Review of Activities

Research Laboratories 1977-78

Telecom Australia

Review of Activities

Research Laboratories 770 Blackburn Road Clayton, Victoria 3168 Australia

Telecom Australia

ISSN 0314-1357

Foreword

This Review is somewhat historic as it is the first review to emanate from the new Research Laboratories' complex at Clayton, where eventually, the whole of the Laboratories will be established.

The research and development (R & D) activities of the Telecom Australia Research Laboratories concentrate on the technical aspects of advances in telecommunications science and technology. The significant expenditure by Telecom Australia on R & D in its Laboratories is evidence of the fact that the Commission recognises that it must maintain a knowledgeable grasp of technological advances in its management of the technology which pervades most of the engineering activities of Telecom Australia.

Advances in technology can be harnessed to meet Telecom Australia's challenge to supply the community's expanding needs for existing telecommunications services and to diversify the services it provides to the Australian citizen.

Through its R & D, Telecom Australia is also able to contribute a share to the international stock of engineering and scientific knowledge in the field of telecommunications. This is very relevant, since the very essence of communications is the removal of barriers due to both time and geography

The management of technology requires that all aspects of proposed applications of new technology should be examined. Only then can balanced judgements be made which ultimately lead to timely, economic and efficient realization of the community's needs for telecommunications facilities. These latter functions are the particular concern of other Departments of Telecom Australia.

In recommending this review of the activities of our Laboratories for you to read, I feel that it illustrates the technical viability and vitality of Telecom Australia as a whole.

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

The cover shows a view of stage one of the new Research Laboratories' buildings at Clayton

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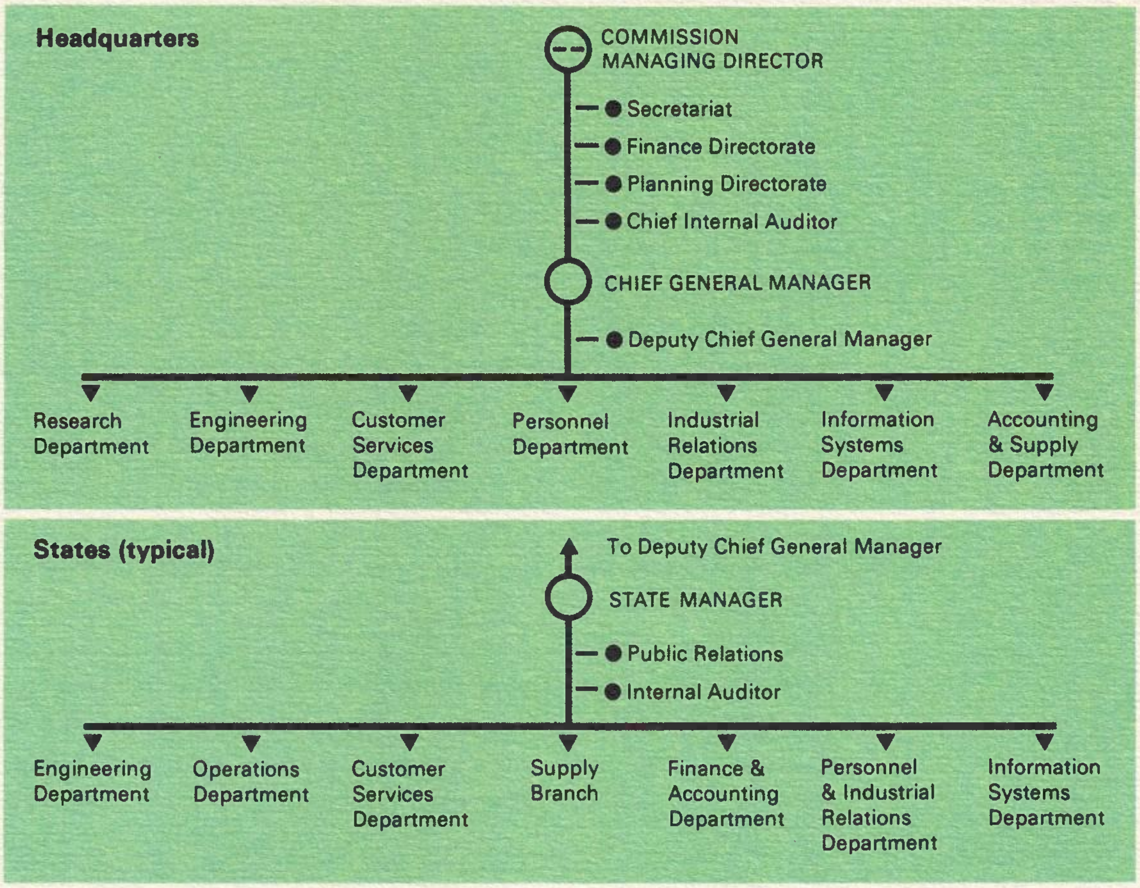
The Role of the Research Laboratories

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

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

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

The Laboratories, through relevant research and development (R & D) projects, seek to develop expertise in the scientific and technological fields to assist Telecom Australia in its implementation and formulation of plans and policies for new or improved services, systems, equipment



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

and practices. Through the application of this expertise, the Laboratories also assist Headquarters and State Administrations in the solution of technical problems that arise in the design, manufacture, installation, operation and maintenance of plant items in service in the telecommunications networks.

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

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

To help make these decisions and judgements with confidence it is necessary for Telecom Australia to have, at first hand, sound and competent technical advice. This is best derived from its own conduct of advanced development in each relevant technological or scientific field. Much of the advice received by Telecom Australia in these new and developing fields of telecommunications is offered by the staff of the Research Laboratories. Most of the projects undertaken by the Laboratories, rather than being directed at production specifications, find their ultimate expression in the performance requirements of procurement specifications for the systems and equipment which is bought from the worldwide telecommunications industry. Other work is expressed in the assessment of materials, components and assembly practices used by suppliers in equipment tendered against Telecom Australia procurement specifications. However, some projects are carried to production when it is evident that the innovation, design and development work of the Laboratories will yield equipment directly suitable for field application.

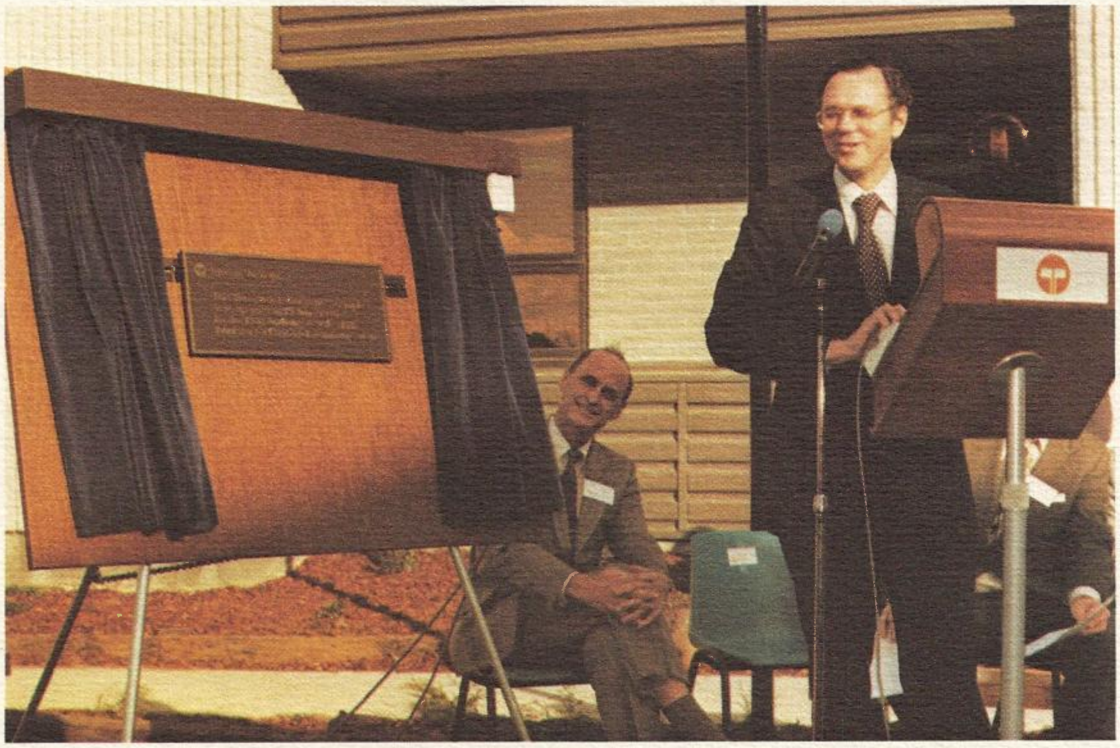
Apart from carrying out a research and development role, the Laboratories have specialist staff with knowledge and facilities in a number of disciplines, including the physical sciences, who conduct investigations into difficult technical problems that arise in the operation of telecommunications plant.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

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

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

In the selection of activities reported in the following pages, this edition of the Review of Activities of the Research Laboratories illustrates the ways in which the Laboratories have sought to fulfil their role during 1977-1978.

Highlights of the Year



The opening ceremony performed by the Minister for Post and Telecommunications, the Honourable A.A. Staley, M.P.

Official Opening of the New Telecom Australia Research Laboratories

The Minister for Post and Telecommunications, the Honourable A.A. Staley, M.P., officially opened stage 1 of the Research Laboratories complex on Monday, 19th June, 1978. The new buildings comprise the initial stage of a long-term programme to establish the whole of the Research Laboratories activities on one site at 770 Blackburn Road, opposite the Monash University, in Clayton, Melbourne.

The official opening was performed by the Minister in the presence of the Chairman of Commissioners - Mr. R.D. Somervaille, the Managing Director - Mr. J.H. Curtis, the Deputy Secretary of the Department of Construction - Mr. K.J. Rodda, senior managers of Telecom Australia and representatives from industry, academia and other government departments and instrumentalities. A total of some 500 invited guests and staff members witnessed the unveiling of a commemorative plaque and the handing over of the keys to the Laboratories' Director, Mr. E. Sandbach.

The guests were then invited to inspect more than 30 exhibits which illustrated a representative cross section of the total work of the Laboratories. These exhibits were on display for the following two days and an estimated 2000 visitors took the opportunity to inspect them.

The opening of the new Laboratories marked a significant stage in the long programme of planning and negotiating for the replacement of the Research Laboratories' many leased, high maintenance and inadequate city buildings (as many as eight were in use at one stage). In the late 1960s, it was agreed that the Laboratories should be accommodated in new specially designed buildings away from the central business district. This culminated with the purchase, in 1972, of a 7 hectare site in Blackburn Road, Clayton, and a subsequent purchase of an adjoining 12 hectares for long-term development. Parliamentary approval to proceed with construction of the first stage was received in November 1973.

The decision to develop a new Laboratories complex in the Clayton area was based on the economics of providing specialized laboratory buildings in a long-term multi-staged building programme. Feasibility studies conducted by the then Department of Works concluded that the most cost effective design would result from the establishment of a number of low rise buildings in a campus-style setting on a large area of land. This arrangement made it possible to spread the development of the project over a number of years requiring relatively small, but regular fund commitments, compared to a large investment for one high rise building. Land suited to this style of building complex was only available in the suburban area and this, combined with the popularity of the eastern suburbs as a residential area and its proximity to the Monash University, led to the choice of the present site.

The Laboratories complex currently comprises two 3 storey and one single storey laboratory buildings designed to accommodate some 200 staff, a single storey plant building and a gatehouse. Building 1 houses the Physical Sciences Branch and the Microelectronics Section; Building 2 houses parts of the Advanced Techniques and the Standards and Laboratories Engineering Branches, the Laboratories Executive and Administrative staff, Cafeteria and Branch Library; Building 3 houses the

A typical scientific laboratory

Environmental Physics activity and Building 4 accommodates centralized mechanical and electrical plant for the building services systems. Buildings 1 and 3 are connected by a single storey laboratory and office link to form an integrated structure.

The Laboratories buildings conform to an overall master plan as a group of several low rise (up to 3 storey) buildings arranged in a campus-style configuration linked by garden courts. This approach allows the necessary flexibility for further stages to accommodate those Sections which are still in the City and at Winterton Road, Clayton. A feature of the modular design of the buildings is the ease with which laboratory needs may be altered in both size and function, and the practicality of converting offices into laboratory space.

The second stage of development of the Laboratories will provide three buildings to accommodate those Sections which are currently in the City, namely Electrical Standards, Time and Frequency Standards, Laboratory Instrumentation and Customer Apparatus. Further facilities will be provided for an enlarged Cafeteria, the main Library and various storage, service areas and workshops. Preparation of the contract documentation for this stage is now well advanced and completion of the new buildings is expected by 1982. A further stage of development will then be considered to provide accommodation for those Sections which are currently in leased buildings at Winterton Road, Clayton.

Delegates being shown fibre optic cable by a Research Laboratories staff member

Delegates from the Institution of Engineers' Annual Conference Visit the Research Laboratories

On 5 April 1978, a group of delegates from the Annual Institution of Engineers' Conference in Melbourne entitled, "Developing a better World" visited the new Telecom Australia Research Laboratories at 770 Blackburn Road, Clayton, Victoria.

The visitors were welcomed by the Assistant Director, Standards and Laboratories Engineering Branch, Mr. L.H. Murfett, on behalf of the Director, Research.

Mr. Murfett outlined the historical development of the Research Laboratories complex at North Clayton and briefly described the modular design and the concept of flexibility of services provision which enables changes of size of Laboratories and variations of service requirements to be easily achieved.

The visiting party then divided into a number of small groups and was conducted on a short tour of the Research Laboratories. The tour included inspection of the following projects and facilities:

- Public Automatic Mobile Radio Telephone Services.
- Voice Transmission over Optical Fibres.
- The Microelectronics Section Thick Film Facility.

Public Automatic Mobile Radio Telephone Services

This exhibit illustrated the contribution made by the Research Laboratories towards the Engineering Department's responsibility to provide public automatic mobile radio telephone services.

The difficulties encountered in using radio as a transmission medium in city and urban environments, for example, multipath propagation were illustrated and explained.

The results of an automatic field strength prediction program were displayed for Melbourne and Sydney; and a comparison with measurements in Melbourne yielded similar accuracies as were achieved overseas.

An instrument, designed and constructed in the Research Laboratories, demonstrated the simulated effects observable under multipath propagation at different field strengths and at a number of simulated vehicle speeds.

Voice Grade Transmission Over Optical Fibres

The visitors were shown the Research Laboratories optical fibre transmission equipment, which has been designed and constructed in the Research Laboratories for up-coming optical fibre-field trials.

This equipment takes a standard 8.448 megabit pulse code modulated (PCM) signal, which is equivalent to 120 voice channels, re-encodes the signal into a format suitable for optical transmission, and generates an amplitude modulated optical signal which is transmitted through the fibre. At the receiver, the optical signal is detected, regenerated and re-encoded back to a standard PCM format.

Also demonstrated was the technique of fibre jointing to be used in the approaching field trial.

The Microelectronics Section Thick Film Facility

Time limitations prevented a full tour of the Microelectronics Section of the Research Laboratories, therefore only representative samples of the work were shown. These included microphoto tools, printed wiring boards, thick-film circuits etc. produced in the Research Laboratories for prototype projects and experimental work. A brief description of the methods used to produce them was given followed by a guided tour of the thick film laboratory. Here, the visitors were shown hybrid microcircuits at various stages of fabrication. Some of the processes of fabrication seen were; screen printing, firing of substrates in the conveyor furnace, drying of printed substrates in ovens, bonding of wires onto active devices and testing of circuits with micro-probes and associated instruments.

It was obvious from the interest shown by the visitors and their informal discussions on the topics seen, that their visit to the Research Laboratories had been a pleasant and beneficial experience.

A Selective Review of Current Activities

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

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

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

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

Specialized Scientific Activities

Introduction

The wide diversity of scientific investigations being undertaken within the Research Laboratories spring from the wide range of activities of Telecom Australia. Hence, when it is realized that at any one time no less than around one hundred and fifty individual projects are in hand, it is understandable that Telecom Scientists have at their disposal many items of highly specialized equipment to assist in their endeavours. These items range through commercially available instruments such as chromatographs, infra-red ultra-violet and visual spectroscopes, thermal analysers, mass spectrometers, electron microscopes etc., to specially designed test assemblages or equipment to meet a special requirement, which in most cases are manufactured within the Laboratories.

Typical of this specially designed equipment is that used for recording the incidence and magnitude of lightning strikes on underground installations, which data, when available, shall be used as a basis for the design and construction of protective equipment.

Assessment of the reliability of reed relays in processor controlled exchanges necessitated the design and construction of specialized test equipment. Currently, up to three hundred contacts may be operated at various rates from approximately 3 to 12.5 contact closures per second, generally with a duty cycle of 50%, although this too may be varied. Each contact under test is continuously monitored for operation and release, and measurements of contact resistance may be made at selectable intervals. An alternative mode of operation allows for progressive totals of the number of contacts falling within a number of preset contact resistance ranges to be accumulated during life testing.

Plans are now in hand to update the facilities of the present relay test equipment by incorporating a microprocessor based central control unit. In conjunction with the minicomputer recently acquired by the Reliability Studies Section this will allow future expansion of life testing to be effected by software changes instead of hardware additions.

CW520 cabinet fitted with louvers, insulation, tinted glass and fan

A standard CW520 cabinet and one fitted with tinted glass

Heat and Noise Discomfort in CW520 Public Telephone Cabinets

The public telephone cabinet, Model CW520, was designed to replace the older wooden cabinet with a more attractive unit having very much lower maintenance costs.

To achieve these aims and to make vandals and others misusing these cabinets more readily visible to people outside the cabinet, the CW520 cabinets were designed with large areas of glass.

Because so much of the door and wall area is glass, there is considerable solar heating of the cabinet, its interior surfaces and, hence, the air inside it. The roof is a simple metal sheet which provides a significant surface area for conduction and secondary radiation to the interior of the cabinet. Air gaps at the floor and roof allow air to pass through the cabinet.

Complaints by the public have led to a study being conducted to explore means of reducing the heat and noise discomfort experienced on hot, sunny days as well as at noisy sites. Seven cabinets have been erected in the Research Laboratories grounds at 770 Blackburn Road, Clayton. One is a standard CW520 cabinet. A second cabinet includes only one modification to the standard design. Each successive cabinet contains one more additional modification.

Modifications aimed at reducing heat discomfort include grey, body-tinted solar control glass, a photoswitch to disconnect the interior light during sunshine, a roof with horizontal air venting rather than the present one which requires hot air to descend before escaping, underceiling thermal insulation, an alternative acrylic roof and a thermostatically controlled exhaust fan in the roof. Modifications which may reduce noise discomfort include the fitting of glass fibre insulation, covered with an open aluminium mesh, to the underside of the roof and shelf; the replacement of the air gaps near the floor by mesh-covered louvres and a slitted rubber skirt fitted to the lower edge of the door.

The effect of these modifications is being assessed by continuous recording of temperature. Every cabinet is fitted with an upper and lower air temperature sensor screened from direct radiation. Certain cabinets have sun temperature sensors and sensors monitoring the upper and underside surfaces of the roof. Relative humidity inside various modified cabinets will also be measured. Subjective assessments will also be included.

Analysis of these results, together with measurements of sound levels inside the cabinets relative to standard sound level generated outside, will enable the various modifications to be evaluated for effectiveness in reducing heat and noise discomfort in the CW520 cabinet.

Nickel-Cadmium Cells

Because of a fortuitous combination of electrochemical properties exhibited by the rechargeable nickel-cadmium battery system, which enables a cell to be completely sealed, such batteries are finding increasing use in domestic and industrial applications. The range of typical applications cover such items as portable electric drills, soldering irons, torches, tape recorders, calculators, emergency lighting packs, radios, shavers, electric knives and toothbrushes plus a wide range of electronic equipment. Various portable electronic devices include voltmeters, chart recorders and monitoring instruments for pollution and toxic or explosive gas detection. The batteries are completely sealed and have a low internal resistance. The ability to deliver substantial currents without excessive drop in terminal voltage explains their successful use in aircraft and high current demand devices such as electric drills and soldering irons. Apart from serving as a stored source of dc power, the nickel-cadmium cell may also serve as an electric filter component for low frequency applications.

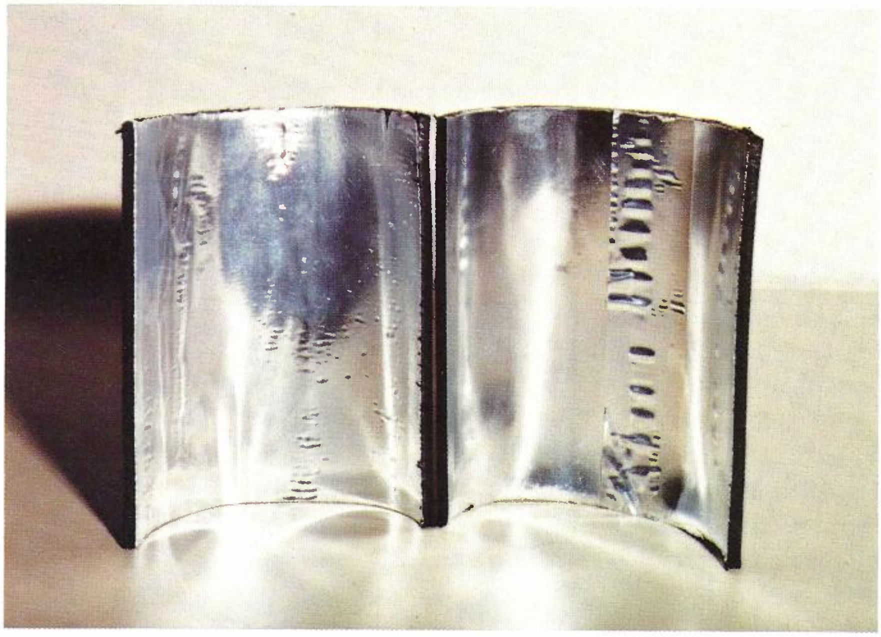
Hydrogen and oxygen gases are normally evolved during the charging of a conventional secondary battery. The successful operation of the rechargeable nickel-cadmium cell as a sealed unit depends on the designed ability of the electrode system to suppress hydrogen evolution and recombine the liberated oxygen by a constant cyclic electrochemical process during the final stages of charging. Gas pressure is typically several atmospheres when the cell approaches full charge, as most of the applied current is used in gas production rather than useful chemical conversion reactions. Consequently, the integrity of the seal is very important if the cell electrolyte, a strong solution of caustic alkali (potassium hydroxide), is not to be lost.

Some problems of electrolyte leakage have been experienced where Telecom Australia used sealed nickel-cadmium cells in portable gas detection equipment. Consequently, a selection of different brands of available batteries were tested to determine their susceptibility to leakage under a variety of test conditions. Figures obtained for total leakage over the whole test period (approximately 100 charge/discharge cycles) indicated a variation factor of approximately 200 between the best and worst brands of battery. The leakage was found to be mostly characteristic of battery brand rather than rate or degree of discharge. When used in equipment, batteries should be placed in separate compartments so as to be completely isolated from electronic circuitry. Slight leakage of electrolyte, which may occur to some degree over the life of the battery, will not present any serious problem in this situation. Other instances of electrolyte leakage causing difficulties have occurred where sealed nickel-cadmium cells were attached directly to printed circuit boards along with normal electronic components. Subsequent leakage of the cells produced circuit failures resulting from electrolytic short circuits. If batteries cannot be installed in a separate compartment, it is advisable to encapsulate them and put them on the bottom section of the printed circuit board where the corrosion hazard due to possible leakage would be minimal.

As well as determining electrolyte leakage, tests were performed also at different temperatures to study cell electrical characteristics.

At 40°C the capacity decreased by an average of 30% and there was a substantial increase in self discharge. At 0°C the capacity and self discharge were little different from those at 20°C. Consequently, for service conditions at elevated temperatures, consideration should be given to the altered electrical characteristics of the nickel-cadmium cells.

Unlike the common lead-acid battery and most other secondary electrochemical storage systems, the nickel-cadmium battery can provide satisfactory service at low temperatures. It is claimed that cells of sintered plate construction, specifically designed for high rates of discharge can provide 80% of nominal capacity at normal discharge rates at temperatures as low as -40°C.



Longitudinal section of a moisture barrier sheath, showing imperfections in the bonding of aluminium to polyethylene (left) and at the aluminium overlap (right)

Adhesion Properties of Aluminium Foil in Moisture Barrier Cable

Aluminium foil is incorporated in plastic sheathed cable used by Telecom Australia to prevent ingress of moisture into the cable core by permeation through the cable sheath. The effectiveness of this aluminium barrier is dependent on it being in intimate contact with the plastic sheath as well as with itself at the overlap. This is achieved by bonding the aluminium foil to the sheath during the extrusion process of cable manufacture, by means of an adhesive layer on the aluminium foil.

Observations of factory samples and field installed cables have indicated many instances of inadequate bonding at both the overlap and the aluminium foil/sheath interfaces, although the bond strength when tested by the stipulated method was well within specification limits.

To determine whether the specification limits should be raised and to study the ageing characteristics of the bonded sheath, a project was initiated in which eleven adhesive coated aluminium foils, obtained from a number of sources around the world were compared.

Test samples were prepared as described in ASTM D 903 and bonded under similar conditions to those described in overseas cable specifications. The samples were aged under various accelerated conditions, viz. in air at 100°C, in water at 78°C, in solvent at 23°C and in cable filling compound at 60°C.

Some samples were removed from each test condition at regular intervals over a period of several months and their bond strengths measured.

Although tests are still continuing, the results obtained to date show that the presently-used coated aluminium foil is much inferior to grades of foils used overseas, not only in initial bond strength, but also in ageing characteristics, indicating the necessity to upgrade the Telecom Australia specification for coated aluminium foil for moisture barrier cable.

Evaluation of New Stabilizing Systems for External Cable Insulants

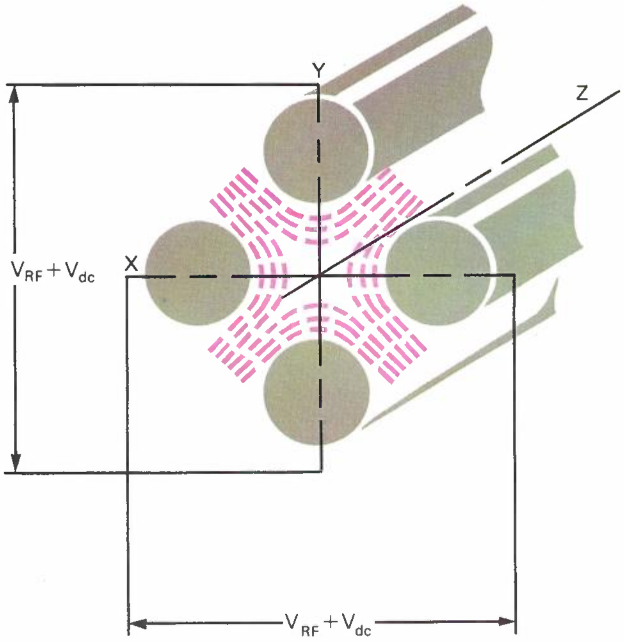
The unique properties of plastics are principally due to the large molecular weights of the polymeric macromolecules. Significant shifts in the distribution of molecular weights by chain scission or cross-linking can occur when polymers are exposed to heat, light, weather and microorganisms. Such changes manifest themselves as a change in colour and/or a deterioration in physical properties such as surface cracking, loss in mechanical properties and poorer electrical properties.

Degradation of polymers can be controlled by the addition of stabilizing agents but for these materials to be effective in polymers such as the polyethylene used as insulation on external telecommunication cable, they must be able to provide resistance to many external influences. These include protection from high temperatures during processing, and against air oxidation at ambient temperature for the service life of the cable, in the presence of copper wire and other metal complexes present as impurities or colouring agents. The kind of stabilizing agents used are chemical compounds termed antioxidants, which include phenols, phosphites, organic sulphides and amines, and metal deactivators of the dihydrazide type. The two types of agents are usually specified together as a stabilizing system. Some systems may contain more than one antioxidant.

Early stabilization systems were formulated on the basis that the heat of processing was the only obstacle to overcome and all polyethylene insulating grades were sufficiently stabilized to prevent degradation during that operation. The antioxidant present, however, could be exhausted or depleted to such an extent that polymer degradation under certain conditions would occur during the service life of the processed material. Such deterioration has been experienced by Telecom Australia in insulation exposed to the atmosphere in above ground jointing pedestals and tail-less boxes. Failures under similar conditions have also been reported in North America.

Therefore a survey of stabilizing systems capable of protecting the polymer during processing and for the entire service life of the cable installed under Australian climatic and practices conditions was commenced.
The most promising systems, chosen from the experience gained by other telecommunication organizations and after consultation with polymer manufacturers and additive suppliers, are being examined on a comparative basis by incorporation into unstabilized, insulation grade polyethylene and subsequent processing into standard laboratory test pieces or as insulation on wire.

An important aspect of the survey has been a review of the appropriate tests to evaluate the stabilizers and the characterization of the life-expectancy of the insulant.



Rods mounted in square array

Tests which are being performed after heat ageing include elongation at break, electrical properties, carbonyl content, oxygen uptake and thermal stress-cracking. However, the thermal stress-crack test of insulants by the 'pigtail' method (wire wrapped around its own diameter for 10 contiguous turns) has been found to provide the most reliable estimate of the insulants' lifetime.

However this test can be affected by many variables notably sample preparation, and the reliability of the results of some overseas workers is therefore doubtful. Developmental work within the Research Laboratories resulted in mechanization of sample preparation, modification to the ageing conditions and has been coupled with a significant increase in sample size. Statistical analysis of the data thus obtained indicates that the results are reliable and reproducible.

The 'pigtail' test is being conducted at several test temperatures, below the melting range of the polyethylene. A plot of the logarithm of time to failure, versus the reciprocal of temperature, should give a linear curve which can be extrapolated to 30°C (the assumed average operating temperature of insulation in above-ground jointing pedestals in Australia), and yield the estimated lifetime of the insulant. A minimum life of 30 years is required for practical considerations.

Quadrupole Mass Spectrometry In Analytical Chemistry

Among the attractions of the application of quadrupole mass spectrometry (QMS) to material studies is the low cost of such instruments compared with magnetic sector or time of flight mass spectrometers and their relative simplicity of operation. Applications include residual gas analysis and as a complementary analyser to other systems such as thermal analysis (evolved gas analysis (EGA)), or gas chromatography (gas chromatography-mass spectrometry, GC-MS).

Quadrupoles of one form or another can be used for the majority of mass spectrometry applications and in some instances have a definite technical advantage over magnetic sector type instruments where freedom from magnetic fields is important, such as in surface analysis.

The mass filtering action is independent of the sign of an ionic charge and, as a QMS has a relatively large ion acceptance area into the filter field space, studies on free chemical radicals are possible.

In any QMS it is the quadrupole assembly which acts as the mass analyser. It functions by selecting ions on the basis of their mass to charge ratio M/e. The most common configuration is the quadrupole which is simply four electrically conducting, parallel, hyperbolic shaped electrode rods. The rods are accurately mounted in a square array. Opposite electrodes are connected and to one pair is applied a potential:

$$\phi_t = V_{dc} + V_{RF}$$

where V_{dc} is a dc voltage and V_{RF} is the peak amplitude of a radio frequency voltage of frequency f. The same potential but with opposite sign is applied to the other pair of electrodes

Ions formed at low energies (a few volts) by electron bombardment are projected into this combination of static dc and RF electric fields generated by the accurately aligned electrode rods. Now, for any given amplitude of the RF/dc fields, ions of one particular mass/charge ratio (M/e) have a stable pathway through the length of the filter.

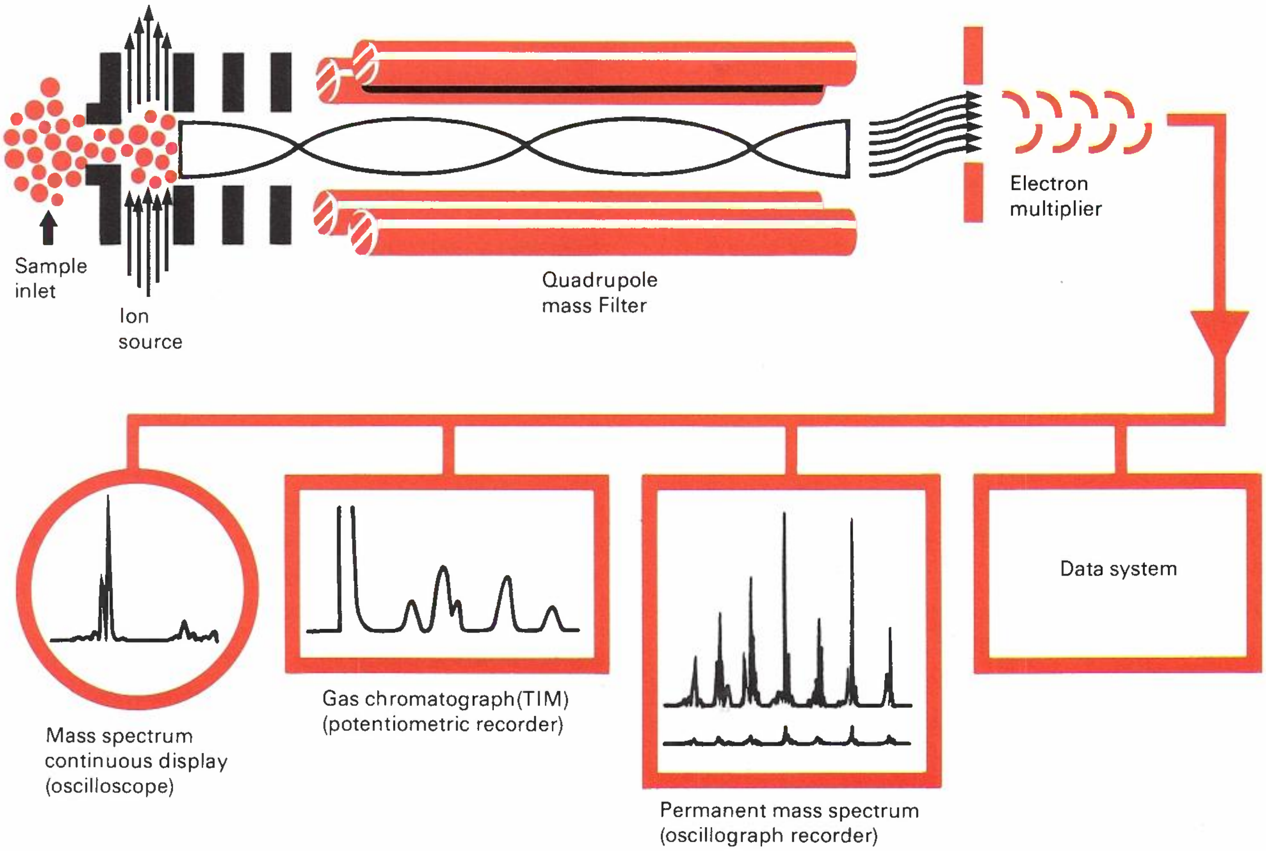
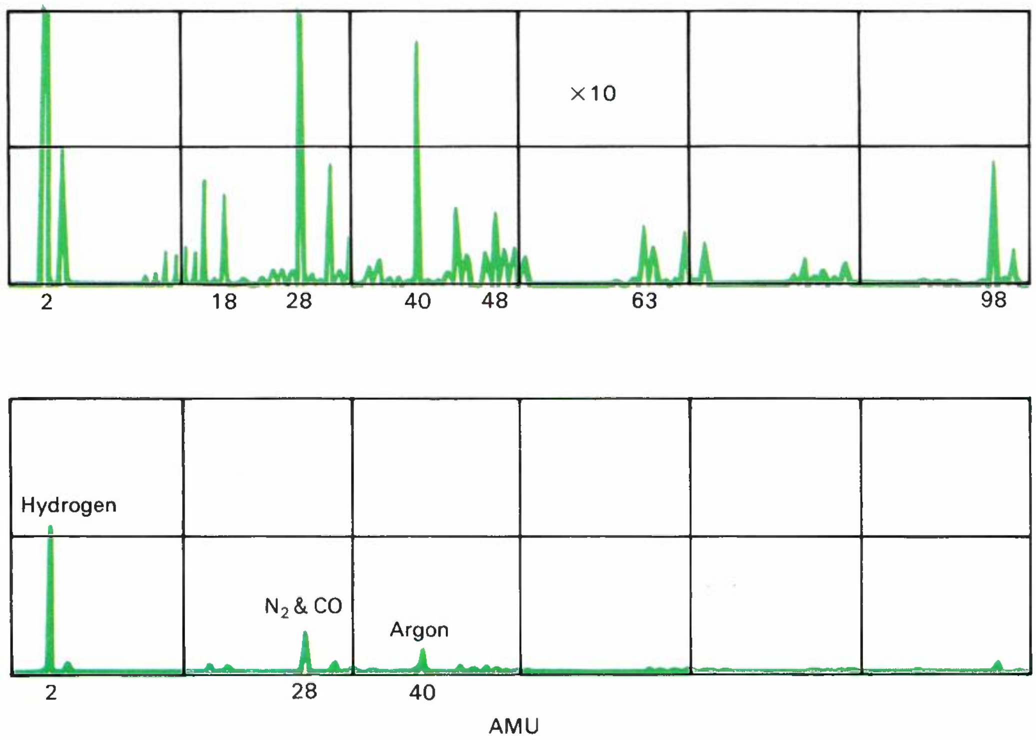


Diagram of system showing detection and display system



Sample spectrum from Mass Analyser

Other ions are defocussed and lost by collision and neutralization with the rods or the enclosing casing.

The ions thus separated are collected on a detector and the very small ion currents generated by the arrival of ions selected by the analyser are amplified by using the secondary emission characteristics of an electron multiplier.

A mass spectrum is obtained by scanning the amplitude of the RF/dc fields while keeping their ratio constant. The spectrum obtained will have a linear mass scale with resolution proportional to mass.

Quadrupoles (like other spectrometers) rely on an initial ionizing means, one of which, Electron Impact (EI), is a beam of electrons passing through a highly attenuated vapour of the material to be analysed, the 'spent' electrons being collected in an electron trap after passing through the ionization chamber.

The ions arising from this bombardment are lined up by an ion focus and are aimed into the quadrupole mass filter.

To ensure long mean-free paths before molecule/ion collisions occur, all mass spectrometers depend on the provision of very high vacuums, 1.33×10^{-5} Pa or less, and diffusion pumps or ion pumps are needed for this service, the former being suitable for analytical work. It has been the ready availability of high vacuum technology as a spin-off from simulated space conditions and manufacturing requirements for semi conductors that has recently accelerated the development of the QMS.

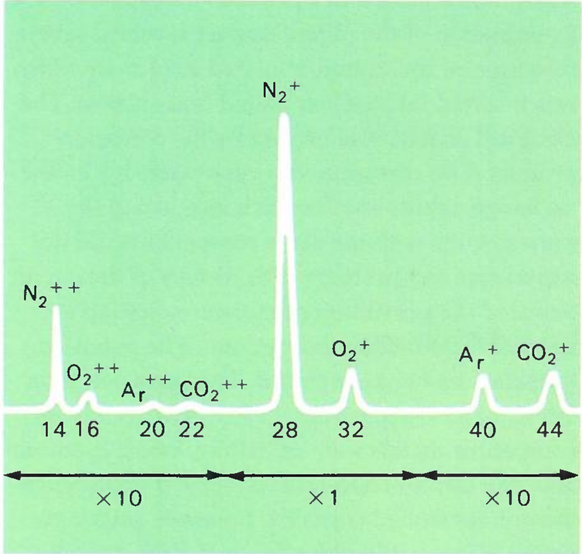
Other characteristics of the QMS as a mass analyser that have caused its development to overtake the earlier forms of mass spectrometers are sensitivity and resolution in a compact device, its light weight without cumbersome magnets, its high speed electronic scanning and a linear mass scale. The trade off of sensitivity against resolution is brought about simply by adjustment of the circuitry.

As is the case with many advanced instrumental techniques, conversion of the electronic output back into chemical terms requires some interpretive skills of the analyst. Because of the initial ionizing electron bombardment a single molecular species gives rise to a family of ion 'fragments' which appear as multiple peaks on the spectrum.

Ions can have a charge of e, 2e, or occasionally 3e depending on whether they have lost one, two or three electrons during the ionization process. For example a doubly charged ion of mass M (that is M/2e) behaves in the analyser just like a singly charged ion of mass -

$\frac{M}{2}$, $\left(\text{i.e. } \frac{M}{2} \times \frac{1}{e}\right)$

Air Spectrum



The mass spectrum for air illustrates this point by an example at mass 14 which can be due to doubly charged nitrogen molecules (N_2^{++}). The molecular mass of a nitrogen atom is of course 14 but in the free state nitrogen is diatomic, that is each molecule consists of two atoms bonded together to give a molecular mass of 28. So at mass 28 on the mass scale the 'parent ion' is shown N_2^+, the single + denotes a single charge.

Similarly the mass 32 units peak is singly charged diatomic oxygen (O_2^+) and the 16 mass unit peak is the doubly charged oxygen molecule (O_2^{++}).

A family of peaks related to one molecular species is called a cracking pattern and for analytical work it is necessary to know the cracking pattern exactly. With a mixture of compounds the spectrum can become so complex as to require computer assistance to sort out superimposed cracking patterns on a spectrum.

Current applications for this technique in the Research Laboratories are those of analysis of gases arising from destructive combustion (fire and smoke hazards), traces of toxic vapours arising from construction or operations in the network, studies on the micro-environments of reed relays and the sealing of encapsulated electronic devices. It is envisaged that QMS may provide a 'universal' detector to support a wide range of gas chromatographic analyses.

Failure of Locking Nuts on Black Mountain Tower

Black Mountain Tower situated on a hill overlooking Canberra, is a composite structure consisting of a reinforced concrete column base topped by an open lattice steel structure.

During the construction of the steel portion it was noticed that a considerable number of 7/8 in. locking nuts had cracked at various times after fastening. The locking nut used is a locking device which is fastened on the outside of a nut as distinct from a normal locking washer which is placed under a nut. These locknuts were made from hardened and tempered steel and were galvanized.

A quantity of unused locknuts was submitted for investigation and routine tests did not reveal any reason for cracking. It was then decided to see if cracking could be induced under laboratoryconditons by tightening new locknuts against normal nuts to controlled torque values. An appreciable number of these cracked in times ranging from 2-30 hours.

The fact that none of the locknuts had cracked on initial tightening indicated that they were not too hard. Hydrogen embrittlement was then suspected as a cause of failure, as one of its main characteristics is delayed fracture, and can occur as long as several thousand hours after initial tightening at stresses corresponding to no more than 20-30% of the notched tensile strength of the steel.

The introduction of hydrogen into the locknuts could have occurred during either an electrolytic or acid pickling cleaning process preceding galvanizing, and then have remained locked in by the outer layer of zinc. Further examination of locknuts using scanning electron microscope techniques tended to support the hydrogen embrittlement concept.

It was suggested that because of the high incidence of cracking all 7/8 in. locknuts on the structure should be replaced, and that a statistically significant sample number of any new supply of locknuts should be pretested in similar fashion to the laboratory tests. Replacement locknuts were subsequently obtained from a new source of supply and after one year on the structure no failures have occurred.

Corrosion of Telecommunication Equipment

Modern corrosion and material science has developed a great variety of corrosion resistant materials in both the metallic and synthetic fields. Corrosion, however, cannot always be the only requirement when material selection is made. It is only natural, that if the choice is made on other physical, chemical or metallurgical characteristics (which can be over-ridingly important) it very often leads to the use of materials which are electrochemically incompatible in their corrosion characteristics. This is very frequently the case in telecommunications equipment. Usually the environment in which this equipment is used is very well controlled; clean air is provided with temperature and humidity control. Under these conditions the incompatibility in corrosion characteristics can be tolerated and it is expected, that equipment will give good reliable service for a long time. Yet, corrosion due to bad design, natural disaster or human error does occur. In the following paragraphs several case histories are discussed and possible remedies suggested.

A whitish powdery corrosion product was found on some equipment in a portable exchange building. The worst corrosion was observed mainly on cadmium plated screws but some passivated zinc plating was affected also. The zinc surface was attacked mainly where fingerprints were obvious.

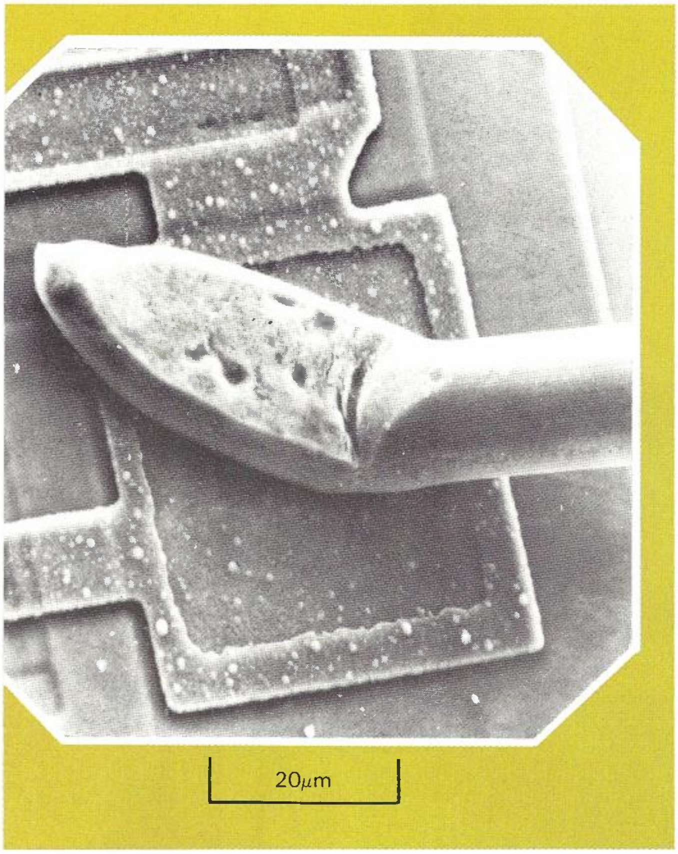
The corrosion product was analysed and found to be cadmium formate. After establishing that neither a certain type of plastic (for example urea formaldehyde, phenolformaldehyde) nor the internal paint material could have been responsible, liquid floor polish (which contains a certain amount of formaldehyde as preservative) was examined. In a simulated laboratory test, the vapour from the floor polish produced a corrosion product which was similar to the one on the original sample. The corrosion most probably was due to the temperature fluctuation in a sealed compartment which contained the organic vapour. Some ventilation is necessary after the cleaning operation to reduce the possibility of organic vapour build up and consequent corrosion.

Corrosion may not be the only fault when an electrical circuit functions incorrectly without any apparent fault in the assembly. For example, on investigation, a printed circuit board was found to have some steel wool particles embedded in the protective varnish, this eventually produced low resistance between conductors.

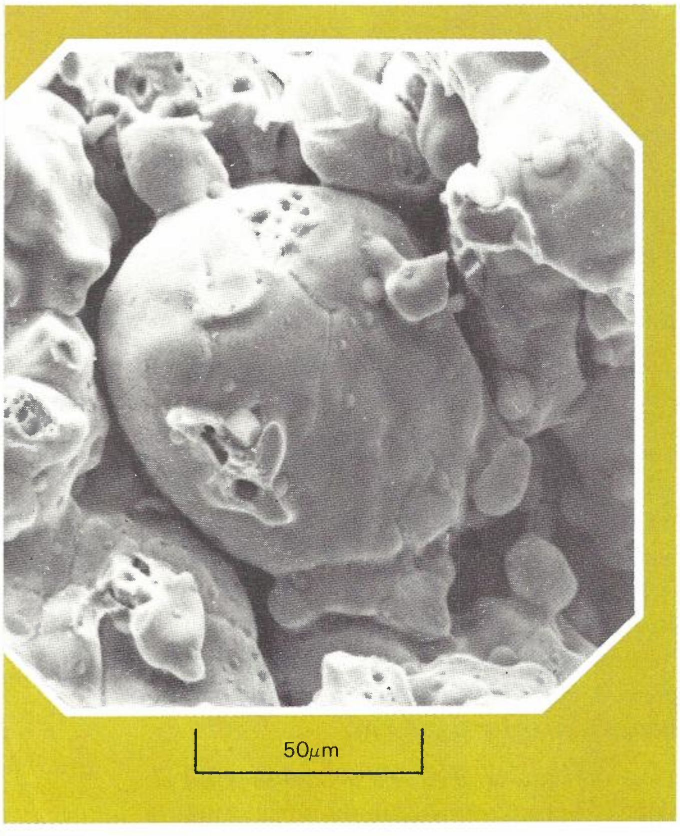
An open circuit developed in a potentiometer which was attached to a printed circuit board. Examination of the potentiometer revealed severe corrosion of the cadmium plated steel shaft which was inserted into a silver plated brass sleeve. The electrical contact was broken by the corrosion product. The corrosion was very extensive in one exchange, whilst another exchange, using the same circuits with the same components did not experience any problem. The history of the circuit revealed the possibility of moisture pick-up at another location due to a cyclone. The potentiometers had to be replaced. The corrosion is an interesting example in that electrochemically incompatible metals such as - silver, brass, cadmium and iron can function satisfactorily, if the environment is controlled correctly; however, severe corrosion is inevitable if the designer does not take note of the possible change in the environment.

Finally, severe corrosion can result from some natural disaster such as cyclone, torrential rain and the not so natural disaster such as fire. When water enters an exchange which is under power (and cannot be switched off because service in such emergency condition is extremely important) the corrosion is very rapid. In case of fire the damage may not only be the loss of equipment directly affected by the fire itself. When organic material, for example PVC, burns beside carbon, it can also produce very toxic and corrosive vapour, for example HCl. The subsequent corrosion can be disastrously extensive. It is important in such cases to switch off the battery as soon as possible. The water has to be dried out and any loose corrosion product has to be removed mechanically as thoroughly as possible. The affected parts can further be cleaned with organic fluids which are suitable for electrical contacts and do not affect the plastic parts of the installation. Due consideration has to be given to the toxic effect of the organic material used. After the power is switched back on, regular inspection is necessary to ensure that the corrosive action has been stopped by the treatment.

Examining corrosion cases and the relevant facts and events which led to their damaging effect can determine the cheapest and most efficient remedy. Investigation to establish the reason behind the corrosion also helps to minimize their reoccurrence.



Microcracks in ultrasonic bond (25μm Al Wire to Al pad)



Sintered structure of stainless steel nut

Solution of Problems Using the Scanning Electron Microscope

For many years scientists have had to rely on various optical microscopes to study fractured metal surfaces, examine small electronic components, evaluate the structure of metals and to identify the constituents present. The purchase of a scanning electron microscope (SEM) with X-ray microprobe analysis facilities by the Research Laboratories has by no means replaced the optical microscopes, but the SEM does provide a range of additional facilities. The major feature of the SEM is that a great depth of focus is obtained combined with direct observation of images at magnifications far higher than possible with optical microscopes. Also, direct compositional analysis of very small areas can be made. These facilities provide the means whereby a wide range of problems can be solved, some examples of which are outlined below.

The development of suitable welding tools to make ultrasonic bonds between 25μm diameter aluminium wire and metallic pads on electronic microcircuits, required the evaluation of various prototype tool profiles to obtain ultrasonic bonds free of microcracks. Unless the tool profile used resulted in a crack-free bond, the aluminium wire would be susceptible to failure at the crack. The depth of focus provided by the SEM meant that a wide selection of bonds could be directly observed and the quality of the bonding tools evaluated, thus assisting in the selection of the correct tool profile.

An investigation into the poor solderability of tinned copper wires used for telephone cables was solved using the high magnifications possible with the SEM. Examination and X-ray analysis of a cross section of the wire revealed that the tin coating was so thin that as a consequence of diffusion, nearly all the tin had transformed to a copper-tin intermetallic compound during storage, thus causing poor solderability of the wires.

On several public telephone cabinets, sintered stainless steel nuts were found to be rusting. Using the X-ray analysis facilities of the SEM it was found that one of the problems with sintered nuts was that pockets of relatively pure iron existed throughout the structure, thus leaving areas that would rust readily in the atmosphere.

Lightning voltage counters on Port Hedland to Mount Newman coaxial cable

Lightning Surges on Port Hedland to Mount Newman Coaxial Cable

Despite the relatively low ceraunic level and soil resistivity along the Port Hedland to Mount Newman coaxial cable route, the coaxial cable, unlike other cables in that area of Western Australia, was found to be prone to considerable lightning damage.

The cable route follows the Port Hedland - Mount Newman railway line for almost its entire length of 412 km at a minimum separation of approximately 55 m. In addition to the coaxial cable, the trench contains a 10/20 and a single quad cable, as well as 415 V power cable and a single cadmium-copper guard wire. Some of these cables are associated with the railway signalling.

The nature and extent of the damage indicated that the faults were caused by rises in soil potential due to lightning strikes to ground in the vicinity of the trench or the railway line rather than by direct strikes to the above ground plant associated with the cable.

Some interim alterations to the cable installation and its earthing system have since reduced the incidence of faults. Further protective measures, however, can be designed and installed only when the magnitude of the electrical stresses on the cable are known and the various interactions between cable, ground, the railway line etc., are better understood.

It is hoped that laboratory tests and measurements taken at several sites along the cable route during the 1977/78 lightning season will provide the required data. The measuring equipment installed in the area by the Laboratories is recording the number of occasions on which preset voltage and current levels are exceeded on various components of the coaxial cable and on its environs during local lightning storms.

The minimum break-down potentials of the coaxial cable components and the effectiveness of various types of guard and earthing methods, are being determined in the laboratory.

Transmission Studies

Introduction

The studies and investigations carried out in the transmission area during the year have continued to be diverse, covering a wide spectrum of topics. These are typified by the examples described in the following items.

Pulse code modulation is now established as a network component, with system type selected and initial contracts placed during the year for volume installations. The Laboratories are continuing to contribute expertise to this project, particularly in the areas of system techniques, bearer studies and planning rules, regenerator performance testing and other specialized PCM testing methods and equipment.

Increasing emphasis is being given to next generation digital transmission systems using both coaxial cable and optical fibre as bearers. Such systems should find application in urban areas in the early to mid 1980s.

Work has continued in the study of prediction methods for determining service areas for public mobile telephone systems and in instrumentation for the measurement of field strengths of such systems at both VHF and UHF. Some basic studies are being made of very high capacity mobile systems.

Digital transmission by radio has two major applications. One is in the transmission of data and data-type signals via radio routes, and the other is in the transmission of general telephony signals in a network which is likely to become much more digitally configured. Present studies include the application of digital transmission on conventional analogue radio bearers and also on systems designed specifically for digital operation.

A model data network comprising three interconnected modes has been established specifically to examine network synchronization problems. All three modes are sited in the laboratory with the interconnected links being 48 kHz channels established by looping back group circuits to several locations in Australia. Links via Sydney, Wagga, Launceston, Adelaide and Perth have been tested. Initially the data route used is 48 kbit/s but this will be upgraded to 64 kbit/s when equipment is available. Parameters examined include jitter and slip performance as well as link error rate.

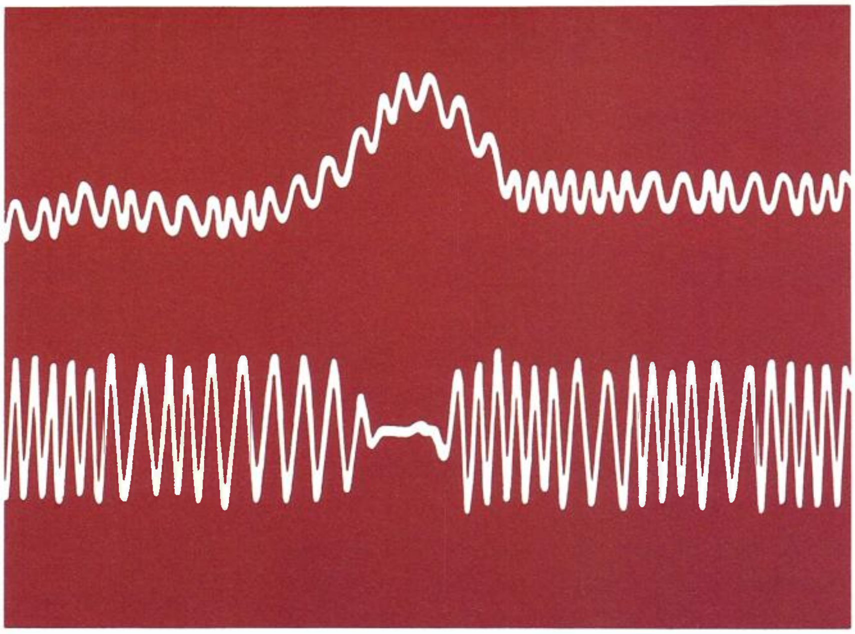
Digital Facsimile Coding for Faster Document Transmission

Visual images in general contain a fairly high degree of redundant information. In the case of business facsimile, where documents are scanned and sent over ordinary telephone lines, redundancy reduction techniques can reduce transmission time, thereby reducing telephone charges on trunk calls and minimizing wastage of staff time. Whilst no single "optimum" solution exists, due to the variation between different types of documents, some coding schemes appear more promising than others. In particular, a code giving consistently high compression ratios is to be preferred to one giving better results with only one kind of source material.

A technique common to many coding schemes is that of run-length coding. In its basic form, this means scanning typical documents to establish the distribution of distances (run-lengths) between transitions (black to white and vice versa) on scan lines, and using this information to assign unique codes to each run-length. Two types of code are generally used: variable-length or fixed-length (block codes). Block coding requires less circuitry to implement, but provides lower compression ratios. This can be improved by using a few discrete steps in block length, e.g. four, eight or twelve bits. A type of variable length coding known as Huffman coding gives the best compression possible; it does this by assigning codes strictly in order of run-length probability, shorter codes being reserved for more frequent lengths and longer codes being used for the rarer events.

This approach assumes a complete knowledge of the run-length statistics - a situation which does not apply in practice as documents vary in composition. To deal with this problem, many documents have to be analysed and their characteristics averaged. This leads to a general reduction in compression ratios achieved, since no document is exactly "average".

Any further reductions can only be achieved by using the fact that adjacent scan-lines are very similar; in other words by using two-dimensional



Data signal as received

Corresponding signal at modem decision circuitry showing a "blanked out" portion

compression schemes.

Element prediction uses points on previous lines and previous points on the current line to predict the point currently being scanned. If the prediction is correct, no information has to be sent, as the information is also available at the receiver.

Another scheme developed by Dacom in the USA takes element pairs in adjacent lines as the basic unit of interest and sends run-lengths using an adaptive (variable-length) code.

The Japanese organization KDD has proposed a system where transitions on the current line are referred back to the last similar transition on the previous line and therefore large areas of blank space are not coded at all.

These codes are all under investigation in the Research Laboratories at present.

Multi-Metering Pulse Interference on Subscriber-Trunk-Dialling (STD) Data Circuits

Following difficulties experienced by Adelaide customers in attempting subscriber-trunk-dialling (STD) data transfer at 1200 bit/s with processing centres in Melbourne and Sydney, an investigation was carried out by the South Australian State Administration. The problem, not encountered in the other two capital cities, was identified with the interference caused by multi-metering pulses on the data signal received by the subscriber initiating the call. A satisfactory interim solution was implemented by the South Australian Administration. Data modems were redeployed and the hardware of the line relay equipment at the terminal exchange concerned was modified, thereby reducing the interference to a satisfactory level.

However, in order to identify the exact interference mechanism and to be able to characterize the Telecom Australia switched telephone network for potential interference to STD data transmission, the Research Laboratories were requested to conduct theoretical and experimental studies on this interference. Using simulated multi-metering pulse interference (MMPI), tests were carried out on four different types of 1200 bit/s data modems presently used in the network. Depending on its level at the receive modem, the interference caused linear and/or non-linear detrimental effects. Linear effects resulted from excessive level of high-frequency components in the interference. On the other hand, non-linear effects were associated with the overloading of the modem input buffer amplifier. Corrective procedures were proposed to rectify the situation. The above results also enabled the specification of a simple test for checking the multi-metering interference level.

In the light of the above findings, the Engineering Department is presently taking measurements in the Melbourne switched telephone network to determine the likely incidence of MMPI of sufficient level to overload the data modems. Interference of sufficient level to overload the least tolerant types of modems has been detected.

As data modems of speeds higher than 1200 bit/s are presently not used in the Telecom switched telephone network, the Research Laboratories investigation was not extended to cover these at this stage. However, it is foreseen that a similar investigation could be carried out as the need arises.

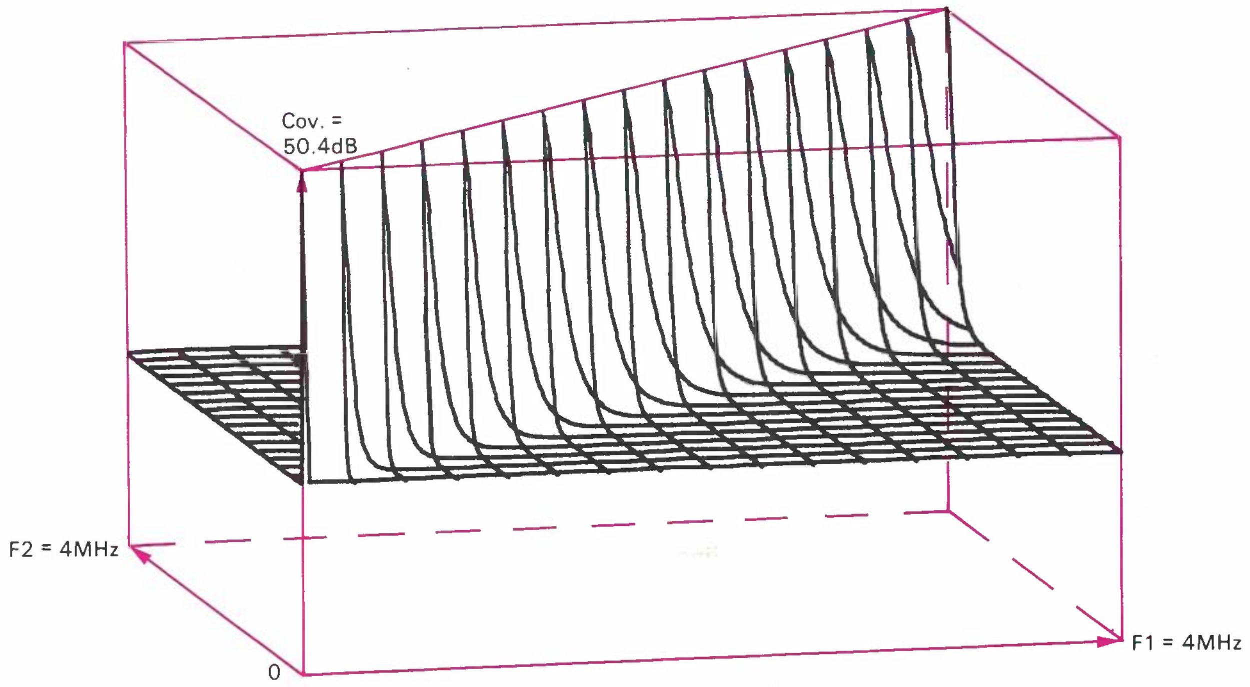
Analysis of Crosstalk in Cables

The capacity of the pair cable network can be greatly increased, and bottlenecks circumvented, by the use of pulse code modulation (PCM) multiplexing. The digital line signals which are used contain high frequencies and so must be regenerated frequently to minimize the effects of crosstalk and noise. Excessive crosstalk causes regeneration errors which degrade signal quality, and near end crosstalk limits the number of systems that will operate satisfactorily in one cable. Crosstalk is a random process, so the problem is one that can only be answered in statistical terms, for example for a particular cable type, there is a regenerator span such that there is a 99 per cent probability that a specified number of systems will operate in the cable at less than a specified error rate. Analytic expressions of these parameters are clearly very valuable system design aids.

To calculate these limits, one needs to know (amongst other things) the covariance of nearend crosstalk in the cable. Models of cable characteristics have long been used to reduce their specification to a few parameters, but the covariance of nearend crosstalk has given difficulty.

A functional expression for this covariance has been developed, based on existing models of the crosstalk process, and stated in terms of four cable parameters. Subsequently, an expression relating a few PCM system and cable parameters to the number of systems that will operate in the cable was derived.

The three-dimensional graph of the covariance function resembles a narrow horizontal ridge across a flat residual plane. To test it (and implicitly, the original model of crosstalk) recently acquired automatic network analysers have measured crosstalk between hundreds of pair combinations. Advantages of the automatic equipment are that the operators are relieved of a great deal of repetitive work, and the statistics of the measurements can be calculated on the spot. Good agreement with the covariance model has been obtained.



Nearend crosstalk covariance model - 30/.64 PIUT cable

Limitations of a Supervisory System Used with Primary Pulse Code Modulation (PCM) Systems

Primary level PCM systems are to be introduced soon into the Australian junction cable network. These digital systems employ regenerative repeaters, or regenerators, at inter-exchange locations to maintain acceptable transmission fidelity. However regenerators which are not housed within exchanges present a considerable maintenance difficulty as their regular inspection and testing is laborious and costly. Fortunately, PCM system manufacturers provide regenerators with a supervisory system which allows their performance to be assessed from exchanges; maintenance is therefore simpler and cheaper. This article describes and evaluates a common method of remote regenerator supervision.

Many manufacturers of primary level PCM systems have adopted a method of regenerator supervision known as the Triples technique; it is favoured because of its simplicity and low equipment requirements. This technique achieves the dual aims of selecting individual regenerators for test and returning test results to exchanges for evaluation via an ingenious combination of dedicated supervisory equipment and special test signals.

Test signals are chosen so that they contain audio frequency components and regenerators have a portion of their output signal returned to exchanges via narrow band-pass filters and an audio cable pair common to all regenerators. Supervisory filters have distinct centre frequencies within the audio band and, by transmitting a test signal containing an appropriate audio tone, the supervisory signal returned to exchanges originates essentially from only one regenerator. By analysing the amplitude of this signal, an indication of the operation of a single regenerator is produced; sequential testing allows the operation of all regenerators along a route to be checked.

A study was conducted by the Research Laboratories to establish the limitations of this method of regenerator supervision. It was found that the Triples technique allows reliable detection of catastrophic faults resulting in total or partial absence of regenerator output signals but is not sufficiently sensitive to allow meaningful detection of more subtle (and more likely) faults - typically, faults must produce grossly inadequate regenerator operation before they can be detected with this technique.

Investigations are being made into possible alternative supervising techniques which will give a better indication of marginal fault conditions.

Data Transmission Tests Over One Hop of a Microwave Radio Relay System

Microwave line-of-site radio systems form the dominant method of carrying broadband telecommunications traffic between major city centres in the Australian network. In particular, the East-West microwave radio system (2 GHz) linking Adelaide and Perth is one of the longest routes in the world. This route is presently under study by the Engineering Department for the purpose of expanding its capacity with an additional radio system operating at 6.7 GHz. As part of the feasibility study of the performance of such a system, special attention has been focussed on the effect on data transmission of severe signal fading which has been observed to occur along the path.

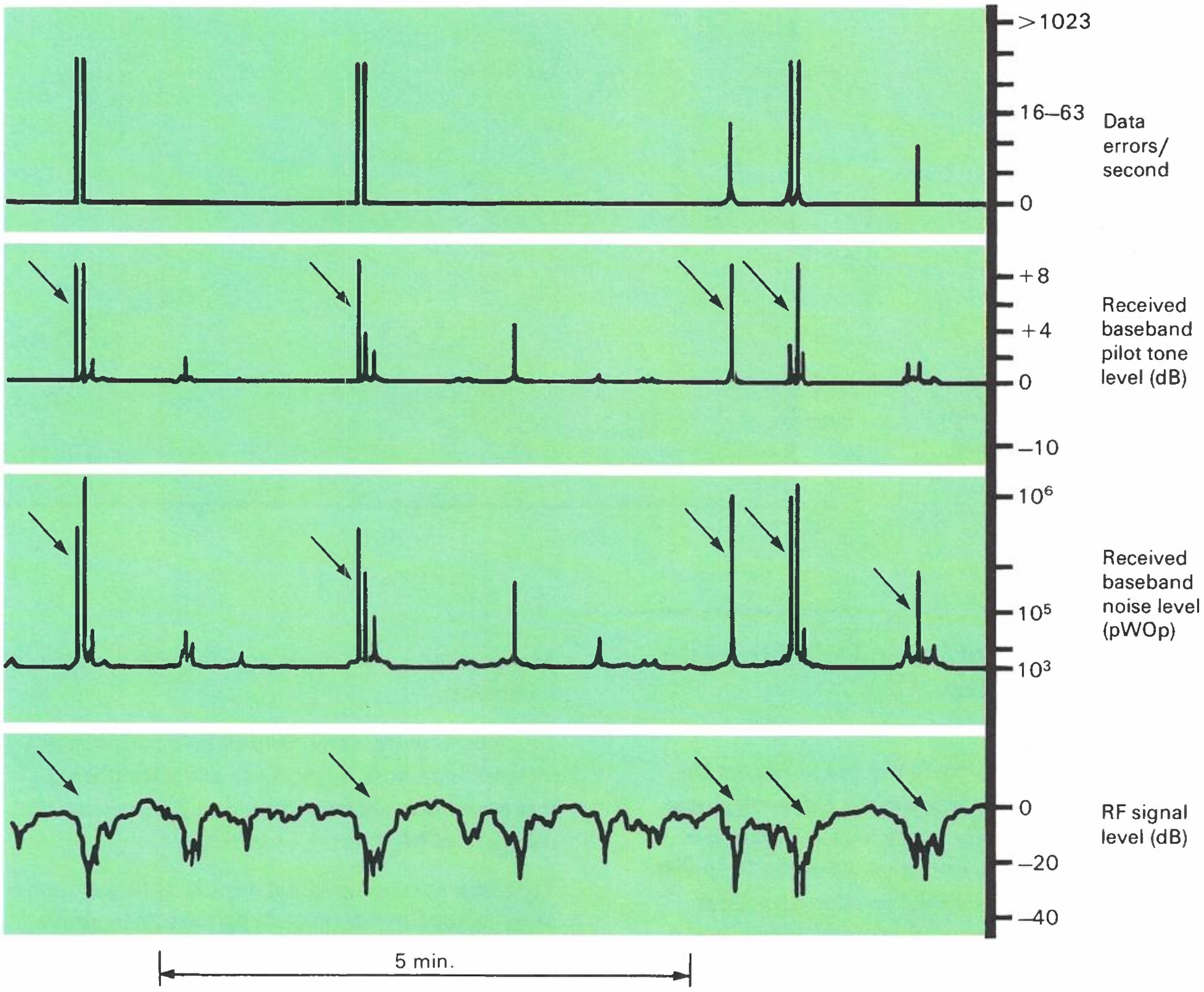
In order to isolate the sources of such problems, the tests are done over one hop (Nullarbor - Wigunda) in one direction of the radio route so that data errors can be directly correlated with the measured radio parameters such as received signal level, baseband noise and pilot level. So that data errors can be displayed directly beside associated radio parameters, an instrument was developed in the Research Laboratories to measure and display the number of data errors per second on a chart recorder. The instrument counts errors over one second giving an output voltage corresponding to the most significant bit. This bit represents the appropriate error category, that is, a discrete output. The radio parameters and the output of this instrument are digitized and then telemetered hundreds of kilometres to the terminal station near Adelaide where these signals drive chart recorders; simultaneously, they are analysed on-line by a mini-computer to produce statistics on both the radio parameters and the data errors.

The purpose of these tests is to relate the occurrence of data errors to changes in easily measureable radio parameters. Once the mechanism of such errors is understood from a study of one hop, the results can be used to predict the data performance of a total radio route of say fifty such hops where several of these hops could be simultaneously experiencing severe fading.

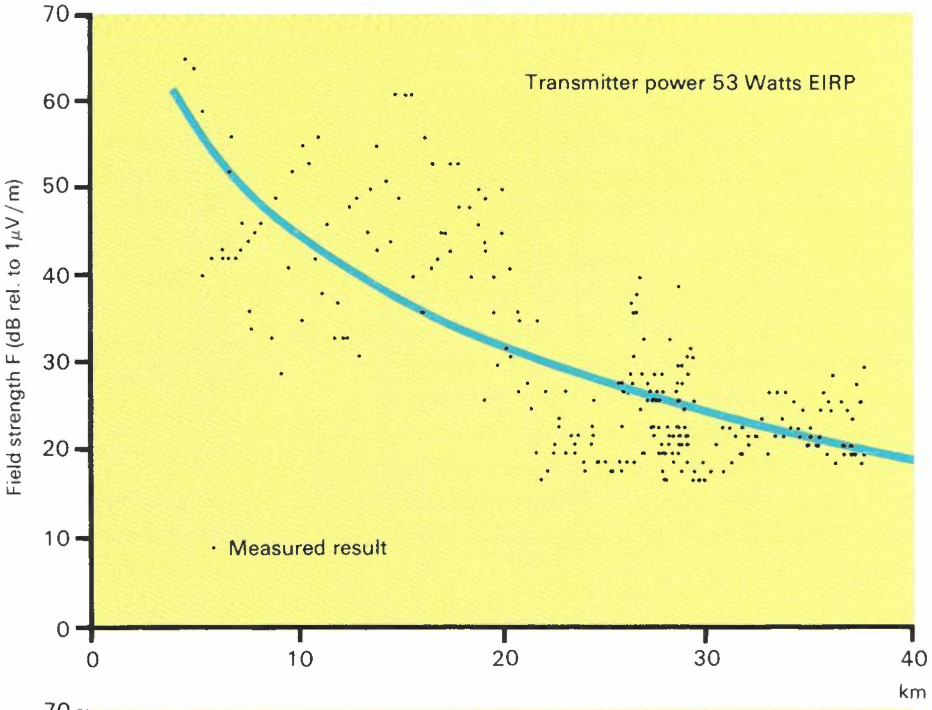
The tests are being conducted with several different styles of modems operating at speeds from 4800 bit/s up to 48 kbit/s. By using several different modems, it should be possible to draw some general conclusions as to the effect of fading on the different modulation schemes. The aim is to establish general correlation between data errors and variations in radio system parameters so as to establish monitoring procedures and aid system design.

It can be seen, from the results obtained for 4800 bit/s operation, that error bursts can be directly correlated with signal fades of the order of 25 dB. This large reduction in received signal level results in a large increase in the relative noise level which causes data errors. Additional to this increase in relative noise level, in some situations, the signal level can actually increase rapidly as shown. Overall, the effects of fading on data transmission are very complex. In these tests, there is no attempt made to explore and to exactly quantify these complex relationships but just to correlate errors with readily measureable disturbances of radio system parameters.

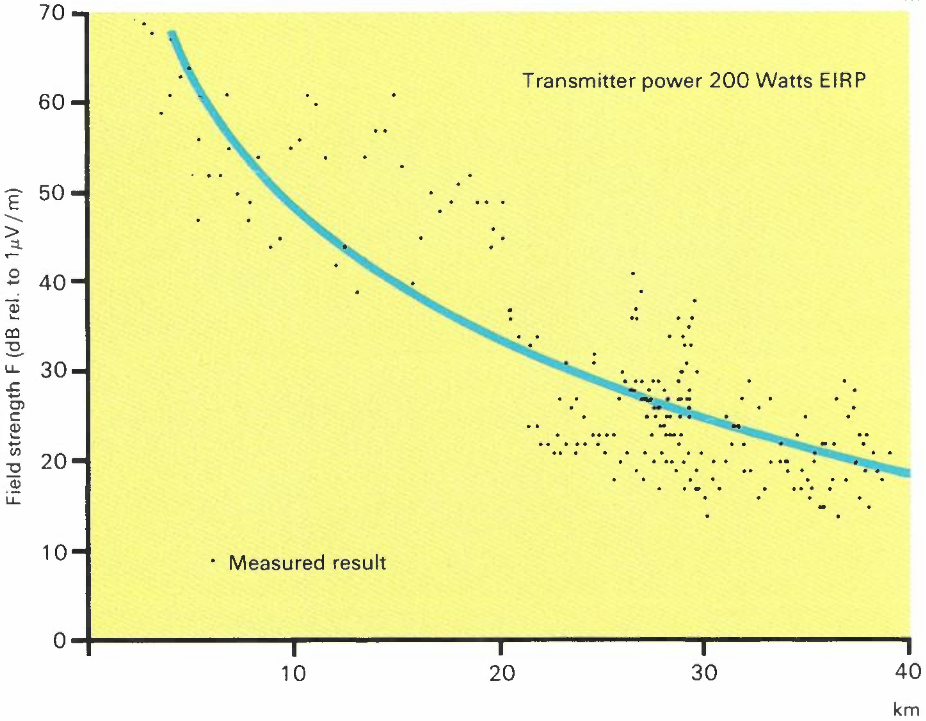
The data tests are still in progress. However, it is hoped that the results obtained from these tests will be sufficient to gain an understanding of the effects of such fading so as to develop a theoretic framework for overall system design and maintenance.



Observed variations of radio system parameters and resultant data errors.



Measured mean field strength value as a function of radial distance from the transmitter at 501 MHz.



Measured mean field strength value as a function of radial distance from the transmitter at 150 MHz.

The Variability of Radio Field Strengths for Mobile Services

Telecom Australia is currently preparing for the introduction of a modern mobile radio telephone service into the Australian network. To assist in determining the size of service areas the Research Laboratories have designed and constructed a portable instrument which when installed in a vehicle can measure and record electric field strength at either VHF or UHF. Using a representative mobile aerial, field strength measurements are recorded on magnetic tape for later analysis by computer.

To determine the variability of field strength in a metropolitan area, a test route and a number of test areas were chosen, located in a representative selection of Melbourne Suburbs.

For these measurements the transmitting antennas were located in the central city area 75 m above street level.

The accompanying diagrams show the mean field strength as a function of radial distance from the transmitter. The commonly applied inverse power law curve was fitted to these results using the minimum mean square error criterion. The variability of the field strength is illustrated by the standard deviations of the differences between the curves and measured values, namely 6.6 dB and 7.7 dB at VHF and UHF respectively. These results are found to be in agreement with published results.

In order to determine the errors introduced into the measurement of mean field strength by the orientation of streets, fourteen test areas were chosen on an eastern radial at a distance of 3 km to 30 km from the transmitter. For each test area two intersecting streets were selected to give results for north, south, east and west measuring runs.

The analysis of these measurements made at UHF revealed that the effect of street orientation in a suburban area is significant. Streets oriented radially towards the transmitter have on the average a 2.5 dB higher mean field strength. This is obviously due to the greater shadowing for streets oriented tangentially.

Further analysis of measurements showed no significant difference in the mean field strength when travelling in opposite directions in a street. A conclusion which may be drawn from this is that the power lines which are normally on one side of a street have no significant effect on the field strength distribution in a street.

Finally, it was shown that the errors associated with the measured results which ignore the effect of street orientation have a standard deviation of 1.7 dB. As this is small in comparison with the spread of the results shown in the diagrams, it is concluded that these measurements are significant.

A New Method of Filter Synthesis - Cross Coupling

The importance of filters in transmission systems and particularly in frequency division multiplex (FDM) systems has been long recognized. Over the years in which FDM systems have developed, design methods for more complicated filters have been refined to overcome numerical problems and to incorporate more accurate models of the real behaviour of the components used. In recent years, active components have been used in addition to the traditional inductor, capacitor, resistor (LCR) components.

Most LCR filters use a ladder structure because this has been found to be a satisfactory practical arrangement. Design methods have, in the main, centred around this particular structure, so there has been little exploration of alternative configurations. Designers have learned to live with the limitations or have developed "special case" approximations. Among these limitations are:

- A poor pulse response - improved with "add on" equalizers.
- A large spread in component values.
- The presence of floating components - particularly troublesome in active, UHF and electromechanical filters.

Recently a new circuit arrangement and design technique has been published which holds promise of improving upon the ladder circuit. The new circuit is based upon the ladder, but the branches are simplified, the inductors are equal in value and additional coupling paths are employed to permit a quite general response. This structure is equally as simple to realize as an active filter using impedance converters, as an LC filter with capacitive coupling elements or as a microwave bandpass filter using coupled resonators. A further advantage over the ladder filter is that it is more suitable for undistorted transmission of pulses.

The Research Laboratories have developed an alternative design method for this new structure and are in the process of using it to design filters for practical evaluation. The design technique is an extension of the method established for ladder filters and, as such, has been readily added to the existing filter design computer program. This allows different configurations to be easily explored.

A cross-coupled circuit:

- Eliminates the need for an equalizer to follow a filter.
- Should allow miniature active filters to be designed.
- Allows the design of bandpass filters employing waveguide, transmission line or electromechanical resonators.

The sensitivity of response to component changes (temperature, ageing) have to be examined and some cross-coupling paths may have to be controlled to avoid sensitivity problems (for example, a direct coupling path from input to output should be avoided). In addition, new alignment techniques will have to be worked out for some types of circuits in which adjustments may be interdependent.

Measuring echo path loss using pink noise

Echo Path Loss : A Proposed Method of Objective Evaluation

When using the telephone for a long distance conversation, a person speaking may be troubled by hearing an echo of his voice unless echo suppressors have been fitted or other corrective action taken. This echo is due to the fact that there is appreciable propagation delay over a four-wire portion of the connection, and part of the transmitted speech is returned to the person speaking via the two-wire/four-wire terminating set (hybrid unit) at the far end of the four-wire circuit.

A quantitative rating of the degree of echo is required for monitoring telephone network performance, and for formulating planning rules for the control of echo. The weighted mean echo path loss (power ratio) over the band is one way to obtain such a rating, but which weighting function is best?

The CCITT provisionally recommends the use of the unweighted mean loss over the band 500 Hz to 2500 Hz. Another method currently being used employs a random noise signal with a weighting function to simulate the spectrum of speech from a telephone, plus the weighting function used in a psophometer which primarily simulates the threshold of hearing for the human ear. It may be argued that since the frequency band of a long distance circuit is usually from 300 Hz to 3400 Hz, then this should be the band used in lieu of the narrower band specified in the provisional CCITT recommendation. It is reasonable to suppose that the annoyance of an echo is related to its loudness. The effective weighting function (for a flat signal) of -3dB/octave (-10dB/decade) is used in some instruments which attempt to measure the loudness sensitivity of telephone sets, and perhaps this weighting should be used for rating echo.

A laboratory investigation sought to answer the question of which weighting function was best. A long distance telephone connection was simulated, using a magnetic tape delay unit to produce the propagation delay, and including a facility to insert one of five different echo path responses. Persons then spoke over the connection for a few minutes and provided a subjective rating of the echo level with regard to its detectability or annoyance. The echo path loss was then objectively measured for each path response using various weighting functions, and it was found that both the CCITT provisional method, and the method using speech plus psophometer weighting gave reasonable agreement with subjective rating. However, a weighting of -3dB/octave over the band 300 Hz to 3400 Hz was the best of those examined, and reduced the variability between subjective and objective ratings to about half of that of the first two mentioned.

As a result of this investigation, Australia has recommended to the CCITT that the echo path loss should be measured using a method based on the mean weighted power ratios of the echo path over the band 300 Hz to 3400 Hz, where the weighting is -3dB/octave.

A simple method of carrying out this measurement is to firstly band limit white noise from 300 Hz to 3400 Hz and apply a "pinking" equalizer to weight the power -3dB/octave. The resultant signal is then fed into a rms responding voltmeter and the level adjusted to a suitable value. The signal is finally fed into the echo path, and the meter transferred to the output of the path. The change in meter reading (in dB) is the weighted mean echo path loss.

If the echo path insertion gain/frequency characteristic is the starting point, then an analogous procedure may also be carried out by calculation.

Advanced Techniques Studies

Introduction

A continuing extension and development of the Telecom Australia network is required to meet the diverse needs of the Australian community for telecommunication facilities in the years to come. When providing for new services advantage must be taken of improved and more economical ways of carrying information signals from customer to customer. The information signals may be voice, data, visual etc., but their essential function is to allow the people who are communicating, to exchange thoughts and feelings as well as facts over as great a distance as required.

In striving to improve the facilities which it offers, a telecommunications authority must face two issues. First, the facilities must match the real requirements of the customer. Secondly, they must be provided as economically as possible. Modern advances in techniques and technology can assist in both these areas as illustrated by the projects selected for this section of the Review.

The television conference facility at the Research Laboratories (Winterton Road Location) differs somewhat from the Confravision Studios in Melbourne and Sydney. Its size and layout provides an informal atmosphere more easily than is possible in the "board-room" layout of the main studios. User reaction to this feature will be of considerable interest in further investigations of conferencing.

Optical fibres, as well as being a potential competitor to metal cables on economic grounds, also offer the possibility of extensive wideband reticulation for new service to subscribers. Similarly, the work on radio propagation is aimed towards improving network performance in the long term by providing a more complete understanding of the propagation phenomena which affect radio systems.

As a basic support in the microwave and optical areas, the materials and device work is directed towards gaining necessary expertise in this specialized area. As well as the innovations which evolve from the activity, the knowledge base produced is relevant to projects in application areas.

The resources employed on these advanced technique studies by the Research Laboratories are relatively small by world standards. Thus it has been important to restrict the activities to the extent necessary to allow useful contributions in the areas selected. The overall objective is to make Telecom Australia a more informed customer as well as providing new devices and advanced techniques for Australian telecommunication systems.

Progress in Optical Fibres

During this past year the promise has become a reality - several administrations around the world have installed systems utilizing optical fibres, some actually carrying telephone signals within a network. What has generally come out of these trials and the developments leading to them, is that it is not too difficult, and certainly not as difficult as was anticipated only a few years ago, to make very strong fibres and to incorporate them into robust cables able to withstand normal handling and laying stresses. These trials have demonstrated that most of the major technical problems have been resolved. It remains now to see whether, with the increasing quantities which will be manufactured over the next few years, the cost will fall to a level to make them economically as well as technically superior to conventional cables.

Optical fibres can now be regularly produced to have losses sufficiently low to allow the transmission of a large number of signals over distances of a few kilometres. Recent developments however, have shown that by using a source of light having a wavelength slightly longer than that used at present, even lower losses can be achieved, and that coincidentally, an even greater number of signals can be transmitted. Considerable research is now going on to exploit this characteristic, as well as to produce suitable light sources, such as light-emitting diodes and laser diodes, and detectors which will operate most efficiently at this wavelength.

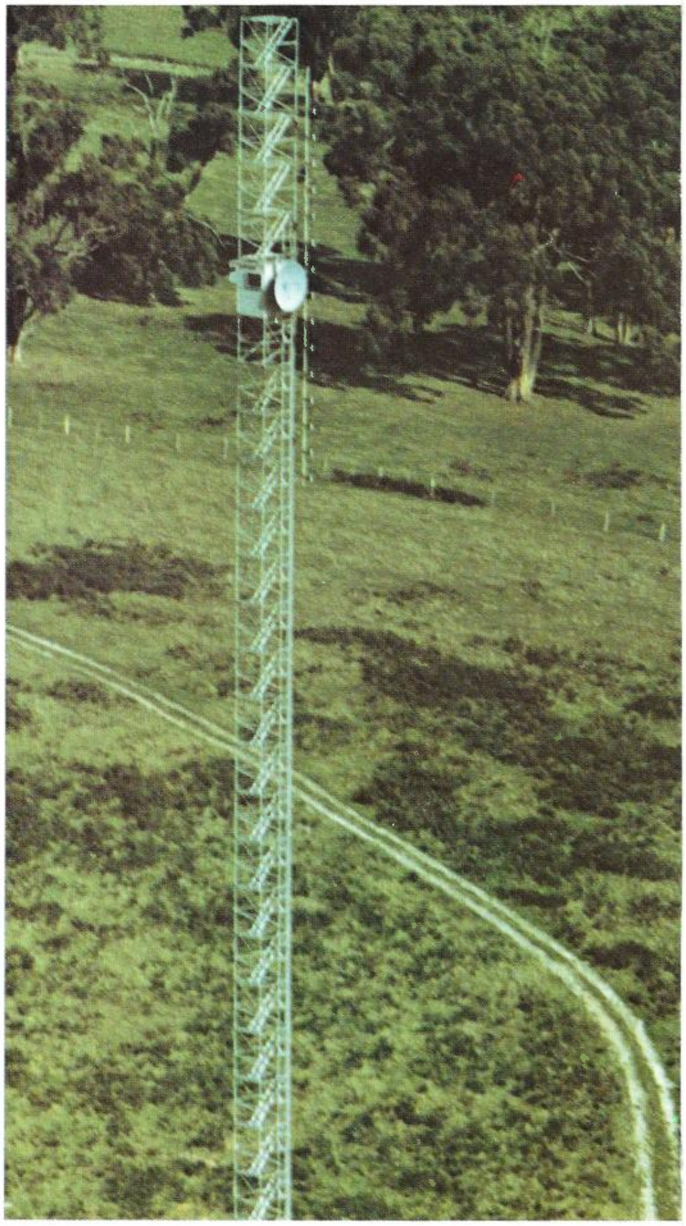
In Australia, Telecom Australia has contracted the Research Laboratories of Amalgamated Wireless (A'Asia) Ltd (AWA) to develop low loss optical fibres by a chemical vapour deposition (CVD) process. Fibres up to 2 km in length have been successfully produced, and refinements of the technique are now being carried out to improve the losses even further and to increase the transmission capacity of their fibres. AWA in collaboration with Olex Cables Pty. Ltd., are also investigating the manufacture of fibre cables. A Telecom Australia field experiment to be conducted within the Research Laboratories during the latter part of 1978 will make use of a Japanese cable initially and later an AWA/Olex cable, to assess the transmission performance of various fibre systems developed within the Laboratories.

Microwave Radio Propagation

Over the years the Research Laboratories have measured the radio propagation performance on paths of planned trunk routes. These tests have been conducted on paths where difficulty was expected in meeting the design objective performance. Usually the tests consisted of transmitting a continuous signal on one or several links and measuring the received signal level. Statistics of the transmission loss over the path were then compiled.

Using this type of simple test signal it is not possible to deduce the precise propagation mechanism which causes 'fading' or excess attenuation of the received signal. Furthermore, it is not possible to predict the degree of additional distortion suffered by an actual information-carrying signal. To do this, it is necessary to use a more complex test signal or receive the transmitted field at more than one point in space.

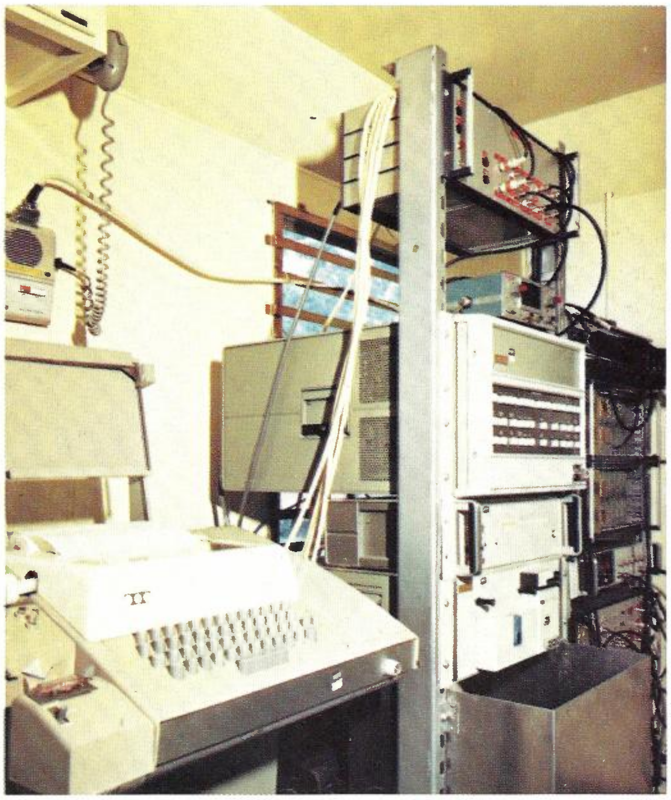
On still clear nights the earth re-radiates the heat absorbed from the sun during the day, forming a temperature inversion - that is, a layer of air which is warmer than that immediately below it. Microwave radio waves can be reflected from these layers causing fading and distortion of the received signal. If moist air (from an on-shore wind for example) is advected across the top of the layer then radio waves travelling in the layer are deflected away from the receiver.



Receiver site - The Gurdies (near Pakenham, Victoria)

When the transmitted test signal consists of a wave whose frequency is swept across a relatively wide band, the received signal amplitude varies due to interference of the component waves with their different delays. In a similar manner, the received field will vary if sampled at a number of different heights.

Both modes are combined in an experiment currently being undertaken by the Research Laboratories. First, the transmitter sends a synchronizing



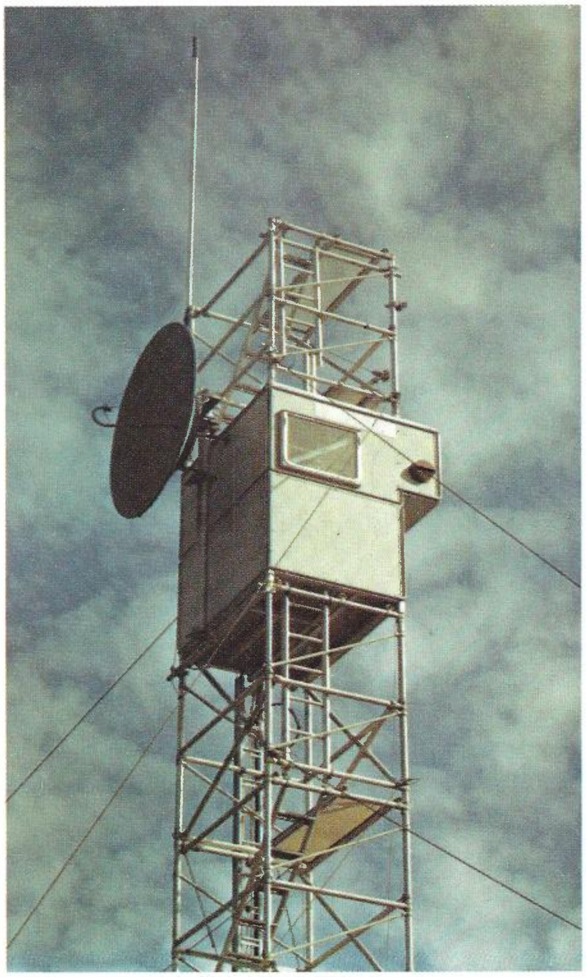
Left: Receiving equipment van showing minicomputer and peripherals

Below: transmitter installation - Pakenham

word and then sends an amplitude-modulated signal which is swept in 100 steps over the band 10.7 - 11.7 GHz. The receiver, 36 km away, decodes the synchronizing word and then steps, 70 MHz below the transmitter frequency. The amplitude of the signal and the phase of the modulation are detected. This allows the complex transfer function of the channel to be determined.

Next a highly stable single-frequency signal is transmitted. From a second transmitter about 1.5 km in front of the receiver a similar signal is transmitted whose frequency differs by 10 kHz from the distant transmitter. The combined signal due to the two transmitters is received by an array of 16 horn antennas spaced 1 m apart and mixed in detectors at the back of each horn. (The reference transmitter has sufficient power to act as a local oscillator). The 10 kHz intermediate frequency signals are then coherently detected.

A minicomputer controls the experiment and writes all data on magnetic tape for subsequent processing. By setting up a recurrence relation between the samples and determining the co-efficients by auto regression analysis it is possible to determine the amplitudes and trajectories of the incoming waves and thus describe the detailed propagation modes which cause serious degradation of trunk radio signals.



The Winterton Road television conference facility

The Research Laboratories Television Conference Facility

The terminal, situated at the Research Laboratories buildings at Winterton Road Clayton, has been designed to meet the needs for conferences between the Winterton Road and the Blackburn Road laboratories, 172 William Street and Sydney as required.

A 21 MHz system transmits and receives the video and coded sound signals between Clayton and the Television Operating Centre (TOC).

The area set aside for conferencing consists of three rooms - an entrance room, an equipment room, and a studio. Part of the studio is partitioned to hold the camera and control unit, a waveform monitor, test equipment, video splitter and audio coder/decoder, as well as mounting the long directional microphone, speakers and video monitors.

In the conference room studio the conferees are seated behind a desk three abreast, with room for several more behind if necessary. One vidicon camera fitted with a wide-angle lens is focussed through a hole in the partition just above the monitors.

Two 63 cm video monitors display the incoming signals from the remote conference point, and two speakers are mounted below them. The sound for the speakers is stereo mode, being transmitted in a coded form within the video signal.

From this conference room, sound is transmitted from a single 'shotgun' highly directional microphone mounted out of sight behind an aurally transparent panel and directed toward those participating in the conference. Not being visible it helps to establish an intimate and relaxed atmosphere.

Lighting is from banks of ceiling fluorescent tubes set in a pattern to provide a soft, uniform illumination without hot spots or distraction to the participants. Light coloured drapes diffuse any reflected light thereby softening shadows created by the overhead lighting system.

A rack containing video, and audio distribution amplifiers, patch panels, the solid state 21 MHz transmitting and receiving equipment, and power supplies is installed in the equipment room. A small picture monitor provides continuous surveillance of the incoming or outgoing video which is selected by means of a switch located on the desk. A test pattern generator, various pieces of maintenance equipment and a work bench are also in the room.

This pleasant, air-conditioned and comfortably furnished room, combined with the advanced forms of communication embodied in the conference facility, initially offer many benefits to users within Telecom Australia, be they department heads conducting a full scale formal meeting, or a small number of people engaged in an intimate type of discussion in a relaxed coffee-table atmosphere.

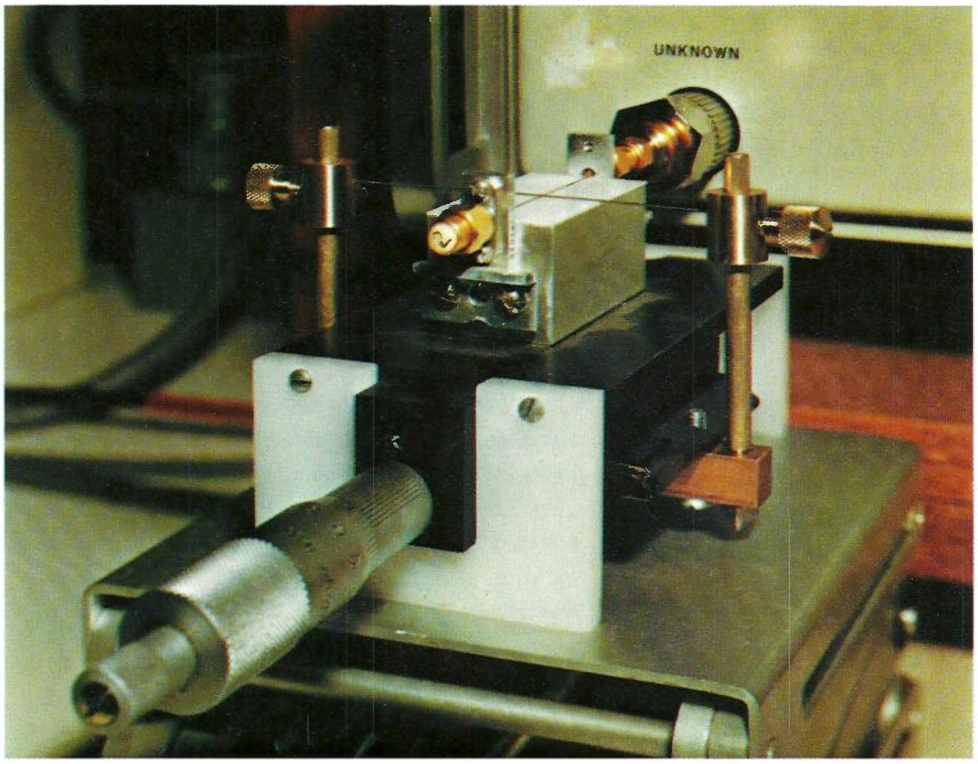
Microwave Devices and Techniques

When printed circuit ideas are extended into the communication bands beyond a few thousand MHz, special techniques are required to maintain the required standard of electrical performance. The Research Laboratories see the need to keep abreast of current technology in this area, and to lead the way in the development of new techniques.

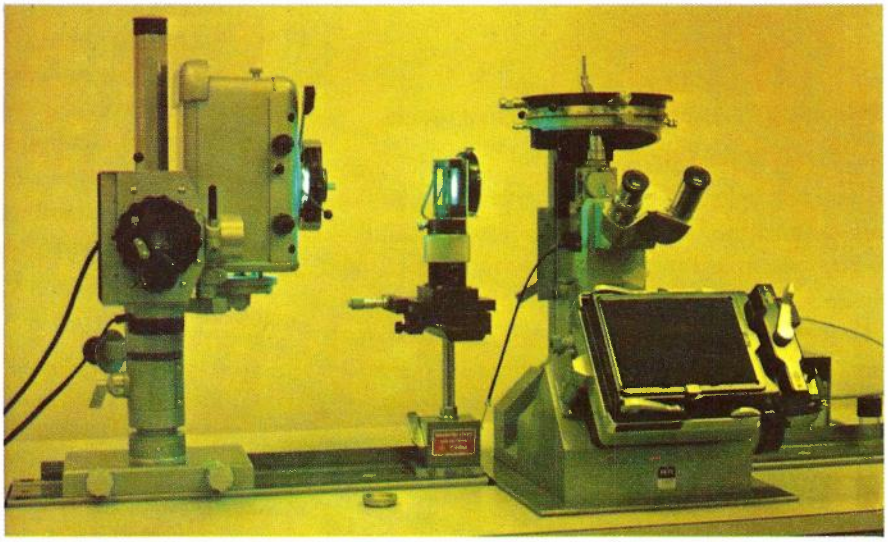
Fabrication methods for microwave integrated circuits (MICs) have been studied in some depth. Of special importance is the reliability of the bond between the supporting dielectric substrate, alumina or fused quartz, and the metal conductor layer which must adhere strongly to it over a wide range of operating environments. An investigation into the use of intermediate metal layers and the application of high temperature baking cycles have led to a substantial increase in conductor to substrate bond strength, and consequently to a marked improvement in the reliability and durability of MICs.

The microwave electrical performance of fabricated circuits must be evaluated before using new techniques in even a limited production run. A scattering element method has been used to determine the wavelength, and hence, the effective dielectric filling factor for a straight length of microstrip line on both fused quartz and alumina substrates. In a second experiment, the circuit Q or quality factor has been determined for a linear microstrip resonator using both thin and thick film fabrication methods on fused silica at frequencies up to 17 GHz.

The relatively low cost and convenience of MIC fabrication leads to ready applications in the areas of terrestrial and satellite radio communications. A typical example is recent work on the basic mechanisms which contribute to directional coupler and hybrid realizations at microwave frequencies, and this has led to some novel designs of such devices. One particular 3 dB hybrid with optimized performance will now be employed as the power splitting element in balanced field effect transistor amplifier designs. The amplifiers themselves form part of a joint project with the CSIRO Division of Radiophysics to develop low noise, sensitive receivers over the range 408 MHz - 22 GHz and operational at both cryogenic and ambient temperatures. Other useful coupler applications envisaged embrace combiner arrays for single or phased-array antenna transmission and/or reception.



Scattering element jig used for microstrip dispersion measurements up to 18 GHz.



Microscope modified for projection lithography

Materials Characterization and Device Fabrication

During the manufacture of semiconductor components for communication purposes close control is required over both the semiconductor material used for the devices and the fabrication techniques. A high degree of control is required to ensure suitable electrical characteristics, high reliability, and reproductibility. In recent years device electrical characteristics such as upper frequency limit and noise figure have been improved, particularly with the use of high quality gallium arsenide semiconductor material instead of silicon. The use of projection photolithographic techniques has enabled pattern resolutions of less than one micrometre (10^{-6}m) to be obtained. This has also helped to increase the upper frequency limit of microwave components.

There are several ways of obtaining information on the characteristics of semiconductor material. Two important ways are the analysis of diode capacitance-voltage data and the use of a scanning electron microscope (SEM).

Capacitance voltage analysis is carried out from measurements on a reverse biased schottky diode, which is formed on the surface of the material being characterized. Analysis of the capacitance voltage data provides information on the distribution and concentration of ionized impurities within the semiconductor, and information about the interface between the diode contact and the semiconductor surface. The distribution and concentration of ionized impurities is of particular importance to the performance of laser diodes, microwave diodes, and field effect transistors.

The SEM, with its microprobe analysis facility is a valuable tool for material characterization. Wavelength and energy analysis can be carried out using the microprobe facility enabling both the identification of unknown contaminants and the mapping of their distribution. Cathodoluminescence can also be used for the study of the properties of materials for light emitting diodes and laser diodes.

When using the SEM in the secondary electron mode, the wide magnification range combined with high resolution enables a detailed study of a semiconductor surface to be made. The smoothness of the surface will depend upon the quality of the semiconductor layer and the etching solution used.

During the fabrication of Gunn effect microwave diodes the SEM can be used for X-ray mapping of the metal contacts. This enables the study of such contact characteristics as "balling up" of the contact metal and metal migration under the high fields during diode operation.

One of the fabrication processes of planar Gunn effect diodes and field effect transistors is the mesa etch of the epitaxial layer to define the device. The angle of the edges after etching can be affected by both the crystal orientation and the etching solution, the SEM being used to provide the detailed micrographs of these edges.

The SEM and capacitance voltage analysis provide important facilities for the characterization of semiconductor material and for controlling device fabrication.

Microprocessor Studies

Introduction

The development of the microprocessor, a single integrated circuit containing all the logic necessary to implement the heart of a computer, has radically changed the approach to the design of a large range of electronic equipment. Although some computers are being built from a microprocessor, the large volume use will be in process controllers, timers, and similar applications.

It has been predicted that by the early 1980s, there will be seven microprocessors in each home and four in each automobile. They are already replacing mechanical timers and controllers in ovens, washing machines, and sewing machines, and will be used shortly as a dedicated controller to keep an automobile engine operating at high efficiency while reducing exhaust emissions to an acceptable level.

In telecommunication applications they are replacing complex electronic or electromechanical logic in equipment ranging from teleprinters to private automatic branch exchanges.

The use of a microprocessor-based design makes it possible to reduce the time required between design concept and manufactured product to as little as six months. However, in order to keep development costs within reasonable limits, and to realize the full potential for rapid design, it is essential to have adequate hardware and software development facilities available to every designer working with microprocessors. Telecom Australia is providing powerful software development tools in its time-share computer network, and is setting up fully equipped development centres in each state.

Design, manufacturing and maintenance costs can be reduced further by using standardized, pretested building blocks for both hardware and software. Standard hardware modules are being developed, and a library of software routines is being built up on TACONET - Telecom's time-sharing computer network.

A Standard Card System for Microprocessors

The use of standard building blocks brings many advantages, and can result in significant savings when new equipment is being designed. As an example, a mechanical designer chooses from a standard range of nuts, bolts, ball-races, motors and other components, unless a special need exists which cannot be met from standard parts. He does this to take advantage of mass produced parts, readily available at a reasonable cost, to reduce inventory and maintenance costs by stocking a minimum number of different components, and most importantly, to reduce the amount of design drafting required, and the resultant mass of documentation produced for each new product.

Where equipment is designed around a microprocessor, the use of standard, tested and proven hardware modules can make very significant savings in development costs, and can save the designer's sanity. Every new design, whether it be a new piece of hardware, or a new segment of a program, invaribly seems to have a few hidden bugs which have to be found and removed from the prototype before production. It's hard enough finding these in hardware or software alone, but when both the hardware and software are new and untested it becomes far more difficult. A good rule to follow is to develop hardware with proven software, and vice versa.

The Switching and Signalling Branch of the Research Laboratories has joined with the Engineering Department in the specification, design and testing of a range of standard card modules, which can be used as the basis for the design of a wide range of microprocessor based equipment. Particular care is being given to the designs to ensure that they can be manufactured readily within Australia, that all components are available from several suppliers, that they are well protected against the effect of interfering electrical signals, and that adequate facilities are included to allow simple performance testing both during manufacture and during maintenance in the field. The complete system includes shielded card shelves for mounting on exchange racks or 19 in racks, portable instrument cabinets, power supplies from battery or mains, and a standardized bus system for interconnecting the cards which make up a system. The initial cards in the system include the central processing card, a 1024 word read/write memory card, a 4096 word read-only-memory card for fixed programs, and a general purpose wire-wrap card to be used for developing the specialized interfaces required in each application between the central processing unit and the equipment it is controlling.

Support Software for Microprocessors

A microprocessor is, literally, a computer on a chip! It can contain significant amounts of read-only and read/write memory, as well as the central processing circuitry, all within a package which occupies less than two square centimetres on a circuit board.

What is perhaps the most remarkable development in the electronics industry today is the growing acceptance of the microprocessor as a circuit element; indeed, it has been confidently asserted that within the next few years we shall be seeing microprocessors used with about the same degree of abandon as are gate and flip-flop packages today. And the reasons are not hard to discover. For one only has to compare the $7 calculators now being offered in chain-stores with their $500 predecessors of yesteryear in order to appreciate the economies and the performance improvements which may be wrought through their application. Realization of this potential is, however, dependent on a means of readily generating, modifying etc., the microprocessor software in a laboratory environment.

Whilst it is possible, but rarely practicable, for a microprocessor program to be "switched" directly into memory by hand, programs are more commonly developed using an assembler or compiler program to translate code, which is readily intelligible to the programmer, into an appropriate form for loading via paper-tape or cassette. The assembler or compiler itself is executed on a medium-scale microprocessor system, usually equipped with a teletypewriter, flexible disk storage, and frequently, a line printer.

An alternative which can be attractive in a large, geographically distributed organization involves the exploitation of a central shared facility for program segment edit/assembly and, in some cases, code debugging via simulation. This alternative can be particularly attractive where such a facility is already provided for some other purpose, such as management reporting, text processing, or scientific computation.

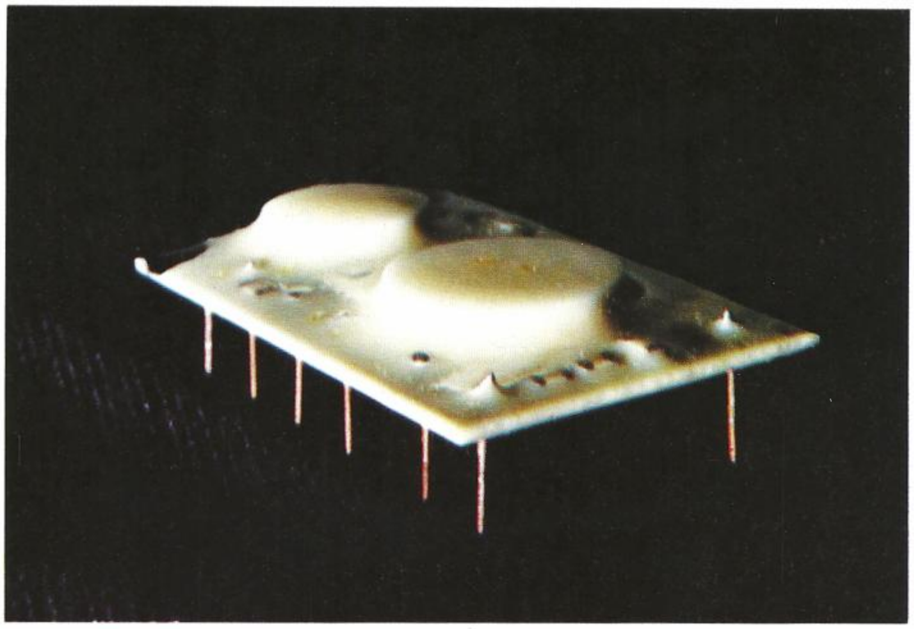
The Computer Applications and Techniques Section of the Research Laboratories presently supports compilers, assemblers and simulators for a number of microprocessor types; these are implemented on the Telecom Australia (H6000) computer network, and are readily accessible to engineers and programmers in every State.

Bit Slice Microprocessors

Recently a new class of microprocessors has become available on the market. These are the bit slice microprocessors.

The family of bit slice microprocessors consists of several modular devices. Each device of the family is a complete block performing a specific function, for example arithmetic and logic, microprogram sequencer or priority interrupts. Members of the family can be used to form a basic processing unit called the processor "slice". A few of these basic processor slices can be used to build a processor with a particular processing capacity. Increasing the processing capacity of the processor can be achieved by adding one or more of the slices. Therefore they can be used to build various systems from simple controllers to powerful minicomputers.

Modularity of the building blocks provides flexibility in processor system design. By using the building blocks (slices) in parallel the size of a processor can be made up according to the requirements: data word length can be made as long as is necessary for processing, and addressing



The complete hybrid clock generator

capability can be specified as required. Processor architecture is also flexible such that it could be made to suit a particular application, for example a complex non-standard interrupt circuitry, a special purpose input output circuitry, unique peripheral interfaces, etc. Flexibility is found also in the instruction set of the processor. By means of microprogramming, the most effective instruction set for a particular application can be created.

Bit slice microprocessors offer considerable speed advantage over the more common metal-oxide semiconductor (MOS) microprocessors. The bit slice microprocessor operates at 9-10 MHz clock rates while MOS microprocessors mostly operate at 1 MHz. The parallel processing mode of the bit slice microprocessor further increases its processing speed.

Bit slice microprocessor systems could be used very effectively as real-time controllers or as special-purpose minicomputers for use in telecommunication systems.

Several families of bit slice microprocessors are being investigated by the Research Laboratories. The objectives of the investigation are:

- To recommend suitable devices for use in Telecom systems.
- To point out specific areas of application of these devices.
- To provide guidelines for designing with these devices.

Vendor support, reliability and cost are important factors apart from technical considerations.

Hybrid Circuit Clock Generator for the 6800 Microprocessor

One component required for use with some microprocessors is a clock signal generator. The 6800 microprocessor requires a two-phase n channel metal oxide silicon (NMOS) - level clock which has non-overlapping of the two output signals. The clock signal source must be able to drive the inputs of the microprocessor which are substantially capacitive.

During the development of a standard card system for microprocessor applications in switching areas, it became apparent that the device which is normally used with the 6800 was difficult to obtain. Consequently, the Devices and Techniques Section of the Research Laboratories designed a thick-film hybrid circuit which could be used to overcome any difficulties in supply of the normal device. The hybrid circuit was to be both physically and electrically compatible with the normal device. The new device offers externally selectable frequency of operation (not available on the standard device) and a number of control inputs to enable various operations to be performed with memory systems, for example, to allow slow memories to be used.

The hybrid circuit was constructed by the Microelectronics Section of the Research Laboratories. It consists of three transistor transistor logic (TTL) chips, four transistor chips and a number of thick film resistors and capacitors.

The microprocessor metering system installed in a suburban telephone exchange

Microprocessors in Subscriber Metering Apparatus

The Research Laboratories' Computer Applications and Techniques Section is presently investigating methods of automating the billing process for telephone accounts for non-processor controlled exchanges. The Section has already developed a minicomputer based system for the automatic recording of the subscribers' meters, and the prototype of this system functions well. The minicomputer in this system scans hardware pulse registers which are connected to the pulse input of the subscriber's meter. Although this system works, and is reasonably cost-effective, it can be improved. This system depends also on hardware for detection of meter pulses and is prone to slight error rates. The Section is now examining a microprocessor based unit in which the interface to the subscribers' meters is minimal, and the pulse filtering and detection is performed by software.

Since the actual interface for each meter must be replicated thousands of times, it is desirable to make it as simple as possible. In the microprocessor prototype, the subscribers' meters are interfaced to the processor through level conversion and multiplexing hardware only. The processor scans each meter line a number of times during a pulse-width period and makes a decision on the validity of any pulses arriving. The processing load is then very large for this system, and this means that fewer meters can be accommodated. However, the actual hardware of this system is much less sophisticated, and therefore less expensive, and the recognition of meter pulses can be much more reliable. The goal is then a low-cost accurate unit with a convenient module size of one thousand lines.

Once a meter pulse has been recognized by the processor, the internal meter reading, held in memory for that particular subscriber is updated by one. These internal meter counts can then be transmitted to the accounting centre by two means; punching a tape locally at the exchange and sending the tape, or by having a larger central computer which collects all the readings from the exchange units via dial-up data links.

A prototype system has been built, and has been tested on both crossbar and step by step equipment, revealing no errors. Although a test in a live exchange has yet to be performed, the method of recognizing meter pulses electronically seems successful.

Switching and Signalling Studies

Introduction

The increasing demands for additional services and additional facilities for both Telecom Australia and its customers are putting increased pressure on both switching systems and signalling systems. This trend has been apparent over the last decade and shows no sign of abating either in Australia or overseas.

Part of the strategy for meeting these pressures is the increased use of stored program controlled (SPC) exchanges in combination with other advances in technology. Work in the Research Laboratories has been oriented towards the early identification of possible operational problems associated with these innovations and the gathering of sufficient operational experience to be able to provide approved technical support for the preparation of specifications.

This work falls into various categories, such as processor control, signalling, device technology and maintenance. Matters under study in the control field include standards for documentation, high level language, software description methods, various approaches towards dimensioning processor systems and the development of an understanding of the mechanisms leading to overload in SPC systems.

Signalling costs can be minimized by taking advantage of both solid state technology for channel associated signalling relay sets and integration of relay sets into PCM equipment. Trials of solid state relay sets are now proceeding. Guidelines for the use of common channel signalling are also being established, as this will have general application when sufficient SPC exchanges are in the network.

Device technology is developing at a rapid pace, with a swing away from discrete logic design approaches to a firmware based approach. The microprocessor, of course, is an outstanding example of the trend. Standards for use of microprocessors have now been developed and are being extended, while other developments in memory and logic systems are being closely monitored. Related electromagnetic compatibility (EMC) considerations are also the focus of a group of studies.

Network studies concerning the configuration of digital networks and the application of remote switching units are being conducted to enable the AXE system to be best exploited in the Australian environment. Maintenance and diagnostic techniques appropriate to a network of SPC exchanges under the control of a higher level SPC network are being examined so that appropriate techniques and algorithms for network management can be developed.

These aspects indicate the major current thrusts of the Switching and Signalling Branch work program, which has been developed to support the on-going engineering activities of Telecom Australia. Some of these activities are described in detail in the following articles.

Generation and Detection of Digitized Multi-Frequency Code (MFC) Tones

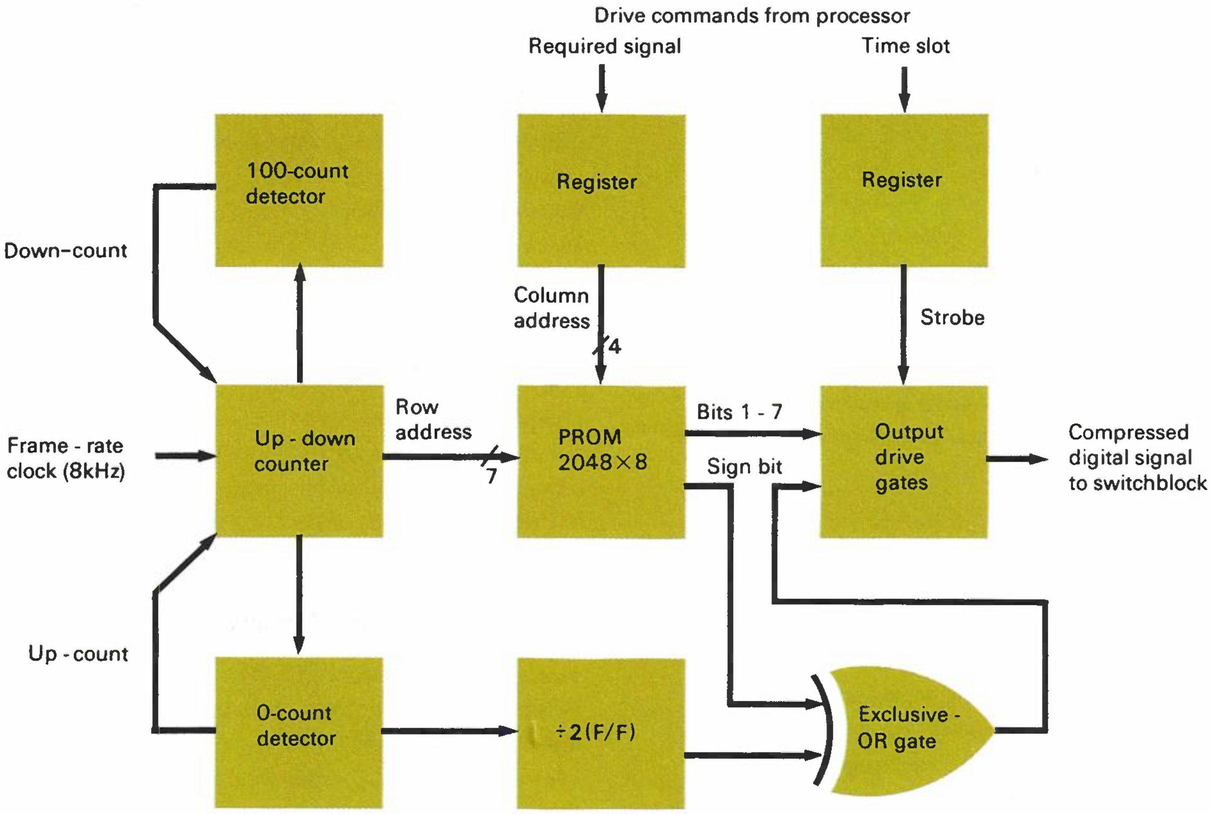
In the switched telephone network, the signalling information between exchanges is transmitted either by decadic pulses or by bursts of multi-frequency tones within the audible range. These tones consist of two out of six frequency combinations per digit or control function. Currently, analogue generation and detection methods are used, that is generated by gating and mixing outputs of appropriate oscillators and detected by sharply tuned band-pass filters. These methods are appropriate for an analogue switched network, although there is possible frequency drift in the many tuned circuits in the long term.

Digital PCM transmission links when used with analogue switching have all signals converted back to analogue before processing through the exchange. However, with increasing numbers of PCM links it will eventually become advantageous, particularly for tandem exchanges, to avoid the digital-analogue-digital conversions and to process all signals through the exchange in digital form. To achieve this fully, it will be necessary to generate and detect the multi-frequency signalling tones directly in digital form.

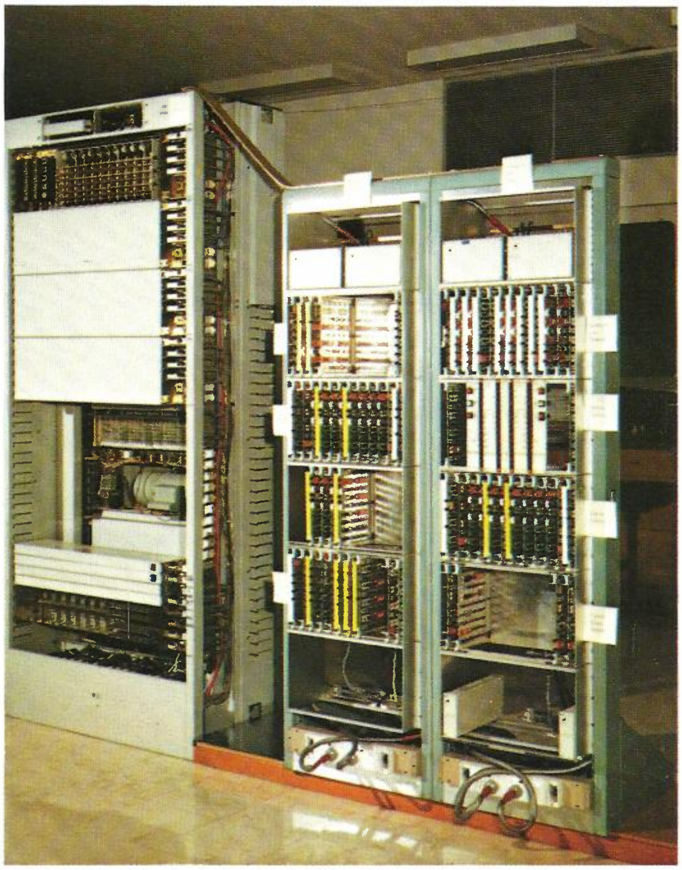
The generation of tones can be elegantly implemented. A two out of six code provides for fifteen signal tones, or sixteen if the "no tone" condition is included. The generation method is based on storing a segment of the waveform for each possible tone combination (including "no tone") and repeatedly reading out the segment when required. Mathematical analysis of the tones has established that all possible combinations of multi-frequency tones (both in forward and reverse directions) repeat with a period of 50 ms or 400 samples. There are also time and skew symmetry conditions (as for a pure sine-wave) so that only a quarter of the period or 12.5 ms of the waveform needs to be stored, that is 101 samples. The basic 50 ms of the waveform is produced by reading out the samples in forward order for the first 12.5 ms, then in reverse order for the next 12.5 ms, then the procedure is repeated for the remaining 25 ms with reversal of the sign of each sample. All the samples for forward signals are held in a single 16 kbit programmable read only memory (PROM) allowing storage for 128 samples of each tone. The first 101 are used which simplifies binary addressing. A second 16 kbit PROM is used for reverse signals. The end result is a stable and accurate generator.

The detection of digitized tones, however, has proved to be quite a difficult problem due, in part, to the relatively wide tolerances permitted for frequency, and particularly amplitude, of the signals in the analogue network. Correlation and transform methods are well known and are feasible; these methods require considerable signal processing, and therefore considerable hardware or time, to extract sufficient information to make a correct and reliable decision. Moreover, the signal must be reprocessed to detect each of the six frequencies individually.

Another method of detection has been proposed in which the incoming signal is processed only once to estimate its spectral moments from which the tone recognition decision is made. The spectral moments are, however, a function of both amplitude and frequency, so that innumerable ambiguities arise when the amplitude is allowed to vary within the analogue permitted tolerances. Hence, the search for a satisfactory detector for digitized multi-frequency tones is continuing.



A simplified block diagram for generation of digitized MFC tones. The outputs from the counter and signal register combine to produce an 11-bit address for the PROM, and the up-down excursions of the counter read out, a prestored compressed portion of the required signal.



The Remote Switching Unit at the Clayton Laboratories. The rack at the left houses crossbar switching equipment, the two smaller racks at right contain the signalling and control electronics that allow remote, unattended operation.

Remote Switching Unit

One of the major factors in the economic provision of subscribers' lines to the local telephone exchange is to achieve an economic balance between reducing the length of the lines at the expense of providing more exchanges and their interconnection.

One approach is to remotely locate part of the switching equipment from the exchange close to a group of subscribers. The number of lines connecting the remote switching equipment and the "parent" exchange is reduced because on average only 10-15% of the subscribers are making simultaneous calls. The parent exchange can thus have a combination of individual subscriber lines and a reduced number of lines to remote switching units (RSU) which serve the more distant subscribers located in the exchange area. This approach to date has been rarely economic as the remote siting of the switching equipment involves penalties from increased costs, (e.g. housing the equipment, additional maintenance and the provision of means for the parent exchange to properly control the RSU.)

However, the world-wide trend towards computer control of telephone exchanges gives the potential for lowering the cost of both the remote control system and the cost of maintenance through the use of self diagnostic programs. Also, advances in electronics technology make possible a RSU design that is small and compact with reduced power consumption at a far lower cost than was possible before.

A model RSU was designed and installed at the Research Laboratories, located at Winterton Road Clayton, and became operational by May, 1978. The control parent is the digital exchange at St. Kilda which is a test bed for studying the principles of digital switching (see Review of Activities 1975/76). The digital exchange was originally designed for tandem traffic with no subscribers of its own. By redesigning and reconfiguring the computer programs (33 altered, 100 added) this exchange is now functioning as a local exchange which controls the model RSU. The RSU subscribers have normal access to the Australian telephone network.

The prime objective of the project is to investigate the techniques of remote control of an RSU. The control link between the parent exchange and the RSU operates over a 64 kbit/s data link. The control link is duplicated for security, with automatic changeover in the event of failure.

The link carries control information to the parent computers concerning changes of state in the RSU equipment, and also commands from the computers to the RSU. Protection against errors in the transfer of information is provided by an error detection and retransmission scheme.

Telecom Australia recently chose the Ericsson AXE equipment for the new generation of local exchange systems. The new system has the capability of controlling RSUs. The experience gained in this project will guide Telecom Australia in exploiting the economics and advantages of remote switching units as one of the means of reducing costs in the provision of future telephone services.

The Advanced Communications Experiment

Since the formation of Telecom Australia a much greater emphasis has been placed on customer needs. The 'Telecom 2000' Report, for example, stressed the importance of examining possible new services from the viewpoint of the potential user. The Advanced Communications Experiment (ACE) has been set up to conduct field research into a variety of new telecommunication facilities. A group of sixteen subscribers from within Telecom Australia is thus being asked to try out new facilities for themselves in their everyday work situation so that it can be discovered whether these services are acceptable, and useful. The group has been carefully selected to ensure that there is sufficient community of interest to provide a realistic trial.

ACE has two major objectives. The obvious one is to examine the particular facilities being provided and the second, and at this stage more important objective, is to learn how best to conduct this type of field research study and to assess the usefulness of the approach for identifying customer requirements for telecommunications equipment and services.

During the study the participants will be provided, as far as possible, with facilities to match communications requirements in their workplace. The range of facilities which will be available include advanced telephones, facsimile machines, telephone message recording machines, telex services and computer based services. Some of these services will be provided over the public network. Others will be based on a private network linking all the participants.

The project is being co-ordinated by the Customer Services Department, with the Research Laboratories providing the special equipment. The Victorian Administration has provided the lines to interconnect the network. The Switching and Signalling Branch of the Research Laboratories arranged purchase of a Private Automatic Exchange (PAX) and suitable "hands free" pushbutton dialling telephones which were substantially modified for the study. Additional facilities were added to the PAX including call knocking, call break-in and automatic call back. Comprehensive monitoring facilities such as call record printout were designed and included. Additional switching matrices for possible future video services have been slaved to the normal PAX matrices. The telephones were modified to integrate facsimile and telephone recording facilities. The subscribers' terminal equipment was logically arranged and accommodated into a suitable side table for convenient operations.

Digital Subscriber Loop Techniques

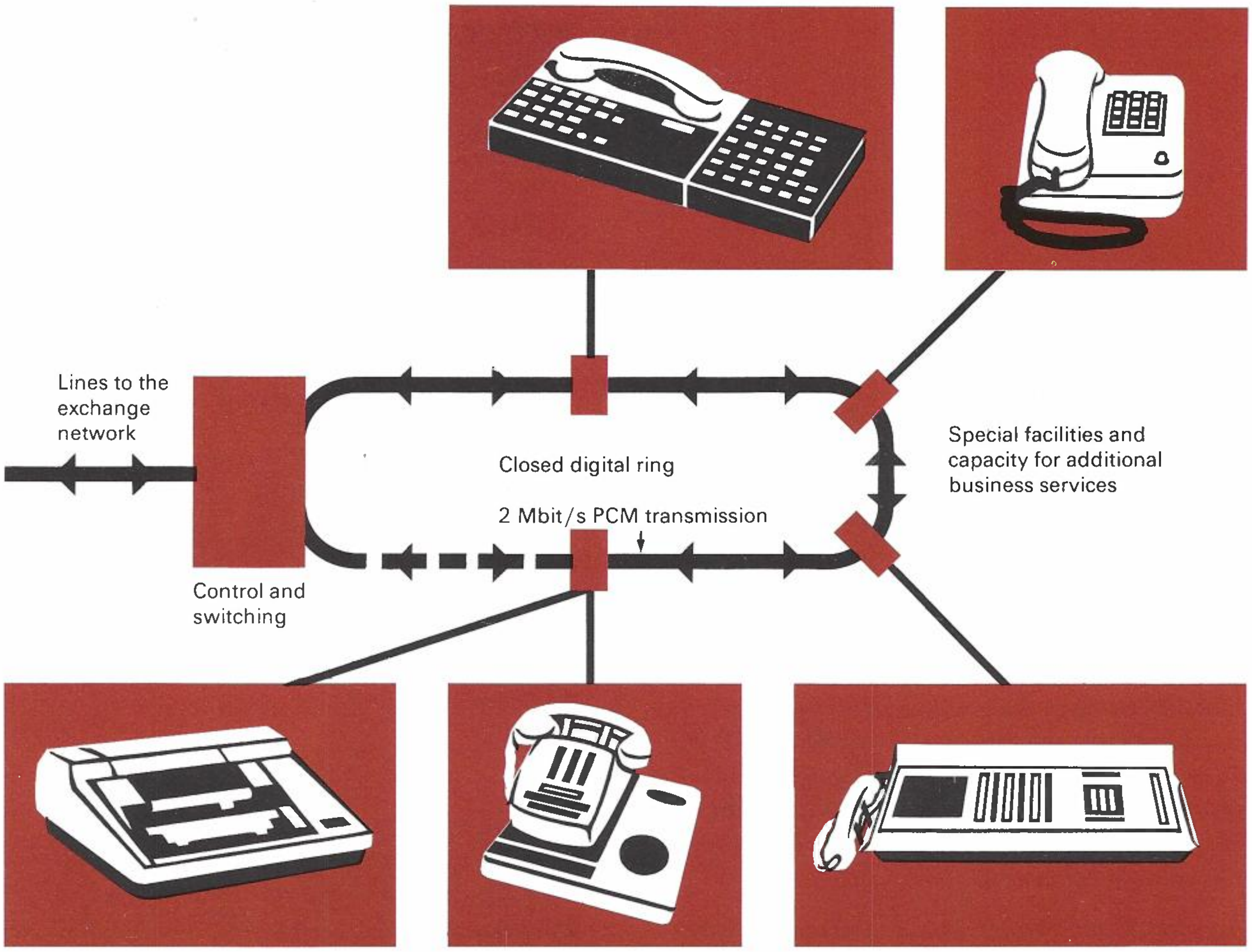
The spread of digital technology into the Australian telecommunication network is becoming apparent in the transmission area, and the use of digital switching is imminent. The extension of digital transmission from the trunk network to the subscribers' local area represents a possible future development for the network. Provision of digital signals right up to the subscriber handset may lead to ultimate benefits by expansion of the range and flexibility of customer facilities.

There are many problems raised by the prospect of digital voice encoding in the handset and subsequent transmission over subscriber lines. These range from the provision of electric power for the telephone circuitry and provision of adequate protection for the semiconductor circuitry, to the design and control problems posed by the application of larger capacity digital signalling schemes.

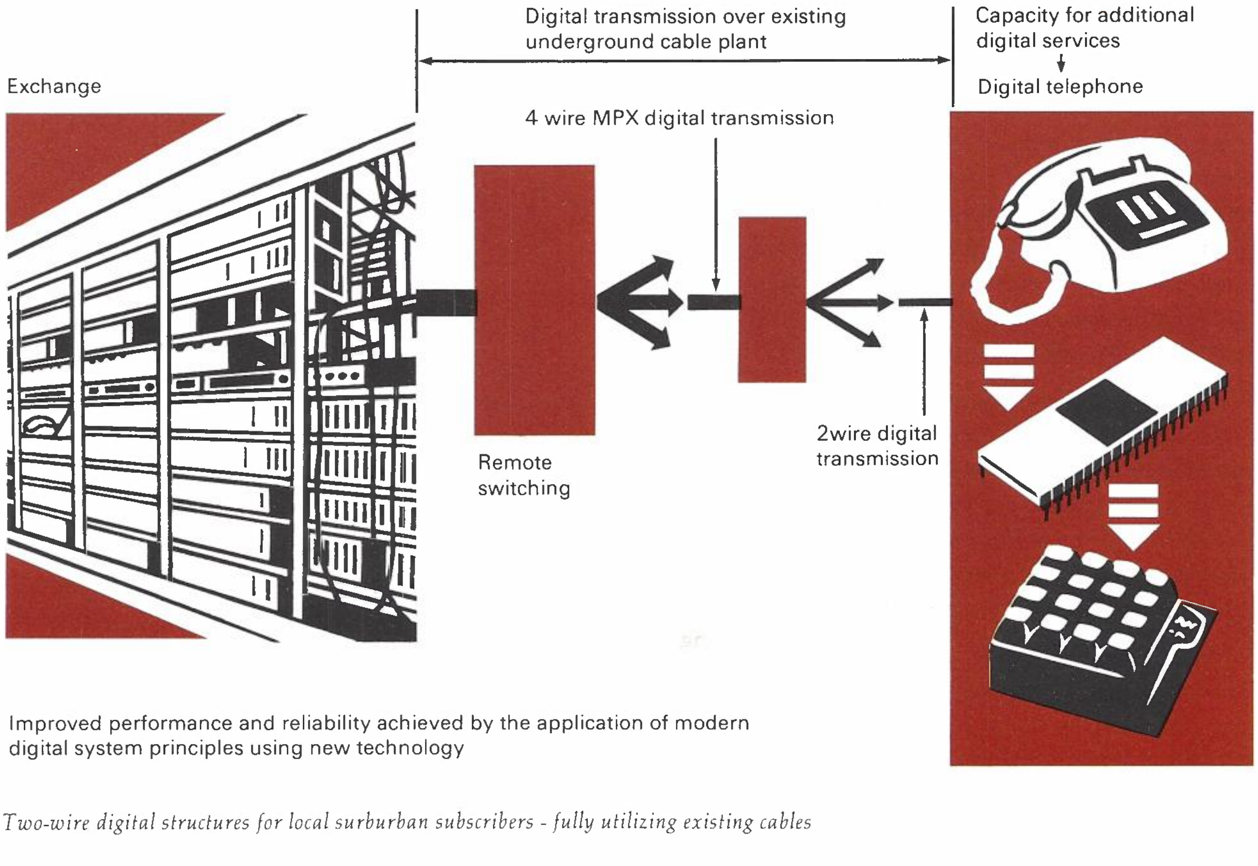
The studies in progress fall into several categories:

- Office environment distribution systems;
- Local area suburban subscriber distribution;
- Rural subscriber applications.

The first area of application is currently under study for those distribution situations where a group of subscribers is located within one office building so that a secure cable may be used to interconnect all subscribers within the group. Laboratory model development is proceeding with a view to evaluating signalling and control methods and some aspects of the future handset circuitry.



Ring structures for multifacility, high usage, secure business systems



Two-wire digital structures for local surburban subscribers - fully utilizing existing cables

Ready interchangeability of cable test samples is a feature of the Quintaxial test fixture

Shielding Effectiveness for Electromagnetic Compatibility (EMC)

Relative shielding effectiveness assessment of signal cables provides important data to the designer and user of digital equipment; to the former when an interference problem is anticipated and magnitudes may be estimated, and to the latter when an interference problem is encountered and reduction techniques are to be determined and implemented.

Understanding of the physical phenomena involved in cable shielding has been gained initially from the literature, followed by laboratory work with models and then measurements using practical cables mounted in a quintaxial test fixture constructed for the purpose.

The test fixture allows a sample length of shielded cable (coaxial cable, shielded twisted pair, etc.) to be almost uniformly illuminated throughout its length by a transverse electrical and magnetic (TEM) wave (the "interfering" signal). The magnitude of the resultant "near-end cross-talk" (NEXT) is measured and compared with the magnitude of the illuminating signal to provide a measure of shielding effectiveness of the sample cable. The upper frequency limit for measurements at present is approximately 400 MHz. Above this frequency the dimensions of the fixture, particularly its circumference, allow propagation of higher order modes which increase measurement uncertainties.

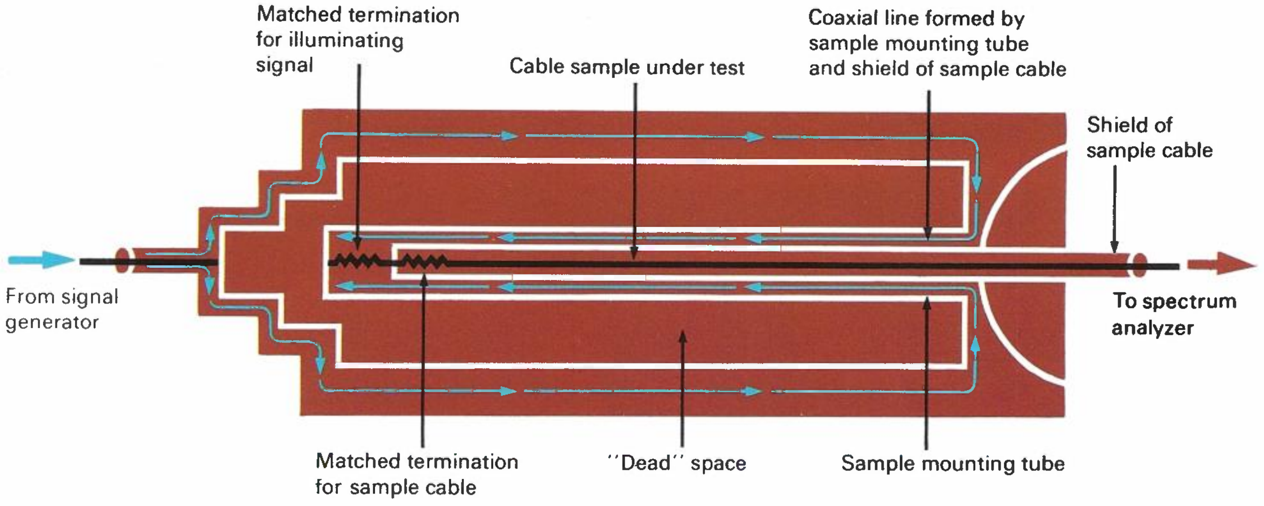
The curve of relative magnitude of the NEXT in the "victim" line when plotted as a function of frequency can be divided into three regions of interest. For coaxial cable, such as RG-223/U, these are the region below about 1 MHz, the region from 1 MHz to about 10 MHz, and the region above 10 MHz.

Below about 1 MHz, the NEXT is almost entirely caused by the low frequency transfer resistance of the cable shield; that is, longitudinal current flow along the shield produces a potential difference that is coupled into the victim signal conductor via the terminating impedances at the cable ends.

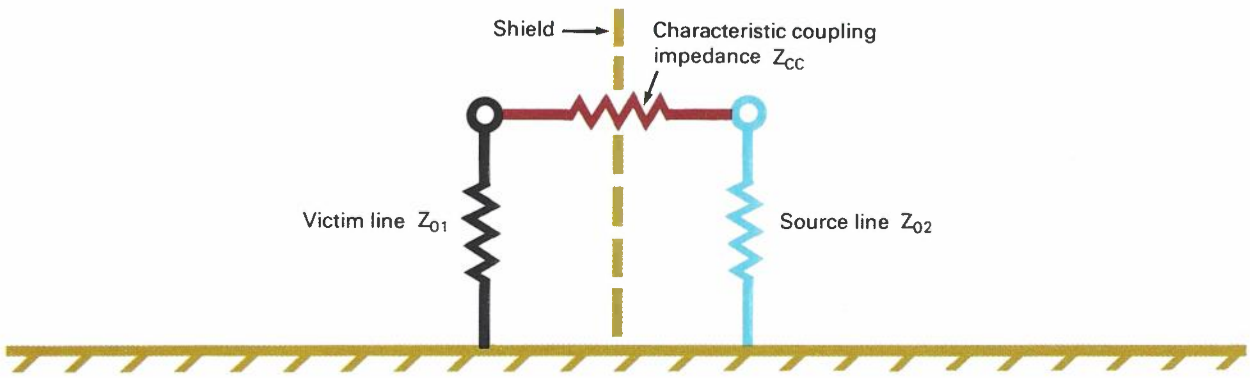
Between 1 MHz and 10 MHz, the NEXT may exhibit an attenuation peak. This generally occurs for cables provided with shields having very good but not perfect optical coverage, such as two-layer braided shield cables (RG-223/U). For such cases in this frequency range, skin depth plays a dominant role.

Due to incomplete optical coverage, the penetration of electric and magnetic fields at frequencies higher than about 10 MHz couples the source to the victim line. Travelling waves are thereby set up on the quasi-transmission-line pair composed of the interfering signal conductor and the victim signal conductor. Therefore, at high frequencies, the quasi-transmission-line pair exhibits a characteristic impedance that we propose to call the characteristic coupling impedance for the cable under test. Since the quasi-transmission-line is not terminated in its characteristic impedance, the measurements exhibit the typical resonant peaks and valleys produced at multiples of a quarter wavelength for the test sample.

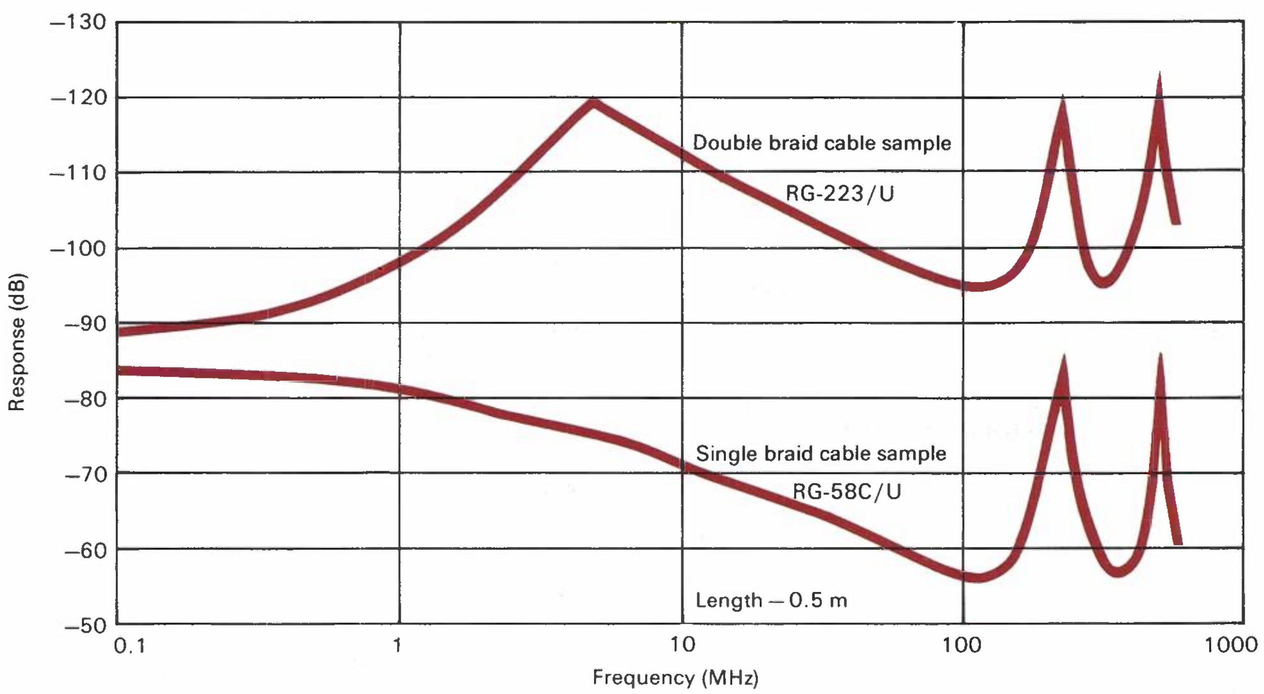
The magnitude of the characteristic coupling impedance can be calculated from parameters measured with the cable sample in the quintaxial test fixture. The characteristic coupling impedance provides "figures of merit" that can be assigned to each cable type being assessed, such that a larger figure of merit (higher impedance) indicates better shielding effectiveness. Such a figure of merit is independent of cable length.



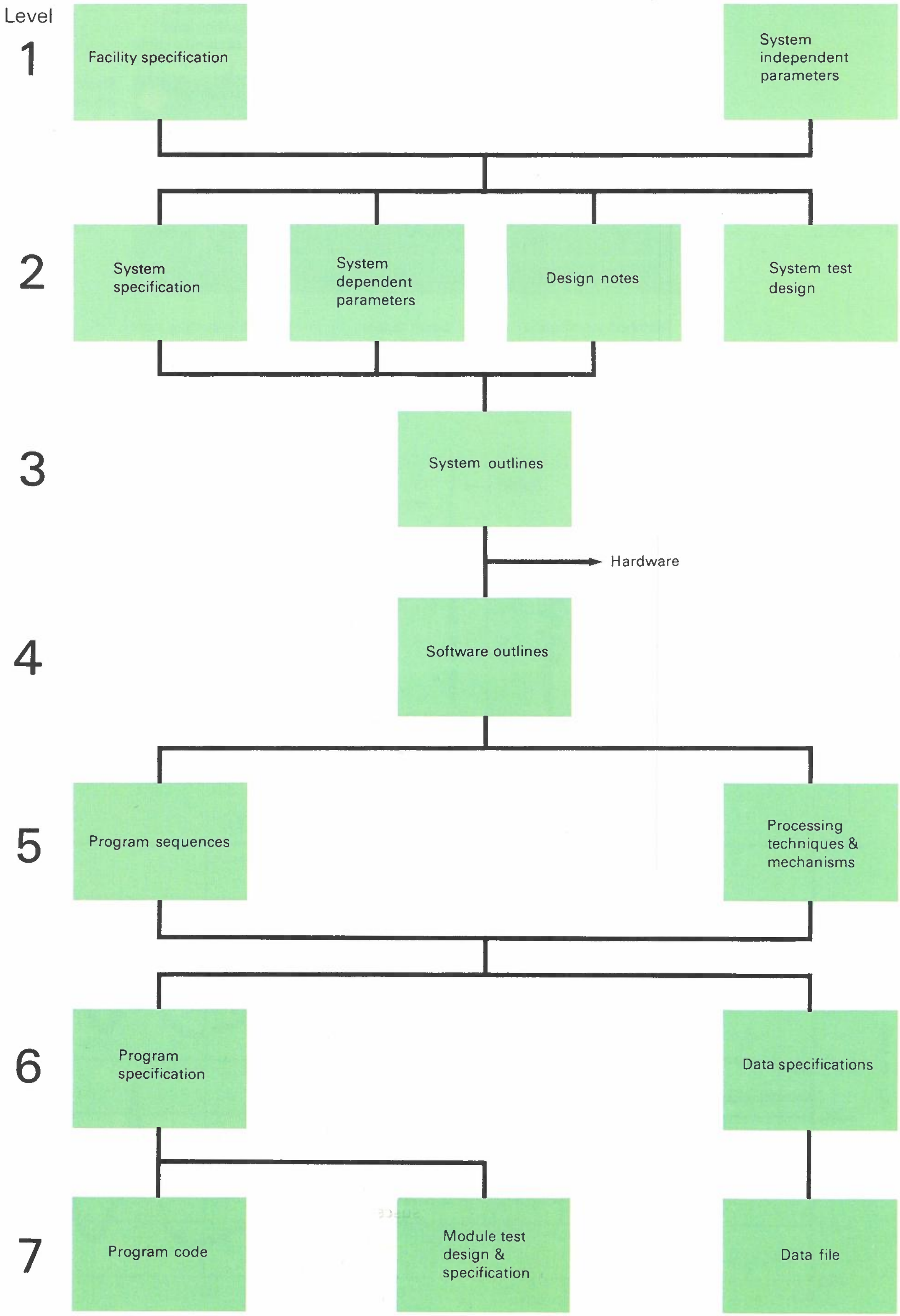
Cross section diagram of quintaxial test fixture



Equivalent circuit used to visualize characteristic coupling impedance



Curves of NEXT (near-end cross-talk) versus frequency for two types of sample cable in quintaxial fixture



Documentation of software design for SPC system

Structured Documentation for Stored Program Controlled (SPC) Systems

This method of documenting software was developed by an ADP Programming Group working with the Switching and Signalling Branch of the Research Laboratories.

Experience has shown that thorough and complete documentation is essential for efficient design implementation and maintenance of complex software systems. The method was developed during the software production of the Integrated Switching and Transmission (IST) Remote Switching unit which requires software with a degree of complexity similar to an SPC Local Exchange. It was first realized that documentation, if treated correctly, can in fact be a design tool rather than a record of what has been done - the rest of the method followed naturally.

The documentation is structured into a number of levels of detail, progressing from broad outlines down to the specific information necessary to implement the system. Each level provides only the detail necessary for a complete understanding of the system at that level thus following the principle of top-down design.

The system also maintains the concept of modularity, for within the levels the documentation is split into functional modules which interface and interact only with documentation at the same or adjacent levels. This leads to straightforward cross-referencing and the possibility of parallel development of interacting modules such as hardware and software, where only the interface needs to be fully detailed before development is commenced.

Hardware and software functions are not distinguished at the highest levels and only when implementation of the system is considered does separation into software and hardware components become necessary.

The method includes the use of pictorial representation wherever possible as the most effective way of presenting information. Among the methods used were the State Transition Diagram, the Program Sequence Diagram and the Program Flowchart.

As the major design tool, documents are the visible output of design and provide a measure of quality and progress. With the system designers being forced to be more thorough it has been found that overall development time is shorter, learning time is reduced, functions are less likely to be overlooked, unforeseen events and interactions are unlikely to occur, errors are pin-pointed more quickly, modifications and/or additions are performed more easily and in total a more efficient design is achieved.

Semiconductor Memory Studies

Integrated circuits are the key elements in the development and production of an expanding variety of telecommunication equipment. One example of the impact of integrated circuit technology is the use of semiconductor memories in electronic switching systems. New high capacity semiconductor memories are making electronic switching systems smaller, more efficient and less expensive.

Wide diversity in existing semiconductor memory device types and technologies, and continued rapid development in these areas, have resulted in Research Laboratories investigations to determine those devices and system design approaches best suited to telecommunication requirements.

The memory of an electronic switching system holds information in the form of binary digits, or bits. The amount of information required to control the operation of an electronic switching system, and thus the capacity of its memory, is huge - many millions of bits for each system.

Due to their complex nature the possibilities for failure in memory devices are numerous, however, they fall into two major categories - "hard" and "soft" faults. Hard faults are characterized by permanent device failure. Soft faults are less obvious and depend on some external parameter or combination of parameters. One aspect of work currently in progress involves determining the susceptibility of large semiconductor memory systems to "soft" faults or errors.

An example of a source of "soft" faults is the semiconductor memory device itself which has been shown to exhibit pattern sensitivity. Different devices and technologies are sensitive to different patterns. Pattern sensitivity can mean that the pattern of data stored at one location produces an unwanted interaction between memory cells which modifies data stored at another location. Effects such as these are further complicated when many devices are combined to form a memory system.

System designers and users cannot place limitations on read or write sequences and the information that is stored in memory. Data patterns and operation sequences are constantly changing during use and cannot be predicted. The memory device must be able to store and retrieve valid information regardless of what it has done previously. The results of present investigations will indicate to what extent "soft" failures can degrade system performance and what additional features or facilities are required to ensure adequate performance in this respect. Related areas of investigation are concerned with memory system testing requirements for "hard" faults, including preventative maintenance techniques and diagnostics for fault finding operations.

Exchange Equipment Fault Correlation

The advent of Stored Program Controlled (SPC) switching systems has introduced many facilities and capabilities into exchange systems which were not previously economically provided, or possible, in some cases. One such capability is the more effective automatic detection and diagnosis of fault conditions within the exchange.

Fault correlation is a diagnostic technique being investigated for application to shared equipment faults within SPC exchanges. As such it is a very attractive technique due to the fact that it obviates, to a very large extent, the need for special hardware test equipment to perform routine diagnosis.

Fault correlation requires monitoring for abnormal call events during the progress of all calls within an exchange. The occurrence of any such event deems the call unsuccessful. Examples of these events are:

- Time out or clear forward during digit reception
- Too many digits
- Time out on busy tone
- Short holding time; etc.

These abnormal events are often indicative of the involvement of an item of faulty equipment with that call, although they may also result from unusual subscriber behaviour. The job of the fault correlation system is therefore to filter these abnormal event reports so that those which do result from faulty equipment are reported. This is done by keeping a count for each item of equipment in the exchange. These counts are increased by a predetermined amount every time the associated item of equipment is involved in an unsuccessful call and decreased by another predetermined value every time the item is involved in a successful call. In this way, providing the count parameters (increment to decrement ratio and maximum value) are correctly selected, the overflow of any count indicates, within confidence limits determined by the count parameters, that that item of equipment is faulty.

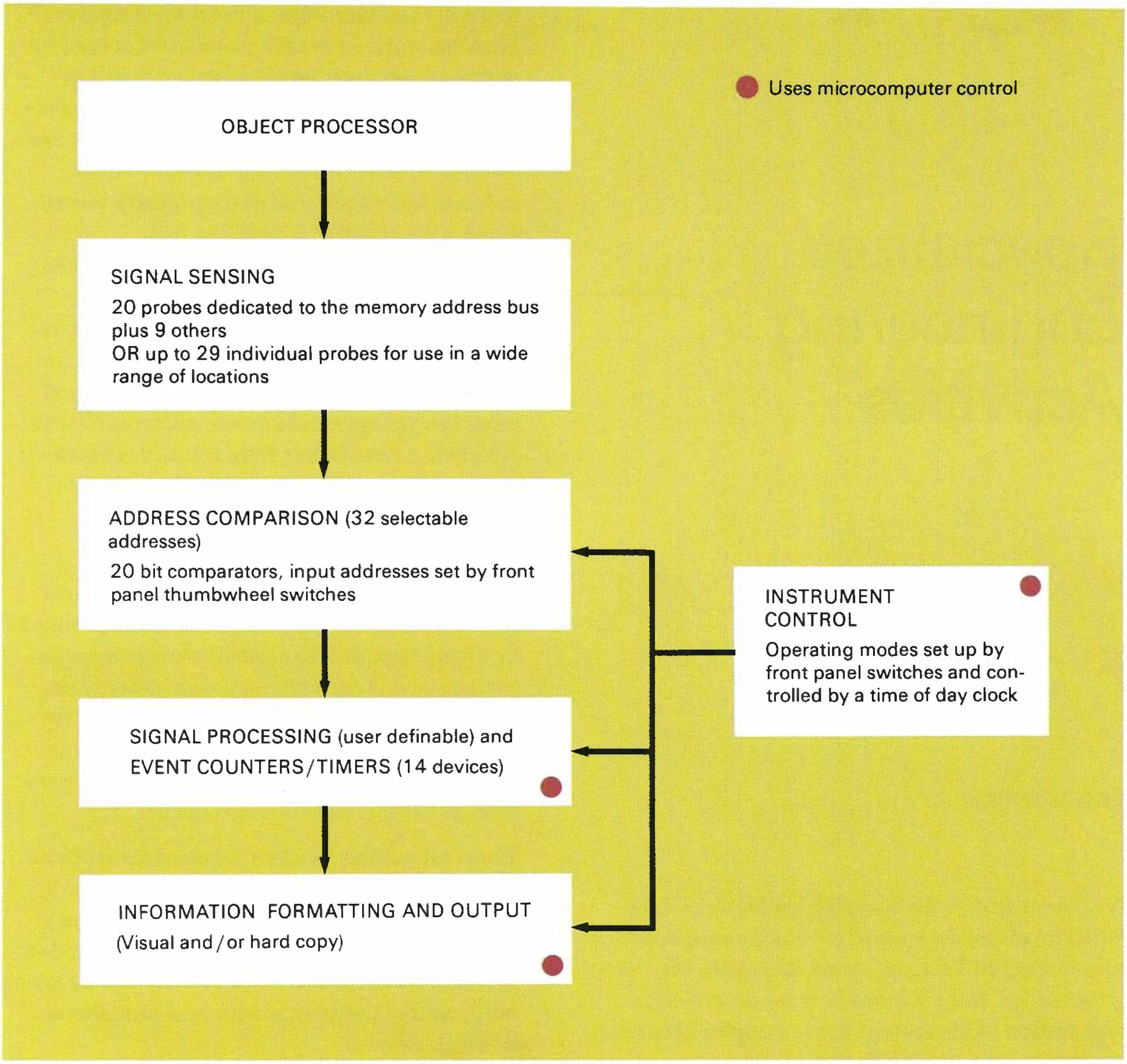
The overflow of a count can thus be used to initiate maintenance on the expected faulty device.

Fault correlation is a promising technique and is to receive further investigation in the future. Original work on fault correlation applied to Telecom Australia's integrated switching and transmission (IST) SPC exchange was performed by Mr. A.R. Willis of the Research Department of the Post Office, UK under the auspices of an engineer exchange scheme with Telecom Australia Research Laboratories.

Processor Capacity Test and Measurement Equipment for Stored Program Controlled (SPC) Telephone Exchanges

The monitoring of SPC exchange software operation is a valuable aid in improving system efficiency and in understanding performance limitations. This task may be attempted within the processor itself, for example with software modifications, but this inevitably ties up some processor capability which usually is not permissible. Consequently, in several administrations, hardware monitor systems have been or are being developed. These systems can be used for detecting system bottlenecks, utilization of Central Processing Unit time, use of peripheral units, etc..

The need within Telecom Australia for a new instrument arose from a desire to monitor the performance of large SPC exchanges, in particular the 10C Trunk Exchanges. The most important type of measurement to be made is that of "processor



Processor monitor instrument - block diagram

loading". This may take the form of counts of different classes of calls handled, or the frequency with which particular call record buffers are used, or the processing time occupied by particular program sequences. Measurements to aid system debugging, or measurements of processing times and frequencies to provide input data for traffic engineering or other planning studies, can also be needed.

In order to make measurements the instrument monitors a selected computer memory address. The memory locations which are subsequently addressed are then used as an indication of the process which is being performed. Further information is obtained by using probes attached to various parts of the computer hardware.

The instrument consists of five parts: signal sensing, signal detecting, signal processing, instrument control and information output.

Signals are sensed using a set of high impedance probes attached to the system being monitored. Signal detection consists of matching the sensed signals with those sought and then producing an appropriate output. The instrument allows for 32 preset addresses to be sought.

Following signal detection the outputs are processed to obtain data which reflects the operation of the computer being examined. This processing is performed by using the outputs to drive counters or timers. A microprocessor controlled system then outputs information to a visual display unit.

Specialized Engineering Activities

Introduction

Various teams in the Research Laboratories continue to undertake specialized engineering activities to support Telecom's overall engineering programme, and a few samples are described in this section of the review. These samples illustrate the variety of both the projects and the manner in which they are originated.

Sunlight Exposure Trials on Telephone Instrument Cases

For the past fourteen years Telecom Australia has used ABS (a thermoplastic terpolymer of Acrylonitrile, Butadiene and Styrene) for the moulding material of coloured telephone handsets. Whilst ABS has performed well, known shortcomings such as surface discolouration and dulling, susceptibility to staining and reduction in impact strength with age, led to an investigation of alternative thermoplastic materials. Information available from overseas telecommunication organizations assisted the Research Laboratories in the selection of seventeen different grades of plastics derived from six polymer types.

In the preliminary stage of the project test specimens moulded from each material were aged for a period of two years under glass and tested at specific intervals. In this way, the deleterious effect of solar radiation and thermal oxidation were continually assessed. As expected, no single polymer was superior in every property investigated. One material, a modified ABS, Acrylonitrile-Styrene-Acrylic elastomer (ASA), whilst not outstanding in any one parameter, exhibited improvement over the currently used ABS grade "Cycolac" T, in the majority of tests conducted. Being a modified ABS its price and mould shrinkage would be somewhat similar to ABS hence from both a technical and economical aspect, ASA could be a suitable alternative to ABS.

A second material, Polyvinyl Chloride (PVC), although found to be likely to undergo serious degradation in the Australian climate, is known to be highly regarded by several overseas administrations, and is currently in use or under evaluation in several countries. These two materials were, therefore, selected for a final evaluation which is being conducted on moulded telephone cases as distinct from test specimens.

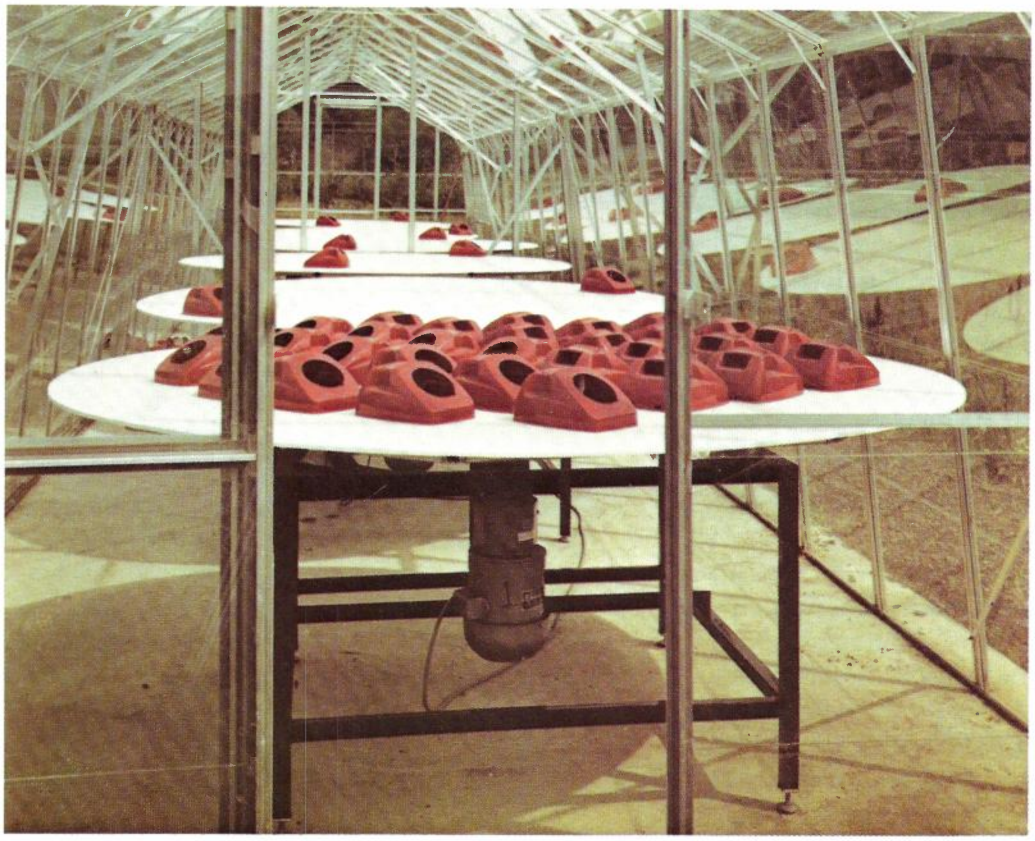
The great number of cases required for replicate evaluation and the need to ensure similar exposure of all faces of the moulding to the sun's rays was a major problem. It was finally decided to follow the UK Post Office practice of automatically rotating the cases placed on a turntable inside a glasshouse.

The Standards and Laboratories Engineering Branch of the Research Laboratories was asked to design and build a sunlight exposure facility consistent with the following parameters:

- Telephone cases were to be housed under glass in similar conditions to those of earlier exposure trials.
- The exposure was to be evenly distributed over all faces of each case.
- It had to be simple, reliable and suited for at least one year's continuous operation in air temperatures of up to 60°C and shade temperatures of 48°C.

The final facility provided was a glasshouse at the Blackburn Road Laboratories housing six rotating tables each holding fifty telephone cases.

The 1.9 m diameter tables are independently driven at 1 rpm during daylight hours and the drive system switches off automatically overnight. The orientation and spacing of telephone cases



Telephone cases on rotating tables

and their slow rotation ensures even exposure to the sun.

The table tops consist of a tubular aluminium frame sandwiched between discs of plywood. This arrangement is light enough to be readily handled by two men, yet has enough rigidity to avoid warpage as the plywood dries out. The top surfaces of the tables are painted flat white to protect the plywood, keep their temperatures down and to reduce unwanted light reflections onto the telephone cases. Each top is supported on four crowned ball bearing rollers fixed to the main tubular steel support frame and is rotated by a geared 1/4 hp single phase electric motor mounted underneath it. Safety clutches couple the motor driveshafts to the tables so that if a table is accidentally stalled its gearbox is not damaged.

The torque available from each motor is many times that necessary to drive a table and a strict maintenance programme is in force. Because of these precautions it is believed that the system will operate reliably with little supervision for the required twelve months, despite the torrid environment in which it is housed. After a minimum of refurbishing at the end of the first year, it is anticipated that this facility will be available for further exposure trials of a similar nature.

Specification Assurance of the Laboratories Electrical and Scientific Instruments

The work of the Laboratories is heavily dependent on the accuracy and reliability of its test equipment. To ensure that the Laboratories' equipment is in fact meeting its claimed performances and to provide user confidence, a regular and systematic scheme is in operation for the calibration and performance verification (and, as applicable, preventative maintenance) of the majority of the general purpose portable measuring instruments.

The Specification Assurance Programme, as the scheme is called, embraces such classes of instrument as analogue and digital voltmeters and multi-function meters, oscilloscopes; spectrum and waveform analysers, component bridges, magnetic tape and chart recorders, signal generators and oscillators, RF power meters as well as a number of more specialized items. There are over

1500 instruments currently covered by the programme including, for example, about 200 oscilloscopes and about 100 digital voltmeters.

The scheme operates on programmed recall intervals, for various classes of instruments, ranging from 6 months to 3 years. However, within these broad assessments, the programme is continually reviewed and both the extent of testing and frequency of recall for any particular instrument are tailored to meet the user's needs. User-initiated remedial service work or special purpose calibration requirements are fitted in with the scheme and recall dates modified accordingly.

Instruments are recalled to a central laboratory where the calibration facilities enable technically skilled staff to check the performance against local working standard instruments. These in turn are verified and supported by a standards hierarchy comprising, in ascending order, local reference standards, standards maintained by the Electrical Standards and Time and Frequency Standards Sections of the Laboratories, and national and international legal standards maintained by standards organizations such as NSL (Sydney), NBS (USA) and NPL (UK).

Because of the volume of work involved in the Specification Assurance Programme the equipping of the calibration facility has to be planned with considerations of throughput of work and operator convenience/effectiveness as well as accuracy. To this end emphasis is placed, where practicable, on semi-automatic equipment and purchase of such commercially available instruments is made where justifiable. However, in the Laboratories situation of widely diverse application, and hence, relatively small numbers of any one type or model of instrument, local developments are continually being made to improve speed of operation whilst retaining versatility of measurement capability.

The main in-house expertise and facilities for calibration work lies in the electronic field which in modern applications covers a very wide scope. Nevertheless there are a number of areas where external services are more appropriate and in these cases service contracts on ad hoc calibration arrangements are made, co-ordinated, assessed and reviewed by the same area which operates the in-house Specification Assurance Programme. The main areas where external services are used are in the computer/calculator systems field and in specialized optical, physical testing and scientific analysis equipment.

Microcircuits for Push-Button Telephones

The production of the multi-frequency code (MFC) signalling function in push-button dialling systems is achieved normally by the use of inductance capacitance oscillators. With recent advances in semi-conductor and microcircuit technology, it is now possible to economically manufacture thick or thin film microcircuits to provide this function. By adopting this approach, the assembly becomes not only smaller in size, but also more rugged and offers improvements in performance, reliability and cost.

The Customer Equipment Branch of Headquarters' Engineering Department is now developing the Touchfone 12 system, and is considering a thick film microcircuit solution to the generation of the signalling tones.

The heart of the microcircuit is a complementary metal oxide silicon (CMOS) integrated circuit tone encoder consisting of a high frequency oscillator, programmable divider, digital to analogue converter, and output driver. As other additional components, including a quartz crystal, power supply bridge and regulator, filter capacitors and protection networks are necessary to perform the signalling function, the circuit becomes a multi-component package.

A thick film microcircuit solution to the packaging problem is being evaluated. Because it is so much smaller than a printed wiring board assembly, it easily fits into the confined space of the shell of the telephone; it has far greater reliability due to the decrease in the number of interconnections and the rugged nature of the high temperature fired resistors and noble metal conductors.

The Research Laboratories' Microelectronics Section, in conjunction with the Customer Equipment Branch, has developed three prototype thick film hybrid microcircuits to perform the MFC signalling function. All have been specifically laid out to allow fabrication in "state of the art" Australian thick film hybrid houses. The three designs represent different degrees of fabrication sophistication and at present a study is being conducted to estimate the comparative reliability and cost effectiveness of the designs. Basically, the designs, in order of decreasing reliability are:

- Hybrid microcircuit with all components, except the crystal, hermetically sealed under a "Kovar" metal cap.
- Hybrid, with all semiconductor devices, except the protection diodes, hermetically sealed under a ceramic cap. Other components are reflow soldered to the conductive pattern.
- A semi-discrete hybrid in which conductors and resistors are fired to the substrate but, in which the dual-in-line fully-packaged integrated circuit and other components are attached by reflow solder techniques to the conductive pattern.

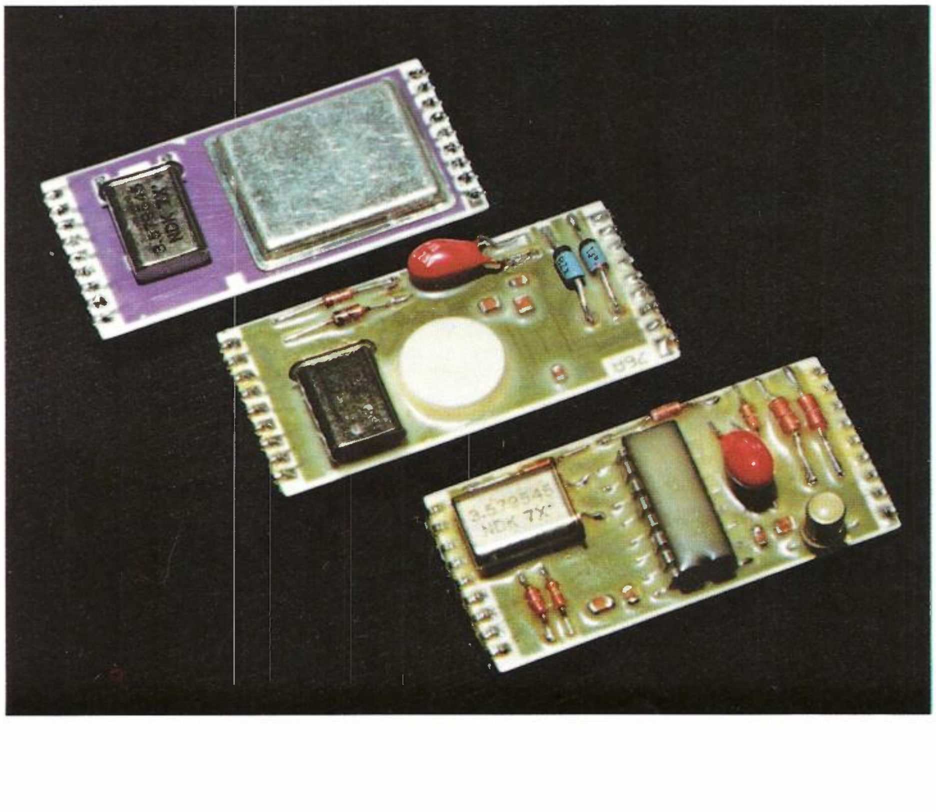
Comparing the three designs, the first two are more difficult to fabricate and suffer a yield problem due to the use of chip devices. The third design, which uses fully packaged and tested semi-conductor devices, is relatively simple to fabricate, however, as there are a large number of seals and additional interconnections, the reliability of the hybrid must be reduced.

It has been clearly shown in many industries that a significant hidden cost is the service cost of replacing faulty components. Because of the greater proven reliability of hybrid microcircuits, service costs have been considerably reduced where hybrids have been used.

Precision Phase Lock Oscillator Systems

The fidelity of both speech and data transmission over the frequency division multiplex (FDM) network depends on the agreement in frequency of the oscillators used in the modulation and demodulation processes. The degree of oscillator synchronization required increases with channel frequency and with data rate. For instance, for the upper channels of a 60 MHz system, the pitch error is about 1 Hertz or 2 parts in 10^8 of frequency error, implying a future high frequency accuracy for speech circuits, with still greater stringency for data circuits. The reference frequency used to check and set the oscillators must of course be several times more accurate again. It is necessary also for the same reference to be available throughout the network, at least to the requirements of pliesochronous systems, to avoid the accumulation of error.

To meet requirements of this sort, the Time and



The three prototype thick film hybrid microcircuits described in the text

Frequency Standards Section has been investigating means of making a satisfactory frequency reference available at distant locations from its standard source. The use of a control signal, transmitted over the network, appears to offer a cheaper solution, both in capital and maintenance costs, than for example the alternatives of the prolific use of atomic clocks or the frequent transport of guaranteed high quality calibrating oscillators, especially since a standard 1 kHz tone transmission now exists from the Caesuim beam standard at the Research Laboratories.

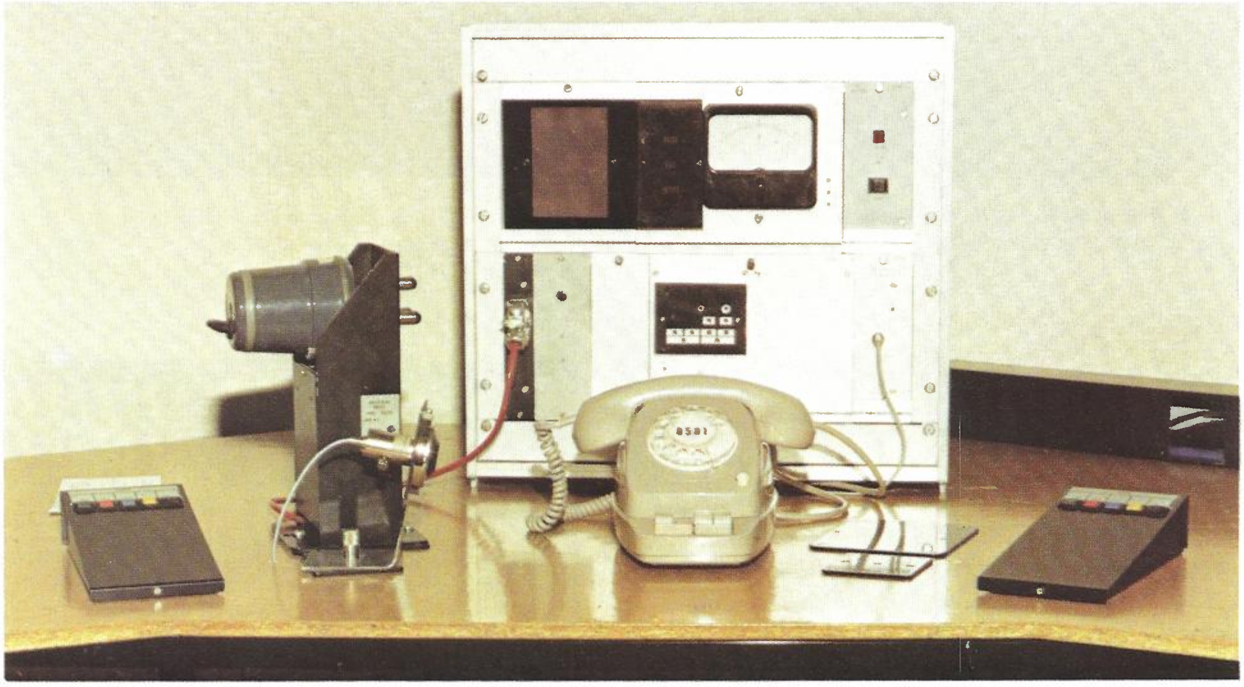
This standard frequency service has been in operation for nine years, and measurements have shown that the average frequency accuracy of the received 1 kHz is excellent provided that certain transmission conditions are met. For example, the intermodulation products of the network must be kept below a specified level. The usefulness of the 1 kHz is limited by its low frequency and by the phase noise added to it by the network. These objections are largely overcome if the 1 kHz can satisfactorily control a good quality HF quartz oscillator at the receiving end. This approach is under investigation and three methods of control are at present being tested, both in laboratory and field experiments.

The first method has been undergoing field experiments in eastern states for some time and gives very good results on circuits with relatively small noise. The control voltage is obtained from an averaging sample-and-hold circuit operating at 124 kHz. For satisfactory operation the amplitude of the phase noise should be small compared with the period of the signal being sampled. On noisy circuits, or circuits subject to phase jumps (due to radio bearer switching) loss of lock can occur. The maximum phase jump of the received 1 kHz which has been observed is 7 microseconds. A further problem with the method is to obtain a correct control voltage for use when the reference signal fails, as the averaging time of the analogue system is relatively small.

In a second method of control the mean frequency of the oscillator is measured digitally over successive time intervals and the frequency is corrected to make the frequency error approach the measuring resolution. For example, for a 20 s measuring interval the theoretical ideal resolution is parts in 10^{12}, a very satisfactory figure, but in practice the slow variation of phase noise and other statistical variations limit the resolution so far obtained to 1 part in 10^9. Therefore it is inadequate both in frequency and phase accuracy. Methods of averaging the residuals from the measuring intervals are being examined to improve the system.

A third method of control has been developed to overcome the deficiencies of the first system. The control loop is operated at 1 kHz to make it tolerant of large phase noise. The control voltage comes from a continuously updating store which represents a long term average against the reference signal, as that frequency accuracy is held during loss of the reference. The system gives a true zero phase error. That is, there is no progressive phase offset as the controlled oscillator ages and there is no constant offset proportional to the ageing co-efficient. The method uses a digital realization of a theoretical solution for zero phase error control systems which shows that the control voltage should derive from three signals, one proportional to the average phase error at any time, one proportional to the continuing time integral of the phase error, and one determined by the sign of the phase error. The circuit has a wide capture range and prevents frequency hang-up (that is indecision during pull-in). It has a simple setting-up procedure, which is important where large time constants are involved. In any system a persistent change in the arrival time of the reference (that is a phase step) requires a decision. Here, there is a choice between allowing the oscillator to move to the new phase at the time constant of the system, and resetting the control loop to the new phase where minimum oscillator disturbance is important. This system is at present being tested in the laboratory and in simulated field trials routing the reference signal through the network via looped-backed channels.

Consultative Activities



This equipment was developed in the Research Laboratories

Introduction

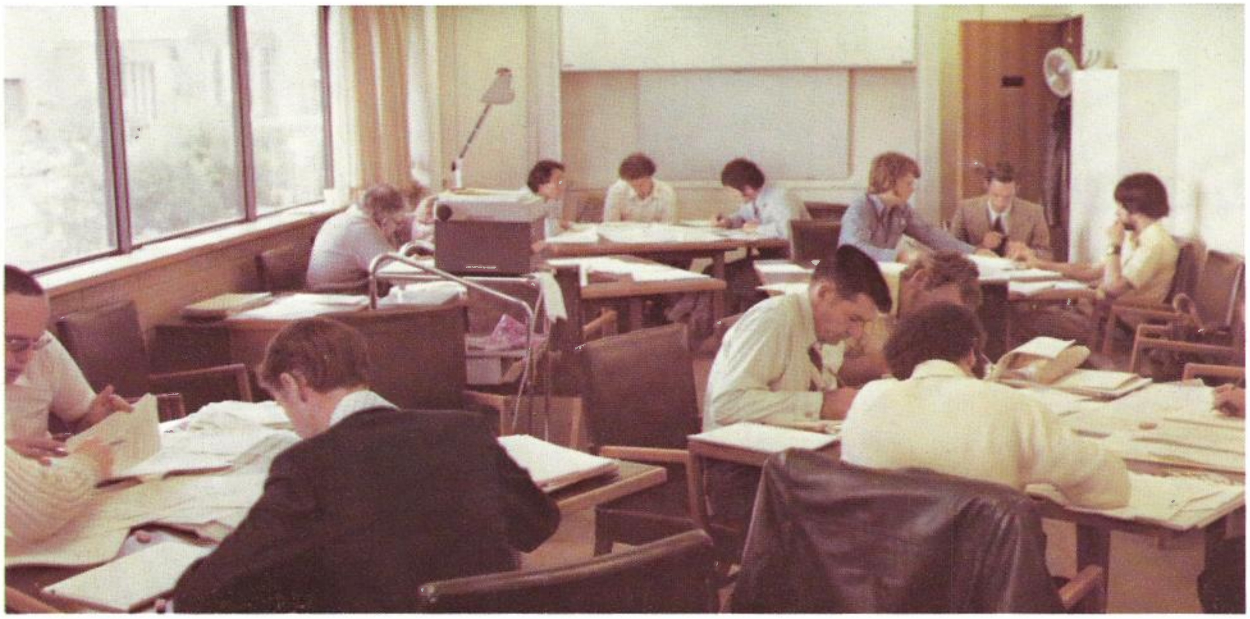
The importance of the consultative activities of the Scientists and Engineers in the Research Laboratories is indicated by the increased demand for these services, and the examples described have been selected to indicate the extensive areas of interest. Requests for advice originate from both within Telecom Australia and from contractors, frequently as a matter of urgency. Possibly the most exciting of these are the "bushfire" type requests which demand immediate action to rectify a serious situation. On a less urgent note, information is exchanged and knowledge gained through participation in and attendance at seminars, conferences, colloquia etc.

On-Site Lectures to Staff Engaged in Telephone Acceptance Testing

A consultative service is provided to Telecom Workshops and Inspection staff, in each state, regarding the testing of customers' telephone apparatus.

Day to day consultation is supported by visits to each state every few years, to instruct new staff, inspect test equipment and investigate problems.

Visits in 1977 enabled many such problems to be identified, the resolution of which, it is estimated, will result in annual savings in excess of $200 000.



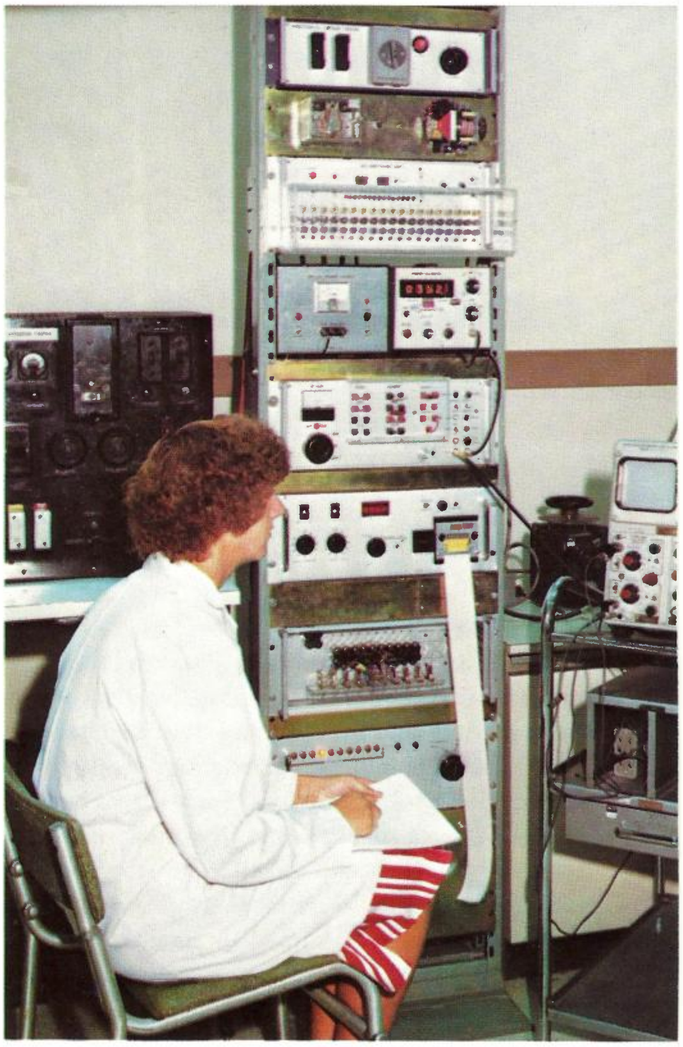
Officers from Telecom Australia and other Government Departments at the 1977 SDL course. Each course is organized around syndicate groups, with a set task such as the design of an advanced SPC local exchange subscriber facility.

Stored Program Controlled (SPC) Exchange Specification Methods

Since the first introduction of SPC Exchanges, telephone companies and in particular telephone administrations have been keenly conscious of the need for a new technical language to describe concisely the operation of control programs. Such a language has now emerged from an international effort sponsored by Administrations such as Telecom Australia, through the work of an international body (CCITT). The language is known briefly as the Specification and Description Language (SDL) and is expected to pass into world-wide use as newer SPC systems are designed and documented.

SDL is a graphical language, firmly based on the concept of suspended processing states, for example the stable states in setting up of a telephone connection, and on analysis of the transitions between such states (call-state transitions). SDL provides an immediately intelligible description of the functional operation of SPC control, without the burdensome minutiae of detailed program instruction listings. It is useful both to the designer and to the purchaser of such systems since it allows exact specification and in due course comparison of alternative systems.

The Research Laboratories commenced work in this area in 1971 following earlier experience with



The arrestor test set

The impulse generator being used to measure earth parameters using a high voltage pulse

SPC systems (the IST project), and its own development of Call-State Transition Diagrams has been a major influence on the definition of the CCITT's SDL. The Laboratories have contributed ideas and maintained Telecom Australia access to the development of SDL by provision of a chairman to the CCITT Working Party. In order to increase the effective use of SDL within Telecom Australia the Laboratories have provided lectures, presentations, manuals and in particular an annual 2-day training course.

Automated Lightning Arrestor Test Set

The increasing use of lightning arrestors to protect Telecom Australia equipment requires the Research Laboratories to frequently test new arrestor types. In the past this has necessitated the sequential testing of individual samples, which because of the length and complexity of the test methods, restricted the numbers which were tested to a statistically insignificant size. A test set has therefore been built which enables dc and impulse sparkover measurements and ac current testing of up to 60 arrestors to be performed automatically, the detailed study of the factors influencing the arrestors performance is expected to provide much clearer insights into the reliability and possible failure modes of new types of arrestors.

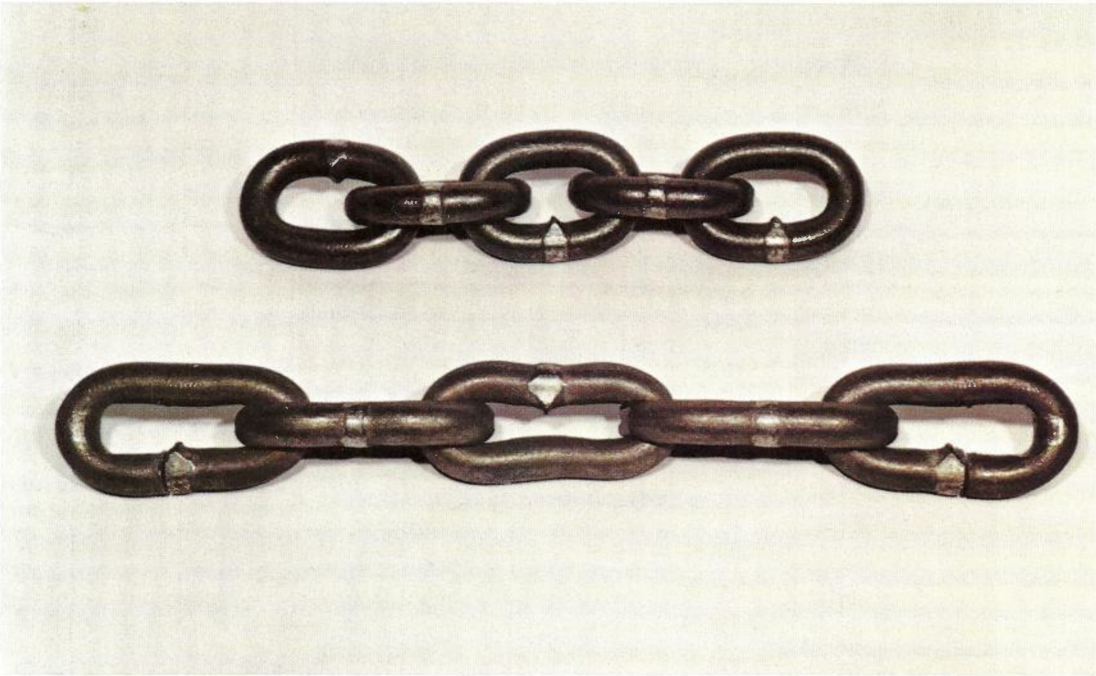
Portable Impulse Generator

A Portable Impulse Generator was designed and constructed in the Laboratories. It is used to simulate lightning effects on plant which cannot be tested in the laboratory owing to size, a need to have it tested in the field, or that its operational environment may not be feasible, convenient or economical to simulate. In its present form the Portable Impulse Generator has a maximum output potential of 60 kV and pulse energy of 3.6 kJ

Engineering Library

One of the most important sources of information in science and technology is the journal and report literature. The enormous volume of this material makes the identification of specific information an extremely complex and frequently time-consuming operation. To minimize these obstacles to rapid information retrieval the Telecom Australia Headquarters' Engineering Library has become a registered user of the Lockheed DIALOG computerized information retrieval system located in Palo Alto, California. By accessing the service directly from a terminal in the Library, the reference staff are able to conduct rapid, comprehen-

Specimens of chain before and after test

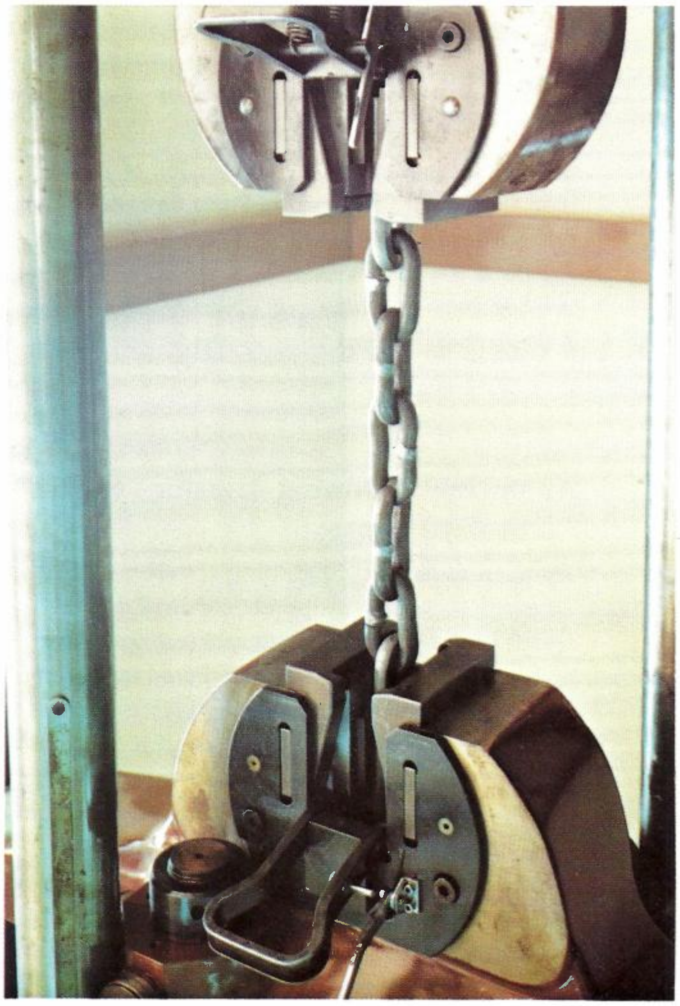


sive searches of major information sources such as Engineering Index, Electrical and Electronics Abstracts, Physics Abstracts and the US Government Research and Development Reports Index. As well as enabling these data bases to be searched quickly and effectively the DIALOG service also provides direct access to a wide range of other indexing and abstracting services for which the high cost of the hard copy cannot be justified by its occasional intermittent use. These include Management Contents, Educational Resources Index and Sociological Abstracts.

This facility is proving to be a highly successful addition to the range of services provided by the Engineering Library to staff within Telecom Australia.

Life Expectancy of Safety Helmets

The safety helmets used by Telecom Australia field staff are mostly made from plastics such as ABS or high density polyethylene. These materials degrade when exposed to ultra-violet solar radiation. Based on knowledge and experience of these plastics when used in the Australian environment, recommendations have been made for the safe working life of helmets. More definitive long term studies of this problem are planned.



Specimen of chain under test

Failed link in chain

Lifting Chains

A Standards Association of Australia Committee is preparing a draft standard on lifting chains. As the influence of the surface finish on the tensile properties of chains was in dispute, the Telecom Australia Research Laboratories were consulted and requested to perform the necessary experimental studies to resolve the problem.

This has entailed tensile testing chains of three different link sizes, each link size manufactured in three different strength levels of steel, and each type supplied in a variety of surface finishes.

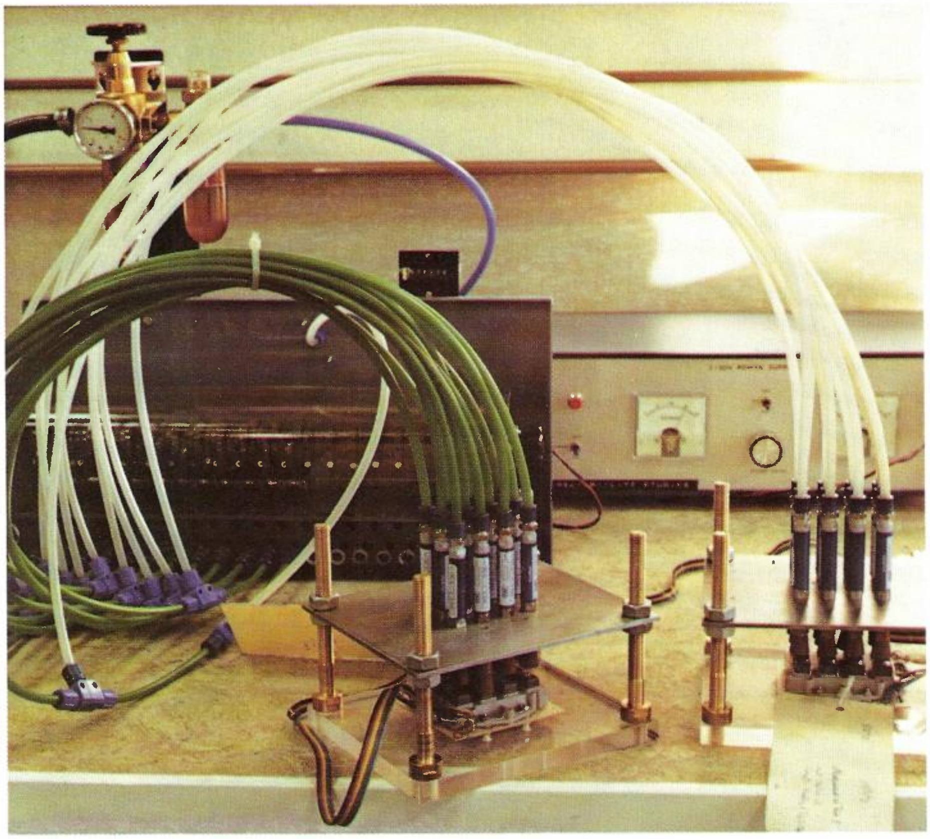
Burning Behaviour Tests for Cables and Wires

Flammability of materials has been the subject of much study during the past few years and several new test methods have been developed for the determination of the combustion propagation characteristics of plastics.

The Oxygen Index test, referred to in SAA documents as Minimum Oxygen Concentration for Flame Propagation (MOC) uses test specimens of standard dimensions and determines the minimum oxygen concentration necessary to just support flame propagation under test conditions of varying mixtures of oxygen and nitrogen. This test has gained widespread acceptance in the quality control of plastics, and for research and development purposes. However, the MOC of sheathing-grade and insulating-grade polyethylene and polyvinyl-chloride is not indicative of the fire hazard of the cables or wires under actual use conditions. The fabrication process of the plastics into insulant or sheath and the final form of the cable itself, together with the manner of installation, the method of termination, the provision of fire barriers and other important factors determine the fire hazard of the plastics.

The Bundle-Flame test, described in the International Telegraph and Telephone Consultative Committee (CCITT) document Com. VI No. 26-E (1975) has been developed for determining the burning behaviour of wires and cables rather than the materials of construction. When testing single wires, such as switchboard wire, flames from two propane-fuelled bunsen burners are directed onto 91 equally spaced (5 mm centres) wires arranged in a parallel array.

The unit containing the wires is placed in a draught-controlled cylinder and the whole assembly is held in a fume hood. The length burnt serves as a measure of flammability. Cables are



Pneumatic test unit

tested in much the same way except that one central length of cable is surrounded by six others, the space between adjacent samples being equal to the cable diameter. The flaming time necessary to achieve a complete burn-up of the cable is a measure of the flammability.

Early results show that the current polyethylene insulated and sheathed distribution cable burns vigorously and completely, producing droplets of molten flaming plastics. These droplets are an additional fire hazard and serve to spread the fire further beyond the immediate area and could also become a hazard to staff. Polyvinyl-chloride exchange cables burn much less vigorously than polyethylene but evolve the highly toxic and corrosive gas hydrogen chloride.

The studies conducted on "filled" cable using a single propane-fuelled bunsen burner inclined at 20°C to a vertically held cable showed that the oil/wax filler mixture appears to have minimal effect on the combustion characteristics of polyethylene insulated and sheathed cables.

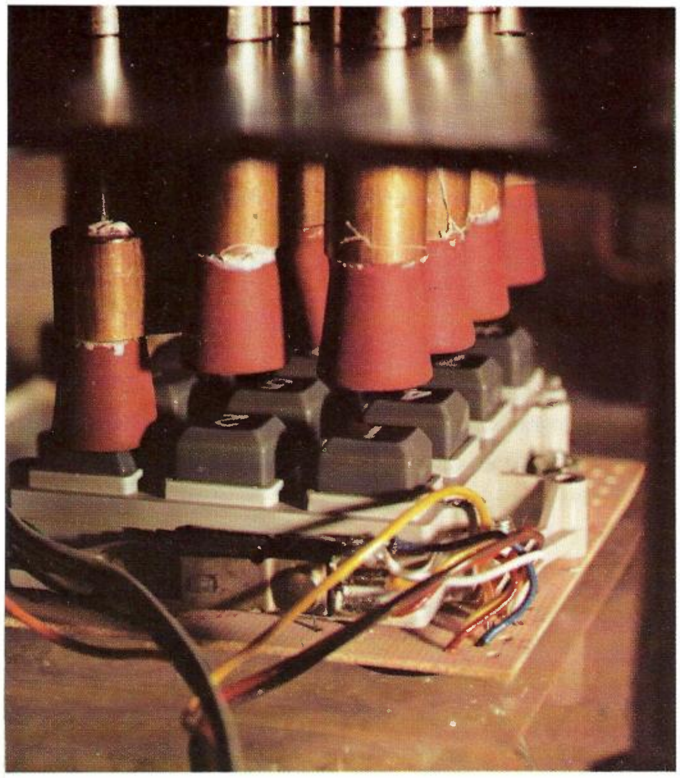
Cables with an aluminium foil laminated to the sheath have a reduced burning rate and require more energy for ignition than cables without aluminium foil.

Mathematical Consultancy Services

Research work in switching and signalling makes frequent use of specialized expertise in mathematics and statistics. This service is provided (in the Laboratories) by a small group of Research Officers.

As well as satisfying local requirements, it has become customary to provide a consulting service to assist projects in other areas of Telecom. This may be by assistance with mathematical techniques in computer programming or else in the solution of problems of mathematical or statistical analyses encountered during technical projects. A recent example has been assistance with the design of statistical experiments for the Performance Objectives Section of the Transmission Planning Branch, Headquarters with their Customer Transmission Interview Project. More recently, discussions with the Laboratories, have resulted in a mathematical solution which should lead to greatly reduced complexity of testing for selection of cable pairs suitable for use as PCM bearers.

The scope for larger project assistance is limited because of the demands of local workload but this service will continue to be made available to



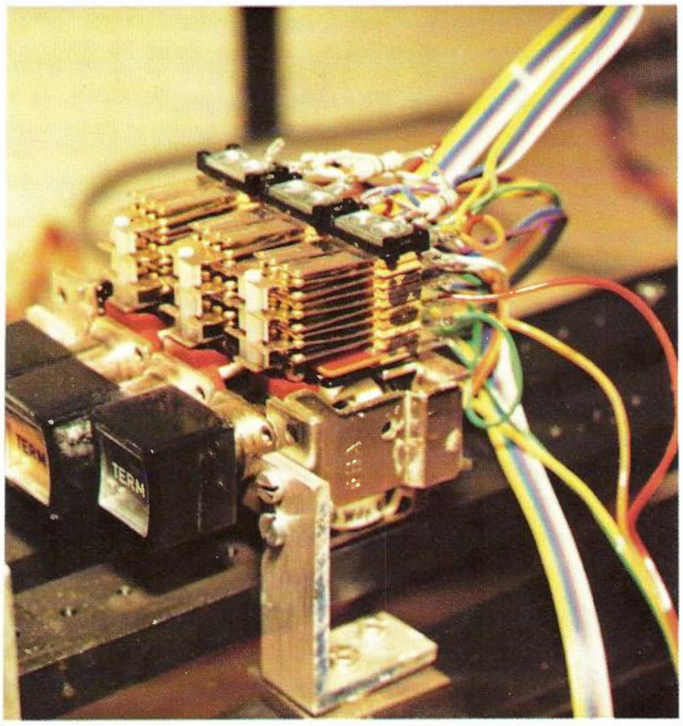
Close-up of key pad under test

people seeking help with the more technically intricate problems of analysis which occur in technical projects.

Push Button Keyblocks for Touchfone

An assessment of the expected useful life of the push button keyblocks used in the recently introduced Touchfone has shown that the most probable cause of eventual failure is breakage of a contact spring due to metal fatigue. Keyblocks are life tested by finger simulating plungers, arranged in a 3 x 4 matrix above the block, operated either by solenoids or pneumatically. The electrical output from the keyblock was initially monitored by hard wired circuits but later tests used microprocessor monitoring.

The tests have shown that the fatigue life of the suspect springs are critically influenced by the plating treatment. Changes in that treatment, as well as alternative metals have been investigated, and the indications are that such changes should lead to satisfactory life expectancy.



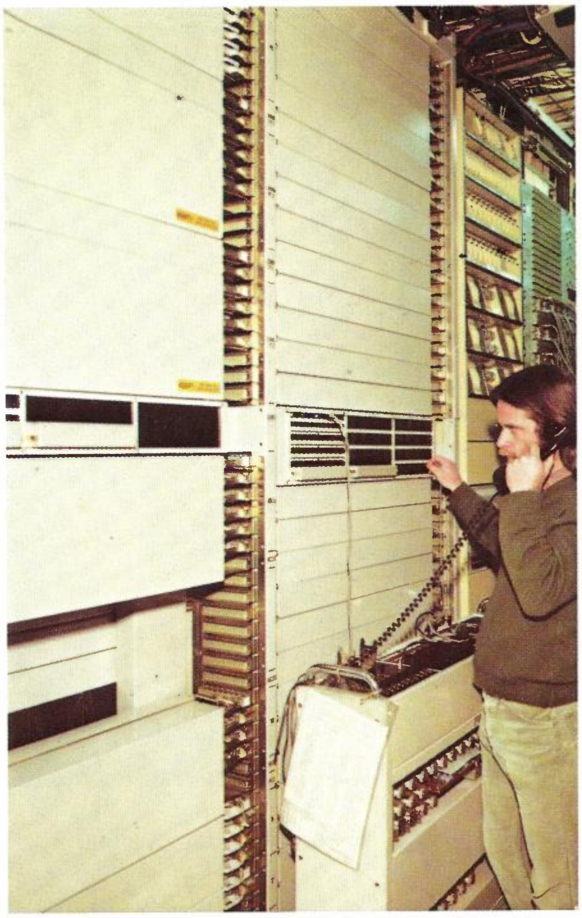
The push buttons shown being switched by mechanical actuation have their contact closures monitored by the microprocessor which also checks the actuator to ensure that it is working. Switch failures detected are printed on a teletype together with the total number of switch operations before failure occurred.

Microprocessor Controlled Component Evaluation

Electronic component evaluation in these Laboratories has always been a labour intensive process. To reduce the need for the repeated construction of specialized test equipment, microprocessors are now being used as general control units.

A large set of sub-routines have been written, to cater for a wide variety of tests. Detailed programs for specific tests may be compiled rapidly, largely by just linking relevant sub-routines thus avoiding the construction of single purpose test equipment.

Tests presently being conducted include the evaluation of telephone key pads and push button switches. A microprocessor system is in the course of construction for testing reed relays.



The T5 relay sets and the PCM systems for use in the IST field trials are integrated into the exchange equipment suites at Windsor (left) and Clayton Exchanges (right). The test jack field on the T5 rack provides facilities for local operations staff to test or monitor the performance of incoming and outgoing circuits during maintenance activities.

Corporate Identity Colour Control

The Corporate Identity Programme, instituted when the Australian Telecommunications Commission was formed included the adoption of a new standard colour, "Telecom Gold", for use on logos, stationery, telephone cabinets, automotive plant, etc. Colour tolerance sets for decorative and automotive paint, which show the required colour and also the maximum allowable deviation from that colour in terms of the MacAdams Laboratory System, are being produced for use by paint manufacturers and others. The tolerance sets have been designed with close tolerances for automotive paint, and broader ones for decorative paints. Tolerance sets for "Telepost White" and "Signal Red" are being obtained also at the request of Australia Post.

Integrated Switching and Transmission (IST) Field Trials

As a continuation of the IST field trials, and in line with policy of maximizing the involvement of state operations field staff in Research Laboratories activities, a series of training sessions have been planned.

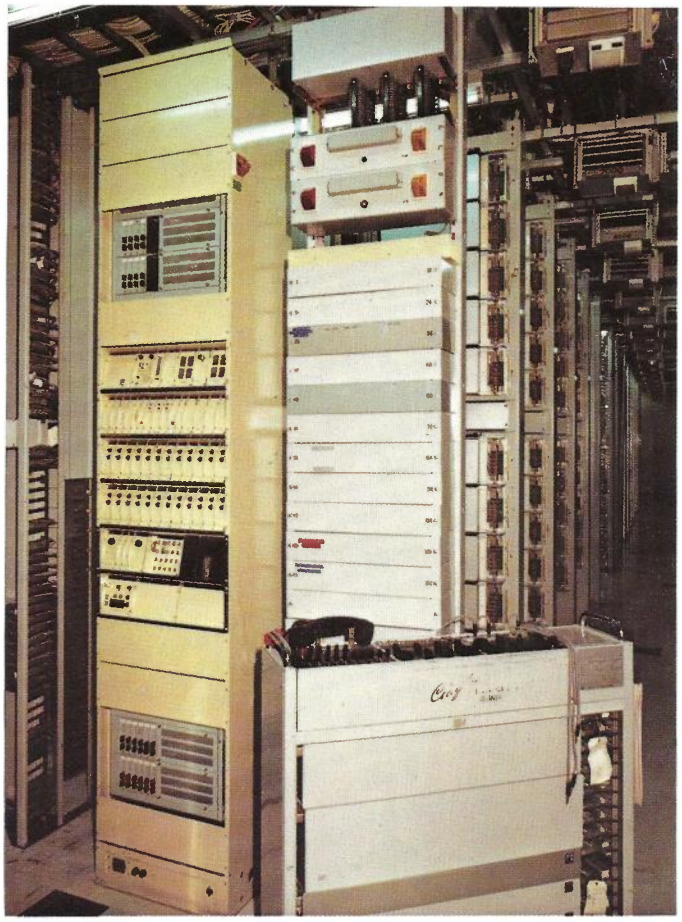
The introductory training session, consisting of a film, and an illustrated lecture was held at the St. Kilda IST Exchange and was attended by Engineers and Technical Officers of Metro Operations South Division.

The topics covered are:

- How the IST system is integrated into the telephone network.
- Basic functions of the cabinets which make up the IST System.
- Introduction to the T5 Signalling System.
- Introduction to Pulse Code Modulation (PCM).
- Derivation of signalling information from a PCM bit stream.
- "Hands on" practice in the "Initialization" and "Start up" of a Stored Program Controlled system.

Future sessions are expected to include:

- IST hardware familiarization.
- Alarm system.
- Routine testing.
- Fault finding.
- Interpretation of maintenance and operational statistics.

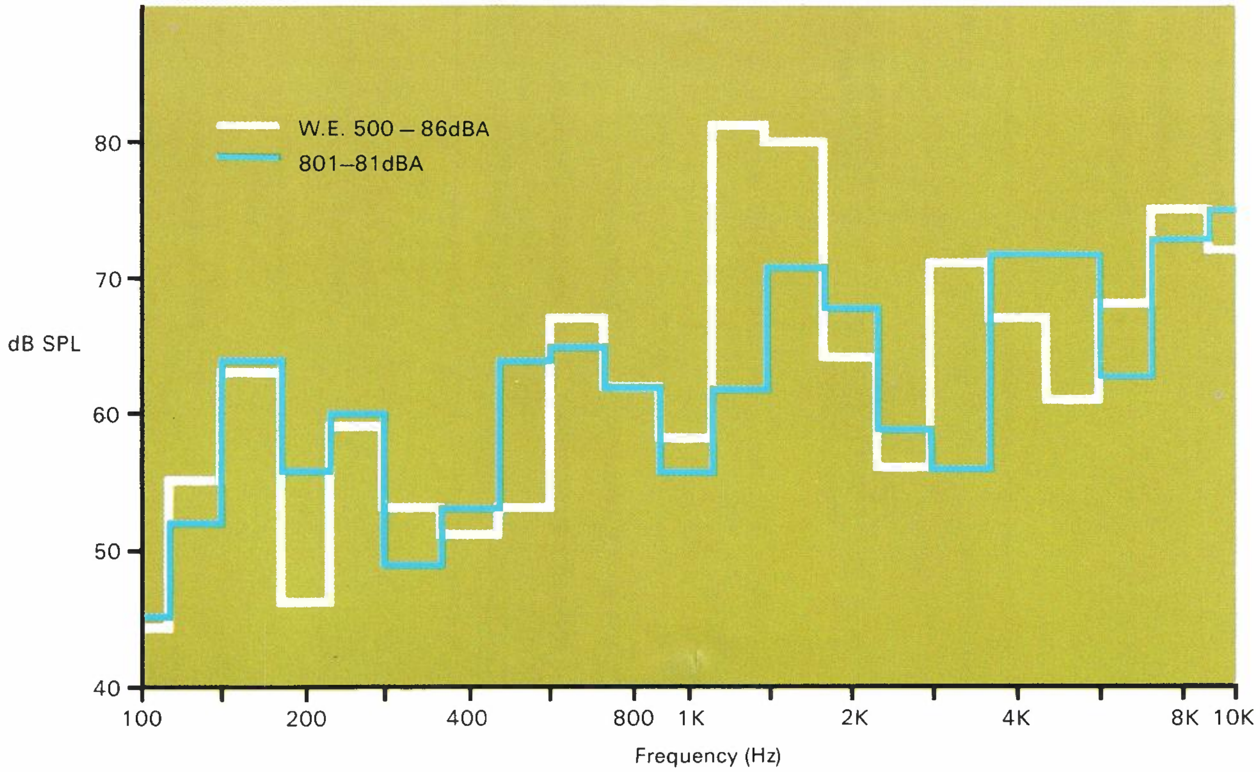


Participation in Inter-Department Committee on Improvements to the Table Telephone

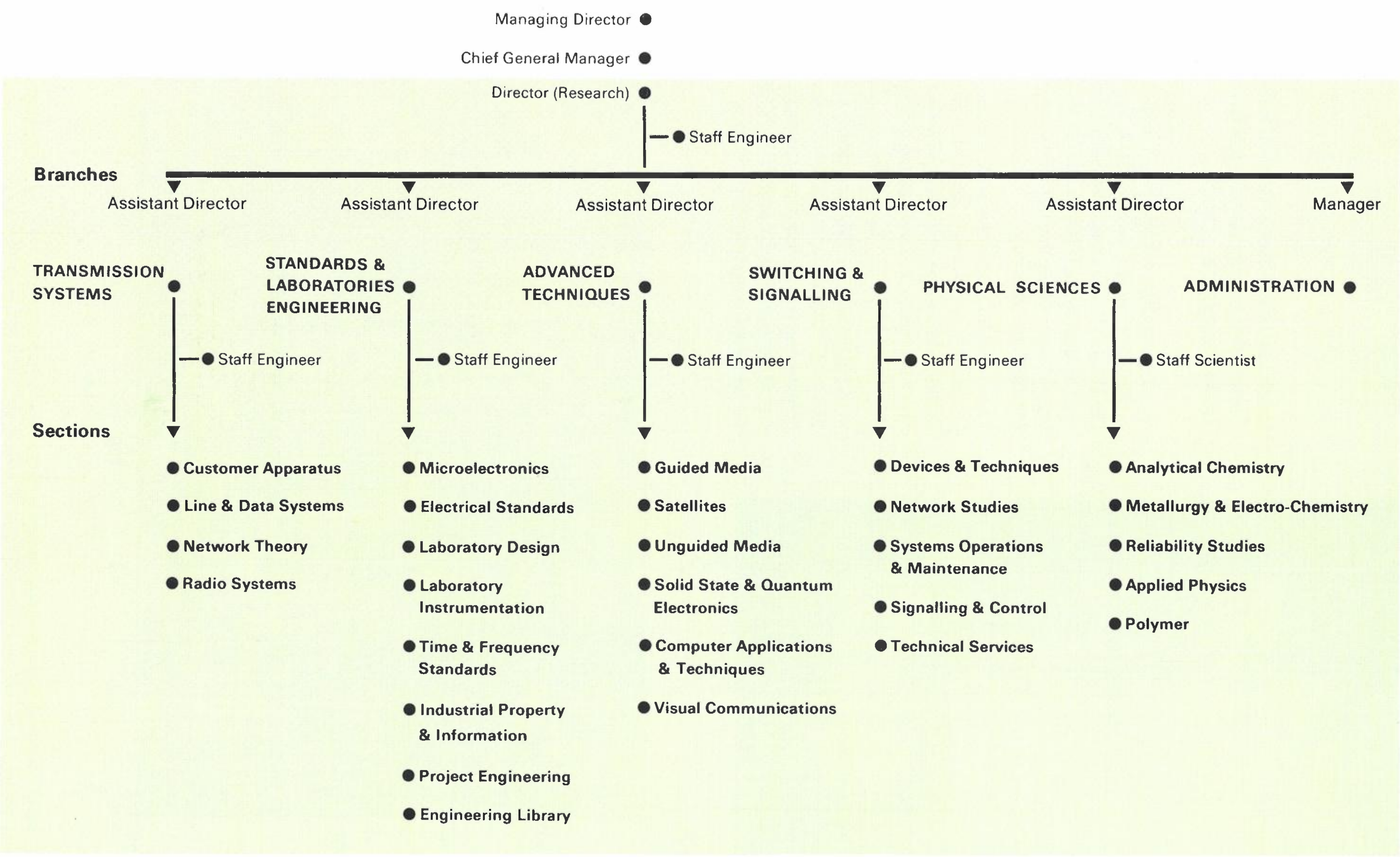
An inter-departmental Working Group convened by the Customer Equipment Branch, Engineering Department Headquarters, was set up early in 1977 to identify engineering deficiencies and to suggest methods for the improvement of the present telephone instrument.

The Research Laboratories made specific contributions towards various transmission aspects, including problems of upgrading performance with new transmitters, and overcoming deficiencies of the bell.

In its final report, the Working Group outlined the various deficiencies in transmission, operating reliability, and bell performance, and proposed several alternative plans for progressively upgrading the telephone instrument performance.



1/3 octave band spectrum comparison of the acoustic outputs of the 801 colourphone and Western Electric 500 series telephone bells, showing spectrum enhancement in the range 1000-2000 Hz of the WE500 due to gong resonators



The Research Laboratories organization

The Laboratories Staff and Organization

Organization

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

The Laboratories comprise, 28 scientific and engineering sections, grouped into five branches, and an administrative section. The scientific and engineering sections comprise, professional, technical and clerical support staff, with each section possessing expertise in particular areas of the engineering and scientific fields.

OVERALL OBJECTIVES OF THE LABORATORIES

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

Professional and Senior Staff

The names given below are those of the actual occupants of the positions (appointed or acting) at 30 April 1978.

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

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

TRANSMISSION SYSTEMS BRANCH

BRANCH OBJECTIVES

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

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

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

Customer Apparatus Section

SECTION FUNCTIONS

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

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

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

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

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

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

Line and Data Systems Section

SECTION FUNCTIONS

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

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

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

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

Engineers:
R.J. Dempsey, B.E.(Elec.)
N.Q. Duc, B.E.(Hons.), Ph.D., M.I.R.E.E., M.I.E.E.E.
P.J. Wellby, B.E.(Hons.), B.Sc.
J.L. Snare, B.E.(Hons.)
L.J. Millott B.E.(Hons.) M.Eng.Sc, M.I.E.E.E.
G. Nicholson B.E.(Hons.) M.I.E.E.E.

Senior Technical Officers:
J. Gillies
J.L. Kelly
R.B. Coxhill

Network Theory Section

SECTION FUNCTIONS

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

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

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

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

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

Radio Systems Section

SECTION FUNCTIONS

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

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

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

Engineers:
R.A. Court, B.E.(Hons.), B.Sc., M.Eng.Sc., M.I.E.E.E.
R.P. Coutts B.Sc.,B.E.(Hons.),Ph.D.,M.I.E.E.E.
J. Billington B.E.(Hons.),M.Eng.Sc.,M.I.E.E.E.
P.R. Hicks, B.E.(Elec.), B.Sc., M.I.E.E.E.
E. Vinnal, B.E.(Hons.)

Senior Technical Officer: D.J. Thompson

SWITCHING AND SIGNALLING BRANCH

BRANCH OBJECTIVES

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

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

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

Devices and Techniques Section

SECTION FUNCTIONS

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

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

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

Engineers:
D.J. Kuhn, B.E.(Elec.), M.Eng.Sc.
E. Tirtaatmadja, B.Eng.(Elec.)
D.M. Harsant, B.E.(Hons)

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

Network Studies Section

SECTION FUNCTIONS

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

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

Senior Engineers:
N.W. McLeod, B.Sc., M.I.E.Aust.
N.G. Gale, B.E.(Elec.)

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

Systems Operations and Maintenance Section

SECTION FUNCTIONS

- Study the characteristics and potential of new approaches in the field of operations and maintenance.
- Develop models which will be used to validate theoretical studies of new operations and maintenance systems techniques.
- Conduct field trials to assess the performance of new approaches and techniques in the field of operations and maintenance.
- Provide specialist consultative advice in matters pertaining to operations and maintenance.

Section Head: E.A. George, A.S.T.C., Post Dip. Elec. Comp., M.I.E. Aust.

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

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

Engineers:
B. Wickham, B.Sc., B.E., M.I.E.Aust., M.I.R.E.E., M.I.E.E.E.
G.J. Dickson, B.E.(Hons.), M.Eng.Sc.
F. Eastaughffe, B.Sc., B.E.(Hons.)

Signalling and Control Section

SECTION FUNCTIONS

- Study the characteristics and potential of new approaches in the field of control and signalling.
- Develop models which will be used to validate theoretical studies of new control and signalling.
- 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: P.H. Gerrand, B.Eng.(Hons.), M.Eng.Sc., M.I.E.Aust.

Senior Engineers
M. Subocz, B.E.(Elec.), M.I.E.Aust.
J.L. Park, B.E.(Hons.), M.Eng.Sc., M.I.E.E.E.

Engineers:
P.A. Kirton, B.E.(Hons.), M.I.E.E.E.
V.F. Peska, B.E.(Elec.) Grad. M.I.E. Aust., Grad. M.I.R.E.E.

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

Research Officer: G.M. Cody, B.Sc.

Technical Services Section

Section Function

- Provide field and laboratory planning, provisioning, investigations, development, production, testing and evaluation support for branch activities.
- Provide specialist expertise on national telecommunications network interworking and performance principles leading to the determination of standards and specifications for novel switching and signalling systems under under research and development.

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

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

ADVANCED TECHNIQUES BRANCH

BRANCH OBJECTIVES

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

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

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

Computer Applications and Techniques Section

SECTION FUNCTIONS

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

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

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

Engineers:
K.S. English, B.E. (Elec. Hons.)
I.L. Jenkins, B.E.(Elec. Hons.)
L.A. Denger, E.N.S.E.M.N., M.I.E.E.E., M.Soc.Fr.de Elec., Grad.I.E.Aust.
R.A. Frizzo, B.E. (Elec. Hons.)
C.A. Hunt B.E.(Elec. Hons.)
I.M. Palmer, Assoc. Dip. Electron. Eng.

Senior Technical Officer: I.J. Moran

Guided Media Section

SECTION FUNCTIONS

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

Section Head: G.P. Kidd, B.E.(Elec.)(Hons.), B.Sc.

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

Satellites Section

SECTION FUNCTIONS

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

Section Head: G.F. Jenkinson, B.Sc., M.I.R.E.E.

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

Senior Technical Officer: G.B. Newman

Solid State and Quantum Electronics Section

SECTION FUNCTIONS

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

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

Principal Engineer: P.V.H. Sabine, B.Sc., B.E.(Elec. Hons), Ph.D.

Senior Engineers:
R. Horton, B.Sc.(Hons.), Ph.D., A.M.I.E.E., M.I.R.E.E.
G.O. Stone, B.E.(Elec.), M.Eng.Sc., Ph.D., M.I.E.E.E., M.I.R.E.E.

Engineers:
J. Hubregtse, Fell.Dip.Comm.Eng., Grad.I.R.E.E.
E. Johansen, B.E.(Hons.)
A.L. Martin, B.E.(Dist.) Grad. I.E. Aust.
G.K. Reeves, B.Sc.(Hons.), Ph.D., M.I.E.Aust.

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

Unguided Media

SECTION FUNCTIONS

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

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

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

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

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

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

Visual Communications Section

SECTION FUNCTIONS

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

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

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

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

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

Senior Technical Officer: G. Quirk

STANDARDS AND LABORATORIES ENGINEERING BRANCH

BRANCH OBJECTIVES

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

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

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

Microelectronics Section

SECTION FUNCTIONS

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

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

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

Engineers:
A. Brunelli, Dip.Electron.Eng., B.E.(Comm.).
G. Heinze, Dip.Electron.Eng., B.E.(Elec.).
P.R. Murrell B.E. (Elec)
D.R. Richards B.E. (Elec) M.I.E.E.E.

Senior Technical Officer: M. Crarey

Electrical Standards Section

SECTION FUNCTIONS

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

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

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

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

Senior Technical Officer: J.B. Erwin

Industrial Property and Information Section

SECTION FUNCTIONS

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

Section Head: L.N. Dalrymple, Assoc.Dip.Elec.Eng., Grad.I.E. Aust.

Senior Technical Officers:
C.D. Barling
A.K. Mitchell
W.W. Staley

Laboratory Design Section

SECTION FUNCTIONS

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

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

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

Senior Technical Officer: N.G. Chandler

Laboratory Instrumentation Section

SECTION FUNCTIONS

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

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

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

Engineers:
I. Dresser, B.E.(Elec.) M.J.J. Valk, B.E.(Comm.)
N.A. Leister, B.E.(Elec.), Grad.I.R.E.E.

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

Time and Frequency Standards Section

SECTION FUNCTIONS

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

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

Senior Engineer: R.W. Harris, B.Sc.(Hons.), B.E.(Elec. Hons.), B.Comm.

Engineers:
B.R. Ratcliff, Assoc.Dip.Comm.Eng.
D.A. Latin, B.E.(Elec.)
J.P. Colvin, B.E.(Elec.) Dip. Elec. Eng. M.Eng Sc.
P. Bernhard, B.E.(Elec.)

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

Project Engineering Section

SECTION FUNCTIONS

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

Section Head: R.L. Kilby, Assoc. Dip. Elec.Eng.

Senior Engineer: P.F. Meggs, Assoc.Dip.Mech.Eng., M.I.E.Aust.

Engineers:
W.F. Hancock, Dip.Elec.Eng.
R. Gilchrist, Assoc.Dip.Mech.Eng., B.E.(Mech. Hons.), Grad.I.E.Aust.
C. Mangalore, B.E.(Mech.), M.I.E.Aust., Grad.Dip.Data Processing.
K. Ho-le, B.E.(Mech.)

Senior Technical Officers:
C.V. Eyre
W.L. Reiners

Engineering Library Section

SECTION FUNCTIONS

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

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

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

PHYSICAL SCIENCES BRANCH

BRANCH OBJECTIVES

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

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

Staff Scientist: G. Flatau, F.R.M.I.T.(App.Phys.) M.A.I.M.F.

Polymer Chemistry Section

SECTION FUNCTIONS

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

H.J. Ruddell, Dip. App. Chem., A.P.I.A.

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

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

Senior Technical Officer:
P.R. Latoszynski

Reliability Studies Section

SECTION FUNCTIONS

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

Section Head: D. McKelvie, B.Sc.(Hons.)

Senior Physical Scientist:
G.G. Mitchell, B.Sc.(Hons), M.Sc.

Physical Scientists:
I.K. Stevenson, B.App.Sc., A.R.M.I.T., Grad.A.I.P.
S.J. Charles, Assoc.Dip.App.Phys., B.App.Sc. Grad. A.I.P.

Senior Technical Officers:
W.V. North
E.L. Wallace, A.R.M.I.T.(App.Phys.)

Applied Physics Section

SECTION FUNCTIONS

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

Section Head: I.A. Dew, B.Sc., M.Sc., M.A.I.P.

Senior Physical Scientists:
E.J. Bondarenko, Dip.App.Phys., B.App.Sc., M.A.I.P., M.I.R.E.E., F.R.A.S.
G.W. Goode, B.Sc.

Physical Scientist:
A.J. Murfett, B.Sc.(Hons.) Grad.A.I.P.

Senior Technical Officers:
M.C. Hooper
B. Listopad

Analytical Chemistry Section

SECTION FUNCTIONS

- Provide information, advice and consultancy as defined in the Branch objectives.
- Conduct exploratory research and investigations in the field of chemistry to the depth necessary to enable this scientific knowledge to be applied to the solution of telecommunication engineering problems.
- Conduct scientific studies into chemical pheonomena and hazards.
- Develop specialized techniques and equipment for the analyses of materials.
- Provide the scientific backing for the operations of the Australian Government Stores and Tender Board, including the formulation of new specifications and approval testing of all relevant types of material and consumer products.

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

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

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

Metallurgy and Electro-Chemistry Section

SECTION FUNCTIONS

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

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

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

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

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

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

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

SENIOR ADMINISTRATIVE STAFF

Manager Administration: J.B. Sidbottom

Senior Planning Officer: J.F. Reid

Executive Assistant: A.B. Conroy

Project Officer: T.W. Dillon

Budgets Officer: E.J Scates

Branch Administrative Officers:
T.H. Brown (Standards and Laboratories Engineering)
C.J. Chippindall (Advanced Techniques)
M.A. Chirgwin (Physical Sciences)
B.F. Donovan (Switching and Signalling)
J.S. Sergeant (Transmission Systems)

Papers, Lectures, Talks and Reports

Research Laboratories Reports are the vehicle by which the results of research studies and investigations, development projects and other specialised tasks undertaken in the Laboratories are officially documented. The staff of the Laboratories also contribute articles to Australian and overseas technical journals and present papers to learned societies. This list shows those papers, lectures and reports from 1-5-77 to 30-4-78.

PAPERS

Albertson, L.A.	"Will the Office Become Obsolete?", Telecommunications of the Future, Human Behaviour, January 1978.
Albertson, L.A. and (Cutler, T. Customer Services)	"Social Science in a Technological World", Part II, Newsletter of the Occupational Psychologists' Division of the APS, No. 14, 1977.
Ayre, R.W., Muoy, T.V. and Hullett, J.L. (University of WA)	"Source - Drive Optimization for Optical Fibre Systems Using LEDs", Electronics Letters, Vol. 12, No. 5, December 1976.
Bennett, J.A.	"A Quasi-Optical Approximation for Absorbing Media having Dispersion Relations with Repeated Solutions", American Geophysical Journal, Radio Science, May-June 1977.
Blackwell, D.M.	"Digital Facsimile-Redundancy Reduction", Radio Research Board Symposium on Digital Communication Systems, University of NSW, December 1977.
Bylstra, J.A.	"A Technique for the Measurement of Random Timing Jitter", Australian Telecommunication Research, Vol. 11, No. 2, 1977.
Cahill, L.W.	"Semiconductor Lasers for Optical Fibre Communications", Institute of Radio and Electronics Engineers (IREE) Australia, International Electronics Exhibition and Convention, Melbourne, August 1977.
Court, R.A.	"Determination of the Parameters of Microwave Transmission Lines from Transmission and Reflection Measurements", IEEE Transactions on Instrumentation and Measurement, Vol. IM-26, No. 4, December 1977.
Coutts, R.P.	"Line Codes for Baseband Data Transmission in a Digital Data Network", Digital Communication Systems, University of NSW, December 1977.
Craick, J.	"Teleconferencing - An 'Electronic Chairman' for Audio Conferences", IREE International Electronics Exhibition and Convention, Melbourne, August 1977.
Davies, W.S.	"An Improved Low-Height Anti-Fading Medium Wave Antenna", Proceedings IEE, Vol. 124, No. 8, August 1977.
Dempsey, R.J.	"A Television Transmission System for Single Quad Carrier Cable", The Telecommunication Journal of Australia, Vol. 27, No. 2, 1977.
Demytko, N. and English, K.	"Echo Cancellation on the Time-Variant Circuits", Proceedings of the IEEE, Vol. 65, No. 3, March 1977.
Duc, N.Q.	"Multi Metering Pulse Interference to STD Data Circuits", Paper Presented to Transmission Network Design Branch, February 1978.
Duc, N.Q. and Smith, B.M.	"Line Coding for Digital Data Transmission", Australian Telecommunication Research, Vol. 11, No. 2, 1977.
Duc, N.Q. and (Rudolph, L.D., Hartmann, C.R.P., Hwag, T.Y., Syracuse University - NY)	"On Algebraic Soft-Decision Decoding", Radio Research Board Symposium on Digital Communication Systems, University of NSW, December 1977.
Duc, N.Q. and (Rudolph, L.D., Hartmann, C.R.P., Hwang, T.Y., Syracuse University - NY)	"Algebraic Analog Decoding", School of Computer and Information Science, Syracuse University - NY, August 1977.
Duc, N.Q. and (Rudolph, L.D., Hartmann, C.R.P., Hwang, T.Y., Syracuse University - NY)	"Recent Results on Algebraic Soft Decision Decoding", International Symposium on Information Theory, Ithaca, NY, October 1977.

Flavin, R.K.	"Encapsulated Varactor Diode Tolerances for Low Cost Broadband Parametric Amplifiers", IREE International Electronics Exhibition and Convention, Melbourne, August 1977.
Fowler, A.M.	"Digital Tone Generation", Australian Computer Society Conference, Canberra, September 1977.
Frizzo, R.A., Jenkins, I.L. and Tyers, P.J.	"Some Representative Applications of Microprocessors", IREE International Electronics Exhibition and Convention, Melbourne, August 1977.
Frizzo, R.A. and Jenkins, I.L.	"Simple Music Generation as a Measure of Microprocessor Capabilities", Australian Computer Society Conference, Canberra, September 1977.
George, E.A.	"Integrated Switching and Transmission (IST) Studies", The Telecommunication Journal of Australia, Vol. 27, No. 1, 1977.
Gerrand, P.H.	"Applications of Processing State Transition Diagrams to Traffic Engineering", Proceedings of the 8th International Teletraffic Congress, November 1976; reprinted in Australian Telecommunication Research, Vol. 11, No. 1, 1977.
Gerrand, P.H. and (Guerrero, A. ITT Laboratories, Spain)	"The Waiting-Time Distribution for Markers and other Peripheral Devices in SPC Switching Systems", Proceedings of the 8th International Teletraffic Congress, November 1976.
Gibbs, A.J. and Addie, R.G.	"The Covariance of Near-End Crosstalk", Radio Research Board Symposium on Digital Communication Systems, University of NSW, December 1977.
Gray, R.L.	"Multi-Coupled Resonator Bandpass Filters", IREE International Electronics Exhibition and Convention, Melbourne, August 1977.
Gregory, P.M. and Kirton, P.A.	"End Coupled Stripline Filters and Diplexers", IREE International Electronics Exhibition and Convention, Melbourne, August 1977.
Horton, R. (Moorey, G.G. and Wellington, K, CSIRO Radiophysics)	"Cryogenic Aspects of Microwave FET Behaviour", IREE International Electronics Exhibition and Convention, Melbourne, August 1977.
Horton, R.	"Crossovers in Microstrip", Electronics Letters, Vol. 14, No. 4, February 1978.
Hubregtse, J.	"Techniques for Bonding Gold to Alumina and Quartz with Suitable Bonds for MIC Fabrication", IREE International Electronics Exhibition and Convention, Melbourne, August 1977.
Ja, Y.H.	"Microwave Holography using One of the Space Sampling Signals as the Reference", Monitor - Proceedings of the IREE Australia, December 1977.
Ja, Y.H.	"Dependence of the Horizontal Pattern of a Circular Array Around a Cylinder on its Radius", Monitor - Proceedings of the IREE Australia, October 1977.
Ja, Y.H.	"Aberration of a Microwave Holographic Imaging System over a Line of Sight Propagation Path", IEEE Transactions on Antennas and Propagation, Vol. AP-25, No. 6, November 1977.
Jenkins, G.K. and Tyers, P.J.	"Support Software for Microprocessor Development", IREE International Electronics Exhibition and Convention, Melbourne, August 1977.
Jenkins, G.K.	"A Minicomputer-Based Telephone Metering System", IREE International Electronics Exhibition and Convention, Melbourne, August 1977.
Jenkinson, G.F.	"Tropical Rain Attenuation at 11 GHz on Earth-Space Paths - Radiometric Measurements in Australia", Proceedings of the IEEE, Vol. 65, No. 3, March 1977.
Johansen, E. and Sabine, P.V.H.	"Structural Characteristics of Optical Fibres Manufactured by a CVD Process", IREE International Electronics Exhibition and Convention, Melbourne, August 1977.
Johansen, E.	"Vertical Dipping Liquid Phase Epitaxy of Gallium Arsenide", IREE International Electronics Exhibition and Convention, Melbourne, August 1977.
Jones, P.S.	"International Symposium on Subscriber Loops and Services", The Telecommunication Journal of Australia, Vol. 27, No. 1, 1977.
Kett, R.W.	"Design Principals of a New Telephone Apparatus Measuring System - Part 1", The Telecommunications Journal of Australia, Vol. 27, No. 3, 1977.
Kett, R.W.	"Design Principals of a New Telephone Apparatus Measuring System - Part 2", The Telecommunication Journal of Australia, Vol. 28, No. 1, 1978.
Kidd, G.P.	"The Effects of Excitation Conditions on Fibre Launching and Coupling Losses", Australian Telecommunication Research, Vol. 11, No. 3, 1977.
Kirton, P.A. and (Pang, K.K., Monash University)	"Extending the Realizable Bandwidth of Edge-Coupled Stripline Filters", IEEE Transactions on Microwave Theory and Techniques, Vol. MTT-25, August 1977.
Lawson, I.C. Stevens, A.J. and Harris, R.W.	"Apparatus for Mobile Measurement and Recording of Electric Field Strength at VHF and UHF", The Telecommunication Journal of Australia, Vol. 27, No. 1, 1977.
Metzenthen, W. Blackwell, D. and Kuhn, D.	"Visual Communication Over Telephone Lines", The Telecommunication Journal of Australia, Vol. 27, No. 1, 1977.
Morgan, R.J.	"Some Trends in Low-Loss Optical Fibre and Cabling Technologies", Monitor - Proceedings of the IREE Australia, May 1978.
Park, J.L.	"Impulse Noise Measurements on a PCM Bearer", Radio Research Board Symposium on Digital Communications, University of NSW, December 1977.
Park, J.L.	"Transient Events in Phase-Locked Loops", Australian Telecommunication Research, Vol. 11, No. 3, 1977.

Reeves, G.K.	"Schotty Barrier Gunn Diode Fabrication", IREE International Electronics Exhibition and Convention, Melbourne, August 1977.
Sabine, P.V.H. and Morgan, R.J.	"Sources for Optical Fibre Communications Systems", 1st Australian National Laser Conference, Canberra, March 1978.
Sabine, P.V.H.	"Refractive Index Profile Determination in Optical Waveguides", Australian Telecommunication Research, Vol. 11, No. 2, 1977.
Semple, G.J.	"Effect of Bit Stealing on Trans Quality of 24-Channel PCM in 1st Environment", IREE Conference, August 1977.
Semple, G.J.	"The Effects of Intersymbol Interference on the Operation of PCM Line Regenerators", Australian Telecommunication Research, Vol. 12, Nol. 1, 1978.
Semple, G.J.	"Techniques for Evaluating the Performance of Digital Line Regenerators", Radio Research Board Symposium on Digital Communications, University of NSW, December 1977.
Seyler, A.J., Horton, R. and Morgan, R.J., Harvey, J.T. and Nicol, D.R. (AWA Research Laboratories), Hullett, J.L. (University of WA)	"Aspects of Optical Fibre Systems Research in Australia", International Conference on Integrated Optics and Optical Fibre Communication, Tokyo, July 1977.
Seyler, A.J. and Sandbach, E.F.	"Transportation and Telecommunication - Conflict or Complement", The Chartered Institute of Transport in Australia, 1st National Symposium, 'Resolving Conflicts in Transport', Canberra, August-September 1977.
Seyler, A.J.	"Voice Store-and-Forward Facilities in Telephone Networks - Needs and Implications", IREE International Electronics Exhibition and Convention, Melbourne, August 1977.
Smith, B.M. and Coutts, R.P.	"The Design of Equalizers for Class 4 Partial Response Data Signals", Australian Telecommunication Research, Vol. 11, No. 2, 1977.
Smith, B.M.	"Impulse Noise and 48 kbits Data Transmission", The Telecommunication Journal of Australia, Vol. 27, No. 1, 1977.
Smith, B.M.	"An Overview of Baseband Digital Data Transmission in the Telephone Network", Radio Research Board Symposium on Digital Communication Systems, University of NSW, December 1977.
Smith, B.M.	"Interaction of 64 kbits Data Signals with other Services in the Local Cable Networks", IREE International Electronics Exhibition and Convention, Melbourne, August 1977.
Smith, B.M.	"The Calculation of the Power Spectral Density of 24-Channel PCM Systems when in the Idle Condition", Australian Telecommunication Research, Vol. 11, No. 3, 1977.
Steel, J., Vinnal, E., Lobert, O.F. and Court, R.A.	"Digital Radio Systems", Radio Research Board Symposium on Digital Communication Systems, University of NSW, December 1977.
Steel, J. and Court, R.A.	"Measurement of Field Strength for Mobile Services at VHF and UHF for the City of Melbourne", Electronic Letters, Vol. 13, No. 24, November 1977.
Stone, G.O., Flavin, R.K., and Barker, G.J.	"Thick Film Circuits on Fused Silica for 12-15 GHz Operation", IREE International Electronics Exhibition and Convention, Melbourne, August 1977.
Symons, F.J.W.	"Modelling and Analysis of Communication Protocols using Petri Nets", Telecommunications Group, Report No. 149, Department of Electrical Engineering Science, University of Essex, Colchester, September 1976.
Symons, F.J.W.	"The Description and Definition of Queueing Systems, using Numerical Petri Nets", Telecommunication Group, Report No. 143, Department of Electrical Engineering Science, University of Essex, Colchester, March 1977.
Symons, F.J.W.	"A General Graphical Model of Processing Systems using NPNs, A Generalization of Petri Nets", Telecommunications Group, Report No. 141, Department of Electrical Engineering Science, University of Essex, October 1976.
Teede, N.F.	"Characteristics of Anodically Grown Native Oxides on Inp", IREE International Electronics Exhibition and Convention, Melbourne, August 1977.
Tenen, O.	"Wide-Band Crystal Filter Design", The Telecommunication Journal of Australia, Vol. 27, No. 1, 1977.
Tirtaatmadja, E.	"A State Machine PROM Programme", IREE International Electronics Exhibition and Convention, Melbourne, August 1977.

LECTURES AND TALKS

Ayre, R.W.	"PCM Transmission Equipment for Telecom Australia Field Demonstrations", 2nd Australian Workshop on Optical Fibre Communication, Melbourne, February 1978.
Burton, J.M.	"Methods of Estimating Rain Attenuation Distributions for Terrestrial Microwave Systems Operating Above 10 GHz", Seminar, Queensland University, July 1977.
Chisholm, B.A.	"Aspects of Engineering Materials", Mature Age Training-Internal Plant, Melbourne, May 1977.
Demytko, N. and English, K.	"Adaptive Echo Cancellors", Professional Officers Association Telepost Engineers Group, Melbourne, Lecture No. 258, July 1977.
Duc. N.Q.	"Multi-Metering Pulse Interference to STD Data Circuits", Transmission Network Design Branch, Melbourne, February 1978.
Duke, P.F.	"Loudspeaker Telephony", Australian Acoustical Society, Melbourne, June 1977.
Elms, T.J. and Western, R.J.	"Hardware Modifications for Pyrolysis-Gas Chromatography of Plastics", 3rd AIST-ANZAAS Conference on Science Technology, ANU Canberra, May 1978.
Flatau, G.	"Introduction to Industrial Practice", Seminar, University of NSW, October 1977.
Fowler, A.M. and Ross, D. (Engineering Department)	"The Microprocessor", Telecommunication Society of Australia, Melbourne, February 1978.
Fowler, A.M. and Ross, D. (Engineering Department)	"Microprocessors - The Coming Technology", Telecommunication Society of Australia, Hobart and Launceston, March 1978.
Fowler, A.M. and Ross, D. (Engineering Department)	"Microprocessors and Microcomputers", Professional Officers Association, Melbourne, April 1978.
Fowler, A.M. and Ross, D. (Engineering Department)	"Microprocessors in Telecommunications Applications", Telecommunication Society of Australia, Ballarat, March 1978 and Benalla, April 1978.
Gerrand, P.H. and McLeod, N.W.	"Electronic Exchanges and Stored Program Control", Post Graduate Lectures to the University of Queensland, Department of Electrical Engineering, M. Eng. Studies Course, August 1977.
Gibbs, A.J.	"PCM System Engineering in Multi-Pair Cable", Canadian Department of Communications, Shirley Bay Research Center, March 1978.
Gibbs, A.J.	"Analysis of Near-End Crosstalk in Multi-Pair Cable", Department of Electrical Engineering, University of Western Australia October, 1977.
McLeod, N.W.	"Digital Telephony" A Seminar Presented to the Tandem Study Task Force, September 1977 and to the Planning and Programming Branch, South Australia Administration, March, 1978
Gerrand, P.H.	"Traffic Engineering Aspects of SPC Switching Systems", Telecom Australia Residential Traffic Engineering Course, Melbourne, April 1978.
Morgan, R.J.	"Optical TDR Techniques", 2nd Australian Workshop on Optical Fibre Communication, Melbourne, February 1978.
Morgan, R.J.	"A Review of Optical Fibre Communications", 3rd International Electrical, Electronic Engineering Measurement and Control Exhibition, Sydney, October 1977.
Morgan, R.J.	"Optical TDR Techniques", 2nd Australian Workshop on Optical Fibre Communication, Melbourne, February 1978.
Morgan, R.J.	"Factors Involved in Digital Transmission via Optical Fibres", Workshop Seminar, Optical Systems for Telecommunications, Footscray Institute of Technology, October 1977.
Morgan, R.J.	"Telecom Australia and Multimode Optical Fibre Systems Technology - A Personal View", Defence Department Seminar, Sydney, April 1978.
Morgan, R.J. and Sabine, P.V.H.	"Component Parameters for Characterizing Optical Fibre Telecommunications Systems", Defence Department Seminar, Canberra, April 1978.
Ruddell, H.J.	"The Behaviour of Polymeric Adhesives Applied to Aluminium Tape used in Moisture Barriered Cables", Polymer and Additives Group, Plastics Institute, Melbourne, March 1978.
Sabine, P.V.H.	"Optical Sources and Signal Processing Devices - A Survey of Some Recent Research", 2nd Australian Workshop on Optical Fibre Communication, Melbourne, February 1978.
Sabine, P.V.H.	"Some Recent Developments in the Fabrication and Characterization of Low-Loss Optical Fibres and Cables", 2nd Australian Workshop on Optical Fibre Communication, Melbourne, February 1978.
Sandbach, E.F.	"Industrial R&D - A Telecom Australia View", Australian Industrial Research Group Seminar, Melbourne, February 1978.
Sastradipradja, S. and Hurren, S.	"Measuring Microwave Antenna Characteristics", Telecom Staff, University of Queensland, Brisbane, July 1977.
Teede, N.F.	"Semiconductor Devices for Optical Communication", Workshop Seminar, "Optical Systems for Telecommunications", Footscray Institute of Technology, October 1977.
Western, R.J.	"Low Cost Construction of Auxiliary Equipment for High Pressure Liquid Chromatography", 3rd AIST-ANZUUS Conference on Science Technology, ANU Canberra, May 1978.
Wickham, B.	"Telecommunications in the 1980s", Caulfield Institute of Technology, Campus Chapter of IE Australia, Melbourne, May 1978.

RESEARCH LABORATORIES REPORTS

Report No.	Author	Title
7124*	A.J. Murfett	Evaluation of Core Balance Earth Leakage Circuit Breakers.
7128*	G.W. Goode	Tests of PTC and NTC Thermistors.
7129*	K.H. Jones	Slow Curing Epoxy Resin for Bulk Pours.
7132	J. Steel	Some Measurements of Echoes on the Australian Switched Network.
7134*	C.J. Scott & E. Tirtaatmadja	Review of Programmable Read Only Memory Technology and Applications.
7135*	B.A. MacLennan	Evaluation of an In-Line Connector for Medium Diameter Conductors.
7139*	S.D. Barnett	Bonding Compound for Jacketted Lead Sheathed Cable.
7143*	N.F. Teede	Aspects of Solar Cell Research and Development in Japan.
7145*	N.F. Teede	Report on Japanese Foreign Specialist Award Tenureship.
7148*	E.L. Wallace	Assessment of an Insulation Crushing Multiway Connector.
7149*	B.A. Mac Lennan	Machine Jointing of Sealed Paper Insulated Aluminium Alloy Conductor.
7150	A.Y.C. Quan	Effect of a Second Parallel Crosstalk Path on Crosstalk Measurements.
7152	J.R. Godfrey	Determination of the Comparative Erosion on Soldering Iron Bits.
7154	G.K. Jenkins	A Cross-Assembler for the F8 Microprocessors.
7155*	G.K. Jenkins	A Variable Type-Font Capability for Text Processing.
7156*	D.T. Miles, R.J. Western & H.J. Ruddell	Evaluation of Colour Masterbatch BXL.PZ157 for Polyethylene Insulation.
7157*	G.J. Semple	The Effect of PCM Bearer Errors on the Transmission of 9600 Bit/s VF Data over Tandem Connected PCM Systems.
7158*	G. Flatau	Report on Overseas Visit - November 1976.
7162*	N.W. Mc Leod	Overseas Visit - November 1976.
7163*	G.K. Jenkins	A Minicomputer - Based Telephone Metering System.
7165*	E.J. Bondarenko	Effect of Lightning on Subscribers' Services - Summervalle NSW.
7167*	J.L. Park	A Guide to Logic Family Selection and Use.
7168*	P.J. Tyers	A Comparison of Microprocessor Software Development Techniques.
7169	R.A. Seidl	Software Support for the DCT132 Remote Batch Terminal - Part 2 : Utility and Support Programs.
7172*	M.W. Wawn	Evaluation of a Water Container for Fire-Fighting Knapsacks.
7174	J.L. Park	Impulse Noise Measurements on PCM Bearer, St. Kilda/Clayton.
7177*	B.M. Smith	Report on Overseas Visit - April-May 1977.
7178*	B.M. Smith	The Choice of Baseband Line Codes for Digital Data Transmission.
7182	P.V.H. Sabine	A Near-Field Scanning System for Determining the Refractive Index Profiles of Multimode Optical Fibres.
7183	J.B. Tye & P.J. Tyers	A Program to Manipulate Data.
7184	J.L. Snare	A Miniaturized, Inductorless, Maximally Flat Delay Network.
7185	J.R. Godfrey	A Study of Whisker Growth on Zinc Electroplating.
7188*	I. Cederholm	Carbon Monoxide Detectors : A Laboratory Evaluation.
7189*	J.R. Godfrey	Relay Springs - Resistance to the Development of a Permanent Set.
7192*	R.A. Seidl	Tektronix Plot-10 Graphics Software for the H6000 Computer.
7194	I.L. Jenkins	Enhanced Action Terminal (Model ACT) Operation and Firmware.
7195*	J.L. Snare	Two Efficient Functions Minimizing Computer Programs - A Review.
7196	G.K. Jenkins	Some Programming Tools for the SC/MP Microprocessors.
7197	R.A. Seidl	Software Support for the DC 132 Batch Terminal Part 1 in a Cross Assembler for the DC 132 Programming Language.
7198*	P. Gerrand	Report on CCITT Study Group XI Meeting, Geneva, May 1977.
7205*	N. Leister	Public Telephone Cabinet Light Fittings.
7208	G.K. Jenkins & P.J. Tyers	M6800 Microprocessor Software Development Facilities.
7218	R.A. Frizzo, G.K. Jenkins & P.J. Tyers	Casper7 - An M6800 Microprocessor Simulator.
7224	G.K. Jenkins	Time Share Interface Programs for the H6000 Computer Network.

Note: The reports marked*are not available beyond Telecom Australia. In addition 16 reports of limited distribution were produced.

Staff Affiliations with External Bodies

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

NATIONAL PROFESSIONAL BODIES (EDUCATIONAL)

Victorian Education Department	
Higher Technician (Applied Science) Certificate	G. Flatau
Course Development Committee	
Victorian Institute of Colleges	
Academic Committee - Engineering	M. Cassidy
Footscray Institute of Technology	
Course Advisory Committee	H.S. Wragge G.F. Jenkinson
Swinburne College of Technology	
Electrical Engineering Departmental Advisory Committee	L.H. Murfett
Master of Engineering Ad Hoc Advisory Committee	L.H. Murfett
Caulfield Institute of Technology	
Course Advisory Committee	H.S. Wragge
Royal Melbourne Institute of Technology	
Capital Funds Committee	M. Cassidy
Course Advisory Committees	M. Cassidy R.D. Slade
Preston Institute of Technology	
Course Advisory Committee	R. Smith

NATIONAL PROFESSIONAL BODIES

Australian National Committee for Radio Science	E.F. Sandbach
Radio Research Board	E.F. Sandbach
Australasian Institute of Metals	
Metals Technology Division (Melbourne Branch)	J.R. Lowing (Secretary)
Australian Institute of Science Technology	
Victorian Branch Council	F.C. Baker
Australian Advisory Council on Bibliography Services	
Victorian Regional Committee	M.I. Cuzens
Working Party on Systems and Communications	M.I. Cuzens
The Institute of Radio and Electronics Engineers, Australia	
Federal Council	A.M. Fowler
Publications Board	R. Horton
Melbourne Committee	R. Horton (Hon. Secretary) H.A. Wills (Hon. Treasurer) A.M. Fowler
The Institution of Engineers, Australia	
Board of the College of Electrical Engineers	H.S. Wragge
Electrical and Communications Engineering Branch Committee	H.S. Wragge B.A. Wickham (Hon. Secretary)
National Committee on Electronics and Telecommunications	H.S. Wragge (Chairman) E.A. George
Australian Acoustical Society	
Victorian Division Committee	D.A. Gray
Federal Council	D.A. Gray
Telecommunications Society of Australia	
Council of Control	E.A. George H.S. Wragge
Board of Editors: ''Australian Telecommunication Research''	H.S. Wragge G. Flatau A.J. Gibbs G.F. Jenkinson W. McEvoy I.P. Macfarlane L.H. Murfett
Board of Editors: 'Telecommunication Journal of Australia'	D.A. Gray
Standards Association of Australia (SAA)	
Telecommunications and Electronics Standards Board and Executive Committee	G. Flatau E.F. Sandbach
Australian Electrotechnical Committee	E.F. Sandbach G. Flatau
Acoustic Standards Committee	D.A. Gray
Plastics Industry Standards Board	R.D. Slade
Co-ordinating Committee on Fire Tests	F.C. Baker
Metallography Committee	T.J. Keogh
Technical Committees	
Acoustic Standards	
• Instrumentation and Techniques for Measurement of Sound	E.J. Koop
Chemical Industry Standards	
• Adhesives	F.C. Baker
Electrical Industry Standards	
• Indicating and Recording Instruments	J.M. Warner
• Electrical Insulating Materials	G. Flatau
• Dry Cells and Batteries	G.G. Mitchell
• Electrolytes	F.C. Baker
• Control of Undesirable Static Charges	G.W. Goode
Mechanical Engineering Industry Standards	
• Tensile Testing of Metals	K.G. Mottram
Metal Industry Standards	
• Zinc and Zinc Alloys	K.G. Mottram
• Lead and Lead Alloys	K.G. Mottram
• Coating of Threaded Components	R.D. Slade
• Galvanised Products	R.D. Slade
• Electroplated and Chemical Finishes on Metals	R.D. Slade
Plastics Industry Standards	
• Polyethylene insulation of sheath electric cable	H.J. Ruddell
• Methods of Testing Plastics	G. Flatau
• Outdoor Weathering of Plastics	G.W. Goode
• Polytetrafluoroethylene	B.A. Chisholm
• Flammability of Plastics	H.J. Ruddell
• Mechanical Testing of Plastics	B.A. Chisholm

Safety Standards	
• Industrial Safety Gloves	F.C. Baker
Telecommunications and Electronics Industry Standards	
• Capacitors and Resistors	G. Flatau D. McKelvie
• Printed Circuits	D.E. Sheridan
• Wires and Cables	G. Flatau
• Semi-Conductors	I.P. Macfarlane
• Environmental Testing	G. Flatau
• Reliability of Electronic Components and Equipment	G. Flatau
• Electro-Acoustics and Recording	E.J. Koop
National Association of Testing Authorities (N.A.T.A.)	
Electrical Registration Advisory Committee	J.M. Warner
Assessor for Environmental Testing	G. Flatau
Assessor for Laboratories Engaged in Testing Plastics	B.A. Chisholm
Assessor for Aerial Equipment and Measurements	O.F. Lobert
Assessor for Laboratories Engaged in Electrical Testing	J.M. Warner E. Pinczower J.B. Erwin

INTERNATIONAL BODIES

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

- The International Telephone and Telegraph Consultative Committee (C.C.I.T.T.).
- The International Radio Consultative Committee (C.C.I.R.).
- The Australian and New Zealand Association for the Advancement of Science. (A.N.Z.A.A.S.).
- The Bureau International de l'Heure (B.I.H.)
- The International Electro-Technical Commission (I.E.C.).
- The International Standards Organisation (I.S.O.).
- The Asia Electronics Union (A.E.U.).
- The International Federation of Documentation, Committee for Asia. and Oceania (F.I.D./C.A.O.)

Industrial Property

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

PATENT APPLICATIONS AND PATENTS

Invention Title (Inventor/s)	Patent Application Numbers: Provisional Specification	Complete Specification	Patent Number (if granted)	Country
Method and Apparatus for Testing Subscribers Telephone Instruments in Situ under Service Conditions (J.F.M. Bryant & R.W. Kett)		233699	3,261,926	U.S.A.
Self Adaptive Filter and Control Circuit (L.K. Mackechnie)	65671/69	23649/70	448805	Australia
		P2063183.8	2063183	Germany
		60513/70	1,334,250	Britain
		45-115560/70		Japan
		70-18580		Netherlands
		33,333A/70	913733	Italy
		70-45,859	70-45859	France
		17270/70	362,763	Sweden
		98800	3,732,410	U.S.A.
Earth Working Implements (E.W. Corless)		45479/68	450397	Australia
		52280/69	1,292,844	Britain
		69/7565	69/7565	Sth. Africa
Dual Speed-Ratio Automatic Telephone Dial (R.J.W. Kennell)		23115/62	264,679	Australia
Tip Welding Means (E.J. Bondarenko)	49395/70	10361/70	455004	Australia
		4714/71	3,657,512	U.S.A.

PATENT APPLICATIONS AND PATENTS

Invention Title (Inventor/s)	Patent Application Numbers Provisional Specification	 Complete Specification	Patent Number (if granted)	Country
Analogue Multiplier (H. Bruggemann)	43033/68	43033/68	414207	Australia
		43817/69	1,271,813	Britain
		P1945125.3	1945125	Germany
		GbmH6934984.4	-	Germany
		70940/69	728044	Japan
		855543	3,629,567	U.S.A.
Apparatus for Routing Discrete Telecommunication Signals (A. Domjan)	61428/69	19808/70	448958	Australia
		94405	756684	Belgium
		12968/70		Sweden
		70-14122		Netherlands
		70-35267	70-35267	France
		44636/70	1,326,626	Britain
		P2046069-9		Germany
		8353370	859026	Japan
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	466670	Australia
		35385/71	1,362,707	Britain
		166819	3,745,418	U.S.A.
		71-28121	71-28121	France
		P2136516.2		Germany
		56442/71	888597	Japan
Apparatus for Use in Feeding Alternating Electric Current to a Load and an Antenna including such Apparatus (R.P.Tolmie)	PA7174/71	49340/72	484853	Australia
Smoke Detector (L. Gibson & D.R. Packham)	PA9230/72	56513/73	482860	Australia
		8221/73	564238	Switzerland
		25660/73	1,419,146	Britain
		63703/73		Japan
		367260	3,874,795	U.S.A.
Method and Apparatus for Detecting the Presence of Signal Components of Predetermined Frequency in a Multifrequency Signal (A.D. Proudfoot)	PB24/72	59138/73	480006	Australia
		387855	3,882,283	U.S.A.
		PV134.478	803494	Belgium
		38106/73	1,439,035	Britain
		178402	984,068	Canada
Improved Electrical Connector (C.R. Bomball, B.C. Bladier & T.E. Woodward)	PC1618/75	13977/76		Australia
An Improved Nephelometer (L. Davidovits)	PC4285/75	20510/76		Australia
Nephelometer with Laser Source (L. Davidovits)	PC4286/75	20511/76		Australia
Tamperproof Telephone Apparatus (C.M. Hamilton & J.A. MacCaskill)	PC5285/76	23264/77		Australia
Line Sync Pulse Fault Monitor (R.W. Ayre)	-	17251/76		Australia
Resilient Coupling Member (A.D. Pontin)	PC4019/75	19789/76		Australia
Optical Waveguides and a Method of Manufacture Therefor (P.V.H. Sabine & P.S. Francis)	PC4499/76	21232/77		Australia
Transmission System (I.R. Bryce and J.C. Blackburn)	-	22403/77		Australia
Method and Apparatus for Reducing Phase Jitter in an Electrical Signal (K. Webb)	-	24926/77		Australia
Programmable Digital Gain Control System for PCM Signals (A.M. Fowler)	PD3192/78			Australia

Visitors to the Laboratories

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

Laboratories' activities are also demonstrated to specialist and non-specialist groups from professional societies, other government departments, universities and other centres of tertiary education. This is achieved through arranged inspection tours and exhibitions, and at longer intervals by formal 'Open Days', when the work of the Laboratories is exhibited to invited guests from many walks of life.

During the year, experts from overseas telecommunications authorities, universities, government departments and manufacturing companies have also visited the Laboratories. Other overseas visitors have participated in the work of the Laboratories for longer periods to further their training in telecommunications technology. Often, these visitors are UN/ITU and Colombo Plan Fellows, whose visit to the Laboratories is a part of a more extensive period of training in Telecom Australia.

Overseas Visits by Laboratories Staff

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

The following staff members have travelled overseas during the past year:
E.J. Bondarenko
E.R. Craig
P.H Gerrand
A.J. Gibbs
R.J. Morgan
W. Metzenthen
P.V.H. Sabine
B.M. Smith
R. Smith
H.S. Wragge

Assistance with Studies

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

The following professional staff have been encouraged to engage in postgraduate studies or to seek wider professional experience during the past year:

N.J. Gale, University Sains Malaysia,
F.J. Symons, University of Essex, UK

Sponsored External Research and Development

Telecom Australia is aware of the external telecommunications research and development capabilities which exist in universities and similar institutions, and also in local industry. Recognising the mutual benefits of co-operative effort, it actively supports pertinent projects in these organizations through formal contracts and agreements and through its participation in the activities of bodies such as the Radio Research Board.

The Laboratories, in particular, support outside research and advanced development projects in specialised fields, particularly those conducted by universities and other centres of higher learning. Current contracts administered by the Laboratories involve research on the topics below:

- Techniques for Automatic Speech Synthesis.
- Assignment of tolerance to minimum sensitivity networks.
- Mobile radio propagation characteristics and subjective assessment.
- Correlation between termite resistance of plastics and certain physical properties.
- Solid State Technology for Circular Design in Microstrip Form.
- Techniques for the manufacture of carbon granules for use in telephone transmitters.
- Continued development of optical fibre manufacture.
- Compensation of gallium arsenide by proton implantation.
- Electrical Discharges and Plumes on High Power HF Antennas.
- Computer Based Correlator for Broadband System Transfer Function Measurements.
- Assignment of Tolerance to Minimum Sensitivity Networks.
- Theoretical Studies of Optical Fibres.
- Channel Capacity of Stepped-Index Optical Fibre Systems.
- Active Devices for Integrated Optics.

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

Printed by The Dominion Press, Joseph Street, North Blackburn 3130