Council.

Mr Barry O. Jones, Minister for Science & Technology, discusses the field trial of Common Channel Signalling System No. 7 with Mr M. Subocz (right) ▷

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 Hon. Barry O. Jones, MP, Minister for Science and Technology.

On 28 August 1984, the Honourable Barry O. Jones, then Minister for Science and Technology, visited the Research Laboratories.

The Minister was welcomed by Mr Ed Sandbach, Director, and Mr Roger Smith, Deputy Director, and discussed with them the functional role of the Laboratories in the Telecom Australia organisation and in the wider context of Australian telecommunications. The discussions covered matters such as the determination and effectiveness of the work programme of the Laboratories, working relationships of the Laboratories with other Departments of Telecom, and with industry, academia, standardisation organisations and other research institutions.

The discussions also extended to trends in telecommunications technology and their implications for a future information society. These matters were amplified when Mr Jones toured the Laboratories to inspect and discuss project work relating to:

- optical fibre and device technology for the 1990s
- cellular mobile radio systems
- the recent trial of the CCITT No 7 Common Channel Signalling System between Australia and Japan, and
- network aspects of the Integrated Services Digital Network.

(ii) Visits by Members of ASTEC Working Party

In July 1984, the Prime Minister commissioned the Australian Science and Technology Council (ASTEC) to conduct a study of telecommunications R&D in Australia. A previous, more general Government Inquiry (the "Ross Inquiry") into Commonwealth Laboratories had recommended, inter alia, that such a study should be undertaken.

The terms of reference for the ASTEC study required that it should cover:

- the nature and extent of telecommunications research and development in the public and private sectors in Australia;
- the degree of dependence of Australia's present and future telecommunications on imported technologies, and opportunities for the development and export of Australian technology; and
- the present and future roles of the Telecom Research Department, its capabilities and scale of operations, and the research and development inter-relations between Telecom (including its Research Department) and other relevant bodies.

ASTEC subsequently established a Working Party for the study. Its members were:

- Mr Lloyd Zampatti (Convenor)
- Professor John Carver
- Dr Peter Jones
- Mr Ken McLeod
- Professor Grahame Rigby

It was assisted by a Secretariat comprising Mr Ian Shortt, Mr Martin Wardrop and Dr Reg Coutts. Dr Coutts was seconded to ASTEC from Telecom's Laboratories to assist the Working Party.

In the course of its studies, the ASTEC Working Party visited Telecom Australia, and in particular, Telecom's Research Laboratories, on a number of occasions during 1984/85 for wide- ranging discussions with the Managing Director and Chief General Manager of Telecom and Heads of several Departments and Directorates. Members of the Working Party and its Secretariat visited the Laboratories on 4-5 occasions for in-depth discussions with management and staff of the role and work of the Laboratories and its working relationships both within Telecom and with external organisations.

At the time of writing, the ASTEC Working Party has almost completed its study and its report is awaited with considerable interest.

(iii) Visit by Mr R.W. Brander, British Telecom

On 22 October 1984, Mr R.W. Brander, Director, Systems Evolution and Standards, and Member of the Technology Executive of the Research Laboratories, British Telecom, visited the Laboratories. After general discussions with the Director and Assistant Directors on the functional role, works programme and working relationships of the Laboratories in the Australian context, Mr Brander visited a number of laboratories for discussions with Laboratories' staff on the following projects and activities:

- lightning detection and mapping in Australia
- solar cell panel evaluation
- reliability assessment of integrated circuit devices
- thick film circuit design and fabrication
- various ISDN-related studies, and
- optical fibre systems and associated device and fibre technologies.

(iv) Visit by Mr Edson Teracine, Head of the Telecommunications R&D Centre of the Brazilian PTT (TELEBRAS) and Messrs Graciosa, Filho and Franzin, Department Heads within the R&D Centre

On 29 October 1984, the above visitors were welcomed by the Director and Laboratories' management and, following the usual introductory overview discussions relating to the role and work of the Laboratories, they toured the Laboratories and inspected projects relating to:

- various aspects of ISDN evolution in Australia under investigation in Telecom Australia
- techniques and standardisation activities for the provision of customer access in multi-service networks
- digital reticulation in the subscriber network
- common channel signalling, and
- packet switched networks and services.

(v) Visit by Mr Reijiro Fukutomi, Executive Vice-President, NTTPC, Japan

On 7 November 1984, Mr Reijiro Fukutomi, NTTPC, Japan, visited the Research Laboratories.
Mr Fukutomi was welcomed by Mr Sandbach and other executive staff of the Laboratories and, in initial discussions, was acquainted with the overall role, size and objectives of the Laboratories and the general scope of Laboratories' activities.

Mr Fukutomi then toured the Laboratories for discussions with research staff on the following projects and activities:

- optical fibre and device technologies
- digital radio experiments
- satellite radio communications studies
- Common Channel Signalling System No. 7 field trial
- the ISDN experimental exchange project, and
- studies of standards for telematic services.

(vi) Visits by Overseas Delegates to ICCC'84

A number of visiting overseas experts took the opportunity to visit the Laboratories in association with their attendance as keynote speakers or delegates at the Seventh International Conference on Computer Communications (ICCC'84), which was hosted jointly by Telecom Australia and OTC(Australia) in Sydney from 30 October to 2 November, 1984. The visitors included:

- Mr A.J.T. Richardson, Head, Integrated Communications Group, British Telecom Research Laboratories, for discussions on customer services and systems, including office automation and telematic services
- Mr A.R. Willis, British Telecom Research Laboratories, for discussions on voice services, speech processing, switching technology, exchange maintenance systems and experimental digital switching systems
- Mr R. Calwallader, ICL, United Kingdom, for discussions on OSI protocols with Switching and Signalling Branch staff
- Ms Debaille and Ms Delosme of CNET, France and Mr R. Parodi of SIE, Italy, for general discussions on switching and signalling activities
- Mr N. Tolleshave of Siemens, Norway, for discussions on data networks and related activities.

(vii) Visits by three Delegations from the People's Republic of China

(a) On 18 December 1984, eight engineers and an interpreter from the Ministry of PTT, People's Republic of China visited the Laboratories. The visitors were:

Mr A. Martin (right) describes digital radio equipment functions to the Chinese Industrial Delegation ▷

- Mr Yang Zhaoqi — Chief Engineer of the Design Institute of the Ministry of PTT, People's Republic of China
- Mr Wang Yunfei — Deputy Chief of Division and Senior Engineer of the Department of Capital Construction, PTT
- Mr Chen Ruming — Deputy Chief Engineer of the Fourth Research Institute of the PTT
- Mr Huang Sanrong — Chief Engineer, Radiocommunications Division of the Design Institute, PTT
- Mr Jiang Honggud — Engineer, Design Institute, PTT
- Mr Zhung Wuyuan — Engineer, Planning Department, PTT
- Mr Lu Junhai — Engineer, Directorate-General of Telecommunications, PTT
- Mr Gao Feng Quan — Engineer, Department of Capital Construction, PTT
- Mr Li Yude — Interpreter, PTT.

The visitors met the Director and Laboratories' senior management, who outlined the role of the Laboratories, its relationships with other Departments in Telecom and its work programme. The visitors then toured a number of laboratory venues for presentations on:

- the Digital Radio Concentrator System (DRCS) project
- digital radio system (DRS) studies for trunk and junction applications
- studies of cellular radio techniques for mobile services
- transmission aspects of ISDN evolution
- research studies of advanced GaAs semiconductor devices
- antenna design and performance measurement, and
- satellite transmission studies.

(b) On 13 February 1985, another party from China visited the Laboratories. They were:

- Mr Qian Ziazhi — Chief Engineer, Department of Science and Technology, PTT
- Mr Wang Fenggui — Head of the Rural Telephone Division, PTT
- Mr. Yao Yongyang — Deputy Chief and Chief Engineer, Transmission Research Institute, PTT

After meeting the Acting Director, Mr Roger Smith, and senior Laboratories' staff for overview discussions of the Research Laboratories, the party visited a number of Laboratories' Sections and discussed the following topics:

- solar power for rural telecommunications
- satellite techniques/technology as applied to rural communications
- DRCS and DRS techniques and investigations, and
- Common Channel Signalling System No. 7 Trial and future applications of the system in IDN and ISDN evolution.

(c) On 7 March 1985, an industrial delegation from the Shandong Province of the People's Republic of China visited the Research Laboratories. The delegates were:

- Mr Cui Tian Zhu — Delegation Leader and Assistant Manager, Qingdao Electronics and Meters Industrial Co.

- Mr Xue Li Ai — Assistant Engineer, Qingdao Economic Planning Committee
- Mr Wu Kaizhen — Vice Chairman, Electronics Department, Shandong University
- Mr Li Wenyou — Manager, Qingdao Radio Factory
- Mr Liu Qizhe — Engineer, Qingdao Radio Factory.

After meeting the Acting Director, Mr Roger Smith, and senior Laboratories' staff for general discussions on the activities of the Laboratories, the visitors toured several laboratory areas for discussions of:

- solar power systems and solar cell module reliability in rural telecommunications applications
- Australia's proposed national satellite system, including related Laboratories' work on transponder simulation and rain attenuation measurements
- the Digital Radio Concentrator System project for rural and remote areas
- studies of digital radio system transmission techniques applicable to Australian transmission network developments, and
- the CCITT No. 7 Common Channel Signalling System field trial between Japan and Australia.

(viii) Visit by Mr Theodor Irmer, Bundespost (FTZ), Federal Republic of Germany

Mr T. Irmer, who is the the executive in charge of ISDN developments at FTZ and Chairman of CCITT Study Group XVIII, visited the Laboratories on 29 June 1984. Mr Irmer was welcomed by the Director, Mr Sandbach, and other members of the Laboratories' management team and was given a brief overview presentation on the Laboratories' functions and activities. Mr Irmer then discussed the following topics of mutual interest with selected Laboratories' staff:

- digital signalling and processing
- ISDN - customer access issues and switching aspects
- the development of technical standards for telematic services
- digital network synchronisation
- the CCSS No. 7 field trial
- data switching techniques and networks
- digital radio transmission techniques
- optical fibre transmission, and
- digital transmission techniques for the local distribution network.

The Laboratories Participate in International Tests of Open Systems Interconnection Protocols

The International Organisation for Standardisation (ISO) and the International Telegraph and Telephone Consultative Committee (CCITT) are developing standards to facilitate communication between different types of information processing systems across various data communication networks. These networks could include Telecom Australia's packet switched network, AUSTPAC, international networks, private networks or a number of networks in a relay. The key standard developed for this purpose is the Open Systems Interconnection (OSI) Reference Model, which provides a framework to facilitate the specification of protocols to support such communications. The Reference Model defines a layered architecture for data communication protocols.

The Network Layer is the third layer of the OSI hierarchy. The purpose of the Network Layer is to support the establishment and use of connections across all kinds of data communications media, e.g. leased lines, packet networks, local area networks and integrated services digital networks (ISDN), singly or in concatenation, such that uniform end-to-end communications functions are provided to the fourth or Transport Layer immediately above the Network Layer. The Network Layer isolates higher level protocols and applications from the characteristics of individual data networks.

The Transport Layer governs the use of network connections. The International Standard for the Transport Protocol specifies mechanisms that can be used in the end computer systems to control traffic in order to reduce charges, and to enhance error performance. The Transport Layer controls:

- the multiplexing of multiple transport connections onto one network connection
- the recovery from network resets and unintentional disconnection, and
- the detection of and recovery from data errors.

Five classes of transport protocol are selectable with respect to the required quality of service and the performance available from the network. Although the transport protocol is a terminal-to-terminal procedure, which is not implemented on Telecom's data switching networks, it can affect the customer's perception of the performance of Telecom's networks and the nature of the traffic offered to the network. Furthermore, some of Telecom's telematic services use the OSI Transport Protocols (e.g. Teletex employs class 0).

As part of a collaborative research project with the Australian Commonwealth Scientific and Industrial

Research Organisation (CSIRO), the Research Laboratories have produced Network Layer software that is being used with the Transport Layer software produced by the CSIRO to evaluate the behaviour and performance of this implementation of the Transport and Network protocols. Part of this evaluation included international tests with workers at the Uppsala Institute of Technology in Sweden which has its own implementations of Transport and Network Protocol software. These tests showed that a substantial amount of testing of an implementation is necessary before it will work reasonably well with other systems and showed again the importance of conducting tests with independently produced implementations.

The Network Layer software was developed using top-down design methods and partitioning into functional modules. Despite the short time allowed for the software design phase, the use of a well established design methodology proved its worth for a system of this size (8000 lines of Pascal source code for the Network Layer), as the resultant software modularity has allowed simple modifications to be carried out to the internal and external interfaces. This modularity will also help to reduce the future coding effort when the planned extensions to the software are made to allow further testing of the protocols.

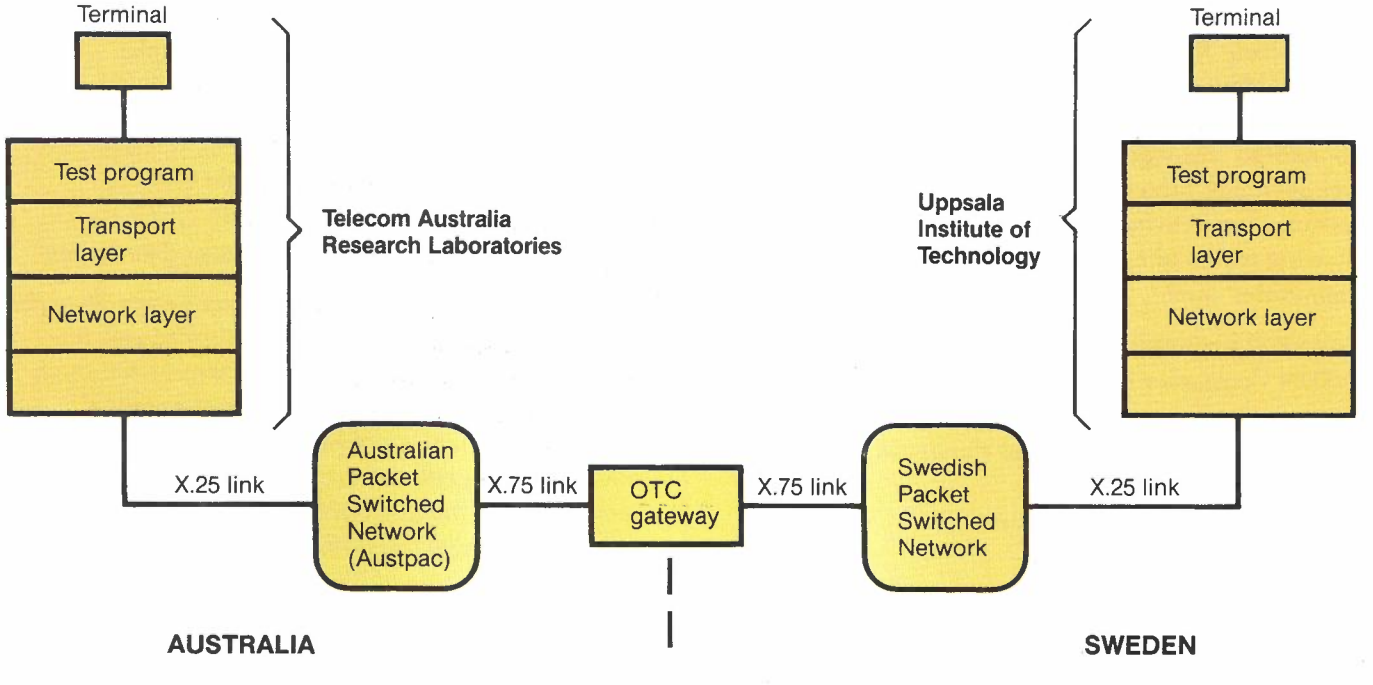
The Research Laboratories intend to use these protocols as the basis of future data communication experiments. The experience gained in evaluation of these protocols will aid this future objective and contribute to the improvement of these protocols.

Telecom's relocated Time and Frequency Standard installation (overview and close-up of operator's position) ▷

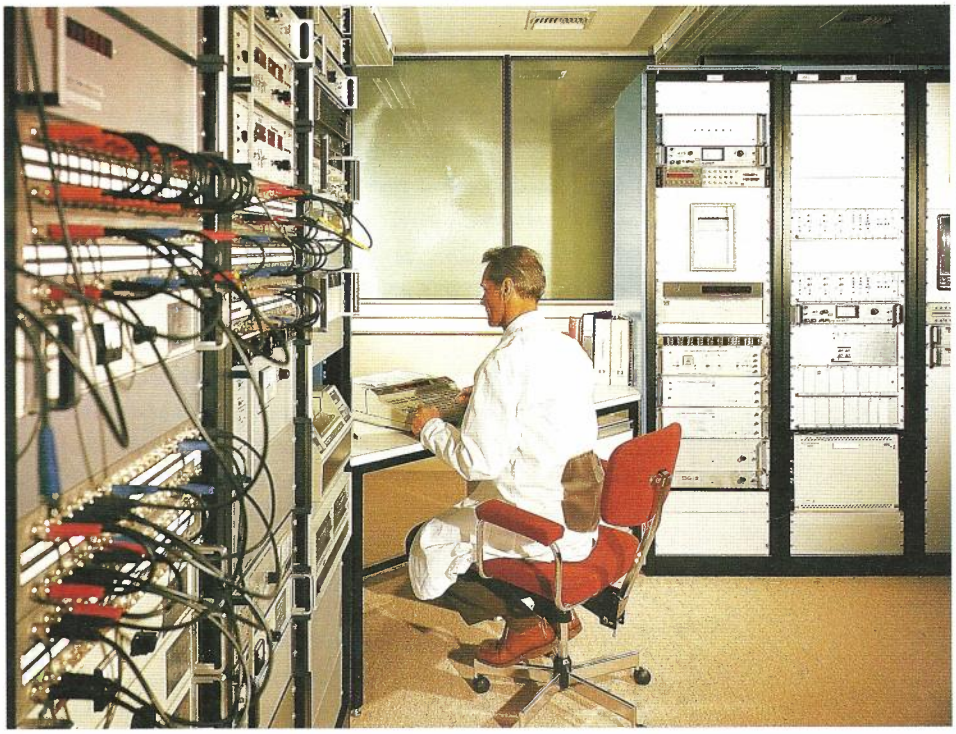
Relocation of Telecom's Time and Frequency Standard

Telecom Australia's Time and Frequency Standard is operated by the Research Laboratories to provide time and frequency references for the various telecommunications operations of Telecom Australia. The standard is also the basis of time and frequency services which are widely distributed by Telecom Australia and used by government departments, academic institutions, armed services, industry and the public.

The primary standard in the time and frequency standard installation is generated by seven caesium beam frequency standards, with backup provided by four rubidium vapour frequency standards and several quartz crystal oscillators. A clock system generates a time scale from the primary standard which is designated Co-ordinated Universal Time UTC(ATC).



Systems used in international tests of OSI protocols



Standard time and frequency signals are distributed from the Research Laboratories by cable pairs, broadband bearers and by radio transmissions. Examples include two tone distribution for the control of the trunk system master oscillators, distribution of local time signals and standard frequencies on cable pairs, and control signals for the Speaking Clocks and radio station VNG. The digital network is synchronised by control signals which are distributed via PCM links from the Time and Frequency Standard.

Commencing in May 1983, the Time and Frequency Standard was progressively moved from 59 Little Collins Street, Melbourne, to the new Research Laboratories' site at 770 Blackburn Road, Clayton, closing a 50-year period of timekeeping at the Little Collins Street site. The previous move of the Time and Frequency Standard occurred in September 1932, when the Laboratories moved from 360 Post Office Place, Melbourne, to the Little Collins Street premises.

The building at Clayton was designed to cater for the special environmental conditions required for the Time and Frequency Standard. Particular attention was paid to temperature and humidity control as well as vibration damping. Two air-conditioning systems are provided, a main system and a completely separate standby system.

Primary power for the Standard is provided from the normal 240V 50 Hz power mains as well as from a diesel alternator set. Essential equipment is powered from a set of batteries which are float charged from a

duplicated set of rectifiers. The whole area housing the Standard incorporates a gas flooding system to restrict any fire which may occur, with as little damage to the essential equipment as possible.

Antenna platforms and two towers are located on the roof of the building housing the Standard to support VLF, HF, VHF and UHF antennas for the reception of various time signals from terrestrial and satellite systems.

It was essential that, in moving from the City site to the Clayton site, standard "time" was not lost. This necessitated a staged, two part shift. Initially, only half the time and frequency standard was relocated and commissioned at Clayton. Distribution circuits for the transmission of standard time and frequency signals were set up and measured, and the calibration of incoming radio time signals was carried out. Portable caesium beam frequency standards were used to make measurements of time signals at both sites to ensure that both were "on time" before the remainder of the old installation was transferred to Clayton.These special procedures ensured that the move to the new premises did not affect the operations of the many users of time and frequency services throughout Australia. From the user's point of view, the time standards continued operating without "missing a beat" during the whole of the transfer of the Standard to Clayton.

New Telecom Antenna Test Range, Caldermeade

For many years, the Laboratories have operated testing facilities for the performance evaluation of a wide range of telecommunications antennas. In recent years, the relocation of the Laboratories at Clayton separated them from the leased antenna test range at Mt. Cottrell by a distance of 48 kilometres. This separation, together with the impending expiry of the lease and the desire for improved antenna test facilities which were site-dependent, resulted in action to re-establish and enhance Telecom's outdoor antenna test facilities at a more convenient and expansive site at Caldermeade, Victoria.

The decision to commit the necessary capital expenditure to establish the new facility reflects Telecom's view that antenna testing will remain an important activity in the future. It is anticipated that, over the next decade, increased numbers of radio services will be connected direct to customers. High capacity, cellular mobile radio services, point-to-multipoint networks and small-terminal satellite

Receive site tower at the Caldermeade antenna test range ▷

communications systems will use antennas with relatively sophisticated performance characteristics, to help overcome the problems of operating in crowded or difficult radio environments. From past experience with trunk, mobile and point-to-point radio services, new antenna types and innovative developments will require characterisation.

The new antenna test range at Caldermeade has been designed to provide the facilities for measurements of a wide range of antennas for present and future telecommunications applications. As such, it will be the most advanced outdoor antenna test range in Australia. During the past year, work to establish the new facility has almost been completed.

The ideal test environment for measuring far-field antenna performance can, by careful design, be approximated by practical ranges. A source antenna at a transmit site is used to illuminate the test antenna at a receiver site. These two sites must be separated sufficiently to give an adequate approximation to ideal conditions over the aperture of the test antenna.

Antenna ranges can be divided into two basic categories, depending on whether they make use of the ground reflected signal or not. Ranges which use the latter technique try to minimise all reflections and are called slant or elevated ranges. Each particular type of range has relative advantages and disadvantages. The Caldermeade range makes use of the ground reflection, and test conditions can be carefully controlled to ensure credible measurement accuracy.

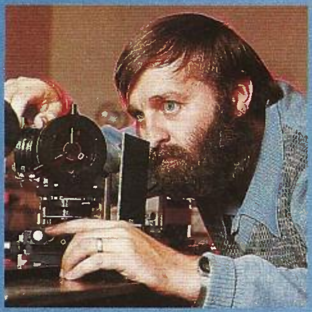
The Caldermeade range is the longest modern ground reflection range in Australia. Other major features are its capacity for the measurement of large

aperture antennas and its computer-based measurement and control system which fully automates range operation.

The receiver site is outfitted with a thirty metre tower, which carries a rotator on which the test antenna is mounted. The tower also incorporates a measurement cabin which houses receiving and computing equipment. The transmit mast and associated equipment are mounted on a trailer, enabling it to be moved to a number of locations on the range. Three range lengths will mainly be used, namely, 2400, 1560 and 440 metres.

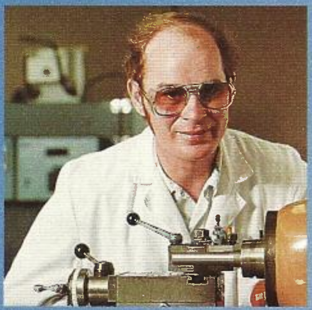
By proper choice of the appropriate range length, high measurement accuracy can be achieved. When measuring very low sidelobe antennas or very large aperture satellite earth-station and terrestrial antennas, long range lengths are required. For wide beam antennas however, shorter ranges are preferred, to avoid receiving any spurious reflections that could otherwise occur.

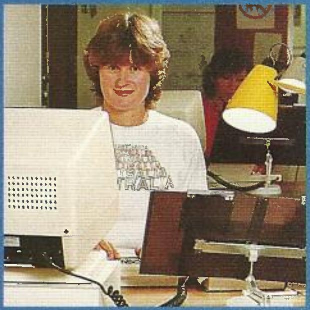
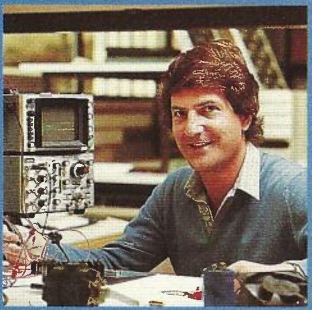
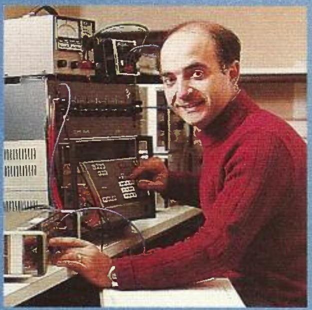
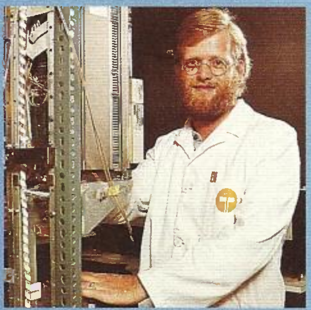
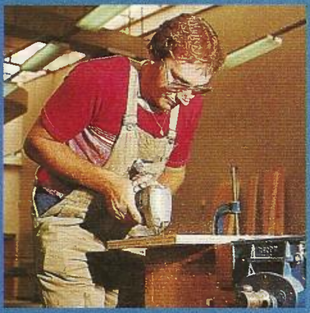
A major feature of the range is its computer-based control and measurement system. This menu-driven system automatically positions the transmit and receive antennas, sets source and receiving instruments, and stores measured data. Measurements which can be performed over the frequency range from 20 MHz to 40 GHz include those relating to gain characterisation, co- and cross-polar radiation patterns, return loss, bandwidth, and aperture probing.



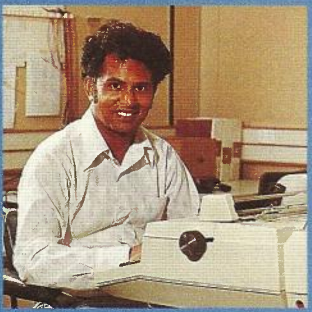








A Selective Review of Current Activities

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", which is available to selected bodies with more specific interest in the work of the Laboratories.

The normal method of publishing the detailed results of a research project is through a Research Laboratories Report, prepared when an investigation has reached a conclusion or a conclusive stage. The report is the vehicle by which the results of the work are conveyed to the "client" and other interested 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.

Learning Processes in the Use of Complex Telecommunications Services

How can new telecommunications services be made easy for people to use? As a step towards answering this question, the Research Laboratories are studying the learning processes of new users as they interact with a computer-simulation of a telecommunications system for message handling.

Ideally, a new user should be able to access the system and select the options needed to complete his or her task without any instruction. Early experiments attempted to make the system's functions self-evident by choosing appropriate names to represent them. The first tests were pen and paper studies in which people rated how clearly each of three alternative names described a number of message handling functions. Subsequent studies showed that the performance of people operating the simulated messaging system and using the most-preferred names was better than that of people using the least-preferred names. However, with all three sets of names, people had initial difficulties, but improved their performance rapidly over the course of the four experimental tasks.

Further experiments were carried out to identify the source of this improvement. Some people were re-tested and others were given various forms of pen and paper training before they completed tasks using the simulated messaging system. It became clear that improvements were not related so much to practice using the messaging terminal, learning the layout of information or learning the particular names assigned to each messaging function, as to a person's understanding of the overall concept of how the messaging system was organised. Once this concept had been grasped, it was found that people could complete the messaging tasks reasonably efficiently, and retained their skills without additional practice for at least a month.

Consequently, the current direction of the Laboratories' study of this topic is to investigate how the "concept" of the system can best be made apparent to new users, for example, by providing on-line training or help functions, and to establish whether the factors studied so far operate similarly in a more complex version of the messaging system.

Time Signal Distribution

Telecom Australia now provides time signals for public broadcasting in most states of Australia. From its Research Laboratories reference time standard at Clayton, Telecom distributes a serial time code which contains time of day, day number and time signal information. This code is distributed to the main exchange in each capital city and hence via special distribution equipment to radio stations and other users throughout Australia.

Three time signals are provided, namely, seconds pulses, six pips per minute and six pips per hour signals. The latter is that normally broadcast by radio stations.

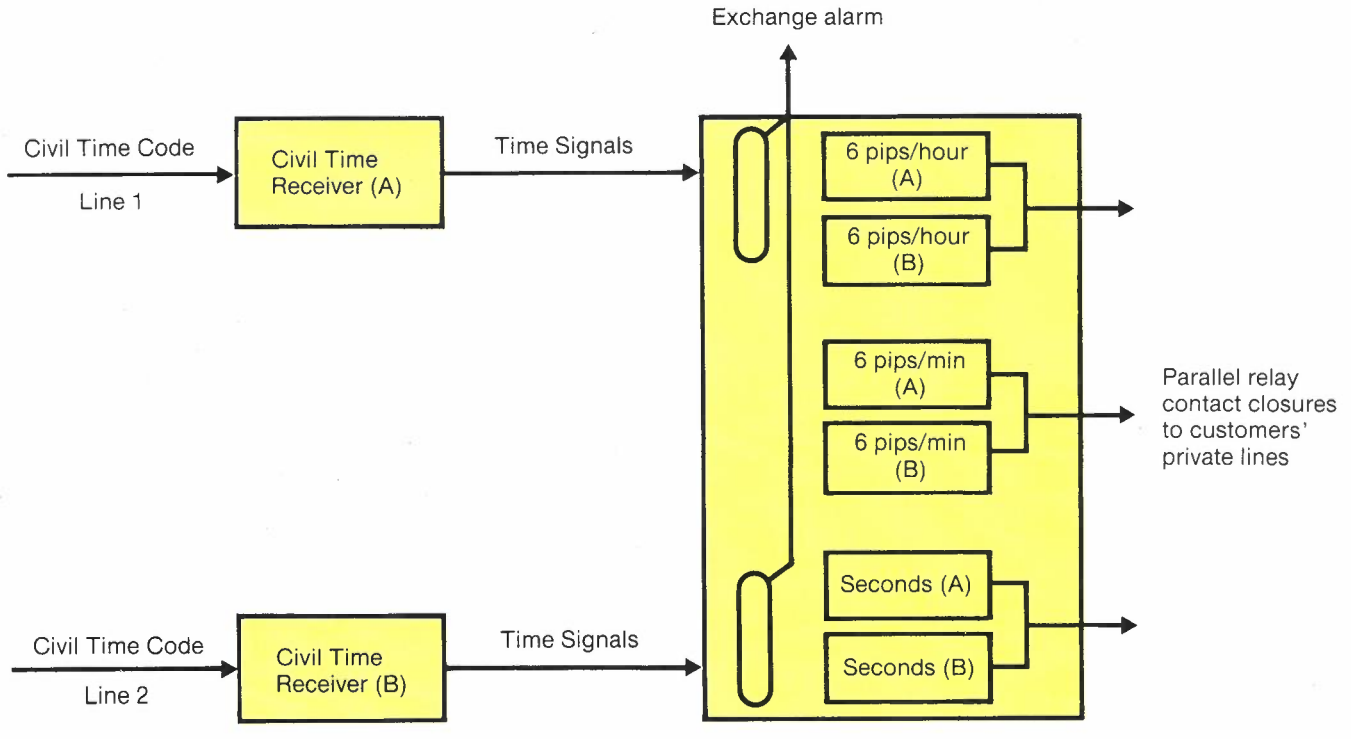
The Research Laboratories are now developing new time signal distribution equipment to replace old equipment in the Melbourne and Sydney exchanges and provide new services in Brisbane and Hobart. The installation of this equipment will be undertaken in conjunction with the installation of new microprocessor-based speaking clock equipment.

The civil time code is distributed over separate lines on diverse routes through the network to the main exchanges, ensuring maximum reliability of operation. At each main exchange, two civil time code receivers accept the incoming signals and passes them to a distribution unit. The distribution unit contains paired groups of relays whose contacts are parallelled to provide contact closures to customers' private lines. The use of relay contact closures allows the customer's terminal equipment to apply a range of voltages or signals to the line to suit particular applications and thereby provides maximum flexibility in the use of the time signals by the customer.

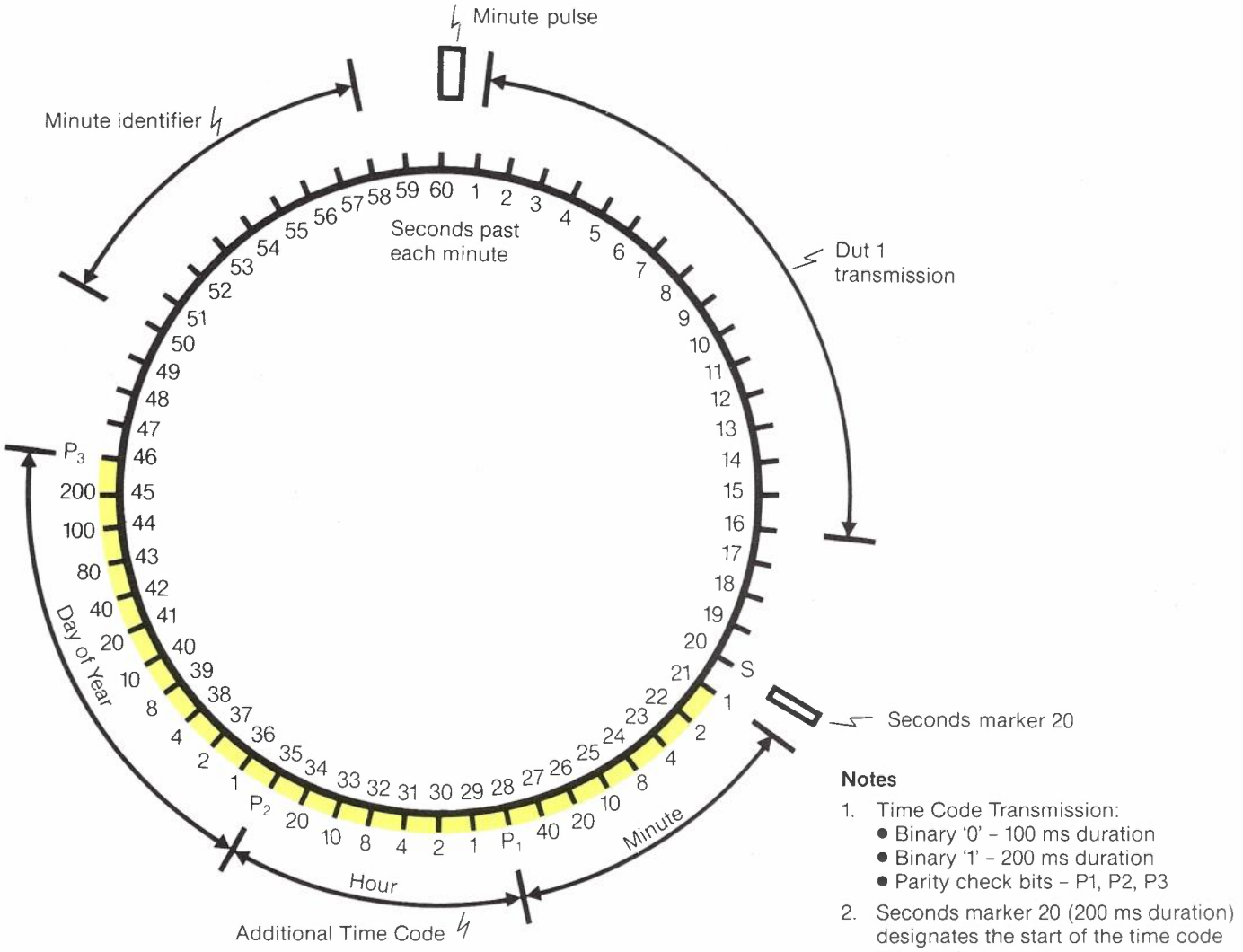
New Time Code for VNG

A short wave standard frequency and time signal broadcasting service (VNG) has operated from Radio Lyndhurst, Victoria, for 20 years. Telecom's Research Laboratories were responsible for the initial establishment of the service and continue to maintain the carrier frequencies and instant of time, as transmitted, to within close tolerances of Telecom's reference standards of time and frequency, which are operated at the Laboratories complex at Clayton.

In the Laboratories, work is in hand to update and



Time signal distribution equipment at main exchanges



VNG time code format

implement an enhanced broadcast time code format which will add time of day and day number of the year information without alteration to the existing minute, 5-minute and 10-minute identifying sequences or DUT1 coding. (The DUT1 Code relates the deviation between the Earth's angular position time scale UT1 and the Co-ordinated Universal Time Scale UTC). The addition of this extra information will enable time code receivers to operate directly from the received signal by decoding the pulse sequences and updating a receiver's time output completely every minute.

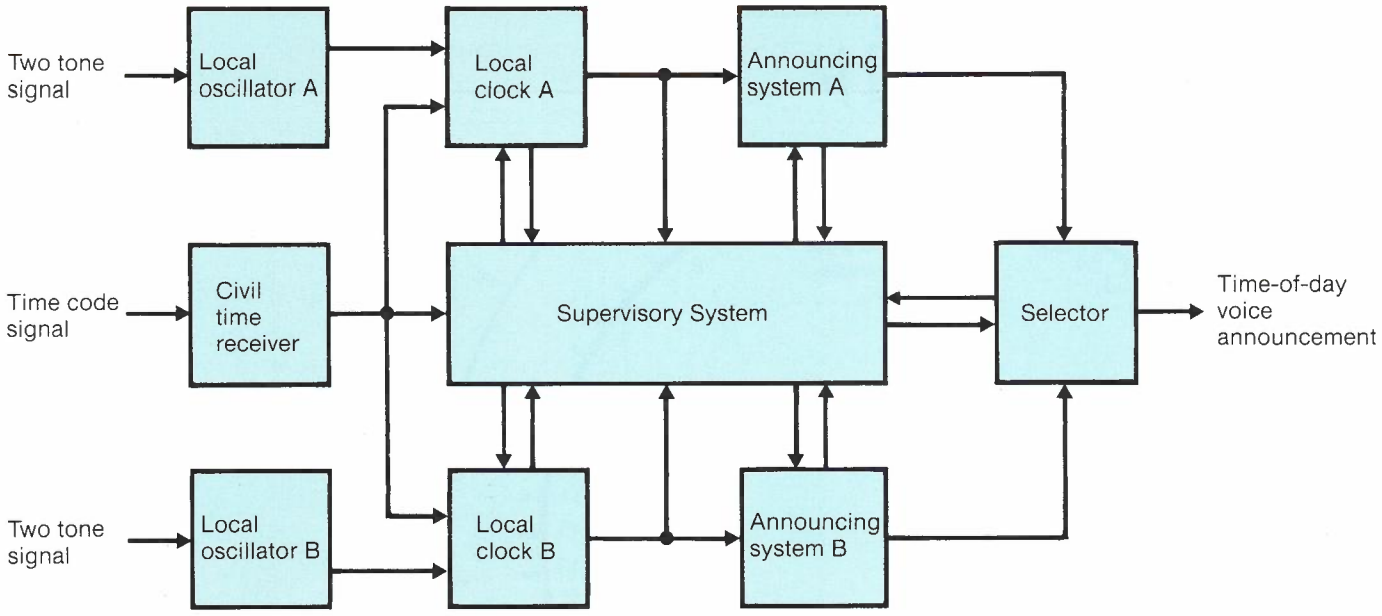
For maximum security under marginal reception conditions, a so-called "slow code" at a bit rate of 1 Hz has been adopted, the complete information thus extending over most of one minute. The low transmission rate also permits decoding by the use of simple recorders.

The method of encoding used complies with CCIR Recommendations for Time Codes and will be similar to the "slow codes" transmitted from the standard frequency and time signal stations MSF at Rugby in England and DCF77 near Frankfurt in West Germany.

The new code is expected to be on air from VNG by the end of 1985. As VNG has Australia wide coverage, the upgraded time service will have many new applications where HF radio reception is the only convenient source of accurate time information. Such applications include surveying, data logging, telemetry systems and shipping.

Announcing System for Speaking Clock

Telecom's existing speaking clock system was introduced into service in 1955 and it is now near the end of its service lifetime. The system generates the time messages, which are the basis of Telecom's Dial-It Time Service, from rotating photographic plates which are read by photoelectric cells. The time



Schematic outline of a speaking clock installation

service is one of Telecom Australia's most used "Dial It" services, accounting for 40% of customer calls to such services. In 1984, over 44 million calls were made to the service.

The Research Laboratories are developing a replacement for the existing speaking clock installation. In the new system, Time Code transmitted from the Research Laboratories is decoded by a Civil Time Receiver which then provides time information to initialise two digital clocks, each providing for separate time announcements. The digital clocks are normally controlled by quartz crystal oscillators and supply time information for the two announcing systems. Both announcing systems are monitored by an automatic supervisory system, which selects one or other of the announcing systems depending upon their performance. The selected announcement system is then configured to give an uninterrupted time-of-day announcement.

The voice signals representing the words required for the speaking clock announcements are digitised by an encoder and stored in solid state memory, using a bit rate of 32 kbit/s. For time announcements, these words are organised under microprocessor control into sentences to give the correct time of day information and to generate the required time announcement. The generated announcement retains the tonal qualities of the originally recorded voice.

The equipment is now undergoing final development and will be incorporated into speaking clock installations proposed for all State capital cities and Darwin.

Production of Australian Speech from Textual Input

Under a research and development contract let by Telecom, research staff of the Department of English and Linguistics at Macquarie University have developed a text-to-speech (TTS) system. The particular objective of the work performed under the contract was the development of a set of rules and a database which permit the synthesis of spoken English, with typical Australian pronunciation characteristics. The work was commissioned since commercially available systems have marked American accents.

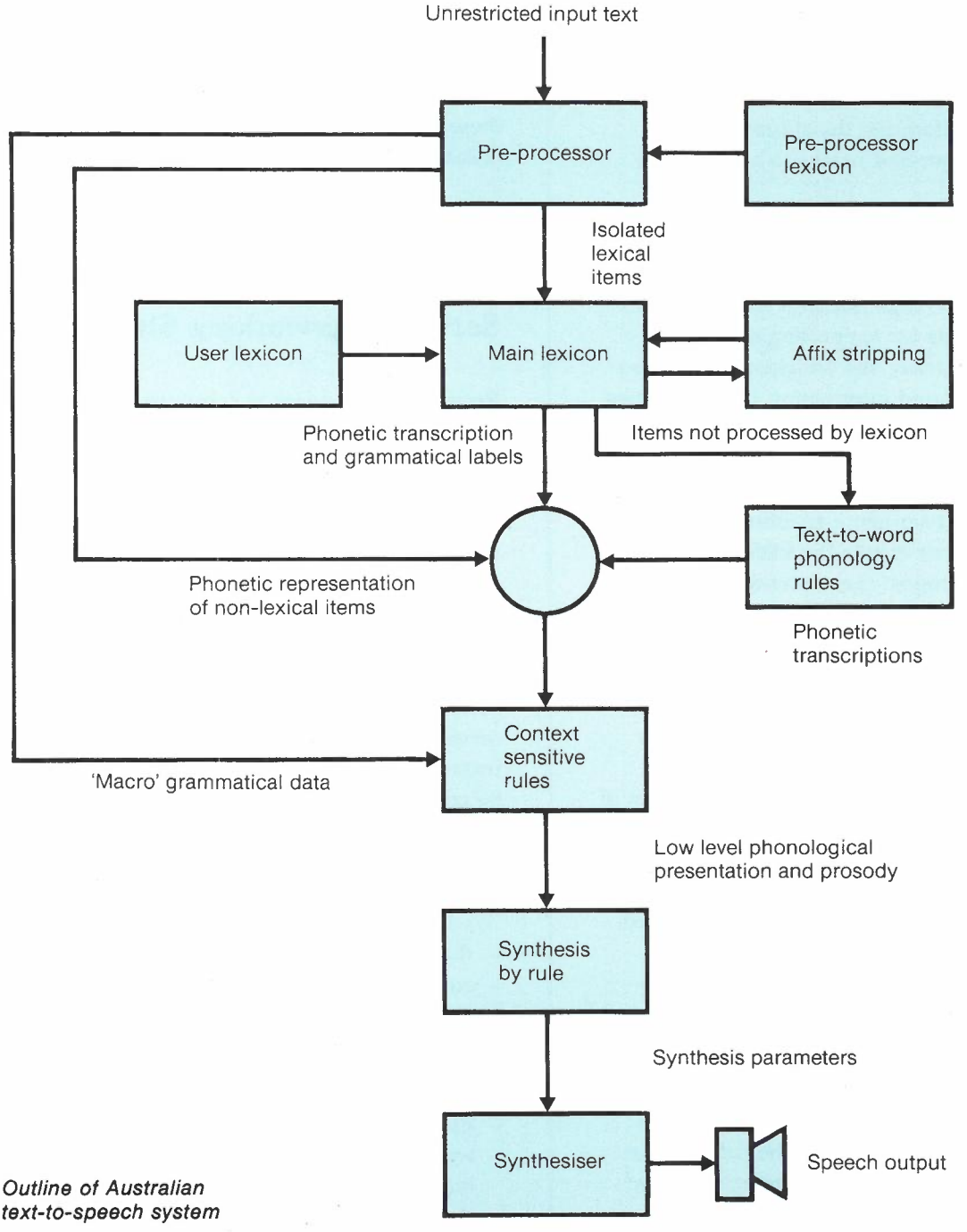
In the resultant TTS system, a text pre-processor identifies sentence length segments of input text, isolates individual words and checks them against an inventory of non-lexical items for which a phonological representation is substituted. Rules associated with deriving the phonological representation of number strings and common abbreviations are included in the system.

The main lexicon contains approximately 6000 entries and provides the phonetic transcription, grammatical and stress information for about 85% of the most common words appearing in text. To extend the total number of words transcribed by the lexicon, a suffix stripping procedure has been implemented, containing an inventory of 33 suffixes which caters

for in excess of 90% of all words eligible for suffix stripping. The main lexicon entries include orthographic joining rules for the appending of valid suffixes, where not precluded by phonological irregularities. Items not covered by the lexicon are converted to phonetic transcriptions by means of text-to-word phonology rules.

The context-sensitive rules which modify the phonetic transcriptions are divided into two parts. The first part consists of the rules for the allocation of low level linguistic features at the single word level. This process presents data to the sentence building sub-routine which connects the single word data into complete sentence data format. The second part of the context-sensitive rules processes the complete sentence and adjusts phonological and prosodic data. These rules include facilities which utilise the word-grammatical information provided by the lexicon and the macro-grammatical data extracted by the input text processor.

The synthesis by rule from the phonetic transcription and software speech synthesiser are closely based upon a previous system developed by Dr. John Clark of Macquarie University for linguistic investigations. Essentially, the synthesis by rule accepts and interprets the low level phonetic information from the context-sensitive rules and transforms this data into an appropriate continuum of parametric data, with the aid of information from the resident database, to drive the synthesiser.



Outline of Australian text-to-speech system

Directory Service Studies

Network addresses for locating end-user systems or computing resources in a telecommunications networking environment are commonly specified as a string of numerical or alpha-numerical digits, which are not meaningful to users and are difficult to remember. With the emergence of a range of new telecommunications services (e.g. videotex, teletex and computer-based messaging), a requirement to remember different addressing schemes for accessing or communicating in different service environments will be inconvenient to prospective users of the services. It would be far more convenient if, instead of using such network addresses, these customers were able to use human names to denote the persons with whom they want to communicate. However, this would require a standardised naming convention and a network-based on-line electronic directory system (EDS) capable of performing the automatic translation of user-specified names to appropriate network addresses.

Recognising this need, the CCITT and ISO have recently begun work to specify the basic features and capabilities of the EDS together with the attendant technical requirements for supporting this future directory service. Basically, the anticipated EDS may store a set of user-related information (i.e. properties such as network addresses, user authorisation, information/service access rights and other communication capability profiles of the user) associated with each user name registered in its database. This will then enable the EDS to provide, for example, "white pages" (i.e. name-to-properties mapping) and "yellow pages" (i.e. property-to-names mapping) facilities for a range of multi-service applications. These facilities will be made accessible to customers for general information retrieval services as well as to telecommunications systems (e.g. message handling systems or service interworking facilities) to assist in the management of these systems. For ease of management and other performance-related reasons, the EDS will generally comprise a number of geographically distributed directory servers which will co-operate, as required, to provide the requested service to the end-users. Associated with this arrangement, however, is the need for appropriate communication protocols to support user-server and server-server interactions.

In order to be able to provide timely advice on trends in the development of directory services to Telecom's service planning groups, the Laboratories have undertaken a programme of research on this topic. In view of its potential impact on all future EDSs, the study includes close examination of the CCITT-proposed specifications.

The protocol requirements mentioned above have been studied and work is in progress to implement the remote operation protocol which could be used to support user-server interactions.

A hierarchically structured naming convention has been proposed by CCITT, which will enable any user to be named unambiguously worldwide and allow names to be easily guessed by users. Associated with this is the need for a name validation service to be provided by the EDS to aid the users. In collaboration with the Computer Science Department of Monash University, the Laboratories have studied the technical requirements and appropriate implementation techniques to support this name validation service.

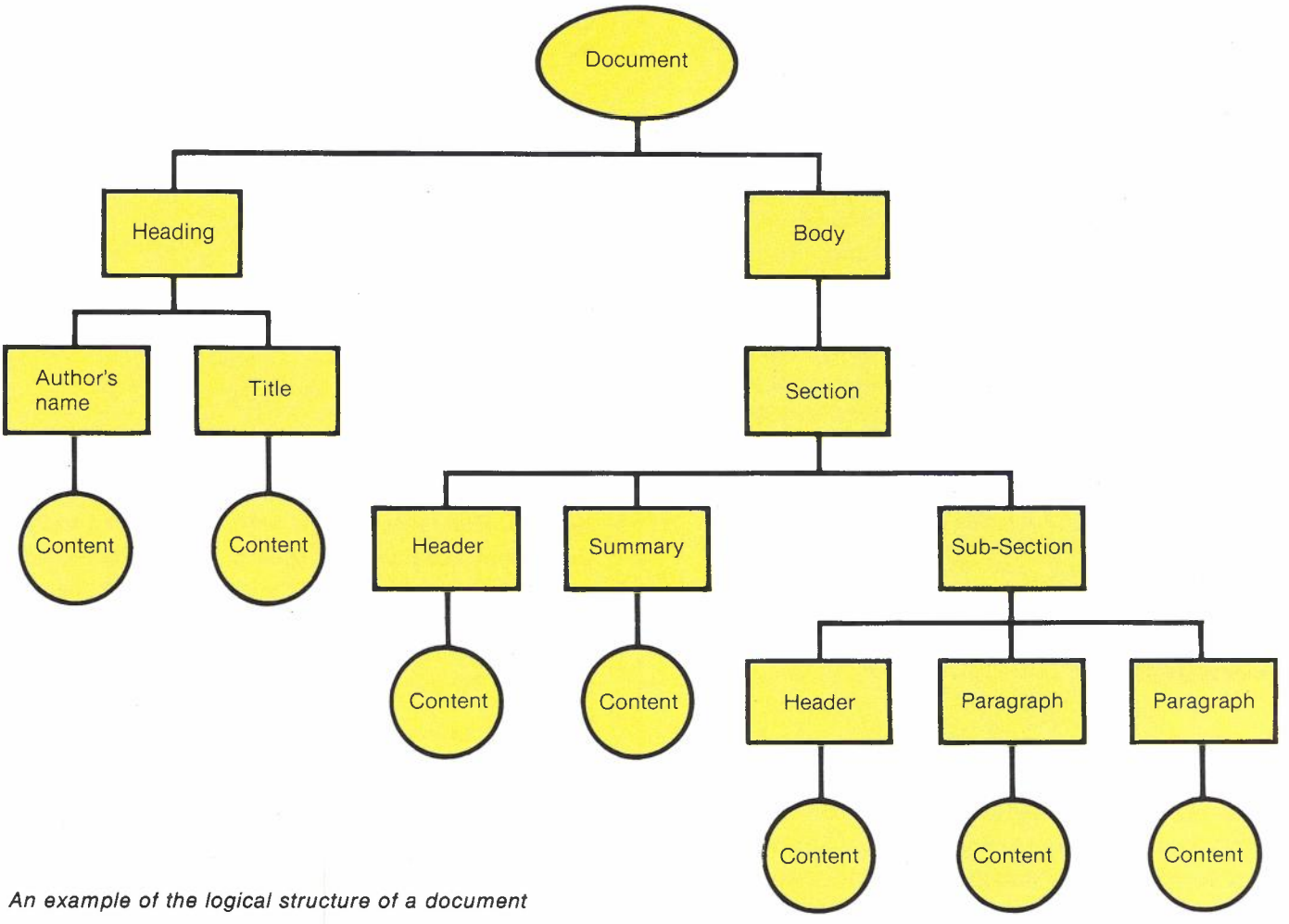
Database organisational aspects of the EDS are complex because of the number of different services to be supported in a distributed manner. Studies of these aspects are also being carried out in collaboration with Monash University.

Service Interworking Studies

Recent developments in computers and data communication have greatly expanded the range of electronic office services (e.g. word processing, electronic messaging) available to users. The need to perform these functions on an inter-office basis has fuelled the demand for new telecommunication services. Customers using these services require that their communications with others should not be restricted by the service or terminal types, creating a need to provide interworking facilities between these services. The realisation of these facilities for existing services has been hampered by serious incompatibilities between them and this problem will be compounded with the anticipated proliferation of additional service and terminal types.

Incompatibility between services may arise due to differences in:

- the representation of information. For example, the currently available alphanumeric text services, telex, teletex and various computer based messaging systems use a variety of character representations or syntaxes.
- the capabilities of the terminal equipments on which these services are provided. For example, terminals supporting these services may differ in the rendition and display of information.



An example of the logical structure of a document

- the protocols supporting these services. For example, protocols used in messaging systems which function on a store-and-forward basis are of a different nature to those that are interactive, as in videotex services.

The interworking issues are complicated further by the emerging need to mix several communication types (e.g. voice, text, image) in the composition and transmission of documents.

Service interworking can involve protocol conversion, conversion of information types, and the mapping of required facilities from one system to another. If implemented on a specialised service-to-service basis, these requirements and the continuing increase and diversification of services would make it impractical to provide one-to-all interworking situations. This would impair the ability to interconnect certain classes of users. Consequently, a more unified service provision strategy is needed, based on a unified approach to:

- the specification of terminal equipment capabilities
- the identification of the value-added services that can support customer access to a range of services, and
- the determination of strategies for interworking with existing networks, such as through the use of gateways or conversion facilities.

Intense international standardisation effort is being applied in the ISO and the CCITT to resolve the fundamental issues that are relevant to service interworking. This effort is exemplified by the work on:

- the definition of the OSI Presentation Layer Service and Protocol, to provide application processes with a syntax-independent communication. Facilities for the transformation of syntaxes and the negotiation of common transfer syntaxes are the main targets in these studies.
- the definition of document interchange protocols. The main aim of these protocols is to communicate the layout and logical structures of a document to preserve its original format independent of the display features of the receiving end system. Moreover, they facilitate the processing of these documents through editing, storage, and retrieval in the user end-system.
- the abstraction of the functions commonly found in terminal access methods, e.g. control and

display functions. This abstraction is used to define a set of communication services to provide a distributed "virtual terminal service" which enables users to mask local differences in terminal capabilities.

The Research Laboratories are currently involved in this standardisation effort through technical contributions and attendance at local and international meetings of the standards bodies. Experimental activities are also being conducted within the Laboratories to verify the applicability of these techniques to service interworking situations in the Australian environment and identify suitable network development strategies based on these technical advances.

Voice Services on Packet Data Networks

Packet networks, such as local area networks (LANs), and public packet switched networks, such as Telecom's AUSTPAC network, form a class of data networks of increasing interest. In these networks, the interactive bursty nature of computer data is exploited by packet multiplexing techniques to enable a group of users, often with different data rates, to share efficiently a common data link. The use of such networks is growing rapidly with the introduction of new computerised information and transaction services, such as those associated with the banking, travel and retail industries.

The integration of voice services over such data circuits could offer potential user benefits, including economic advantages from sharing a common network and the convenient realisation of various service enhancements. In the case of LANs particularly, additional benefits would result if the voice service could be extended beyond the limited boundaries of the private local network by its interconnection with the public telephone network.

Because a real-time voice service has substantially different basic requirements from packet data, the Laboratories have undertaken studies of the important requirements of voice communications, the particular characteristics of various packet data networks, and the special measures which need to be implemented to achieve an acceptable quality of voice service on packet networks.

A fundamental problem in realising a real-time voice service on any packet network is the irregular arrival of packets at the receiving station. All packets not only suffer a fixed delay due to the time required to assemble a packet of data from the digitised speech, but also a variable delay in obtaining access to the network. The latter delay is both network and traffic dependent. For fidelity of speech output, the receive terminal must re-assemble the randomly arriving packets and play out a smoothed stream at the same rate as originally generated. This process further increases the overall delay.

Model of a circuit comprising a long terrestrial link and a cascaded satellite link, each equipped with a pair of echo suppressors ▷

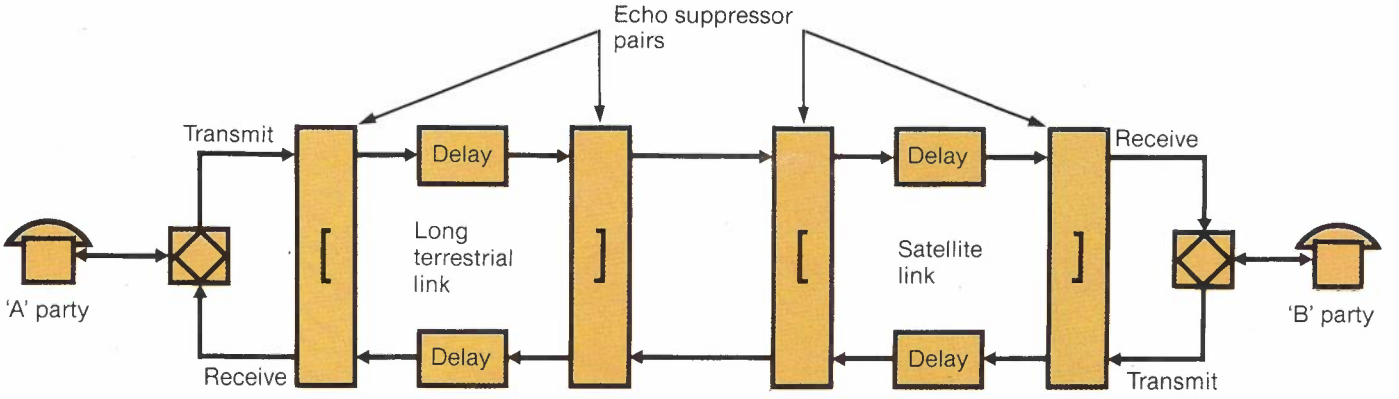
Assuming an effective packet re-assembly strategy which minimises the effect of lost or severely delayed packets, three major effects need to be considered in packet voice services namely, delay, echo and voice quality.

Voice quality is largely dependent on the type of speech encoding used. For LANs, which accept reasonably high data rates, high bit rate encoders (e.g. 64 kbit/s PCM or 32 kbit/s ADPCM) can be used unless a very high traffic capacity is demanded. For Telecom's AUSTPAC network, which currently provides a maximum input data rate of 9.6 kbit/s, a low bit rate coding system with inherent marginally acceptable voice quality would have to be tolerated.

Provided limitations of maximum traffic can be implemented, the typical range of LAN delays (10 to 100 ms) can readily be tolerated, particularly within a private network. Echoes will not present a problem if full four-wire working is used.

The Laboratories' studies suggest that economic use of the AUSTPAC network for voice services is unlikely, except over very long distances, when the network would include at least several switching nodes and exhibit a typical end-to-end delay of 800 ms. Such a delay is barely tolerable even for private use and would necessitate echo suppression measures.

If a packet voice service is to interconnect to the public telephone network, additional restrictions will need to be placed on the service in order to meet national and international recommendations. These restrictions will particularly relate to maximum delay limits and control of echoes. With the



implementation of special protocols which minimise end-to-end delay and delay variations, and provided traffic loading is suitably controlled, LANs can be constrained to meet the criteria for both private and public network voice services. However, voice service provision on the AUSTPAC network does not appear attractive technically or economically, even for private point-to-point services.

Tandem Connection of Echo Suppressors

Echo suppressors are used in trunk telephone circuits which have a transmission delay long enough for a signal reflected from the distant receiving end to be heard as an echo at the transmitting end. Such echoes are suppressed by placing a pair of "half" echo suppressors within the trunk circuit - one at each end of the four-wire portion. When only one party is speaking the echo suppressor at the distant end, on detecting the incoming speech, inserts a large loss in its transmit path, effectively converting the circuit to a half-duplex circuit. During any "double-talk" condition, each suppressor inserts a small loss, allowing the conversation to continue while achieving a moderate reduction in echo level which will tend to be partly masked by the incoming speech signal.

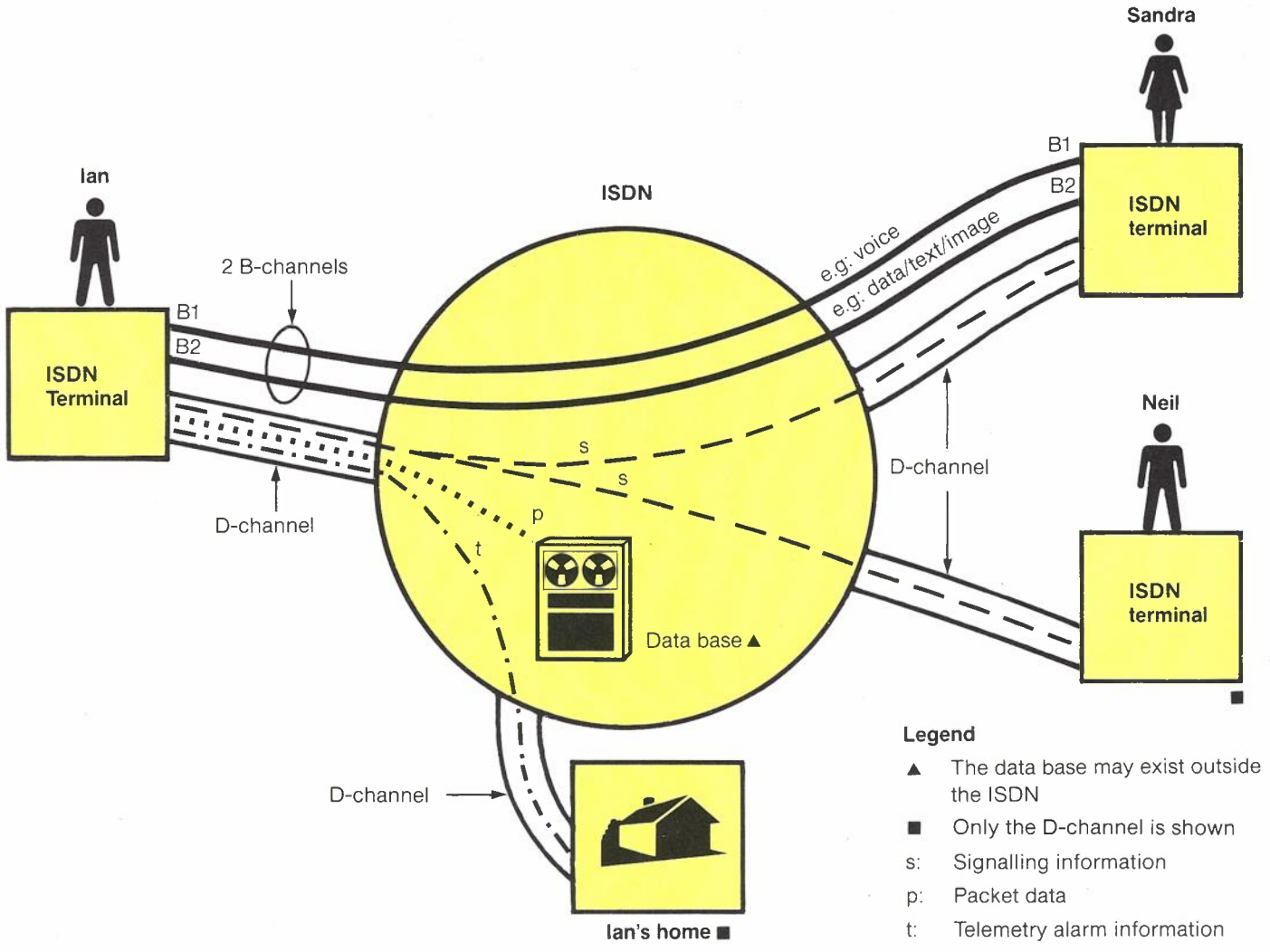
Traditionally, echo suppressors have been required only on long international circuits, whether provided by satellite or cable, and on very long haul national terrestial circuits. However, circuits derived by satellites and by time assignment speech interpolation are being introduced into the national network. By virtue of the transmission delays involved, these circuits require the inclusion of echo control equipment. Unless complex and expensive signalling and switching systems are introduced, it will be difficult to avoid the possibility of two or more pairs of echo suppressors being included in a telephone circuit. Experience gained from previous Laboratories' studies with relatively unsophisticated designs of echo suppressors and moderately lossy trunk circuits has led to a strong recommendation to avoid tandem connection of suppressor pairs.

More recently, experiments have been undertaken in the Laboratories to determine the effect of including more than one pair of echo suppressors of modern design in low loss trunk circuits. An experimental four-wire telephone circuit with provision for four variable delays and four pairs of echo suppressors was so arranged that each pair could be either cascaded with or nested within another pair. The circuit had unity overall gain in each direction and was tested with a range of transmission delays and echo loss values and with the echo suppressors operating in a fixed or adaptive mode.

Objective measures in the laboratory showed that, during "double-talk", the introduction of more suppressors reduced the percentage of speech signal that reached the listener. The reduction varied from 80% with one suppressor pair to about 65% for four pairs. However, the introduction of more suppressors also reduced unsuppressed echo, ranging from 65% to 15%, for some configurations. The reduction of received speech signal could be regarded as detrimental, while reduced echo could be viewed as beneficial.

Subjective conversational tests were then performed using an eleven point opinion scale. For six of the eight configurations tested, the mean conversational opinion score was not significantly changed by introducing more suppressors, but for two configurations which corresponded with those giving big reductions in percentage returned echo, the mean opinion score improved.

The Laboratories' studies concluded that, subject to the constraint of ideal transmission levels and the use of modern echo suppressors, the introduction of more than one pair of suppressors into a telephone connection will not degrade its conversational performance.



An ISDN communication scenario

ISDN Terminals and Integrated Services Delivery

Currently, a number of proprietary "integrated terminals" are available that can support more than one service (e.g. voice and data). These terminals use a combination of several separate sets of standardised interfaces and procedures to access various service-dedicated networks, such as the public switched telephone network or data networks. Examples of these interfaces and procedures include dual tone multi-frequency (DTMF) arrangements and CCITT V-series and X-series interfaces.

With the emergence of the 1984 CCITT ISDN access interface recommendations or standards, a new generation of terminals is expected to become available during 1985/86. These "ISDN multi-functional terminals" will be able to support a range of services (e.g. voice, data, text, image) using an integrated user-network access interface, such as the ISDN basic access interface consisting of two B-channels at 64 kbit/s and a D-channel at 16 kbit/s. The new ISDN interfaces will have a multi-channel access arrangement together with an out-of-band common channel signalling scheme for controlling circuit-switched user traffic channels.

With the expected capabilities of the emerging Integrated Services Digital Networks (ISDNs) and associated access protocols, ISDN terminals will provide users with new ways of using present and new telecommunications services. Examples of these communication capabilities include:

- circuit-switched connections under the control of common channel signalling which, once established, can support any user traffic (e.g. voice and non-voice, including in packetised form) at compatible bit rates
- packet-switched communication over the user traffic channels (e.g. the B-channels) and the (mainly) control traffic channel (e.g. the D-channel)

- compatibility checking of terminal capabilities, prior to and during call establishment (e.g. with respect to communication and application-oriented characteristics), using the out-of-band common channel signalling facilities
- signalling between end-users and network-based facilities (e.g. data bases such as electronic directories)
- end-to-end signalling between users in the out-of-band control facility (e.g. to change mode of communication over an already established connection)
- combination of above as in multi-media communication, whereby several simultaneous modes of communication can take place under common signalling control.

More importantly, ISDN terminals will facilitate the integrated delivery of multiple services to the end-users, for both information carriage or "bearer services" and user-oriented applications or "teleservices". The latter will include the new out-of-band end-to-end signalling facility or "order wire" facility, allowing a range of new communication capabilities to be exploited.

An experimental ISDN terminal and associated protocol testing arrangement is being implemented within the Research Laboratories. This experimental development will enable investigation of various aspects of the new ISDN communication capabilities mentioned above, in particular those of the integrated services delivery concept.

An ISDN Customer Access Protocol Test Bed

From a telecommunications user's perspective, the Integrated Services Digital Network (ISDN) is characterised by the ISDN user communications capability and associated call control procedures available at the ISDN user-network interface. This user capability is represented by the combined resources of the B and D-channels, whilst the call control (signalling) procedures form part of the D-channel protocol hierarchy (Layer 3) defined by the CCITT in 1984.

A key feature of the basic communication service offered at the ISDN user-network interface is the user control capability of the D-channel. Not only can it be used to effect call set up and clear down, it can also be used to co-ordinate multiple services associated with a single communication, which may require the simultaneous and/or sequential connection of image, data and voice services. The most important part of any ISDN terminal is therefore the module which makes the control capabilities of the D-channel available to the user. This module may comprise software, hardware or a combination of both.

Because of the importance of the D-channel protocol for future service provision at the ISDN user-network interface, the Laboratories are undertaking the development of an ISDN Customer Access Protocol Test Bed. During the development stage of this project, it is expected that this facility will provide the means to:

- study the techniques of service provision using the control offered to the customer by the D-channel (Layer 3)
- critically examine and test emerging D-channel protocols
- enhance the D-channel protocols in the light of the above studies.

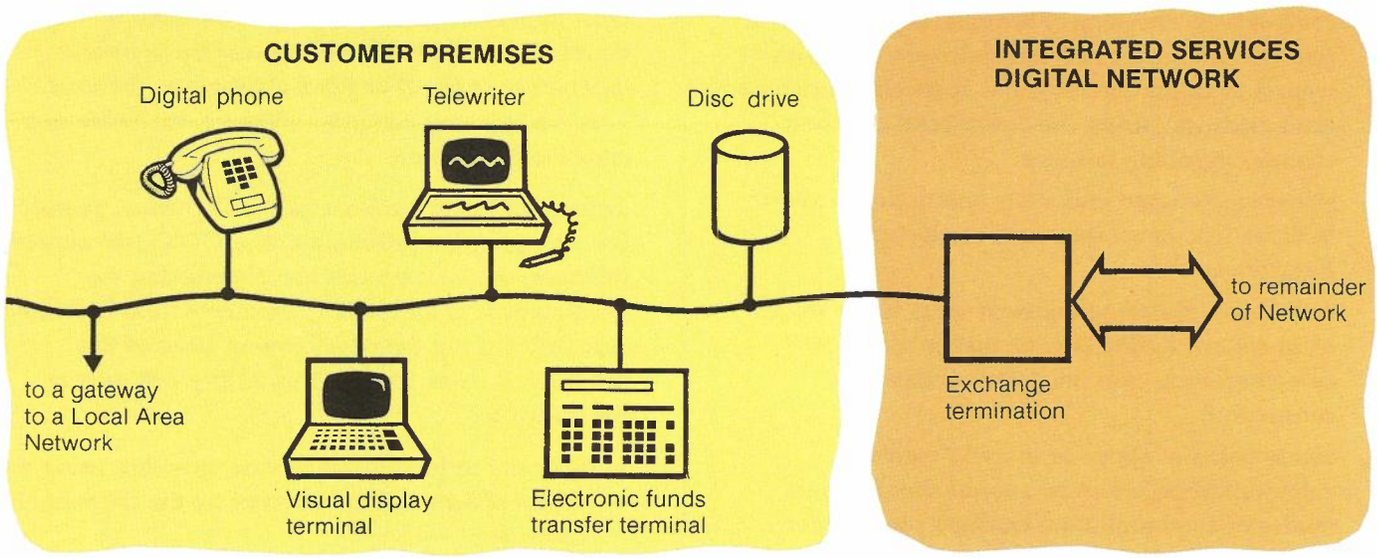
The first stage of the project involved the design and construction of the D-channel module identified previously. It is called an ISDN Access Unit (IAU) and is designed to interface with a wide variety of existing equipment through standard parallel and serial interfaces. The early version of the IAU provides terminals with extensive monitoring and testing capabilities as well as the ability to effect ISDN communications. Thus, an ISDN terminal equipped with this version of the IAU can double as a protocol test instrument.

In the future, the ISDN Access Unit will be replicated to provide a number of terminals with ISDN access. The end result will be a multi-terminal ISDN customer installation which will provide a test bed for the study of ISDN service issues and access protocols.

SDL Description of the Link Access Procedure on the User-network Interface

The Link Access Procedure on the D-channel (LAPD) at the ISDN user-network interface has been developed by the CCITT to provide a reliable information transfer service between the user's terminals and the exchange. LAPD is based on ISO HDLC (High-level Data Link Control) procedures and LAPB (Link Access Procedure - Balanced) of the CCITT X.25 packet user-network interface.

LAPD is used to carry all information types generated by Layer 3 of the D-channel. This includes the signalling (s) information for ISDN call control



Link access procedures on the D-channel allow:
- *multiple terminals to be connected to a single exchange termination*
- *a number of customer premises to be connected to a single exchange termination*

and user packet (p) information. In conjunction with the D-channel Layer 1 procedures, it also permits the connection of multiple terminals to a single exchange termination (ET) each of which can support many active calls of different types simultaneously. This allows the user a wide variety of choices of different terminal types, thereby enhancing the flexibility of the ISDN user-network interface.

Since the LAPD protocol is complex, its natural English language specification causes several problems, in that:

- errors and omissions in the protocol are difficult to detect
- different people can interpret the text differently
- the effect of illegal signals and extensions to the protocol is difficult to gauge, and
- implementation from the text is difficult.

In an attempt to overcome these problems, the Laboratories have used the CCITT's Specification and Description Language (SDL) to provide more rigorous, logical and simple descriptions of the LAPD protocol. The resulting specifications have the added advantages of being more concise and more understandable.

As a result of describing LAPD using SDL, Telecom Australia has been able to make a number of contributions to the CCITT, firstly presenting SDL descriptions of LAPD, and secondly, suggesting several enhancements to prevent protocol errors. The SDL descriptions are also being used by the Laboratories in an experimental implementation of Layer 2 of the ISDN user-network interface, both in an ISDN customer multi-terminal installation and in an ISDN experimental exchange.

SDL Description of the ISDN User Part

The Integrated Services Digital Network User Part (IUP) of the CCITT Common Channel Signalling System No. 7 is a multi-purpose call control facility providing a wide, open-ended range of basic signalling functions to enable the establishment, maintenance and release of circuit switched services for voice and non-voice applications in an integrated services environment. It also supports a wide variety of supplementary services permitting the creation of sub-networks with controllable access. It replaces traditional line and information signalling and is suitable for both national and international applications. A similar facility for application to packet switched services will also be developed in the future.

Network connections can either be 64 kbit/s transparent or 64 kbit/s non-transparent. The 64 kbit/s transparent connection is used to carry data transmission services provided by a communication system such as a data network in which the data signalling rate, the data terminal equipment operation modes, the data code structure and other feature facilities and services are standardised. The 64 kbit/s non-transparent connection is used primarily for voice communication where the connection may include bit manipulating devices such as echo suppressors. Additional connection types such as sub-rate channels, which may be subject to future standardisation, are also catered for.

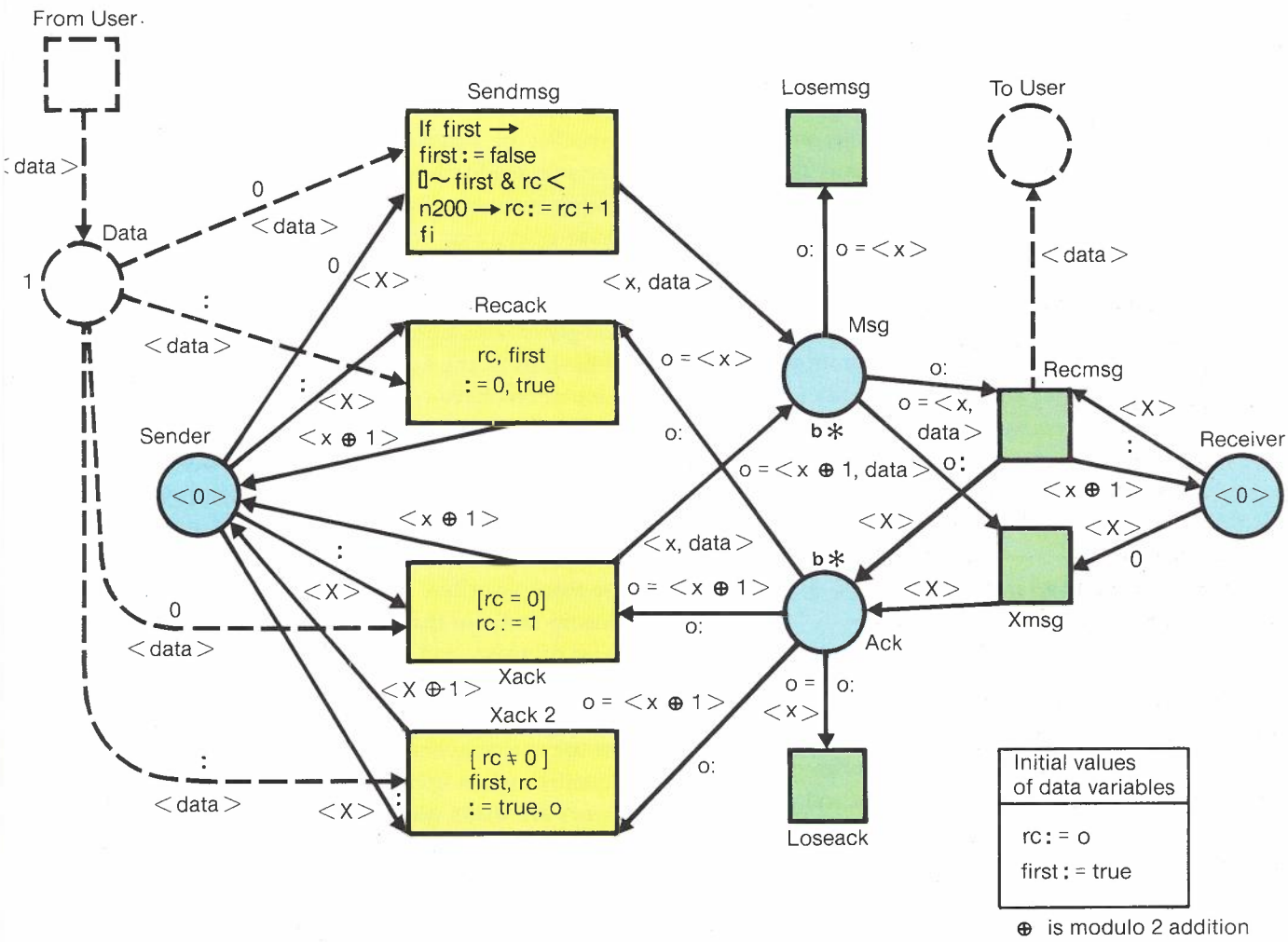
During the last year, the Laboratories have contributed to the work of the CCITT Working Party XI/2, which is concerned with specifying the call control procedures of IUP using the CCITT

Specification and Description Language (SDL). The twofold purpose of this exercise is to allow the procedures to be represented in a more explicit, unambiguous and concise way and to discover if any inconsistencies exist, so that these can be rectified and incorporated in the CCITT 1984 Recommendation. Work is also being carried out in the Laboratories to investigate the interworking of the IUP with existing signalling systems and the D-channel access protocol.

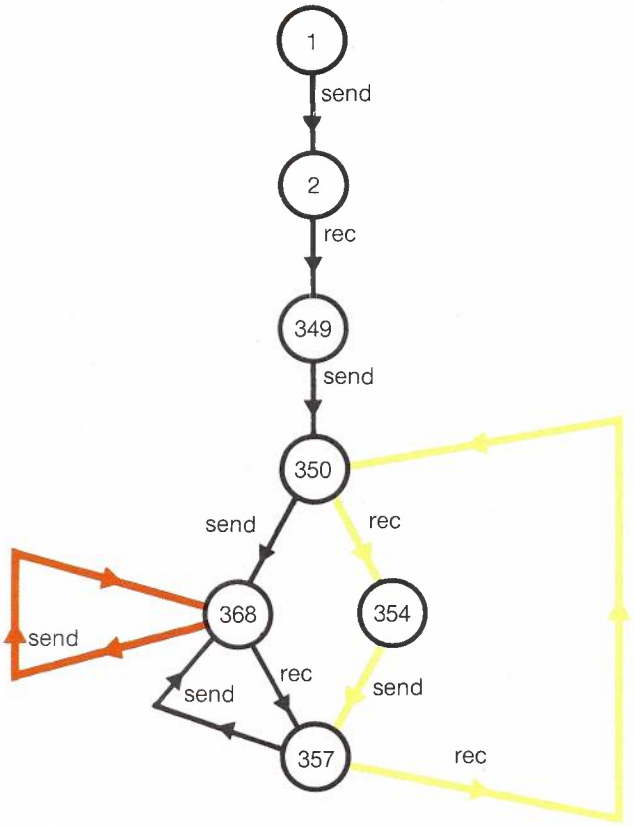
Analysis of an ISDN D-channel Protocol

At a meeting of CCITT Study Group XI in 1984, an addition to the suite of existing ISDN basic access Data Link Layer procedures operating on theD-channel was proposed by AT&T. This addition was a set of single frame procedures, a variation of an alternating bit protocol that is intended to permit the use of simpler and more economic customer terminals. The single frame procedures were suspected of having errors that could cause problems in operation. Accordingly, the procedures were analysed in the Laboratories using the protocol analysis package, PROTEAN, a software package developed by the Laboratories to analyse protocols modelled by Numerical Petri Nets.

It was discovered that the protocol did not provide its basic service, that is, the transfer of information across the D-channel between users of the Link Layer without loss or duplication of that information. Loss and duplication were discovered to occur in a number of ways, including ways that were not previously suspected. Subsequently, the unsatisfactory nature of the single frame procedures was recognised in two contributions to the CCITT Study Group, one from Australia and one from the United States. These led to a revised draft in May 1984 which has become part of Recommendation Q.921 in the CCITT Red Book.



Numerical Petri Net model of the single frame Data Link Layer D-channel procedures (as originally proposed)



PROTEAN analysis showed loss of information as indicated by loop of sends (red) and duplication as indicated by loop containing two received messages for each one sent (green)

The revised version has also been subjected to similar analysis in the Research Laboratories and has been shown to operate correctly under many of the previously troublesome conditions. However, it was found that under certain conditions (initially both ends unsynchronised, after power failure, resetting, etc.), loss and duplication of information can still result. Further Telecom contributions to the CCITT Study Group on this topic are envisaged in order to assist the development of adequate standards for Australian as well as international use.

Transmission Studies for ISDN Basic Access

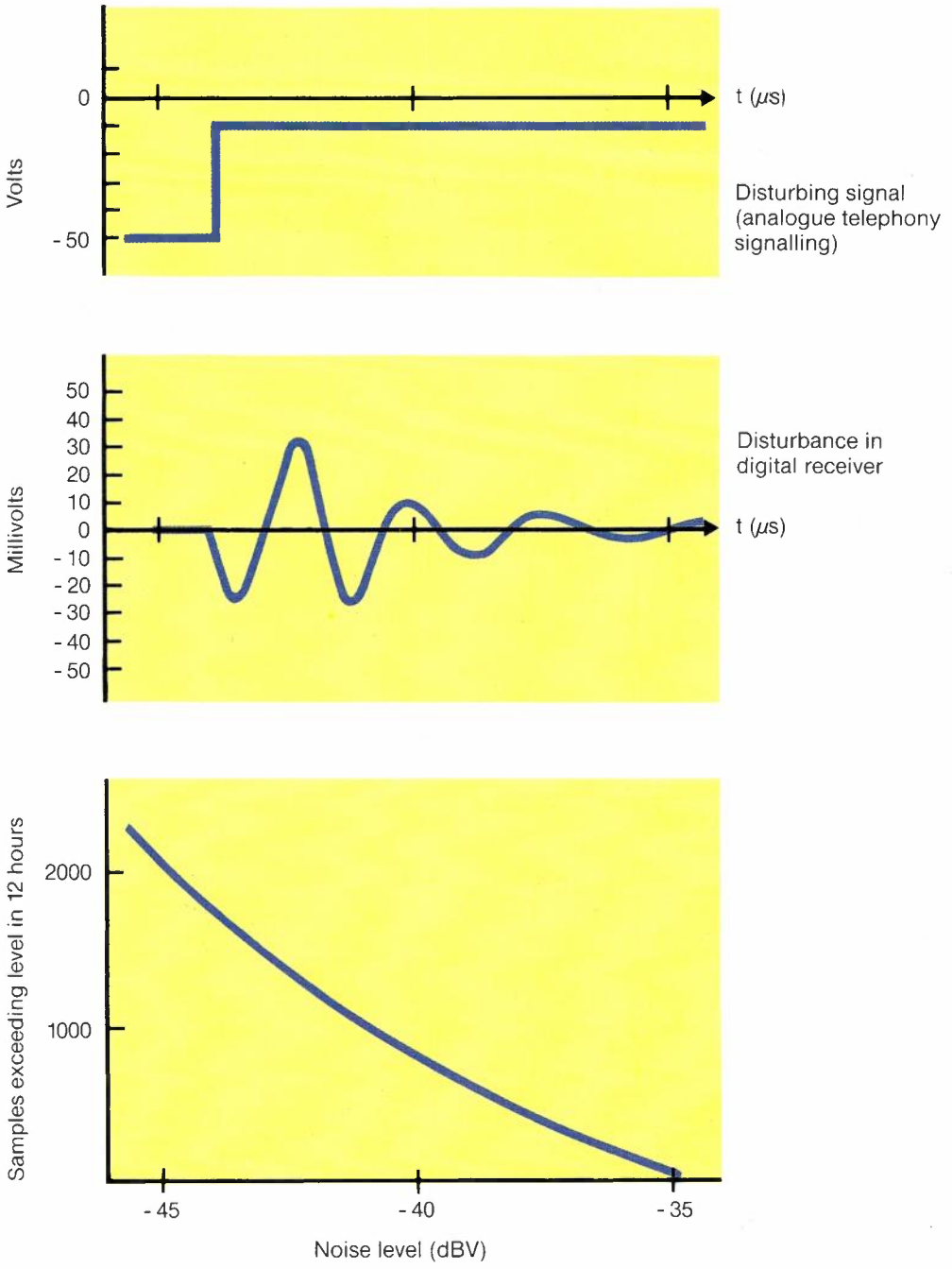
The telecommunications networks of many administrations around the world are evolving towards Integrated Services Digital Networks (ISDNs). Customer access to these ISDNs will utilise digital transmission techniques which support two 64 kbit/s B-channels for voice and/or data services plus a 16 kbit/s D-channel for signalling and packetised data transfer. It appears that the most economic approach to providing this 2B+D customer access (144 kbit/s) will be to utilise the customer's existing (twisted) pair of wires. However, this cable pair was designed only for analogue speech transmission. As a consequence, the customer access network is a very demanding transmission environment for basic access. Complex digital transmission techniques are required to achieve the necessary simultaneous both ways transmission between the local exchange and the customer's premises on the single pair of wires.

The Laboratories have undertaken extensive studies to examine techniques suitable for such digital transmission over customer pair cable.

Two transmission techniques, referred to as burst-mode and echo cancellation, have received considerable worldwide attention. However, the echo cancellation technique offers significant transmission advantages and is expected to be the technique adopted in the Australian network. With this approach, full-duplex operation (or separation of the send and receive paths) is partially achieved by a simple balance network (termed a hybrid). However, due to variations in customer line characteristics, this hybrid must be supplemented by an adaptive echo canceller, which adapts to provide a replica of the transmitted signal that leaks across the hybrid into the receiver.

A digital transmission system employing the echo canceller technique must perform several complex operations. The adaptive functions include echo cancellation, equalisation (usually in the form of decision feedback equalisation), gain control and timing recovery. To obtain a good understanding of these operations, the Laboratories have been investigating various digital system implementations. Proposed solutions have been analysed and computer simulations have been utilised to assess the behaviour of the adaptive functions. These simulations have confirmed the validity of the proposed solutions and have contributed to an understanding of their performance limitations. Computer simulations accessing a cable data base have also been used to determine the necessary complexity of the echo canceller and the decision feedback equaliser for satisfactory performance. Results indicate that, for a diphase line code, a 7-tap echo canceller and a 4-tap decision feedback equaliser are sufficient for most customer access cables. Theoretical studies have also been completed on the convergence of an adaptive decision feedback equaliser when initially a high proportion of decision errors are made due to the presence of intersymbol interference. These studies have shown that convergence will occur in most cases but that the convergence time is increased.

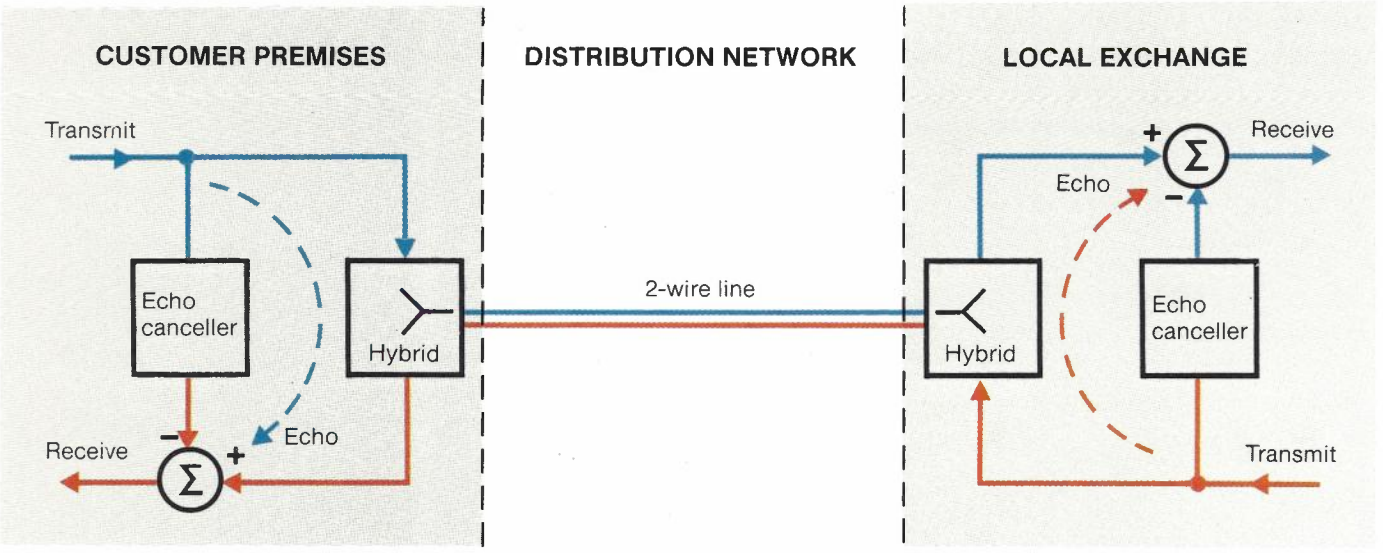
Crosstalk interference has also been studied. Such interference arises from electromagnetic coupling



Effect of impulsive noise on distribution of noise samples at signal rate

between adjacent pairs of wire in the same cable. The maximum transmission spans which satisfy a given error performance specification have been determined for the cases where the disturbing system is identical to the disturbed system. These spans have been found for burst-mode and echo canceller techniques with a variety of line codes, including diphase (WAL1), AMI, WAL2, MWAL2, HDB3, 4B3T and 3B2T. The compatibility of echo canceller and burst-mode systems with each other and with existing digital systems has been investigated. This has revealed that compatibility considerations impose significant constraints on transmission spans for burst-mode systems, limiting their use. The upper limit on allowable transmit levels imposed by compatibility considerations for both echo canceller and burst-mode systems has also been determined.

Another area of considerable significance is impulsive noise. This occurs when rapid transitions in voltage produced by signalling events on neighbouring telephone circuits are coupled electromagnetically into the disturbed cable pair. A computer simulation based on a theoretical model for dial pulse disturbances has been developed to predict impulsive noise error performance. The accuracy of this model has been confirmed in the laboratory and maximum transmission spans have been determined. These results indicate that, in many cases, impulsive noise rather than crosstalk is the dominant noise source. Instrumentation for extensive field measurements of impulsive noise waveforms and level distributions has been developed and is being used to obtain an improved understanding of impulsive noise events and their occurrence patterns.



Hybrids with echo cancellers for digital customer access over a 2-wire line

These Laboratories' studies of the transmission aspects of digital customer access will allow the performance of proposed systems to be assessed and predicted, thereby enabling the Laboratories to provide timely advice to other Departments of Telecom Australia concerned with planning and implementing future digital customer access network developments.

Data Traffic Studies

New telecommunications services and networks employing new telecommunications techniques present the network provider with ongoing problems of ensuring compatibility between various services and the connecting network, and the efficient use of network resources. Often, the traffic characteristics and performance requirements of new services are service-dependent. So that he can correctly dimension the network, the network provider must model the offered traffic intensity and distribution and develop dimensioning rules relating performance standards with the particular requirements of different types of traffic.

From the teletraffic engineer's point of view, telecommunication services can be conveniently divided into data and voice services, each of which have different service requirements and traffic engineering capability. The major differences between the performance characteristics demanded from the network for voice and data services lie in their requirements of throughput, delay and information integrity.

The assumption of Poisson call arrival process and negative exponential call duration distribution are considered to be adequate for voice traffic using a circuit switched network. However, for data services, the network traffic pattern is the aggregate of traffic profiles produced by users utilising one or more available services.

The Research Laboratories have recently undertaken a study of data traffic characteristics, with the objective of developing realistic mathematical models for these traffics. Such models are needed for data network performance estimation and dimensioning.

Within data services, three major categories of data transfers can be identified - bulk (e.g. file transfers), interactive (e.g. videotex) and short transfers (e.g. electronic funds transfers). The general characteristics of these categories are:

- bulk transfer - high data volume, connection via high speed line
- interactive transfer - low data volume, long interval between transfers, terminal and remote host may follow a certain response time distribution for a particular task
- short transfer - low data volume, short session time, short and generally fixed message time, small number of dialogue cycles per session.

As the first step of the Laboratories' study, a literature search was made for published material on data traffic characteristics. The next step involved the collection of samples of data traffics of various kinds and their analysis. The final step will involve the classification of traffics with similar characteristics into generic types and selection of suitable mathematical models to represent them.

Optimisation of Packet Switching Networks

To assist future development of Telecom's national packet switching network, AUSTPAC, the Laboratories are researching methods of analysis and design of such networks. The work involves delay analysis to enable the estimation of call set-up delays and data packet transfer delays as seen by the user. Network design proposals have been developed for configurations of fifteen and twenty-nine packet switching exchanges (nodes).

The work is being carried out by the adoption of the currently available body of theory on this topic, together with modifications and enhancements which have been developed in the Laboratories.

In the studies, the first task is the estimation of the network average node-to-node delay, given some offered traffic demand. The problem of design is then formulated as that of finding the minimum cost network subject to a delay constraint, given the placement of the nodes and a forecast of the offered traffic matrix. The design variables are the network topology, specified in terms of the interconnection of the nodes and the routing plan for every origin-destination (OD) pair of nodes in the network. An important consideration is that the primary route used by any OD pair must be either a direct link or via one transit node only. This constraint results in a large number of direct interconnections between the nodes in the network. However, limiting the number of permissible transit nodes helps to limit the maximum delay experienced by any user.

With the above considerations in mind, the first stage of the Laboratories' design process is the determination of a starting topology, together with a specification of the links which cannot be removed from the network because they already physically exist. The routing plan for this network is then optimised, using an algorithm derived from the theory of network flows. This algorithm is applied to the minimisation of cost functions which are specific to the operation of the AUSTPAC network, whilst retaining desirable mathematical properties, such as convexity. A list of links is then determined, the removal of which is possible under a pre-defined set of conditions. These link removals are investigated in order to reduce the network costs of switching and transmission. The routing plan is then re-optimised, and the whole process stops when the cost of the network can no longer be reduced under the given delay constraint and the connectivity requirement.

One of the useful outputs of the procedure is an input to the delay performance algorithms, so that a full report on the final network link loadings and terminal-to-terminal delays can be obtained. In the future, it is intended to extend this work to the design of hierarchical packet switching networks.

Performance Testing of Packet Switched Data Networks

Since it is important to ensure that the performance of Telecom's packet switched data network, AUSTPAC, is within the requirements specified by Telecom and expected by Telecom's customers, the Laboratories are investigating packet switched data network performance testing techniques.

The objectives of this work are:

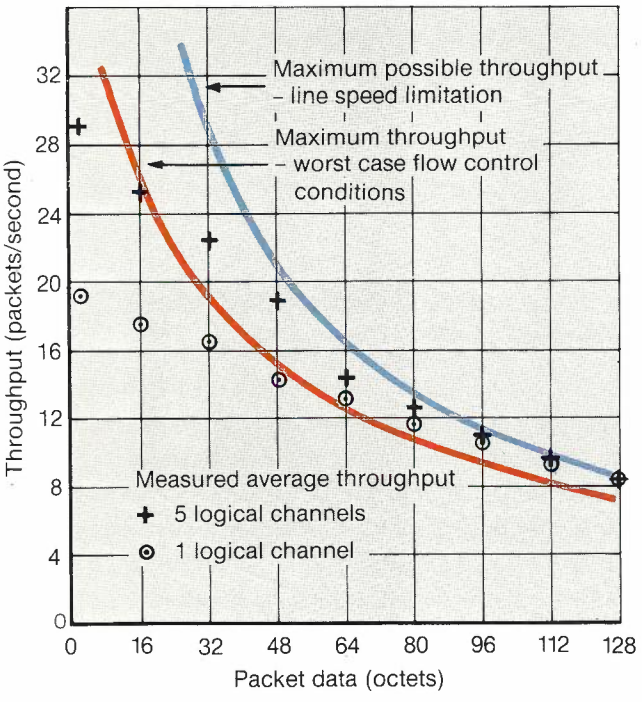
- to develop testing techniques which will enable packet switched network performance (including capacity and delay) to be quantified
- to develop traffic generators to load data networks under various connection conditions
- to contribute to the definition and extension of international standards on the performance aspects of packet switched networks.

The quality of service of a packet switched data network can be quantified by the following performance parameters:

- call set-up, packet processing and transfer delay distributions
- probability of call failure due to network congestion
- transmission performance, including throughput and residual error rate
- probability of call failure due to network malfunction
- probability of loss of service.

International standards that specify the performance parameters for data switched networks are being developed by the CCITT. Standards for the delay (Recommendation X.135) and the congestion aspects (Recommendation X.136) of grade of service for public data networks have been drafted. Many of the parameters specified to date are interim suggestions only, with further study required. Although the standards refer to networks providing international packet switched data services, the performance of the portion of the connection in the national networks is also specified.

In addition to specifying the quality of service parameters, methods for their measurement must be



Measured and calculated throughput figures for a packet switched data network

developed. A general measurement methodology involves setting up a call and generating a known and sufficient quantity of traffic. The protocol and user information signals transferred across the user/network interfaces are then observed in real time and a chronological event history compiled. Later analysis of this event history provides various performance parameters. This method is particularly suited to throughput measurements and delay measurements. However, end-to-end transfer delay measurements are further complicated by the requirement for synchronised real time clocks at each end of the call.

To assist the measurement of throughput, the Laboratories have developed a suite of computer programs to run on a super-minicomputer which has a connection to AUSTPAC. These programs utilise a packet switching interface software package and are capable of generating traffic for various connection configurations between the computer and the AUSTPAC network. Using these programs in conjunction with a software facility that records all protocol exchanges with the network, tests have been conducted from which capacity parameters have been calculated.

In addition to testing the AUSTPAC network physically, a simple model (based on the required protocol transactions) has been developed from which maximum achievable throughput can be estimated.

For particular connection configurations, it has been possible to achieve throughput figures of 32 packets/second (using a 9600 bps line). For a data packet size of 128 octets, the effective data transfer rate can approach 90% of the line speed while achieving a line utilisation of 99%.These initial tests have demonstrated the versatility of the event history methodology for testing packet switched networks. As a result of the experience gained from its tests of the AUSTPAC network, the Laboratories will be in a strong position to enable Telecom to contribute to the development of international standards for quality of service parameters for packet switched data networks.

A CHILL Support Environment

As the telecommunications environment becomes more and more complex, switching systems must support this complexity and be capable of future adaptation to meet new network configurations and provide new customer facilities. The growing dominance of software over hardware has accentuated the importance of programming language technology in this field. It has long been recognised that the use of cryptic low-level assembly languages for producing such software systems is no longer practical.

A CCITT study group, consisting of computer science experts from various telecommunications administrations and manufacturers, decided in 1975 to design a new computer language especially suited to the type of software used in switching systems. This CCITT High Level Language (CHILL) was finalised in 1980 and has become widely used by the telecommunications industry. CHILL is part of a wider aim to provide an environment for efficient software development, maintenance and hardware independence. CHILL provides powerful process scheduling facilities which necessitate the careful design of a run-time support system to provide synchronisation of processes, queueing of signals and isolation of the applications programmer from the complex implementation issues.

In order to gain deeper understanding of these issues, the Laboratories are building a software package to implement a version of CHILL, producing software to run on a PDP-11 computer equipped with the RSX-11M operating system. It consists of an existing simple CHILL compiler enhanced by a pre-processor and a run-time support system which interfaces to RSX-11M.

The package will be available as a development tool for real-time software generation for Research Laboratories' projects, releasing the programmers from the need for detailed knowledge of lower-level components of the system.

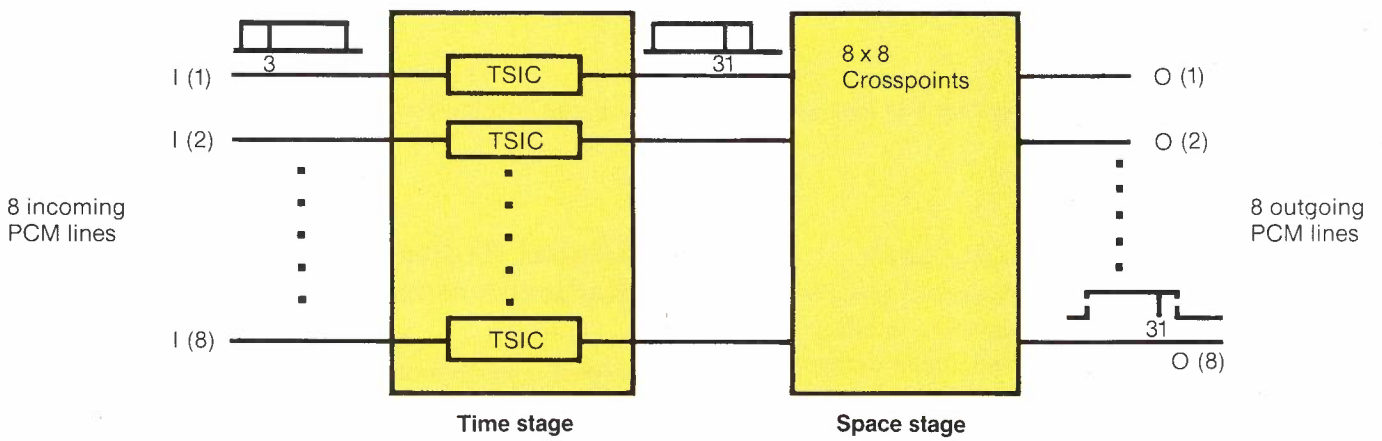
An Experimental Digital Switch Architecture

Rapid developments in silicon semiconductor technology in the last two decades have provided highly complex digital circuits at an ever reducing cost. This is one of the major factors which has made digital switching an economic proposition for the provision of future telecommunication services.

The economics of integrated circuit production are such that they favour the high volume use of identical components. A specialised application, such as a digital switch device, necessitates the design of highly modular switch architectures. A number of manufacturers have devised a time-space (TS) switch component which allows the implementation of various switch sizes using appropriate numbers of identical components. The TS structure offers both time and space switching of digital signals on a single integrated circuit chip. It is particularly suitable for very large scale integrated (VLSI) circuit implementation due to its extensive use of memory. A number of such devices are now available on the market and may well be the basis of future generations of switching machines.

A prototype of one such switch device is currently undergoing evaluation in the Laboratories. A major objective of the investigations is to study the effects of introducing these devices in new generation switching machines in terms of current Telecom practices. This is expected to lead to better specification and standardisation of future switching machines from a Telecom point of view.

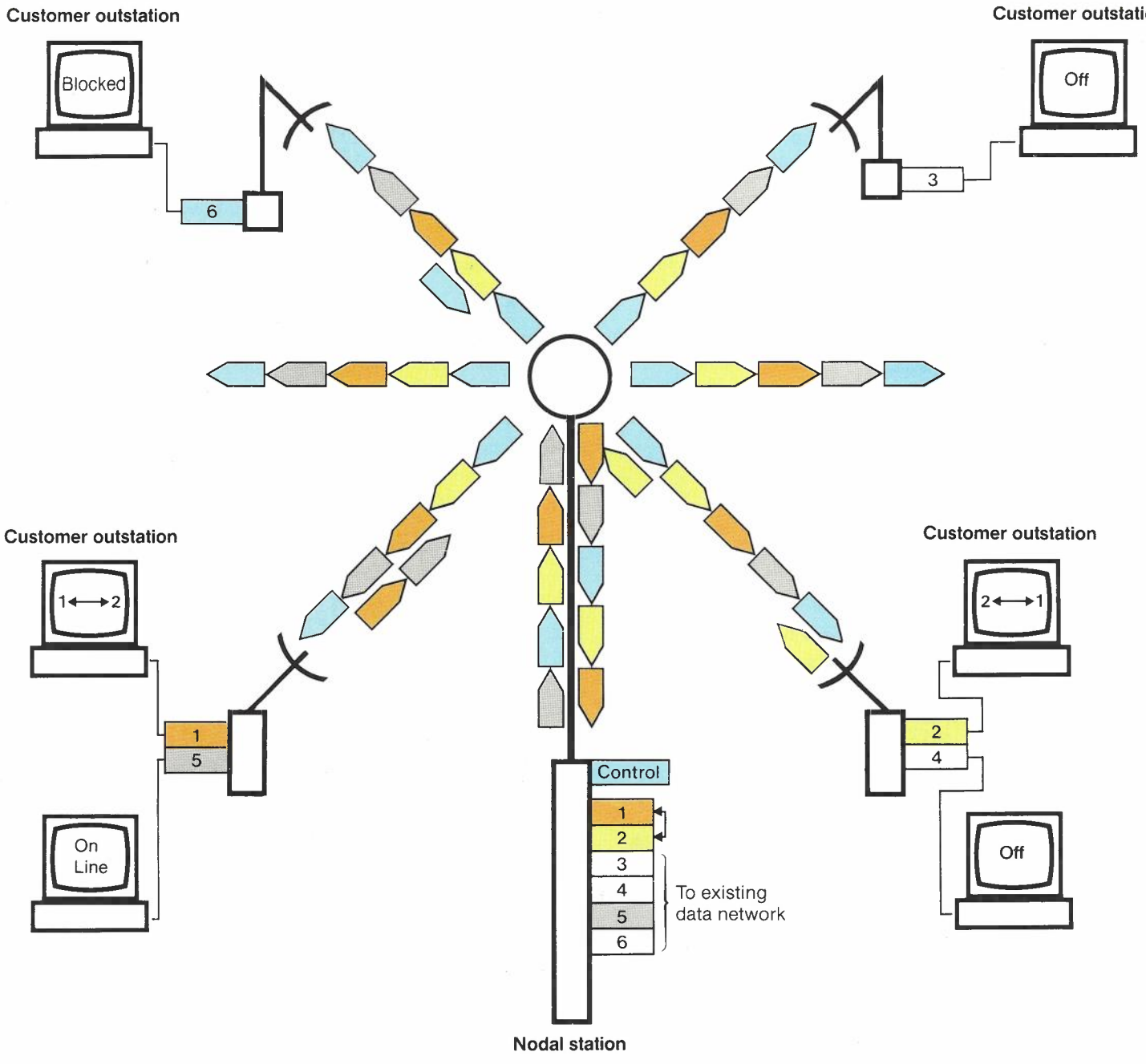
The switch device under study is capable of switching up to 256 PCM channels simultaneously. These are made up of eight incoming and eight outgoing primary PCM lines (at 32 channels per PCM line). The bit rate of each incoming line is 2.048 Mbit/s. The dimension of the switch can be expanded in a modular fashion. For example, an expansion of the switch to 2048 PCM channels requires a switch structure of three switching stages, where each stage consists of eight switch devices. In turn, this structure can be used as a building block for further expansions to switch structures of still larger dimensions. The blocking probabilities of these structures are much lower than the typical probability of equipment failure.



Notes:

1. TSIC = time-slot interchange circuit
2. In the above example, the time stage interchanges time-slot 3 to time-slot 31 on PCM line 1, whilst the space stage connects line 1 to line 8 during time-slot 31)

A basic 256-channel time-space switch device



Digital point-to-multipoint radio system with time division multiplexing and time division multiple access

The preliminary results of the Laboratories' investigations substantiate predictions that digital switch costs will be small compared to interface module costs. In the case of small digital exchanges, these will become economically viable in the near future because their 'first in' costs will be relatively low. This fundamental economic relationship could also mean that current dimensioning and provisioning techniques and practices may have to be modified to reflect these changes. Further investigations will be conducted to develop a knowledge base within Telecom to assist the specification of future switching systems which provide cost effective measures for network evolution.

Digital Access by Point-to-Multipoint Radiocommunication

Digital point-to-multipoint radiocommunication (DPMR) is a versatile, quick and efficient method of providing medium rate both way digital services, e.g. n x 64 kbit/s, ISDN access, etc., to city and urban business customers when they cannot be reached easily by equivalent cabled services or when access diversity is required.

In a DPMR system, a nodal station with conventional digital network access is installed with prominently located fan-beam microwave antennas covering its

service area in three or four sectors. Customer outstations, each with a small pencil beam antenna directed on a line of sight to the nodal antenna at up to 10 km range, are easily installed as required. Each sector can serve hundreds of outstations, using time division multiplexing and time division multiple access for full and part-time access at various digital rates, with a maximum sector throughput of 2 to 8 Mbit/s.

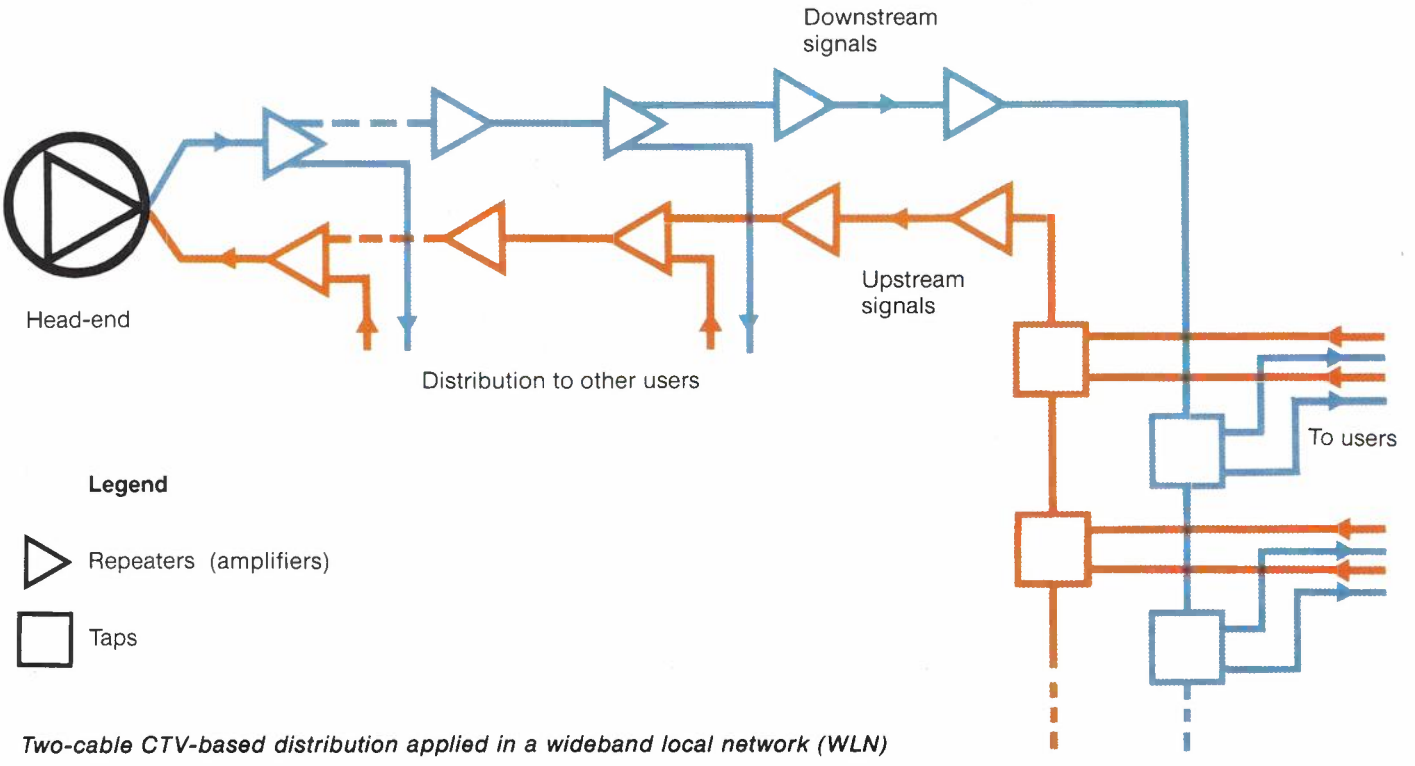
The Research Laboratories are participating with other Telecom Departments in field trials of DPMR systems. The Laboratories are also studying the limitations of high capacity multi-node systems, in which nodal service areas are overlapped, as in cities with high-rise buildings, to provide visibility of one or another nodal antenna from most of the system's service area. In such systems, radio spectrum usage is conserved by re-using carrier frequencies at non-adjacent nodes. However, interference between sectors using the same frequency can then be caused by radio beam scattering from tall buildings, or simply by line-of-sight overshoot from unfavourably located outstations. Thus, the service availability, the maximum number of services, the system cost and spectral efficiency are all related to the service area topology as well as to the equipment capabilities.

Presently available systems use the centimetre wave bands (10 to 30 GHz). Similar systems using the millimetre wave bands are also being studied by the Laboratories because the greater bandwidths that are available can accommodate high speed digital or video services. Resonant atmospheric absorption of signals, e.g. in the 60 GHz band, is of special interest because it reduces intercell interference and very high service densities may be possible. However, the maximum transmission range is severely restricted by present day microwave hardware limitations.

Frequency Allocation Plans for Coaxial Cable Based Wideband Local Networks

Wideband Local Networks (WLNs) support mixed services communications, including data, video and voice, between users over a limited geographical area of the order of 10 km radius. One way of implementing these networks is to use coaxial cable television (CTV) equipment to provide a wide bandwidth bearer, and to operate different communication links at different frequencies, using frequency division multiplexing (FDM).

The achievable range of such networks is determined by noise and non-linear distortion, which accumulate along the cascade of repeater amplifiers. Studies have been undertaken in the Research Laboratories to investigate these two sources of signal degradation, their origin and characterisation, and the manner in which distortion components combine. The impact of the choice of frequency allocation plan upon signal



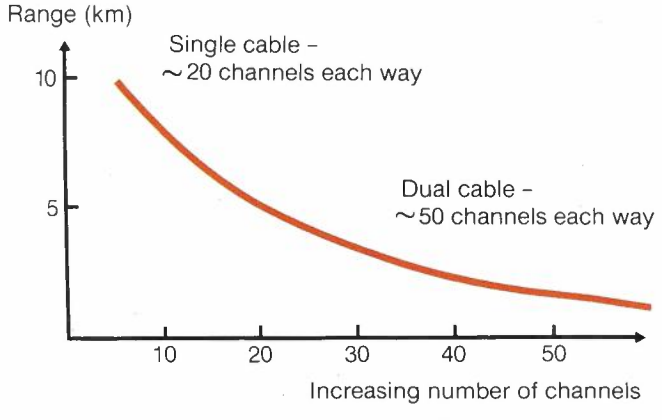
Two-cable CTV-based distribution applied in a wideband local network (WLN)

degradation, and ultimately the network range, have also been investigated.

The studies recognise that, if Australian standard analogue video channels are to be supported in any future networks based on this technology, an appropriate frequency allocation plan must be selected. Standard plans adopted in North America are not suitable because they are based on 6 MHz channel spacing. This is incompatible with the 7 MHz video channel spacing used in Australia. Since there are no standard allocation plans at present for cable transmission in Australia, a number of possible plans have been investigated. Analogue video channels are the most sensitive to degradations, and a worst-case study assumed a fully-occupied network incorporating only video signals in the available channels.

While broadcast networks (such as CTV) involve transmission of a signal along a bearer once, the bi-directional services supported by a WLN necessitate the transmission of the signal from a user to the head-end (central control facility), and then re-transmission down the network to the intended recipient. The Laboratories' study showed that, while broadcast CTV networks may have ranges of the order of tens of kilometres, the need for bi-directional communication in a WLN reduces the available range to only a few kilometres in some cases. A trade-off exists between range and capacity, since the systems which support the greatest number of channels ("dual-cable" systems, using one cable for each direction of transmission) offer considerably less range than those with a more modest number of channels (such as "single-cable" systems using one frequency band for transmission in each direction on a single cable).

The studies have highlighted the need for reliable estimates of the future required capacity and distribution of users if this bearer is to be used in any future WLNs in Australia.



Variation of range with the number of channels supported by a WLN

Interference Levels in the Digital Radio Concentrator System

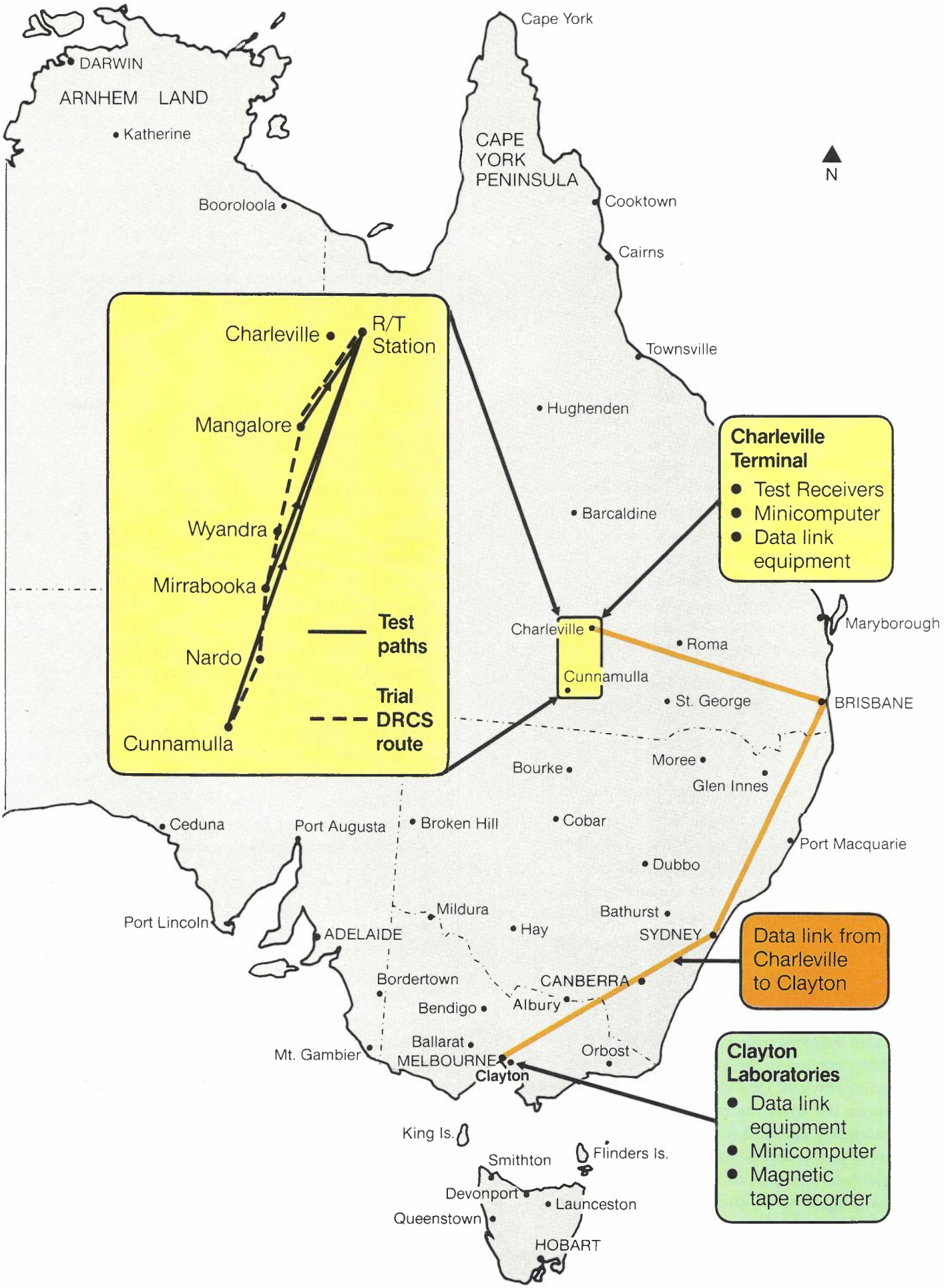
Analyses made at the Research Laboratories during 1981 and 1982 of the effects of co-channel interference and noise on the performance of the then proposed Digital Radio Concentrator System (DRCS) required the assumption of the validity of a number of methods of estimating radio path loss and its variability. Measurements to test these methods in areas of likely application of the DRCS were considered necessary, and an experiment for this has been mounted near Charleville, Queensland.

The experiment is being conducted in conjunction with a trial of a 500 MHz version of the DRCS itself. This trial is based at Charleville and extends through a number of repeaters to a subscriber terminal at Cunnamulla. The DRCS is currently set up with a permanent call to the subscriber at Cunnamulla, and, at Charleville, three transmissions are received and their level measured. The three signals are transmitted from Mangalore, (distant 53 km), Mirrabooka (distant 128 km) and Cunnamulla (distant 196 km). The Mangalore-Charleville path is a proposed repeater-cell centre path for a planned DRCS installation in this area, and the transmissions from Mirrabooka and Cunnamulla potentially present interfering signals.

At Charleville, the levels of the received signals are measured under the control of a local minicomputer, and the results are transmitted with other data to the Research Laboratories at Clayton, Victoria, over a dedicated data link. At Clayton, another minicomputer accepts the data and makes a permanent record on magnetic tape. This record is later analysed as required. Overall control of the experiment is from Clayton and, other than for maintenance, no intervention is required in the field.

The experiment aims to test some methods for estimating path loss and its variation that are applicable to these paths and are described in the CCIR documents - Report 715-1, Recommendation 370-4, Report 283-4 and Report 569-2. These reports describe methods for estimating diffraction path loss, fading effects, troposcatter path loss and ducting, respectively.

The experiment was installed late in 1983 and will continue until mid-1985. To date, the analysis of field results is confirming the validity of the estimating methods used in the earlier theoretical studies by the Laboratories, and hence, the methods used earlier for estimating the system performance.



Digital radio concentrator system field experiment

Prediction of the Performance of Digital Satellite Communications Links

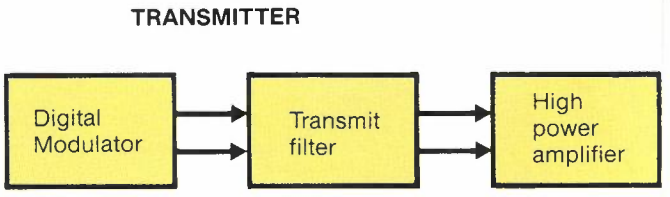
Telecom Australia is presently considering the introduction of a number of new customer services based on high speed digital communications via satellite. This requires a prior understanding of the design and performance of these satellite links so as to ensure their optimum use and compatibility with existing terrestrial systems. Studies and simulation experiments are being undertaken in the Laboratories to develop this understanding.

A satellite communications link is different from a terrestrial link in several ways, the most important being in the use made of non-linear transmission elements. The onboard amplifier is one such example, showing both gain and phase non-linearities. The Laboratories' investigations of these and other effects have primarily been based on computer simulation of the satellite links. A simulation package has been developed within the Laboratories and this has provided a means to predict overall performance, evaluate trade-offs and locate sources of channel degradation of satellite links under various conditions and configurations.

The basic principle used in the simulation is to emulate the system described by the adjoining block diagram. The input signals are simulated as time domain discrete samples and passed through the elements of the channel. The output at each element can be accessed and the performance of the link up to and including any element can be predicted. Thus, the usual performance characteristics of a digital communications link such as bit error rates, spectrum, eye diagrams, state transitions, etc, can be evaluated easily at any desired point on the link.

By using this software simulation package with an appropriate form of transponder non-linearity, the Laboratories have studied the Australian National Satellite System (AUSSAT). The studies have provided valuable information about AUSSAT which has been applied in the planning of efficient customer services. One such study determined the effects on the spectrum of the signal caused by operating the onboard non-linear amplifier at different power levels. Another study concerned the interference of a time division multiple access (TDMA) signal with other signals to be carried by AUSSAT.

The simulation software package contains subroutines and is modular in nature. This provides flexibility to configure these subroutines according to



any particular application. The software has been developed to facilitate its continuous evolution as a general tool for the investigation of technical aspects of satellite communications.

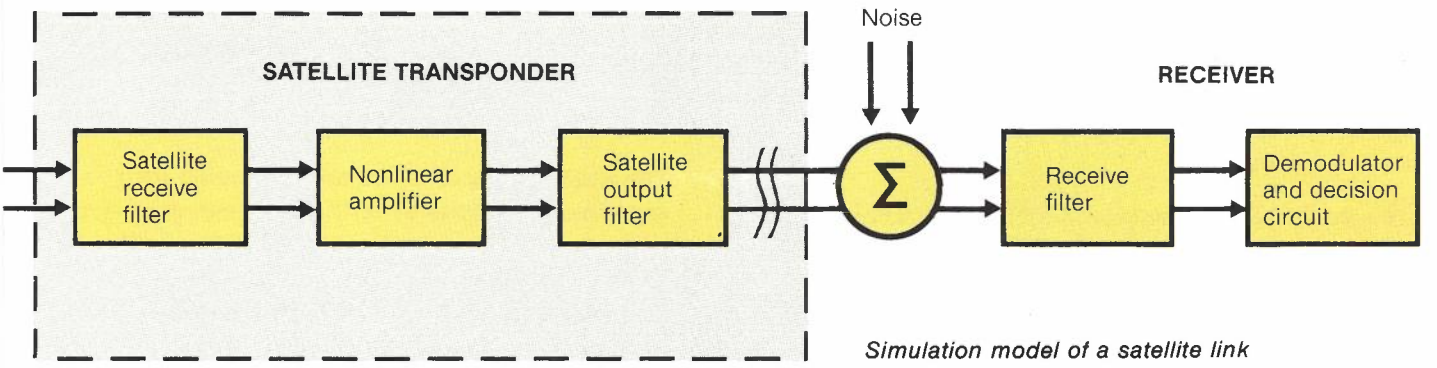
Direct Sequence Spread Spectrum Communications

Spread spectrum communications techniques use transmitted bandwidths which are much larger than that required by the source bandwidth or data rate, a factor in excess of 1000 being common. Such techniques were originally pioneered for military applications, but in recent years, civilian applications have begun to emerge. Spread spectrum techniques can be based on several different principles, the most popular being "frequency hopping" and "direct sequence".

The Research Laboratories have commenced studies of possible telecommunications applications of spread spectrum techniques which might be relevant to the future operations of Telecom Australia. Present studies are centred upon aspects of the direct sequence spread spectrum technique.

The direct sequence principle involves "modulating" a high speed pseudo-random binary sequence by the lower-speed user-data bits. The "code" used for the high-speed sequence is often a "Gold Code", named after Robert Gold, its originator. The resultant transmitted signal comprises digital "chips", where many chips are transmitted for each user-data bit. Thus, the spectrum used for the transmitted bit-stream is much wider than that which would normally be used with narrow-band techniques. However, the codes allow several users to transmit simultaneously in the same frequency band. A receiver attempting to receive data from a particular transmitter must match its code to the code of the transmitter. The effect of other transmitters on such a receiver is that they produce interference, that is, there is mutual interference between the codes.

The Gold Codes are sets of near-orthogonal codes, chosen so as to reduce the mutual interference



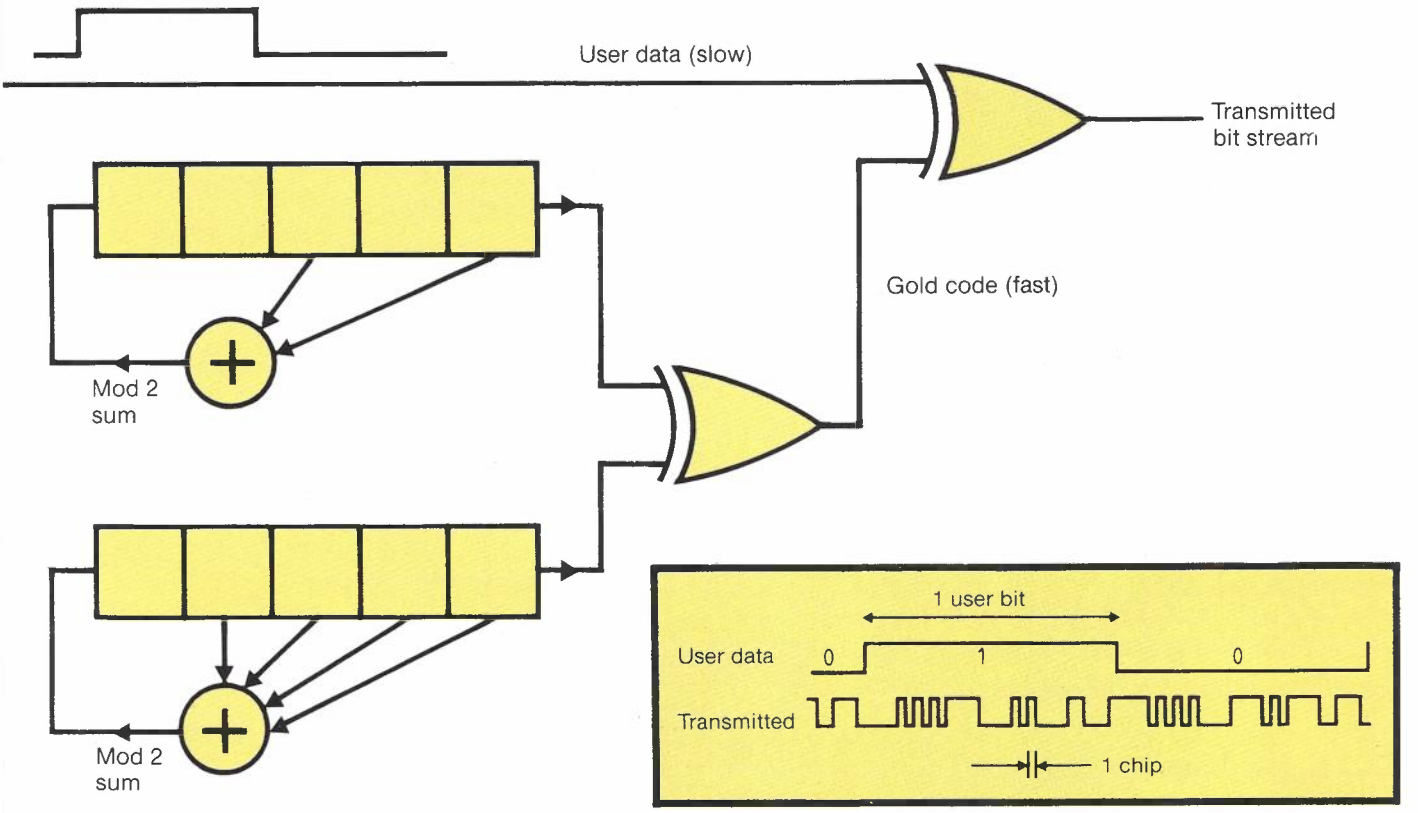
Simulation model of a satellite link

between multiple users of a spread spectrum system. Gold Codes are generated by combining the outputs of shift registers and the modulation process is achieved by logical gating of the user-data and the generated Gold Code.

The Research Laboratories are studying the mathematical properties of such codes.

A particularly important application of the direct sequence spread spectrum technique is in the multiple access environment. The two most common multiple access techniques are Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA). In FDMA, all users transmit simultaneously in different frequency bands. In TDMA, users transmit in sequential time slots in the same bandwidth. By contrast, spread spectrum communications allow the use of Code Division Multiple Access (CDMA), where all users transmit simultaneously and occupy the same bandwidth. An obvious advantage of CDMA over TDMA and FDMA is that no time or frequency co-ordination is required between the various transmitters in the system.

To assist the Research Laboratories investigations, an experimental system has been designed to demonstrate the main features of a CDMA system, particularly as might be applied in the development of a PABX with distributed control. The experimental system exists in the form of a bus architecture in which each node uses its assigned code to modulate the data to be transmitted. This results in spreading the bandwidth of the signal. Assuming that only a



Schematic description of the direct sequence spread spectrum technique

(Inset) Relationship between user-data and transmitted bit stream using the direct sequence principle

reasonable fraction of connected nodes are active at any given time, a node may transmit without first sensing the media, since interference between simultaneous transmissions is avoided by careful code selection.

This could be of advantage in PABX applications employing distributed control. Whereas conventional PABXs have a central controller and the possibility exists that a severe fault could bring the whole system down, a PABX with distributed control is only likely to suffer faults in distributed locations, presenting the less severe problem of individual user isolation.

CDMA has other advantages when applied to local area networks. In systems with distributed control, such as Ethernet, nodes attempt to sense whether the network is idle before transmitting. Collisions between data sent by different nodes can occur and this results in the need for a collision detection mechanism. Direct Sequence CDMA can be used to solve the problems of bus arbitration in such a system in the same way as for a PABX with distributed control. The result is a considerable improvement in performance. Also, by paying attention to code selection, such features as addressing and network priority can be readily provided.

Other possible applications of CDMA include domestic cordless telephones, and computer networking by radio and satellite systems.

Propagation Studies for Satellite Communications

The Research Laboratories are continuing their experimental studies of earth-space path propagation effects on satellite signals above 10 GHz. At these frequencies, the major considerations are rain attenuation (fading), reduction of polarisation discrimination, and scintillation or rapid fluctuations in received signal level. While the latter two propagation effects require a satellite signal for their measurement, the most important effect of rain attenuation has been studied by the Laboratories for many years.

The latter studies employed radiometers to measure thermal radiation from the sky, or sky noise temperature, which in turn was related to the effective path attenuation at the elevation angle of the radiometer antenna and the measurement frequency. Measurements have been conducted at 11 GHz and 14 GHz under the tropical weather conditions of northern Australia and in the temperate climate of the southern state of Victoria. Radiometer data for a three-year period has been accumulated by the Research Laboratories at Clayton, Victoria, using two radiometers at different elevation angles.

The data from the radiometer measurements has been analysed and the results have been incorporated into a rain attenuation prediction model,

Radiometer measuring microwave signal attenuation due to rain at Bendigo

which incorporates features relating to the unique Australian climatic conditions. The work has enabled Telecom Australia to make important contributions to the CCIR's effort to produce an acceptable worldwide prediction model.

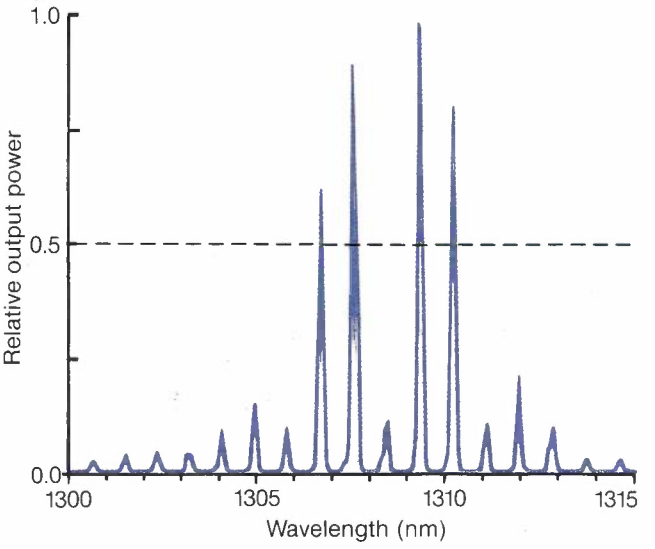
With the planned installation by Telecom of the main earth station and central control facility (MES/CCF) for its ITERRA Service at Bendigo in central Victoria, twelve months of radiometer measurements at 11 GHz were commenced there in late 1983. The radiometer was mounted on the roof of the exchange building which will house the MES/CCF. The rain attenuation data collected at this site is being used to upgrade the Laboratories' rain attenuation prediction model, as well as to provide directly relevant rain attenuation statistics for Telecom's major earth station site.

During the past year, Telecom and Aussat Pty. Ltd. have entered into a co-operative project to measure the beacon signal transmission from a satellite. This project will commence with the launching of the AUSSAT satellites about mid-1985. The AUSSAT system will use orthogonal polarisations to re-use frequency and thus increase useable bandwidth. Rain can reduce the cross-polar discrimination, thereby causing interference. It is therefore important to measure the effects of depolarisations under Australian conditions. The satellite will provide a stable beacon signal transmission at 12.75 GHz, which, with the appropriate earth terminal receiver, will provide cross-polarisation discrimination and scintillation information.

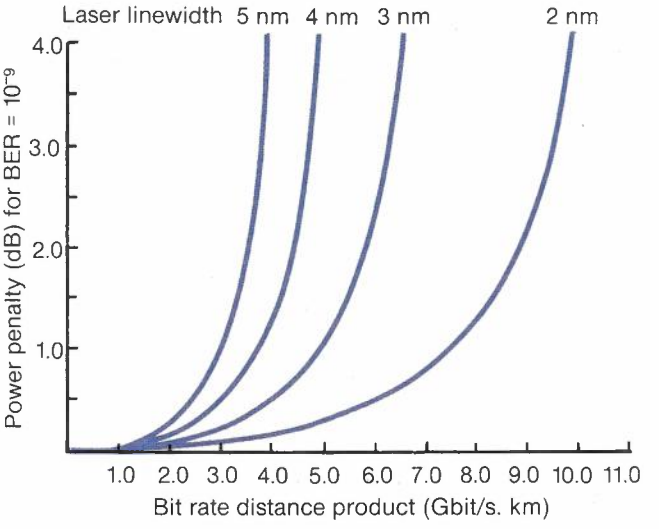
The continuing earth-space propagation studies by the Research Laboratories will use a beacon receiver terminal and associated 12 GHz radiometer provided by Aussat, co-sited with a Laboratories-designed 30 GHz radiometer, which is presently nearing construction in the Laboratories. The 30 GHz system will provide much needed data on rain attentuation at frequencies to be used for future satellite systems.

Mode Partition Noise in Single Mode Optical Fibre Systems

The laser diodes which are being used in the single mode optical fibre communication systems currently being installed around the world, are characterised by a power distribution in which the power is essentially concentrated at discrete wavelengths. These wavelengths correspond to the longitudinal resonant wavelengths of the laser cavity. Such laser diodes have been collectively termed multi-longitudinal mode laser diodes. An important



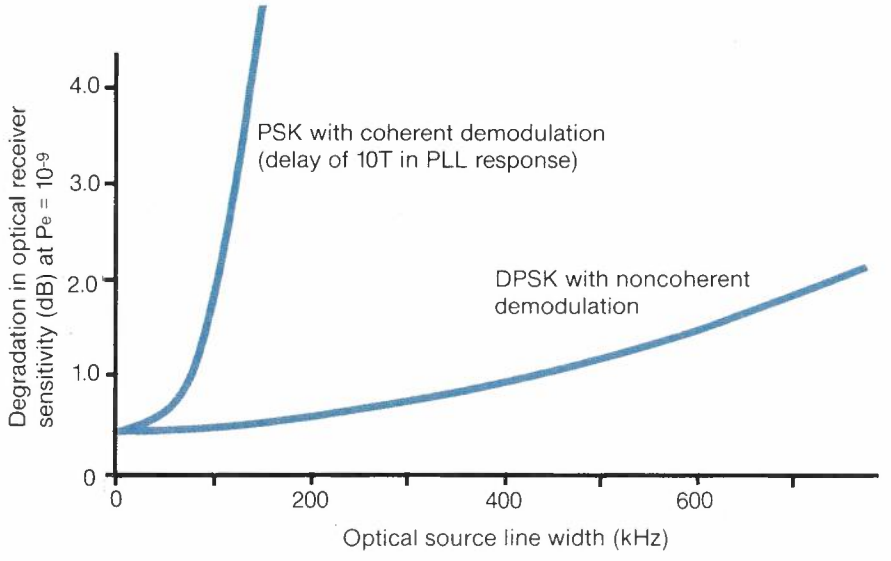
Output power distribution of a multi-longitudinal mode laser diode for use in the 1300 nm window



"Power penalty" due to mode partition noise for laser diode operation in the 1550 nm window and for a range of laser diode linewidths

characteristic of these laser diodes is that when they are subjected to intensity modulation, the distribution of the powers between the modes varies, even though the total output power may be stablised to an approximately constant value.

An important transmission characteristic of optical fibres is chromatic dispersion, i.e. wavelength-dependent dispersion. As a consequence of this dispersion, the modulation imparted on each of the longitudinal modes of the laser diode, travels the fibre with a different transmission delay, producing a time varying distortion in the received pulse shape. In these circumstances, the system is said to suffer from mode partition noise. A property of mode partition noise is that the ratio of the signal power to the mode partition noise power at the decision point



Effect of quantum phase noise on the performance of 140 Mbit/s heterodyne optical fibre systems

is independent of the received signal power. As a consequence, the bit error ratio will approach a "floor value" as the transmitted power is increased. Thus, mode partition noise is a very important consideration in the determination of the repeater spacing achievable in single mode optical fibre communications systems which employ multi-longitudinal mode laser diodes.

In order to determine the limitations imposed by mode partition noise on the route design of single mode optical fibre communication systems, the Laboratories have been undertaking studies to determine bit error ratios resulting from mode partition noise, where this is dependent on the group delay characteristics of the optical fibre and the mode partition statistics of the laser diode.

The studies have indicated that, while no serious problem should be met with systems operating in the 1300 nm window, mode partition noise could seriously limit the section lengths (or bit rates) achievable for systems which operate in the 1500 nm window where the fibre dispersion is approximately 18 ps/km.nm. Measurements are being conducted to quantify the mode partition statistics of multi-longitudinal mode laser diodes in a manner which can be used directly in expressions developed for the system performance.

Heterodyne and Homodyne Optical Fibre Communication Systems

The optical fibre communication systems currently being installed in telecommunication networks around the world operate on the principle of intensity modulation at the transmitter and direct detection at the receiver. In effect, this simply involves modulating and detecting the power of an optical signal which, with modern practical semiconductor laser diodes, possesses a bandwidth far in excess of the modulating signal bandwidth.

The use of heterodyne or homodyne optical communication systems, in which a local optical signal is mixed with the received optical signal prior to photo-detection, offers the promise of up to 10-20 dB better performance than those systems which employ the simpler intensity modulation and direct detection principle. Such improved performance could be translated into significantly longer repeater spans or increased bit rates on existing repeater spans, providing the possibility of upgrading existing systems. However, the most attractive future application of these systems may be with optical amplifiers and frequency division multiplexing of a few optical channels.

Before heterodyne or homodyne optical fibre systems can become of practical interest, many problems must be overcome. For example, substantial improvements in the stability and spectral purity of semiconductor laser sources must be achieved. Also, low loss modulators and polarisation-matching receivers must be realised.

In order to assess the performance of heterodyne and homodyne optical fibre systems, the Laboratories are currently undertaking studies of these systems. The objective of this work is to develop specifications for many of the system parameters involved and to investigate experimentally particular system implementations.

Different modulation and demodulation techniques have been reviewed in terms of the optical receiver sensitivity required for a given probability of error, in the presence of shot noise from the local optical source. This analysis has been extended to include

the effect of quantum phase noise from both the transmit and local optical sources on the performance of systems using phase-shift keying (PSK) modulation. The quantum phase noise arises from spontaneous emission in the laser causing random phase changes in the laser field output. The quantum phase noise is specified in terms of the laser or optical source linewidth.

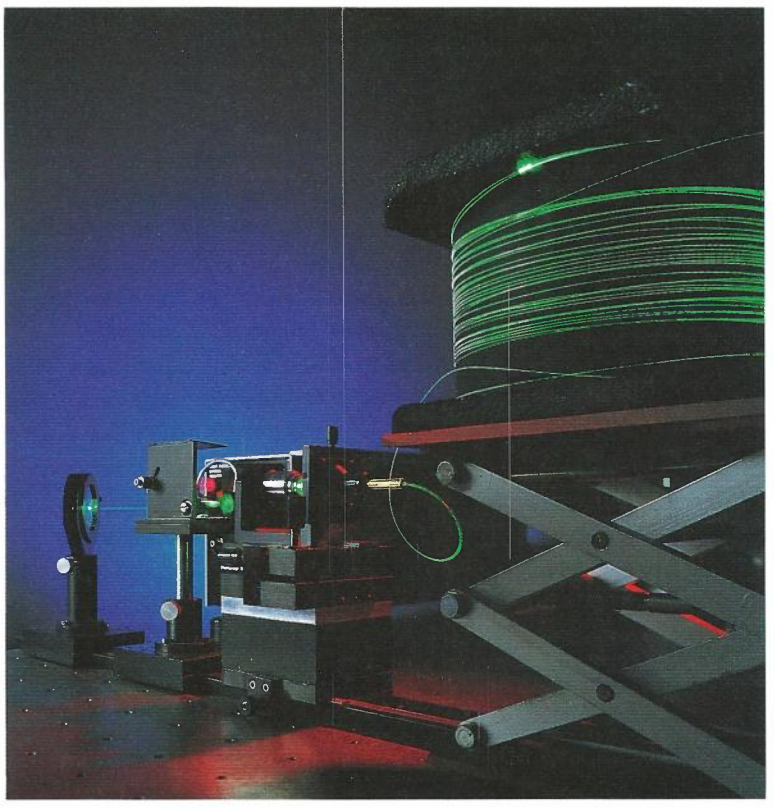
Two of the more attractive heterodyne system options under study are differential phase shift keying (DPSK) with non-coherent demodulation and PSK with coherent demodulation. In the latter case, the varying phase of the intermediate frequency signal is assumed partially tracked by a phase locked loop acting on either the electrical IF carrier and/or the local optical source. Results to date indicate that DPSK may be the more attractive option as a compromise between performance and receiver complexity.

Polarisation-preserving Optical Fibres

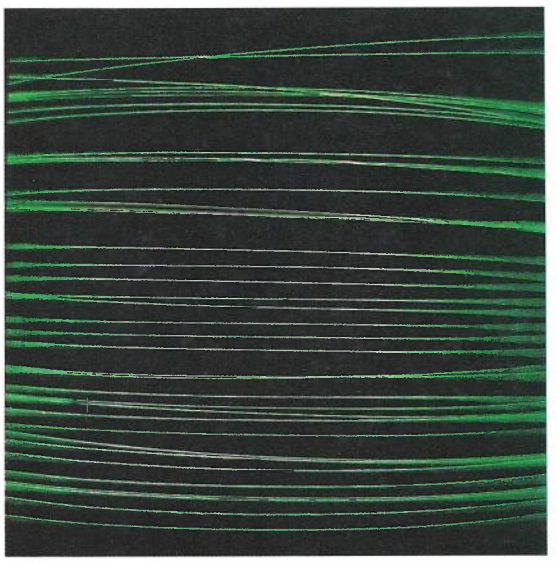
Recently, there has been wide interest in a new kind of single mode optical fibre known as polarisation-preserving fibre (PPF), which, unlike conventional fibres, can maintain a fixed polarisation as light propagates through it. If such fibres were used in optical communications systems, the design of optical receivers could be simplified, as the polarisation of the received signal is not susceptible to random environmental factors such as vibration and temperature variations, as is often the case with conventional fibres. Polarisation-preserving fibres are also finding applications as new phase sensitive optical elements in their own right, for example, in optical couplers and sensors which exhibit unprecedented sensitivity. Their performance is enhanced still further if one polarisation is suppressed or reduced significantly in amplitude to produce a single polarisation fibre (SPF). Presently available fibres achieve this at some cost in terms of loss of signal from the wanted mode (expressed as dB/km). Hence, a clear understanding of the mechanisms involved is essential for SPFs to be useful for communications.

In the Laboratories, experiments have been conducted on samples of PPF which demonstrate characteristic periodic "beats" or regular variations in the intensity of light scattered from the fibre core. The occurrence of such beats is direct evidence of the unique polarisation-preserving properties of PPFs. Furthermore, the variation of beat length with temperature has been observed, and these results provide information on how stress has been frozen into the fibre during its manufacture. Such stress is fundamental to its operation.

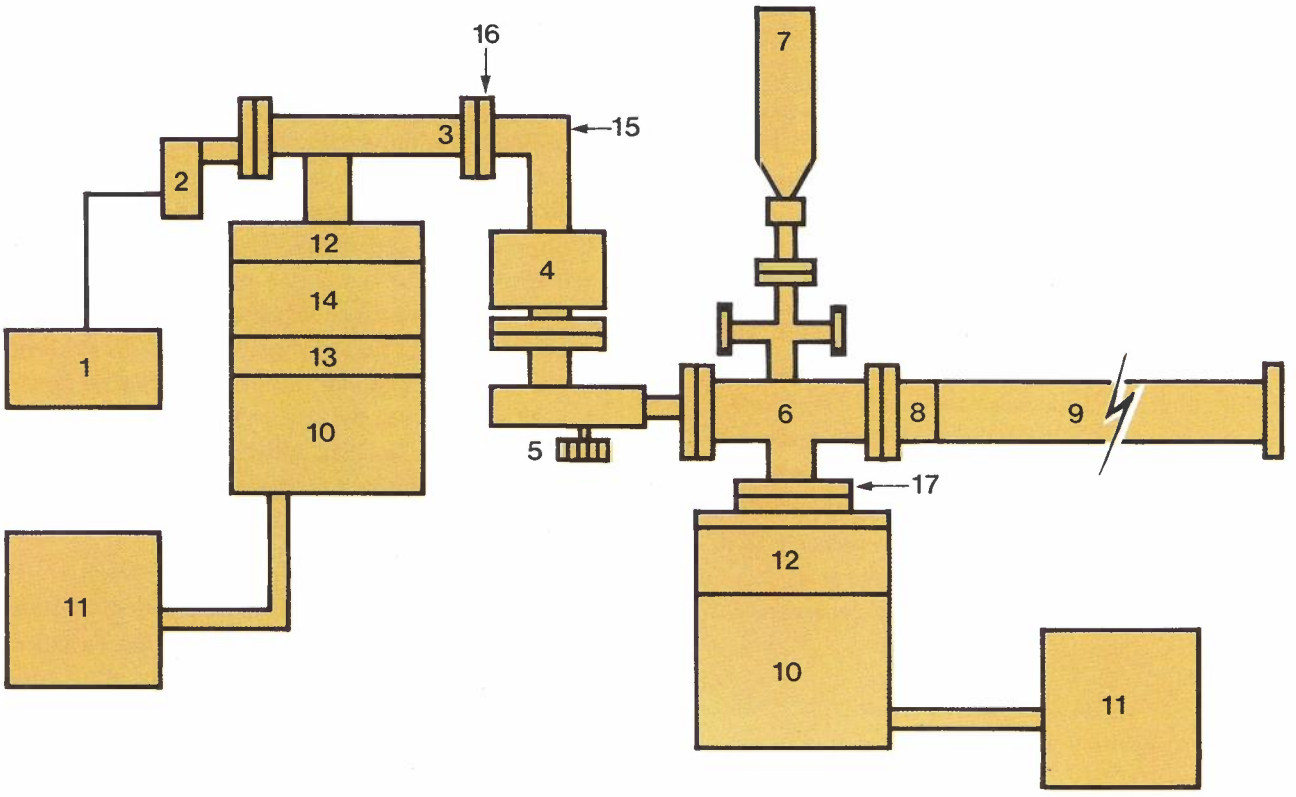
Measurement of subtle changes in beat length of PPFs has been achieved by designing an experiment based on the Faraday effect. If an illuminated optical fibre is subjected to an axial magnetic field, the



◁ *Experimental configuration for measurement of beats in polarisation-preserving fibres*



(Inset) Beats occurring in light intensity scattered from the core of a polarisation-preserving fibre



Legend

1. Mass spectrometer control unit
2. RF generator
3. Mass spectrometer chamber
4. Cryogenic trap/valve
5. Fine leak valve
6. Stainless steel tee
7. Standard hydrogen leak
8. Conflat flange to glass adaptor
9. Glass sample chamber
10. Diffusion pumps
11. Rotary pumps
12. High vacuum isolation valves
13. Water cooled baffle
14. Liquid nitrogen trap
15. Stainless steel elbow
16. Adaptor (S.S. elbow → M.S.)
17. Adaptor (70 mm conflat → diffusion pump)

optical field in the fibre suffers a slight change of polarisation. Since the magneto-optic coupling (Verdet constant) for glass is small, a magnetic field strength of about 10 kilogauss is required to produce a measurable change in polarisation. For the measurement of beats, the axial magnetic field must also be axially confined to less than a beat length accurately translated along the fibre's length, whilst polarisation changes are monitored.

Beats would not normally be expected to be observed in SPFs, since two polarisations are required to see beats. However, beats have been observed in samples of SPF by illuminating them with light shorter in wavelength (514 nm) than that at which the SPF has been designed to operate (1300 nm), thus opening a new avenue of investigation for such fibres. Further, the beat length of an SPF has been observed to increase or decrease measurably when a transverse stress is applied externally over only a few centimetres of fibre. This is consistent with the known internal structure of the fibres.

It is envisaged that a clearer understanding and more accurate characterisation of such fibres will follow from further experiments within the Laboratories.

Gas Evolution from Optical Fibre Cabling Materials

There are various physico-chemical effects in the silica glass used in the production of communications quality optical fibre which result in signal attenuation. Hydrogen gas permeation has recently been recognised as one such source of transmission loss. These absorptive losses of energy arise from weakly bonded hydrogen molecules and hydroxyl ions (OH) vibrating within the interstices of the silica atomic lattice. They can also come from the stronger, irreversible chemical bonding with phosphorus when that element is used as the pentoxide dopant to raise the core index or when added to improve the glass fibre drawing characteristics. These losses occur in wavelength bands (i.e. transmission spectral windows) which are of major current interest in telecommunications development of optical fibres. It is therefore essential to find and minimise the effects of any sources of mobile molecular hydrogen from materials used in the production of optical fibre cables and which are near the optical fibres so that an acceptable service lifetime can be obtained from this type of cable.

◁ *Schematic outline of apparatus for the detection of hydrogen in optical fibre cabling materials*

Materials proposed for use in Australian optical fibre cable manufacture have been assessed in the Laboratories to determine their ability to act as sources of hydrogen outgassing, to postulate chemical mechanisms of generation and to measure gaseous diffusion rates.

The equipment used in the Laboratories for evolved gas analysis was adapted to allow comparison with results obtained by overseas laboratories engaged in this type of investigation. The apparatus consisted of a temperature controlled sample compartment and a liquid nitrogen cooled condensibles trap, with the off-gases being led into a narrow range quadrupole mass spectrometer used as a residual gas analyser. The spectral gap for analysis was set to cover the mass/charge ratio for hydrogen. A calibrated hydrogen gas 'leak' was incorporated for standardisation of the system.

In the adopted test procedures, samples of the materials were introduced into a subsequently evacuated chamber and the relative amounts of hydrogen evolution above a predetermined background were measured. Comparative relationships were then derived from the quadrupole ion intensity responses.

It was found prudent to minimise the use of glass fittings under high vacuum stress and to normalise results by comparing changes taking place in the background nitrogen to hydrogen gas ratios, rather than to rely on hydrogen response taken in isolation.

Examples of various functional materials allied with optical fibres to permit their strain-free use in cables are shown in Table 1. They were drawn from pilot lengths of optical fibre cables laid in Telecom Australia's recent direct ploughing field trials.

The routes of hydrogen permeation into fibres are shortest at the primary fibre coatings laid on at the drawing stage. Then in order of decreasing proximity follow materials used as buffer layers, cushioning compounds, water excluding fillers, spacer materials, axial strength members, bundling and reinforcing tapes, core wraps, barrier foils and finally sheathing and jacketing plastics. Based on the response of the mass spectrometer for room temperature outgassing of specimens at one millionth torr pressure, the following materials have been rated relatively to one another on their propensity for hydrogen evolution. The first listed material has the greatest propensity:

- Polyamide fibre coating
- Barrier laminates, single-sided
- Polyamide hard jacket
- Polyethylene sheath
- Cured acrylic fibre coating
- Barrier laminate, double-sided
- GRP axial strength member.

Where jelly-type fillers are used as stress buffers or to prevent the longitudinal ingress of water in optical fibre cables, these materials appear as significant sources of non-condensible gases including hydrogen. With petroleum based jellies, hydrogen can be introduced from raw material preparative processes; with silicone resins, hydrogen can result from some catalysed curing reactions.Other laboratory techniques are being developed to measure the rates of hydrogen evolution with the increased accuracy necessary for service life forecasting for optical fibre cables in commercial production. This will enable optical fibre transmission losses related to hydrogen permeation to be estimated on a reliable basis. The end objective of this work is the specification of the technical parameters affecting cable design and hence, transmission performance and service lifetime. These specifications will find their expression in Telecom's future procurement contracts for cable.

Type of Cable Construction	Spiral Slotted Core Spacer	Grooved Cylinder Core Spacer	Tube
fibre coating	radiation cured acrylate	acrylate	acrylate
buffer coat		PA (soft)	
spacers	PE	PE	PE
fillers	PJ	PJ	jelly
strength member	GRP, central	GRP, central	concentric tube
core wrap & bundling	PET tape	PET tape	aramid
barrier laminates	none	none	none
sheath	PE + CB	PE + CB	PE + CB
outer jacket	PA (hard)	PA (hard)	PA (hard)

LEGEND

PA	- polyamides (Nylons)
PE	- polyethylene
PJ	- petroleum jelly
GRP	- glass reinforced plastics
PET	- poly(ethylene terephthalate)
CB	- carbon black
aramid	- poly(p-phenylene terephthalamide) (kevlar)

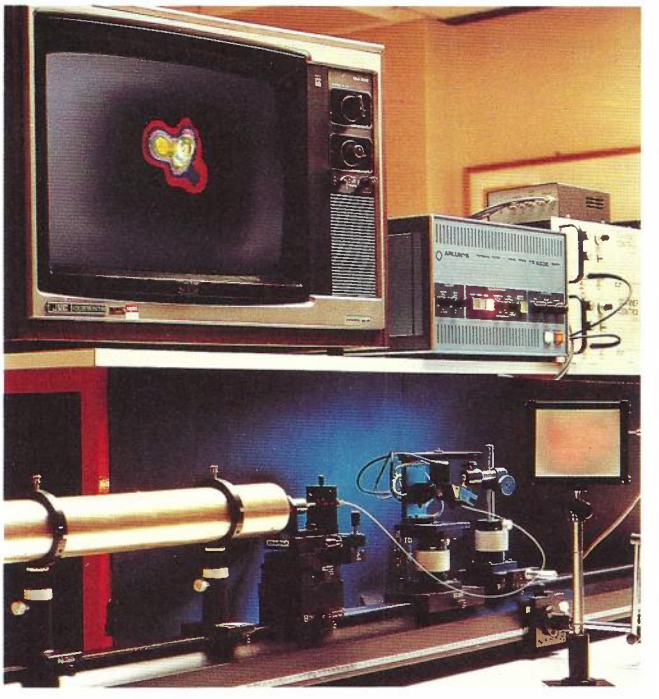
Table 1: Examples of materials used in non-metallic, loose tube cables

New Materials in Optical Fibre Technology

Optical fibre technology has advanced beyond the most optimistic expectations of the early seventies when, for example, experiments had just started in Telecom's Research Laboratories on a liquid-filled fibre developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). The material limit has now been reached with silica fibres, such that their transmission loss is not expected to be reduced below the 0.16 dB/km already demonstrated. This achievement is important in its own right and also in terms of the lessons which it provides for the design of new fibre materials.

The first lesson is that two distinct mechanisms operate to produce the valley in the loss/wavelength curve, namely Rayleigh scattering at the shorter wavelengths and infra-red absorption at the longer wavelengths. For practical glass-forming temperatures, the Rayleigh scattering at a given wavelength, due to the microscopic fluctuations in refractive index, will not be dramatically reduced by future technological advances. However, if the infra-red absorption peaks can be pushed to longer wavelengths by the use of new materials, the movement of the operating point along the Rayleigh scattering characteristics will result in dramatic loss reduction. Glasses made from heavy metal halides such as zirconium tetrafluoride are possible candidates and are being studied in a number of laboratories around the world. In Australia, Telecom's Research Laboratories have issued a research contract to the Chemistry Department of Monash University for investigations into these new glasses, which will ultimately be drawn into experimental fibres at Telecom's Research Laboratories on a specially designed drawing tower developed by AWA's Research Laboratories under a separate contract with Telecom.

The longer operating wavelengths of the newer fibre materials will require a new range of opto-electronic devices. Materials which seem particularly suited to the fabrication of these devices are based on mercury-cadmium-telluride (MCT) and related compounds. A unique feature of this materials system is that, by varying the composition, the operating wavelength can be tuned from 0.8 μm to beyond 20 μm, thereby covering the entire range of possible fibre systems. This wide tuning range can be achieved without lattice matching problems and the band gap is always direct, potentially yielding laser devices over this wide band of wavelengths. Another feature of this materials system is that by substituting certain elements, such as manganese, compounds known as diluted magnetic semiconductors can be



Mechanical scanning and digital image analysis provide a laboratory simulation of light emerging from a mid-IR optical fibre

formed. With these materials, optical isolators can be fabricated, which are the counterpart of the microwave isolators used to de-couple active devices in radio systems. These new optical devices fill an important gap which remains in the duplication at optical frequencies of all components used in microwave systems. As heterodyning experiments using lasers in the visible part of the spectrum have already commenced at Telecom's Laboratories, the availability of a full range of devices in the near and mid-infra-red bands will enable this work to be translated to the wavelengths suitable for fibre transmission.

Electronic Circuitry for Gbit/s Optical Fibre Transmission Systems

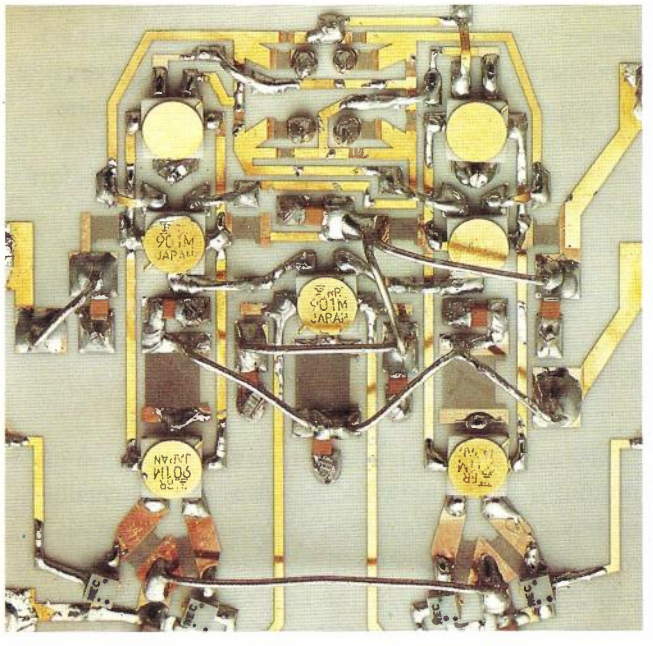
Predictably, Telecom Australia will increase the transmission capacity of its long distance trunk network to meet growth in services and traffic largely by using digital single mode optical fibre systems, as its most economic option. The use of high order time division multiplexing is presently less expensive than alternatives such as space division multiplexing (i.e. using more optical fibres) or wavelength division multiplexing (i.e. using more than one wavelength on each fibre). Whilst the initial Melbourne-Sydney optical fibre system to be installed shortly by Telecom will use 565 Mbit/s bit rates on some fibres,

future systems are expected to operate at higher bit rates, possibly 1.2, 1.6 or 2.0 Gbit/s.

At bit rates in excess of about 500 Mbit/s, emitter coupled logic (ECL) integrated circuits and active devices, such as VHF bipolar and field effect transistors, are of limited use in digital systems. For very high bit rates, custom-designed digital and analogue circuit functions must be realised by using microwave silicon (Si) and gallium arsenide (GaAs) devices. In addition to the inductance of device interconnections, parasitic and stray capacitances must be minimised to obtain maximum circuit speed or bandwidth.

The layout and construction of the circuitry is therefore critical for these applications. At these high bit rates, complete circuit integration achieves best results. The use of thick and thin film construction techniques yields poorer results, but provides, in turn, better performance than the use of discrete components assembled on copper clad circuit boards.

In the Laboratories, two high speed circuits have been built to develop expertise in, and to determine operating speed limitations of, thin film circuit construction techniques. The circuits, a 4-channel multiplexer and a 4-phase divide-by-2 clock generator, form two key components of a high speed pseudo-random sequence generator. The generator will be used to characterise the performance of high bit rate optical fibre digital transmission systems in terms of bit error ratio and to aid in the characterisation of mode partition noise (a phenomenon that degrades the performance of single mode optical fibre systems using conventional laser diode sources, especially at high bit rates).



Thin film circuit implementation of a 4-phase divide-by-2 clock generator

The two circuits fabricated in the Laboratories operated satisfactorily up to input clock frequencies of 850 MHz (1.7 Gbit/s), with output waveforms having rise times (10-90%) of 180-200 ps and fall times of 200-250 ps. This use of thin film construction techniques provided a significant improvement over the performance of earlier prototypes, built using the simpler construction technique of discrete components mounted on copper clad circuit boards. The maximum performance realised with these earlier prototypes was limited to 550 MHz.

The experience gained will be used to develop and fabricate other high speed circuitry used in investigations of coherent, single mode optical fibre communication systems.

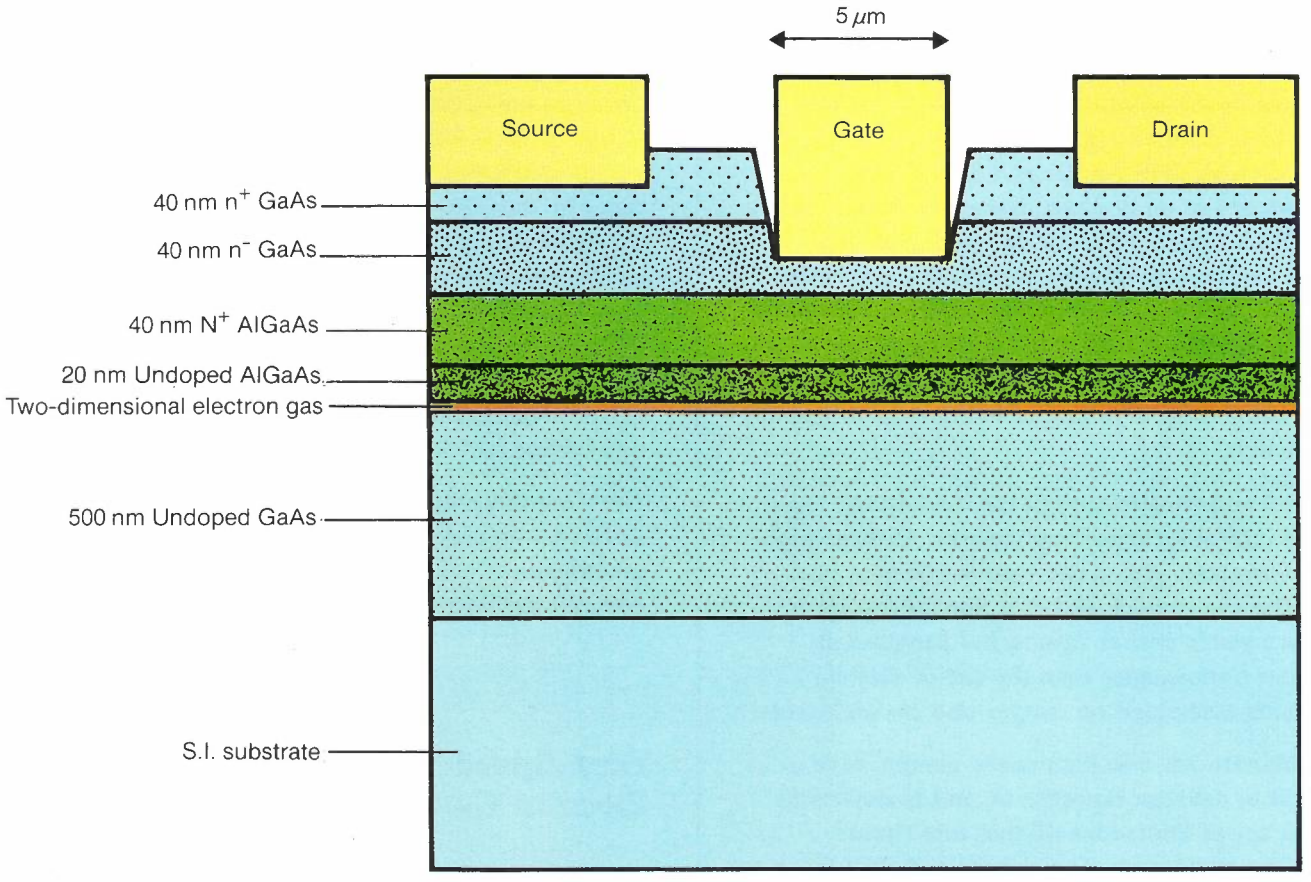
High Speed Two Dimensional Electron Gas Transistors

Future rapid growth in telecommunications traffic and services will generate demands for electronic components able to satisfy increasing speed and reduced power consumption requirements. Devices based on the recently discovered formation of a two dimensional electron gas at the interface of GaAs/AlGaAs single crystals have been identified by leading telecommunications and computer equipment manufacturers as holding great promise for applications in advanced high speed digital electronics.

Telecom's Research Laboratories have recently joined the ranks of only a handful of institutions in the world able to grow modulation doped GaAs/AlGaAs heterostructures suitable for Two Dimensional Electron Gas Field Effect Transistor (TEGFET) fabrication. The Laboratories have produced experimental devices in small quantities to gain insights not only of the production processes but also of the performance capabilities of such devices.

Production of the TEGFET material by the Laboratories required the full capabilities of the Laboratories' Molecular Beam Epitaxy (MBE) System, an apparatus for growing semiconductor crystals in an ultra-high vacuum environment. Features of MBE making the technique particularly well suited to this task include:

- the ability to grow high purity, defect free, single crystal epitaxial layers of controlled composition
- the ability to form sharp boundaries on an atomic scale between dissimilar materials



Cross section of an experimental two dimensional electron gas field effect transistor (TEGFET)

- precise control of the concentration and location of dopant atoms.

To appreciate fully the precision required of the material growth techniques, it should be noted that a typical 20nm undoped AlGaAs layer is only 80 atoms thick. It is anticipated that, in future devices, the thickness of this layer will be reduced to 5nm, or 20 atoms.

Operation of the TEGFET can be explained in the following way. To maintain thermodynamic equilibrium, electrons are transferred from silicon donor atoms in the N+ AlGaAs into the undoped GaAs. Some of these electrons, those in the two dimensional electron gas, go into a potential well, only 10nm wide, which owes its existence to the presence of the GaAs/AlGaAs interface. These electrons are free to move parallel to the interface. The remainder of the transferred electrons are bound to charged acceptors in the GaAs and play no further role.

Because the electrons in the two dimensional electron gas are spatially separated from their parent ionised donor atoms in the N+ layer (the undoped AlGaAs layer serves to increase this separation), they are free to move at very high speeds between the source and drain electrodes with which they are in electrical contact. High frequency operation results from the high speed of these electrons. Transistor action is brought about by varying the gate potential, which in turn causes a variation in the density of the underlying two dimensional electron gas.

TEGFET materials grown and tested in the Research Laboratories have demonstrated excellent electronic properties, and experimental TEGFET devices have exhibited appropriate DC characteristics at cryogenic temperatures. Through this work, the Laboratories are now in a position to begin assessing the high frequency performance of these devices long before they become commercially available.

Magnetic Bubble Memory

Utilisation of the Telecom network will increase in the future as the network impact of the information society grows. Foreseeably, demand for increased memory requirements will be a corollary of network evolution. Accordingly, the Laboratories have devised studies to investigate the characteristics and application of magnetic bubble memories in communication systems.

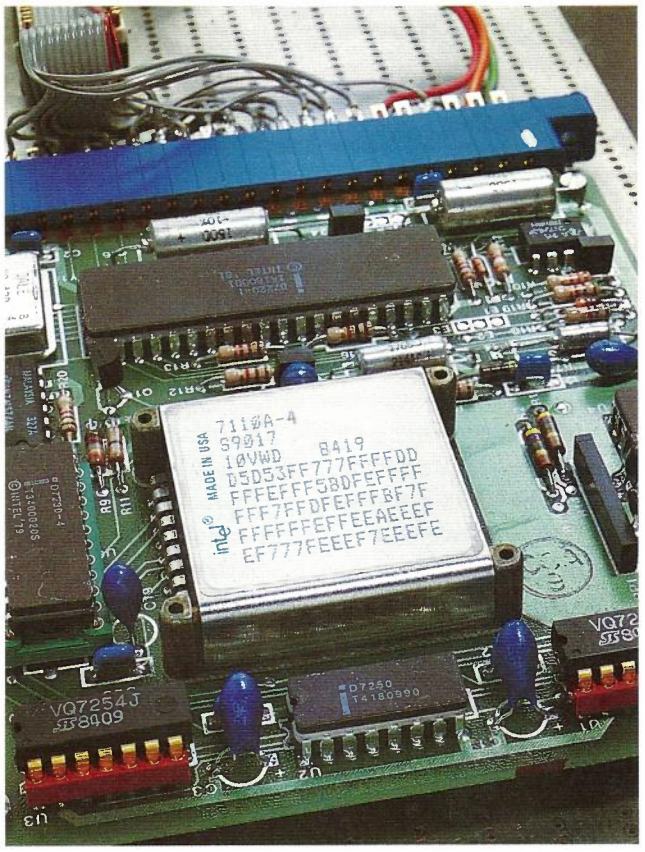
Magnetic bubble memory has been available since about 1979. Initially, it was expected to be a more important technology than it has in fact become. Difficulties in translating laboratory models to production caused most of the early manufacturers to withdraw. Advances since then have permitted ongoing manufacturing developments and restored the potential of the technology to provide cheap, reliable mass memory.

The heart of a magnetic bubble memory is an integrated circuit, made by the usual crystal growing and photolithographic processes, but distinguished by the absence of semiconducting materials. The most important layer of material in the device is a magnetic material, in which data is stored in the direction of magnetisation at a lattice of points. In this respect, it resembles rotating magnetic disc memory, but it differs crucially in that there are no moving parts. Instead, access to the data is obtained by moving the pattern of magnetisation so that the required data is below a magnetic field detector in the layer above. Alteration of the data is performed in a similar way. However, the chip package is bulky, due to the need for two coils for moving the bubbles, a permanent magnet and a magnetic shield.

The data capacity of available bubble memory chips is, at 4 Megabits, several times that of available semiconductor memory chips. Further, it is both writeable and non-volatile, unlike the larger capacity semiconductor memories, which are one (RAM) or the other (ROM). However, data access is much slower, due to its basically serial architecture, with mean access times of a few tens of milliseconds and data rates around 100 kbit/s, i.e. only a little faster than discs. The niche for bubble memory application is where discs would be used were it is not for the need for ruggedness, unattended operation, or to a lesser extent, compactness.

Theoretical studies undertaken in the Laboratories, supported by model testing, indicate that bubble memories are particularly suitable for voice message applications and storage of exchange-dependent data.

At present, at least seven manufacturers in the world are engaged in research, development and production activities associated with bubble memory. A flow of new and improved products is beginning to reach systems manufacturers. The Laboratories plan to conduct further investigations to evaluate these new developments in bubble memory technology and its application in telecommunications equipment.



Bubble memory chip package (at centre of photograph)

VLSI Design Techniques

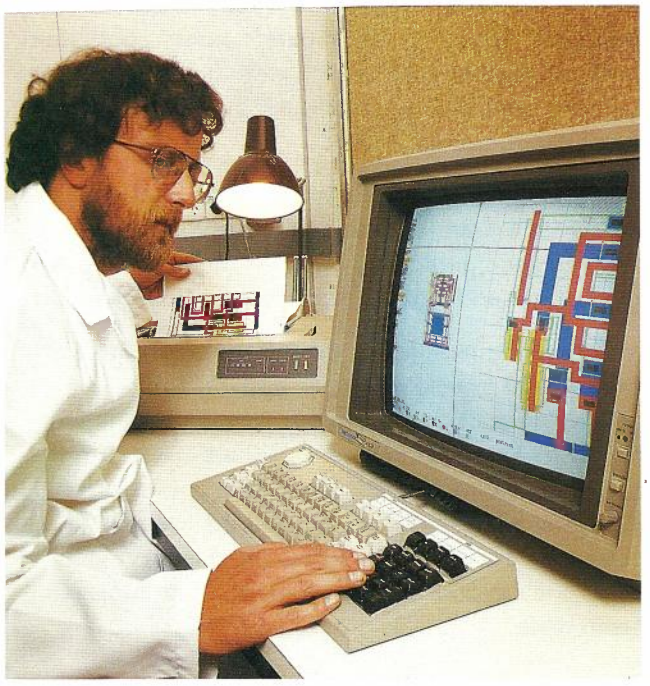
Very large scale integrated (VLSI) circuit devices are fast becoming the main components of telecommunications equipment. The use of more complex chips will certainly increase in the future. The Laboratories are developing expertise in this fundamental area of technology and have recently been involved in the design of integrated circuits through participation in the design of multi-project chips (MPC).

The MPC approach reduces the cost of implementing a particular circuit on silicon by sharing the fabrication cost among a number of circuit designers. Whilst it is an excellent means of bread-boarding a circuit on silicon at a reasonable price, devices produced by the MPC approach often fall short of requirements.

To investigate the pitfalls and problems involved in the production of integrated circuits, the Laboratories have undertaken a project to fabricate chips by emulating production requirements. Some of the more important conclusions drawn from the project to date are that:

- complete system specification prior to design is vital for project success
- design must be insensitive to processing parameter variations

CAD tools available to circuit designers in the Laboratories



- consultation with the fabrication house early in the design stage is essential to enable exploitation and incorporation of processing features and other specialities into the design
- test specifications and test circuits for automatic wafer testing should be included during the design stage, with particular consideration given to the test program to suit the test equipment
- some factors such as placement of bonding pads, spacing of active circuitry from pads and scribe-channel may seem trivial but have significant effects on yield
- allowance should be given for two or even three design iterations before production begins; circuit changes may also be necessary during production to improve yield.

Another aspect of the technology currently being investigated by the Laboratories is the development of computer tools used in the design of integrated circuits.

The development of VLSI circuit technology offers system designers the potential for realising large complex digital systems that previously were considered too complex to be effectively implemented. As with any complex system, however, the design task is often large and time-consuming, and it is usually made even more complex by the need for detailed circuit and geometrical layout design that would not be required had the designer used standard integrated circuits. It is further complicated by the difficulty of constructing or modifying prototypes. The error-prone nature of geometrical layout design also requires the design to be checked at every stage for correctness.

To help reduce the magnitude of the task and ensure correctness of the completed designs, computer aided design (CAD) tools are used. Current CAD tools are aimed at assisting designers in their traditional design tasks, such as generating circuit schematics, verifying correct circuit operation by simulation, and generating the geometrical layout of the integrated circuit. Computer simulation of the circuit is particularly important because of the prototyping difficulty and the increase in development cost and time caused by design and fabrication iterations to correct errors. Other CAD tools are used to ensure that the integrated circuit layout geometries adhere to fabrication process design rules and that the layout correctly represents the electrical circuit diagram. Such CAD tools have been made available to Laboratories staff to assist them to realise complex telecommunications systems and subsystems.

Current work in the Laboratories continues to investigate and develop computer tools for the automation of the more abstract components of the design task, such as the graphical or algorithmic functional specification of designs or functional behaviour verification.

Photovoltaic Power System Design for Remote Telecommunications Installations

Many telecommunication links in Australia traverse large expanses of uninhabited and often inhospitable terrain in which no reticulated power source is available. Communications equipment installed along these links must be accompanied by suitable power generating equipment so that each unmanned site is completely energy self-sufficient all year round. The inaccessibility and remoteness of many of these sites and the requirements for a highly reliable telecommunications network place stringent demands on the associated power sources. There are a number of options available for stand-alone power supplies, but those utilising renewable sources are now becoming economically competitive with those using more traditional and conventional power generation techniques.

The last few years have seen a considerable increase in both the number and range of stand-alone power supplies required for remote telecommunications

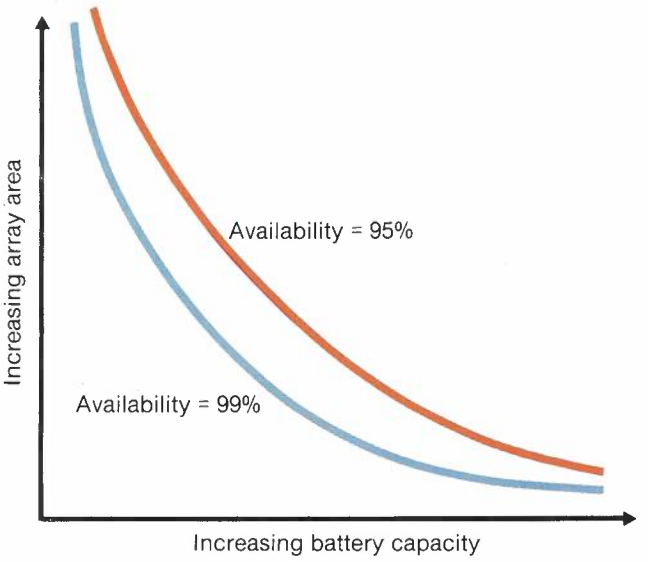
installations, including optical fibre repeaters, microwave radio systems, small satellite earth stations and radio concentrator systems providing services to remote homesteads. These applications require continuous power over the range of 8W to 1kW, experience widely different climatic conditions, and have vastly different availability requirements. For example, a single user at a remote homestead in arid central Australia may be prepared to accept a total of several hours lost service per year, but a trunk link between major cities in southern temperate areas carrying thousands of circuits must be much more reliable in service.

The Laboratories have developed a technique for designing stand-alone photovoltaic systems, with availability as an input parameter. The array size and the associated storage battery capacity are uniquely determined to yield a system that provides the specified availability at minimum total cost. The design process draws on a large collection of insolation data obtained from the Australian Bureau of Meteorology. The use of actual insolation data rather than a statistical weather model was preferred. Despite the increased computation time, the use of actual data gives far greater insight into real system performance, both from one day to the next and from year to year.

The Laboratories' technique simulates on computer a photovoltaic system with a particular array/battery combination. Solar input is calculated at half-hourly intervals over the entire period of available data, sometimes in excess of ten years. Simulation is then repeated with many different array/battery combinations and the results show how array area and battery capacity can be interchanged without sacrificing system performance. Only one combination, however, provides the specified availability at minimum cost, and knowledge of current array and storage prices allows the optimum system to be determined analytically. The effects of future price trends on system design can also be evaluated.

System designs obtained using the Laboratories' technique differ significantly from those obtained by using simpler system sizing programmes that use only average monthly insolation data.

Optimum selection of azimuth and elevation angles of the solar array has also been investigated by the Laboratories, as part of the total design process. A stand-alone power system need not necessarily be designed for maximum total annual energy input. It is preferable to achieve a high and relatively uniform input over the year with no severe minima. Suitable choice of elevation angle improves energy collection in winter at the expense of that in summer and depends heavily on the proportions of direct and



Characteristic curve showing that array area and battery capacity can be exchanged without loss of photovoltaic power system performance

diffuse radiation at a site as well as its latitude. The azimuth angle is chosen in recognition of local climatic conditions. For example, some areas in tropical northern Australia experience clear sunny mornings but cloudy, overcast and wet afternoons, in which case an easterly azimuth could prove beneficial.

Experimental evaluation and verification of the Laboratories' design technique is current, in the form of a field trial of a small (10 W) system. The performance of the system is being extensively monitored, analysed and compared to the computer simulations. The potential of extending the technique to include wind systems and photovoltaic/wind hybrid systems is also under study.

Telecommunications Applications of Sealed Lead-acid Batteries

A relatively recent development in lead-acid battery technology is the sealed, rechargable cell. This new type of battery was primarily developed for the automotive (starter battery) market, but the Laboratories have recently investigated the potential application of these batteries to provide power for small items of telecommunications equipment requiring relatively limited capacity back-up power supplies. Sealed lead-acid batteries are available in the following configurations:

- flooded, with limited volume electrolyte
- restricted volume electrolyte, using recombination technique
- gelled electrolyte, with recombination technique.

The batteries are provided with a seal which allows gas to escape above a certain pressure, if a cell is inadvertently overcharged. The batteries are sometimes called "maintenance free", as they do not need water addition. However, the charging half cycle requires precision. The voltage limit must not exceed a preset level and thus the charging procedure is more critical for maximum battery life than with conventional flooded batteries.

The grids are either pure lead or a proprietary alloy composition. The cycle life, capacity, float life and self-discharge characteristics are influenced and/or controlled by such parameters as the ratio of α PbO_2 to β PbO_2, paste density, additives and electrolyte density.

Several batteries having the flooded, limited volume electrolyte configuration were tested in the Laboratories to telecommunications service requirements. The sequential test procedures were as follows:

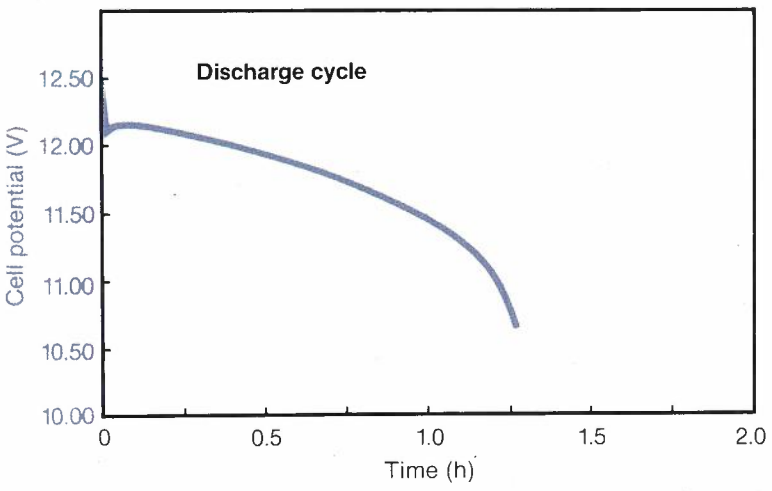
- discharge the battery using constant current at the one-hour rate to a pre-set voltage
- charge the battery using ripple-free constant current to a pre-set battery potential, and then maintain this potential for a pre- determined period, with the current slowly decreasing.

In these particular tests, the 10-hour charge rate was used for constant current to a constant potential of 14.40 V (2.40 V/cell), which was maintained for two hours. This completed the charging cycle. Float currents were determined between 0° and 40°C at four different potentials in the range of 12.90 and 14.40 V. The float conditions were established after every 10 cycles. Two batteries were discharged fully to 11.10 V, while another sample was discharged approximately 50% in depth to 11.90 V. The test was terminated when the battery capacity was reduced to less than 40%.

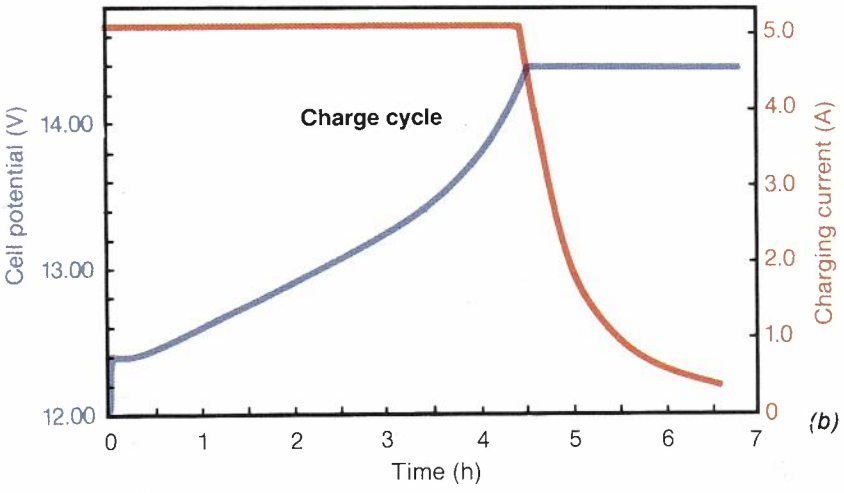
The results of the discharge tests showed that the capacity of this type of battery increased slightly during the first few cycles. After the fifth cycle, the capacity started to drop. The rate of reduction was almost linear, and after 20 cycles, the available capacity was about 80% of the initial value. This can be considered the practical cycling limit for these batteries.

The current converting efficiency of a new battery was found to be high; almost 100% capacity was returned at constant current before the battery

Charge-discharge performance of a sealed battery under test:



(a) Cell potential at 1-hour discharge rate to 10.5 V



(b) Cell potential and charging current at constant current charge to 14.40 V plus further constant potential charge for two hours

potential reached 14.40 V. The efficiency decreased continuously during the test, and at the end, only 80% capacity was returned at constant current. The number of ampere-hours which the battery accepted at constant potential during the two hours of charging increased with cycling. With the temperature maintained at 25°C, the float currents at 2.20 V/cell and at 2.40 V/cell were found to be similar to those of the conventional (vented) stationary battery of similar capacity. The float current increased with increasing potential, but the influence of temperature on float current between 0° and 40°C appeared negligible.

The failure mode of the battery was positive grid corrosion. Due to its construction, the internal ohmic resistance of the battery is low. The sealed battery is expected to withstand vibration during transport better than the conventional stationary battery. However, its deep cycling performance is poor and its use is recommended only for stand-by power back-up where emergency deep discharge demand is low.

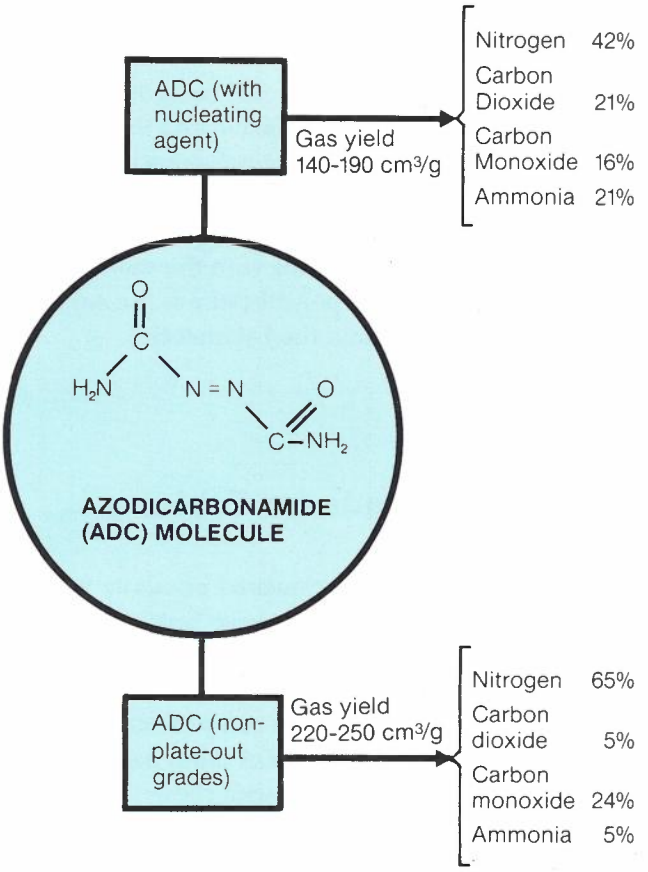
Chemical Additives in the Production of Cellular Form Cable Insulation

In recent years, there has been an increasing use of small size, metal conductor cables with core spaces filled with petroleum 'grease' or 'jelly' and with cellular polyethylene primary insulation instead of solid insulation. The composition and reliability of such insulation in service and its effect on the transmission characteristics of such cables are being investigated in the Laboratories.

The use of the water-excluding hydrocarbons as core filling material increases the mutual electrical capacitance between conductors by approximately 20%, so that the subsequent deterioration in transmission performance must be offset by increasing the thickness of the insulation or by reducing its permittivity. A compromise solution can be obtained by the use of cellular form insulation, which restores most of the attenuation characteristics to those exhibited by earlier designs of solid plastics insulated cables with air filled cores.

In Australia, this cellular insulation is currently produced from medium density polyethylene, which is gas expanded by 35% to approximately the same total insulated wire diameter as the solid insulated, air core cable.

For telecommunications cable manufacture, the closed cell structure of the primary plastics insulation is created by foaming either with the injection of a



Gas evolution by thermal decomposition of two types of ADC used as a chemical blowing agent

non-reactive gas at high pressure or by gas evolution from the thermal decomposition of incorporated chemical blowing agents (CBAs). In present Australian practice, the organic CBAs provide a means of obtaining cellular polyethylene insulation at economic rates in cable wire production.

The decomposition temperatures available during the extrusion of medium density and high density polyethylene restrict the choice of CBA to mildly inhibited, non-plate-out grades of commercial azodicarbonamides (ADC). The thermal decomposition of commercial ADC compounds is largely dependent on the nature and amount of various auxiliary substances which are added to modify the rate and quantity of gas evolution.

An undesirable side effect from the chemical blowing of polyethylene with ADC is the evolution of ammonia, which can contribute to significant processing losses of the stablisers incorporated in the insulation. A secondary consideration is the possible corrosive effect ammonia may have on the beryllium-copper parts of the extruder. Although product data sheets claim only small percentages being liberated, decomposition from within matrixes similar to polyethylene and monitored by thermal analysis

show the quantities of ammonia to be considerably greater.

There are also non-volatile residual components of ADC decomposition such as urazole and the linear and cyclic low molecular weight polymers of cyanic acid, traces of which can remain dispersed throughout the cellular plastics structure. The interaction of these compounds with the stabilising systems employed in the polyethylene is the subject of ongoing research within the Laboratories.

Filling Compounds for Cables

Cable filling compounds formulated primarily from mineral oils and paraffin waxes have been used by Telecom Australia and many other telecommunications network operators throughout the world for many years. Such compounds provide a waterproof barrier in the core of multi-pair plastic insulated cables. Shortcomings with these compounds have been their tackiness and messy handling characteristics.

In attempting to overcome these problems, Bell Laboratories in the USA developed a rubbery gel compound known as "Flexgel". The compound is based on oil, thickened with synthetic styrene-butadiene rubber (SBR) and low molecular weight polyethylene. Although extensively used in the USA, past studies carried out in the Research Laboratories

Comparison of oil separation in Flexgel (left) and a re-formulated gel (right)

demonstrated that Flexgel suffered from excessive separation of the oil component and was not suitable for use within the Australian network.

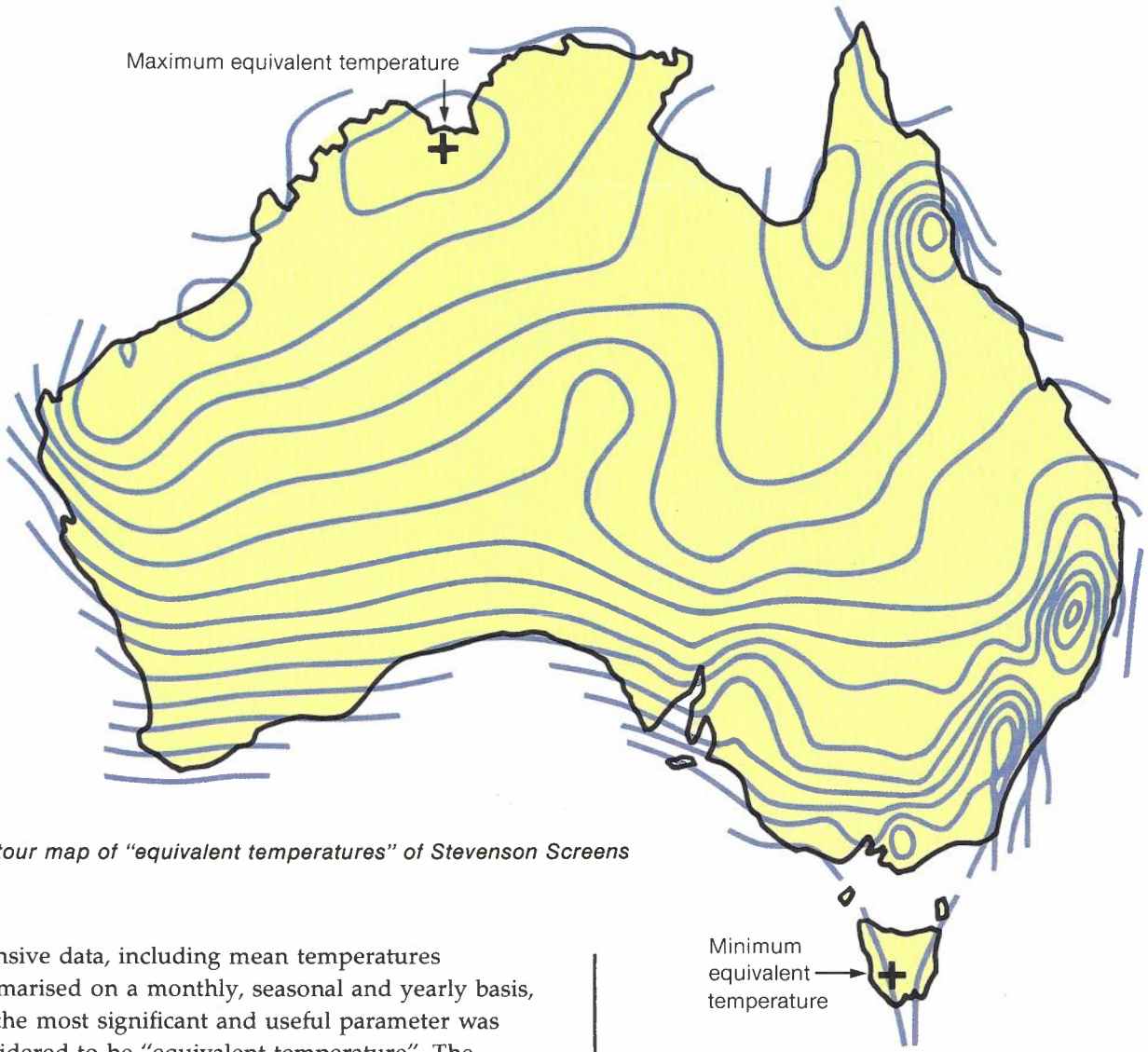
Subsequently, as a result of further Laboratories' investigations, a series of alternative gel compounds were developed from the basic flexgel formulation. The alternatives use the same grade of SBR, but in combination with high viscosity Australian produced oils and high molecular weight polyethylene. These compounds met Telecom Australia's specified requirements for filling compounds currently used by Telecom in Australia, and they overcame the problems associated with older compounds due to tackiness and excessive oil separation. Pilot plant batches were produced by the Australian manufacturer of filling compounds and cable production trials were carried out by the three major Australian cable companies which produce cable for Telecom Australia. The new gels processed easily, using existing equipment without major modifications. The properties and performance of these trial cables are presently being assessed by Telecom Australia.

Equivalent Temperature Contour Mapping

In the early 1980s, a significant number of faults were found in the polyethylene insulation of cable conductors jointed in above ground jointing enclosures used in Telecom Australia's external cable distribution network. The insulation had become brittle and cracked where the sheath had been removed for jointing.

A thorough field and laboratory investigation by the Research Laboratories showed a number of interrelated causes of the problem, and the suspected high temperatures within the joints was considered a significant contributing factor. Detailed information about the range of temperatures which might prevail in Australia inside the standard jointing enclosures was not available, despite the wide use of the enclosures. This information was considered important to the Laboratories' investigations, particularly for the hotter regions of Australia where the deteriorated polyethylene insulation was most prevalent.

Consequently, a programme of field testing was instituted to measure and record the temperatures inside various joint enclosures at 30-minute intervals over a 15-month period at two test sites, one at Clayton, Victoria and the other at Mt. Isa, Northern Queensland. A number of different temperature parameters were extracted by analysis of the



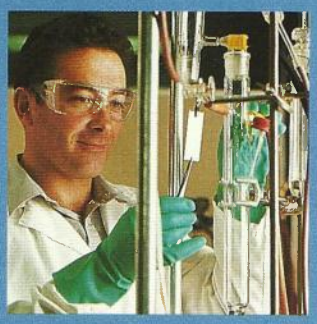
Contour map of "equivalent temperatures" of Stevenson Screens

extensive data, including mean temperatures summarised on a monthly, seasonal and yearly basis, but the most significant and useful parameter was considered to be "equivalent temperature". The "equivalent temperature" is that constant temperature at which a sample of polyethylene insulation will degrade to the same level as that of a similar sample of polyethylene which has been subjected to the seasonal and daily temperature cycles within a jointing enclosure. This temperature parameter, unlike mean temperature, is directly related to the reaction rates of the polyethylene degradation process and can be used in high temperature artificial ageing experiments to predict lifetimes of various formulations of insulation. An analysis of the "equivalent temperatures" derived from measurements in all types of enclosures at both test sites showed that the temperature of a given jointing enclosure can be correlated with the calculated "equivalent temperature" by the Bureau of Meteorology. Further analysis of data from the Bureau's stations throughout Australia gave a contour map of "equivalent temperatures" of Stevenson Screens located anywhere in Australia. From this map, and the established correlations, the equivalent of any type of jointing enclosure can be determined for a location anywhere within Australia.

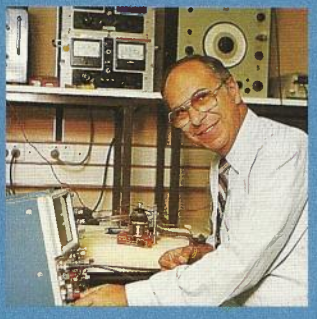
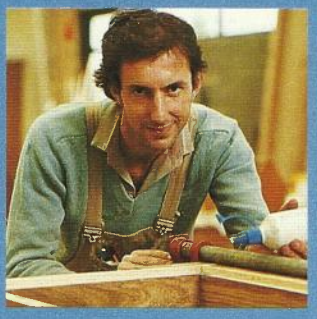
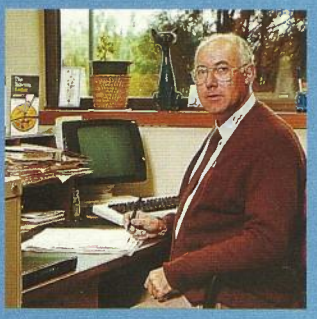
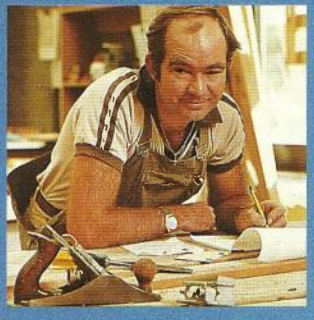
As a matter of interest, the Laboratories' investigation showed that the worst location is at Wyndham, Western Australia, where the pole-mounted, black coloured jointing enclosure has an "equivalent temperature" of 33.4°C, whilst that of a similarly mounted white enclosure is 29.7°C. The studies have shown that, in this instance, insulation which will survive for 40 years in a white jointing enclosure at Wyndham will fail after about 29 years in the black enclosure.

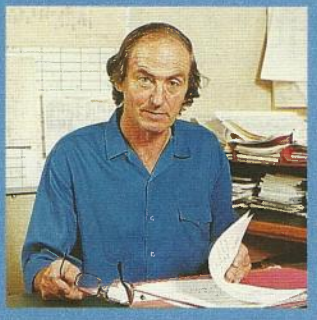
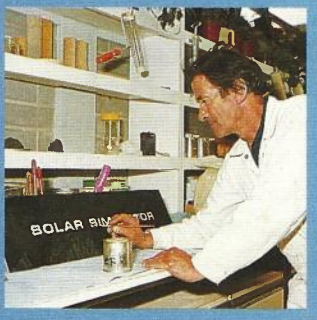
The best location was determined as Butlers Gorge in Tasmania, where equivalent temperatures of 16.4° and 10.8°C were obtained for the black and white boxes respectively.

The significance of the vast difference in equivalent temperatures obtained for the two extreme cases cited above is that insulation lasting 40 years at Butlers Gorge would last about nine years in the same enclosure at Wyndham. The Laboratories' studies have provided a means for Telecom to ensure that appropriate joint enclosure designs and polyethylene formulations are specified for different locations in Australia, such that the insulation does not deteriorate within the required engineering design life.



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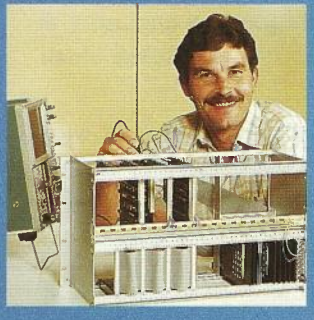
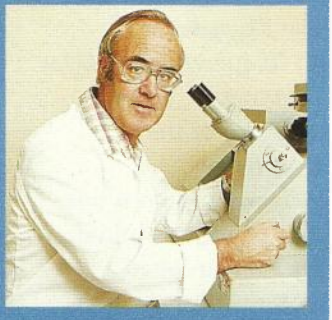
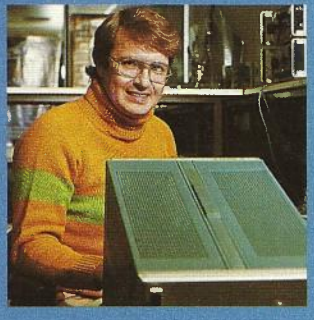
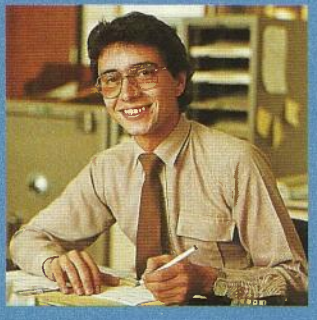
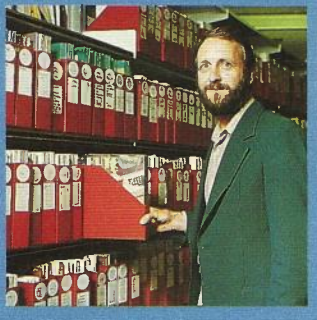





Consultative Activity and Laboratory Facilities

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 the development 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.

Thick Film Technology Solves a Packaging Problem

During 1984, the Laboratories undertook the fabrication and testing of microprocessor controlled meter relay (MRP) printed circuit board assemblies (Eurocard 100 mm x 160 mm) with their associated thick film hybrid circuits - for field trials. The use of thick film hybrid technology provided the solution to a tight packaging problem experienced with the early discrete component prototype circuit board assemblies (100 mm x 230 mm).

The MRP printed board assemblies (together with the microprocessor board and the transformer board) provide a number of additional functions to the public coin telephone, namely, digit analysis, call barring, call identification signalling for coin operated telephones, timed local calls and checks for fraudulent manipulation. Each printed board assembly contains two MRP circuits.

The design strategy used in the manufacture of the ten prototype MRP printed board assemblies and thick film hybrids was a "top-down" strategy. The

thick film hybrids were designed first, giving firm pinout requirements which were then implemented on the printed board layout. The thick film hybrids were configured in a single in-line package mounted vertically on the printed board at 2.5 mm spacing between single in-line packages, allowing tight packing to be obtained. A number of discrete power resistors were also converted to single in-line thick film hybrids, again to increase packing density.

The thick film hybrids were implemented using surface mounted active and passive components. The active components (semiconductor integrated circuits, diodes and other devices) were of the microminiature Small Outline plastic package type, capacitors were in chip form and all resistors were screen printed. All components were solder attached to the thick film hybrid substrate metallisation by way of a "hot belt reflow solder" technique. The thick film hybrids were then conformally coated with a flame retardent grade epoxy coating to provide added physical and some environmental protection.

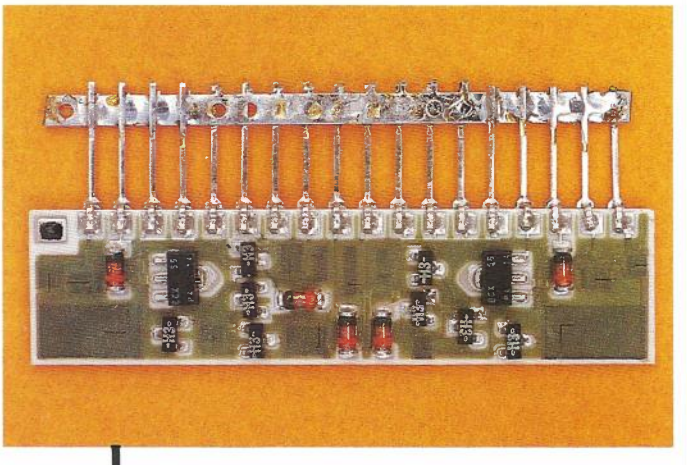
The Laboratories completed the layout design, production, mounting, assembly, electrical testing and the necessary documentation for ten printed board assemblies each containing twelve thick film hybrids.

Structure of a multi-layer wiring system for high density circuit board assemblies ▷

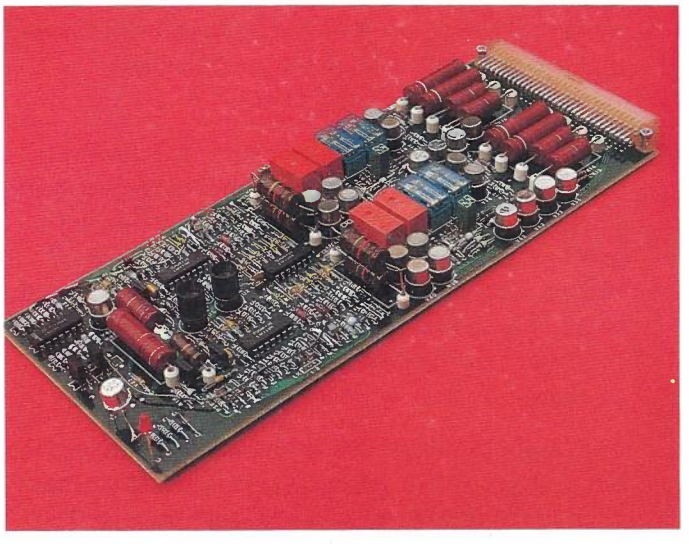
High Density Circuit Board Assemblies

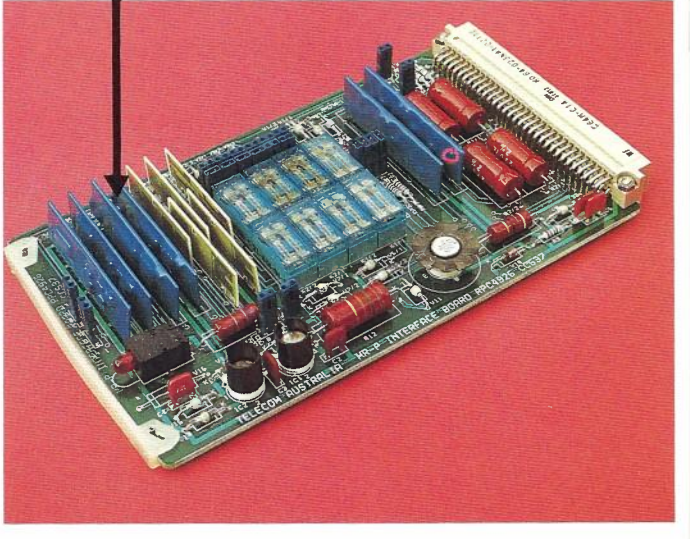
For complex high density applications, there are several alternatives to printed wiring board (PWB) techniques. One alternative to conventional multi-layer PWBs, which has been recently examined in the Laboratories, is to mount thin (0.16mm) insulated wires on one side of an adhesive coated epoxy-glass substrate. The completed wiring pattern layout is then epoxy-coated. As insulated wires are used, crossovers can easily be made, and this technique can give interconnection at densities comparable with those achievable with six to eight layer multi-layer boards. The layout and fabrication of boards using this technique involve relatively few processes and can be highly automated.

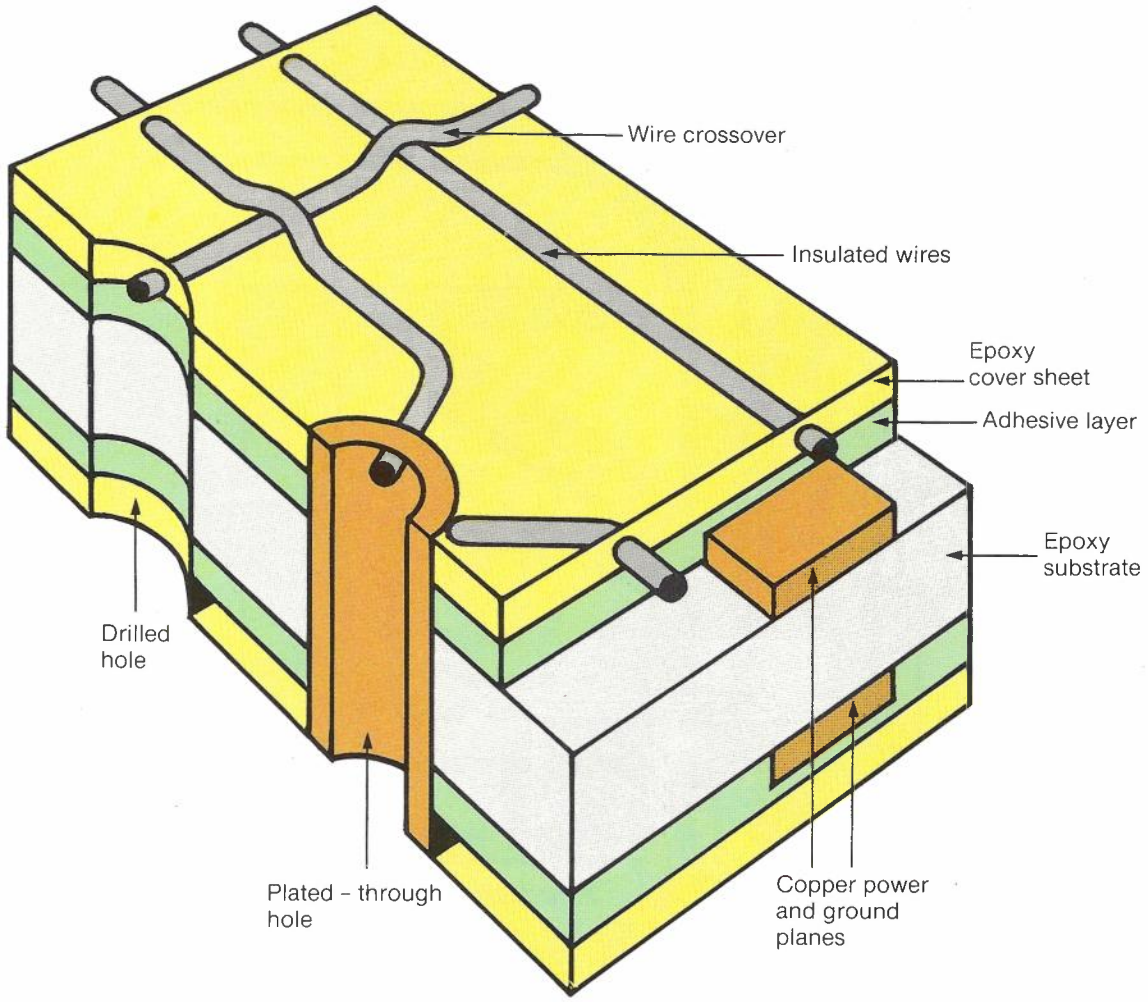
Thick film hybrid circuit without the conformed coating ▷



Discrete component version of 250 mm x 100 mm MRP board assembly (left) compared with 160 mm x 100 mm thick film hybrid circuit version ▽







The connections between components and the wire conductors are established by drilling through the conductors and board, etching back to expose the end of the conductors, and then forming plated-through holes to accomplish interconnection.

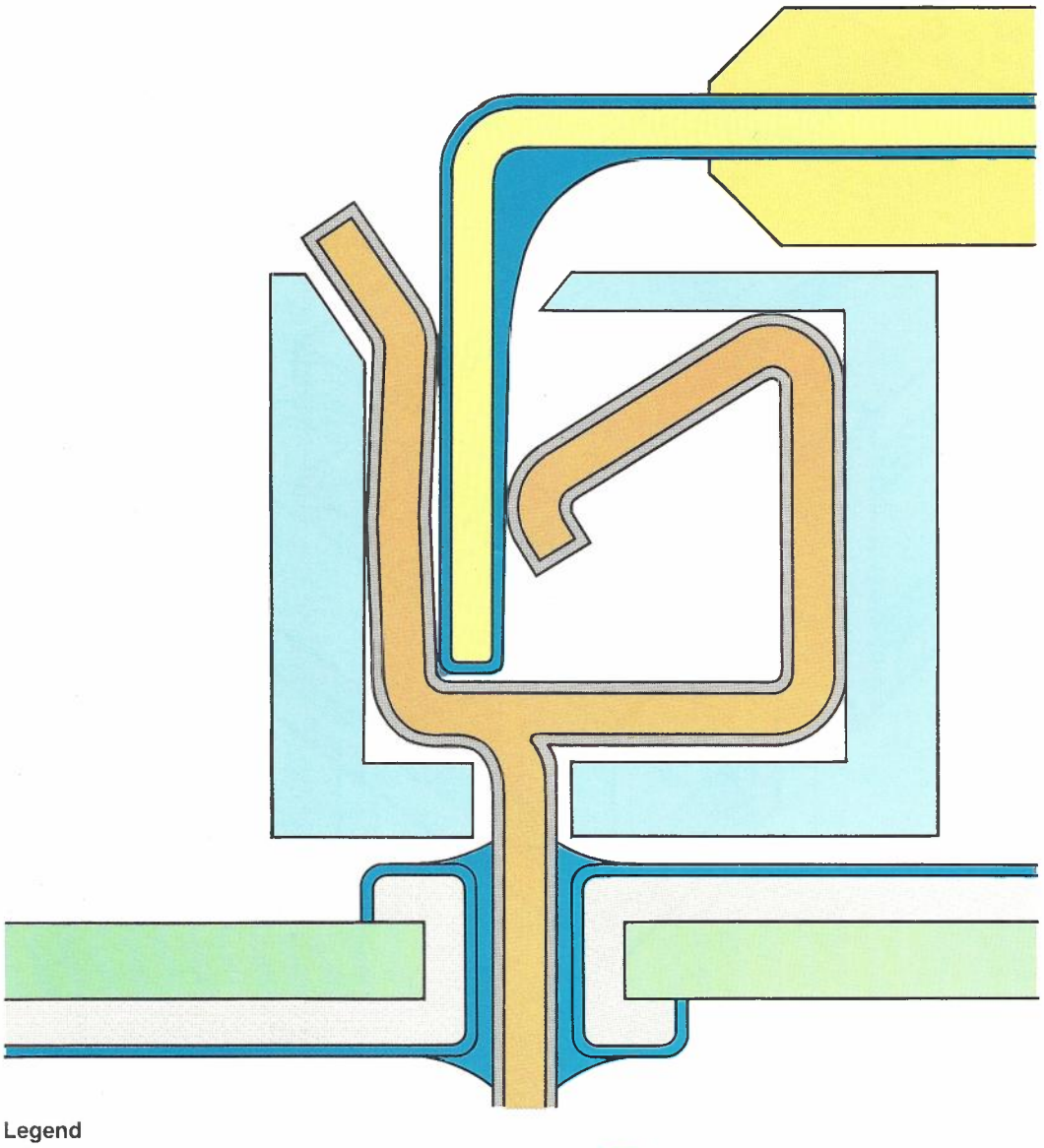
Commercially produced examples of both these wired boards and multi-layer PWBs have been subjected to a programme of electrical and environmental testing in the Laboratories. In each case, the results were satisfactory and detailed physical examination revealed no significant deterioration in the achieved interconnections of components to the wiring pattern. It was concluded that, for high density applications, this applied wiring technique is an acceptable alternative to that employed in conventional multi-layer PWBs.

Developments in Connector Systems for Printed Wiring Boards

Apart from connector systems which have been conceived exclusively for soldering into printed wiring boards (PWBs), various press-fit techniques have been developed which now enable solderless connection to be made between PWBs and the connector. The connector terminations are made either compliant or a force-fit to produce a secure connection when pressed into plated-through holes in the PWB. Compliant pin designs have the advantage that they will fit a range of board thicknesses and plated-through hole diameters, alleviating the need for tightly controlled tolerances in PWB production.

Tests have been conducted in the Laboratories on four types of compliant pins. The electrical performance of the different pin types was assessed by monitoring the contact resistance of various connector pin and plated-through hole combinations before, during and after a number of mechanical and environmental tests. The greatest change detected was less than 0.1 milliohm, indicating that electrically stable contact had been formed between the pins and the plated-through holes.

Detailed examination using a scanning electron microscope revealed contact adhesion (cold welding) had occurred on the mating surfaces of all four types of pin, providing reliable gas tight connections. Such connections are ideal when base metals such as tin and lead are used for dry pressure contacts, as is the



Schematic cross-section of a typical asymmetric dual-face wipe IC socket contact with IC pin inserted, soldered into a printed circuit board

case with the plated-through holes. The advantage of compliant pin techniques is the ease of connector removal and replacement, which may be performed without the need for specialised tools. On the other hand, soldered-in multi-pin connectors are usually difficult to remove from a PWB should replacement be required.

The Laboratories' tests concluded that compliant pin terminations are an acceptable, reliable alternative to soldered terminations. This technique is especially suitable for back plane circuitry and is expected to offer significant savings in equipment assembly costs.

Evaluation of IC Sockets

Dual-in-line integrated circuit (IC) packages are normally permanently wired into external circuitry, but sometimes it is desirable for them to be extracted and replaced more easily; IC sockets serve this purpose, but some sockets perform the function better than others.

The Laboratories have surveyed currently available sockets, listed more than 140, and tested 64.

The contact resistances of the sockets were measured

and monitored continually during rigorous environmental tests, including dry heat, damp heat, cold, variable temperature, vibration and sulphurous atmospheres. Flammability and insertion and withdrawal tests were performed, and the sockets sectioned and examined microscopically. The results were used to evaluate the relative merits of different contact geometries, spring materials, contact coatings, manufacturing techniques and quality control.

The Laboratories' evaluation showed that sockets employing thick tin contact coatings (>5 μm) generally performed better than those with thin gold coatings (0.0 - 0.75 μm). Beryllium copper contact springs were not found to be clearly better than phosphor bronze ones, and the major influence on socket performance appeared to be the geometry of the contact springs. Asymmetric single-face wipe contacts proved the most reliable, while four-finger "machine screw" (circular) contacts performed generally rather poorly and suffered from problems such as high retention forces, accumulation of dirt and breakdown of spring-to-shell contacts.

Characteristics of Protective Devices

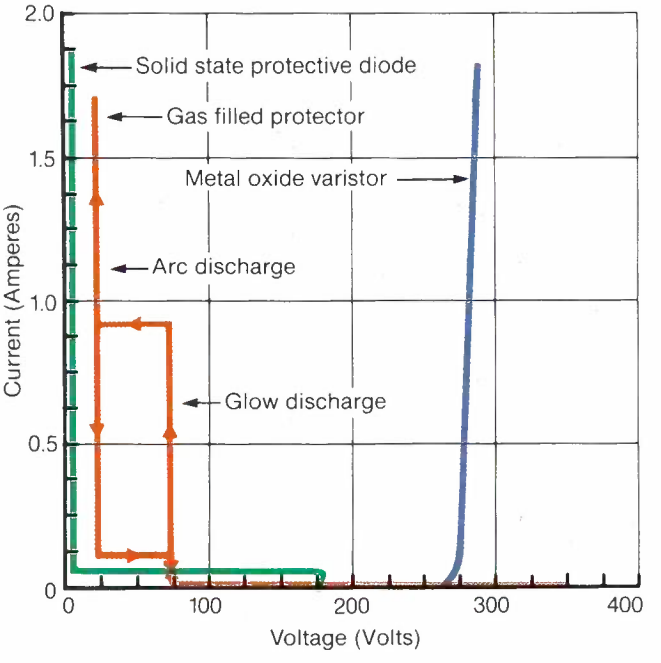
In ongoing investigations of techniques and devices available to protect telecommunications equipment from over-voltage surges, the Laboratories regularly examine the electrical characteristics of protective devices to determine whether they conform to the relevant specifications and whether they can withstand the environmental and electrical conditions which exist in the Australian telecommunications network. The devices under consideration range from fuses and heat coils to special-purpose semiconductors. The devices most commonly used by Telecom Australia are gas-filled protectors, metal oxide varistors and diodes.

The choice of the protective device or devices to be applied in particular situations depends on a number of factors, the most important being:

- the amount of energy to be absorbed and the time interval involved
- the response time of the device
- the safety margin required between the operational voltage and the maximum voltage to which the equipment may be exposed without damage.

The gas-filled protector, which is the protective device most widely used by Telecom, consists of a spark gap in an enclosure containing a low pressure gas mixture, which is normally a combination of neon, argon and helium gases. The spark gap becomes conductive at a voltage which is a function of the gap width, the gas pressure and the voltage gradient of the surge. Initially, the protector operates in the glow discharge mode, conducting less than one ampere and limiting the voltage across the protector to between 50 and 100 volts. Prolonged operation under these conditions can destroy the protector due to localised heating. However, the majority of electrical surges produce currents well in excess of one ampere, and the glow discharge normally converts to an arc soon after turn-on. In this mode, the voltage across the protector drops to about 10-20 volts and the surge peak currents may be as high as 20 000 amperes.

As the surge dies away, the protector does not turn off until the current flowing through it falls below 100 milliamperes. This can cause a problem if the protector is in a circuit which can itself supply sufficient power to maintain a current of 100 milliamperes or more at 50 volts. In this situation, the protector will remain latched-on and eventually burn out. Gas-filled protectors can be manufactured to operate at voltages over the range of 70 to 12 000 volts and handle surge currents of up to 60 000 amperes. A major performance limitation is their relatively long response time, when compared with that of other protection devices. Thus, a voltage transient with a steep leading edge may reach 1000 V before the protector turns on, exposing the equipment being protected to a voltage spike of that magnitude.



Typical steady state electrical characteristics of three types of protective device

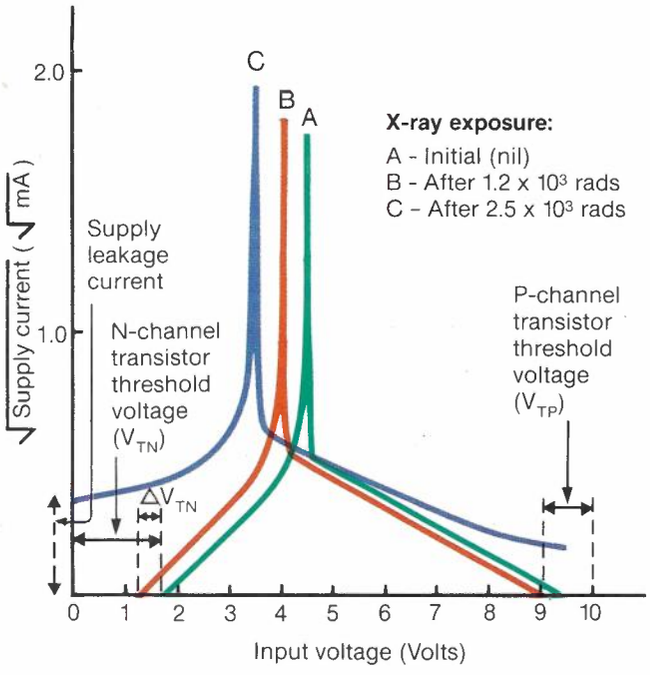
Metal oxide varistors (MOV) are a special type of voltage-dependent resistor. They are used as protective devices in both the power and telecommunications industries. The type of MOV used in telecommunications equipment generally has a much lower energy handling capacity than gas-filled protectors, but they have a considerably shorter response time (10-100 nanoseconds). MOVs behave in a similar manner to gas-filled protectors in that they exhibit very high input impedances until their firing voltage is reached. They then start to conduct current with a minimal increase in the voltage drop across the MOV.

MOVs can be manufactured to turn on at voltages in the range 16 to 2 000 volts, conducting surge currents of up to 6 500 amperes. The limitations of these devices include their sensitivity to temperature variations and the fact that the equipment being protected is subjected to electrical stress (i.e. the MOV firing voltage or greater) for the duration of the surge.

There are two general types of protective diodes available. One is essentially a zener diode modified to enable it to handle high surge currents for short durations. The other also initially exhibits the characteristic of a zener diode, but when the current through it exceeds a critical figure (typically 150 milliamperes), the voltage drop across it decreases rapidly, giving a characteristic similar to that of a gas-filled protector. The limitations of both types of diode devices are their very low average power rating, their unipolar characteristics (which normally require the use of an additional conventional diode to block the reverse voltage), their high capacitance, and their limited surge current capacity (typically 150 amperes).

Non-destructive Techniques for Monitoring Integrated Circuit Degradation

Integrated circuits are subject to a number of processes which cause progressive degradation and lead to eventual loss of functionality or failure to operate within specification. Some failure mechanisms result from random latent defects occurring during manufacture; others are a result of the processing technology and materials used. A user wishing to study the quality and reliability of vendor supplied ICs, without access to the sophisticated test structures used by IC manufacturers, must evaluate commercially available devices. Consequently, the



Square root of supply current plotted against input voltage for a CMOS IC, showing effect of X-rays on threshold voltage and leakage current

information which can be extracted from the IC on degradation resulting from accelerated stress testing is limited to the results of electrical testing at the device function pins.

In the Laboratories, novel methods such as Supply Current Analysis and Marginal Voltage Analysis have been investigated in order to determine their effectiveness in detecting hidden defects and progressive deterioration in representative types of devices in CMOS and TTL logic families.

CMOS devices are based on Metal-Oxide-Silicon (MOS) technology and are thus subject to gradual loss of performance and eventual failure as a result of changes in the MOS transistor threshold voltage and the appearance of leakage currents. Such changes which result from the motion of ionic impurities or the trapping of charge in the transistor gate region can only be investigated by observing the effect of high temperature and bias or ionising radiation on the individual transistor characteristics.

The Supply Current Analysis technique can be used to directly measure the threshold voltage of selected N and P channel transistors on a typical CMOS device. In this method, the current drawn from the supply pin on the IC is monitored as a selected input, is ramped from zero volts to the supply voltage, and the threshold voltages and leakage current are obtained directly from a square root plot of the measured response. Successive measurements made on batches from different manufacturers, after exposure to various periods of stress such as bias-

temperature stress or exposure to X-rays, reveals any significant threshold voltage instability.

A related technique, known as Marginal Voltage Analysis, has also been evaluated to assess its potential for detecting latent defects as well as its ability to monitor degradation during life. In this technique, a measurement is made of the minimum supply voltage (Marginal Voltage) at which the chip will function correctly. Devices which have a marginal voltage significantly different to the majority of any given batch are suspected of containing hidden defects which may result in early failure. Several hundred low power Schottky TTL devices from four batches were evaluated using this method and a number of anomalous devices subjected to detailed analysis. In each case, a defective transistor was located by microprobing in the suspect area of the chip. In a study of Marginal Voltage Analysis applied to CMOS devices, the resulting marginal voltage has been shown to be related to the threshold voltage of transistors on the chip. Accelerated ageing using X-rays indicated that the measured marginal voltage followed threshold variations until the appearance of junction damage, at which point it rose abruptly.

These Laboratories' studies have indicated that the use of novel electrical test methods can produce a device signature which enables the detailed observation of ageing processes in integrated circuits.

A Novel Method for Junction Temperature Measurement in Microprocessor ICs

The reliability of a semiconductor device is directly related to its junction temperature. Under severe thermal stress, leakage currents increase and individual components can drift in value or fail prematurely. The method normally used to measure the chip temperature is to monitor the change in forward bias voltage of an input protection diode with temperature, as this is proportional to temperature. However, this has the double disadvantage that, unless the chip is powered down for each measurement, error results from common currents flowing in the device substrate, and if the power is turned off, error results from the drop in the chip temperature while the measurement is being made.

A relatively simple, non-destructive technique which overcomes these difficulties has been developed by the Research Laboratories for the measurement of the chip temperatures of NMOS microprocessor ICs and memory devices while they are wired into a circuit board and operating under normal electrical conditions. To perform this measurement, a suitable output transistor is monitored, as there is an approximately linear relationship between transistor gain factor and temperature, and this quantity can be easily measured. For microprocessors with programmable output ports, a simple loop program is executed to hold one port at a low output level. This voltage is monitored and is directly related to the temperature of the chip. Since all outputs have pull-up resistors to ensure that the current flowing in the measured transistor is insignificant compared to the total current flowing in all output devices, the effect of localised heating within the device is reduced. For microprocessors and memory devices which have shared input and output pins, the valid low level output voltage needed for the temperature measurement exists only for short periods, and consequently, a voltage sampling system must be used.

Calibration is required for each device, and this is achieved over the specified operating temperature range by measuring the device whilst it is in a temperature-controlled environment. Once thermal equilibrium is attained, power is applied to the device and the increase in the output voltage with time is recorded. This process is repeated at 10°C intervals up to the maximum ambient operating temperature specified for the device. For each ambient temperature, the voltage at the instant the chip is powered up can be determined, giving a calibration chart of voltage against temperature. The ambient temperature found under either normal or worst-case conditions can then be set, and the device can be powered up and allowed to reach thermal equilibrium. The chip temperature can then be directly read from the calibration chart.

Interestingly, the time taken for some microprocessors encapsulated in 40 pin plastic packages to reach thermal equilibrium was found to be as long as 50 minutes.

Moisture Content in Integrated Circuit Packages

Water vapour in an integrated circuit package can contribute towards the premature failure of the device from mechanisms such as electrolytic corrosion, gold migration and MOS inversion. The ability to measure the moisture content inside the cavity of integrated circuit packages is therefore an

important process in the screening of devices during manufacture and for failure analysis investigation.

Techniques normally used for moisture determination involve destruction of the package. Therefore, these methods can only be used on a sampling basis.

One non-destructive technique investigated and applied by the Laboratories has been the 'Capacitance Ratio'. This relies upon the measurement of small changes in the parasitic capacitance between two selected surface tracks on an IC die due to the presence of moisture. To perform this measurement, the device is cooled down to -6°C, causing any moisture in the package cavity to condense on the die. The capacitance between two suitable surface tracks is then measured, firstly at a low frequency at which the contribution from any moisture present on the surface will be significant, and then at a higher frequency at which the contribution due to water is negligible. This allows the effects of individual circuit elements on the measured capacitance to be eliminated.

A criterion for failure is established by exposing a number of de-lidded devices to atmospheres of 75% and 0% relative humidity, and measuring the capacitance ratio under these conditions. The value thus obtained corresponds to the accepted water content for general purpose components (5000 parts per million volume), and a simple non-destructive pass or fail test can be made by comparing this calibration capacitance ratio to those of "as received" devices.

Suitability of Plastic Encapsulated Integrated Circuits

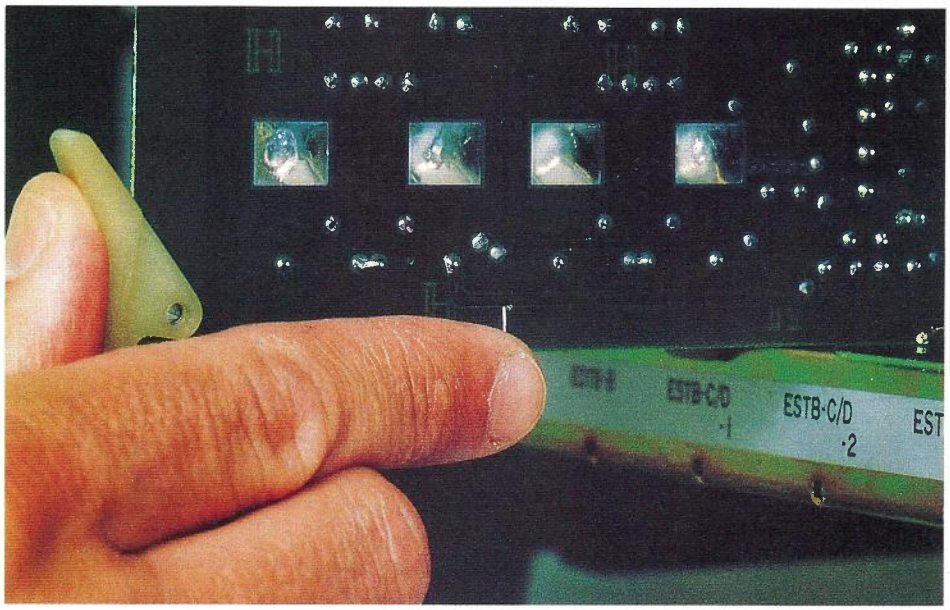
Although plastic encapsulated integrated circuits (ICs) have been common for many years, their use in high reliability, long life applications such as in telecommunications equipment has until recently been minimal. A major factor has been the encapsulant's permeability to water, which can result in parameter drift and ultimately, failure due to corrosion of the chip metallisation. However, improvements in chip encapsulation have resulted in much longer-lived components, with expected lifetimes approaching those required in telecommunications applications. Since the extensive use of plastic encapsulated ICs would result in substantial cost savings on equipment, provided that increased maintenance costs are not incurred, the Laboratories have been investigating their reliability.

For corrosion to occur in an IC, ionic carriers must be present. These may be leached from the plastic or passivation as water permeates through, or may be present as process residuals on the chip. As it is not possible to reduce the permeability of the encapsulant to a suitably low level, manufacturers have concentrated on minimising ionic contamination by improving chip cleanliness and reducing the hydrolysable ionic content of the encapsulant, and by increasing moisture resistance by improvements in the passivation and better adhesion of encapsulant to lead frame and chip.

The industry standard accelerated test conditions for moisture resistance measurements have been specified as 85°C and 85% relative humidity with voltage bias applied to the device, and as "pressure cooker" conditions of 121°C and 100% relative humidity with an unbiassed device. The latter test condition has now fallen into disfavour, as only bond-pad initiated corrosion was produced, yielding no information on the quality of the passivation. There is a need for shorter test durations of two to seven days duration for batch acceptance testing before equipment assembly, and highly accelerated tests using an autoclave to produce unsaturated conditions at temperatures above 100°C are gaining popularity. This has added impetus to investigations on the correlation between the results of these tests and those obtained with biassed devices at 85°C/ 85% relative humidity and under operational use at ambient conditions.

The temperature dependence of the corrosion is generally thought to follow the Arrhenius equation (logarithm of lifetime inversely proportional to temperature). The humidity contribution is controversial and mathematical models based on the moisture adsorbed by the plastic, the conductivity of a moisture film on the chip surface and on the Arrhenius equation, among others, have been proposed. All models fit the available data, mostly all from accelerated tests, reasonably well. As no model is technically preferable, a generalised one has been chosen, with scaling factors calculated from experiments on a wide range of devices.

It is recognised that extrapolations from tests of a few days duration to predict reliability over years of service life make the use of such formulae approximate. However, an estimate of lifetime under various climatic conditions, the effect of chip power dissipation and equipment operating temperature (both of which reduce the effective RH at the chip), and the likely consequences of storage on spare parts are all necessary for evaluating the possible regular use of plastic encapsulated ICs by Telecom in its networks.



Electrostatic discharge from finger to integrated circuit

Antistatic Products

Faults attributed to electrostatic discharge (ESD) damage of electronic components have become significant in recent years, corresponding with increased usage of sensitive components such as MOS integrated circuitry. As the primary means by which high electrostatic voltage levels reach devices is via personnel, the problem is being tackled in Telecom, as elsewhere, by education of staff in safe handling procedures, coupled with the use of antistatic products.

The range of products assessed over recent years by the Laboratories in relation to the generation or reduction of electrostatic discharge has included packaging materials, workstations, floormats and flooring material, apparel (dust coat and shoes), a chair and antistatic sprays.

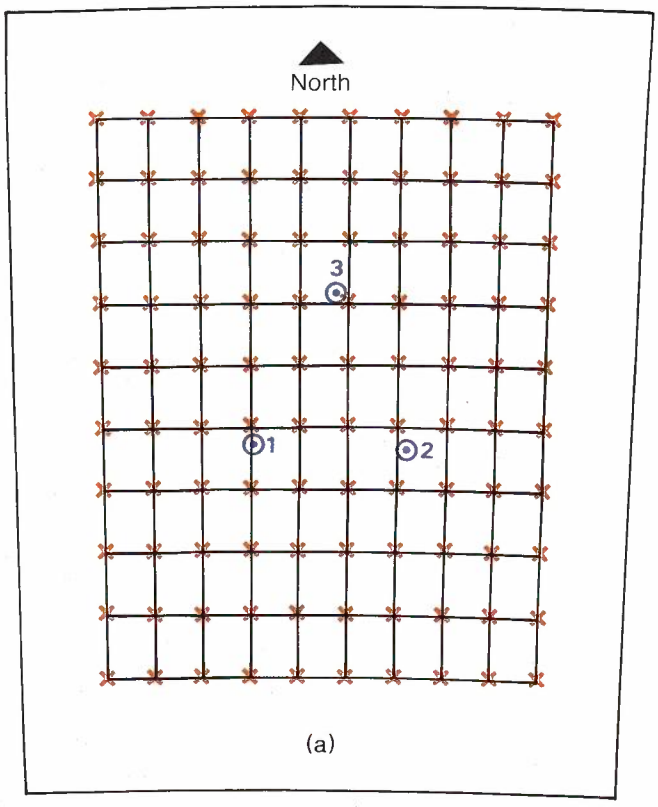
Packaging materials are designed to equalise an applied or induced voltage over their surface at a rate dependent on their resistivity. They may also minimise charge build-up due to friction between a device or assembly and the packaging during transport.

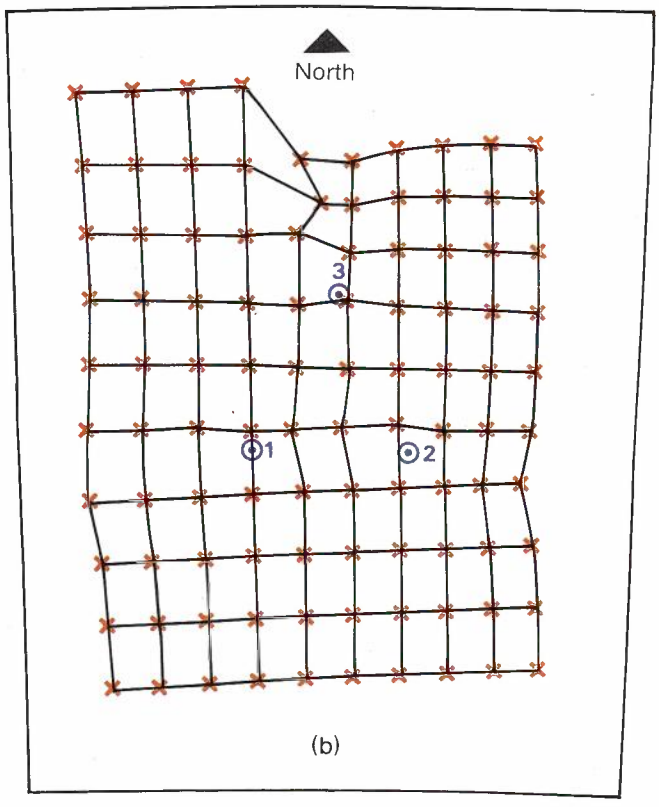
Most other products speed the rate of charge dissipation by providing a resistive path to earth. In the case of workstations, this is standardised at 1 Megohm for wrist and earth straps, to provide a rapid bleed-off of charge without presenting a safety hazard when used with faulty mains-powered equipment. The effectiveness of products such as flooring and chairs is strongly dependent on the clothing and footwear of personnel, and so vary considerably. For flooring, this can be overcome by the use of antistatic footwear or heel straps with ordinary footwear. However, as the charge decay rate for such footwear is generally longer than for a wrist strap, the wrist strap is preferred for critical applications (e.g. printed board assembly repair). The use of antistatic mats or flooring with ordinary footwear results in some reduction of the voltage levels on personnel, which may be sufficient to prevent faults or damage in many applications. Effective antistatic carpet sprays give similar results, but need regular re-application.

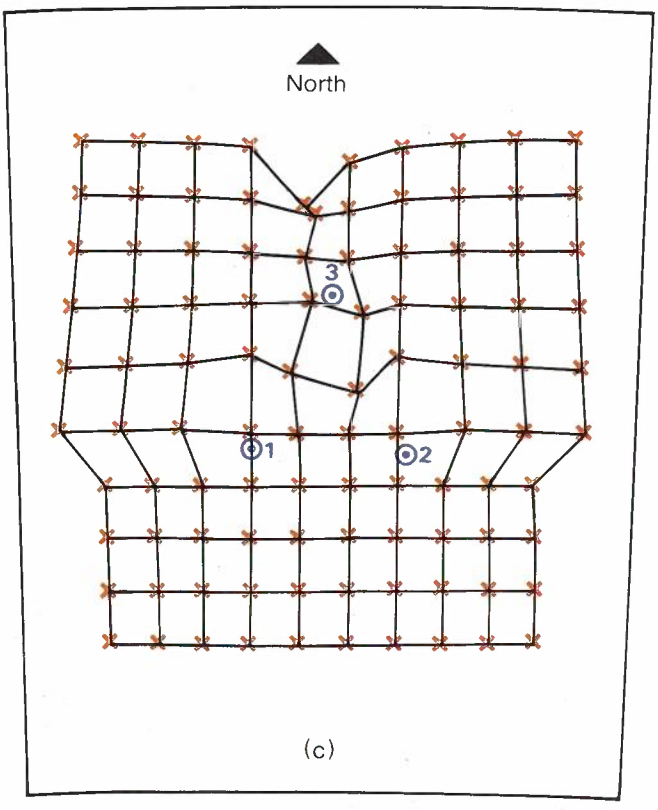
The information gained from the Laboratories' investigations has been incorporated in a guideline on the prevention and minimisation of static electricity problems. Present indications are that, in situations in which appropriate measures have been taken, the incidence of equipment faults has dropped.

Effects of Errors on Lightning Tracking by Triangulation

The Laboratories operate a lightning tracking system that consists of three direction finder installations located at the apexes of an equilateral triangle of side length approximately 180 km (Clayton, Maffra and Benalla in Victoria). The function of each installation is to measure and report to a central computer the direction and magnitude of lightning strikes. If two or more direction finders report strikes within a 50 ms time period and the vectors intersect, the nominal location of the strike will be at the intersection of the vectors. The effect of various errors associated with the system on the accuracy of the nominal location of strikes is currently being studied.







Legend

- Computed position of lightning strike
- Direction finder

Computer simulations of the effect of errors in the computed pattern of 100 lightning strikes detected by detection finders 1, 2 and 3

(a) Regular pattern - no introduced errors

(b) Distorted pattern - caused by alignment errors of - 1.5° in each direction finder

(c) Distorted pattern - caused by errors (5 sin 2Ø) in the true direction (Ø) of each strike at each direction finder

Each direction finder has detection errors caused by the physical environment at the site and the alignment of the receiving antenna. These errors cause the incoming angle to be incorrectly calculated, i.e. the reported angle is equal to the true angle plus the error. The error associated with the antenna alignment is a constant and can be kept to less than 0.5 of a degree, but the errors introduced by the effect of physical features in the environs of the sites are not constant. These site-related errors can be as large as 10° and their magnitude varies with the direction of the signal. A study of theoretical models has shown that the error magnitude can be related to sin 2Ø, where Ø is the angle between the signal direction and true North.

The effect of these errors on a system with only two direction finders is easily understood and demonstrated, but if a third direction finder is introduced and it is assumed that all three detect the strike but only the two closest direction finders are used to compute its nominal location, quite a large displacement of the nominal location of some strikes can result.

To demonstrate the type of distortion of lightning strike patterns that can be caused by the effect of

these two types of errors, the normal location procedure was reversed. Starting with a regular array of 100 theoretical strikes, the angles from these to the various direction finders were determined. These angles were then modified to simulate the existence of alignment errors of -1.5° in each of the direction finders 1, 2 and 3. The resultant data was analysed using a software model of the central computer to produce the pattern of nominal locations. The procedure was repeated after adding an error, $E = 5 \sin 2\emptyset$, to every true direction angle and the resultant pattern of nominal locations was produced.

As expected, these studies showed that the magnitude of the distortion caused by direction finder errors is generally directly proportional to the distance of the strike from the direction finder. They also indicated that the presence of local physical features can produce a large degree of distortion in regions relatively close to a direction finder.

Transducer Monitor for Gas Pressure in Cables

To maintain the integrity of its underground trunk, junction and main subscriber cables, Telecom Australia uses positively pressurised cables. The advantages of this approach are that the ingress of moisture is restricted by the escaping gas (air) and that the pressure profile of the cable can be used to locate any faults due to rupture of the cable sheath.

Until recently, a "good/bad" pressure alarm network was used to indicate if there were any faults. This network consisted of contactor alarms, arranged such that contacts closed when the pressure dropped below a pre-determined level, connected in parallel on a dedicated pair of wires. Contact closure sounded alarms in the exchange, whence staff measured the loop resistance to obtain an approximate location of the fault. Manual techniques were then used to locate the fault more accurately. This method was inherently labour intensive, slow and costly.

Telecom has commenced a programme to replace the older contactor alarms with computer-addressable pressure monitoring units. The monitoring units are to be polled from a central station (exchange) to determine the cable pressure at the location of each monitoring unit, enabling the pressure profile of the cable to be determined regularly and quickly.

The system which is being implemented uses a variable resistance pressure transducer, which has a resolution of 3.5 kPa. It is felt that this may not be adequate, because the inertia of the cable may result in delays of several hours before a drop in pressure is noticed. A further possible disadvantage lies in the mounting of the tranducer and the electronics in a container mounted on the cable pit wall with a plastic tube connected to the cable.

With these perceived drawbacks, the Laboratories, in association with the South Australian Administration of Telecom, have been investigating and enhancing a digital pressure monitor unit, which was originally constructed in South Australia using discrete LSI devices and an integrated pressure transducer. As presently configured, the unit uses the same mounting techniques as the previous unit.

This unit is being redesigned by the Research Laboratories with state-of-the-art components. It is being constructed using hybrid circuit technology with the aim of reducing its size to enable its installation inside the actual cable joint. The unit is partitioned such that any transducer, be it temperature, humidity, etc, could be used to provide a small monitoring unit capable of being powered from exchange battery fed over line.

Australian Standard AS1049 - Polyethylene for Telecommunications Cables

Specifications play a key role in the provision of telecommunications services by linking together the design and manufacturing phases of a product and inherently influencing the product's performance and service lifetime.

Since 1971, Australian Standard 1049 has formed the basis of Telecom Australia's specifications for cables with polyethylene insulation and sheaths. However, with the changing commercial and technological environment, this specification became outdated and required substantial revision. Telecom Australia prepared a document which formed a basis for discussion by the Standards Association of Australia Committee TE/9 - Polyethylene Insulation for Telecommunications Cables. This Committee comprised delegates from polyethylene producers, cable manufacturers, cable design engineers and polymer scientists from Telecom Australia, and other interested organisations. A draft Standard, DR 84011 - "Plastics for Telecommunications Cables" has since been developed and is scheduled to be published during 1985.

The new draft Standard draws heavily upon Australian technology and experience with telecommunications cables in the Australian

environment. This is particularly the case in those of its parts dealing with polymer stabilisation, which, in turn, embrace the considerable work carried out in this field in recent years at Telecom's Research Laboratories.

The revised Standard comprises four major sections. The first three include a general introduction which sets out the scope of the document and its field of application, specifications for the raw materials used in insulating and sheathing telecommunications cables, and specifications of the physical and electrical requirements of finished cable. These apply to solid and cellular insulation of both filled and air-core cables, and to solid sheath with a moisture barrier or without a screen. The fourth section specifies the test methods which are applicable to both raw materials and finished cables, enabling the document to stand alone without the need for cross-referencing to other documents. Many of the test procedures have been specifically developed for the Standard and have been checked for reproducibility by the member organisations represented on the Committee.

The revised Standard provides a solid basis so that all sections of the telecommunications industry involved in design, manufacture and applications of telecommunications cables have a means of specifying high quality polyethylene materials and cables.

Validation of a Titanium Dioxide Analysis Method for Unplasticised PVC Pipe

Finely ground titanium dioxide uniformly dispersed throughout unplasticised polyvinyl chloride (UPVC) at low percentage concentration improves the mechanical strength and effectively screens out solar ultra-violet radiation which would otherwise degrade the UPVC if it is exposed above ground.

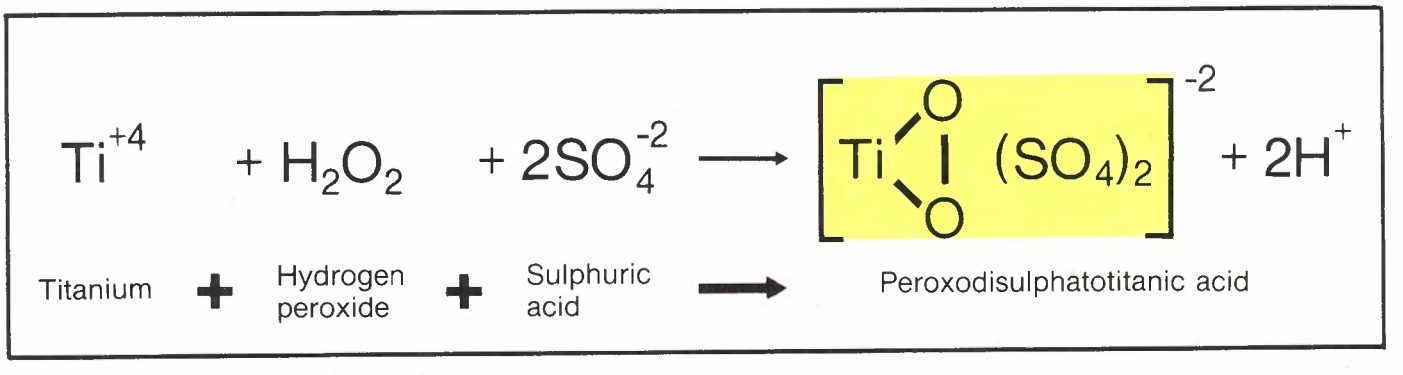
Telecom Australia specifies the proportion of titanium dioxide which must be present in a range of sizes of UPVC pipes and fittings which are used to accommodate telephone cables. However, the specification does not detail a test method to be used for the estimation of the percentage of titanium dioxide required to give the desired properties to UPVC. A chemical test method has therefore been developed recently by the Research Laboratories for use in Telecom's Materials Inspection and Quality Assurance laboratories for the accurate estimation of titanium dioxide.

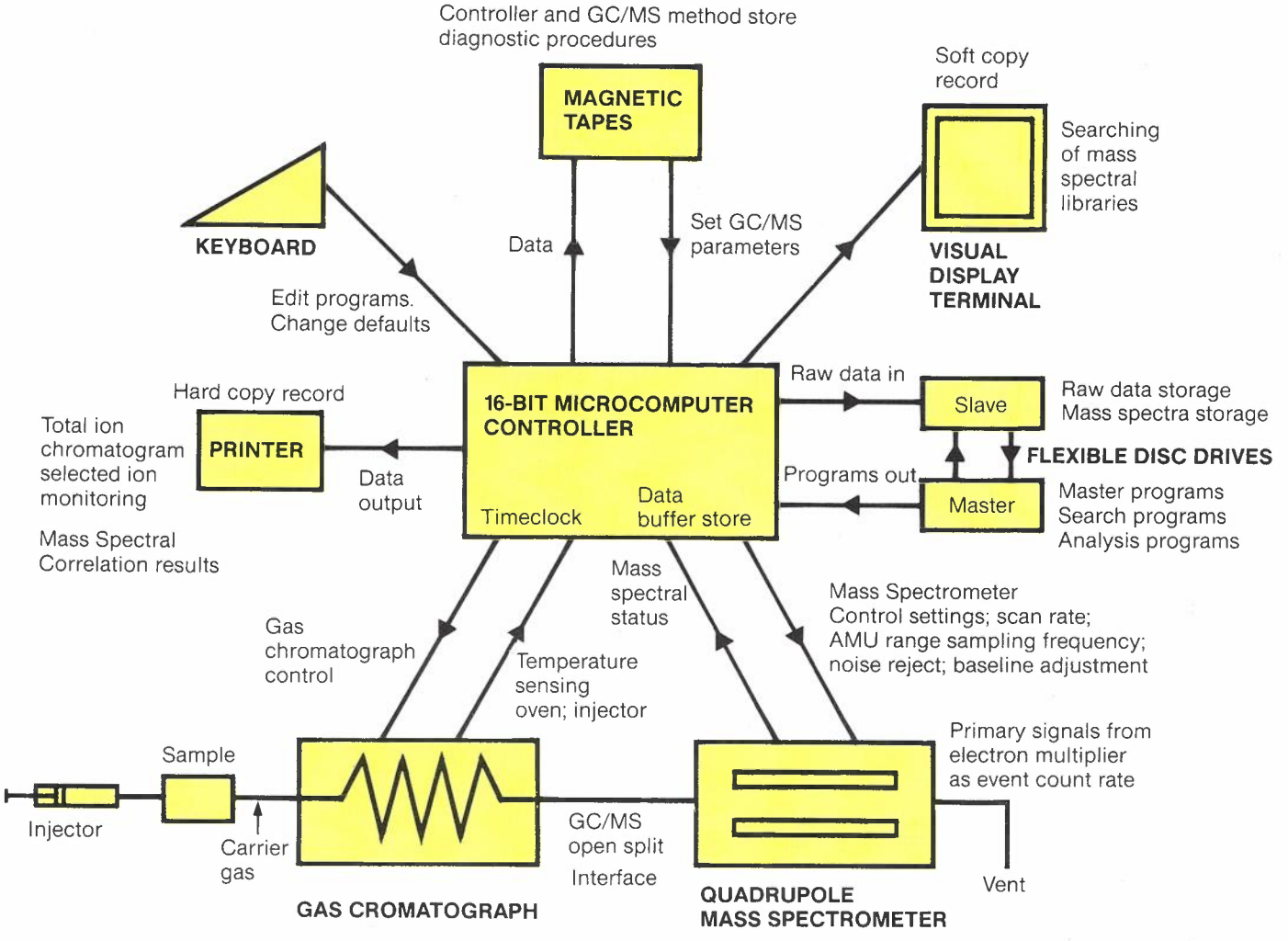
In the test method, an accurately weighed sample of UPVC is ignited at 850°C in a muffle furnace. The ash is reacted with a mixture of sulphuric acid and sodium sulphate. The titanium in the resulting solution is reacted with hydrogen peroxide to form peroxodisulphatotitanic acid, which ionises to give a yellow complex peroxidic ion. The yellow colour intensity is measured with a spectrophotometer, using a wavelength of 408nm, and quantified by comparing it with the colour produced by standard amounts of titanium in solution.

The Standards Association of Australia (SAA) Committee for UPVC Pipes and Fittings has proposed that the test method be included in a current standard. To establish the precision and accuracy of the method, sample test-pieces of UPVC containing titanium dioxide have been prepared by a commercial plastics laboratory and distributed to the Research Laboratories and to four other co-operating laboratories. Each laboratory has carried out analyses to the prescribed procedure and reported to SAA.

Results from the co-operative study are being examined by the SAA Committee, and it is confidently expected that the proposed test method will be incorporated into a revised Australian Standard for UPVC pipes and fittings.

Chemical reaction involved in test method for titanium dioxide analysis





Schematic outline of a microcomputer-controlled gas chromatograph linked to a mass spectrometer

Management of Analytical Instrumentation in the Chemical Laboratory with Microcomputers

Modern chemical laboratories, including Telecom's Research Laboratories, now rely heavily on microprocesser-based control of instrumentation. Commercial desktop computers provide a ready means of operator communication with the control systems of these instruments and add a major bonus by collecting and processing considerable amounts of output data at high speed.

The general advantages of microprocessor-controlled instruments when compared with those requiring manual operation are well known. In a chemical laboratory, the major advantages can be summarised as follows:

- Once the system has been set up, routine work can be repeated indefinitely under the same operating conditions.
- Data entry and transcription errors are reduced.
- Increased sample throughput, coupled with greater accuracy and reproducibility of analytical measurement and presentation, leads to the derivation of more reliable results.
- Post-run processing of results is faster.
- Sorting, identification, matching and correlation of data sets can be performed with greater speed and without loss of detail.

In the area of chemical analysis, instruments that are now effectively under the control of microcomputers include:

- gas chromatographs
- gas chromatographs linked to quadrupole mass spectrometers
- high performance liquid chromatographs
- thermal analysers.

In the research and investigation of material properties, not all of the equipment can be completely controlled to the exclusion of the operator. However, in the particular case of the gas

chromatograph linked to the mass spectrometer, the desktop computer not only collects, stores and analyses the data, it also optimises the system and controls the running of the machine.

Generally, the controllers supplied with the original equipment lack adequate storage capacity for output data. In order to retain the information, it becomes necessary to add a central data storage unit with greater permanent storage capacity. Data, in the form of digitised detector outputs or plotted spectra, can be temporarily stored in the dedicated units and then transferred to their control unit, either for further manipulation or long term storage.

The acquisition and use of microprocessor-controlled instrumentation by the Laboratories has not only enabled chemical analyses to be performed more efficiently, but has also extended the analytical capabilities and improved the sensitivity and accuracy of investigations.

Evaluation of Zinc-Aluminium Casting Alloys

Aluminium-silicon die castings are presently used by Telecom Australia in manholes for gas pressure alarm cases. In this environment, their corrosion resistance is poor. Hence, the Laboratories recently undertook an investigatory project to determine whether any of four so-called "International Lead Zinc Research Organisation" (ILZRO) zinc-aluminium alloys were more suitable for casting gas pressure alarm cases, repeater housings and other fittings used in service in manholes and similar environments.

Comparative corrosion tests were conducted on ILZRO 3, 5, 12 and 27 alloys and a control aluminium-silicon alloy, BS401. From previously obtained chemical analysis data of manhole waters, four corrodent solutions were selected, as follows:

- pH 8
- pH 8 + 500 ppm of chloride
- pH 12.5
- pH 12.5 + 500 ppm of chloride.

Two tests using each solution were carried out to investigate the effect of wetting and drying. The tests comprised:

- constant immersion in the above solutions
- intermittent immersion on a twenty-four hour cycle.

During the testing programme, inspections were conducted daily. After forty-five days, the test was terminated due to extensive corrosion on a number of samples.

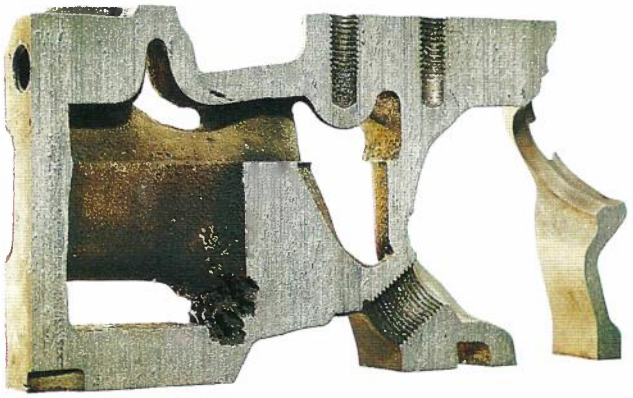
Corrosion damage was assessed by visual examination of the test specimens, mass and volume loss measurements, and pit depth measurements. The visual examination showed the type and extent of any corrosion that had occurred, and enabled qualitative comparisons to be drawn. The mass loss measurements were converted to quantise the volume of metal removed by corrosion, enabling further comparisons to be made in relation to the extent of corrosion in alloys of differing densities. The pit depth measurements quantified the effect and extent of localised corrosion.

The test programme concluded that, in general, the ILZRO alloys are more susceptible to localised corrosion, mainly pitting, whilst the BS401 samples corroded in a more uniform manner. For most of the test environments, the BS401 samples lost a greater volume of metal than the most corrosion resistant ILZRO alloy (ILZRO 3) due to general corrosion. As a result of the observed increased susceptibility to localised corrosion, ILZRO alloys 3, 5, 12 and 27 were not recommended as suitable replacements for aluminium-silicon alloys for the production of castings used in manholes. They are also considered unsuitable materials for underground repeater housing covers.

Corrosion Inhibitors for Automotive Cooling Systems

Corrosion in the cooling systems of automotive engines has been a long standing problem that has been accentuated with the increased usage of aluminium cylinder heads in modern engines. These and other aluminium alloy components, such as water pumps and thermostat housings, often undergo severe corrosion, despite the fact that the corrosion inhibitors used in the cooling water of the engines complied with an Australian and/or international standard.

A number of organisations, including the Laboratories, saw a need to obtain correlation between the performance of corrosion inhibitors in laboratory and service conditions, so that products that meet the requirements of a Standard in a laboratory environment can be predictably applied in service. As part of a programme to achieve this aim, the Laboratories participated in a series of co-operative laboratory tests conducted among corporate members of the Society of Automotive Engineers, Australasia. The purpose of this work was to establish the degree of reproducibility of results that could be obtained within individual laboratories, and also to ascertain the correlation possible between laboratories, using a method developed under the auspices of the Society.



Cross section of an alloy automotive cylinder head showing corrosion damage

The new method is expected to enable more reliable forecasting of the performance of corrosion inhibitors for automotive cooling systems. The new method differs from current methods in two important aspects, as follows:

The coolant containing the corrosion inhibitor under test circulates through a water-jacketed heat exchanger, which simulates the automobile radiator. By this means, any tendency for solids to precipitate in the lower temperature zones of a cooling system is highlighted.

As in most earlier corrosion inhibitor test methods, solution-heated metal specimens suspended in the coolant solution are included.

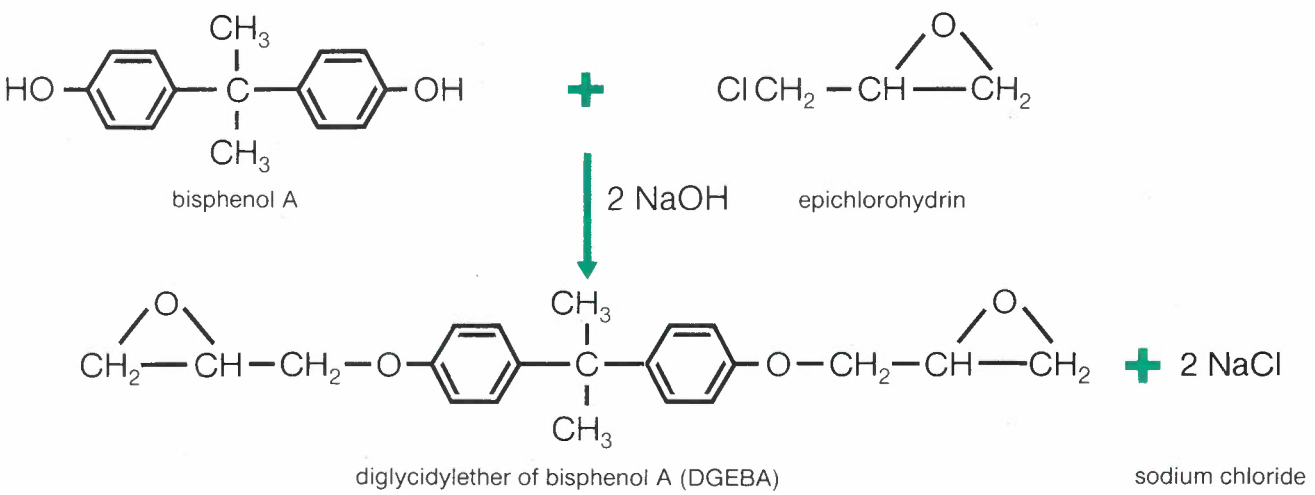
Metals such as brass, steel, cast iron, solder and aluminium normally found in automotive cooling systems are common to the various test methods. However, the new procedure has an additional 'heat rejecting surface' which simulates the aluminium alloy cylinder head of a modern automotive engine. It takes the form of a small specimen disc which is directly heated on its lower surface by a thermostatically controlled electric hotplate, while its upper surface is in direct contact with the coolant solution.

The results of work carried out by car manufacturers so far indicate promising agreement between laboratory and service experience. However, before it can be considered as an SAE or Australian Standard, it must be subjected to longer term validation, which includes the current inter-laboratory co-operation.

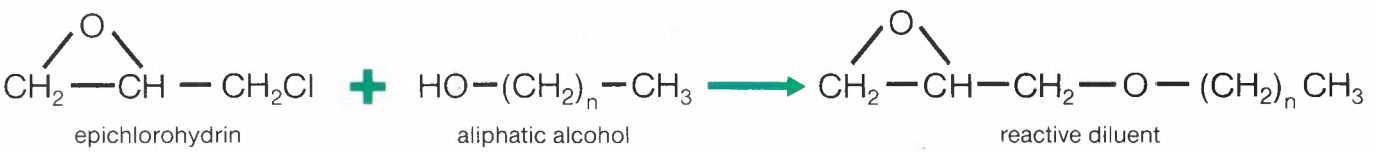
A Semi-automated Chromatographic Procedure for Determination of Epichlorohydrin

Commercial epoxy resins are predominantly based on the diglycidyl ethers of bisphenol A (2,2-**bis**-4-hydroxyphenylpropane), formed from reaction with epichlorohydrin (3-chloro-1,2-epoxypropane). Epoxy resins are modified by the inclusion of a diluent, which can change the viscosity and reactivity of the

Reactions involved in the production of epoxy resins and modifying diluents:



(a) Diglycidyl ether of bisphenol A (DGEBA)



(b) Reactive diluent

components being mixed initially and which can also impart various chemical and physical properties to the cured, thermosetting resin.

For example, to achieve the requisite electrical properties as a cable joint encapsulant and yet provide ease of mixing in field packs, a reactive diluent is included in the relevant epoxy resin formulations used by Telecom Australia. This reactive diluent is produced by reaction of epichlorohydrin with long chain aliphatic alcohols. The safe handling properties of subsequent stages of resin curing depend on the completeness of this reaction in the course of manufacture. To assess this process, the Laboratories have developed an analytical method to determine the residual traces of epichlorohydrin which may remain in any raw materials going into epoxy resins produced for use by Telecom Australia.

The procedure depends on vaporisation from a sample injected directly into a gas chromatograph which has its operating parameters optimised and controlled by a microcomputer. An internal standardisation technique is used wherein a known amount of reference analyte is added to the sample being measured. Calibration of the response of the detector and plotting of data is performed in parallel with the passage of the sample. The microcomputer then generates a report of the quality of unreacted epichlorohydrin found in the sample. This process is completed within minutes of the conclusion of the chromatography.

The development of this new procedure has provided a useful and efficient facility for the determination of epichlorohydrin in the Laboratories.

Mechanical Design of TAMS-4

Over some years, Telecom Australia has designed and developed a versatile Telephone Apparatus Measuring System, Series 4 (known as TAMS-4). The more recent development of the System has been performed by the Headquarters Engineering Department, although early development of TAMS-4 took place in the Research Laboratories.

TAMS-4 automatically performs a series of electrical safety and performance tests on a variety of telephone instruments. It is intended to provide the basic quality control of new telephones during production or of older telephones after re-conditioning.

In the last year, the Laboratories have assisted the TAMS-4 project by providing assistance in the design and development of the pneumatic and mechanical aspects of the TAMS-4 workstation adapted for the automated testing of push-button telephones on a production or re-conditioning line. The workstation incorporates features achieving acceptable ergonomic characteristics for production operations. The prototype comprises a sliding test bed which is flush-mounted in a height-adjustable table. The test bed indexes the telephone under a test jig containing the dial tester, switch hook and recall button tester. A bell loudness control device is mounted beneath the test bed. An artificial voice/ear unit is positioned level with the table top and is transferable to either left or right sides of the table, depending upon conveyor or feed chute location.

The modular design of the workstation allows easy adaptation for the testing of different types of telephone apparatus. Present studies are aimed at developing a test jig for testing rotary dial telephones of the 800 Series.

National Signalling System No. 7 Specifications

Today, it is possible to connect almost any telephone subscriber to almost any other telephone subscriber anywhere in the world. In most cases, this can be performed without assistance or intervention of an operator, because of the high degree of standardisation in international communication systems achieved over the past 100 years.

The cost of developing the modern computer controlled exchanges is causing many countries to use international standards within the country as well, thus minimising equipment changes to cater for local requirements. In recent years, this trend has been further encouraged with inclusion of facilities for national use in the internationally agreed specifications.

Common Channel Signalling System No. 7 (CCSS7) is perhaps the first major system that was specifically intended for both international and national use. It is a network (exchange to exchange) signalling system, designed for digital network environments and capable of providing signalling facilities for telephony, data, and all other services that will be possible in a future Integrated Services Digital Network (ISDN).

The versatility of CCSS7 is achieved through its structured architecture. The system is partitioned into two broad parts, the Message Transfer Part (MTP) and User Parts, each of which may be further partitioned. The MTP consists of three levels and is common to all applications of CCSS7, providing

reliable transfer of signalling messages to their destination.

User Parts are specific for the application, and many may exist as required to provide the services. Telecom Australia is introducing CCSS7 in its network in 1986, initially for telephony service, and extending to other services as ISDN is introduced.

Although international specifications can form the basis of national requirements, some adaptation is still generally required because :

- additional signalling may be required to interwork with existing exchanges that are specific to the country
- optional procedures in the specification must be selected as appropriate to the environment in the country, e.g. different error correction procedures are used for satellite links
- the signalling network structure for the country must be defined so that routing procedures can be designed, and
- the system must be "dimensioned" to carry the expected signalling traffic load with specified performance criteria.

The last three aspects are relevant to the MTP and the Research Laboratories have produced a specification for the Australian MTP, which defines the options and procedures relevant to the Australian conditions and the services to be provided in Australia in the future. The use of an international specification as a basis considerably shortened the timescale for introduction of CCSS7 in Australia, as well as providing considerable cost savings in the development of a specific signalling system for Australia.

Digital Selective-calling Systems for the Royal Flying Doctor Service

In an on-going programme to develop and improve short wave radio services to outback Australia, the Royal Flying Doctor Service is assessing the feasibility of adding a digital selective-calling system to its network. At the request of the Service, the Laboratories have provided technical assessments of some proposed systems.

The essential role of a selective-calling system is to allow individual communications transmitted on a radio channel shared by a number of users to be directed to specific stations only. This facilitates operation of the network in terms of the amount of manual message monitoring required, and it introduces a significant degree of privacy. Digital systems offer ready means to address very large numbers of users. From 10 000 to 1 000 000 addresses are easily accommodated, depending on the address word length. They may also be configured to have category codes or other information embedded within the calling sequence, and they facilitate error detection and correction.

As a criterion for the comparison of various possible systems, the Royal Flying Doctor Service has chosen a detailed specification recommended by the International Telecommunications Union for the maritime mobile service (CCIR Rec. 493-2). This employs a synchronous system using a ten unit error detecting code, with a 10/7 character format, and time diversity. Although the final specification selected may differ in minor respects from this proven CCIR standard, all parameters affecting performance are expected to be retained.

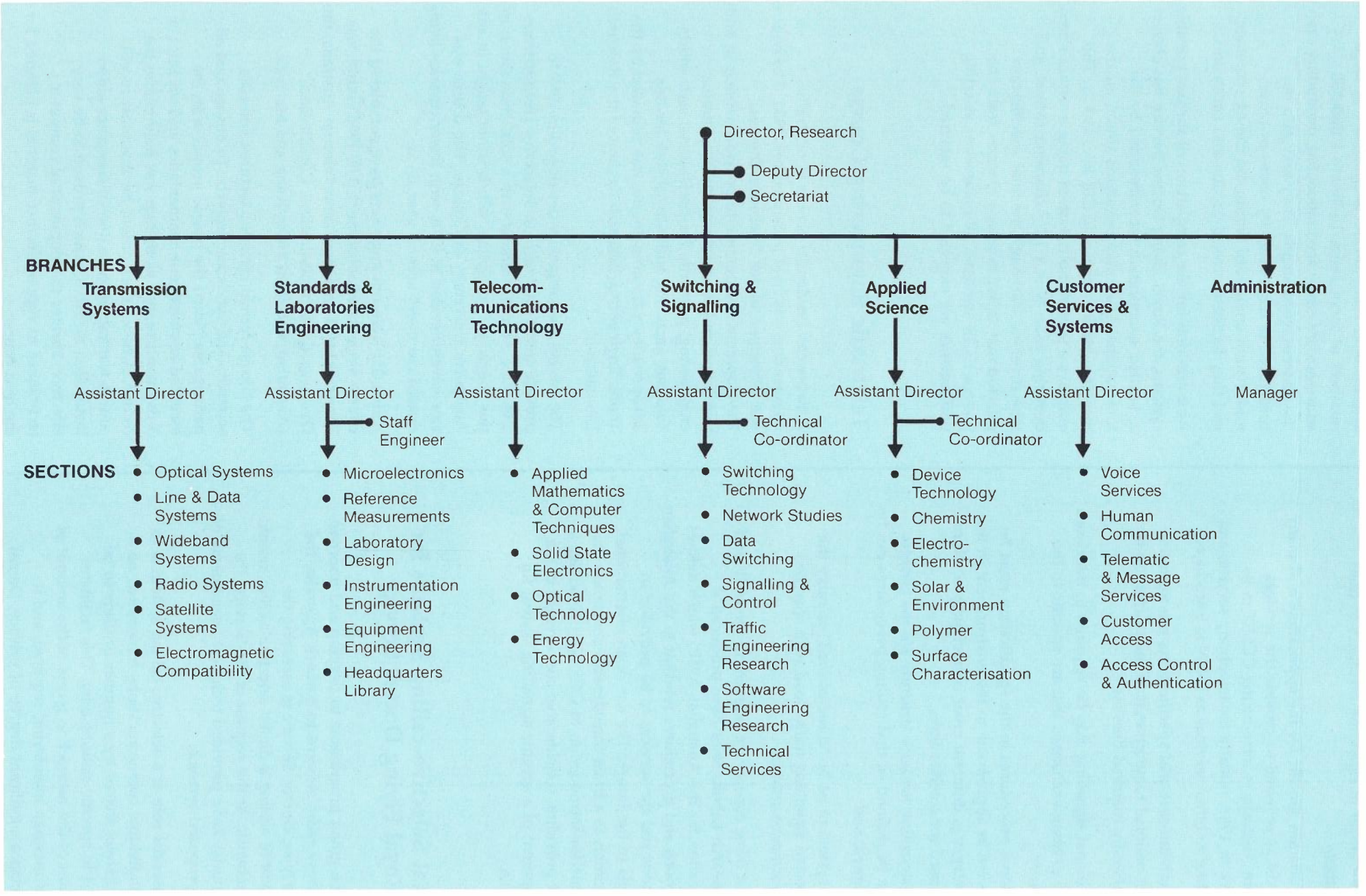
Teletraffic Engineering Course

A two-week residential course in teletraffic engineering was held in September, 1984. The course was presented under Telecom's Engineer Development Programme to provide training in both theoretical and practical aspects of teletraffic engineering, primarily for professional staff within Telecom. Lecturing and tutorial staff for this advanced level training course was provided by the Traffic Engineering Research Section of the Research Laboratories.

The course was originally developed in 1967 to provide traffic engineers in Telecom's Headquarters and State Administrations with a solid foundation in this specialised discipline, which is not taught in any Australian University or College. The course was extensively revised in 1978, with lesser updates being carried out every second year since.

About 250 Telecom engineers have completed the course since its establishment. The 1984 course was attended by 31 engineers from Telecom Australia, the Overseas Telecommunications Commission (Australia), and from Hong Kong and Malaysia.

The course format included lectures, tutorials, seminars and syndicate projects. To ensure that all participants joined the course proper with the essential knowledge in mathematics and statistics, a 3-day mathematics workshop was held before the course. A new development for this most recent course was the introduction of computer-aided instruction methods, which proved to be very effective. Further development of computer techniques to support lecture material is planned for the next course.



The Research Laboratories' Organisation

The Laboratories— Summary Information

Overall Objectives of the Laboratories

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

Organisation

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

Professional and Senior Staff

The names given below are those of the actual occupants of the positions (appointed or acting) at 31 March 1985.

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

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

SECRETARIAT

Functions

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

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

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

Principal Engineer: R.P. Coutts, BSc, BE(Hons), PhD, MIEEE

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

Engineers:
P. Gretton, Dip Elec Eng
G.R.G. Smart, Dip Rad Eng, ARMIT, MIREE, MTV Soc Aust

Executive Officer: T.H. Brown

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

ADMINISTRATIVE SERVICES GROUP

Functions

The Administrative Services Section provides administrative and clerical support to the Laboratories. This includes information and advice on various matters relating to:

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

Manager, Administration: B.M. Douglas

Senior Planning Officer: T.W. Dillon

Project Officer: M.A. Chirgwin

Budgets Officer: R.J. Beveridge

Staff Services Co-ordinator: L.J. Roberts

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

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: L.J. Millott, BE(Hons), MEngSc, MIEEE

Principal Engineer: W.S. Davies, BE, MEngSc(Hons), PhD

Senior Engineers:
M.J. Biggar, BE(Hons)
I.C. Lawson, BEE
A.L. Martin, BE, Grad IE Aust, SMIREE

Engineers:
D.J. Bakewell, BEE(Hons)
A.M. Brooks, BEE(Hons), MEngSc

Scientist: G. Bharatula, MSc, MTech

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

Line and Data Systems Section

Functions

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

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

Principal Engineers:
A.J. Jennings, BE(Hons), PhD, SMIEEE, SMIREE
P.G. Potter, BE(Hons), PhD, MIEEE
G.J. Semple, BE(Hons), MEngSc

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

Engineers:
B.R. Clarke, BE(Hons), PhD
P.A. Evans, BE(Hons)

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

Optical Systems Section

Functions

- Provide information, advice, consultancy and recommendations as defined in the Branch objectives
- Conduct research and exploratory development into the transmission characteristics of optical media
- Conduct research into transmission systems which utilise optical media
- Evaluate the potential applications and utilisation of systems using such media for the 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

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

Senior Engineers:
J.C. Campbell, BE(Hons), MEngSc, MIEEE
B. Goczynski, MEng Comm
K. Hinton, BE(Hons), BSc, PhD
T.D. Stephens, BE(Hons), MEngSc, MIEE

Scientists:
J.L. Adams, BSc(Hons), PhD
F. Ruhl, BSc(Hons)

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

Wideband Systems Section

Functions

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

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

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

Senior Engineers:
F.G. Bullock, BE(Hons), Grad IE Aust, MIEEE
M.D. Hayes, BE(Hons), BSc
J.G. Hollow, BE(Hons), PhD, MIREE

Engineer: J. Burgin, BE(Hons)

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

Satellite Systems Group

Functions

- Provide information, advice and consultancy as defined in the Branch objectives
- Conduct research into, and advise on, applications of communications satellite technology in Australia by technique studies, hardware development and experimentation.

Group Leader: G.F. Jenkinson, BSc, SMIREE

Principal Engineer: R.K. Flavin, BSc, MSc

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

Engineer: K. Balasubramanya, BE, MTech, PhD, SMIEEE

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

Electromagnetic Compatibility Group

Functions

- Provide information, advice and consultancy as defined in the Branch objectives
- Investigate interference effects of conducted and radiated electromagnetic fields and waves on telecommunications equipment and make recommendations on electromagnetic compatibility as appropriate
- Conduct research and exploratory development in the field of freely propagated electromagnetic waves, including the study of antennas for launching and receiving electromagnetic radiation, and make recommendations in relation to the performance and design characteristics of radio communication systems.

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

Principal Engineer: S. Sastradipradja, BE, SMIREE

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

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

STANDARDS AND LABORATORIES ENGINEERING BRANCH

Objectives

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

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

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

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

Provide a laboratory design and instrumentation facility for the Research Department

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

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

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

Branch Administrative Officer: P. Rodoni

Reference Measurements Section

Functions

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

Section Head: R.W. Harris, BSc(Hons), BE(Hons), BComm

Principal Engineer: R.L. Trainor, BSc

Senior Engineers:
E. Pinczower, Dip Elec Eng, MIE Aust
B.R. Ratcliff, Dip Comm Eng, ARMIT

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

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

Laboratory Design Section

Functions

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

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

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

Senior Technical Officer: J.T. Blake

Instrumentation Engineering Section

Functions

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

Section Head: A.M. Collins, BSc

Principal Engineer: N.A. Leister, BE, Grad IREE

Senior Engineer: F.R. Wylie, BE, MIEEE

Engineers:
D. Beard, BE, BComm
I. Dresser, BE
P. Standaert, BE(Hons)
B. Nigli, BSc

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

Headquarters Library

Functions

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

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

Senior Librarians:
M.B. McAllister, BSc(Hons), Dip Lib, ALAA
D.J. Richards, BA, Dip Lib

Librarians:
L.M. Gough, Dip Lib
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.
E.M. Tunaley, Dip Lib
B.A. Wilson, BA, LLB, Dip Lib
G. Woods, Dip Lib

Equipment Engineering Section

Functions

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

Section Head: F. Wolstencroft, C Eng, MI Mech E

Principal Engineer: P.F.J. Meggs, Dip Mech Eng, ARMIT, Dip IM, MIE Aust, SM RI of SME

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

Engineers:
A.R. Gilchrist, Dip Mech Eng, BE(Hons), Grad IE Aust
V. Lee, BSME, MSME
R.E Proudlock, BE

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

Microelectronics Section

Functions

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

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

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

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

Scientist: S.J. Faulks, BSc(Hons), PhD

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

TELECOMMUNICATIONS TECHNOLOGY BRANCH

Objectives

Conduct studies, exploratory development and field experiments, provide advice and recommendations, and contribute to equipment specification and assessment relating to:

- the application of newly emerging, extended or improved technologies in telecommunications engineering
- the characteristics and properties of new devices, circuits and techniques in communications applications
- the impact and compatibility of new technology and new applications of existing technology with those already in the Telecom Australia network
- the forecasting and evaluation of developing trends in telecommunications technology particularly suitable for application in Australia.

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

Assistant Director: W.J. Williamson, 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 on, and recommend or implement as appropriate, modelling and simulation methods, as applicable to telecommunications systems and techniques, and related activities
- Investigate and recommend or implement computing techniques and facilities including hardware and software to meet special needs within Telecom Australia.

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

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

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

Scientist: A. Kowalczyk, MAppSc, PhD

Engineers:
L.A.R. Denger, ENSEMN, MIEEE, MSoc Fr de Elec
S.A. Leask, BE(Hons)
P.L. Nicholson, BE

Senior Technical Officer: I.C. Meggs

Solid State Electronics Section

Functions

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

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

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

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

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

Engineer: J.Dell, BElectron Eng(Hons)

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

Senior Technical Officers:
R. Garner
F. Gigliotti

Energy Technology Section

Functions

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

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

Senior Engineers:
D.J. Kuhn, BE(Hons), MEngSc
I. Muirhead, MEnv Studies, BSc(Hons)

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

Senior Technical Officer: E.D.S. Fall

Optical Technology Section

Functions

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

Section Head: G.E. Rosman, BEE, ME

Principal Engineer: Y.H. Ja, BE, PhD, MAOS

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

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

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

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

SWITCHING AND SIGNALLING BRANCH

Objectives

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

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

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

Technical Co-ordinator: vacant

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), MIE Aust

Engineers:
G. Foster, BE(Hons)
T. U. Nguyen, BEE, PhD
J. Smith, BE(Hons)

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 Engineer: M. Subocz, BE(Hons), MEngSc, MIE Aust

Senior Engineers:
B.T. Dingle, Dip Elec Eng, BE(Hons)
G.K. Millsteed, Dip Elec Eng, BE(Hons)

Engineers:
T. Batten, BE(Hons), MIEEE
H.K. Cheong, BE(Hons), PhD
N.D. Kim, BChemE(Hons), Dip Data Proc
M.C. Wilbur-Ham, BE(Hons)

Scientists:
I.P.W. Chin, BSc(Hons), AIEE
G.R. Wheeler, BSc(Hons), MSc

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
G.J. Dickson, BE(Hons), MEngSc, MIEEE
J.C. Ellershaw, BSc, BE(Hons), PhD, MIEEE
P.A. Kirton, BE(Hons), PhD, MIEEE

Senior Engineers:
P.R. Hicks, BE, BSc, MEngSc
C.J. O'Neill, BE(Hons)

Engineers:
G.A. Foers, BE(Hons), MIEEE
M. Littlewood, BE(Hons)
S.L. Sutherland, BE(Hons)

Traffic Engineering Research Section

Functions

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

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

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

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

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

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

Technical Services Section

Functions

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

Section Head: W. McEvoy, AAIM

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

Software Engineering Research Section

Functions

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

Section Head: R.H. Haylock, MACS

Senior Computer Systems Officers:
P. Hui, BSc
G.P. Rochlin, BSc, MACS
E.M. Swenson, MSc, Dip Data Proc, MAIP, MACS, MIEEE

Computer Systems Officers:
J.B. Cook, BSc(Hons), AACS, MACS
J.A. Gilmour, BAppSc
D.M. Heagerty, BTech(Hons), MIEEE
R. Liu, BSc(Hons), Dip Comp Sc, AACS
H. Stein, Diplom-Informatiker, MIEEE

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, Post Dip Elec Comp, MIE Aust

Principal Engineer: E. Tirtaatmadja, BE, MIEEE

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

Engineers:
B.W. Keck, BSc(Hons), BE(Hons), PhD
R.A. Palmer, BE, PhD
C.J. Scott, BSc, MAIP, MIE Aust, MIEEE

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 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

Technical Co-ordinator: A.M. Fowler, MIE Aust

Branch Administrative Officer: G.A. Galvin, BA

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 Scientists:
K.G. Mottram, Dip Met Eng
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, MAppSc, PhD, FRMIT

Senior Technical Officers:
R.A. Galey, BE(Comm)
M. Jorgensen, Dip Sec Met
J.M.F. Pidoto, BE(Comm)
R.W. Rydz

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 procedure and thereby improve operational reliability of these devices. The work includes the development of 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.J. Der, BSc, ARACI

Senior Scientist: R.C. Wallis, BSc(Hons), PhD

Scientists:
P.J. Gwynn, Dip App Chem
G.R. Thompson, BSc(Hons)

Senior Technical Officer: F.M. Hamilton

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, ARACI, AAIST, C Chem, MRSC

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

Senior Scientists:
G.I. Christiansz, BSc(Hons), PhD, Dip Ed
T.J. Elms, Dip App Sc, Dip Anal Chem, Grad RACI
F.M. Petchell, Dip App Chem, ARACI

Senior Technical Officers
R.R. Pierson, Dip Res Cons Stud, MAIST
B.C. Eva

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'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, C Chem

Principal Scientist: B.A. Chisholm, Dip App Chem, MSc, Grad RACI, Grad PRI

Senior Scientists:
D.J. Adams, Dip App Chem, Grad RACI
R.J. Boast, Dip App Chem, Dip Pol Sc, Grad RACI

Scientists:
S. Georgiou, B App Sc, Dip Anal Chem
P.R. Latoszynski, Dip App Sc, Dip Anal Chem, Grad RACI

Senior Technical Officer: D. Coulson

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 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: I.A. Dew, BSc, MSc

Principal Engineer: I.K. Stevenson, BAppSc, Dip Elec Eng, Grad AIP, Grad IE Aust

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

Scientist: 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
G.W. Lipback, Dip Elec & Com Eng
S.R. McAllister
I.M. Tippett

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, MAXS

Senior Technical Officer: C.J. Ellery

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 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:
P.C. Craig, BE(Hons), PhD
N.H. Duong, BE
J.P. Goldman, Dip Rad Eng, Dip Comm Eng, Grad IE Aust
P.H. Newland, BE
J.S. Spicer, BE(Hons)

Senior Technical Officers:
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 system issues
- Conduct studies into the interworking of Telecom's networks with customer systems and networks.

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

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

Senior Engineers:
D.M. Blackwell, BE
B.J. McGlade, BE(Hons)

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

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 data base services, including electronic directory services
- Conduct theoretical and experimental research into interworking between these service types
- Develop structured models of telematic and message based service types.

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

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

Senior Engineers:
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
M. Blakey, BE(Hons), MEngSc
P. Nuuttila, MEngSc, MIEEE

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

Senior Technical Officers:
B.W. Booth
I.J. Moran

Human Communication Section

Functions

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

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

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

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

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

Psychologist: G. Lindgaard, 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 telecommunication 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

Engineer: J.P. Nakulski, BE

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

Boast, R.J. & Latoszynski, P.	'Comparison of DSC and HPLC as Techniques for Analysis of Stabilisers in Polyethelene', Polymer 85: International Symposium, Characterisation and Analysis of Polymers, Melbourne, February 1985.
Bundrock, A.J. & Murphy, J.V.	'A Broadband 11 GHz Radio Propagation Experiment', IEEE Transactions on Antennas and Propagation, Vol. AP-32, No. 5, May 1984.
Campbell, J.C.	'Outage Prediction for the Route Design of Digital Radio Systems', Australian Telecommunication Research, Vol. 18, No. 2, 1984.
Campbell, J.C., Martin, A.L. & Coutts, R.P.	'140 Mbit/s Digital Field Experiment - Further Results', International Conference on Communications, ICC '84, Amsterdam, The Netherlands, May 1984.
Chew, E.K. & Chong, K.N., McDonell, K.J. (Monash University)	'A Name Validation Procedure for Hierarchically Distributed Directory System Database', 8th Australian Computer Science Conference, Melbourne, February 1985.
Chin, I.P.W. & Cheong, H.K.	'A Simulation of the Level 2 of the CCITT Common Channel Signalling System No. 7', Australian Telecommunication Research, Vol. 18, No. 2, 1984.
Chin, I.P.W. & Dingle, B.T.	'An Introduction to the Integrated Services Digital Network User Part of the CCITT CCSS No. 7', Telecommunication Journal of Australia, Vol. 34, No. 2, 1984.
Court, R.A., Tirtaatmadja, E. & Harsant, D.M.	'The New Microelectronics Revolution', Telecommunication Journal of Australia, Vol. 34, No. 1, 1984.
Craick, J.K.	'Teleconferencing - An Overview', The International Teleconference Symposium, Sydney, April 1984.
Dew, I.A. & Dunsmuir, W. (Siromath P/L)	'Study of Temperature Data in Above-Ground Jointing Boxes Located at a Remote Site', 3rd Applied Physics Conference 'Physics and Australia's Resources', Melbourne, December 1984.
Dickson, G.J. & de Chazal, P. (CSIRO)	'Status of CCITT Description Techniques and Application to Protocol Specification', Special Issue of Proc. of the IEEE Vol. 71, No. 12, December 1983.

Dickson, G.J. & Wheeler, G.R. — 'A Comparison of Formal Description Techniques Proposed for International Standardisation',The 7th International Conference on Computer Communication, ICCC '84, Sydney, October/November 1984.

Duc, N.Q. & Chew, E.K. — 'Evolution Towards Integrated Services Digital Networks, Telecommunication Journal of Australia, Vol. 34, No. 2, 1984.

Ellershaw, J.C. & Snare, J.L. — 'Aspects of Interworking between Private and Public Packet Switched Data Networks', International Conference on Communications, ICC '84, Amsterdam, The Netherlands, May 1984.

English, K.S. — 'Maximum Likelihood Estimation of the Frequencies of Multiple Tones in Noise', Australian Telecommunication Research, Vol. 18, No. 1, 1984.

Fidge, C.J. & Cain, G.J., Jackson, L.N., Pascoe, R.S.V. (RMIT) — 'An Overview of the Melba Automatic Code Generation Project', Australian Telecommunication Research, Vol. 18, No. 1, 1984.

Flatau, G. — 'The Need for Approved Components', National Design Co-ordination Conference, Melbourne, September 1984.

Frueh, P.F. — 'Local Area Networks', Telecommunication Journal of Australia, Vol. 34, No. 2, 1984.

Georgiou, S. — 'Olefinic Unsaturated in Polyethylenes - an Infrared Spectrophotometric Study', International Symposium Polymer 85: Characterisation and Analysis of Polymers, Melbourne, February 1985.

Gerrand, P.H. & Jackson, L.N., Fidge, C.J. & Pascoe, R.S.V. (RMIT) — 'Computer-Aided CHILL Program Generation from System Specifications: Design Experience from the Melba Project', XI International Switching Symposium, ISS '84 Florence, Italy, May 1984.

Harris, R.J. — 'Comparison of Network Dimensioning Models', Australian Telecommunication Research, Vol. 18, No. 2, 1984.

Heagarty, D. — 'Implementation of a Run-Time System to Support the Concurrency Features of the Chill Programming Language under RSX-11M', 1984 Decus Australia Symposium, Sydney, July 1984.

Hinckley, S. & Haneman, D. (University of NSW) — 'Derivation of Charge Transfer Parameters of Semi-Conductor - Liquid Interfaces', Third International Conference on Solid Films and Surfaces, University of NSW, August 1984.

Ja., Y.H. — 'Optical Beam Equalisation using Degenerate Two Wave Mixing', Electronic Letters, Vol. 20, No. 25, December 6, 1984.

Ja, Y.H. — 'On the Multiple-Root Problem when Solving Directly the Non-Linear Coupled-Wave Equations for Two-Wave Mixing in a Reflective Geometry', Applied Physics B Vol. 34, 1984.

Ja, Y.H. — 'The Significance of Trapping Centre Concentration in Photorefractive Crystals used for Four-Wave Mixing', Optical and Quantum Electronics, 16, July 1984.

Ja, Y.H. — 'Beam Coupling and Decoupling in Degenerate Two-Wave Mixing in a Reflection Geometry with Photorefractive Bi_{12} GeO_{20} Crystals', Optical and Quantum Electronics, 16, 1984.

Ja, Y.H. — 'Matrix Method to Solve Non-Linear Coupled-Wave Equations for Degenerate Two-Wave and Four-Wave Mixing', 1984 Annual Meeting of the Optical Society of America, California, November 1984.

Ja, Y.H. — 'Energy Exchange between Beams in Degenerate Two-Wave Mixing Experiments using Photorefractive Crystals', Progress in Optical Physics Conference, Melbourne University, August 1984.

Jenkins, A.R. — 'Teleconferencing Studio Design', The International Teleconference Symposium, Sydney, April 1984.

Jennings, A.J. & Gray, R.L. — 'Extension of Levy's Large-Aperture Design Formulae to the Design of Circular Irises in Coupled - Resonator Wave Guide Filters', IEEE Microwave Theory and Techniques, Vol. MTT-32 No. 11, November 1984.

Jennings, A.J. & Pang, K.K. (Monash University) — 'Switched Capacitor Equalisers for Time-Compression Multiplex Digital Transmission', TENCON '84, Trends in Electronics Conference, Singapore, April 1984.

Kemeny, P.C. — 'Composition of AlGaAs Films Grown by Molecular Beam Epitaxy', Third International Conference on Solid Films and Surfaces, University of NSW, Sydney, August 1984.

Kemeny, P.C. & Hubregtse, J. — 'Modulation Doped AlGaAs/GaAs Heterostructures for TEGFET Fabrication', 3rd Applied Physics Conference, Royal Melbourne Institute of Technology, Melbourne, December 1984.

Kemeny, P.C., Linard, B.J. et al — 'Functional Dependence of Electron Mobility on Spatial Separation of Remote Donor Impurities in AlGaAs/GaAs Heterostructures', Third International Conference on Solid Films and Surfaces, University of NSW, Sydney, August 1984.

Kirton, P.A. & Pang, K.K. — 'Minimum Order Selective Linear Phase Filter', Journal of Electrical and Electronics Engineers (Monash University). Australia, Vol. 3, No. 3, September 1983.

Kirton, P.A. et al — 'Name Server Design for Distributed Systems', The 7th International Conference on Computer Communication ICCC '84, Sydney, October/November 1984.

Kirton, P.A.	'The Data Communications Transport Services and Protocols', Telecommunication Journal of Australia, Vol. 34, No. 1, 1984.
Kirton, P.A.	'Some OSI Experiences of the OARPA Internet', The 2nd International Conference on the Introduction of Open Systems Interconnection Standards, Ottawa, Canada, May 1984.
Ko, K.T. & Davis, B.R. (Adelaide University)	'Delay Analysis for a TDMA Channel Contiguous Output and Poisson Message Arrival', IEEE Transaction on Communications, Vol. COM-32, No. 6, June 1984.
Ko, K.T. & Davis, B.R. (Adelaide University)	'Space Division Multiple Access Protocols for a Satellite Switched Spot Beam Communication Network', International Conference on Communications, ICC '84, Amsterdam, The Netherlands, May 1984.
Ko, K.T. & Davis, B.R. (Adelaide University)	'A Space Division Multiple-Access Protocol for Spot-Beam Antenna and Satellite-Switched Communication Networks', IEEE Journal on Selected Areas in Communication, Vol. SAC-I, No. 1, January 1983.
Kwietniak, M. et al	'Surface and Interface Studies of Sputtering CdS and $CuInSc_2$ Thin Films', Third International Conference on Solid Films and Surfaces, University of NSW, August 1984.
Kwietniak, M. et al	'Structural and Physical Properties of Copper Ternary Components for Photovoltaic Application', Sixth International Conference on Ternary and Multinary Compounds, Caracas, Venezuela, August 1984.
Leech, P.W.	'Prow Formation in the Wear of Cast Iron', Wear, Vol. 96, No. 2, 1984.
Leech, P.W. & Borland, D.W. (Melbourne University)	'The Process of Severe Wear of Graphitic Cast Iron', Materials Science Engineering, Vol. 66, No. 2, 1984.
Linard, B.J.	'Photoluminescence Study of Be and C Acceptors in the MBE Grown $Al_xGa_{1-x}As$', Third International Conference on Solid Films and Surfaces, Sydney, August 1984.
Macfarlane, I.P.	'Electromagnetic Interference (EMI) and Digital Technology', Seminar on the Electromagnetic Compatibility of Electronic Trade Measuring Instruments, National Standards Commission, Sydney, May 1984.
Martin, A.L.	'Amplitude Distortion - A Means for Characterising Line-of-Sight Microwave Radio Paths during Multipath Fading', Electronic Letters Vol. 20, No. 19, September 1984.
McKelvie, D.	'Testing, Evaluation and Demonstration of Solar Cell Arrays for Communications Applications in Remote Areas', End of Grant Report, Department of Resources & Energy, Canberra, 1984.
Millott, L.J. & Smith, R.	'Synchronisation and Slip Performance in a Digital Network', Special Issue of the Radio and Electronic Engineer (IERE), UK, Vol. 54, No. 2, February 1984 and British Telecommunications Engineering, Vol. 3, Part 2, July 1984.
Mottram, K.G. & de Boer, B.T (Engineering Department)	'Use of Plain Copper Conductors in Lieu of Tinned Copper for Internal Cables', Telecommunication Journal of Australia, Vol. 34, No. 1, 1983.
Murrell, P.R.	'Radio Frequency Emission from an Incandescent Lamp - A Curious Case', Australian Telecommunication Research, Vol. 17, No. 2, 1983.
Nicholson, G.	'Effect of Fibre Endface Angle on the Measurement of the Mode Spot Size from the Far-Field Pattern', Optical and Quantum Electronics, 16, 1984.
Potter, P.G. & Cambrell, G.K.	'A Combined Finite Element and Loop Analysis for Nonlinearly Interfacing Magnetic Fields and (Monash University) Circuits', IEEE Trans. Magnetics Vol. MAG-19, No. 6, November 1983.
Price, G.L.	'High Resolution Electron Energy Loss Spectroscopy of Ga As (001)', Third International Conference on Solid Films and Surfaces, Sydney, August 1984.
Price, G.L.	'GaAs and Related Compounds', Metals Forum, 1984.
Reeves, G.K.	'Laser Diode Structures and Fabrication', 3rd National Applied Physics Conference, Melbourne, December 1984.
Reeves, G.K. & Harrison, H.B. (RMIT)	'Determination of Contact Parameters of Interconnecting Layers in VLSI Circuits', Seminar, Aero Space Corporation, Los Angeles, October 1984.
Reeves, G.K. & Harrison, H.B. (RMIT)	'Ohmic Contacts Formed on Single and Polycrystalline Silicon Using Ion Implantation and Low Temperature Annealing', IEEE Electron Device Letters, Vol. EDL-5, February, 1984.
Reeves, G.K. & Harrison, H.B., Sai. Halasz, G. (RMIT)	'Layer to Layer Interconnections: Impact on VLSI Circuits', IEEE 1984 Custom Integrated Circuits Conference, Rochester, NY, USA, May 1984.
Rochlin, G.P.	'Experience with GAG, A Compiler Generator', 1984 Decus Australia Symposium, Sydney, July 1984.
Rochlin, G.P. & Heagerty, D.	'An Implementation of CHILL Concurrency Features', Third CHILL Conference, Cambridge, UK, September 1984.
Rosman, G.E.	'Time Domain Interpretation of Four-Photon Spectra from Optical Fibres', Electronics Letters, Vol. 20, No. 6, March 1984.
Rossiter, M.H.	'Optimal Analysis and Design of a Packet Switching Network', The 7th International Conference on Computer Communication, ICCC '84, Sydney, October/November 1984.

Rubas, J.	'Evaluation of Reference Load from Daily Traffic Distributions', Australian Telecommunication Research, Vol. 18, No. 2, 1984.
Ruddell, H.J.	'Development of an Insect Resistant Telecommunication Cable for the Australian Environment', Protection of Cables Symposium, Shanghai Foreign Trade Symposium, China, April 1984.
Ruddell, H.J. & Chisholm, B.A.	'Deterioration of Polyethylene Insulation in Service. Development of Improved Polyethylene Compounds', Urban Distribution Policies and Practices Conference, Brisbane, November 1983.
Sabine, P.V.H.	'Fibre Optic Systems and their Role in the Future of Australian Communications', 3rd Applied Physics Conference, Melbourne, December 1984.
Sandbach, E.F.	'Telecom Attitudes to the Issues Involved in Satellite Orbit Planning', Department of Communications Symposium on Satellite Orbit Planning, Canberra, November 1984.
Snare, J.L., Ellershaw, J.C.N., Park, J.J. et al	'Interworking Using the CCITT Network Service', The 7th International Conference on Computer Communication, ICCC '84, Sydney, October/November 1984.
Stevens, A.J.	'HP86/87 File/80 Binary', Crosstalk - Journal of HP Technical Computer User Groups, 1984.
Stone, G.O.	'Accurate Estimation of the Communication Parameters of Irregular, Practical Optical Waveguides and Fibres, based on Perturbation Theory', Progress in Optical Physics Conference, Melbourne University, August 1984.
Subocz, M. et al	'CCITT Signalling System No. 7 Field Trial Between Japan and Australia', International Switching Symposium, Florence, ISS '84, Italy, May 1984.
Thompson, J.	'The Use of Marginal Voltage Analysis as a Screening Tool for Increased IC Reliability', VLSI - PARC - Melbourne '84, (Pacific Asian Regional Conference), Melbourne, May 1984.
Wilbur-Ham, M.C., Billington, J., & Bearman, M., (CSIRO)	'Experience and Analysis of the OSI Class 0 Transport Protocol', The 7th International Conference on Computer Communication, ICCC '84, Sydney, October/November 1984.
Warfield, R.E. & Foers, G.A.	'Application of Bayesian Methods to Teletraffic Measurement and Dimensioning', Australian Telecommunication Research, Vol. 18, No. 2, 1984.

LECTURES AND TALKS

Adams, J.L. & Stephens, T.	'Error Probability Calculation for Optical Fibre Systems', 9th Australian Conference on Optical Fibre Technology, Wollongong, December 1984.
Bullock, F.G.	'Customer Access by Radio', Research Staff, Science/Engineering Faculties at Deakin University, Geelong, February 1985.
Campbell, J.C.	'Mode Participation Noise in Single Mode Optical Fibre Technology', 9th Australian Conference on Optical Fibre Technology, Wollongong, December 1984.
Davies, W.S.	Trends in Telecommunications Radio Systems', Swinburne Institute of Technology, Melbourne, June 1984.
Der, J.J.	'Corrosion and other Battery Failures in Battery Rooms', Battery Failures Seminar, Sydney, October 1984.
Der, J.J.	'Battery Failures in Exchanges', Battery Failures in Exchanges Seminar, Canberra, June 1984.
Horton, R.	'Wideband Services', Deakin University Engineering Faculty, Staff and Students, Geelong, October 1984.
Jennings, A.J.	'Adaption of Decision Feedback Equalisers with Decision Errors', Victorian Section, IEEE, Communications Chapter, Melbourne, February 1985.
Johansen, E.	'The Development of Optical Sources for Heterodyne Systems', Radio Research Board Workshop, Coherent Techniques for Visible and Infrared Wavelengths, Melbourne, October 1984.
Johansen, E.	'Devices for Heterodyne Communication Systems', 9th Australian Conference on Optical Fibre Technology, Wollongong, December 1984.
Kabaila, P.V.	'On Cramer-Rao-Like Inequalities and their Application to Time Series Analysis', Department of Electrical and Computing Engineering, University of Newcastle, NSW, August 1984.
Kabaila, P.V.	'Empirical Transfer Function Estimates', Department of Statistics, LaTrobe University, Melbourne, February 1985.
Kemeny, P.C.	'Molecular Beam Epitaxial Growth of III-V Compounds and Alloys', Electron Physics Seminar on Molecular Beam Epitaxial Growth of III-V Optical and Electronic Materials and Devices, La Trobe University, Melbourne, June 1984.
Kemeny, P.C. & Austin, M.W. (RMIT)	'Measurement of Semiconductor Optical Waveguide Loss using Fabry-Perot Interference Techniques', Progress in Optical Physics Conference, Melbourne University, August 1984.
Kwietniak, M.S.	'Progress towards Mid-Infrared Fibre Communications: Materials for Opto-Electronic Devices', Progress in Optical Physics Conference, Melbourne University, August 1984.

Kwietniak, M. & Ito, Y. 'Applications of Mercury Cadmium Telluride ($Hg_{x-1}Cd_xTe$) in Optical Fibre Communication', 9th Australian Conference on Optical Fibre Technology, Wollongong, December 1984.

Macfarlane, I.P. 'Examples of EMI Emmission and Susceptibility Investigations and their Resolutions', IREE Panel Discussion EMI/EMC, Parkville, Melbourne, November 1984.

Nicholson, G. 'Transmission Performance of an Optical Heterodyne DPSK System', Radio Research Board Workshop on Coherent Techniques for Visible and Infrared Wavelengths, Melbourne, October 1984.

Nicholson, G. & Campbell, J.C. 'Performance Studies of Heterodyne and Homodyne Optical Fibre Systems', 9th Australian Conference on Optical Fibre Technology, Wollongong, December 1984.

Park, J.L. 'Impact of OSI and Current Status of Standards Activity', NSW Branch, Australian Computer Society, Sydney, September 1984.

Perry, L. & Clark, D. 'Computerised Telecommunications and the User', The Australian Share Guide Conference, Adelaide, July 1984.

Rosman, G.E. 'Stimulated Raman and Four-Photon Spectra from Optical Fibres', Wednesday Colloquium, Physics Department, Melbourne University, June 1984.

Rosman, G.E. 'Intermodel Delays in Curved Fibres, Measured with Stimulated Four Photon Mixing', Progress in Optical Physics (PIOP 1984) Conference, Melbourne University, August 1984.

Ruddell, H.J. 'Some Observations on the Long-Term Behaviour of Stabilisers in Polyethylene', Australian Polymer Discussion Group, ANU, Canberra, November 1984.

Ruddell, H.J. 'Polymer Degradation', Australian National University, Canberra, November 1984.

Sabine, P.V.H. 'Optical Fibre Communications 1970-1995', Materials Engineering, Monash University, November 1984.

Sabine, P.V.H. 'Progress towards Mid-Infrared Fibre Communications: Fibre Materials and Fabrication Techniques', Progress in Optical Physics Conference, University of Melbourne, August 1984.

Stephens, T.D. & Rockliff, S.C. 'Electronic Circuitry for G/Bit/s Optical Fibre Communication Systems', 9th Australian Conference on Optical Fibre Technology, Wollongong, December 1984.

Stone, G.O. 'Accurate Estimation of the Communication Parameters of Irregular Practical Optical Waveguides and Fibres Based on Pertubation Theory', Progress in Optical Physics Conference, Melbourne, August 1984.

Symons, F.J.W. 'OSI Activities at the Telecom Australia Research Laboratories', 2nd International Conference on the Introduction of Open Systems Interconnection Standards', Ottawa, Canada, May 1984.

Symons, F.J.W. 'Opening Address', Seminar on X25 and Related Packet Network Protocols, Melbourne, October 1984.

Teede, N.F. 'Photovoltaics: Future Issues and Promises', Workshop on Remote Area Power Systems, Department of Resources and Energy, Canberra, November 1984.

Teede, N.F. 'Trends in Photovoltaics R&D', Photovoltaic Solar Cells Public Interest Project Steering Committee, Research Laboratories, Melbourne, October 1984.

REPORTS

Report No.	Author(s)	Title
7048*	G.J. Barker	A Guide to the Processing of Single and Double-sided Printed Boards
7465*	G.M. Horne	Fabrication of Emulsion Stencils to Thick Film Screens
7534*	G.J. Barker	Sputter-Etching Microstrip
7562*	J. Billington	Overseas Visit Report on Protocol Specification, Verification and Assessment Activities in USA, France & UK, May-June 1982.
7579*	I.C. Meggs	A 2764 Adaptor for a Standard Telecom EPROM Programmer
7583	P.A. Kirton	An Approach for Specification of the Transport Service using Enhanced SDL
7599*	I.E. Long	An Evaluation of Miniature Dual-In-Line Relays
7600*	S. Iskra	68000 Cross Macro Assembler Users Manual
7603*	E.K. Chew	Issues in the Connection of Private and Public Networks
7608*	G.W.G. Goode & A.J. Murfett	Customers' Terminal Blocks and Frames: Insulation-Displacing Type
7610*	J.L. Adams & E. Johansen	Effective Techniques for the Measurement of Joint Loss with OTDR
7615*	P.G. Potter	Impulsive Noise Models for Local Digital Reticulation
7623*	D.E. Thom	Insulation Displacement Terminating Modules for Main Distribution Frames
7626*	B.T. Dingle	Overseas Visit, ISDN Signalling, January-February 1983

7629*	R.W. Harris	Digital Network Synchronisation, Overseas Visit, November-December 1982
7634*	I.J. Moran	Overseas Visit, Port Moresby, January 1983
7641*	R.W. Hyland	Configuration Effects in Teleconferencing: The Participation Model
7643*	N.Q. Duc	ISDN Customer Access Standardisation and Related Developments
7649*	P.I. Mikelaitis & B. Dingle	A Specification of the Layer 3 ISDN Access Signalling Protocol
7650*	G.J. Semple	The Impact of Crosstalk on Local Digital Reticulation
7651	I.P.W. Chin, J.B. Cook & H.K. Cheong	Simulation of CCITT Common Channel Signalling System No. 7 using the GES Software Package
7655* Add.1	G.W.G. Goode	Heat Shrink End Caps for Pressurised Cables
7662*	A.Y.C. Quan & N. Wolstencroft	WELLNET - A Wideband Experimental Laboratory Local Network
7663	M.J. Biggar	Distortion in Coaxial Cable Based Wideband Local Networks
7664*	S. Dart & G.P. Rochlin	Report on Overseas Visit to Investigate Software Developments
7666*	R.I. Webster	An Interface Program for Users of TACONET Plot 10 Graphic Facilities
7667*	P.G. Potter	Computer Modelling of the Equaliser Response of a 72 kbit/s DDN Modem
7668*	P.G. Potter	The Hilbert Transform Property of Particular Lengths of Twisted Pair Cable
7670*	D.R. Richards	The Electromask Conversion Routine for the Gerber IDS2
7675	G.J. Semple	Diphase (WAL 1) to AMI Code Conversion
7676	G.J. Semple	An Assessment of a Pulse Differentation Technique for AMI Code Generation Based on Crosstalk-Noise Figure Performance
7680*	G.W.G. Goode	Prototype Plastic Body Gas Pressure Alarm Contactor
7681	R.W.A. Ayre	Measurement of Longitudinal Strain in Optical Fibre Cable
7682	S. Georgiou & G.I. Christiansz	Diffusion of Stabilisers in Polyethylene
7683	K.G. Mottram & F.M. Petchell	Painting New Galvanised Structural Steel
7684*	R.P. Coutts	Digital Radio Developments - ICC'83
7685*	G. Brinson	Printed Board Solution Maintenance Manual
7688*	J. Hubregtse	Failure Mechanism in Transistors Received from the Radiocommunications Construction Branch
7692*	N. Demytko & R.I. Webster	Extended Survey of the Australian Urban Subscriber Loop Network
7696	M. Kwietniak & R. McPherson (Monash University)	Reactively Sputtered Hard Coatings on Steel
7698	J.V. Murphy	A Robust Estimation Technique and its Application to Multipath Channel Identification
7699*	K. Ho-Le	An Electronic Form for Data Entry on Desk Top Computers HP 9835/ HP9845
7700*	J.L. Snare	Report of an Overseas Visit to Attend Meetings of CCITT and ISO and Related Discussions in the UK, August-September 1983
7705	L.J. Millott	A Survey of Modelling Techniques for Travelling Wave Tube Nonlinearities
7706*	A.H. Al-Tarafi & E.K. Chew	Issues and Implications of Naming and Addressing in a Multiservice Environment
7710	G. Nicholson	Comparison of Three Mode Spot Size Measurement Techniques
7712*	K.F. Barrell & I.C. Meggs	A Computer Aid for the Production of Overhead Projector Transparencies
7713	M.J. Biggar	Frequency Allocations in Coaxial Cable Based Wideband Local Networks
7714	B.M. Smith, G.J. Semple & P.G. Potter	The Concept of Line Coding
7715*	D.Q. Phiet	A Convenor Controlled Conference Bridge, Circuit and Software Descriptions
7717*	G. Flatau	Report on Recall to Duty, June-July 1983

7719*	W.S. Davies	Developments in Cellular Mobile and Local Distribution Radio Systems: Overseas Visit Report, November-December 1983
7720*	E.K. Chew	ISDN - 1983 Symposium : An Overseas Visit Report
7722	P. Skopakow	Measurement of Cutoff Wavelength of Single Mode Optical Fibre
7725*	R.B. Coxhill	The Digital Network Synchronisation Field Trial - Transmission of Timing References Over the Analog Trunk Network
7727*	J.S. Spicer	Tandem Connection of Echo Suppressors
7731*	G.J. Dickson	Summary of Overseas Visit - CCITT Study Group V11 Meeting, March 1984
7733	R.W.A. Ayre	Measurement of Elongation of Optical Fibre Cables During Installation: Report on Ploughing Trials, May 1984
7735*	J. Rubas & R.J. Harris	Report on Overseas Visit to Canada & USA, June 1983
7738*	A.J. Murfett	Solar Photovoltaic Modules - Overseas Visit, May 1984
7740	J.J. Sekfy	A Satellite Footprint Plotting Facility
7741*	H.J. Ruddell	Report on Visit to China, April 1984
7742*	R. Smith	CCITT Study Group XVIII Meeting, A Report of an Overseas Visit, May-June 1984
7745*	R.P. Coutts	CCIR and Radio Developments, Overseas Visit Report, May-June 1984
7750	S.J. Charles & R. Rydz	Component Reliability Guide, Part 1
7752*	G.F. Jenkinson	Satellite Communications for the Future, Report on Overseas Visit, June-July 1984
7756	W.S. Davies, S.J. Hurren, E.D.S. Fall & P.R. Copeland	Guy Wire Effects on Microwave Radio System Antenna Patterns
7761*	N.F. Teede	Energy Conversion and Storage Options for Telecommunications Applications, Overseas Visit Report

Note: The reports marked * are classified as 'Telecom Australia Use Only'. In addition, four 'In Confidence' reports with restricted distribution were produced.

Staff Affiliations with External Bodies

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

NATIONAL PROFESSIONAL BODIES (EDUCATIONAL)

Technical and Further Education Board, Victoria	
Science Laboratory Standing Committee	F.C. Baker
Applied Science Joint Standing Committee	F.C. Baker
Monash University	
Research Associate - Department of Materials Engineering	M.S. Kwietniak
Footscray Institute of Technology	
Course Advisory Committee	G.F. Jenkinson
Chisholm Institute of Technology	
Course Advisory Committee	R.J. Morgan
Royal Melbourne Institute of Technology	
Industrial Fellow Applied Physics	R. Horton
Course Advisory Committee	J.E. Hollow
National & State Professional Bodies	
Australian National Committee for Radio Science	W.J. Williamson
Australian Telecommunications and Electronics Research Board	R. Smith
Australian Computer Research Board	F.J.W. Symons
Australian Institute of Energy	N.F. Teede
The Institution of Radio and Electronics Engineers, Australia	
Vice-President, Chairman Melbourne Division	R. Horton
Publications Board	R. Horton
Secretary, Melbourne Division	A.J. Jennings
Telecommunication Society of Australia	E.A. George
Council of Control	G.F. Jenkinson
Board of Editors: "Australian Telecommunication Research"	G.F. Jenkinson G.D.S.W. Clark G. Flatau A.J. Gibbs M.A. Hunter R.J. Harris D.J. Kuhn I.P. Macfarlane G.K. Reeves H.V. Rodd
Board of Editors: "Telecommunication Journal of Australia"	A.J. Jennings
Institute of Electrical and Electronic Engineers	
Victorian Sub-Section Committee	R.A. Court R.P. Coutts A.J. Gibbs
Secretary/Treasurer Region 10	A.J. Gibbs

University of Queensland

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

Standards Association of Australia (SAA)

Council	E.F. Sandbach
Executive Board of Council	E.F. Sandbach
Telecommunications and Electronics Standards Board and Executive	G. Flatau E.F. Sandbach
Australian Electrotechnical Committee	G. Flatau E.F. Sandbach
• Reliability of Components and Equipment	G.G. Mitchell
• IEC Quality Assurance Scheme for Electronic Components	G. Flatau
Acoustic Standards Committee	E.J. Koop
Co-ordinating Committee on Fire Tests	F.C. Baker

Technical Committees

Acoustic Standards	
• Instrumentation and Techniques for Measurement of Sound	E.J. Koop
Chemical Industry Standards	
• Adhesives	F.C. Baker
• Heavy Duty Paints	F.C. Baker
Computers and Information Processing Standards	
• Data Communications	J.L. Snare
• Information Systems	F.J.W. Symons
• Open Systems Interconnection	J.L. Park
• Text and Office Systems	P.S. Jones
Electrical Industry Standards	
• Plastics	G.W.G. Goode
• Lightning Protection	E. Bondarenko
• Electrolytes	F.C. Baker
• Control of Undesirable Static Charges	G.W.G. Goode
• Copper & Copper Alloys	K.G. Mottram
• Electrical Accessories	E. Bondarenko
Mechanical Engineering Industry Standards	
• Engineers Hand Tools	P.F.J. Meggs
• Solders	K.G. Mottram
• Vibration & Shock Measurement & Testing	I.A. Dew
• Fasteners	F. Wolstencroft
Metal Finishing Standards	
• Methods of Test	T.J. Keogh
• Anodic Oxidation Coatings	K.G. Mottram
• Surface Preparation	T.J. Keogh
• Nickel/Chromium Electroplating	K.G. Mottram
• Zinc & 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 Telecommunication Cables	H.J. Ruddell D.J. Adams
• Methods of Testing Plastics	G. Flatau
• Outdoor Weathering of Plastics	G.W.G. Goode
• Flammability of Plastics	D.J. Adams
• ISOTC 61 Plastics Advisory Committee	B.A. Chisholm D.J. Adams
• Safety Helmets	R.J. Boast
• Fuel Containers	H.J. Ruddell
Safety Standards	
• 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
• Printed Circuits	D.E. Sheridan
• Electromagnetic Interference	I.P. Macfarlane
• Environmental Testing	G. Flatau M.C. Hooper
• Electro-Acoustics and Recording	E.J. Koop G.R.G. Smart
• Hazards of Non-Ionizing Radiation	S. Sastradi-pradja
Victorian Solar Energy Council	
• Project Steering Committee	N.F. Teede

National Association of Testing Authorities (NATA)

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

Overseas Telecommunications Commission

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

International Bodies

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

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

In particular, staff of the Research Laboratories held offices in the following international bodies during the year:

• IEC Joint Co-ordination Group- Optical Fibres, Working Group 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 Component, Treasurer Certification Management Committee	G. Flatau
• Special Rapporteur, CCITT SG VII/39	G.J. Dickson
• Special Rapporteur, CCITT SG XI/14	M. Subocz

Industrial Property

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

PATENT APPLICATIONS AND PATENTS

Invention Title (Inventor/s)	Provisional Specification	Complete Specification	Patent No. (if granted)	Country
Method and Apparatus for Testing Subscribers' Telephone Instruments in Situ under Service Conditions (J.F.M. Bryant & R.W. Kett)		233699	3261926	USA
Self Adaptive Filter and Control Circuit (L.K. Mackechnie)	65671/69	23649/70 98800	448805 3732410	Australia USA
Tip Welding Means (E.J. Bondarenko)	49395/70	10361/70 4714/71	455004 3657512	Australia USA
Analogue Multiplier (H. Bruggemann)	43033/68	43033/68 855543	414207 3629567	Australia USA
Apparatus for Routing Discrete Telecommunication Signals (A. Domjan)	61428/69	19808/70	448958	Australia
Apparatus for Monitoring a Communications System and a Detector Therefor (J.A. Lewis)	PA1474/70	29415/71	458997	Australia
Monostable and Bistable Devices (I.P. Macfarlane)	PA2298/70	32612/71	465242	Australia
Control of Operation of a System (N.W. McLeod)	PA2035/70	31550/71 166819	466670 3745418	Australia USA
Apparatus for Use in Feeding Alternating Electric Current to a Load and an Antenna including such Apparatus (R.P.Tolmie)	PA7174/71	49340/72	484853	Australia
Smoke Detector (L. Gibson & D.R. Packham)		367260	3874795	USA
Method and Apparatus for Detecting the Presence of Signal Components of Pre-determined Frequency in a Multi-frequency Signal (A.D. Proudfoot)	PB24/72	59138/73 387855 178402	480006 3882283 984068	Australia USA Canada
Nephelometer with Laser Source (L. Davidovits)	PC4286/75	20511/76	507518	Australia
Tamperproof Telephone Apparatus (C.M. Hamilton & J.A. MacCaskill)	PC5285/76	23264/77	502780	Australia
Fault Monitoring Apparatus (R.W.A. Ayre)		17251/76	504585	Australia
Optical Waveguides and a Method of Manufacture Therefor (P.V.H. Sabine & P.S. Francis)	PC4499/76	21232/77	507723	Australia
Method and Apparatus for Reducing Phase Jitter in an Electrical Signal (K. Webb)		24926/77	510034	Australia
Programmable Digital Gain Control System for PCM Signals (A.M. Fowler)	PD3192/78	43735/79	519441	Australia
Transversal Filter (K.S. English)	PD7273/79	54367/80 109589/80 00263/80	532103 4340875	Australia USA Japan

Fibre Optic Termination (P.V.H. Sabine)	PD6157/78	50841/79	521528	Australia
		P2938649		Germany
		G79271195		Germany
		126329/79		Japan
		266321	4381882	USA
Noise Assessment of PCM Regenerators (A.J. Gibbs)	PD6790/78	52160/79	525766	Australia
		793025727	0012515	Europe (designating France Germany Britain Italy Holland Switzerland)
		339841	1134915	Canada
		148305/79		Japan
		093228	4300233	USA
Tap Coupler for Optical Fibres (E. Johansen & E. Dodge)	PF0272/81	87251/82		Australia
Hydrometer (F. Bodi)	PF1183/81	89297/82		Australia
Apparatus and Method of Cable Hauling (J. Alcorn)	PF5293/82	17465/83		Australia
Method and Apparatus for Testing Bells and other Electrically Actuated Devices (B. Sneddon)	PF5557/82	17570/83		Australia
Etching (Z. Slavik)	PF7347/82	22712/83		Australia
Instant Speaker Algorithm for Digital Conference Bridge (D.Q. Phiet)	PG4037/84			Australia
LAN for Mixed Traffic (P.F. Frueh)	PG5956/84			Australia
Cable Laying Apparatus (R.A. Vidler)	PG7266/84			Australia
Conforming the Frequency Spectrum of an Output Signal to a Desired Form (B.W. Sneddon & S.G. Beadle)	PG8284/84			Australia
Characterisation of Digital Radio Signals (A.L. Martin)	PG4999/84			Australia
	PG8701/84			

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

Visitors to the Laboratories

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

The Laboratories' activities are also demonstrated to specialist and non-specialist groups from industry, professional societies, government departments and academia. This is achieved through arranged discussions, inspection tours and demonstrations and, at longer intervals, by formal "Open Days", when the work of the Laboratories is exhibited to invited guests from many walks of life.

During the year, experts from overseas telecommunications authorities, academia, government departments and manufacturing companies have also visited the Laboratories. Other overseas visitors have participated in the work of the Laboratories for longer periods to further their training in telecommunications technology. Often, these visitors are sponsored by an international organisation and the visit to the Laboratories is a part of a more extensive visit programme within Telecom Australia.

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

- Mr M. Sajkowski, of the Computer Centre at the Technical University of Poznan, Poland, was invited to provide a number of lectures in the area of formal protocol specification and analysis during an informal three day workshop on the modelling and analysis of telecommunication protocols, held at the Research Laboratories.
- Mr Kevin Brooke, OBE, of ASEA visited the Laboratories to see and discuss work in the fields of optical fibre transmission, lightning incidence, photo-voltaics, voice synthesis and teleconferencing.
- Dr Ed Sciberras, Economist at the Technical Change Centre, London, UK, visited the Laboratories to discuss technical changes in the subscriber equipment of the telecommunications industry, as part of a world-wide study in association with the OECD.
- Dr M. Venning, Counsellor, Energy, Science and Technology, of the Australian Embassy, Tokyo, Japan, visited the Laboratories to see and discuss work in the fields of optical technology and energy, with particular emphasis on aspects of Japan/Australia co-operation. The visit was made under the sponsorship of the Department of Science and Technology.
- Members of the Electrical, Electronics and Information Industries Industry Council (EEIIIC) visited the Laboratories for the purpose of holding one of their periodic meetings and to inspect the various activities of the Laboratories with emphasis on optical fibre transmission, microelectronics, plastics, environmental testing and MBE facilities and applications.
- Participants in a United Nations Industrial Development Organisation Workshop on Solar Energy, visited the Laboratories to view the solar cell testing facilities and the VSEC/Telecom thin-film project.
- Members of the Victorian Government Task Force on Telecommunications, during a visit to the Laboratories, discussed with the Director the role of the Research Laboratories in Telecom Australia and the relationship of Telecom with other organisations. Discussions and demonstrations then took place on the work of the Laboratories in the fields of conferencing, DRCS, optical systems, plastics and reliability studies.
- Mr S. Ohtani, of the Japanese Optoelectronic Industry and Technology Development Association, visited the Laboratories to hold discussions on optical systems technology, semiconductor materials and solar modules.
- Visits to the Laboratories were made during the year by a number of student groups as part of their training programmes at the following tertiary institutions:
  - Bendigo College of Advanced Education
    Ballarat College of Advanced Education
  - RMIT - Industrial Design Department
  - Chisholm Institute of Technology - Engineering Department
  - Monash University - Engineering Faculty.
- Mr P. Allen, Education Officer with the CSIRO Division of Manufacturing Technology, Adelaide, South Australia, visited the Laboratories to hold discussions on the Laboratories and to view working displays and equipment which could be used by students in a proposed new joint Education Department/CSIRO Science and Technology Training Laboratory.
- Mr Nigel Christianson and Mr John Yarrall, Supervising Engineers from the New Zealand Post Office, held discussions with Laboratories' staff, chiefly in the fields of digital network performance, common channel signalling and ISDN.

Overseas Visits by Laboratories' Staff

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

The following staff members have travelled overseas during the past year:

K.F. Barrell
J. Billington
J.J. Der
N.Q. Duc
K.S. English
G. Flatau
R. Horton
Y.H. Ja
G.F. Jenkinson
P.V. Kabaila
G. Nicholson
J.L. Park
G.P. Rocklin
T.P. Rogers
H.J. Ruddell
G.J. Semple
D.E. Sheridan
M. Subocz
N.F. Teede

Assistance with Studies

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

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

- P.A. Kirton, Development Training Programme Award, Information Science Institute, University of Southern California, USA
- G.C. Heinze, Development Training Programme Award, British Telecom, Martlesham, UK, and Hewlett-Packard, USA.
- M.J. Biggar, Postgraduate Scholarship leading to Doctorate of Philosophy, Imperial College of Science and Technology, London, UK.

The following staff member has been given an award to enable him to pursue full-time undergraduate study:

- R.W. Rydz, Undergraduate Scholarship, Swinburne Institute of Technology, course for the Degree of Bachelor of Engineering.

Sponsored External Research and Development

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

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

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

- Index Profiling of Single Mode Optical Fibres
- An Optical Fibre Strain Measurement System
- An Optical Parametric Oscillator
- Static Fatigue in Optical Fibres
- A Multi-purpose Drawing Machine for Mid-IR Optical Fibres
- Receiver Structures for Optical Systems
- Fault-tolerant Microcomputer Systems for Telecommunications Applications
- A Digital Transmission Error Performance Analysis System
- Gas Exposure and Weathering Chambers
- Early Indicators of Electrical Deterioration of Polyethylene Spacers in Coaxial Cable
- Simulation of Numerical Petri Nets using Data-driven Computer Architectures
- Rules for the Production of Speech from Text
- Customer Reaction to Telephone Circuit Delay
- Spectral Properties and Error Probabilities of Block Codes
- A Multiple Output ISDN Line Signal Generator and Switch
- An Adaptive Digital Hybrid for Data Transmission on a Subscriber Loop
- An Optical Time Domain Reflectometer
- VLSI Impacts on Telecommunications Equipment Design
- Stability Properties of Transmultiplexers
- Bismuth Impurities in Stationary Lead-acid Batteries
- Stress Relaxation of Thermoshrinkable Polyethylene Sleeves for Jointing Moisture Barrier Cable
- Interworking of Packet Switched Networks using Standard Protocols
- Control Theory applied to Dynamic Routing and Telecommunications Traffic Control
- Dimensioning Techniques for Non-hierarchical Digital Networks
- ISDN Customer Access Protocol Architectures
- Computer-aided Graphics System for SDL-based Specification of Switching Systems
- Analysis of Lightning Strike Data
- Termite Resistance of Rubber Modified PVC
- Telephone Conferencing Studies
- Equalisers for Digital Subscriber Loops
- Capacity and Resource Allocation for Satellite-switched TDMA Systems
- Digital Switch Design using MPC Methods
- A Dual Module Digital Cross-connect Switch
- An Antenna Rotator
- An Optical Regenerator Test Instrument
- Metal-insulator Semiconductor Structures
- Local Area Network Developments
- A Message Transfer Agent
- A Fluoride Glass System for Mid-IR Optical Fibres
- Design Feasibility Study of Signalling Terminals for CCITT Signalling System No. 7

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

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