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FOREWORD

The introduction which follows gives a brief outline of how the Telecom Australia Research Laboratories have come into existence and the role they are playing in the development of telecommunications generally. Many aspects of our Research and Development Programme may not be generally well known and 'Research Quarterly' is intended to bring about a better understanding, in as broad as possible presentation, of our activities.

You will find in this publication summaries of various reports on particular investigatory projects, items of special interest concerning work being carried out in a number of fields including, transmission systems, advanced communications, switching systems, physical sciences and laboratory services and many other aspects. In all cases a telephone number and point of contact is given. If you require additional information or wish to discuss any aspect of a particular article you are invited to contact the person concerned.

I look forward to a long and fruitful association with you and hope that 'Research Quarterly' is read with interest.

E. Sandbach
Director, Research

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I N T R O D U C T I O N

TELECOM AUSTRALIA, RESEARCH LABORATORIES - HISTORY, FUNCTIONS AND ACTIVITIES

The Research Laboratories owe their origin as a special unit of the former Australian Post Office to the need, after World War 1, for the introduction of new technology into the telephone and telegraph networks; i.e., to improve their capacity and quality of service while maintaining their economic viability. This called for specialists who would carry out investigations into the technical aspects of new systems and give timely advice to the Department on their benefit to its operations.

World War 1 had advanced Lee De Forest's vacuum tube, which by 1920, had demonstrated its potential in overseas use as a voice frequency (v.f.) repeater in extending the distance of trunk routes. A Mr. Sidney Witt visited the U.S.A., England and Europe in 1922, to assess its use, which subsequently led on the nineteenth of March 1923, to the establishment of a Research Section to provide specialist technical advice on the introduction of the new devices. Mr. Witt was set to work as a one-man Research Section with little equipment and about 300 square feet of space in the then Headquarters building in Treasury Place, Melbourne.

The early years saw the Laboratories involved in transmission measurements and determination of standards for the national trunk network and through to the early thirties it contributed also to radio broadcasting in Australia. During the second world war the Laboratories assisted in the development of radar systems and subsequently radio telephone systems. As a preliminary to the introduction of TV broadcasting, the Laboratories were involved on TV propagation studies and the coding of television signals for optimum bandwidth utilisation. The extension of radio telephony work at v.h.f. and u.h.f. naturally involved the Laboratories in the investigation of satellite systems. Expertise was developed through the late 1940s in microwave fields which extended through the 1950s in the coaxial cable phase and latterly to investigations of the potential of optical devices and optical fibre media.

Many other developments were made in the investigation and development of digital electronic switching and transmission techniques and systems, and through the evolution of stored program controlled systems and networks provided a shift in conceptual emphasis to the examination of the total network and its capacity to provide integrated services - telephony, data, facsimile, perhaps video - through a common network. Considerable contributions have been made also in material investigations and evaluations with physicists, chemists and metallurgists capable of providing specialist advice and investigational facilities to assist with the many problems encountered by the telecommunications equipment and cable manufacturing industries. Other specialist groups maintain reference standards of time, frequency and electrical calibration with the precision required of national verification bodies.

The Laboratories have provided the former Australian Post Office from the outset with the technological research, development and back-up needed to allow it to prepare for the technological demands of the future and as a Department of the Australian Telecommunications Commission it will continue to maintain this position under the following charter:

(1) to conduct research and development in telecommunications theory and practice, particularly as applying to the Australian region;

(2) to appraise new developments in telecommunication equipment and in appropriate cases to conduct field trials;

(3) to develop apparatus and systems required in the Australian communications network which are not available from commercial sources;

(4) to act as consultant to the Commission on scientific and engineering matters;

(5) to participate in the work of national and international organisations associated with telecommunications research and to be represented on their committees; and

(6) to encourage research and development in telecommunications and allied disciplines in tertiary educational institutions and industrial laboratories.

USE OF PRE-AGED CARBON IN TRANSMITTERS NO.13 FOR LOCAL BATTERY TELEPHONES

Carbon transmitters deteriorate with age, with one of the main effects being an increase in electrical resistance. Particularly for local battery (LB) telephone applications, this effect causes a rapid loss in transmitting performance in service. Investigations with Morganite type NA68D8 pre-aged carbon granules in local battery telephone transmitters have shown that although a slightly reduced performance results initially, an acceptable level of performance is maintained long after the performance of a transmitter with normal carbon has become unacceptable.

Proposals have now been forwarded to Customer Equipment and Transmission Planning Branches, recommending the use of transmitters with pre-aged carbon for all local battery telephone (e.g. 400LB) applications and giving details of operating conditions and line limits for both conventional and "long-line" services. The detailed recommendations cover battery requirements, sidetone control and return loss improvements and are such that if the specific recommendations are applied, the performance of the 400LB telephone on the normal range of subscribers lines is comparable to that of the 400CB, and on the longer lines can be comparable to the 804CB.

(Contact : G.M. Casley, Transmission Systems Branch, 03-630 6339)

PROCESSORS AND RELATED PROJECTS

The stored program control (SPC) telephone switching exchange has recently been adopted by Telecom Australia with the installation of the Pitt Street, Sydney, Trunk Exchange. Similar exchanges are being installed at Lonsdale (Melbourne), Bendigo, Victoria and Weymouth, (Adelaide). Evaluation of tenders for an SPC local exchange are currently in progress, and it is anticipated that many such exchanges will be installed in the coming years. The Switching and Signalling Branch has played an important part in this evaluation because of the expertise which it has developed in the SPC field over the last eight years.

With two major projects in view, the International Telegraph and Telephone Consultative Committee (C.C.I.T.T.) Signalling System No.6 and the Integrated Switching and Transmission (IST) projects, the Branch bought its first processor, an I.T.T. B.T.M.X. in 1968. This machine was an experimental one with a 16 bit word length and 16 K of core memory. It was developed by I.T.T. into the I.T.T. 1600, and the Branch purchased three of these machines between 1969 and 1971. The most recent processor acquisition has been the purchase of two Digital Equipment Corporations PDP 11/10 mini-processors, associated with bulk storage.

Software Development:

The following table summarises the software work done by the Branch since 1968.

Project	Processor	System Size	Effort Man-years
C.C.I.T.T. S.S. No.6			
Basic System	BTMX	16 K	15
Traffic Simulating System	BTMX	10 K	2

contd.....

Project	Processor	System Size	Effort Man-Years
I.S.T.			
One Processor System	ITT 1600	16 K	40
Dual Processor System	ITT 1600	26 K	10
Simulation Testing System	ITT 1600	12 K	8
Remote Control and Signalling Studies	ITT 1600	10 K	8
High Level Languages	PDP 11/10	12 K	2
Support	BTMX ITT 1600 PDP 11/10	32 K	12

In addition to the above, a considerable amount of programming work has been performed by outside contractors, and the Weapons Research Establishment, Department of Defence.

This work has provided considerable insight into the functioning of SPC systems, an appreciation of the development effort required to incorporate system modifications and changes, and a realisation of the magnitude of effort necessary to support and maintain an SPC system.

Hardware Development:

The hardware developed for the C.C.I.T.T. Signalling System No.6 Field Trial included complex terminals for the common signalling links, a 100 line exchange based on an ARM crossbar switchblock including electronic network signalling devices and the interface circuitry necessary to connect the exchange to the BTMX processor.

The IST exchange has been fully developed by the Branch and consists of a space-time-space, fully electronic, digital switchblock with associated network signalling devices catering for four 24 channel Pulse Code Modulation (PCM) systems.

In addition to the major hardware developments, a number of features have been added to the I.T.T. 1600 processors which considerably assist system testing and fault location. These include a satisfactory a.c. power fail detection and restart mechanism, a register history memory, a status register and a light emitting diode (LED) panel to display selected sections of processor memory. Currently the paper tape reader and punch equipment is being replaced by magnetic tape cassette units.

Many of the shortcomings of the I.T.T. 1600 have been discussed with I.T.T. and it is noted that most of the points suggested for improvement will be included in the I.T.T. 1602 processor which is now under development.

Interfaces have been built to connect a line printer and paper tape equipment to the PDP 11s. The following summarises the equipment forming the Branch's processor installation.

Processors		High Speed Paper Tape Punches	- 4
I.T.T. 1600	- 3	High Speed Paper Tape Readers	- 5
PDP 11/10	- 2	Mag. Tape Cassette Units	- 6
Mag. Tape Units	- 2	LED Memory Displays	- 4
Mag. Disc Units	- 2	Teletypewriters	- 13
Line Printers	- 2		

(Contact : G. Champion, Switching and Signalling Branch 03-541 6388)

EFFECTS OF SIDETONE ON TELEPHONE TRANSMISSION PERFORMANCE

Although the qualitative effects of sidetone on telephone transmission performance are generally well known, the quantitative effects and hence the trade-offs between, for instance, sidetone and circuit loss, are not well known. This information is required for the design and assessment of new telephone instruments, a better understanding of existing telephones, and the review of installation rules for the long line telephone and subscriber's loaded cable.

A series of subjective tests were recently conducted to study the effects of sidetone reference equivalent, overall reference equivalent, room noise level, microphone type, and possible interactions between them on telephone transmission performance. The handset shape, sidetone frequency response and circuit noise level were predetermined, in order to limit the number of variables. A total of 54 different circuit combinations were selected.

Staff from other Headquarters sections were used as subjects, covering a range of occupations, ages and both sexes. One hundred and eight subjects, arranged as pairs, each conversed on six of the fifty-four possible circuits, with the subject pairs and circuits being arranged in the form of an incomplete Latin square.

The subjects were asked to converse over each circuit for about three minutes and then rate the quality of the circuit using a five point scale. From this the mean opinion score was subsequently calculated. In addition, the speech power was monitored and expressed as a function of circuit parameters.

The results showed that speech power varied only moderately with the circuit conditions selected (e.g., 3 dB when sidetone varied from 0 dB to 20 dB reference equivalent). The carbon microphone and a linear ceramic microphone (with good frequency response) produced very similar opinion ratings, and there is a definite trade-off possible between sidetone and circuit loss for a certain room noise level. For example, with a room noise level of 55 dB(A) and a sidetone reference equivalent of 15 dB, the circuit loss should be reduced by about ½ dB per dB drop in sidetone reference equivalent, while for 5 dB sidetone reference equivalent, this rate changes to about 1 dB per dB.

In a subsequent series, it is hoped to investigate the effect of sidetone frequency response and interaction of sidetone with other factors not yet studied.

Research Laboratory Report No. 7039, which is now in preparation, will describe this work in greater detail.

(Contact : P.F. Duke, Transmission Systems Branch 03-630 7622)

SCANNING ELECTRON MICROSCOPE

The Research Laboratories of Telecom Australia have recently installed a scanning electron microscope (SEM). The instrument significantly enhances the analytical capabilities of the Research Laboratories and the purpose of this article is to outline its functions and characteristics so that it can be used to maximum advantage.

Features of the SEM:

- great depth of focus
- direct observation of images at high magnification
- wide range of magnification
- ease of operation and specimen preparation
- formation of an image from many different specimen responses
- information in an electrical form which allows signal processing.

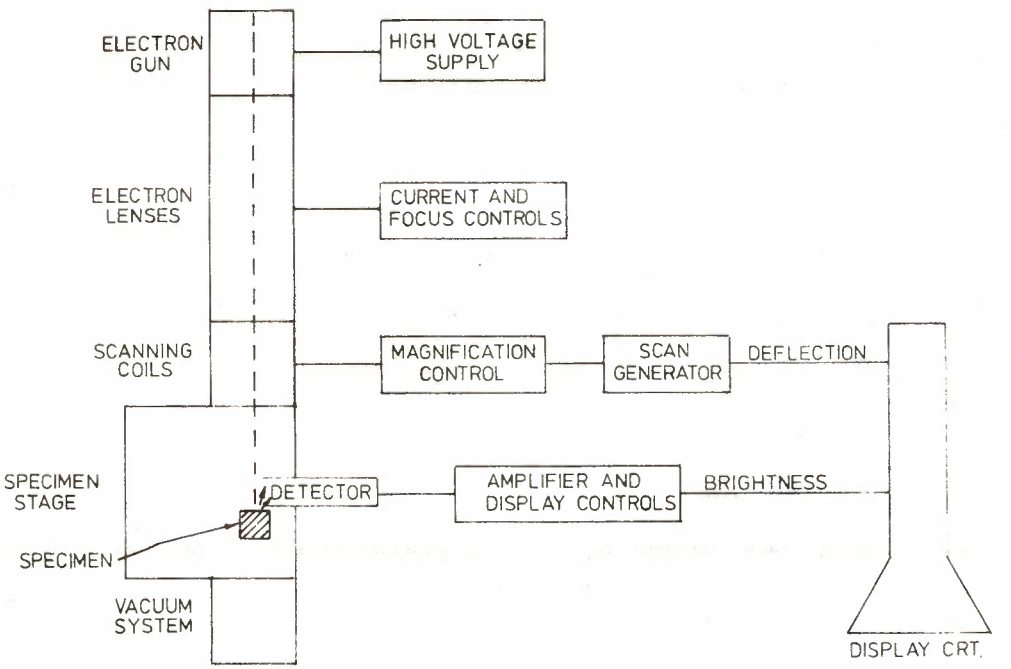
A comparison of these features in the scanning electron, transmission electron and optical microscopes is given in the following table:

	Optical	Scanning Electron	Direct Electron
Resolution - easy	5 μm	0.2 μm	10 nm (100Å)
- skilled	0.2 μm	10 nm (100Å)	1 nm (10Å)
Depth of focus	poor	high	moderate
Specimen - preparation	usually easy	easy	skilled, liable to artefacts
- available space	small	large	small
Signal	only as image	available for processing	only as image

Comparison of Microscopes

Operation:

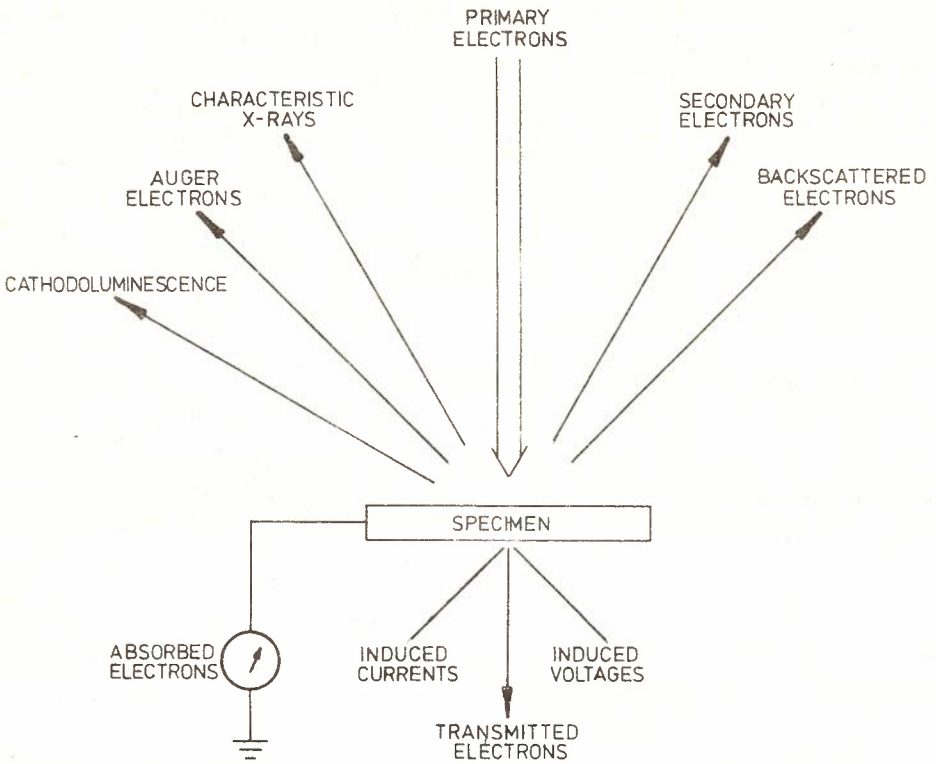
The fundamental principle behind the SEM is the use of a fine electron beam to strike the specimen surface and emit information related to the topography and composition of the specimen. The diagram below illustrates the basic components of the SEM.



The high energy electrons are focused onto the specimen and the desired signal amplified for display. By synchronising the display on the cathode ray tube with the scanned raster pattern of the electron beam, an image of the specimen surface is mapped onto the screen.

Signal Types Available for Display

The various electron-specimen interactions that are used to form an image are indicated in the following diagram.



Secondary Electron Mode

The most commonly displayed signal uses the secondary electrons that are ejected as the high energy primary electrons strike the specimen. The secondary electron collection from a surface is related to the material properties and the angle between the incidence of the electron beam and the detector. The result is a signal strongly dependent on the topography of the specimen. The displayed image shows a close similarity to that obtained on an optical microscope, but there is a significant difference. The electron beam of the SEM is near parallel and ensures a large depth of focus, so that coupled with the high magnification it is possible to display fine detail on a rough surface.

Backscattered Electron Mode

Some of the electrons of the primary beam are elastically scattered by the nuclei of the atoms within the specimen and are ejected after several high angle collisions. These electrons have on average a higher energy than the secondary electrons and may be collected separately from the latter. Since the interaction is atomic number dependent, denser materials backscatter a larger proportion of electrons. The backscattered electron image relates to the composition of the material and the greater the difference in atomic number the greater the image contrast.

Cathode Luminescence

Many of the optical properties of materials and semiconductors can be investigated using cathodoluminescence. The emission of light as the specimen returns to its equilibrium condition dependent on impurities within the material, and in some circumstances can detect parts per million impurity concentrations.

X-Ray Analysis

In addition to light, the specimen can emit x-ray photons as the outer electrons of the atomic shell fill the vacated inner levels. Since the energy level scheme for each atom is distinct, the wavelength or the energy of the photon can be used to analyse the specimen composition. The spatial resolution of such analysis is less than one micrometre and for most metals, concentrations of less than 0.005% can be detected.

Absorbed Current

The difference between the primary and ejected electron rates results in a current flow through the specimen to earth. The effect of surface topography is minimized and the point to point variations in compositions and structure are emphasised. The absorbed current image can be used to isolate such defects as precipitates, dislocations and slip lines. Far more important is the specimen current associated with the bombardment induced conductivity. This technique offers valuable information relating to detects in semi-conductor junctions, the location of the depletion region boundaries under applied bias, junction breakdown behaviour and other facets of semiconductor devices.

Voltage Contrast

The application of voltage to a semiconductor device modifies the secondary electron yield depending on the bias condition. This effect allows the study of the logic state of large scale integrated circuits and identifies logic faults and device failures otherwise inaccessible due to circuit complexity.

Typical Applications in the Laboratories

Already the features of the SEM have proven essential in a number of investigations in the Laboratories. The Solid State and Quantum Electronics Section has used the instrument to examine sub-micrometre pinhole formation in silicon dioxide layers used to fabricate gallium arsenide light emitting diodes. The causes were identified as either dust particles or thermally induced microcracks. Suitable system redesign and temperature annealing has rectified these problems.

The advantages of great depth of focus and sub-micrometre resolution have also permitted the characterisation of surface defects in evaporated gold on the alumina substrates used for microwave integrated circuits. The studies have determined the optimum baking temperature to obtain maximum thin film adhesion.

The analysis of zinc diffused electroluminescent diodes has been furthered as the whole device is in focus for observation, and the etch angles and rates can be accurately measured.

The high magnification allows examination of the sub-micrometre detail of gallium arsenide liquid phase epitaxial films and native oxide growth, and provides invaluable information for the development of epitaxial Gunn diodes.

Preliminary investigations of failure mechanisms in ovonic devices have been made on devices provided by the Devices and Techniques Section.

The Electrochemistry and Metallurgy Section has been examining crossbar relay contacts in which failure is apparently due to silicon based growth on the contact causing high resistance and open circuit behaviour. Once the growth is characterised and identified, the source can be located in the exchange and either eliminated or the relays suitably protected.

Studies of the metal failure of tool tips and the degradation of the cutting edge of a punch have also commenced.

Summary

The inherent advantages of the SEM and the display modes available combine to give the Research Laboratories a powerful analytical instrument. With the planned installation of wavelength dispersive x-ray facilities to extend the instrument to a full microprobe unit, the application of the SEM in the fields of semiconductor technology, electrochemistry, metallurgy and device analysis depends only on the imagination of the investigator.

The SEM is located at 10 Lonsdale Street, Melbourne.

References

J.W.S. Hearle et al, "The Use of the Scanning Electron Microscope", Pergamon Press (1972).

(Contact : E. Johansen, Advanced Techniques Branch 03-630 5499)

HIGH RESISTANT CONTACTS IN PRIVATE AUTOMATIC BRANCH EXCHANGES (PABXs)

Open circuit contacts in a PABX at an oil refinery have given trouble for a period of five to six years. The exchange, consisting of Ericsson equipment, is owned by the oil refining company and has been maintained by Telecom Australia under contract.

As the result of a recent failure of a fire alarm system, operated through the PABX by a dialling mode, the problem of open circuit contacts was brought to the attention of the Research Laboratories.

Examination of contacts using a scanning electron microscope showed the presence of a deposit in a contact crater. The deposit had a form characteristic of a chemical decomposition product, i.e., rough and porous. Subsequent electron microprobe analysis showed the deposit to have a high silicon content indicating that the material was silica from the decomposition of silicone compounds. Sulphur content was low showing that sulphides were not the cause of the trouble; further investigation is continuing to determine the source of the silicone contamination. Because of the small quantities of contaminant involved, large surface areas of the exchange have been sampled for likely sources of silicone. The analysis includes floor polishes, and chemicals used in a Xerox machine situated nearby.

(Contact : T. Keogh, Physical Sciences Branch 03-630 7895)

SUBSCRIBERS' METER READING - FACILITY FOR TRANSCRIPTION OF READINGS USING 35 mm FILM AND VIEWING APPARATUS

Following adverse criticism concerning accuracy of metered telephone calls, the Director-General's Committee Meeting in January 1973 established two working parties, to investigate (a) the nature and cause of metered call disputes, and (b) the technical reliability of the metering system.

A major recommendation was that errors could be reduced by photographing subscribers' meters and displaying this data in a form suitable for use by data processing operators.

The advantages of such a system were seen to be (a) reduction of errors by eliminating the previous method of recording involving a meter reader in an exchange calling readings by telephone to the data operators: (b) elimination of the necessity to involve local exchange staff in checking abnormal reports: (c) ability to store a photographic record in microfiche form to allow immediate access following customer queries.

A commercial manufacturer was contracted to develop suitable cameras and viewing equipment. In mid '74 it was found that the progress, particularly on the viewer, was unsatisfactory, so the problem was referred to the Research Laboratories.

The requirement was to produce a viewer which, using 35 mm film, allowed data processing operators to view only one row (10 meters), of the 100 meters readings per film frame, at a time. The original microfiche viewer chosen for development was found to be unsatisfactory, as it had no film transport mechanism. A commercially available audio visual viewer overcome this problem, and this has now been modified to meet specifications.

To minimise equipment and maintenance costs, an unusual method of viewing each row of meter readings has been developed. This involves 10 rows of tiny light emitting diodes, about 2 mm in diameter with 5 in each row. The operator can turn on each row in sequence, thus effectively underlining the row of meter readings being transcribed. In this way, errors caused by confusing readings in different rows are minimised.

Trials have now commenced, with the aim of finding the best position of the viewer for operator comfort, and to incorporate a suitable hood and anti-glare arrangement to reduce eye strain.

Modern subscribers' meters are arranged in blocks of 100, i.e., 10 rows of 10 meters as mentioned above. However most older style meters are arranged in blocks of 5 rows of 20: A second viewer, together with a camera hood adaption, is currently being developed to cater for these.

(Contact : R. Kilby, Standards and Laboratories Engineering Branch 03-541 6213)

NETWORK STUDIES

The Network Studies Section of the Switching and Signalling Branch performs studies and conducts research into the basic fundamentals of switching networks and systems. The following activities are typical of some of the larger projects in which this Section is involved.

Comparison of Analogue and Digital Stored Programme Control (SPC) Tandem Exchanges

This study considered and compared the factors that contributed to costs of the tandem network and provided a background upon which discussions can be based concerning future telephone switching systems, as well as highlighting areas requiring further studies. The resultant reports are contained in Switching and Signalling Paper No.4.

Automatic Exchange Tester

This project is a study of the feasibility of using a microprocessor system with a simple interface as a test instrument. The sequence of tests performed is under the control of a stored program which, amongst other factors, features a high level of man-machine language to assist the operator in his task. The exchange testing function was chosen as a practical application of this technique and a field-trial will be conducted with a feasibility model within the next few months. This project is providing an insight into future methods of exchange testing and remote testing as well as providing initial experience in the development of design techniques for microprocessor systems, and an appreciation of their potential for system application.

Call State Transition Diagrams (CSTD)

The need for a more flexible and adequate documentation method for use in SPC switching systems was realised some time ago both in the Research Laboratories and in the International Telegraph and Telephone Consultative Committee (C.C.I.T.T.). Study Group XI has a question specifically dealing with this topic. The CSTD technique has been developed within the Network Studies Section, and is forming a base for C.C.I.T.T. recommendations which are currently being drawn up. The technique has also been extended for use with the existing crossbar system and a manual describing the use of CSTD is being prepared.

SPC Local Exchange Tender Evaluation

This Section has been represented by Mr. Vizard as a member of the main working party, with considerable support from the Section in many of the sub working party activities. This support has been made possible by virtue of the experience gained in the C.C.I.T.T. No.6 and Integrated Switching and Transmission (IST) projects in the past.

DIMEX (formerly known as DIMARF)

This Section has been involved in the specification, design and preparation of a set of computer programs used for the dimensioning of telephone exchanges. The initial suite of programs should be completed in January 1976; they will then be able to interface directly with the Exchange Network Provisioning Aid (ENPA) system. Within the design, provision has been made for the expansion of the suite of programs in such a way that systems other than ARF can be readily added by following the same philosophy, and using the same structure developed for the DIMARF.

Topics which should receive future attention within the Section include:

- Data Switching Networks and Systems
- Network Testing and Maintenance
- System Design Techniques
- Simulation Techniques
- Microprocessor System Applications and Comparisons
- Common Channel Signalling
- Queueing Techniques in SPC Systems
- Network Transitions - the introduction of digital switching, etc.
- Consultation - including Mathematical in particular
- Processor Capacity Calculation Techniques

Priorities for these and other topics are dependent upon progress of current projects, availability of expertise within the Section, and resources and assistance from within the Branch and elsewhere. And last but not least, the Research, Development and Innovation Programme (RDI) endorsements received for this work.

The method of operating within the Section places emphasis on team activities, with various combinations of members of the Section, and sometimes people from outside the Section, making up these teams, depending upon the size and timetable of the activity.

(Contact : N.W. McLeod, Switching & Signalling Branch 03-541 6348)

ENGINEERING LIBRARY SERVICES

With the relocation of many of the Engineering Branches, two sections of the Engineering Library have been amalgamated and relocated on the 17th Floor, 518 Little Bourke Street, Melbourne, primarily to serve staff in that building.

One of the important functions of the Engineering Library is the compilation of bibliographies. These are reading lists which provide background information on a particular subject or an overview of the current state of research in a particular field. Listed below are bibliographies compiled between July - September 1975, copies of which are available on request.

1. Asbestosis
2. Backscatter in HF Radio Broadcasting
3. Common Channel Signalling
4. Digital Simulation of Communications Systems
5. Electronic Switching Systems (recent references only)

   (a) AKE (b) DEK (c) METACONTA (d) PRX
6. Ferrite Phase Shifters - articles by L.R. Whicker
7. Integer Programming
8. Intermodulation Distortion due to Filters
9. Linear Programming
10. Omnidirectional Antennas
11. PCM Systems - Evaluation
12. PCM Systems (recent references only)
13. Selective Epitaxial Growth
14. Subscriber Loop Systems

(Contact : Mrs. S. Peters, Standards & Laboratories Engineering Branch 03-630 7936)

FAULTY PVC SHEATHED AND INSULATED TELEPHONE CABLE

In April 1975, the Research Laboratories were asked to evaluate PVC sheathed and insulated telephone wire and cable in which the wire insulation, both plain and ink marked, whether in the form of single wire or made up into cable, felt tacky to the touch. The ink marking showed little affinity for the PVC and was transferring to adjacent wires in the cable. It could be removed readily from the majority of wires by wiping with a dry cloth or even the fingers. The insulation also appeared weak and could be easily stripped by the fingers. The sheath of the cables had a wet shiny surface and a greasy feel. It looked and felt as if it had been soaked in oil.

Tests showed that the insulation of all wires failed to comply with the flammability and shrinkage tests, whilst the sheaths failed the BS Softness test. One particular length of suspect cable submitted for electrical evaluations failed the insulation resistance measurements whilst neither its insulant nor sheath met Telecom Australia requirements of "no undesirable surface bloom or exudation".

Due to problems with the drying of marking ink, experiments with three new formulations of ink had been carried out during a two month period prior to the complaint of insulation tackiness. It was considered that the insulated wire problem was mainly one of unsatisfactory ink and was distinct from the sheath problem.

Additionally, plant failure between September 1974 and February 1975 through malfunction of a weighing device for the liquid components (the plasticiser, di-iso-octy phthalate (DIOP) and the extender, a chlorinated paraffin sold under the trade name of "Cereclor") had led to improperly compounded PVC being used for cable manufacture. This had the effect of adding up to about 26% more of these ingredients than was called for in the formulation. About 2-6 weeks after the cable had been produced, an oily exudation appeared on the sheath and in many cases it was reported as being severe enough to cause liquid to drip from the cable. The handling of the cable was thus a messy business but medical opinion is that the exudate does not constitute a health hazard to operators. It could, however, cause electrical contact problems in switching equipment and work is continuing to determine the degree of risk involved in leaving obviously faulty cable installed in telephone exchanges.

Most of the unused faulty sheathed cable is being re-sheathed with MOD100, a PVC of a different formulation, which has been used since May 1975, for the sheathing of production cable.

(Contact : H.J. Ruddell, Physical Sciences Branch 03-630 7995)

THE TRANSMISSION OF NON-TELEPHONY SIGNALS OVER PULSE CODE MODULATION (PCM) DERIVED VOICE FREQUENCY (VF) CIRCUITS

Two investigations have recently been carried out in the Research Laboratories to gain insight into the possible effects that the widescale introduction of PCM systems into the Australian telecommunications network may have on the transmission of non-telephony signals.

The first investigation examined the effect of tandem VF links on the transmission of non-telephony signals such as VF data (600/1200/2400/4800/9600 bit/s), MFC, VFT and facsimile. The aim of this investigation was to examine the effects of the transmission impairments produced by the successive encoding/decoding operations performed by the PCM terminal multiplexing/demultiplexing equipment associated with the individual PCM links in a tandem connection. The measurements were performed on commercial primary level PCM multiplex equipment which conformed to the relevant C.C.I.T.T. Recommendations G732, G733 and G712. The tandem connected circuits used were derived from both 24 channel and 30 channel PCM systems. The PCM multiplex terminal was looped at the multiplex/line equipment interface, and no attempt was made to include the transmission impairments, which could arise in a field situation due to the possible introduction of digital line errors, and the accumulation of timing jitter on the PCM Bearers between terminal equipment.

Although only a limited range of equipment types was used in the investigation the most common forms of non-telephony signal transmission were included. (A list of the actual signals used is given in Appendix I).

It was found that the effect of the accumulated signal impairments produced by the terminal multiplex equipment of up to 14 tandem PCM links had little effect on the transmission performance of the non-telephony signals tested, with the exception of baseband and 9600 bit/s data transmission. The major form of impairment was found to be due to the linear amplitude and group delay distortion produced by the analogue filters used in the PCM VF channel units and not the accumulated quantization distortion produced by the analogue-to-digital coding operations involved. Consequently, if necessary, it is possible to compensate for the transmission impairment produced by tandem PCM links by equalising the circuit with the conventional equalisers currently used on leased data circuits. One exception occurred with 9600 bit/s data transmission through 14 tandem PCM links where only a marginal transmission performance was achieved due to a resulting error rate of about 10^{-4}. In this case the accumulated quantization distortion appeared to be a major cause of the data errors which occurred. However, with seven links in tandem an error rate better than 10^{-5} was obtained and consequently it should be possible to achieve an adequate error rate for 9600 bit/s data transmission provided less than seven links are connected in tandem (say up to five links).

The reason for the poor transmission performance achieved with baseband data was not established, but it did not appear to be due to quantization distortion.

To examine the effect of bearer line errors on the transmission of non-telephony signals, a second investigation was carried out on a commercial 24 channel 1.544 Mbit/s PCM terminal which conformed to the C.C.I.T.T. G733 and G712 Recommendations. In this investigation the 24 channel PCM multiplex terminal was looped at the multiplex/line equipment interface, through a special bipolar error insertion unit, which allowed bipolar errors to be introduced into the PCM line signal in a controlled manner.

Tests were carried out on a range of commercial data modems involving different modulation techniques and transmission rates. A pseudo-random sequence generator was used to introduce errors into the PCM line signal in a pseudo-random fashion to produce a pre-selected average error rate. The distribution of the resulting PCM line errors, although not purely random, was representative of the distribution of line errors which could occur on an actual PCM bearer. No attempt was made to include the effect of line jitter, and the additional impairment that may arise from this source in a field situation was left for further study.

A list of the data transmission rates and commercial modems used in the investigation is shown in Appendix II. For a particular measurement the PCM line error rate of the looped PCM multiplex terminal was preset to a particular value. The modem under investigation was looped through a VF channel from the PCM terminal and its error rate measured with a conventional data test set. Measurements were carried out with different PCM line error rates and with the level of the data signal at the 4-wire input to the PCM VF channel adjusted in turn to -10 dBm0 and -25 dBm0 to establish the significance of the data signal level on the sensitivity of the modem's operation to the PCM line errors.

Although only a limited range of commercial data modems was used in the investigation and at some data transmission rates only one modem type was involved, the results indicate that the line errors which occur on PCM bearers should not place any restriction on data transmission at rates up to 24 00 bit/s. However, at rates above 2400 bit/s a data modem's sensitivity to PCM bearer errors can become significant and in some cases the data error rate produced by PCM line errors was in excess of 20 times the PCM line error rate. Consequently, it may be difficult to achieve extremely low data error rates (i.e., error rates less than 10^{-6}) at 4800 or 9600 bit/s on some PCM links. This will depend however on the actual PCM line error rates than can be achieved in practice and this will not be known until PCM systems are installed in quantity.

By using the highest data signal level permitted at the input to the PCM VF channel the effect of PCM line errors can be minimised. In general, it was found that the higher the data transmission rate the more sensitive the modem was to PCM line errors. One exception to this was the Racal Milgo Type 4600-48 modem which at 4800 bit/s was more sensitive to PCM line errors than the Codex 9600 modem operating at 9600 bit/s.

Summary

The effect of tandem PCM links and bearer line errors on the transmission of non-telephony signals over PCM systems has been investigated. The results of the investigation indicate that the widescale introduction of primary PCM carrier systems into the telecommunication network should not place any restriction on the transmission of non-telephony signals currently used (with the exception of baseband, 4800 bit/s and 9600 bit/s data) provided the effect of PCM bearer timing jitter (which has not as yet been investigated) is not significant. Transmission at the higher rates should be restricted to no more than four links.

The accumulated transmission impairment produced by the terminal multiplex equipment of up to 14 tandem PCM links was found to have negligible effect on the transmission of MFC, VFT (FM), facsimile and data signals up to 4800 bit/s. However, the effect of PCM bearer line errors was found to be significant for data rates above 2400 bit/s. To achieve satisfactory data transmission at 4800 bit/s over PCM, a bearer error rate of more than an order of magnitude better than the maximum data error rate than can be tolerated, is necessary. Satisfactory data transmission at 9600 bit/s over PCM would be limited to cases where few tandem links are involved (e.g., say less than four) and the overall bearer error rate is about two orders of magnitude better than the maximum data error rate permissible.

Although the effect of PCM line errors on VFT, MFC and facsimile was not investigated it is unlikely that line errors will have any significant effect on the transmission of these non-telephony signals due to the relative insensitivity of the lower speed data modems (i.e., at 600, 1200 and 2400 bit/s) to this form of interference.

(Contact : G.J. Semple, Transmission Systems Branch 03-541 6402)

APPENDIX I

The following commercial equipment was used in the non-telephony signals transmission investigation.

- Standard MFC generator included as part of a commercial AET "Exchange Tester" manufactured by L.M. Ericsson.
- "Mufax" Black and White (DSBAM) Facsimile Unit (Type D900/1-B/S).
- Philips 24 Channel FM Voice Frequency Telegraph Modem.
- 1200 bit/s SRT FSK Data Modem.
- 2400 bit/s Racal Milgo 4-phase Data Modem (Type 2200-24).
- 4800 bit/s Racal Milgo 4-phase, 2 level Data Modem (Type 4600-48).
- 9600/7200/4800 bit/s Codex Multiphase and Multilevel Data Modem (Type 9600).
- 1200/2400/4800...../38400 bit/s TRT Baseband Data Modem (Type Sematrans 1001).

APPENDIX II

The following transmission rates and commercial data modems were used in the investigation into the effect of PCM bearer errors on the transmission of VF data over PCM carrier systems.

Data Modem	Type of Modulation Involved	Data Rate (Bit/s)
SRT (GH-2002)	FSK	600
SRT (GH-2002)	FSK	1200
Racal Milgo (2200-24)	4-Phase	2400
Racal Milgo (4600-48)	4-Phase	2400
Racal Milgo (4600-48)	4-Phase 2 Level	4800
Codex (9600)	Multiphase/multilevel	4800
Codex (9600)	Multiphase/multilevel	9600

COLOUR TV TRANSMISSION SYSTEM FOR SINGLE-QUAD CABLE

The Line and Data Systems Section has been investigating the use of single-quad cable as a bearer for colour TV signals. A transmission system was developed initially for monochrome TV for use on a 740 m single-quad bearer in Hobart, Tasmania. This system was installed in May 1972.

The system design has been upgraded for colour TV, and is being used at present on a 400 m single-quad bearer in Bendigo, Victoria, from the BCV 8 studio to the Bendigo radio-telephone terminal. This system was installed in April 1975.

System Configuration

The system can be employed in either the duplex mode, double-simplex mode or single-simplex mode; the first two modes employing both pairs in the quad, with the last mode employing only one pair in the quad. The presently available system hardware is configured for the duplex mode; altering the hardware for the other modes does not present any problem.

The present system does not employ intermediate repeaters and the transmission limits are determined by near-end crosstalk for the duplex mode and thermal noise for the simplex modes. The transmission limits are:

Duplex Mode : 1 km

Simplex Modes : 1.8 km for Local Link Objective
2.4 km for National Reference Video Connection (NRVC) Objective

System Manufacturing and Cost

The transmission and protection equipment is being constructed by Adelaide Workshops at a cost of approximately $1000 per (duplex mode) terminal; two terminals being required per duplex transmission link.

The cost of equipment for the simplex modes is expected to be much the same, with a small saving for the single-simplex mode.

Repeatered System

It is expected that the above quoted transmission limits can be increased by using intermediate repeaters. These are not yet designed, but it is assumed that the single-simplex mode would be used, with the spare pair being used for power feeding and order-wire provision.

The extent to which the transmission limits can be increased depends on the build-up of thermal noise and non-linear distortion. The latter effect is under consideration at present while the former effect limits transmission as per the following:

Local Link Objective : 13 km using 12 repeaters
NRVC Objective : 40 km using 25 repeaters

These limits are quoted as a guide to the likely transmission limits; the actual limits will almost certainly be governed by the build-up of non-linear distortion.

Use as Surveillance System

A consideration of likely transmission objectives for surveillance systems indicates a transmission limit of about 3 km for an unrepeatered surveillance system.

(Contact : R. Smith, Transmission Systems Branch 03-541 6422)

THE DEGREE OF INTERNATIONAL STANDARDISATION OF PRIMARY LEVEL PULSE CODE MODULATION (PCM) SYSTEMS

Primary level PCM systems deriving 24-30 telephone circuits are designed to provide medium distance (10-50 km) inter-exchange circuits. Until now, such systems have only been installed in Australia under field-trial conditions, although some field trial routes have been expanded in PCM as an expedient to meet traffic requirements.

However, at present, serious consideration is being given to the introduction of PCM systems in significant quantities and it is pertinent to examine the degree of standardisation of such systems on a world-wide basis. The degree of standardisation is important as it directly affects the compatibility of equipment which might be obtainable in the international market-place i.e., from different manufacturers in different countries, and consequently the size of that market-place. It is also important as a basis for determining what additional parameters might need to be specified to ensure compatibility within any system which might be adopted for Australian use. Further, should local manufacture be encouraged, international standardisation will be important also in determining any export trade and possible consequent domestic prices.

The main international forum for the standardisation of PCM systems is the International Telegraph and Telephone Consultative Committee (C.C.I.T.T.), principally within its Special Study Group D and primary level systems have been under study for some ten years or so and indeed the study is continuing. However, the present studies could perhaps be described as "tidying-up".

Outside the C.C.I.T.T. the major group influencing PCM standardisation is the organisation of Western European administrations (C.E.P.T.) which has been very active in the PCM area and frequently has presented a unified and disciplined viewpoint within the C.C.I.T.T., although of course the C.C.I.T.T. recognises only the individual Administrations as members and not the C.E.P.T. itself.

Within the C.C.I.T.T., two system types have emerged. These are the 24-channel system operating at 1544 kbit/s, to which the North American and Japanese Administrations are committed, and the 30-channel system operating at 2048 kbit/s which is favoured by the C.E.P.T. and many of the Eastern-European administrations. It is interesting and important to note that, even within each class of system and taking into account the ongoing points of study, there are system parameters which are not specifically defined. In particular, the line section remains completely unspecified. The apparent reason for this is that primary level systems are essentially short-haul systems and are seen as national or domestic systems. Consequently, in the main, only those parameters which affect an international connection have been specified.

The following points refer to C.C.I.T.T. Recommendations relevant to primary level PCM systems which might be used for derivation of inter-exchange telephony circuits. Points specific to digital switching and integrated services digital networks are not considered here.

Interfaces

Recommendation G703 refers but is minimal in that it states little more than that the characteristics of interfaces are still under study. During the present Plenary Period, the concept of a digital distribution frame (d.d.f.) has been formed and electrical interface recommendations are being developed. The d.d.f. is a flexibility point (similar in concept to, for example, a group distribution frame) to which may be connected PCM multiplexes, line and other transmission systems. Draft Recommendations exist for interfaces at 1544 kbit/s and 2048 kbit/s. It is proposed that a Recommendation for an interface at 64 kbit/s will be developed. A line interface, i.e., the electrical parameters at the line termination, is not defined.

PCM Multiplexes

Primary level multiplexes deriving 24 and 30 voice-frequency channels are fairly completely defined. Recommendation G711 defines the source coding (analogue-digital and digital-analogue) process in terms of sampling rate, coding law, audio level in relation to the coding overload, for both types of systems; Recommendation G712 defines the performance characteristics to be obtained from PCM channels at voice frequencies and is reasonably comprehensive.

The specific multiplexing arrangements are defined fairly completely in Recommendations G732 (30 channel) and G733 (24 channel). Currently proposed additions and amendments relate mainly to the provision of alarms and the recommended action in the event of an alarm.

Signalling Arrangements within the Multiplex

Both G732 and G733 provide for channel associated signalling (in which specifically allocated time slots are used for inter-exchange control signalling for individual channels) or common channel signalling. The signalling capacities are covered by the following Recommendations:

G732, channel associated 2 kbit/s per channel.

G732, common channel : 64 kbit/s.

G733, channel associated : 1.667 kbit/s per channel.

G733, common channel : 4 kbit/s.

Provision is made within G732 for the nominated time-slot when not required for signalling purposes, to be used for other purposes. (It is interesting to note that PCM equipment so far offered to Telecom Australia against tender schedules which comply essentially with G732 or G733 have all been equipped for channel associated signalling; none has had provision for direct access to a digital interface for common channel signalling).

Additional capacity for common channel signalling may be obtained by directly accessing any time slot with an appropriate data interface.

64 kbit/s Data Interface

64 kbit/s is the transmission capacity of a channel time slot. It will be convenient to be able to access such a digital time slot for specialised non-telephony purposes, such as data transmission, digital facsimile, etc. No recommendation exists for an interface at 64 kbit/s, nor has it been possible to agree to a draft recommendation during the current Plenary Period. It is technically feasible to provide a 64 kbit/s interface to any time slot within the multiplex, although the present view in regard to the G732 multiplex is to provide access to only a small number of nominated time slots. The bit sequence interdependence, or transparency, of the data channel provided is not a function of the multiplex, but is a function of the use of particular line codes within the line transmission systems (not defined) or the use of scramblers.

It is likely that, when agreement is achieved on the provision of 64 kbit/s data channels within a G732 multiplex, this agreement will not be incorporated within G732 but that a separate Recommendation G732-Bis will be drawn up.

Line Systems

There are no Recommendations concerning line transmission systems for primary level PCM, nor is there any indication that such Recommendations may be produced. It appears that the C.C.I.T.T. has taken the attitude that primary level line systems are essentially national systems and therefore have not attempted to rationalise the many variations which exist or which will be adopted by various administrations, even among those committed to a particular multiplex, i.e., G732 or G733.

A line system comprises three parts; an information transmission system, a power-feeding system and a supervisory system.

The information transmission system comprises terminal equipment including line drivers and terminal pulse regenerators. It may include also code conversion equipment, scramblers, or rate adjustment equipment to assist in overcoming regenerator operational problems with particular information patterns, i.e., to assist in attaining bit-sequence interdependence; there being no uniformity among administrations for these items.

The information transmission system includes also line regenerators. Again there is little uniformity in several design parameters which have an important influence on system performance. These parameters include the maximum electrical span between regenerators, output voltages and wave shapes, and time extraction circuitry. The latter is particularly important in determining the degree of jitter which is introduced into the signals; quality factor (Q) of this circuitry, which is the important parameter, varies between about 40 and 2000, depending upon the manufacturer.

The line feeding arrangements are fairly uniform in that the phantom of the four-wire duplex line circuit is used for d.c. transmission. However there is little uniformity in terms of the voltages and currents which are used.

There is also no concensus in terms of supervisory systems. Several supervisory techniques are in use and, even within a particular technique, operational details vary considerably.

Coded Sound Programme Transmission

The study of sound programme encoding has been entrusted to C.M.T.T. (Joint C.C.I.R./C.C.I.T.T. Committee on sound and television programme transmission). At this time there is a U.K. coding proposal and an Italian/German proposal before C.M.T.T. The gross bit rate nominated in each proposal is of the order of 320 kbit/s. This assures that a number of digital sound programme channels may be transmitted within the capacity of the primary level bit rates of 1544 and 2048 kbit/s. A proposal for multiplexing six monophonic sound channels into a 2048 kbit/s stream has been made. However, the C.C.I.T.T. cannot proceed in the specification of a suitable PCM multiplex frame structure before the study of C.M.T.T. in the areas of coding and of protection against errors is completed.

Summary

Primary level PCM systems are the basic building blocks of a digital communication system and furthermore are almost invariably the first digital transmission systems to be introduced into existing telecommunication networks. Hence, at this stage, much interest is focussed on them. There is considerable definition included in C.C.I.T.T. Recommendations for primary level PCM systems. There is an obvious partition into two types of system, one a 30-channel system supported principally by the C.E.P.T. Administrations, the other a 24-channel system supported by North America and Japan. However, even within each type of system, and apart from obvious differences in mechanical construction, there can be considerably variation in electrical characteristics. This is particularly so in the case of the line transmission system, where compatibility of equipment purchased from different manufacturers, particularly when they have different domestic markets, must be suspect.

There is no standard or Recommendation for the coding or multiplexing of sound programme channels within a primary level system.

(Contact : R. Smith, Transmission Systems Branch 03-541 6422)

RESEARCH LABORATORIES REPORTS

In the interests of economy and to reduce the unnecessary time involved in handling unwanted reports the present wide automatic distribution has been discontinued. In future, a summary of each report presented for publication in the preceding three months will be included in 'Research Quarterly'.

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RESEARCH LABORATORIES REPORT SUMMARIES

REPORT 7002 - LIGHT EMITTING DIODES - INITIAL MEASUREMENTS

BY I.A. DEW

Discrete light emitting diodes (LEDs) are now used extensively. There is, however, some doubt as to the useful life that may be expected from an LED. An examination is currently being made of LEDs in order to assess their possible weaknesses. Red, yellow and green samples from different manufacturers are currently being examined. Initial measurements which were made on 20 samples of each type and manufacture were:

1. Electrical Parameters

   (a) Forward voltage drop at 10 mA and 50 mA.

   (b) Reverse leakage at 3 V.

2. Optical Parameters

   (a) Relative total luminous flux.

   (b) Spatial distribution of emitted light.

The LEDs are presently being life tested and when this is concluded the parameters measured initially will be measured again and the results analysed. This report deal only with the results of the initial measurements.

Examination of the LEDs has shown that considerable variation in both brightness and beam orientation between individual LEDs of all colours can be expected. The types of LEDs examined are sold for use as visual indicators and are generally suitable only for use as such. Use in optical apparatus may require selection from a large batch in order to achieve a desired standard of performance, and replacement could then be a problem.

Some yellow and green LEDs were found to be unsatisfactory because of their poor mechanical construction. Some red LEDs were also considered unsuitable because of faulty welds of the header lead to the anode post.

REPORT 7007 - 'MURATA' PIEZOELECTRIC TUNING FORKS

BY G.W.G. GOODE

Telephone Switching Construction Branch is considering the use, for testing switching equipment in telephone exchanges, of portable pulse generators which would incorporate an oscillator controlled by a piezoelectric tuning fork as its master timing clock. The generators would need to operate within the range 20 $\pm$ 20°C. The tuning fork being considered is the 'Murata' 1 kHz miniature type EFM-S.

The report describes the dimensions and materials and other details of construction of the fork, its method of operation and its electrical characteristics. Its temperature coefficient of frequency; its ability to withstand humid and corrosive environments, vibration and electrical overloads; and the results of 1500 h life test at 40°C and the effect of electrical and magnetic interference on it are discussed.

Details and graphs are given of the output signal produced by the fork under various conditions. These include outputs produced by external vibration applied to the fork, both with and without the normal driving circuit connected, and by application of an external sinusoidal signal to the fork over a wide frequency range. The circuit diagram of the standard driving circuit and photographs of the fork unit are supplied.

Most of the fork units which underwent the 1500 h life test showed a long term frequency stability of better than $\pm$ 1 Hz over the temperature range expected in service and the remainder were better than $\pm$ 2.5 Hz. The temperature coefficient of frequency was found to be small.

The fork units satisfactorily withstood electrical overloads and were not readily affected by corrosion or the effects of operation in a humid atmosphere.

Quite low amplitudes of externally imposed mechanical vibration can easily induce unwanted potentials on the fork and medium amplitudes can damage it. The fork and its associated circuitry are affected by magnetic and electro-magnetic fields and they should be screened against such fields.

REPORT 7008 - CORROSION PROTECTION OF ALUMINIUM CONDUCTORS IN TELECOMMUNICATION CABLE BY CHROMATE TREATMENT OF THE CONDUCTOR AND SILICONE IMPREGNATION OF THE PAPER INSULATION

BY Z. SLAVIK

The major disadvantage of aluminium when compared with copper for use as conductors in telecommunication cable is its inferior corrosion resistance in moist conditions. Furthermore, as the corrosion products of aluminium are hygroscopic, the drying of a moist aluminium conductor cable is difficult and original insulation resistance cannot be restored.

A simple chromate conversion treatment of the aluminium conductor improves its corrosion performance significantly. In all tests the chromated conductors withstood the near-saturated humidity condition with periodical water condensation and 50 V d.c. potential applied for many weeks showing only minor corrosion attack while unprotected conductors were invariably breaking down. In addition to the upgraded corrosion resistance, chromated conductors have a lower and a more uniform surface resistance than plain conductors.

An impregnation of the paper insulation eliminates water adsorption by the paper from both vapour and liquid phase. The resulting decrease in current leakage further reduces the corrosion of the conductors. The major contribution of the paper impregnation is the possibility of restoration of the original insulation resistance by drying, as no hygroscopic corrosion produce can be adsorbed by the insulation. During the tests the original insulation resistance had been restored several times in repeated wetting and drying cycles.

It is believed that the combined treatment of both conductors and insulation as suggested in this report would significantly enhance the compatibility of aluminium as a conductor in telecommunication cable and improve the performance of such cable, especially under fault conditions.

REPORT 7009 - EARTHING MATERIALS FOR LEAD SHEATH CABLES

BY P.J. GWYNN

The usage of plastics cables is increasing; consequently, the amount of metallic lead in direct contact to the soil is reduced. This trend is desirable to eliminate cable corrosion. However, it also makes it necessary to install independent earth systems more frequently. Very often, these earth-rod materials would have inevitable metallic connections to existing cable installations.

The earthing material should not cause accelerated corrosion to lead and it is also important that the lead should not reduce the life of the earth-rod by galvanic corrosion.

Five different earth-rod materials were studied during five years of a field trial to determine their suitability for earthing and their compatibility with lead. A comprehensive literature study was also made and relevant information to characterise these materials is included in the report.

In the field trial, twelve samples of each of the five different earth-rod materials were individually connected to lead and buried underground. The generated galvanic current and electrode potentials of the connected and disconnected couples were recorded at regular intervals. Statistical analyses were made of the obtained results. Metallic losses, due to galvanic induced and parasitic corrosion versus time were also determined.

The work showed that "Niresist" is the most compatible material when connected to lead. Aluminium and galvanised iron were anodic, copper and stainless steel were excessively cathodic in their behaviour.

Further studies are envisaged to determine the suitability of nickel-clad steel for the same purpose.

REPORT 7010 - OPTICAL CHARACTER RECOGNITION - THEORETICAL INVESTIGATIONS

BY R.A. SEIDL

This report covers theoretical investigations into character recognition carried out by the author both within the Research Laboratories and while at Newcastle University. The report has been written in three parts.

The first part of the report presents an overview of the area of character recognition. It briefly discusses the various approaches to character recognition that have been adopted over the last decade and a half. Techniques vary from template matching, to global transformations such as autocorrelations and moment transforms to local template techniques for feature extraction which encompass the "ad hoc" topological type of features. Feature extraction has been recognised as the most important aspect of character recognition. Unfortunately, however, the literature concentrates overwhelmingly on the various aspects of classification procedures.

Part two of this report presents an investigation into the use of "lateral inhibitory fields" as feature extractors for character recognition. These "lateral inhibitory fields" are essentially local templates or filters. This work was prompted by the promising results reported by Dr. Stringa in his mail address recognition system (MARS). His investigations were based upon the findings of Hubel and Wiesel of similar "feature extractors" in the visual cortex of the cat. This section of the report discusses the response to a particular type of "lateral inhibitory field" to visual input as the various feature extractor parameters are varied. The analogies and extensions to other types of similar fields is obvious.

The final section of the report is an extraction from the author's doctoral thesis, which describes a theory of structure and encoding of visual patterns and is applicable to character recognition. Most other systems rely upon intuitive ideas and subjective judgements, however, this is an objective theory, and it is shown to work.

The theory of structure is hierarchial, but it is mainly second order structure which is used in the character representations. Second order structure can be detected by examination of the statistics of the chords of the pattern. "Points of interest" in the pattern can also be detected by second order analysis. Configurations, which are also hierarchial objects, are used as representational models. These configurations are extracted by local second order analysis of "complex points", or "points of interest".

REPORT 7011 - A VERSATILE SCANNER FOR OPTICAL CHARACTER RECOGNITION STUDIES

BY G.K. JENKINS

Optical character recognition algorithms are currently under investigation within research establishments throughout the world. Potential applications are found in postal/telecommunications sorting, billing/ordering systems, and the multitudinous variety of turn-around document processing systems with which the (individual or corporate) twentieth century consumer is confronted.

A scanning system was implemented in order to digitise hand-printed and/or machine generated (i.e., typed, computer produced, lithographed, etc.) alphanumeric characters of varying (but not necessarily intermixed) sizes, these digitised characters then being used for an investigation of OCR techniques.

A primary component within the system is a general purpose mini-computer, the use of which enables an extremely simple hardware realisation, whilst offering (via appropriate software) an almost unlimited range of scanning capabilities.

Character images are scanned off automatically fed/stacked cards, and output (as a binary or multilevel matrix) on punched paper tape.

This report deals with the selection of system parameters, then describes the (minimal) hardware/interface component. The software component (implemented in assembly-code for execution efficiency) is then covered in detail; a feature of this component is that it enables fully buffered testing of ASCII paper tape, and punching of previously scanned characters whilst scanning/display is in progress.

REPORT 7012 - RESEARCH INFORMATION SYSTEM - AN OVERVIEW

BY G.K. JENKINS

Corporate information systems have traditionally been employed in the accumulation/distribution of statistics for management decision-making. Access to such a system within an organisation is usually available only to a select group of qualified practitioners. The system discussed in this report is intended for use by both management and non-management components of an organisation. As well as providing the usual type of management information, it facilitates the conduct of day-to-day transactions at all levels; the delays previously incurred in committing such transactions to paper for distribution (and the associated consumption of a valuable ecological resource) are thereby obviated.

A somewhat singular characteristic of the RINSY system is its dual experimental/live-transaction nature; to this end, it has been implemented in modular open-ended form on a general purpose time-sharing facility. Access may be effected via conventional (VDU or hard-copy) interactive terminal devices; alternatively, an innovative micro-programmed data-entry device may be used in conjunction with those other communication equipments which might be found in a modern office environment.

This Report provides an overview of the RINSY system, starting with the design philosophy employed; it then goes on to detail implementation of the base system components.

REPORT 7014 - TRANSMISSION OF NON-TELEPHONY SIGNALS OVER TANDEM PCM CARRIER DERIVED PCM CIRCUITS

This report summarises the result of a series of measurements carried out to investigate the effect of tandem VF PCM carrier links on the transmission of non-telephony signals such as VF data (1200/2400/4800/9600 bit/s), MFC, VFT and facsimile. The aim of the investigation was to examine the effects of the transmission impairments produced by the successive encoding/decoding operations performed by the PCM terminal multiplexing/demultiplexing equipment associated with the individual PCM links in a tandem connection. The measurements were performed in the laboratory on commercial primary level PCM multiplex equipment which comprised both 24 channel (1.544 Mbit/s) and 30 channel (2.048 Mbit/s) systems which conformed with the appropriate C.C.I.T.T. Recommendations G732, G733 and G712. No attempt was made to examine the effects of the transmission impairments which could arise in a field situation due to the introduction of digital line errors and the accumulation of timing jitter on the PCM bearers between terminal equipment.

Although only a limited range of equipment types was used in the investigation the most common forms of non-telephony signal transmission were included. The results of the investigation indicate that the wide scale introduction of primary PCM carrier systems into the telecommunication network will not place any significant restrictions on the transmission of the non-telephony signals which are currently used (with the possible exception of baseband and 9600 bit/s data transmission), provided the effects of PCM bearer line errors and timing jitter are not significant. The effects of line errors and jitter are a subject for further investigation (preliminary studies indicate that line errors and jitter could cause some problems with data modems at higher bit rates). From the results of the investigation it was found that the effect of the accumulated signal impairment, produced by the terminal multiplex equipment of 14 tandem PCM links, on the operation of the equipment used for the transmission of non-telephony signals, was in most cases insignificant. The major form of impairment was found to be due to the linear distortion (i.e. amplitude and group delay) produced by the analogue filters used in the PCM VF

channel units and not (except at 9600 bit/s) the accumulated quantization distortion produced by the analogue to digital coding operations involved. Consequently, where necessary it should be possible to compensate for the linear distortion by using the conventional equalisers currently used on leased circuits involving data transmission.

REPORT 7017 - A REVIEW OF INTEGRATED TELEVISION SOUND BROADCASTING

BY R.A. COURT

This report is the result of a brief survey into techniques for the direct broadcasting of television signals by satellite. In particular it is concerned with the transmission of the associated sound, including stereophony, in the horizontal and vertical blanking intervals of the video signal.

Satellite transmission of television programmes between continents is now common practice. However the use of satellites to extend existing national terrestrial television broadcasting systems is only now emerging. The small receiving antennas which would be required for such a service, demand a higher output power from the satellite than is currently available. For broadcasting purposes it is clear that the audio content of the signal must accompany the video content. The analogue solution to this is to provide a sub-carrier away from the video band to transmit the audio. However both power and bandwidth can be saved if digital techniques are used to integrate audio signal into the video signal. A number of integration methods have been proposed in various organisations and administrations and they are reviewed in this report. The report also includes the I.T.U. frequency allocation for satellite broadcasting as well as a comprehensive list of references. A short bibliography of papers on related topics is also given.

REPORT 7021 - DIGITAL CIRCUITRY FOR A 140 Mbit/s REGENERATIVE REPEATER

BY A.Y.C. QUAN

The investigation of high speed digital communication over coaxial pair by the Line and Data Systems Section of the Research Laboratories has resulted in the design of an independent repeater for operation at an information rate of 139.264 Mbit/s. This corresponds to the output of a fourth-order multiplexer in the PCM hierarchy proposed by various European telecommunications administrations.

In order to reduce the required system bandwidth and transmitted power, 4B3T coding of the information was adopted. Consequently, three level transmission and a line transmission rate of 104.448 Mbaud were used.

This Report describes various types of circuitry suitable for use in the digital processing sections of the high speed repeater. A digital repeater can be either regenerative or non-regenerative. The repeater described in this Report is of the regenerative type. That is, it contains a timing recovery circuit for retiming the digital signal to be retransmitted. The sections of the repeater described include the circuits for threshold detection, timing recovery and line driving.

The circuits employed were chosen because of their simplicity, reliability of operation and low power consumption. Discrete rather than integrated components were used.

REPORT 7024 - THE EFFECTS OF BEARER ERRORS ON THE TRANSMISSION OF VF DATA OVER PCM CARRIER SYSTEMS

BY G.J. SEMPLE

This report records the results of an investigation into the effects of PCM bearer errors on the transmission of VF data over PCM carrier systems. The investigation was carried out in the laboratory on a commercial 24 channel 1.544 Mbit/s PCM terminal. The channel multiplex equipment was looped at the multiplex/line interface through a special "Bipolar Error Inserter" which allowed bipolar errors to be introduced into the PCM line signal in a controlled manner. Tests were made on a range of commercial data modems involving different modulation techniques and bit rates.

For a particular measurement the PCM line error rate of the looped PCM multiplex terminal was preset to a particular value. The modem under investigation was looped through a VF channel from the PCM terminal and its error rate measured with a conventional data test set. Measurements were repeated with the PCM line error rate adjusted to different values. In addition, the level of the data signal applied to the four-wire input of the PCM channel was adjusted in turn to -10 dBm0 and -25 dBm0 to observe the effect of signal level on the sensitivity of the modem's operation to PCM line errors.

Although only a limited range of commercial data modems was used in the investigation and at some data transmission rates only one modem type was tested, the results indicate that the wide scale introduction of PCM systems into the telecommunication network should not place any severe restriction on data transmission at rates up to 2400 bit/s. However, at rates above 2400 bit/s, a data modem's sensitivity to PCM bearer errors tends to become significant and it may be difficult to achieve extremely low data error rates on some PCM links. This will depend on the PCM line error rates that can be achieved in practice and this information will not become available until PCM systems are installed in quantity.

In general, it was found that the higher the data transmission rate, the more sensitive a particular modem was to PCM line errors. However, one exception to this was found with a 4800 bit/s modem which was more sensitive to PCM line errors than another modem operating at 9600 bit/s.

By using the highest data signal level permitted at the input to a PCM channel, the effect of PCM line errors can be minimised. Any additional contribution to the data error rate of a modem as a result of the timing jitter which can arise along a PCM bearer is a subject for further investigation.

REPORT 7025 - RESEARCH INFORMATION SYSTEM - THE NEWS SERVICE

BY G.K. JENKINS

A previous Report (Research Information System - An Overview) described the RINSY program currently implemented in the dual role of a research vehicle, and a practical information system for use within the Research Laboratories. This Report describes one of the services available within that program.

The leading of a viable existence within today's technological society almost demands of an individual (both as a social entity, and a work-force component) that he be aware of happenings outside his own immediate field of perception. Such an awareness is most generally gleaned by his subscribing to one or more of the media services.

By their very nature, these services tend to be either easily digested, and non-specific in their relativity, and/or ecologically wasteful (in presenting a wide range of news in detail, only some of which will be of use to the subscriber).

It is in the light of the foregoing considerations that the News Service component of RINSY has been implemented.

The service enables a subscriber (through any time-share terminal, and at any time suitable to himself) to access current news items appended since his most previous access, selecting only those items of interest. The selected items are then displayed (in detail) to the user; after viewing, any of these items may be directed (via a RINSY point-file) to a hard copy terminal device.

This Report covers the design criteria used for the service, then describes its implementation on a general purpose time share utility. Those features which inhibit simultaneous file access and item update, and which contribute to the low storage and usage costs involved are described in some detail.

REPORT 7026 - SOME USEFUL TIME-SHARE UTILITY PROGRAMS

BY G.K. JENKINS

During the recent proliferation of time-shared computer applications within the Research Laboratories, several comparatively minor, but none the less vexatious shortcomings of the time-share terminals and/or utility services in use have become apparent. These shortcomings relate particularly to certain applications within the Research Laboratories; however, it may be expected that at least some of them will be of concern in other areas.

A suite of programs designed to overcome or alleviate these shortcomings is described (in terms of both content, and usage) in this Report. Each of the programs is implemented (through necessity and/or convenience) in Honeywell Mark-3 Fortran, and some programming techniques of particular utility in that language are illustrated; however, conversion (where appropriate) for use on the Telecom Australia computer network would present few difficulties.

The first program in the suite enables a user to generate and enter mixed case text material from a terminal (such as a Teletype Corporation ASR-33) having only an upper-case ASCII subset. Once editing is complete, text material may (optionally) be listed at the terminal with case indicators for verification, then directed to a full-ASCII remote print-station. Alternatively, an upper/lower case interactive terminal (such as the IBM-2741) may be employed for final print-out.

The second program in the suite may be used for the (attended or unattended) listing of one or more program/data files (in full or in part), and is able (optionally) to mark transparent characters, and/or list wide lines by wrapping them around onto two (or more) narrower lines.

A versatile catalog descriptor program is also provided, and is of particular utility where a user wishes to search a catalogue for the files whose names begin with his initials, or contain some key character group; it also includes a global password modification facility.

The last of the programs described in this Report enables a user to efficiently generate personalised letters (or other appropriate correspondence) directed to a number of different (personal or corporate) entities.

REPORT 7027 - RSALX - A CROSS-ASSEMBLER FOR THE ALPHA SERIES OF MINICOMPUTERS

BY R.A. SEIDL

This report describes the capabilities of a cross-assembler written in Honeywell Mark-3 Fortran, for the Alpha series of minicomputers. The cross-assembler generates a binary object-file which may be loaded into the minicomputer from a time-share teletype terminal. The teletype and time-share interface is also discussed.

REPORT 7028 - A TIME-SHARED ASSEMBLER FOR NOVA AND NOVA-COMPATIBLE MINI-COMPUTERS

BY G.K. JENKINS

During the past decade, the cost of mini-computers has decreased to an extent which is little short of incredible; there is every reason to believe that it will continue to fall, particularly in view of the almost daily emergence of new micro-processors which require only power supplies and chassis to give them virtually the same capabilities as a conventional mini-computer. The application of such mini-computers/micro-processors in a process control (or even a computational or information processing) environment must therefore be regarded as an extremely attractive proposition.

One major encumberance has been the necessity of acquiring special peripherals (such as paper-tape reader/punch, cassette or flexible disc equipment, small line-printers, etc.), often costing more than the processor itself, in order that assembly language source programs might be generated/edited and assembled. And even when such equipment is available its use is often cumbersome, always tedious, and (especially where paper-tape equipment is involved) a source of acute frustration to the user.

Whilst several micro-processor manufacturers have come to terms with the problem, and are now offering well-supported cross-assemblers (and even cross-compilers) through widely accessible time-share utilities, the mini-computer vendors have chosen to ignore the problem. One suspects that such apparent ignorance is occasioned by a (understandable) desire to market their own peripheral products.

This Report describes and illustrates the use of a generally available cross-assembler, suitable for Data General (Nova), Digital Computer Controls, Keronix, Rolm, and other Nova-compatible mini-computers, and for the several Nova-compatible micro-processors which we may expect to see on the market in the near future. For convenience, the cross-assembler has been implemented on the Honeywell Mark-3 system; however, it was designed with portability in mind, and will be transferred to the Telecom Australia computer network at a later date.

REPORT 7029 - PAPER TAPE FACILITIES FOR CDC 6000/7000/CYBER COMPUTERS

BY G.K. JENKINS

CDC 6000/7000/Cyber computers are now widely used in Australia (and indeed, throughout the world) in commercial, engineering, and scientific data processing applications. In many cases, these computers are accessed through remote batch terminals, consisting (in the main) of a card reader, a line printer, and a visual-display/controller.

The application of such computing facilities in the processing of data-logged records, ASCII/EBCDIC program sources, etc. necessitates some means of entering and/or generating (5, 6 or 8-channel) paper-tape. In the past, this was usually effected by use of a batch service bureau for intermediate transfer of paper-tape to (or from) magnetic tape. The delays inherent in such an approach are (to say the least) an acute source of frustration to the user; indeed, it is probable that they have led to the curtailment of a number of otherwise viable projects.

Two solutions to the problem are presented in this Report. In each case, interfacing (at user level) to the CDC 6000/7000/Cyber computer is achieved by calls to either a reading or a punching sub-routine, having as its single parameter the integer representation of the next frame read/to be punched. The generation of direction marked leaders, trailers, etc., and blocking of data for efficiency is handled (transparently as far as the user is concerned) by these sub-routines.

The first of these solutions is applicable where a programmable terminal having paper-tape facilities is available, a DCT-132 terminal has been used in the initial implementation, but adaptation for other terminals should pose few problems. No intermediate media transfers are involved, so that turn-around can be almost instantaneous (according to requested job priority).

The other solution is applicable where a CDC 160, 160A, or 8090 computer is available (for instance at those processing centres where such computers are employed for input/output buffering). An intermediate transfer to magnetic tape is involved, but this is transparent to the user.

REPORT 7030 - PEAK SIGNAL POWER LEVELS FOR HIGH-SPEED BASEBAND DIGITAL TRANSMISSION SYSTEMS

BY A.Y.C. QUAN and J.L. PARK

One essential parameter to be specified in the design of a baseband digital transmission system is the peak signal power level required from a digital repeater.

This Report sets out the computation procedure to give the peak signal power level needed to achieve a desired error rate for two and three level digital transmission and various repeater spans. Comments on symbol rate reduction are made.

REPORT 7032 - COUPLING COEFFICIENTS BETWEEN MODES OF ANY ORDER IN CURVED CIRCULAR WAVEGUIDES

BY L.A. DENGER

Maxwell's equations can be developed into coupled wave equations. They are very helpful in that form for studying the propagation of microwave power through waveguides at any frequency either in the microwave range or in the optical range (Ref. 1).

Conventional methods of processing the coupled wave equations pursue an iterative scheme with two elements, the fundamental wave and a spurious, processed at a time. Such techniques can be in error in some instances (Ref. 2). The knowledge of coupling coefficients between modes of any order is necessary for equations with more than two elements.

The programming of these developments represents considerable work. Moreover the computer time required for the processing of programs is already of the order of minutes (CYBER 75). The computation of the coupling coefficients is only a part of the work involved in the solution of the coupled wave equations. After finding the coefficients, it is necessary to process the equations themselves, and this represents another major operation. It is obvious that the labour required for the whole operation makes it very expensive. The actual mathematical technology is still not sufficient for the efficient numerical processing of such systems.

Mode generators as represented in the above computations are ideal and are very unlikely to be found in reality, where radii of bends, as well as their length are random quantities. Furthermore, in reality, mode generators are of mixed nature. This is a supplementary addition to the complexity of the problem.

Similar observations can be made about other more complicated structures than dielectric coated waveguides. In that case, the mathematics is more intricate and the programming labour is greater. The computer time for the processing follows the same trend.

The main conclusion of the analysis is that another simpler model, not involving the computation of coupling coefficients, to the same extent as in the actual model, could be most helpful in the design of overmoded telecommunication systems.

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3. S.P. Morgan, "Theory of Curved Circular Waveguide Containing an Inhomogeneous Dielectric". BSTJ 36, pp. 1209-1251 (1957).

REPORT 7036 - PLASTICS ENCAPSULATED INTEGRATED CIRCUITS FOR THE STC "MINIMAT" PABX

BY G.G. MITCHELL

Plastics encapsulated integrated circuits, originally developed for low cost non-critical applications, are now being put forward for uses where reliability is most important. It is clear from the published work on the reliability of plastics encapsulated semiconductors that no "ideal" plastics encapsulant exists and that present moulding materials are of necessity a compromise. Most failures in plastics encapsulated integrated circuits result from either thermal mismatch of the metal and plastics giving rise to broken wires or bonds, or moisture induced corrosion of the aluminium metallisation of the circuit. A test programme directed at these weaknesses has been applied to three integrated circuit types proposed for use in the "Minimat" PABX system. Ninety integrated circuits, encapsulated in silicone or epoxy B, and six ceramic encapsulated integrated circuits were tested. Parameter measurements were made before and after the testing and the functioning of each sample was checked after each stage of the testing.

The initial parameter measurements at 20°C detected four of the integrated circuits as being faulty when received. Function checks at 0°C, 70°C and after storage for 24 h at 180°C did not reveal any further failures. A monitored temperature cycle, followed by an 8 day "Burn-in" at 70°C and under worst case load conditions produced no failures. The integrated circuits were then subjected to moisture resistance testing at 85°C, 85% RH for 1000 h and eight failures occurred. Subsequent exposure of a third of the samples to 121°C, 100% RH for 25 h produced one further failure. Six silicone and three epoxy B encapsulated integrated circuits failed to complete the test programme, all failures being open circuit failures. None of the ceramic encapsulated integrated circuits failed. Analysis of the results of the parameter measurements did not show any significant changes in any of the other samples.

Clearly, the plastics encapsulated integrated circuits tested were vulnerable to moisture penetration and ultimate failure of such components appears inevitable, especially when used in environments having uncontrolled humidity. The acceleration factor for humidity stressing, although not yet accurately determined, is small and demonstration of reliability takes a considerable length of time. The weight of evidence indicates that plastics encapsulated integrated circuits do not yet meet the reliability levels that would allow their widespread use in critical applications.

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RESEARCH LABORATORIES CASE STATISTICS

Upon receipt of a request for development or investigational work or, in certain cases, for some specialised construction, a decision is made as to whether it is appropriate and practicable for the Laboratories to undertake that work. If the work is to proceed, a "Case No." is allotted. Requests are initiated mainly by the Research Laboratories; many originate from other Branches in the Headquarters Engineering Divisions; some are from State Engineering Divisions or Branches and, in a few cases, from outside Administrations or Authorities.

Listed below are statistics of cases undertaken during the period Sept./Oct./Nov. in two categories; the Originating Section, and the Investigating Section.

(a) Originator

Branch or Authority	Previous (as at 1.9.75)	Added	Closed	Current (as at 30.11.75)
Lines Construction	35	-	4	31
Long Line Equipment Construction	6	1	-	7
Network Performance & Operations	3	1	-	4
Radiocommunications Construction	18	-	-	18
General Works	4	-	-	4
Customer Equipment	16	1	1	16
Telephone Switching Construction	19	1	1	19
Planning	12	-	2	10
Switching Design	-	1	-	1
Broadcasting	-	1	-	1
National Telecom. Plan	2	-	-	2
Others	36	5	-	41
Research Laboratories	200	13	5	208
TOTAL	351	24	13	362

(b) Investigating Section

Research Section	Previous (as at 1.9.75)	Added	Closed	Current (as at 30.11.75)
Customer Apparatus	20	6	-	26
Line and Data Systems	23	1	-	24
Network Theory	10	1	-	11
Radio Systems	16	-	-	16
Microelectronics	3	-	-	3
Electrical Standards	8	1	-	9
Laboratory Instrumentation	12		-	12
Time and Frequency Standards	17		-	17
Project Engineering	4		-	4
Computer Application & Techniques	6		-	6
Guided Media	2		-	2
Satellites	3		-	3
Solid State & Quantum Electronics	6		-	6
Unguided Media	15		-	15
Visual Communications	6	-	-	6
Switching & Signalling Branch	6	-	-	6
Devices and Techniques	7	-	-	6
Network Studies	8	-	-	8
Systems Development	22	3	4	21
A.D.P.	-	2	-	2
Physics and Polymer	107	8	8	107
Analytical Chemistry	23	1	-	24
Electro-Chemistry & Metallurgy	27	1	-	28
TOTAL	351	24	13	362