Volume 34 No. 1, 1984

the telecommunication journal of Australia

FEATURED IN THIS ISSUE

34/1

Australia produces another first for Telecom!

Small Traffic Recorder

Designed to Telecom Australia specifications, can be used for either Individual Circuit Monitoring or Traffic Group measurement.

- Fully programmable with user friendly dialogue.
- Facilities for data verification prior to study.
- Longline remote control for unattended operation.
- Computer legible data output for tertiary processing.
- Programmable thresholds and time delays.

- ○ Dual range 0-63/0-200 erlangs analog groups.
- ○ 128 individual occupancy inputs.
- ○ 16 analog group inputs.
- ○ 8 programmable software groups.
- ○ 1.2 megabytes of digital data storage.

There are two important features of the STR unit, generally not found in existing equipment and similar equipment developed overseas:

1. It enables the staff setting up the study to check and verify the data prior to, during, and after the study, before the data is forwarded for further processing. This facility is also extremely useful for network maintenance field engineering.

2. Computer legible data output.

The STR microprocessor design is flexible and easily adapted to a host of measurement applications including, for instance, in the telephone traffic measurement field: decadic dispersion and Traffic Data Equipment (TDE) data recording.

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Cover:
The Gold Phone — a new coin telephone with STD and ISD facilities, offered by Telecom Australia.

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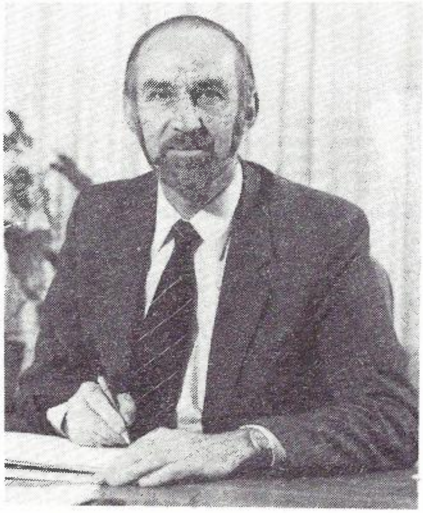

Editorial

K. A. Barnes
Chief Planning Engineer
Telecom Australia
and
Chairman
Council of Control
Telecommunication Society
of Australia

When one sees the range of technologies and depth of treatment covered by the topics in just this issue of the Telecommunication Journal of Australia, it is not hard to understand how increasingly difficult it is becoming for technologists to stay in touch with developments in telecommunications as the rate of technological change continues to increase.

This difficulty is compounded by the rate at which the environment in which we work is also changing. We are all becoming more aware of the changed requirements of operating in a more business and commercially oriented world — the need to be more customer responsive; to cope with the demands of competition in some areas; and to adapt to changes either in our own part of the organisation, or in those parts with which we normally interact.

There will be an increasing obligation, therefore, on key people in the telecommunications industry, whether they be in Telecom Australia or in the industry outside it, to inform others and to pass on the benefits of their learning experience.

Particularly it places a special obligation on members who have been fortunate enough to become involved in areas of work outside the traditional technical areas, to pass on that special knowledge. No doubt you can think of many of your colleagues who, having been trained as technologists, now work in areas previously considered the domain of those with different backgrounds, and as a result have learned new skills. This is the way our organisation is changing, and the roles of individuals in it will also continue to change, of that there will be no doubt. With the passage of time, contributions from key people such as these will assume even more importance in the process of providing a broader background for those of us still involved in specialist areas of technology.

The Society is there for the express purpose of assisting this knowledge transfer to take place. However, it requires a commitment by each of us as members to become more involved in the work of the Society. A small but dedicated increase in our individual involvements is vital, whether that be through attending more lecures by those of us who want to learn, by submitting articles by those of us who already have learned, or by making the role of the Society more widely known.

The sum total of all of these personal efforts, no matter how individually small, will be a significant increase in the spread of learning. Not only will everybody in the information transfer industry benefit, but the role of the Society will assume even greater importance in the years to come.

The new Gold Phone from Telecom Australia

J. C. MITCHELL. Dip. Elec. Eng.

The Gold Phone is a new coin telephone intended for the generally supervised small business market. As a successor to the familiar Red Phone it will provide a service to customers and an attractive source of revenue for the business. This paper looks at the reasons for the development of the Gold Phone and discusses its basic features. The very latest technology is employed to provide many new facilities including STD/ISD access, electronic coin validation and display of remaining credit.

THE DEVELOPMENT PHASE

Telecom Australia rents coin telephones to service a wide range of business customers. The most familiar product in this range is of course the Red Phone. There are approximately 40,000 Red Phones currently in service in clubs, hotels, shops, hospitals, railway stations etc. There are also a smaller number of older style multi-coin instruments which are being phased out of service. For those customers requiring STD facilities the Green Phone (CT3) is also available for rental. However, because this instrument was designed for street cabinet locations where vandalism is a serious problem, it is somewhat overdesigned for use in the more protected and generally supervised rental location.

With the ever increasing penetration of STD and ISD into the network, there arose the need for a low-cost coin telephone with STD and ISD facilities for those rental customers who did not require the additional security of the Green Phone. While the Red Phone had served this market very well for many years, it could not be readily and economically modified for STD working.

Fig. 1 The Red Phone, Gold Phone and Green Phone Installed In The Telecom Business Office, Melbourne.

In 1981 a specification was prepared and world-wide tenders invited for a new generation coin telephone for use in supervised locations. The specification was for a coin telephone that could be used for all types of outgoing calls — local, STD, ISD, as well as receiving incoming calls. The facility to switch the instrument from a coins mode to a no coins mode was also required so that the owner could make calls without coins. Advanced features such as an LCD display and electronic coin validation were also required. Mounting flexibility was essential since the instrument would be installed on a bench, wall or mobile stand. British Telecom was one of the first administrations to introduce a table-top coin telephone with these enhanced facilities and the Telecom Australia specification was for an instrument with generally similar features. Offers were received from most of the major coin telephone manufacturing companies in Europe and Japan. While some companies had developed or were working on designs for table-top coin telephones at the time the tenders were invited, no design was immediately available to fully satisfy the Telecom Australia specification.

Standard Telephones and Cables Pty. Ltd. (STC), had offered a coin telephone to be manufactured by Anritsu Electric Company from Japan and this instrument was selected for further development. Anritsu also manufacture the Green Phones for Telecom Australia and are one of the foremost coin telephone manufacturing companies in the world.

Anritsu continued their development and the resulting Gold Phone now embodies the latest state-of-the-art coin telephone technology. Preparations are already underway for STC to manufacture the Gold Phone at their Sydney factory.

It has been traditional in many countries including Australia to name a coin telephone by its colour and to use the colour of the instrument to denote the facilities provided. In Australia we currently have Red Phones and Green Phones. It was decided early in the development of this new instrument that the colour should be Telecom Gold, the corporate colour for Telecom Australia, and hence the marketing name Gold Phone was adopted.

With the introduction of this new instrument into the coin telephone range, the opportunity was taken to develop new marketing concepts for the product. Instead of being rented to Telecom's customers, the Gold Phone will only be available for outright sale. Some leasing companies are also expected to purchase Gold Phones from Telecom Australia and lease them to those customers who may not wish to purchase a Gold Phone outright. Gold Phone customers will receive a margin on each call and therefore have the opportunity to make a profit.

GOLD PHONE — FEATURES AND FACILITIES

The Gold Phone incorporates many new facilities not previously available in leased coin telephones in Australia. Many of these have been made possible by the use of CMOS microprocessor technology. The Gold Phone contains one microprocessor to control the collection of coins and other functions, and a second microprocessor in the coin validation circuit.

The important features and facilities incorporated in the Gold Phone are listed in Table 1 and explained in more detail later.

- Local, STD and ISD Calls.
- Incoming Calls.
- Manually Assisted Trunk Calls.
- Line Powered.
- Push Button Dial.
- Follow-on-Call Button.
- KS Lock and Key.
- Credit Display.
- Call Warning Signals.
- Single Coin Slot.
- Coin Validation.
- Sequential Coin Collection.
- Tariff Flexibility.
- Coin-Box-Full Check.
- Mounting Flexibility.
- Handset and Hearing Aid Coupler.

Table 1. Gold Phone: Features & Facilities

Local, STD and ISD Calls

Users may dial local and STD calls. If ISD access is available, these calls can also be made. No coins are required for non-chargeable calls, such as Service Difficulties and Faults 1100, Directory Enquiries 013, and of special importance, no coins are required for Emergency 000 calls.

Fig. 2 The Gold Phone.

Incoming Calls

The Gold Phone has a two tone ringer for incoming calls. This is an essential requirement where the Gold Phone is provided in boarding houses, university colleges, nurses homes, service stations, small shops, etc.

Manually Assisted Trunk Calls

The instrument is not equipped to generate coin identification signals to an operator and hence no manually assisted trunk calls can be made when operating as a coin telephone. If the owner has used his key to switch to the no coin mode, he will have access to the Trunk Operator on most exchanges.

Line Powered

Many older generation sophisticated coin telephones require local mains power to operate the complex circuitry and coin collection relays. The Gold Phone does not require any external power supply. Capacitors are used to store the energy required to operate the coin collection mechanism and these capacitors are charged over the line from the telephone exchange. Even during the longest ISD call, the capacitors can still supply enough charge to ensure the correct collection of coins.

JIM MITCHELL joined the Coin Telephone Section of the Customer Equipment Branch in 1971 after graduating from Swinburne Institute of Technology in Electrical Engineering. He was closely involved with the Australian introduction of the Green Phone (CT3). Since his appointment as Engineer Class 3 in 1978 he has been responsible for all the engineering aspects of coin telephones including the co-ordination of the Coin Telephone Replacement Programme. He prepared the technical specification for the Gold Phone and has been responsible for the development and introduction of this new coin telephone. In 1983 he visited overseas telephone administrations and manufacturers to study the development of Card Operated Public Telephones. Mr Mitchell (centre) is pictured with Mr Takao Saito, Manager, Engineering Department, Terminal Equipment Design, Anritsu, Japan, and Mr Ralph Price, Project Manager — Telephones, Standard Telephones and Cables Pty. Ltd., Sydney, all of whom were involved in the design and development of the Gold Phone.

Pushbutton Dial

Both DTMF and decadic pushbutton dials will be available. The Gold Phone will be supplied with a decadic pushbutton dial as standard, but the * and buttons on this dial are not functional. The digit 5 pushbutton has a raised point in the centre to aid blind users.

A Last Number Redial facility was considered for the Gold Phone but was abandoned to preserve the privacy of the user.

Follow-On-Call Button

The Follow-On-Call Button allows the user to make a follow-on-call and use up any remaining credit from a previous call. Further coins may be inserted to extend the call. Thus it is not necessary to hang up the handset and recover the coins between calls. If an error is made during dialling, a caller can simply press the Follow-On-Call Button to re-establish dial tone before commencing to dial the number again. If credit remains at the end of a call and the handset is replaced, the credit is lost, but any unused coins are refunded.

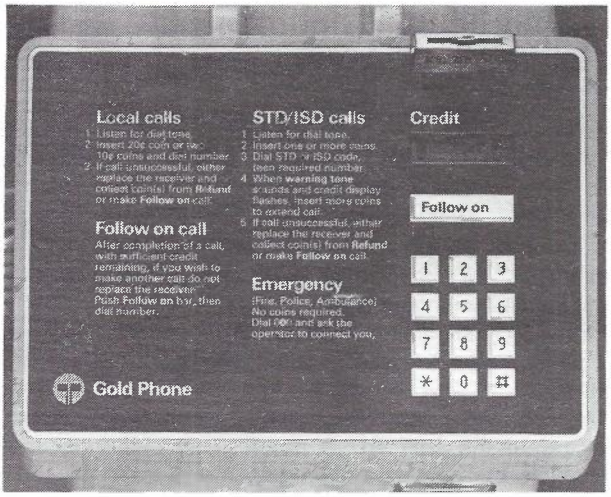

Fig. 3 The Gold Phone Instruction Plate.

KS Lock and Key

A lock mounted on the left side of the Gold Phone is provided to allow the owner to make calls without the insertion of coins. The lock may be set to one of three positions on the lock, designated "C", "D" and "L". The KS key is removed when the lock is set to the C or D position, but is held captive when in the L position. The owner will retain two KS keys.

"C" Position — coins are required for all chargeable calls. No manually connected trunk calls may be made in this position.

"D" Position — no coins are required but the cost of the call, or the number of meter pulses, is indicated on the credit display. The owner must recover the cost of the call from the user when the call is completed.

"L" Position — no coins are required for any calls and the credit display is blank. Access to the Trunk Operator for manually booked trunk calls, reverse charge or credit card calls is provided. This is the position which the owner would normally use.

Credit Display

The credit display is a 5 digit LCD display, plus a $ sign, which is mounted on a small circuit board which also contains the Follow-On-Call button. When operating in the Coins ("C") mode, the display shows the value of remaining credit as a call proceeds. The display will flash shortly before disconnection. If further coins are inserted to extend the call the display will show the value of the increased credit.

When the KS lock is switched to the "D" position the display can be set to show either the cost of the call in $0.00 or the total number of meter pulses received by moving a strap provided on the network unit labelled DMS. The amount shown in $0.00 is that which a customer using coins would need to insert. When set to display meter pulses the microprocessor switches off the $ sign. See Figure 4. Subsequent calls may be made using the Follow-On-Call button or by first replacing the handset and making a call in the normal manner. The display continues to record the cost of the calls made and can only be cleared when the handset is replaced and the KS key turned to the "L" or "C" position.

The "D" facility is expected to be very popular in hotels, restaurants and hospitals where callers can make long calls without the use of coins. The LCD display can be read at the end of the call or calls and the cost recorded on the customers bill, either by debiting the $0.00 amount on the display, or by converting the number of pulses on the display to a dollar amount.

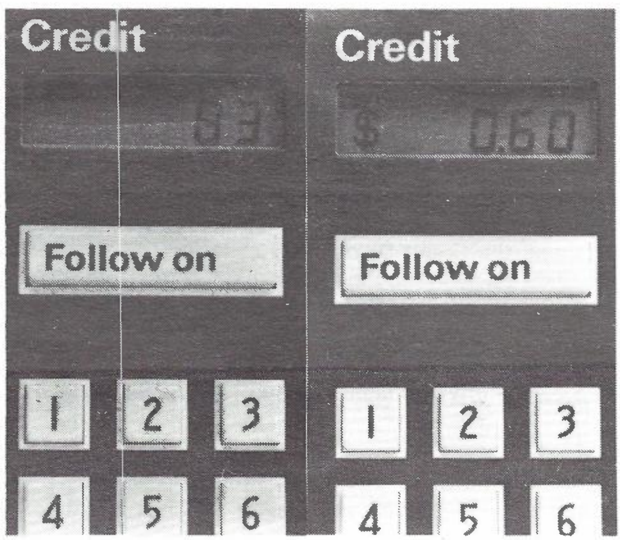

Fig. 4 a. Credit Display Showing Meter Pulses.
b. Credit Display Showing Cost of Call.

Call Warning Signals

The Gold Phone provides 0.5 seconds of 900 Hz warning tone in the receiver shortly before disconnection. When the warning tone sounds the Credit Display will also flash until the call is disconnected, or additional coins are inserted to restore credit.

Single Coin Slot

The single coin entry slot will accept 10c, 20c and 50c coins. The validation circuit and coin slot may be readily modified to accept other coin denominations if introduced at a later date. The denominations of the coins which the Gold Phone will accept are engraved on the coin entry slot.

Coin Validation

The validation of genuine coins and the rejection of others is performed by a fully electronic coin validation system which checks each coin for correct diameter, thickness and alloy content. See Coin Validation description later. New coin denominations that may be introduced in future will require only a software change.

Sequential Coin Collection

During a chargeable call, 50 Hz metering pulses are sent from the exchange at intervals which vary with the route distance of the call and the time of day. The microprocessor on the main network board controls the sequential collection of coins during the call in accordance with the metering pulses and the value of coins held on the coin mechanism. No metering pulses are sent on non-chargeable calls.

Tariff Flexibility

The Gold Phone has been designed to permit changes in the tariff structure for all calls. A Programmable Read Only Memory (PROM) containing the tariff setting for local and STD/ISD calls is fitted in the network unit.

The PROM can be readily replaced to suit changes in the call tariffs.

Coin Box Full Check

Past experience shows that many apparent coin telephone faults are due to over-full coin boxes. When the coin box is full, coins bank up through the coin mechanism causing it to jam. A coin-box-full sensor is provided to detect when the coin box fills to capacity and to render the Gold Phone unusable before a coin blockage can occur. When the coin-box-full condition is detected, the Credit Display will show an "F" when the KS key is switched to the "L" position. If the Gold Phone develops an apparent fault the owner can use the KS key to check if the coin box is full before reporting a fault. It is important that this indication is only given to the owner who can empty the coin box and restore the service.

Mounting Flexibility

The Gold Phone can be mounted in a variety of locations. A base plate will anchor the instrument to a bench or table top. A range of stands and shelves is being developed where installation is required on a wall or a fixed or mobile stand.

Handset and Hearing Aid Coupler

The Gold Phone is equipped with a handset which, in addition to providing the usual handset facilities also incorporates a hearing aid coupler coil to assist users with hearing difficulties. The hearing aid coupler is used to magnetically couple the receiver to a hearing aid and consists of a coil of wire wound around a plastic former and wired in series with the receiver.

The Gold Phone handset weighs 450 grams and contains a small amount of lead weight to fully restore the switchhook when the handset is gently replaced in its cradle. With limited power available, the weight of the handset is used to operate flappers to clear blockages from the mechanism. However, the handset is substantially lighter than the Red Phone handset which is heavily weighted with lead.

The handset caps are tightly screwed on but can be removed to allow the transmitter, receiver, hearing aid coil and handset cord to be replaced for maintenance purposes.

CONSTRUCTION

Design Philosophy

The Gold Phone will be installed in generally supervised and protected locations. The Gold Phone being owned by the customer will assist in ensuring that the instrument is not vandalised. The top case is moulded in 3 mm ABS which enabled the creation of a unique and innovative shape. The coin safe compartment is steel to provide maximum security. While it was possible to provide less physical security for this instrument than is required in Public Telephones in street locations it was considered essential to incorporate the best possible protection against all known methods of manipulation to obtain free calls. The circuit and mechanical construction incorporate many safeguards to prevent manipulation for free calls.

The Gold Phone styling is the product of Australian industrial design expertise and houses an advanced mechanical and electronic design resulting from close co-operation between Anritsu in Japan and STC in Australia.

To assist the user, all interface elements of the Gold Phone such as the coin slot, credit display, follow-on-call button, dial and refund chute are aligned on the right side. The coins are inserted at the top through the single coin slot, and refunded coins drop to the refund chute in the coin safe door. Coins collected during a call, fall into the coin box through a slot beneath the coin mechanism. Access to the coin box is obtained by unlocking and removing the coin safe door. See **Fig. 5**.

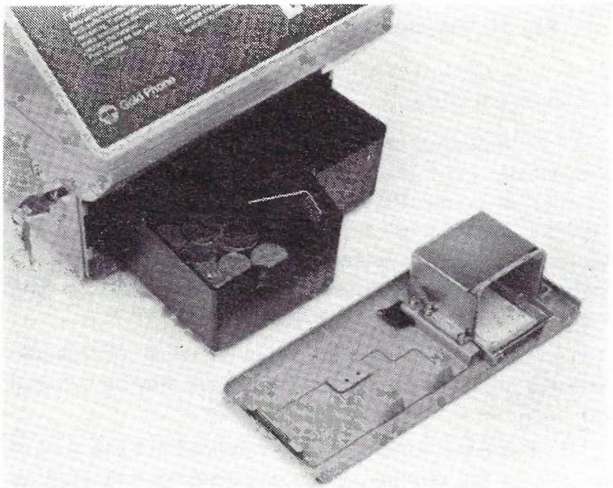

Fig. 5 The Coin Safe Is Removed To Clear The Coin Box.

The mechanism, KS and coin safe locks and cord entry positions are all grouped on the left side to allow the Gold Phone to be installed in locations where access is restricted at the rear of the right side. See **Fig. 6**.

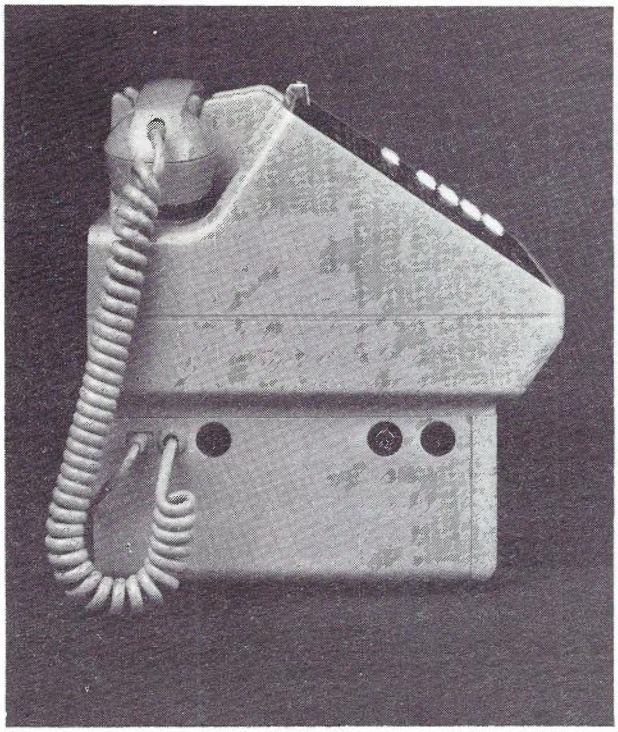

Fig. 6 Gold Phone Locks and Cord Entry.

Basic operating instructions are provided on a black anodised aluminiun front plate and additional information is supplied in a booklet for the Gold Phone owner.

For areas where Emergency (000) access is not available, as in some remote country districts, and where ISD access is not available, alternative instruction plates can be fitted on which the reference to ISD or 000 is deleted.

Case Assembly

The case of the Gold Phone consists of two assemblies. The coin safe compartment/assembly houses the coin box, safe door, refund chute and coin safe lock. The mechanism compartment assembly houses the coin mechanism, network unit, credit display unit, locking mechanisms, ringer and dial. The top cover, which can be removed to permit mechanism maintenance, contains the instruction plate, the coin slot and the handset cradle assembly. The bottom cover is fixed to the coin safe compartment assembly.

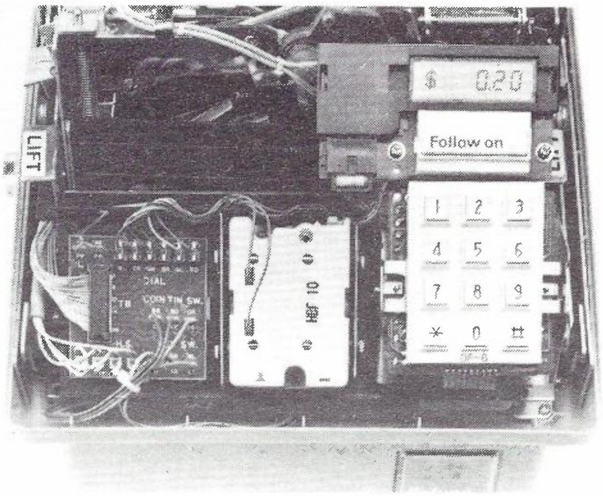

Fig. 7 Inside the Mechanism Compartment.

The coin safe compartment case is 1.6 mm steel plate which provides adequate protection for the cash box. The surface is coated with non-toxic Telecom Gold powder

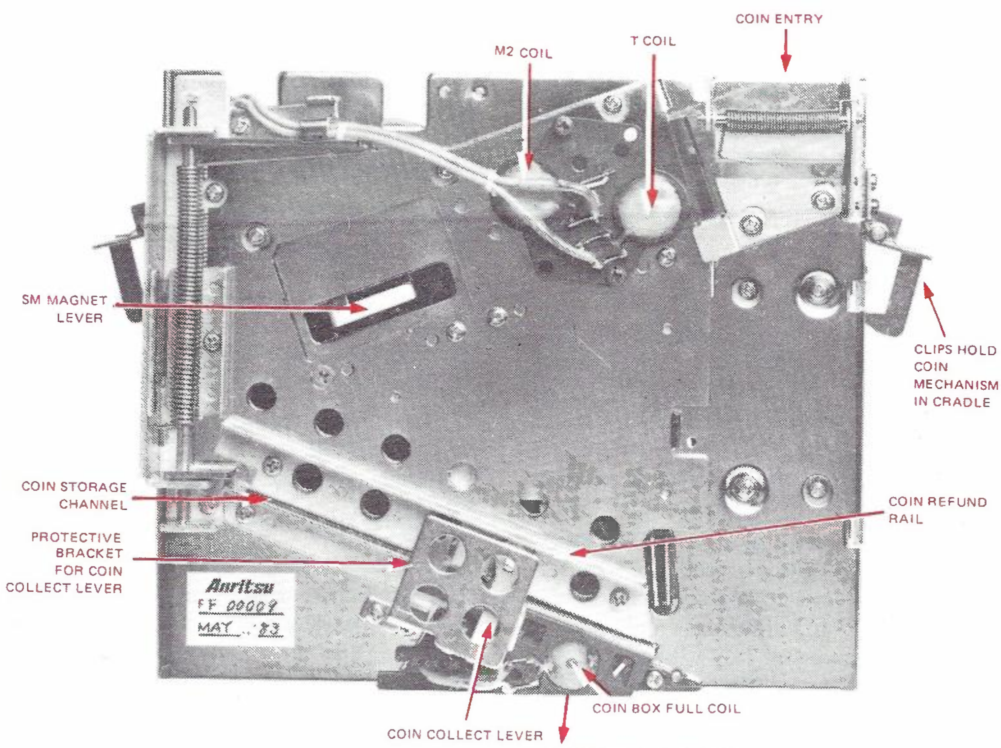

Fig. 8 Coin Mechanism With Refund Cover Removed.

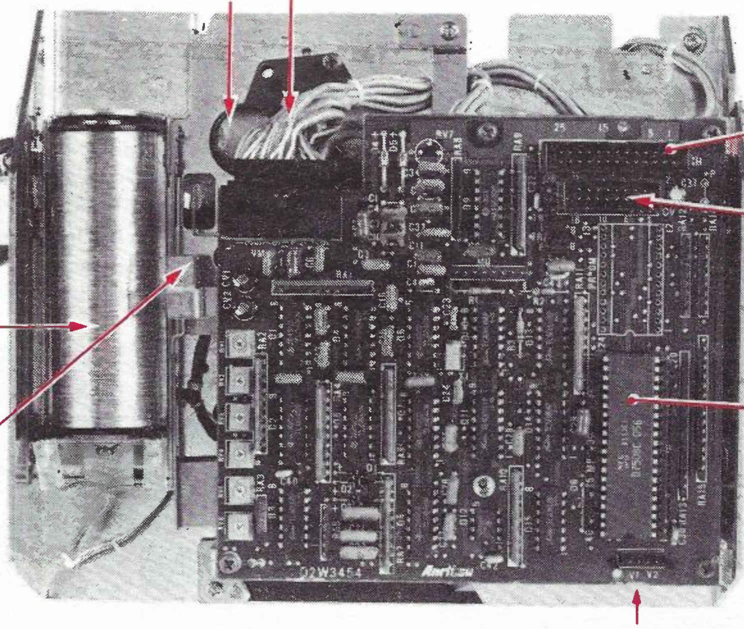

Fig. 9 Rear Of Coin Mechanism Showing Coin Validator Board.

paint with a very low lead content. The coin safe door containing the refund chute, the telephone identification label for fault reporting, locks into the coin safe and must be removed before the coin box can be removed. The coin box is polypropylene and holds approximately $80 in 10ᶜ, 20ᶜ and 50ᶜ coins.

Mechanism and Coin Safe Locks

Each Gold Phone is fitted with a coin safe lock and a mechanism compartment lock. The keys have four blades, each capable of a different profile, giving each lock the possibility of 100,000 different combinations.

The owner will retain two coin safe keys, while the mechanism key will be held only by the Telecom maintenance technician. As indicated earlier the owner will also retain two KS keys.

COIN MECHANISM MODULE

The coin mechanism module consists of the coin channel mechanism and the electronic coin validation circuitry as shown in **Figs. 8** and **9**. The precision demanded of the validation circuitry requires that it and the coin channel mechanism are tuned for each individual telephone. The items cannot be separated without requiring further tuning.

Coin validation is performed electronically and is explained later in this article. When a coin is recognised as genuine, the SM magnet lever is released allowing the coin to push the lever aside and enter the storage channel. Validated coins are stored in the storage channel before being collected into the coin box in the order of insertion. The total credit remaining is shown on the Credit Display. Coins which fail any of the checks are refunded. A sensing coil beneath the coin collecting mechanism monitors the collection of coins into the coin box and detects when the coin box is full. If a coin is held at this coil because the coin box is full, or for any other reason, the call in progress is disconnected after the credit of the last collected coin is used.

The storage channel will hold either:

- six 10 cent coins,
- five 20 cent coins,
- five 50 cent coins,
- or a mixture of all three coins.

A coin located at the entry of the coin storage channel detects when the storage channel is full and prevents the SM magnet lever being released; additional coins inserted are refunded.

COIN VALIDATION

Electronic Coin Validator

The coin mechanism contains the electronic coin validator which accepts genuine coins into storage pending collection. The description which follows refers to **Figs. 10** and **11**.

Coins are subjected to electrical tests to derive measurements for three parameters — thickness, diameter and alloy content.

Thickness Measurement

The Thickness (T) coil, mounted on the front of the coin mechanism is fed from a single frequency oscillator. As a coin passes the T coil, the voltage across the coil varies because the impedance of the circuit is affected by the presence of the coin. The magnitude of the voltage variation is a function of the thickness of the coin. A signal is fed to the microprocessor which compares the magnitude of the voltage drop against pre-determined values for genuine coins.

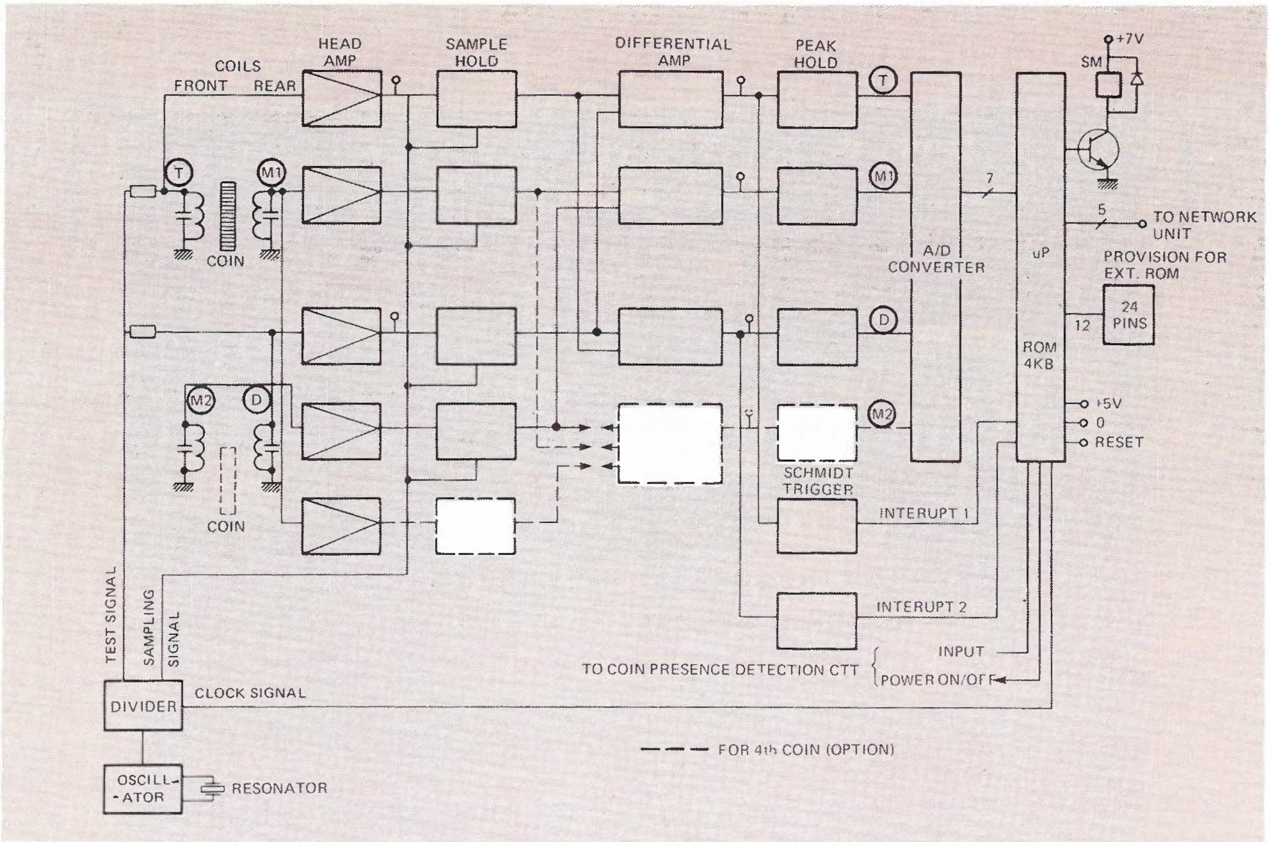

Fig. 10 Coin Validation Circuit Block Diagram.

Material Measurement

The material of the coin is measured using a pair of coils — the T coil and the M1 coil which is mounted opposite the T coil on the rear of the coin mechanism. The a.c. signal in the T coil induces a signal in the M1 coil. As the coin passes between the T coil and the M1 coil the level of the signal in the M1 coil varies. The voltage across the M1 coil is fed to the microprocessor through associated circuitry and used to determine the material content of the coin.

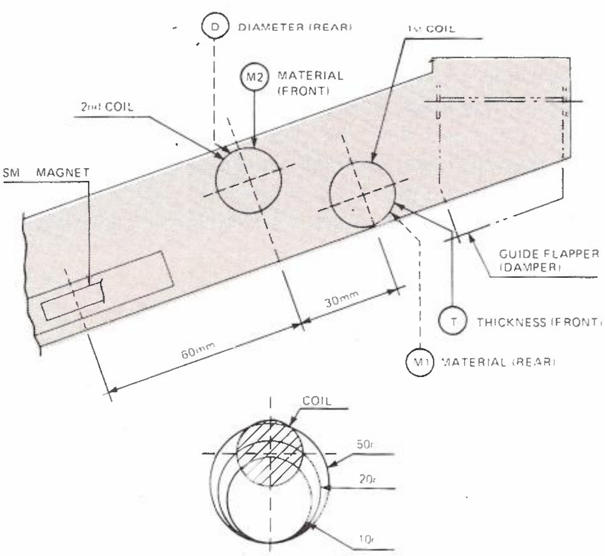

Fig. 11 Coin Validation Measurements.

Diameter Measurement

The Diameter (D) coil is mounted on the rear of the mechanism and is fed from an a.c. signal. When a coin passes in front of the D coil, the impedance of the circuit is reduced depending on the extent to which the area of the coil is covered by the coin. The voltage drop across the D coil when the coin passes, is used by the microprocessor to determine the diameter of the coin.

The fourth coil, M2, mounted on the front of the coin mechanism provides temperature compensation for the coin validation circuitry and also provides an additional composite measurement for thickness, diameter and material. The M2 coil and the diameter coil operate in a similar way to the material measurement circuit described above.

When a coin passes all three tests, it is allowed to enter the storage channel pending collection into the coin box.

The Coin Validation circuit is capable of validating four different coin denominations and can thus be readily programmed for the proposed $1.00 coin if required.

NETWORK UNIT

The coin control circuit and transmission circuit are contained on a single large circuit board which is mounted at the rear of the Gold Phone. Two clips on either end of the top metal frame hold the network unit firmly in place.

Two multi-way connectors on either side are used to connect to the coin mechanism assembly and other parts of the telephone. The incoming line cord terminates with

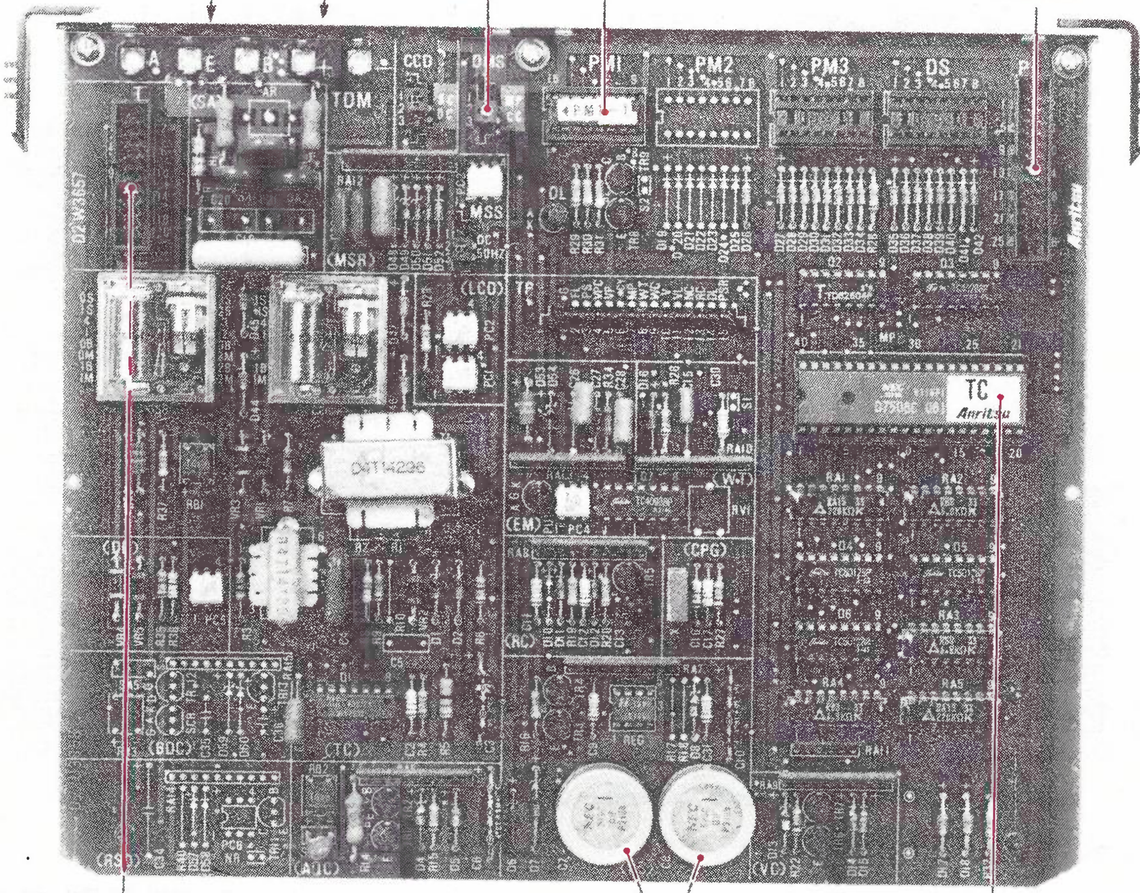

Fig. 12 Gold Phone Network Unit.

quick connect tags on the top left hand side of the board. Coin collection is controlled by a CMOS single chip microprocessor. The tariff and coin data are contained in a PROM which can be readily replaced with each change in tariff. Several movable straps on the Network Unit are provided to allow a selection of various Gold Phone options.

The two capacitors which supply power for the coin mechanism are mounted at the bottom of the board. These electric double layer capacitors are a recent development in miniature capacitor design, and values as high as 3.3 farads can be packaged in volumes as low as 16.4×10^3 mm^3.

The power to operate the Gold Phone is supplied from the telephone line via a charging circuit. With the handset restored the capacitors are charged by a current limited by a resistor to 3 mA. At the time of installation, when the Gold Phone is first connected to the line, an automatic quick charging circuit switches out the resistor allowing the capacitors to charge to the operating potential in approximately 30 seconds. Once charged, the Gold Phone is ready for operation each time the handset is lifted.

The Gold Phone normally requires a 50 Hz meter pulse sent from the exchange at intervals during the call to control the collection of coins. If the Gold Phone is installed on a radio system where 50 Hz meter pulses are not available, connection is made to two quick connect terminals provided. A d.c. meter pulse which can be locally generated from the radio terminal equipment is connected to these terminals via an extra pair of wires. This facility permits Gold Phones to be installed in remote rural areas or where a 50 Hz mains supply is not available.

MAINTENANCE PROCEDURES

The Gold Phone will be maintained by Telecom Australia under a maintenance agreement entered into at the time of purchase. For the annual maintenance fee Telecom will provide necessary maintenance and convert the coin mechanism for any tariff changes. Damage caused by vandalism will not be covered by this agreement but will be repaired at cost.

The Gold Phone is constructed from basic modules and assemblies to reduce maintenance costs and ensure

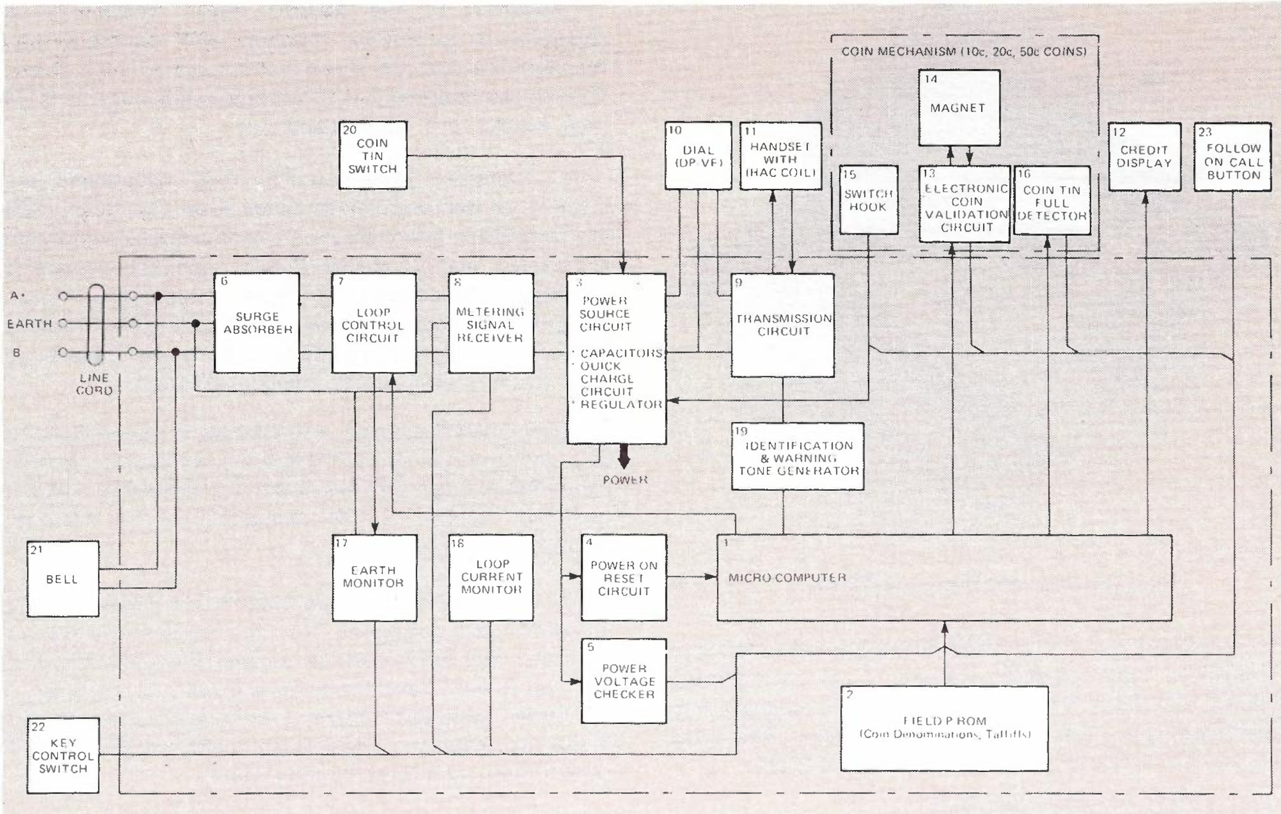

Fig. 13 Gold Phone Block Diagram.

that the coin telephone can be quickly put back into service.

Reference to Figs. 14, 15, 16 shows that the coin mechanism is mounted on a cradle which enables the mechanism to be moved to a test position to facilitate maintenance. In this position, coins may be inserted into the coin mechanism and collected into the refund chute instead of the coin box. A technician without access to the coin box can test the Gold Phone using his own coins which can be easily recovered from the refund chute. The subscribers account would then be credited with the cost of the test calls made.

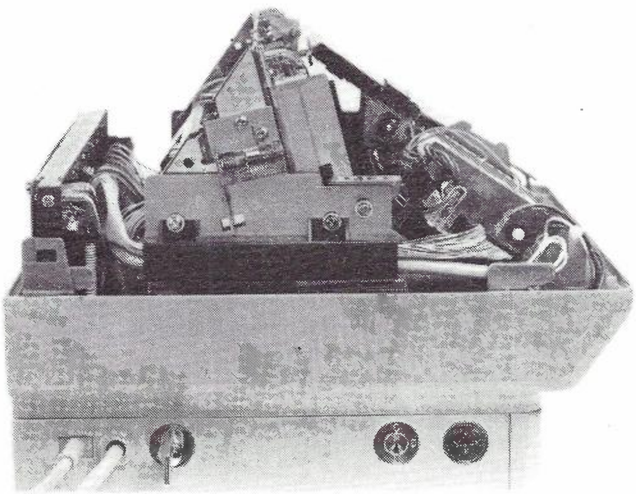

Fig. 14 Coin Mechanism In Normal Position.

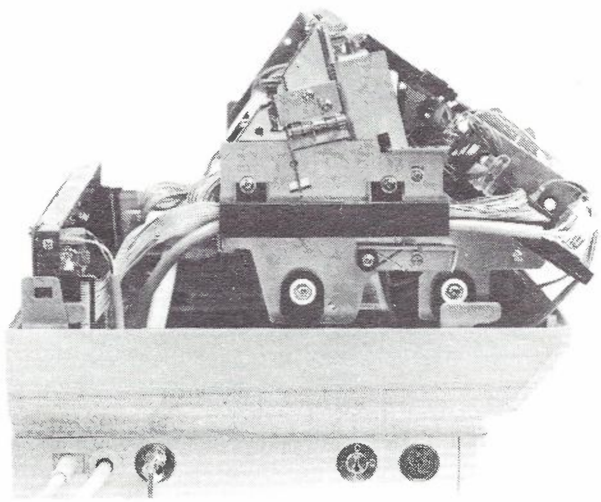

Fig. 15 Coin Mechanism In Test Position.

At the bottom of the coin mechanism is a small detector coil which monitors the massage of coins into the coin box and detects when the coin box is full. This facility, referred to earlier, alerts the owner to clear the coin box thus avoiding an unnecessary fault repair report.

SURGE PROTECTION

The Gold Phone requires a local earth for surge protection and to detect the 50 Hz meter pulses from the exchange. This earth creates a hazard to the CMOS circuitry during a lightning strike. The line cord is not capable of carrying a lightning fault current safety to earth and therefore external lightning protection must be provided. A special lightning arrestor block has been

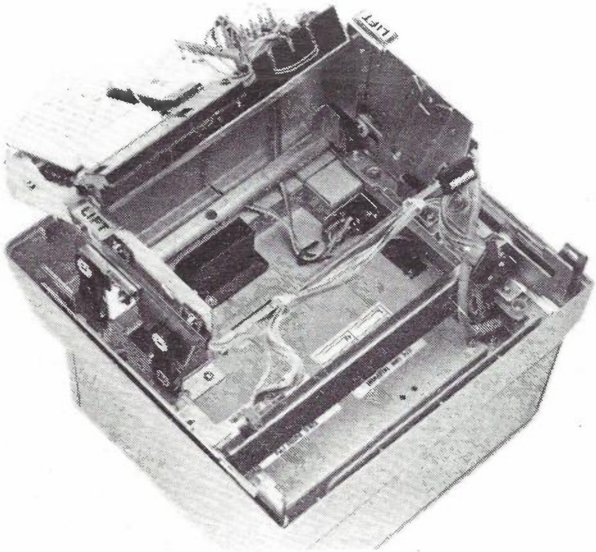

Fig. 16 Coin Mechanism Cradle.

developed for use on the Gold Phone and other terminal equipment; this lightning arrestor block is mounted behind the Gold Phone for security and contains a 3 electrode gas arrestor and a spark gap. Additional protection is also provided on the network unit.

THE GOLD PHONE MARKET

Coin telephones in the Australian network may be divided into two broad groups; those that are installed as Public Telephones in cabinets in street locations and those that are provided as rented coin telephones to shops, clubs, hotels, small businesses, schools, etc.

Vandalism to the 40,000 Public Telephones in Australia is a serious problem and operating and maintenance costs for these instruments are high. Public Telephones are provided so that the public may have 24 hour access to a public telephone.

In Australia, some 40,000 coin telephones are installed as Rented services. Since these coin telephones are installed in generally supervised locations, vandalism is reduced and a reliable Public telephone service is provided with considerably lower maintenance costs. Rented coin telephones provide a stimulus to business, a service to customers or patrons, and a source of revenue both to the renter and to Telecom Australia.

Many small businesses can only justify one telephone line, and a rented or purchased coin telephone, like the Gold Phone, must fulfil the dual role of providing a public telephone service to the customers and a business telephone for the owner.

For almost 20 years the Red Phone has been the standard coin telephone for this 'rented' market in Australia. The Red Phone is confined to local calls only and has limited flexibility to be adjusted for changes in call tariffs. Without the ability to make STD calls, the Red Phone is generally restricted to metropolitan areas of capital cities and large country towns.

The Gold Phone has been specifically designed to provide enhanced and modern facilities for the supervised renter's market. A strong demand is expected in country areas where this service has not been readily applicable until the advent of an instrument with STD capability.

Invitation to the Readers

The position of the Editor-in-Chief is a challenging one. In conjunction with the Editorial Board and a great deal of people working behind the scene, we try to produce a Journal which covers a wide spectrum of the Information Transfer industry. As far as I am aware, the TJA is a fairly unique Journal in Australia, in covering areas as diverse as computer communication to the more traditional areas of telecommunications. The Society is over 100 years old and the Journal will be 50 years old in June 1985. Whilst the Journal may not be perfect, we think we are achieving something — our aim is to disperse information about the ever changing Information Transfer industry in Australia. We are also always striving to improve the Journal.

As the new Editor-in-Chief, here is my challenge to you, the readers of this Journal. Drop me a note. Suggest improvements. Suggest topics that the Journal should cover. Suggest how we should obtain this information. Suggest the names of potential authors. Mankind is always fascinated with the new although we must not forget about the past. For the historians, document that story before it is lost in the mists of time. For the readers from overseas, are there any interesting items which you think our readers should know about. Readers: transfer your thoughts and information to me and help us to share this information with your fellow readers.

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Low Cost Power Supply Systems for Rural Telecommunications Networks

N. K. THUAN B.E., MIE AUST., MIEEE, MAIE.
M. R. MACK DIP. E.E., MIE AUST.

There are many problems and issues which power supply designers must resolve in the powering of a rural and remote telecommunications network. Power supply solutions and systems developed for Australian outback communications have evolved around an array of plant and equipment including diesel-driven generators, lead-acid batteries, rectifier/dc power supplies, wind-driven generators and solar photovoltaic systems. This paper examines the issues, problems and some fundamental principles concerning the provision of reliable low-cost power supplies to meet the demands of both new transmission technology and the unique Australian environment.

INTRODUCTION

There are many problems and issues which power supply designers must resolve in the powering of a rural and remote telecommunications network. These problems and issues are linked intimately to the source or sources of power available in the rural area, the terrain, the climatic conditions and the size and remoteness of the land mass.

Power supply solutions and systems developed for Australian outback communications have evolved around an array of plant and equipment and are designed for specific applications to meet demands both of new transmission technology and of the unique Australian geographical and climatic conditions while remaining cost effective.

Telecom Australia has been particularly active in the development of alternative power sources for its massive outback communications network and has achieved gratifying results in this field.

The array of telecommunications power plant and systems useful for rural networks ranges from diesel-driven generators, lead-acid batteries, rectifiers and dc power supplies to innovative alternative power sources such as wind-driven generators and solar-photovoltaic (PV) systems. By proper selection and deployment of these components, and by matching the power needs of the rural communications system, cost effective rural power supply systems with excellent reliability can be achieved.

Despite the diversity of rural communications networks and systems comprising the network in Australia, they are fundamentally dependent on the ability to "tap" power from the various energy sources available in the vicinity of the site to operate 24 hours a day.

There are a number of fundamental principles and issues arising from the Australian experience which are relevant to the design and provision of power supply systems for rural telecommunications networks in other parts of the world.

This paper examines the issues, problems and some fundamental principles concerning the provision of low cost power supplies for rural telecommunications load requirements, the power supply system options and a cost comparison between various alternative energy sources.

BACKGROUND

The performance of any telecommunications network can be judged by the degree to which uninterrupted transmission of speech and other signals is achieved. As the power supply is a series link in any communication system, it can be deduced that the degree of reliability of communications systems can at best be only as high as that of the power supplies which energise them.

The choice of any particular energy source for telecommunications is motivated by the location, the size and level of power demands, and the nature and function of the telecommunications system. (1)

Despite the differences and diversity of rural communication networks, there are common principles, requirements and issues which must be addressed in the design of appropriate, cost-effective power systems for rural applications.

Virtually all rural communication systems require a continuous dc power supply. This continuous dc power supply can be readily realisable if there is a source of power available nearby. The commercial ac means supply is the most convenient and economical power source for rural communications.

There is a "power crisis," however, in most rural and remote parts of Australia where the ac supply is either unreliable, intermittent or unavailable and power for communications must be generated on-site using alternative energy sources.

The design and operating principles of power supplies for rural and remote areas also differ markedly from urban telephone power systems. Although both types of applications require power supply continuity, rural and remote power supplies usually operate on a battery charge and discharge cycle, while telephone power supplies operate on a battery float principle.

Energy is drawn continuously from the battery to power communications equipment at remote sites, and hence the battery is on a discharge cycle. The charging source or sources will recharge the battery as required, depending on its output capacity, starting control and running cycles. Batteries used in charge/discharge mode in remote areas do not last long, their service lives are around 5-7 years and none have survived more than 10 years.

In contrast, in an urban exchange environment, power to run communications equipment comes from the rectifiers and the battery is being float charged by the rectifiers. The battery, therefore, does little work and can have a 15 to 20 year service life.

Despite all these constraints, Telecom Australia's achievements with rural power supplies during the last decade have assisted in bringing telecommunications to many remote parts of Australia. Telecommunications microwave links in Australia have spanned over 24,500 route kilometres and have almost completed a circle around the Australian continent.

Each of these breakthroughs in microwave links was made possible by an innovative and unique application of alternative energy systems.

POWER NEEDS OF RURAL COMMUNICATIONS

The power needs of communications systems in a rural network are sometimes simple. For example, a simple low capacity power supply may be adequate for rural exchanges or single channel subscriber radio services but most of the time the needs are fairly complex. The ability to generate power on-site is a prerequisite for the existence of a rural communications system where mains power is not available.

With the fast-changing developments in communications technology, it is conceivable that a rural telecommunications network may be required to carry voice communications, data communications and other types. Developments which have emerged in the digital transmission area may cause a drastic increase in the power consumption and this has pointed up the need to closely watch the ultimate power demands in the design of a power supply for rural communications.

The power supply system must therefore match the requirements of the communications system it powers, not just today, but also for the future.

At the other end of the scale, where low cost subscriber's services are concerned, a fine balance of system cost prevails and this requires a most critical examination of the reliability and continuity of supply against the overall system cost.

It may well be that the power supply cost will be a predominant factor in the cost of providing the service and power supply cost may become the limiting factor preventing the penetration of the much needed services to rural communities.

There are a host of issues which must, therefore, be considered when designing and selecting a power supply solution for rural communications. Some of these are:

- degree of continuity of supply,
- degree of reliability of supply,
- load demands initially and ultimately,
- priority of the service (trunk repeaters, minor repeaters, rural exchangers, subscribers, etc.),
- availability and reliability of, or distance from, ac mains supply,
- cost effectiveness of power line extension,
- forms of alternative energy sources (solar, wind, diesel, natural gas, etc.),
- transport, access, terrain,
- climatic conditions,
- staff expertise, maintenance, replacement, expansion,
- flexibility of the system, life of equipment,
- economic factors, return on investment, funds, etc.

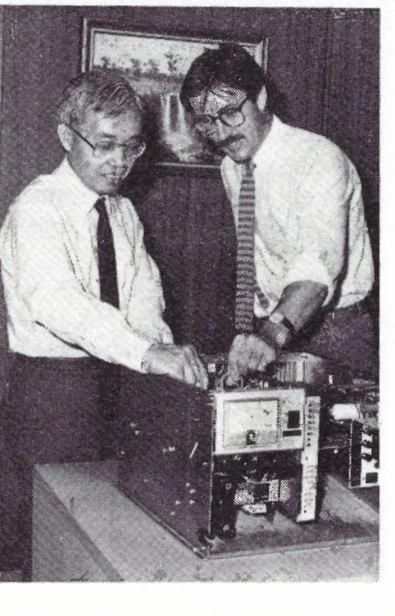
N. K. (Robert) THUAN (left) is an engineer with 16 years experience in the field of telecommunications power supply. In his present position as Supervising Engineer, Telecommunications Power, he is responsible for the planning, approval, co-ordination and control of design, development and provision of power supply equipment and systems, and the formulation of standards and policies for a full range of this equipment in the Australian Telecommunications Network.

Robert is a graduate from Monash University, Melbourne, Australia. He is a member of the Institute of Electrical and Electronics Engineers, the Institution of Engineers Australia, and the Australian Institute of Energy, and has published 11 papers on telecommunications power systems.

MICHAEL MACK (right) graduated in 1971 with a Diploma of Electrical Engineering from Caulfield Institute of Technology. He is a member of the Institution of Engineers Australia.

During his 12 years with Telecom, he has worked on various aspects of communications power plant and systems, mainly for rural and remote area applications.

In particular, Michael has been heavily involved with the widespread introduction of solar power into the rural network. He is currently an Executive Member of the Solar Energy Industries Association of Australia and an Advisor to the Victorian Solar Energy Council.



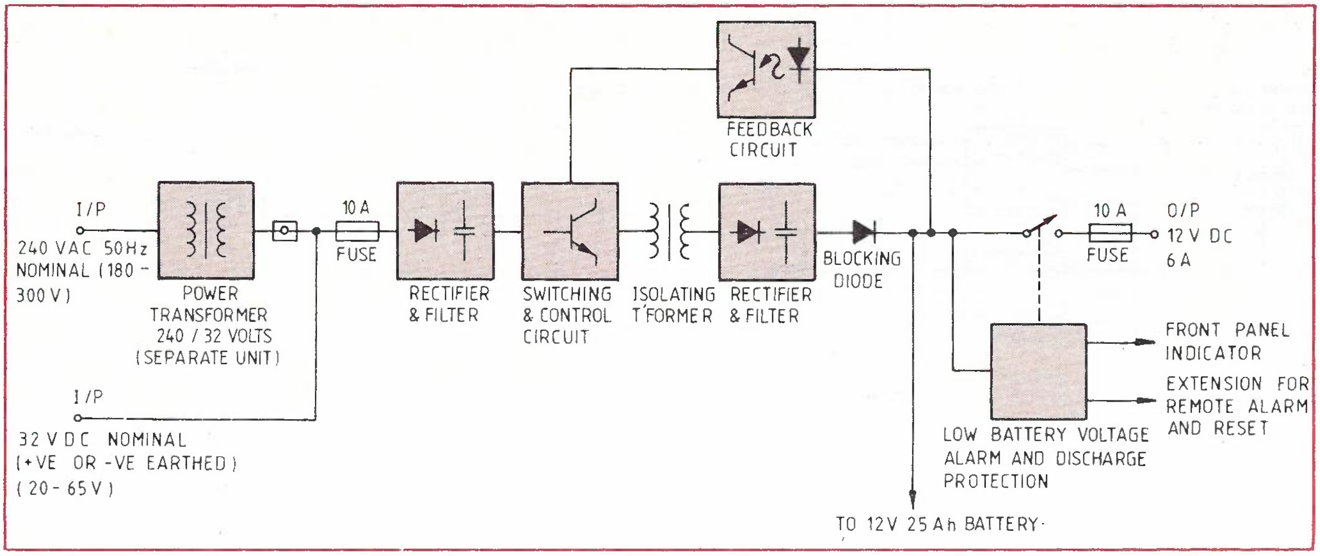


Fig. 1. Regulated Power Supply Interface — Block diagram.

POWER SUPPLY SYSTEMS FOR RURAL COMMUNICATIONS

Power supplies used in Telecom Australia for rural communications range from the familiar dc power supplies and rectifiers, diesel-driven generators, lead-acid batteries to innovative alternative power sources such as wind-driven generators, closed-cycle vapour turbines, and solar photovoltaic systems.

Although many installations requiring power can be solar powered, the decision to adopt any particular power scheme depends greatly on the load demands and where the installations are located.

WHERE AC POWER IS AVAILABLE

Small DC Power Systems

Consider first, sites where a primary power source is available. This may be mains power from a local electricity authority received over a single wire earth return (SWER) system, or it may be power generated locally by a subscriber. In this case it will generally be 240 V ac 50 Hz nominal or 32 V dc nominal and often of dubious quality and reliability.

Where 240 V ac is available, a rural exchange will be powered by a rectifier (power supply) and battery float system, (no-break dc supply) which may have a small diesel-alternator as back-up in the event of a mains failure. Dual rectifiers and batteries may be provided depending upon the relative importance of the system and remoteness of the station. A diesel-alternator back-up is generally incorporated where the mains is considered unreliable.

Where a subscriber's own power is utilised, for powering a single channel VHF or UHF radio telephone system, a large variation in voltage or frequency can be expected and a special power interfact system is used. A small power interface using a pulse-width-modulated switching regulator technique has been developed by Telecom for this application and is shown in **Figs. 1** and **2.** The unit comes in two forms: ac/dc and dc/dc both with nominal 12 V, 6 A outputs. These units will operate over an ac voltage range of 180-300 V and frequency range of 40-60 Hz. A storage battery is installed with the ac/dc version to ensure a 24 hour service. The battery is 12 V with a nominal capacity of 25 Ah. The dc/dc version will operate over an input voltage range of 20-60 V dc without the need for "tap-changing". The reason for separating the mains transformer from the dc/dc portion of the interface unit is to enable a technician to install both the power plant and the radiotelephone equipment in a common equipment cabinet outside the subscriber's premises. That is, an electrician is not required as only low voltage ac is run from the mains transformer.

Medium-Large DC Power Systems (Conventional Type)

For medium to large load demands from communications systems in rural areas, Telecom employs a standard dc power system similar to those used in its urban telephone exchanges.

The system consists of two rectifiers, one dc output cubicle and two banks of lead-acid batteries. Each rectifier is capable of supplying the total load of the station. Either rectifier can be selected to operate as the duty or standby set.

The system capacity ranges from 50 A to 200 A; the output voltages can be either 24 V or 48 V nominal. Battery reserve time is about eight hours to allow enough time for field staff to reach the repeater site and carry out

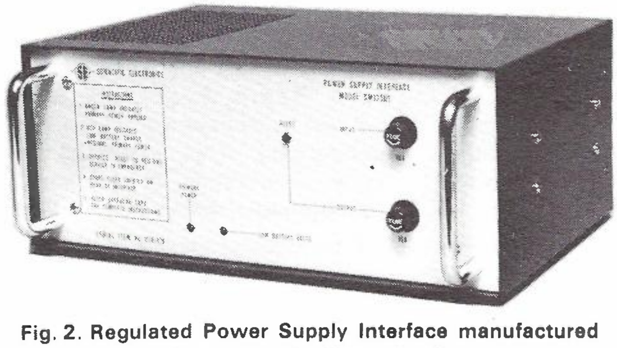


Fig. 2. Regulated Power Supply Interface manufactured by "Scientific Electronics".

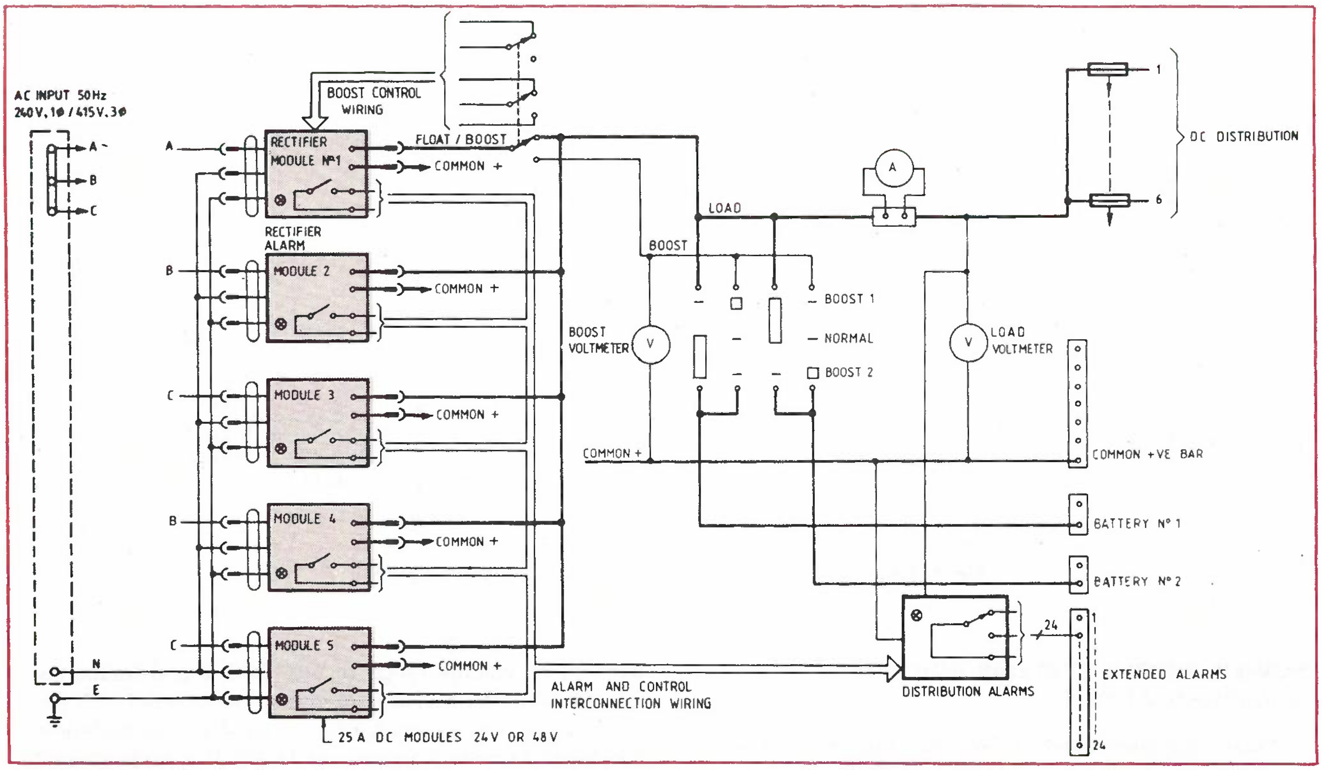


Fig. 3. Modular Rectifier Suite — Block diagram.

the necessary repair work although reserves of up to 24 hours have been used.

This system is used widely in the Australian radio network and has proved its economy and reliability for the last 15 years.

Medium-Large DC Power Systems (Modular Type)

With many modern microwave links going through expansion phases and with the introduction of digital transmission techniques, the loads of many of our systems have increased dramatically, making it extremely difficult for the power supply designed in the 1960s and 1970s to cope with the new demands. Furthermore the economical dimensioning of power equipment for dc loads between 20 A and 200 A has always been difficult, in particular, when flexibility of selection, operation and expansion of the power system is required. Telecom Australia has improved this situation with the development of the Modular Rectifier Suite (MRS) using discrete 25 A rectifiers as power units. A typical MRS configuration is show in **Figs. 3** and **4**.

Modular Rectifier Suites have been used successfully for powe'ing communications on the long distance Perth-Dampier Natural Gas Pipeline and are presently being employed in the expansion and upgradiing of the East-West Microwave Radio System where accommodation is limited and loads have increased considerably since commissioning. This approach is considered suitable for a wide range of dc loads, including rural exchanges and radio repeaters.

The cost advantage of the modular system versus the conventional larger power units is about 22% to 38%, depending on the size of the loads. A breakdown of the cost of items of conversion plant capable of supplying 100-200 A at 24 V is shown below.

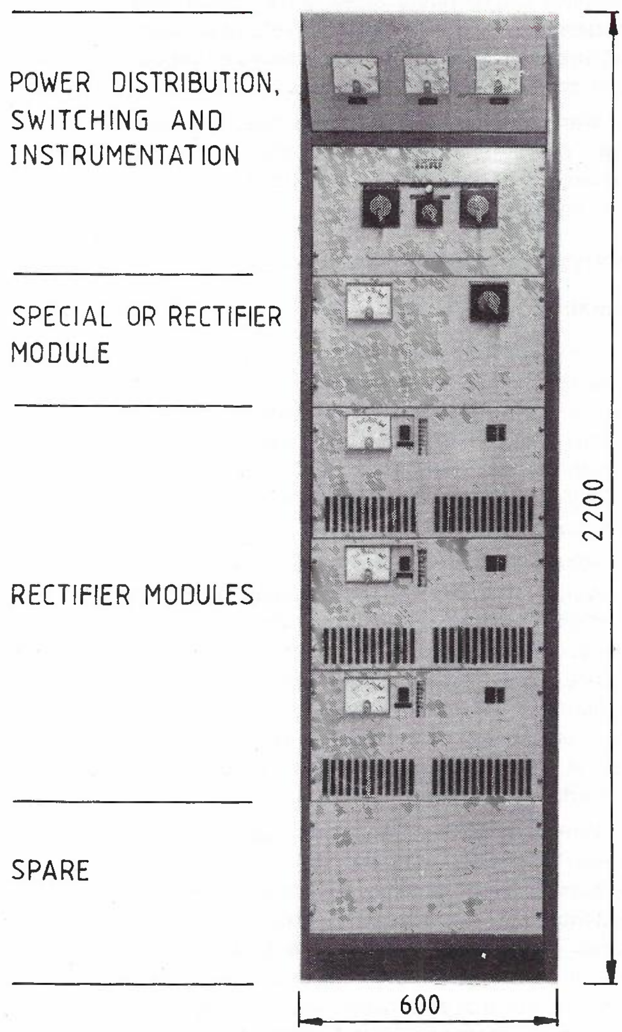


Fig. 4. Modular Rectifier Suite manufactured by "L. M. Ericsson".

Load A	Conventional Equipment * Cost $A	MRS Equipment * Cost $A	% Cost Savings
100	20,000	12,380	38
200	31,630	24,800	22

* Battery reserve: 10 hours.

There are also benefits in being able to size standby diesel-generator plant more closely to the load using MRS because 100% redundance is not incorporated in the rectifier system.

WHERE AC POWER IS NOT AVAILABLE

Diesel-Driven Generator

The diesel-driven generator/alternator has long been a proven source of relatively large quantities of power when mains power is not available. Telecom has had a great deal of success in remote areas with diesel-driven generators which are still one of the best energy converters for loads from about 200-300 watts upward.

Diesel-driven generators are usually operated in two modes by Telecom — charge/discharge or cycling mode, and continuous mode.

Run in either mode, the diesel-driven generator has proven very reliable if properly maintained. Large trunk communication systems such as the East-West Microwave Radio system and Darwin-Mt Isa Microwave System have been successfully powered by diesel plant for many years.

- Charge/Discharge Systems
For loads of up to about 1500 watts, a charge/discharge approach has been used. The station battery is discharged by the load to about 50%-75% and the diesel-generator is automatically started on voltage or time control. The recharge is terminated by voltage control with a run-on period of a few hours to return the batteries to a near fully charged state.

The most successful use of cycling diesel plant has been on the East/West Microwave Radio System. (2) Forty-three non-mains powered sites have been provided with about 1200 watts of power for about 12 years using a single charge/discharge diesel-generator of 4 kW 24 V dc capacity, with the assistance of a wind-driven generator and a 1000 Ah battery. See **Fig. 5**. The wind-driven generators have now been phased out and another diesel added as loads approach 2.5 kW. With the additional load, the diesel-generators are now operated continuously.

- Continuously Operated Diesel Systems
Continuously operated, small diesel-generators are usually employed for loads greater than 1500 watts or where air conditioning is required for communication equipment. Air conditioning is generally not welcomed where mains power is not available. It often means that to start the compressor of the air conditioning unit, a diesel of much greater capacity is required than would otherwise be necessary to power the dc equipment load alone.

Fig. 5. A Repeater Station on the East-West Microwave Radio System.

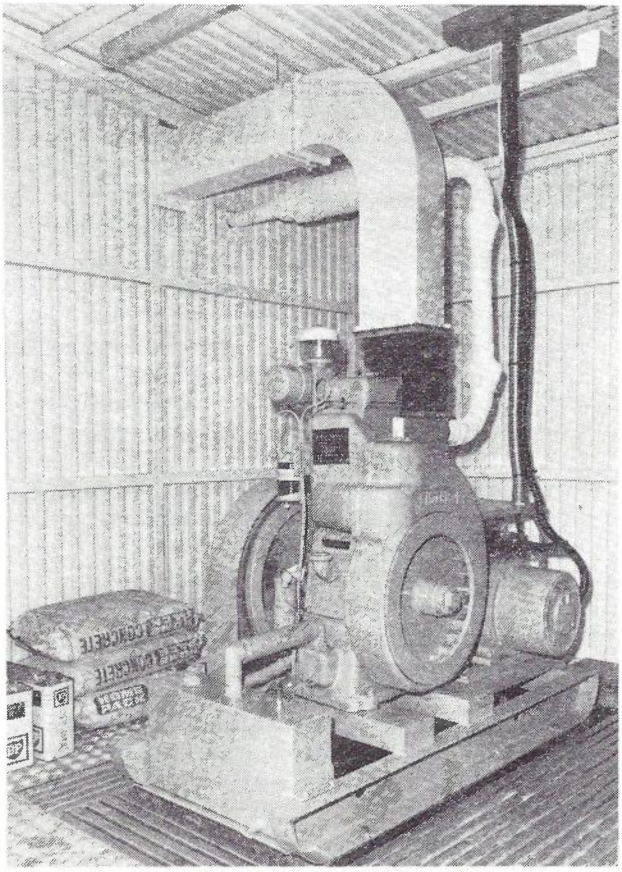


Fig. 6. Slow speed, continuously run diesel-generator plant at a repeater station on the Darwin-Mt Isa Microwave Radio System.

On many systems efforts have been made to avoid the need for air conditioning by housing equipment in underground shelters or using special double-skin shade-screen building techniques to limit diurnal temperature variation.

Continuously running plant may be a diesel-driven alternator powering a conventional rectifier battery-float system or may be a rectified low voltage brushless alternator as shown in **Fig. 6**.

Normally, battery reserves for this application are sufficiently large to enable the diesel to be started from the station battery without affecting equipment operation and thereby obviating the need for a separate starting battery and charger.

Wind-Driven Generators (WDG)

Telecom Australia has depended for many years on the wind as a source of energy for some of its more remote installations where wind conditions are favourable.

Applications include subscribers' VHF and microwave radio systems. All the machines in current use are the locally produced "Dunlite" model. At present, there are about 50 of these machines in service in various parts of Australia. A typical installation is shown in **Fig. 7**.

Some of the major problems with the WDG stem from the fact that it must be serviced on the mast in all weather conditions. Routine maintenance is therefore suspect at some locations, with the end result that failures are usually dramatic. A new type of "see-saw"

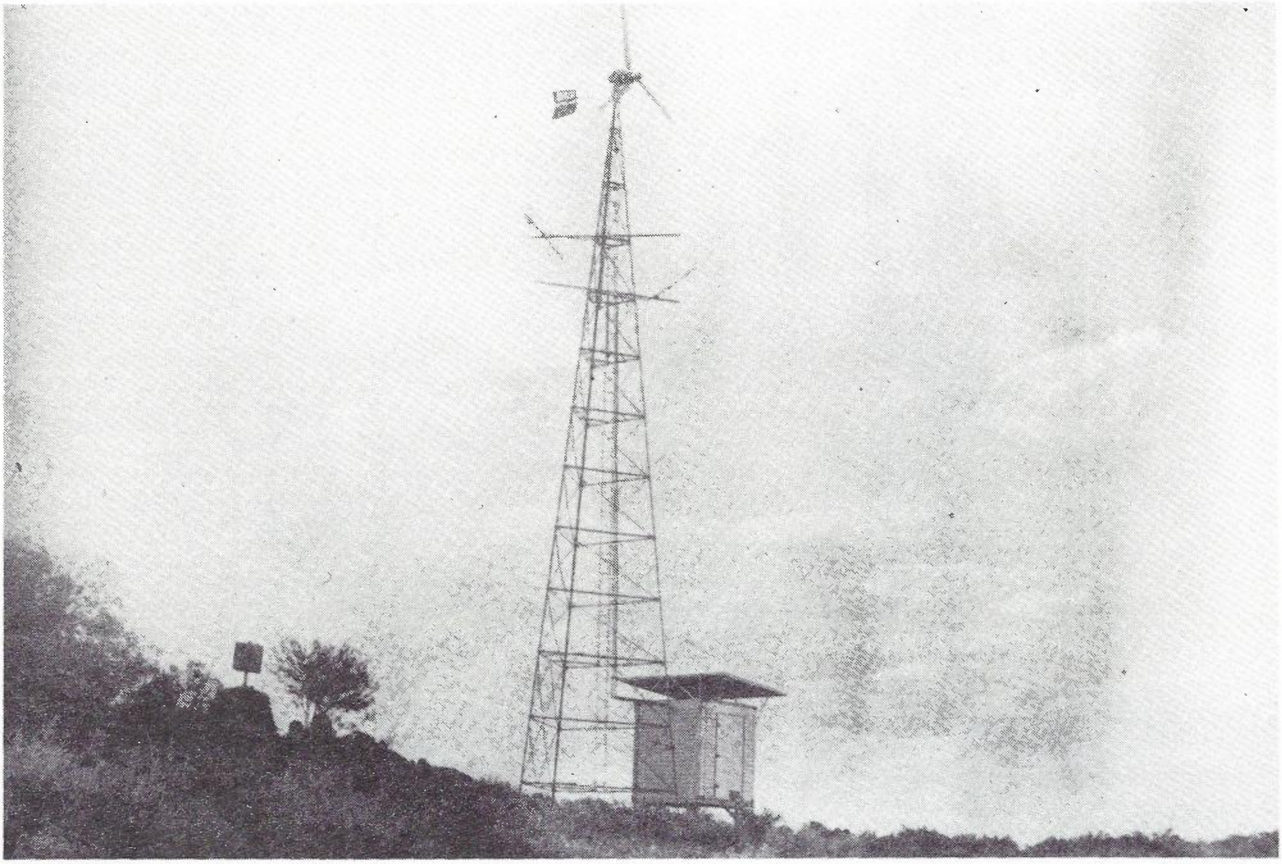


Fig. 7. Wind powered subscriber radio terminal at Packsaddle Ridge, NSW — The site has since been converted to solar power.

mast is being evaluated at present which if successful will greatly improve access for maintenance.

Other locations are subject to unusually severe climatic extremes and suffer major damage during storms. Protection against the effects of driving rain, dust, heat and ice is not easy, and corrosion and seizure of components in the governing system have taken their toll.

System design is made difficult by the lack of reliable wind data and one cannot economically take into account all factors in some minor installations, and long windless periods result in the need for manual battery charging several times per year. Other sites have abundant wind, such as Three Hummock Island in Bass Strait, Tasmania, where 3 machines, with reduced windmill size, support a major microwave repeater of about 1200 watts consumption.

Storage Batteries

The storage battery is the most important component of any no-break dc power supply. The type of battery used almost exclusively throughout Telecom is the "Faure" type which is a pure-lead positive pasted-plate battery. It has been designed for float duty with a service life in excess of 15 years. These batteries are made locally in Australia in different capacities ranging from 25 Ah to 3200 Ah (**Fig. 8**).

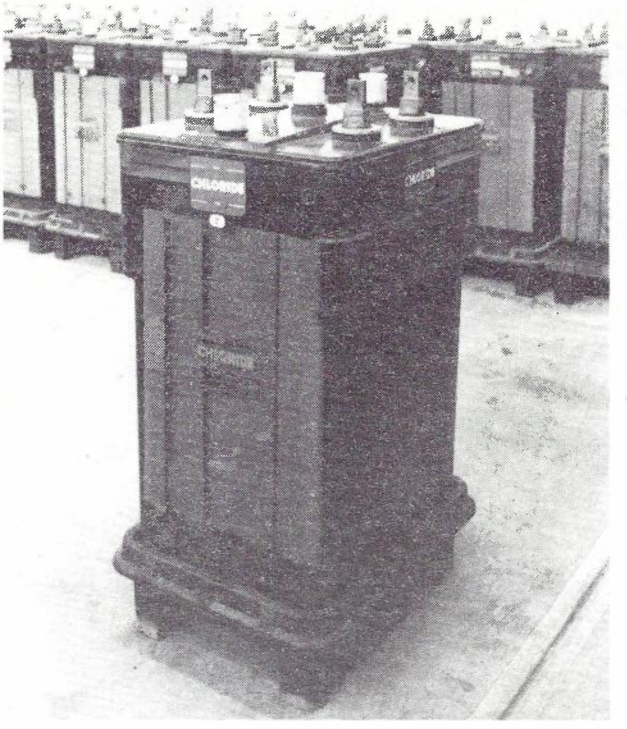


Fig. 8. A typical pasted-plate lead-acid battery used in large telephone exchanges (2V-2170 AH).

They appear ideally suited to the solar application as, in most cases, the duty is essentially float. A small daily charge/discharge of a few percent is superimposed on a relatively deep discharge once per year.

Although batteries are normally rated at an 8 or 10 hour rate of discharge, the actual rates on solar duty are often in excess of the 100 hour rate. This means that the actual useable capacity under emergency conditions is nearly twice that of the 10 hour rate capacity (**Fig. 9**).

The newly developed sealed-recombination lead-acid

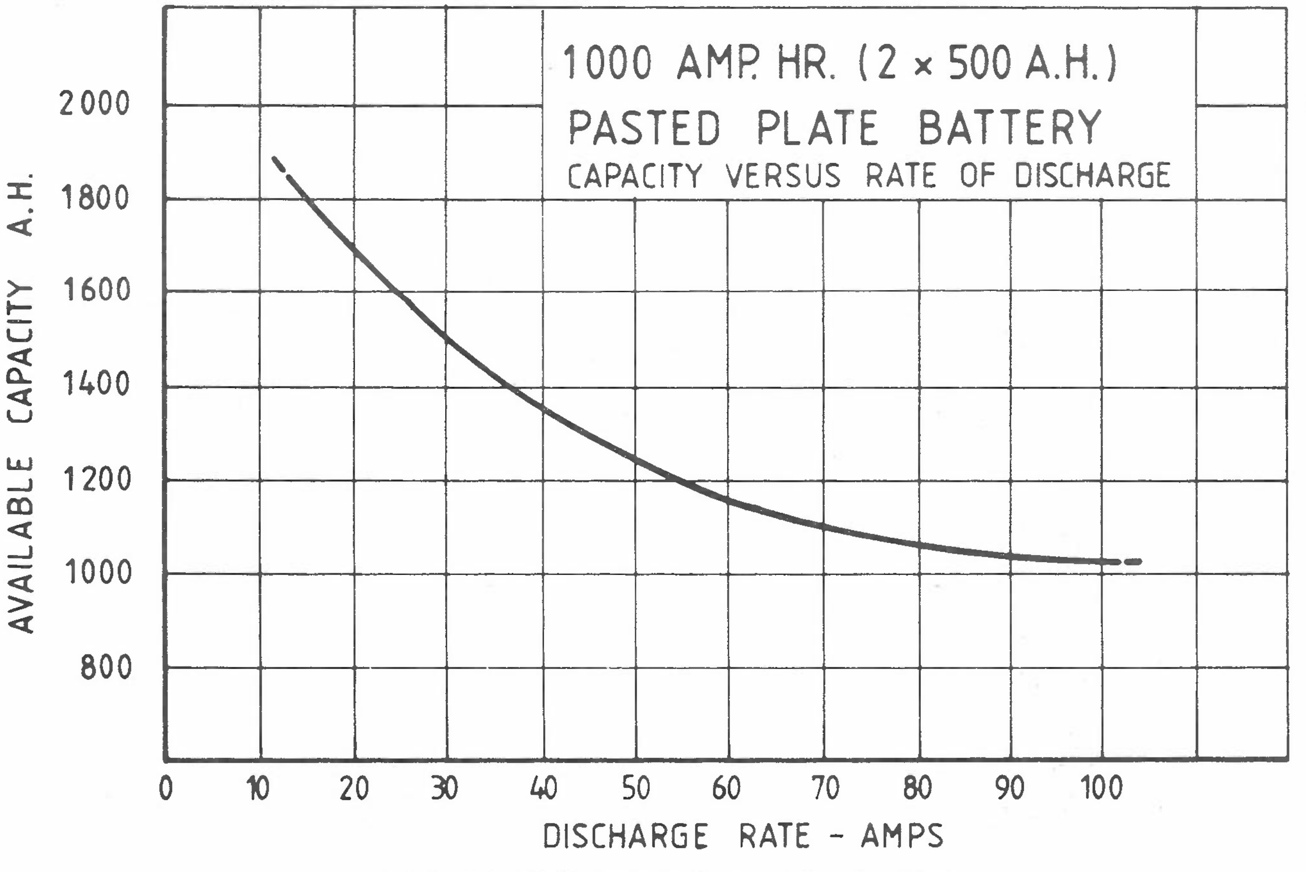


Fig. 9. Available Battery Capacity (1.85 V/Cell end voltage).

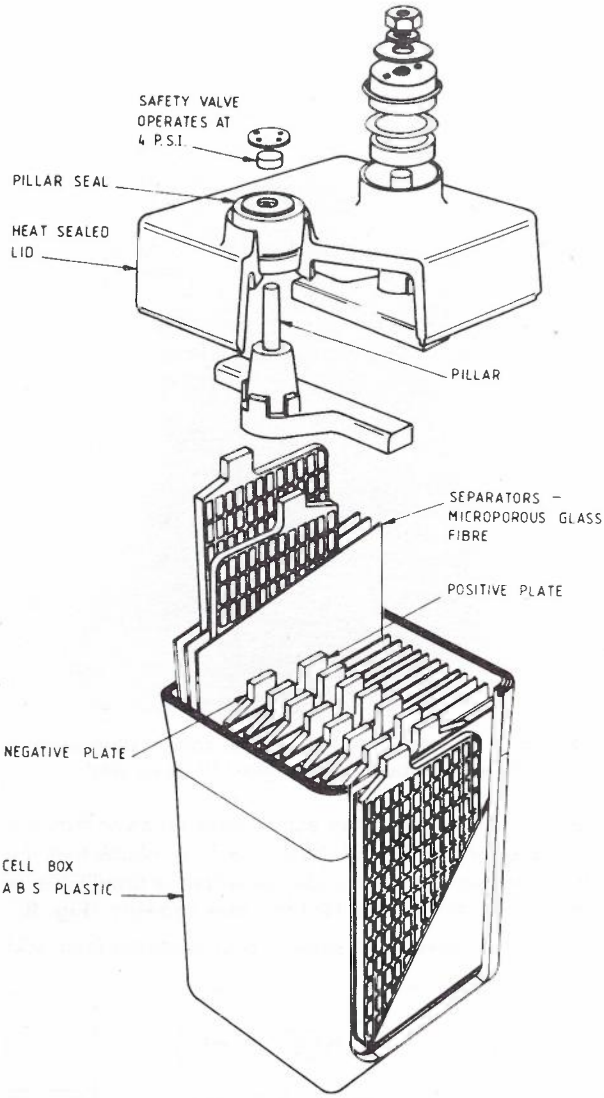


Fig. 10. Cut-away section of a Chloride "Power Safe" recombination battery.

batteries available on the world market in the last few years have been examined by Telecom for a number of applications, including rural power supply systems. These batteries are based on the latest sealed-recombination electrolyte technology. The cells contain either pure lead grids (Gates) or ternary lead alloy grids (Chloride) with microporous sponge separators which absorb the electrolyte (**Fig. 10**).

As the cells are sealed, there is no risk of acid spillage and they are compatible with electronics and office equipment. They are maintenance free batteries in the sense that, if properly used, they will never need water or electrolyte checks.

The manufacturers have claimed that these cells exhibit good performance over a wide temperature range, high discharge and recharge capabilities, good resistance to shock and vibration and are suitable for float or cyclic charge/discharge operation. Because of the ways these cells are constructed, they are very rugged and promise packaging flexibility and ease of transportation, in particular, by air.

Telecom Australia is presently investigating the performance characteristics of various types of recombination batteries to assess factors such as service life, risk of explosion if abused, optimum float voltage and overall reliability.

Solar Power Systems

Solar PV power systems are now the preferred power source for low consumption telecommunication systems in areas isolated from the mains grid. In 10 years, solar power has progressed from being considered as an exotic, expensive power supply to an acceptable "conventional" supply.

Telecom Australia's experience with solar power systems has been good. To date, there are more than 200 kW peak of solar modules in the field, powering a wide range of telecommunication loads, ranging from single channel VHF subscriber radiotelephone services (**Fig. 11**) to repeaters on major microwave radio trunk routes (**Fig. 12**). Telecom presently purchases more than 60 kWp of solar modules annually. The reported fault incidence is very low indeed (less than 1%).

A solar power system consists of other items of plant which are common to most power systems. The most important and yet least understood item of plant is the secondary lead-acid storage battery. The battery provides the buffer between the rather spasmodic output of the solar array and the reliable 24 hour supply required by the load. In a solar power system the battery will often comprise more than 25% of the system cost — the cost sometimes being greater than the solar modules themselves.

Whereas the cost of solar modules has reduced from over $A100/W peak to less than $A10/W peak in the last 10 years, the cost of lead-acid storage batteries has risen from$A60/kWhr to $A200/kWhr.

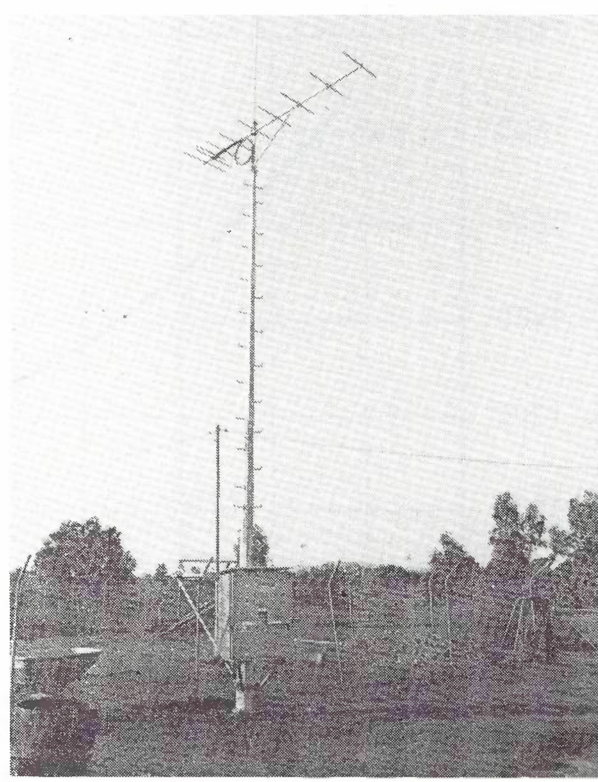


Fig. 11. Single channel VHF subscriber radiotelephone in Western Australia.

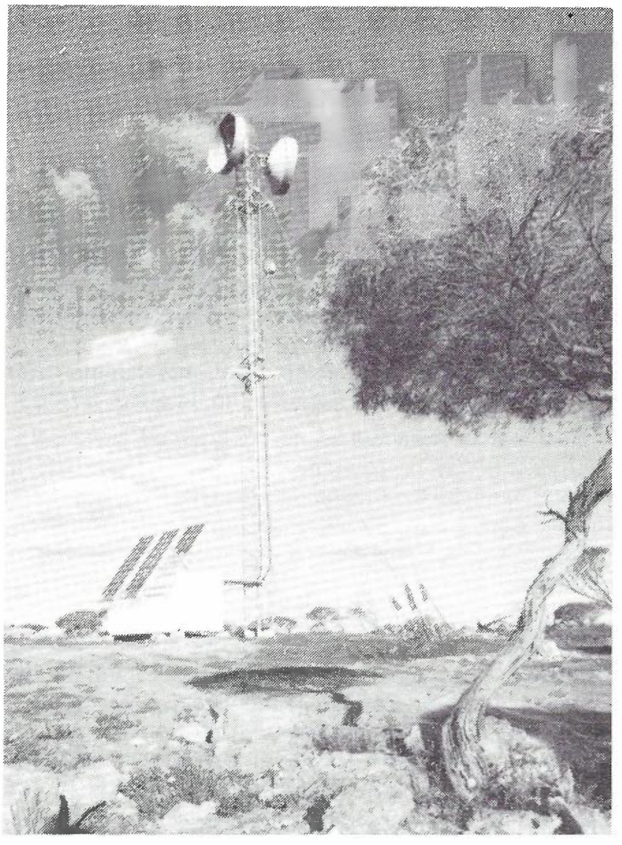


Fig. 12. A repeater station on the Tennant Creek-Alice Springs Microwave Radio System.

The cost of shelters and control equipment is also rising steadily. It is clear that with the real cost of solar modules continuing to fall and the upward trend in battery and ancillary equipment costs, methods of reducing the so-called "balance-of-system costs" will have to be employed.

The storage battery of a solar PV system is large by comparison with that used in a dc power system supplied by the mains. A typical battery for solar systems will have a reserve of about 10-12 days, whereas the practice at mains supplied stations is to provide 3-24 hour battery reserves, depending on the location. The main reasons for the large battery capacity in solar power systems are:

- the need to supply the night-time load,
- the need to provide adequate reserve in poor weather,
- to limit battery cycling to increase battery lifetime.

Lead-acid batteries used in solar power plant are expected to have a lifetime of between 8-10 years and experience to date indicates that this will be realised.

PACKAGED APPROACH TO POWER SYSTEMS

In the past diesel-generator equipment has been packaged to:

- reduce installation cost in the field,
- improve reliability,
- increase flexibility,
- reduce transportation cost.

More recently, Telecom adopted a packaged approach to its solar power supplies, the first of which was used on the Tennant Creek-Alice Springs Microwave Radio Relay System which was completed in 1979. (3). Standard 6 metre long shipping containers were used to house the storage batteries and control equipment and to mount the solar array on the roof (Fig. 12). The containers were fitted out prior to dispatch to the field. Solar array frames and batteries were packed and transported to site inside the container. These items were then installed on-site. The shipping container is simply bolted to foundations provided at the time of tower erection. Considerable savings in transport and installation costs resulted in this package becoming standard for powering repeaters on major radio trunk systems. To date, about 70 of these units have been installed throughout Australia. Similar techniques have been employed to house diesel-driven generator plant.

A breakdown of the cost of items of plant for a typical solar power system described, are given below:

	COST ($AUST)
SOLAR MODULES & FRAMES (1 200 W peak)	10 600
(Array frames comprise 10% of cost)	
CONTROL & DISTRIBUTION CUBICLE	4 000
BATTERIES (2 000 Ah-24 V)	9 600
CONTAINER SHELTER	15 000
TOTAL	39 200

The above system will support a continuous load of about 200 W in a high solar radiation region such as Central Australia.

One of the limiting factors in reducing the cost of installation is the present practice of installing batteries on-site. The need for special packing to ensure batteries survive an often long and arduous trip to site and the fact that batteries are "wet charged" prohibits their pre-installation.

COST REDUCTION TECHNIQUES

What makes a system 'low cost'? There is no absolute figure for low cost and therefore it must be relative to previous experience or communication equipment cost. Historically the capital cost of power plant has been considerably less than the cost of the communications equipment. The introduction of solar power supplies has increased the relative cost of the power plant. To compare the cost of a solar power supply with conventional alternative systems on the basis of capital cost alone does not present the true economy of solar power plant **(Fig. 13)**. Other factors such as reliability, lifetime, maintenance cost, installation cost, design flexibility, ability to package, building requirements, access road cost, fuel cost, and level of expertise and training must be considered. A better comparison between various alternative systems is shown in **(Fig. 14)** which is based on the Net Present Value of each system.

Some of these factors have been discussed; some are not immediately obvious. For instance, the cost of access roads may be as much as the cost of the communication system if all-weather access is required, as will be the case where diesel fuel is to be transported to site. Power systems relying on renewable energy sources may have minimal access roads as there is no need to provide fuel and reliability is high. In fact, maintenance staff generally do not visit solar power repeater stations more often than every 6 months.

Building design is another aspect related to the source of power. Clearly it would be uneconomic to use air con-

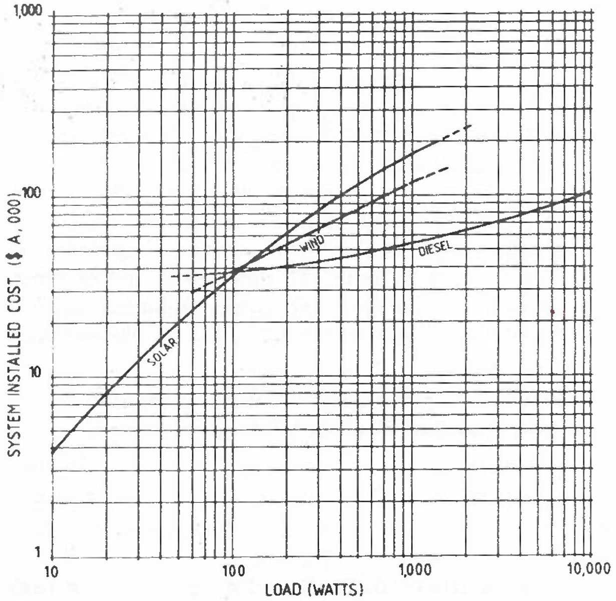


Fig. 13. Comparison between the installed cost for various power systems.

ditioners at a site powered by solar power. The most popular techniques being used to provide an acceptable working environment for communication equipment are to either house the equipment underground or in a double skin "thermally-transparent" building (2). Both of these techniques obviate the need for air conditioning with modern radio equipment.

POWER SUPPLY FOR DIGITAL RADIO CONCENTRATOR SYSTEMS (DRCS)

Telecom will introduce DRCS from about mid 1984. Some 1100 repeaters will service about 6000 rural and some remote dwellings by 1990. Power consumption at repeaters will vary between 50 and 160 W average at 12 volts nominal. Each repeater will service a number of subscribers and their equipment is expected to consume between 5 and 10 W average.

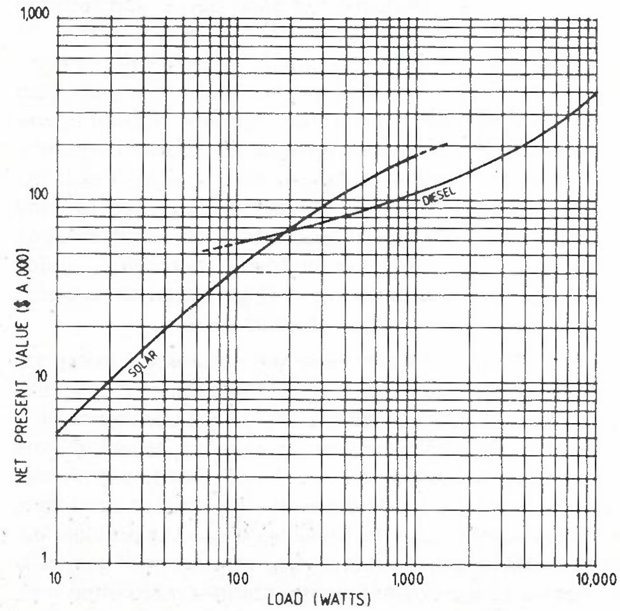


Fig. 14. Comparison between net present value of typical diesel and solar power systems (interest rate 15%, plant life 10 years).

A decision has been made to provide solar power at repeaters with no mains power, which is the majority case. The subscriber end units will also be powered by solar power, despite the fact that some form of power is usually available at the premises.

A reduction in the cost of the total system is being achieved by using solar power and economies of scale. By making all subscriber's end equipment identical and adopting a modular approach at repeaters, the costs are expected to be significantly reduced. **Fig. 15** shows what typical subscriber's end equipment will consist of. The radio and solar power equipment comes completely wired in a double skin cabinet. The approximate total cost of this equipment is expected to be about $7,000.

This cost is expected to be apportioned as follows: triad mast (including equipment cabinet) — 15%, DRCS equipment — 60%, antenna and feeder — 5% and solar power equipment (including batteries) — 20%. Installation time in the field is expected to be less than half a day.

At the repeater, a double skin "thermally transparent" equipment cabinet will also be used to house the radio equipment, solar control equipment and batteries. A maximum amount of installation will be carried out before the cabinets are transported to site thus reducing installation and commissioning costs. The possible introduction of sealed-recombination batteries in lieu of the conventional vented wet type would mean that the cabinets could be fully equipped, including batteries, prior to delivery.

The cost of the repeater is expected to be about $60,000. The solar power system component will cost between $4,000 and $7,000 depending on the location and load.

Fig. 15. Typical DRCS subscriber's end.

To date, all solar power systems used by Telecom have been designed using identical design principles. That is, a solar power system powering a rural single channel radio telephone will have the same ratio of battery capacity, array power, etc., to load as for a system powering a radio repeater on a major trunk system. A 'minimum' power system could be provided for rural networks with cost savings in the battery reserve and level of instrumentation. If a lower system availability can be tolerated, the battery reserve can be reduced to 8 days rather than 10 or 12 days for trunk systems. The cost reduction of solar modules from $12 to $8/W peak in the last year has further assisted in meeting the cost objectives for this system.

HYBRID SYSTEMS — A NEW POWER SUPPLY CONCEPT FOR RURAL TELECOMMUNICATIONS.

Solar PV systems are now used almost exclusively for powering rural telecommunications systems where mains power is unavailable and the average load is less than 300 watts.

Diesel-driven generators were once the traditional power source for such applications, and still are where the average load exceeds about 1000 watts. Above 300 watts solar PV power is generally uneconomic compared with diesel plant; however the use of diesel plant for loads below 1000 watts usually requires that the cycling mode of operation be used to avoid the well known problems associated with light load running of diesel engines. There are also many problems with cycling charge/discharge systems, not the least of which is rapid battery ageing.

Modern analogue microwave transmission techniques have resulted in a reduction of typical repeater loads, by an order of magnitude in the last decade, to figures as low as 70 watts average at major microwave repeaters. Reducing costs of solar modules, combined well with the above to achieve a low cost, highly reliable system. With the introduction of digital transmission techniques and plans to overlay the existing trunks network with digital systems, power consumption is again on the increase. Typical repeater loads are 700 watts and a pure PV system is generally uneconomic at this magnitude of load. So, what are the alternatives?

Wind power is enjoying renewed interest and there are many new small machines available which have been designed for high reliability and low maintenance. Modern machines have excellent low wind speed performance which is essential for efficient operation in inland Australia. Unfortunately, the output from a wind energy system is very site dependent, far more so than a solar PV system. However, some modern 2000 watt rated machines could be expected to provide between 200-500 watts average at many locations and as much as 700-800 watts at very windy locations such as islands in Bass Strait. The battery reserve would generally be comparable to that used in a PV system of similar load rating.

Another solution to the problem which is gaining popularity is that of hybrid systems comprising solar PV, wind and diesel-backup. (4). The concept of combining more than one energy source is not new (2) and has been used on the East-West and the Coen-Mossman microwave radio systems.

Natural energy systems such as wind and solar PV, used in stand-alone configurations suffer from a common problem — their dependence on a backup supply when the sun is not shining and the wind is not blowing. Even in regions exhibiting excellent insolation and isovent conditions, some form of auxiliary supply is essential to provide continuous power. Generally battery storage is used as backup for both types of systems with reserve times, from a fully charged state, of typically 10-12 days. With the cost of batteries steadily increasing, any means of reducing battery standby capacity would be advantageous and it is seen that this can be achieved by combining the various power sources.

Solar, wind and diesel-generators have their own specific advantages and disadvantages. By combining these different power sources, a symbiotic relationship is established between each of the energy sources in order to obtain the most cost effective system. There is an inherent advantage in combining the sun and the wind resources. They often have a complementary nature during the year which smoothes out the variations in the power supply from the separate sources. This allows for reduction in costs in two areas:

- It is possible to install a lower level of peak power as compared with a non-combined system.
- The battery capacity may be smaller, as probability of continuity of supply increases. Reserves of 2 days are contemplated.

There will, of course, be times when both the wind and solar resources are low and some form of backup fuel-fired generator is therefore required. The most efficient energy converter is the diesel engine although, thermoelectric generators and close-cycle vapour turbines have been proposed for this purpose. The introduction of a small, simple, low cost and reliable diesel-generator will provide the following benefits:

- Further reduce the installed peak power of the wind and solar energy source by reducing safety factors in the wind and solar energy sources.
- Further reduce the battery reserve as the long term standby is provided by the diesel-generator in lieu of the battery.

When a hybrid system is compared with a single system, the cost of installed peak power can be reduced by 10-20%. Furthermore, a substantial increase in the system reliability will be achieved.

The tilt of the solar modules can be chosen to optimise for the summer period instead of for the winter period or for the season when the wind resource is low. This increases the energy production per module and reduces the required number of solar modules. A further gain in output can be obtained by incorporating peak-power tracking techniques using highly efficient pulse-width-modulated dc/dc converters between the solar array and battery — a technique not used by Telecom to date. This technique utilises the higher efficiency obtained from a solar array operating at low winter temperatures and is probably more appropriate for the colder parts of Australia.

In sizing a hybrid system the following factors need to be considered:

- meteorological, geographical and topographical conditions.

- the final battery reserve necessary to enable repair staff to reach a site if the small diesel-generator has failed to start.
- the amount of energy each energy source is assigned to produce (i.e. capacity of the solar array and wind-generator and capacity and running hours of the diesel-generator).

The addition of the standby diesel enables the wind and solar sources to be minimised and eliminates the need for accurate meteorological data in sizing a system for a given site.

In investigating the viability of hybrid systems, Telecom Power Section Headquarters is currently developing and will install a prototype system at its Maidstone field site near Melbourne. The components are shown in **Fig. 16.**

Further work is to be done regarding the control of hybrid systems, especially in the area of optimising the output power from each system component. It is envisaged that microprocessor techniques will be well suited to this task.

The success of such a concept is dependent on many factors, such as the ability to obtain low cost highly reliable wind-generators and small diesels, and the ability to modularise and package the equipment to reduce installation and commissioning time. It is hoped that the trial system, to be installed early in 1984, will prove the viability of hybrid systems in the difficult to supply load range of 500-1000 watts.

CONCLUSION

The design and provision of a reliable and economical power supply for rural communications requires considerable engineering knowledge, judgement and foresight together with an understanding of the interdependence between the communications system, the power supply and the environment.

It has been Telecom Australia's experience that whatever type of power source is selected, it is important that a "systems" approach be adopted so that the power supply can match the needs of, and can be integrated with, the rural communications equipment it powers.

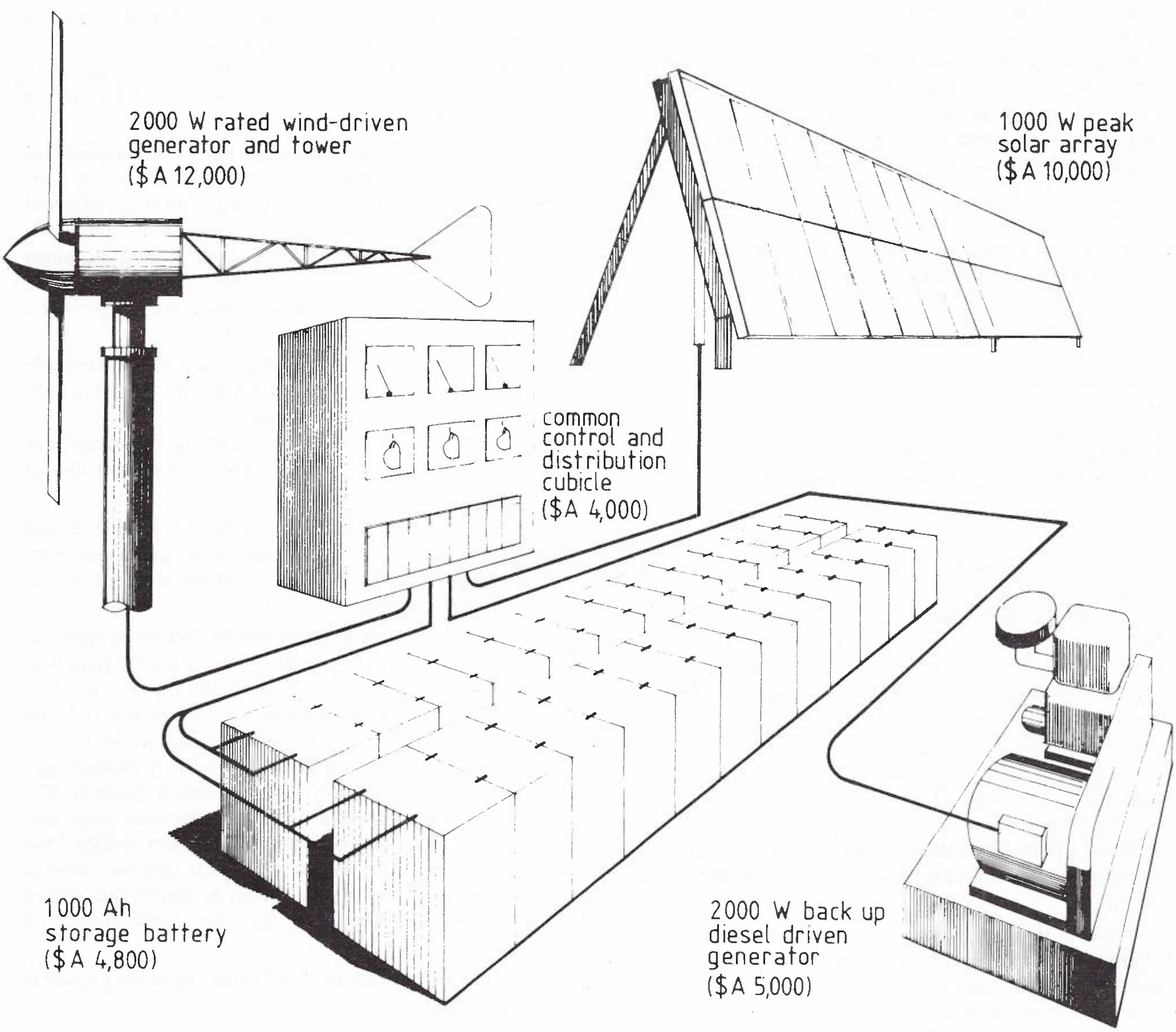


Fig. 16. Trial Hybrid power system equipment.

All of the power supply schemes mentioned will no doubt have applications in rural and remote communications. However, solar power systems have emerged as a promising power source for rural communications where a convenient source of ac power is not available. Solar power plants have become the preferred power supply for the Australian outback communications network in recent years, and have proved to be reliable, economical and adaptable for a range of small-load applications.

New developments in the alternative power field will need to be undertaken in the area of hybrid power systems to allow for further utilisation of solar photovoltaic cells in the powering of large rural communications loads in the range of 500 to 1000 watts.

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Information Transfer News Item

IBM Supports High Technology Research at UNSW and RMIT

An agreement between an Australian microelectronics research centre and IBM Australia which will ultimately benefit high technology industry was announced in Sydney today at a news conference attended by the Minister for Science and Technology, Mr Barry Jones.

Through the agreement, the Joint Microelectronics Research Centre is to receive more than $1 million over four years from IBM in the form of scholarships, personnel exchanges and laboratory and computer equipment.

This will help the Centre continue and expand its work in areas such as the design and fabrication of electronic chips, research into improved microelectronic materials and processes and the development of better and cheaper solar cells.

Set up in February 1982 through a $2 million grant from the Federal Government, the Joint Microelectronics Research Centre combines the work of scientists at the University of New South Wales and the Royal Melbourne Institute of Technology. (The Centre is one of the Commonwealth Government's Special Research Centres.)

Already, Centre researchers have attracted international attention through their achievements, including:

- The creation of the most efficient silicon solar cells in the world. Commercial units usually are able to turn about 10 to 13 per cent of sunlight into electricity, but the Centre has achieved 19 per cent and aims to go higher.
- The development of a transistor with two-and-a-half times more amplification than any other. This could lead to cheaper consumer electronic devices such as hi-fi sets and power accessories for cars.
- The discovery that the silicon used in electronic chips can be 'doped' more heavily than was thought possible. Doping is the addition of different materials — such as phosphorus — to boost the electrical activity of the silicon. More concentrated doping could lead to better and smaller chips.
- The development of a technique to dramatically improve the adhesion of thin metallic films to almost all materials. This method involves bombarding poorly adhering films with ionizing radiation such as fast ions or electrons. The process called 'stitching' has wide application both in the microelectronics industry and in most areas using coating technology.
- Work on a method which enables people without any design experience to design a chip, with the aid of a computer. This opens up what has been a highly specialised field to a great many researchers and to industry. The Centre intends to use one of two IBM XT Personal Computers being donated by IBM, to assess whether a widely available microcomputer can be used for designing chips.

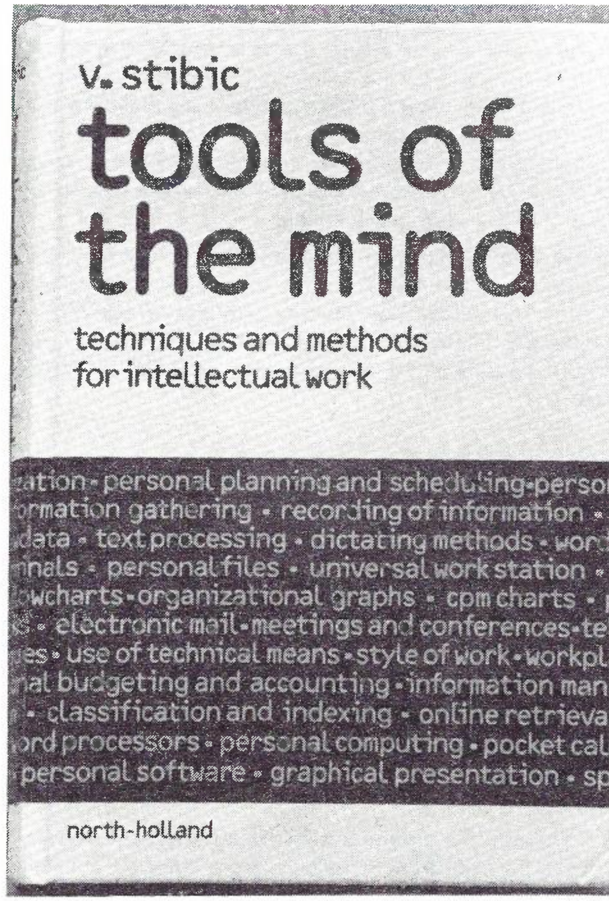
The Centre's work touches on many high technology areas — the industries of the future. Research is going on, for example, into microelectronic devices for medical use, such as improved heart pacemakers and a digital hearing aid able to filter out background noise.

Solid interest has been shown overseas in Centre projects. America's National Aeronautics and Space Administration (NASA) has provided a grant to help research into solar cells that are used to power spacecraft.

Another grant has come from the US National Bureau of Standards, to develop better ways of measuring the intensity of light.

Issued by:
The Public Affairs Unit,
The University of New South Wales,
Kensington, Sydney

TOOLS OF THE MIND
Techniques and Methods
for Intellectual Work by
V. Stibic
North-Holland Publishing Company
Amsterdam 1982



The author sets out to discuss the attributes of systems and devices useful as aids in the performance of "intellectual" work, ie. work which mainly involves use of the intellect. The author recognises that such work occupies only a portion of the work spectrum and acknowledges that there is a mix of physical and intellectual activities in most work roles.

This book has a number of interesting features:

- The writer's observations are clearly based upon experience melded with an analytical approach.
- The writer has put into effect in the preparation of the book the very techniques he advocates for others.
- The tools described cover the range from the blackboard to the word-processor; from the desk to the 'universal work station.'
- A number of topically related quotations are given throughout the book, unfortunately in most instances without source references.

Perhaps the most interesting section of the book is that in which Stibic examines the personal work space and the user's requirements in that space. He makes interesting observations about what should and should not be on the normal workspace, and advocates the use of a fitted desk approximating the style of the old and familiar roll-top desk.

However, his strong advocacy of a very detailed personal resource accounting and documentation system raises the question of how a person would find the time to do something productive. He advocates that the keen professional person should carry in addition to the necessary wallet, a pocket diary, a set of standardised cards in a plastic envelope and a pocket dictating machine, so that detailed notes may be made at any time.

Necessarily, he recognises that such activities are useless without the employment of a systematic retrieval system. Hence the cards must be used somewhat in the fashion of reference card in a Dewey library system. There may be people this systematic, but I've not yet met any.

The author's observations on features essential to a useful word-processor are particularly interesting. He advocates the necessity of "flag" and "search" facilities for utmost practicality of use. The layout of his book clearly conforms to the principles of composition that he advocates.

An interesting resume is given of the various names by which Videotex is known. Particularly interesting, from the Telecom point of view is his observation that a Videotex facility or similar public access interactive computerised information system will make money if it provides ready access to inconsequential trivia. In other words, marketers of modern communications and information systems will not go broke by underestimating public taste.

However he cites a useful and timely warning, that there are "precarious discrepancies in the classification scheme in public viewdata systems". Further, he advocates that basic rules for graphic design of a viewdata page are an essential aid to this communication medium. This area of the book may be of particular interest within Telecom right now.

The author presents an interesting section on the preparation of typed material for camera-ready printing and phototypesetting. This section would be of challenging interest to staff and supervisors in typing pools and similar work areas where textual material is prepared for printing.

With reference to personal computers and their capabilities, the author makes some useful observations. People considering the purchase of these items may find his comments useful eg. "the capacity of every computer installed has in a short time been found to be insufficient" and "the effectiveness of applications will grow (by synergic effect) if other applications are added."

It was interesting to note that while Stibic states that the slide rule has "disappeared without a trace . . . as no other tool has done in history" he considers that Gantt and Z charts are undergoing a renaissance. Stibic presents numerous useful comments on the development and application of charts and other visual aids. The book is a useful reference for this reason alone.

All round, this is a book packed with practical ideas from professional specialties that other professionals may be able to adapt to their needs. Further, the book represents a challenge to professionals that they should ensure they are aware of the aids available for the performance of their work and that they should be adopted and used efficiently.

Reviewed by
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Fatigue Cracking in Ormat Energy Converters

ROBERT J. A. MASON BE, MBA

The failure of several Ormat Energy Converters which provide power on the Moomba-Sydney gas pipeline was found to be due to cracking of the boiler area immediately above the gas burners.

The fatigue cracking in the boilers was due to the flame impingement heights within the burners being too low. A relatively simple and inexpensive modification to overcome this problem has been carried out on each of the converters in the field, but further cracking can be expected because of the already accumulated fatigue damage. Any further cracking however, is not expected to be of a serious nature and may be repaired quickly on-site.

Discussions with the manufacturer in Israel led to the rapid identification of the cause of cracking, and provided other information essential to the safe and reliable repair of the damaged units.

BACKGROUND

Ormat Energy Converters (OECs) were installed approximately six years ago to power the broadband radio system along the Moomba-Sydney gas pipeline. They are located in the remotest areas where reticulated power is not available. Their sealed construction and minimum number of moving parts makes them suited to installation in very remote areas.

The basic concept and design of the OEC may be seen in **Fig. 1**, and is explained in the following paragraphs. Although this design has a very low efficiency of energy conversion — about 5%, the units should operate satisfactorily and provide their rated output over long periods. The OEC is a fully sealed and self contained unit which burns gaseous or liquid fuels to produce electricity through a turbine driven generator utilising the Rankin cycle. The generating set contains only one rotating part — the shaft on which the turbine wheel and brushless generator rotor are mounted.

There are 36 OECs installed in NSW and SA along the pipeline burning natural gas as a main fuel, and Liquid Petroleum Gas (LPG) as a back-up fuel. Initially, the only fuel available was LPG, as the pipeline was not completed. The units ran for approximately six months on LPG, and have a rating of 1500 watt.

SYSTEM OPERATION

Natural gas, or LPG is used to fire the burner located at the bottom of the unit. As the burner heats the organic fluid, trichlorobenzene, contained in the boiler, some of it vapourises and flows up the vapour inlet tube to the turbine wheel where it produces rotational shaft power to drive the alternator. The vapour then passes into a condenser, is cooled and converted back to a liquid which is returned to the boiler. As the liquid returns it cools the generator while supporting the shaft within the fluid-film journal bearings. This cycle continues as long as heat is applied to the boiler.

Because the entire system is sealed, none of the organic fluid is lost in the process, and the fluid is immune to conditions outside the sealed container.

The turbogenerator, rotating at approximately 20,000 r.p.m. at full load, produces 3-phase, 660 Hz AC power which is rectified and filtered. The DC output is regulated in accordance with the load, by automatically switching the fuel supplied to the burner.

The reliability of the system is dependent on the continued integrity of the sealed boiler — turbogenerator system.

DESCRIPTION OF FRACTURE

Early in 1979 some of the OECs developed hairline cracks about the boiler, and automatically closed down on low voltage alarm. The number of units out of service increased to six by October. The cracks were extremely fine and in most cases could only be seen with the aid of a microscope.

All of the cracks were characterized by the following:

- their length was approximately 50mm,
- width was hairline,
- cracks in the same area i.e. front segment near the burner securing bolt — right hand side,
- cracks were in the parent metal of the boiler, immediately adjacent to the weld forming the boiler base.

Fig. 2 is a sketch of the fracture location in the boiler. The metal of the boiler walls and base is 304L grade stainless steel, welded with 308L grade stainless steel.

INITIAL CONSIDERATIONS

No perceptible vibration existed in any of the components since the single rotating shafts were well balanced, and vibration was not seen as a contributing factor.

The desert conditions, in which the OECs are located, produce thermal cycling ranging from approximately 10°C to 60°C. The internal working fluid temperatures are approximately 150°C in the boiler and 80°C in the turbine. Failure due to thermal variations arising from these relatively constant temperatures was considered unlikely.

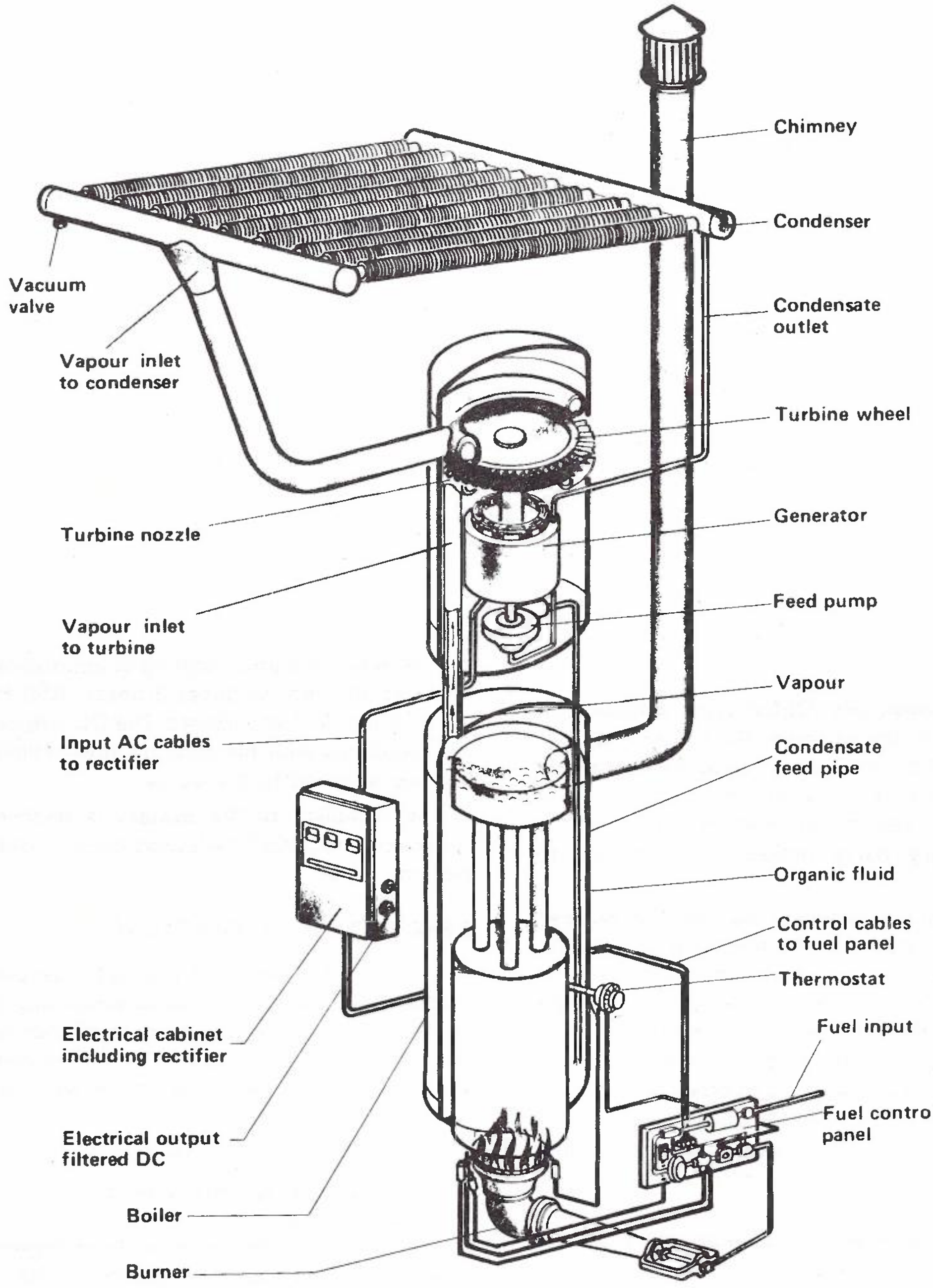
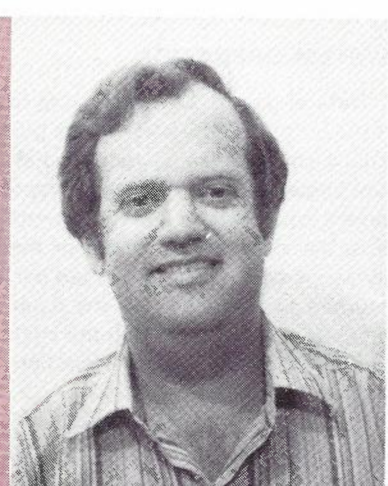


Fig. 1: Ormat Energy Converter — General Construction

ROBERT J. A. MASON entered the then Post Master General's Department as a Technician-In-Training in 1962, and on completion of the course worked in the area of exchange maintenance for several years.

He began studying part-time at the University of NSW for an Engineering Degree in 1972, but later was successful in acquiring a trainee engineer position to allow these studies to be completed full-time.

He currently holds an M.B.A. as well as an Honours Degree in Engineering; and the Senior Engineer — Systems in the NSW Buildings Branch, working mainly with automated buildings control systems.



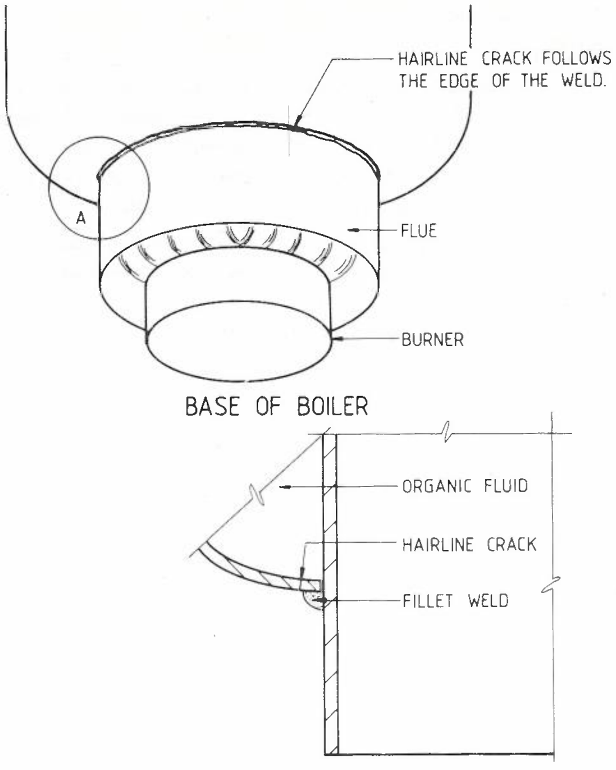


Fig. 2: Location of Fracture

Internal pressures are very low, being below atmospheric. Fatigue due to pressure fluctuations was not considered likely.

DISCUSSIONS WITH ORMAT TURBINES PTY. LTD.

The remoteness of the installations made an indepth investigation of the problem very costly and difficult, with the most accessible faulty site being some 165km north west of Cobar. An opportunity arose to visit Ormat Turbines Pty. Ltd., the manufacturers, in Yavne, Israel at this stage, and it was hoped that such a visit might lead to a quick identification and solution of the problem.

In collaboration with Ormat's engineers, several possibilities were examined, the most promising of which concerned the height of the flame within the burner. If the flame strikes the flue in the weld zone, very large cyclic thermal stresses would result in the weld. To prevent this the burner should have been set so that the flame strikes the flue at least 25mm above this zone.

It was conceivable that, when burning natural gas, the flame would strike the flue in a lower region. Natural gas has a lower calorific value than LPG, and as such more gas is burnt to develop the required output. The concomitant increase in velocity of gas particles would have the effect of lowering the flame.

No other satisfactory theory was evolved, and it seemed that if the flame theory was not the case, a very detailed examination would be necessary to determine the cause: i.e. design, workmanship, material, transport or installation damage, etc. The workmanship and inspection procedures evident at the Ormat factory made the possibility of cause arising from these areas most unlikely.

RESULTS OF SITE INSPECTION

The two OECs designated "A" and "B", at site 2621 were examined in light of the overseas investigations to determine their respective flame patterns. The OECs share the load and thus have similar operating hours but only one, the "A" unit, had developed cracks.

When the burners were tested with natural gas and LPG, a considerable difference in the flame patterns was apparent. It was also evident that the natural gas flame was burning lower, in each of the units, than was the LPG flame.

Two other factors were also noted however:

- The burner was marginally lower in the region of the failures (on both units) because of a large washer between the burner support bracket and its mounting; and
- Regardless of the type of fuel, there appeared a stronger flame in the "A" unit. It is felt that this was due to the "A" regulator allowing more gas through. The "A" flame was lower than the "B" flame as a result.

RESULTS AND CORRECTIVE ACTION

There was no doubt that the flame impingement heights within the flues of the two OECs examined were too low, and no evidence existed to suggest that the burner height was adjusted on either of the units when installed.

Careful adjustment of the gas regulators would probably result in a reduction in gas consumption, and hence improvements as far as the flame impingement heights were concerned. Such adjustments require special instruments, and could not be reliably carried out in the field without an extensive training programme.

A programme was subsequently implemented to raise each of the burners, and hence the flame impingement heights, by 38mm. Such a modification should not affect the efficiency of the system but should significantly reduce the temperature range in the weld zones and thus reduce the thermal stresses. This modification should have been performed on installation.

One of the nearby sites was modified to determine on-site dimensions and requirements etc., and after satisfactory results, all other sites were then modified, using this modification as a pattern.

At each installation, the project entailed the following steps:

- dismantle burner assembly
- modify burner or support
- test and re-establish vacuum as required
- load test and readjust gas regulator as necessary
- any other periodic test and/or maintenance.

It was estimated that one day would be required at each site if no difficulties were encountered.

FAULT HISTORY

The modifications to raise the heights of the burners in all of the OECs were completed in the cooler months of 1980. The success of the project can be gauged from the fault statistics relating to boiler fractures tabled below:

YEAR	NUMBER OF BOILER FRACTURES
1979	11
1980	7
1981	1
1982	2
1983	3*

* 1983 figure is year-to-date as of the end of November.

The fault rate had dropped from 11 in 1979 to one in 1981. Increased failures recently apparent (from boiler cracking) are not symptomatic of the earlier faults, and are seen as resulting from accumulated stress damage — possibly accelerated by the earlier incorrect burner settings.

As a direct result of the investigation by Telecom, the manufacturer issued a modification for all OECs raising the burner heights by some 15mm.

The early identification of the cause of the boiler cracking has saved Telecom many thousands of dollars and enhanced the reliability of the broadband system served by the Moomba-Sydney gas pipeline.

CONCLUSIONS

The fatigue cracking in the Ormat Energy Converters (OECs) appeared to be mainly due to cyclic thermal stresses, resulting from incorrect adjustment of the burners. A re-adjustment was required which entailed raising the burner heights by means of spacer rings or sleeves, or modifying the supporting brackets.

All of the OECs needed to be carefully examined and modified where necessary, but it is to be expected that further cracking would continue to occur as a result of the already accumulated stress damage.

The locations of the cracks adjacent to the welds was due to the structural inflexibility of the burner in the area adjacent to the join of the boiler to the flue.

Discussions with Ormat Turbines Ltd., the manufacturer in Israel, were of great benefit in that they led to a greater understanding of the OECs and the rapid identification of the problem. As a direct consequence of the information gained during the visit, repairs were able to proceed immediately upon return to Australia.

Information Transfer News Item

INMARSAT approves introduction of leased circuits

The shipping and offshore industries will be able to lease telephone circuits on the maritime satellite system operated by the International Maritime Satellite Organization (INMARSAT). This follows a decision by the INMARSAT Council, which concluded its 17th Session in London recently. INMARSAT provides the satellite capacity for telephone, telex and data communications to the worldwide shipping and offshore industries. The Council, INMARSAT's policy-making body, meets at least three times a year.

Circuits will be leased for one or two hours per day for periods as short as one month. The leased circuit will be between a designated ship earth station via a designated coast earth station. Leased circuits will be offered during a one-year trial period which will enable INMARSAT to evaluate the service.

INMARSAT has also approved its first application, from British Telecom, the UK Signatory, for a very high speed data (VHSD) service. INMARSAT announced last November that it would grant access to the system for such a service. This application is for service at 1.024 megabits per second, using the operational Atlantic Ocean Region satellite, a receive only coast earth station, to be located near Glascow, Scotland, and a high power ship earth station, installed on a seismic survey vessel operating in the North Sea. Operation of the service is expected to start after September 1984.

The Council also approved an investment share of 1.64 per cent in INMARSAT for Saudi Arabia, which will enable that country to become a member of the INMARSAT Council. Saudi Arabia joined the Organization last October and has announced its intention to build two coast earth stations. It also anticipates a substantial increase in the number of ships of Saudi registry fitted with ship earth stations.

Issued by:
INMARSAT
London

Call Charge Analysis System

G. CONROY M. Eng. Sc.
R. G. JAMES B.E., B. Sc.

Telecom Australia is now installing the Call Charge Analysis System (CCAS) in all State capitals to provide greatly improved facilities for the investigation of the metered call component of customer accounts and also to provide automatic surveillance of the metering system. This article describes the equipment and the facilities of CCAS.

INTRODUCTION

With the introduction of multimetering for the STD service in the late 1950s, it was necessary to provide equipment which would check the accuracy of the metering system and in particular the metering of individual customer services where a complaint has been made about the telephone account.

For this purpose Telecom purchased Call Record Printers (CRPs) from the United Kingdom. (ref. 1) These electromechanical devices have provided a valuable tool for the investigation of metered call disputes, and over 1,000 CRPs are still in use. However, considerable effort is required to connect and maintain these devices and the paper tape outputs must be laboriously checked for correct detail call by call.

CRPs will be replaced by a combination of modern microprocessor based units called Single Channel Call Analysers and the Call Charge Analysis System (CCAS).

This article describes the Call Charge Analysis Systems which have been installed in each capital city to serve the State.

SYSTEM OVERVIEW

CCAS uses terminal and computer equipment provided by Telesciences Inc. of the USA under the brand name of TBAX (Telephone Billing Analysis Complex). The terminals are connected to the computer over a data network provided by Telecom. CCAS uses a central control minicomputer with software developed by Telesciences and a network of SRS 2020 and SRS 2030 microprocessor controlled call detail recording terminals in exchanges. The SRS 2030 terminal monitors up to 50 customer lines (up to 200 lines in the case of the SRS 2020 terminal) and forwards the call details to the central control minicomputer using data modems and multipoint datel lines.

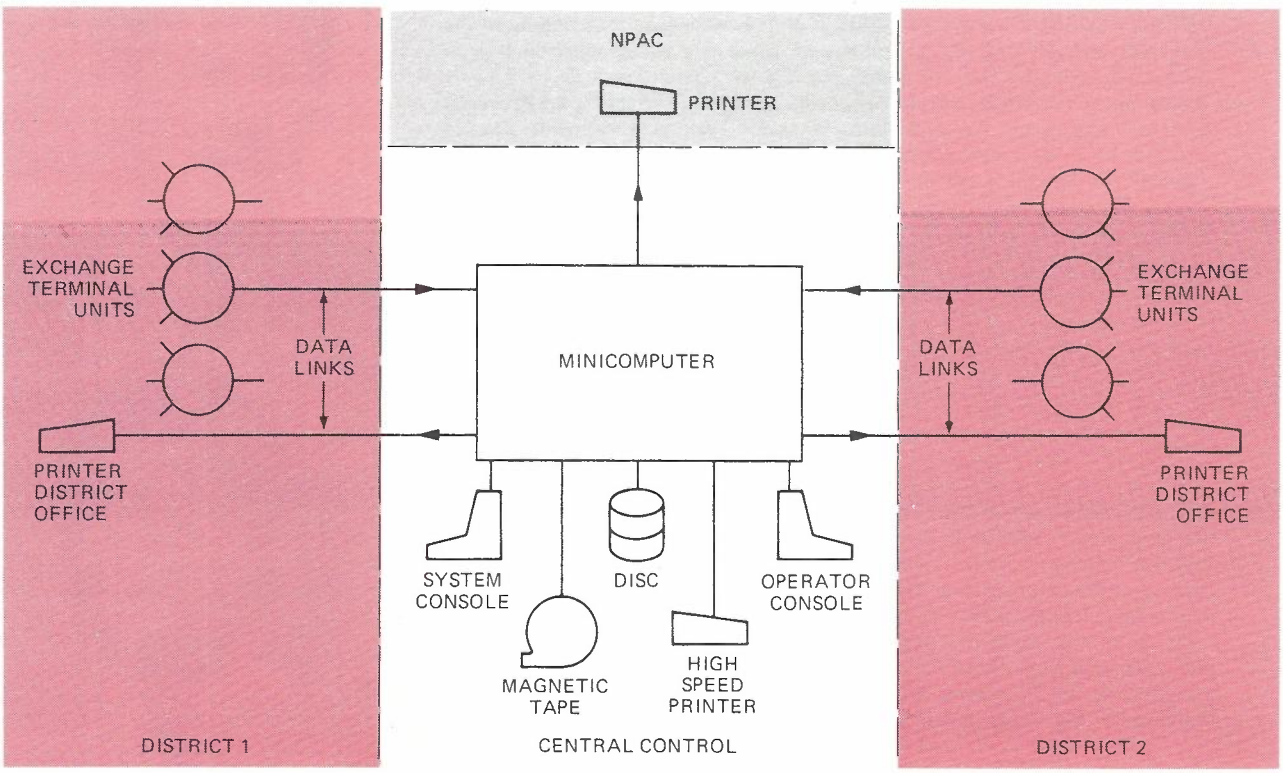


Fig. 1 Schematic Diagram of CCAS.

Each system has the capacity of processing many thousands of customer line studies simultaneously. The call data provided per line includes all pertinent information for outgoing and incoming calls, including:

- Calling line number (monitored customer) — 7 digits.
- Seizure Time — Day, Month, Hour, Minute, Second.
- Called Number (B Customer) — up to 16 digits (decadic or multifrequency code (Touchtone 12)).
- Time to Answer of B Party — Minute and Second (except for unit free calls).
- Conversation time — Hour, Minute and Second.
- Meter Pulses — 5 digits.
- Terminal Identification.
- Input port (terminal inlet) number.

The central control accumulates call details for all customers being monitored and automatically generates a report as each study is completed.

SYSTEM APPLICATION

The CCAS is to be used in the telephone network for two main purposes:

Checking Customers' Metering — this consists of a record of the calls (date, time, conversation time, meter pulse discrepancy) made by customers. The flexibility in design permits:

- The investigation of metered call complaints.
- The checking of super and subnormal meter reports. These reports are generated by the computer

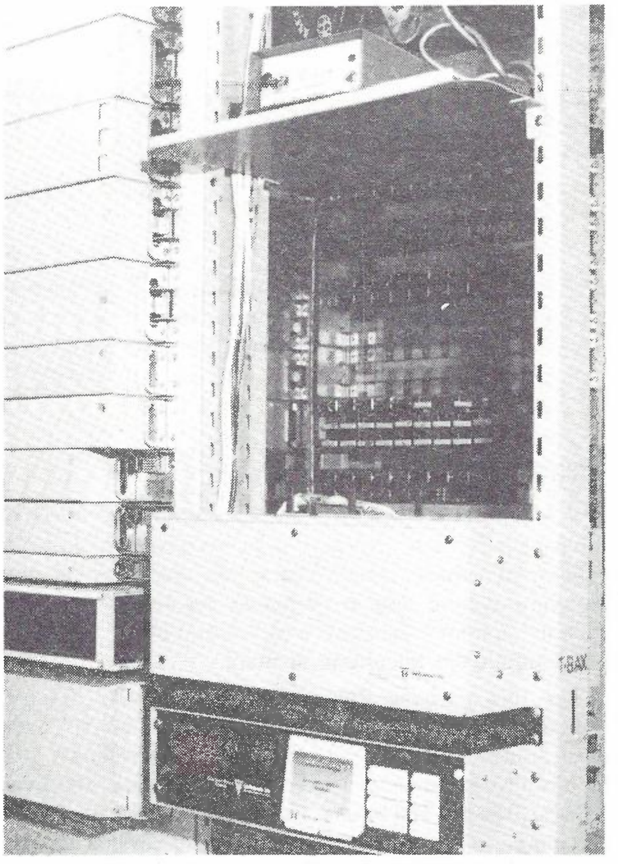
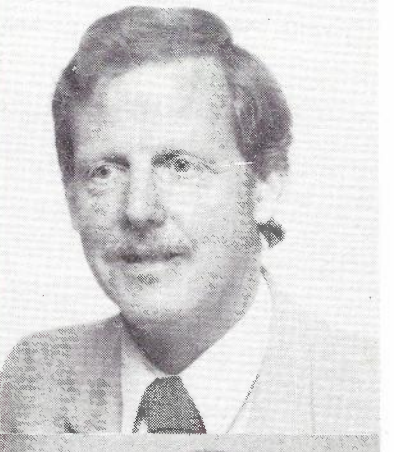
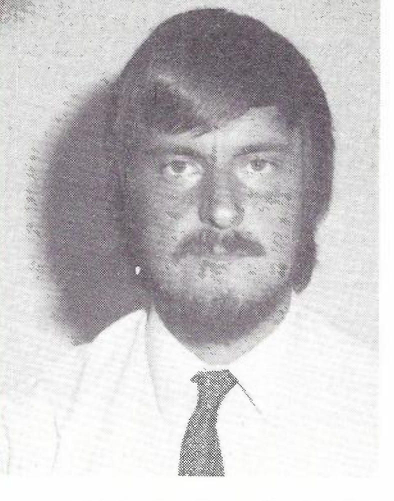


Fig. 2 Exchange Terminal Unit and Data Input Display Unit.

GORDON CONROY completed a Master of Engineering Science degree at the University of N.S.W. in 1971. After several years as a design engineer both in Australia and in the U.K. he joined the P.M.G.'s Department, Trunk Service N.S.W. Section in 1973. In Trunk Service he completed projects in the specialist areas of Transmission, Network Performance and Telephone Switching. Articles on some of these projects appear in earlier issues of the Telecommunication Journal (Vol. 26 No. 3 and Vol. 30 No. 2). Mr. Conroy was the N.S.W. CCAS Project Manager and is now a Principal Engineer in the Network Services Branch.



ROBERT JAMES joined the P.M.G.'s Department in 1971 as a cadet engineer and graduated in 1974 with the degrees of Bachelor of Science and Bachelor of Electrical Engineering from the University of Adelaide. Mr James worked on a number of projects including the External Plant Workload Assessment System before being transferred to the Northern Territory in 1977 as an acting Engineer Class 2. In the Northern Territory he was primarily engaged in subscriber radiotelephone work. Since 1980 he has been a Senior Engineer in the Network Performance and Operations Subdivision, Headquarters. He is currently Project Manager for the FACS project and is acting Principal Engineer.



processing telephone accounts when a sudden and dramatic change in the size of the account occurs (either up — supernormal, or down — subnormal).

- The investigation of service complaints generally.

Network Performance Monitoring — This consists of monitoring call record and call charge information for use by the Network Performance Analysis Centre (NPAC) in assessing both the short and long term metering performance of the network. Information on irregular metering is provided on an exchange and network basis.

SYSTEM CONFIGURATION

Each system consists of terminal units located in telephone exchanges and a centrally located call storage and processing unit for a network of up to 256 telephone exchanges. The terminal units record the customer call data, provide call processing and short term storage. The stored information is automatically transferred to the central control minicomputer.

At the central control, the storage and data processing unit provides medium term storage on disk, and long term storage on magnetic tape.

The central control has direct access to remote printers in each District Telecom Office for automatic report distribution.

Exchange Terminals

The exchange terminals are microprocessor controlled electronic terminals which are connected in parallel with the customer equipment in a telephone exchange. The exchange terminal units are connected to the central control equipment by a 1200 bits/sec multi-drop data network. Each terminal unit is equipped with buffer memory which will store call record data in the event of failure of the data link. The period of protection provided will be dependent on the calling rate of monitored lines but will be at least several hours.

The connection to the customer's service is made using jackstrips located in the subscriber stages of the telephone exchange. Studies are initiated and terminated by exchange staff at the Data Input and Display Terminal. This unit is also microprocessor based and has a keyboard through which commands can be entered and a display which allows line activity to be monitored. Studies are terminated after a fixed time period — typically one or two weeks — or when a sufficient number of calls has been recorded.

Central Control Site

The Central Control equipment consists of:

- Central Processing Unit — Hewlett-Packard type 2113E CPU with a 1024 kbyte memory.
- 120 mbyte Cartridge Disk Subsystem — (~ 2 million call records).
- Magnetic Tape subsystem IBM compatible 9 track NRZI 800 or 1600 cpi.

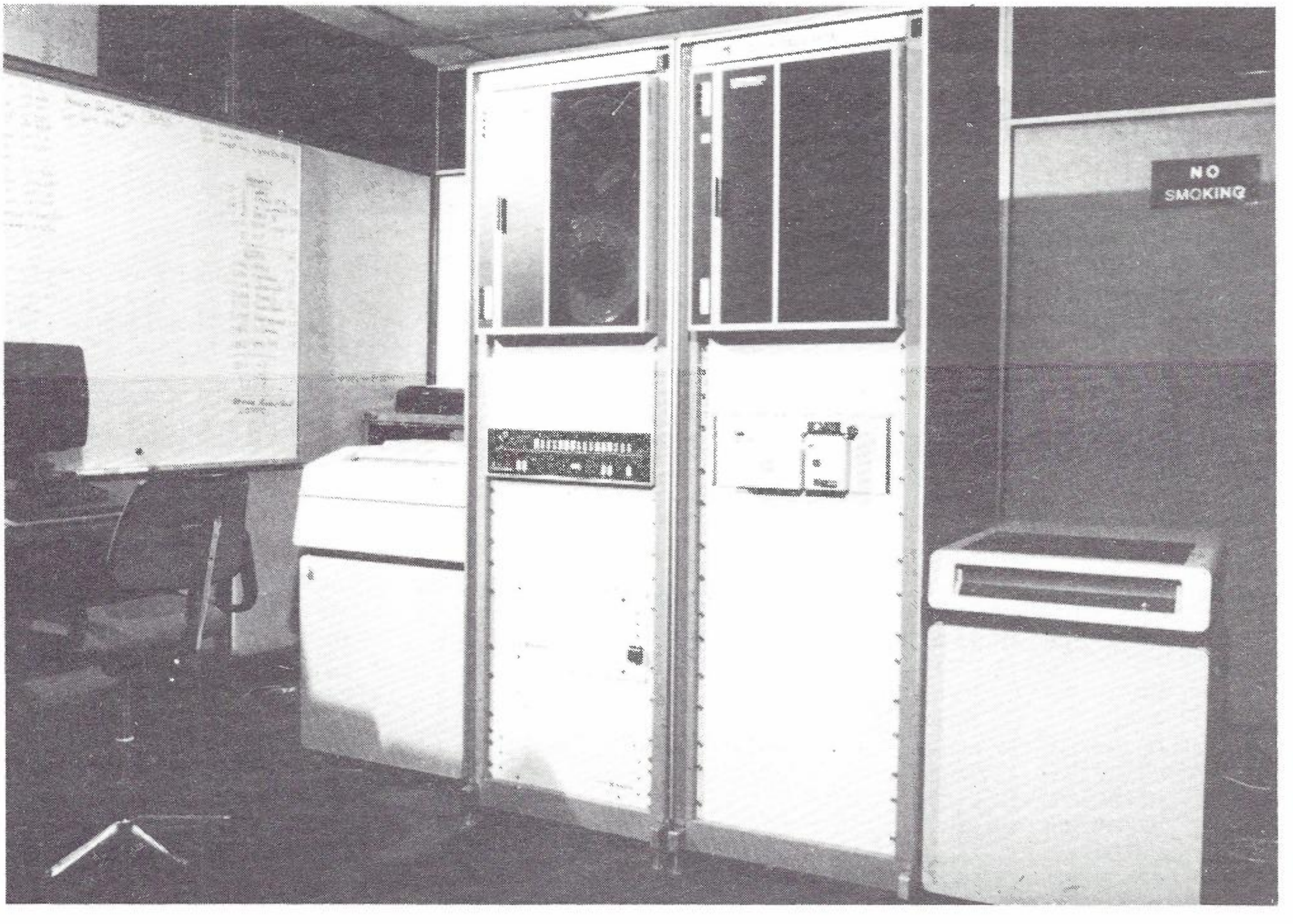


Fig. 3 Central Control Unit.

- High Speed Line Printer 400 lines per minute, 136 columns.
- Communications Line Unit providing up to 52 I/O ports.
- Visual Display Units (VDU) — System and Operator consoles.

The Central Control polls each exchange terminal according to a predefined schedule and call data is received by the communication line unit and checked for parity, format, etc. Call data is stored on disk and checked for the correct metering rate. If the call fails the rate check, it is stored on the disk and output to the NPAC daily. All call records are recorded on magnetic tape for later processing. Call records for study in progress are written to disk, in an area allocated to the particular study.

Once a study is terminated the call record data for that study is written to a report tape and a summary and/or detail report is sent automatically to the printer in the District Office. The operator can re-transmit reports from the report tape on demand.

SYSTEM OUTPUTS

Fig. 4 to 7 show some examples of CCAS reports:

Detail Report (Fig. 4)

The "Customer's Service End of Study Report — Detail (All Calls)" is referred to as the "Detail Report." It provides comprehensive information about:

- Usage of the Service ("Call Classifications").
- Metering ("Meter Pulses").
- Detail of all calls ("Call Details").

Fig. 4. CUSTOMER'S SERVICE END OF STUDY REPORT — DETAIL (ALL CALLS)
SERVICE STANDARDS REPORT

EXCHANGE NAME: RUSSELL — CUSTOMER'S NUMBER: 03 606 6718
DATE OF REPORT: 14/09/83 19:03 — CHARGE SYSTEM: ISD CCR

PORT NUMBER: 04
TERMINAL NUMBER: 14 — REASON FOR CONNECTION: COMPLAINT
LINE NUMBER: 1013

START OF RECORD: 03/09/83 11:11 — EXCHANGE METER: START = 9094
END OF RECORD: 14/09/83 16:08 — END = 9375

CALL CLASSIFICATIONS			NUMBER OF CALLS
OUTGOING UNANSWERED	(OU)		22
OUTGOING ISD CCR	(OCI)		1
OUTGOING ANSWERED	(OA)		24
UNIT FEE	(OAU)	6	
STD	(OAS)	18	
QUESTIONABLE	(OAQ)	0	
UNKNOWN	(OAX)	0	
OUTGOING NON-METERED	(ON)		0
INCOMING UNANSWERED	(IU)		4
INCOMING ANSWERED	(IA)		43
METER PULSES — NO CALL	(MNC)		4
OTHER			0

METER PULSES

EXCHANGE METER RECORDED:	281
EXCHANGE APPLIED:	281
CCAS CALCULATED:	227

CALL DETAILS 606 6718 — 7:03 PM WED., 14 SEPT., 1983 — page: 2

DAY	DATE & TIME		CODE	NUMBER DIALLED	ANS. TIME	CHARG TIME	PULSE TIME	EXCH. METER	DIFF
TUE	06/09/83	15:22:08	OUS	09384988	15	39			
TUE	06/09/83	16:12:12	IA		6	54			
WED	07/09/83	08:33:49	OAU	669622	10	190		00001	
WED	07/09/83	09:46:44	IU		66	0			
WED	07/09/83	09:59:00	OCI	0011121609232525	32	145			
WED	07/09/83	12:04:29	OUU	638593	11	61			
WED	07/09/83	12:14:36	MNC		0	0		00001	+1
WED	07/09/83	12:15:47	OAS	03654485	22	89	14	00006	
WED	07/09/83	12:25:44	OAS	0492041	64	39	19	00002	
WED	07/09/83	12:56:57	OUS	0334528	9	1			

(Part of Detail Report only shown)

Fig. 5. OBSERVATION STATUS REPORT

EXCHANGE: BROWNTOWN — DATE: 14/09/83 16:40

LINE	DIR	START DATE	OAU	OAS	OAI	OAZ	METER PULSES OC	ON	IC	MNC	OTH	TOTAL	TOTAL CALLS
1001	8881234	050983	147	0		0	0	0	0	1	0	148	317*C
1009	8881678	260883*	431	157	0	33		0	0	2	0	623	548*C
1010	8882234	030983*	29	1060		0	0	0	0	6	0	1095	201 C
1011	8883901	050983	205	0		0	0	0	0	1	0	206	302*C
1013	880041	030983*	6	271		0	0	0	0	4	0	281	97 C
1017	883456	030983*	0	0		0	0	0	0	0	0	0	346*C

Note OAZ = OAQ + OAX on Report 1

This report is mainly used for customer complaints. A copy is also sent to the exchange in those rare cases where a fault exists.

Observation Status Report (Fig. 5)

This report provides a brief indication of the usage of each service which is connected to CCAS. It provides one method of determining when a study should be terminated.

NPAC Exception Report (Fig. 6)

The Network Performance and Analysis Centre will receive Exception Reports of all calls which CCAS has recorded and which are found to have metering errors. This report will be produced daily. Each exchange will receive the relevant portion of this report.

NPAC Statistical Report (Fig. 7)

This report on the performance of the metering system is produced automatically every 28 days.

METERING SUPERVISION

Samples of the order of one hundred thousand calls are needed to accurately measure metering performance because of the very low incidence of metering errors. Samples of the order of thousands of calls per exchange per month will be obtained with CCAS. This will almost allow real time monitoring of metering performance, at least on a network basis.

CCAS monitors the customer calling loop and dialling signals and the metering pulses. Because it does not have a voice detection facility it cannot determine the precise outcome of each call checked. For example, it cannot determine that the correct number has been reached, or that metering was the result of an incorrect answer condition.

Also, CCAS cannot properly determine when there has been nil metering. A call which is successful but which does not receive B Party answer condition will not meter. CCAS will record this as an unsuccessful, unmetered call. A service assessment operator observing the same call would hear conversation and observe a metering fault.

In general, CCAS will record whether or not the metering that did take place is correct for the digits dialled and hence provides a check of the charging equipment, ie: the tariff setting equipment and the line relay sets and 'cord circuit' equipments which generate the meter pulse. A full discussion of the application of CCAS to metering supervision is beyond the scope of this paper.

CONCLUSION

During the 1982/83 financial year, Call Charge Analysis Systems were installed in all State capital cities. Approximately 20,000 CCAS inlets are now becoming available to assist in resolving or preventing metered call disputes. Also, the continuous monitoring of very large samples of traffic will ensure that faults causing metering irregularities are detected more efficiently than with currently available maintenance aids.

REFERENCES

1. R. W. Cupit, V. Holliday "Call Record Printing Equipment" Telecom Journal of Australia, Vol. 17 No. 2, 1967.

Fig. 6. N.P.A.C. EXCEPTION REPORT

DATE OF REPORT: 02/09/83 11:00
PREVIOUS REPORT: 01/09/83 11:00

EXCHANGE: BROWNTOWN

ORIG No.	No. DIALLED	CODE	DATE & TIME		ANS. TIME	CHARG TIME	PULSE TIME	EXCH METER	DIFF.
6387123	6272777	OUU	01/09/83	12:00:23	11	358			— 1
6388890	8681111	ONU	01/09/83	16:15:24	10	119		1	+ 1
6380022	02806111	OUU	02/09/83	08:08:11	23	445			— 1

OUU = Outgoing Unanswered UF Call
ONU = Outgoing Non-Metering UF Call

Fig. 7. N.P.A.C. STATISTICAL REPORT

DATE OF REPORT: 10/08/83 12:57
PERIOD: 04/08/83 to 10/08/83

EXCHANGE:		OU SS NM%	OAU SS OM%	 UM%	OAS SS OM%	 UM%	OAI SS OM%	ON SS OM%	MNC SS OM%
BROWNTOWN	1	1005							1005
BLACKVILLE	1	80	1190						1270
		3.75							
BLUETOWN	1	16	306		93				415
			11.44						
NETWORK TOTALS		2631	2332		93		0	0	5056
		.19	1.50	000	.000	.000	.000	.000	0.00
NETWORK SUMMARY		SS	EF	UM%		OM%		NM%	
		3056	2425	0.000		.692		.190	

Note: Above is not a complete report — it is illustrative only.

UM% = per cent undermetered calls
OM% = per cent overmetered calls
NM% = per cent nilmetered calls
SS = sample size
EF = effective

Message from the Secretary-General of the ITU for the 16th World Telecommunication Day, 17 May, 1984 "Telecommunications: expanding horizons"

World Communications Year, celebrated by all the Member countries of the ITU in 1983, has strengthened the emerging collective awareness of the importance of communications infrastructures, without which true communication would be impossible.

World Communications Year 1983 also provided the opportunity in many countries to bring together those who, as operators, manufacturers or users, are directly concerned in their everyday lives with the improvement of the communication media.

The dialogue thus initiated has brought out the vast potential of these media and in many ways has undoubtedly opened up new horizons for cooperation between all the parties involved in this sector.

By proposing "Telecommunications: expanding horizons" as the theme for the 16th World Telecommunication Day, the ITU Administrative Council has chosen to emphasize the new dimension assumed by telecommunications in the development process and the remarkable possibilities offered by current technologies.

However, the concentration of resources in one half of the world, leaving the other half in a state of underdevelopment, particularly in telecommunications, raised a challenge to us all and compels us to seek the most appropriate means of redressing this imbalance.

It is for this reason that many of the countries which have established National Committees for World Communications Year, have decided to keep them in order to pursue the quest for appropriate solutions.

At the global level, an International Independent Commission for World-wide Telecommunication Development made up of eminent figures of world-wide reputation has also commenced its work in the search for new methods aimed at speeding up the development of telecommunications infrastructures.

Hence increasing efforts are being made in every continent to realize the aspirations associated with telecommunications and to open up truly broader horizons in this field for every human being.

Exchange Reference File

MUN CHIN, B.Sc. Hons., M.Sc., MIEE, C. Eng.
ROBERT TRUSCOTT

This article briefly traces the development of the Exchange Reference File data base and broadly describes the major components of the system.

INTRODUCTION

Over a decade ago, the Australian Post Office, the predecessor of Telecom Australia, published a survey document on the application of computers in telecommunications planning in Australia (Ref 1). The survey defined the scope and structure of planning work, discussed problem areas and indicated three general areas where computer application would be beneficial and attractive to the Administration. The general areas are namely:

- A generalised network dimensioning facility co-ordinated with both;
- an effective record keeping system for network planning information, (a planning reference data base), and;
- an adequate traffic measuring, processing and forecasting system, (a planning traffic base).

Thus, the framework for an orderly development of application of computers in telecommunications planning in Telecom Australia was laid down and progressive development work on the three areas proceeded.

By the early '70s, forms of the various systems began to take shape. SWITCHNET and, later, TRANSNET were developed as the generalised network dimensioning facility. The Exchange Reference File (ERF) became the record keeping system referred to above and the Traffic Recording Analysis (TRA) and the BALFOR (Balanced Forecast) traffic measuring, processing and forecasting system were also developed. All the systems evolved as the organisation gained more experience in the area of application of computer assisted planning systems. In this paper, we focus on the development of ERF and discuss in broad terms how ERF works and the impact of ERF on the organisation as a whole.

SCOPE OF ERF

As it was originally conceived, ERF is the initial component of the Planning Reference Data Base and has been developed to assist Telecom in areas of decision-making by providing ready access to accurate up-to-date and comprehensive data referring to the Australian telecommunication network.

The heart of ERF is a data base, but surrounding this core are external systems and a network of information providers and users. Currently, ERF holds data for approximately 5000 exchanges, with approximately 250 items of telephone exchange and general network data. Data is maintained accurate and up-to-date by the presentation of input forms, indicating amendments to the data, provided either on a regular basis (4 weekly period, quarterly, annually) or, as such charges occur. Major update sources include Engineering, Operations and Customer Services Departments. Outputs are provided as regular or irregular preformatted printouts and on an ad hoc basis.

The system has been designed and developed using System 2000, a data base management software product available through most computer service bureaux. ERF offers data retrieval facilities for day-to-day operations using simple English-like language commands while providing the supporting data for a number of computer applications which are developed either centrally at Headquarters or locally by interested users.

SYSTEM DESCRIPTION

Structure

The ERF data base has a hierarchical structure as shown in **Fig. 1**. Each of the data base items contains a number of data components, the major ones being summarised in **Table 1**. The data base caters for both Transit and Terminal exchanges which may be either existing or planned. The data components are strategically located in the data base structure so that updates and retrievals may be made faster and, hence, more economically.

Logically, the data base is divided into the Current Data Base (CDB) and Historical Data Base (HDB). As the names suggest, each of the logical parts refer to information which is either current or historical. Thus, users can select and examine the network data for a given date.

Features

Containing approximately 16 million characters, the ERF data base is a moderately large and complex data base. It has many input data streams and corresponding output requirements. To enable a flexible use of the data base, many facilities have been developed, some of these are listed in the following.

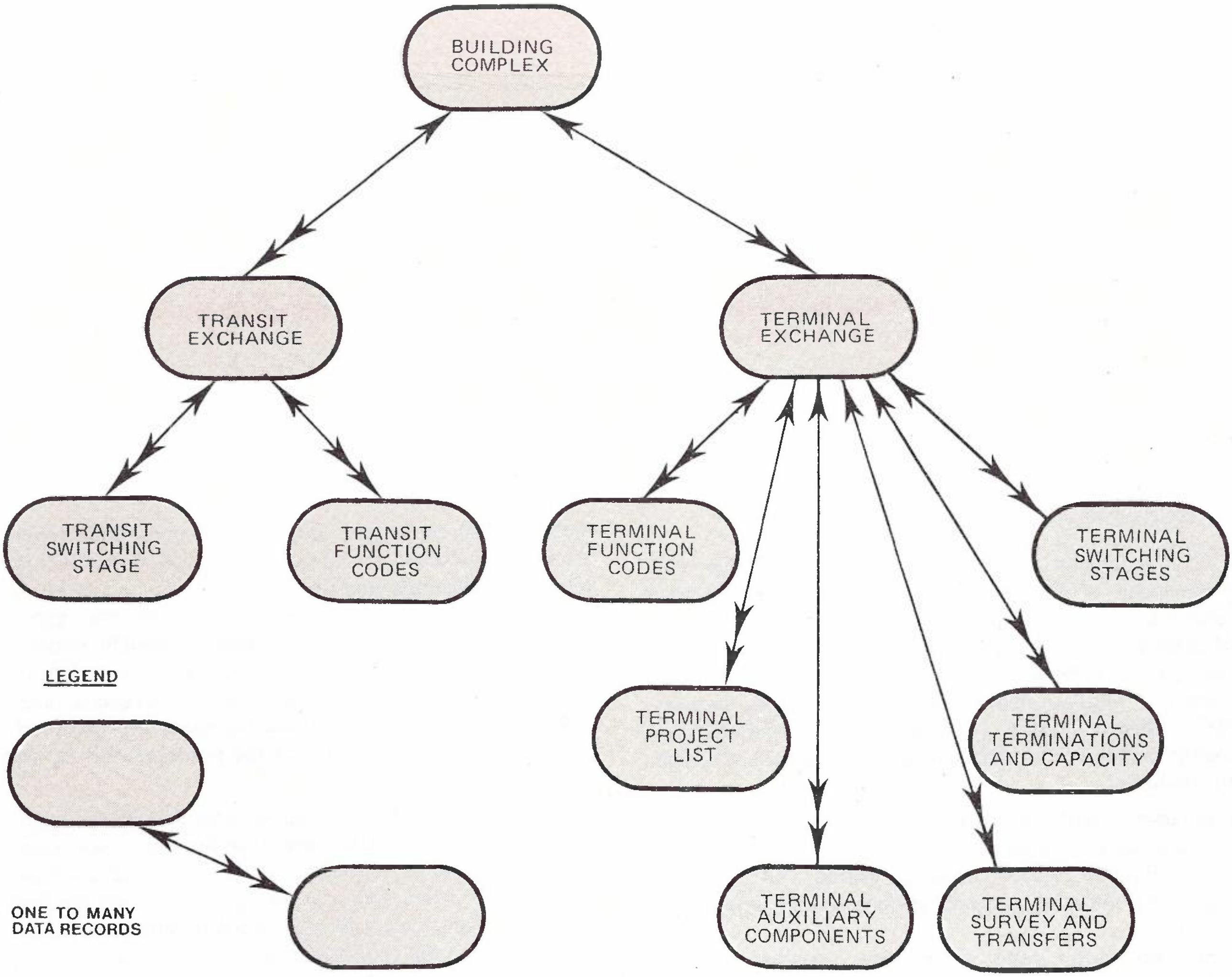


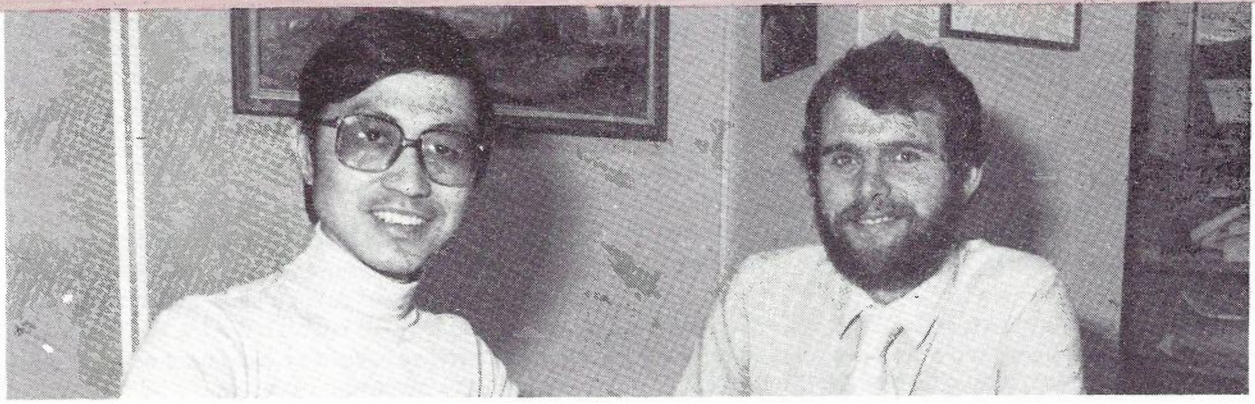
Fig. 1 Exchange Reference File Data Base Structure.

MUN CHIN was recruited from London in December 1971, and commenced his career with Telecom Australia in the New South Wales Planning and Programming Branch. He moved to Headquarters in 1978 where he was attached to Telephone Switching Planning Branch for a while. He now works in the Computer Assisted Planning System Section where he is responsible for the operational aspects of engineering planning software packages such as SWITCHNET, MARC and ERF. Mun is an active member of the Telecommunication Society of Australia. He collects fossils in his spare time.

ROB TRUSCOTT joined the APO as a Trainee Technical Officer in 1971. On completion of this training he was appointed to Switching and Facilities Section, Planning Branch, Victoria.

In 1975 he moved to Traffic Engineering Section, Planning Services Branch, Headquarters. Two years later he was shifted into the position of Exchange Reference File User Advisor in the Planning Mechanisation and Techniques Section of the same Branch.

He is currently employed as the SWITCHNET Co-ordinator in the Computer Assisted Planning Systems Section, Planning Services Branch, Telecom Headquarters.



DATA BASE ITEM	SUMMARY OF DATA COMPONENTS
Exchange Complex	Location and Status details
Terminal Exchange	Administrative details
	Closed Numbering Area code
	Deferred Applications
	Public Telephone data
	Terminations-in-use totals
Terminal Terminations and Capacity (per number range)	Itemised installed capacity
	Prefix/number ranges
	Itemised Terminations-in-use
	Traffic capacity index
	Number range totals
Terminal Project List	Details of future exchange extensions
Terminal Auxiliary Components	Used by State Administrations for any local requirement
Terminal Survey and Transfers	Subscriber forecast data together with transfer information
Transit Exchange	Installed Capacity
	Working ends/
	Occupancy Administrative details
Transit/Terminal Switching Stages	Equipment Codes
	Itemised Working ends
Transit/Terminal Function Codes	Hierarchy Codes and Indicators

Table 1. SUMMARY OF COMPONENTS ON THE ERF DATA BASE

- Uniform national system of data collection and processing.
- Automatic data validation before data base updates.
- Regular and ad hoc data base updates.
- Instant ad hoc retrievals of any of the information stored about any exchange in Australia.
- Storing of some components of the data base on computer files and tapes that enables users to produce complex reports.
- Production of regular reports on hardcopy and microfiche.
- Historical retrievals from archived data bases.

Data Collection Method

The information collected by the ERF project covers a range of interests and, hence, the data source comes from a wide area. **Fig. 2** illustrates the method of data collection and the data input sources. Although each individual exchange is covered, some returns are prepared by "concentrating points" before forwarding to State Input Control Centres (ICCs). At the ICCs, the forms are checked visually for any fundamental errors, and the data transcribed into a computer legible form either locally or at designated data transcription units. The resulting input medium to ERF could be tapes, traditional computer cards, floppy diskettes or disk packs. On the average, ERF processes in excess of an equivalent of 20,000 punched cards per month. Functionally, the State ICCs are responsible for the collection of data and ensuring data quality is of a high standard. Thus, the ICCs form an important element in the ERF data collection/information dissemination network. Each capital city has an ICC and by placing control and responsibility of data input as close as possible to the source, data quality is assured.

Data Collection Timing

In order to collect the information timely, consistently and on a common time base, a strict timing control must be adhered to. To achieve this, the collection, updating and reporting cycle strictly follows an agreed predefined timetable. In line with the accounting practice of the organisation, the ERF "production cycle" also follows the 4 week period time base. **Appendix A** provides more information on this aspect. The ERF project revolves around a 28 day cycle as illustrated in **Fig. 3.** From day 2 of the period until day 7, the input sources collate the required data and forward it to their States Input Control Centre. From day 8 until 15, the ICC checks the incoming data and forwards it for transcription to a computer legible format. Data validation then takes place. At day 12, the ERF Project Team in Headquarters will start updating the data base with the validated data; this continues until day 15. The remainder of the period is needed for report production, despatch and general housekeeping tasks.

Data Validation and Processing

The validation of data inputted to the ERF data base is initiated by the ICCs in each State. When the data is ready for validation, the ICC runs a computer job which attaches the specified data file or reads the punched cards attached to the deck; refer to **Fig. 4.**

The information updating the data base is split into separate input streams depending on the input form number. This is required so that a logical sequence of exchange updates takes place. For instance, exchange 1000 line prefix and number range information must be amended before the installed services data is updated.

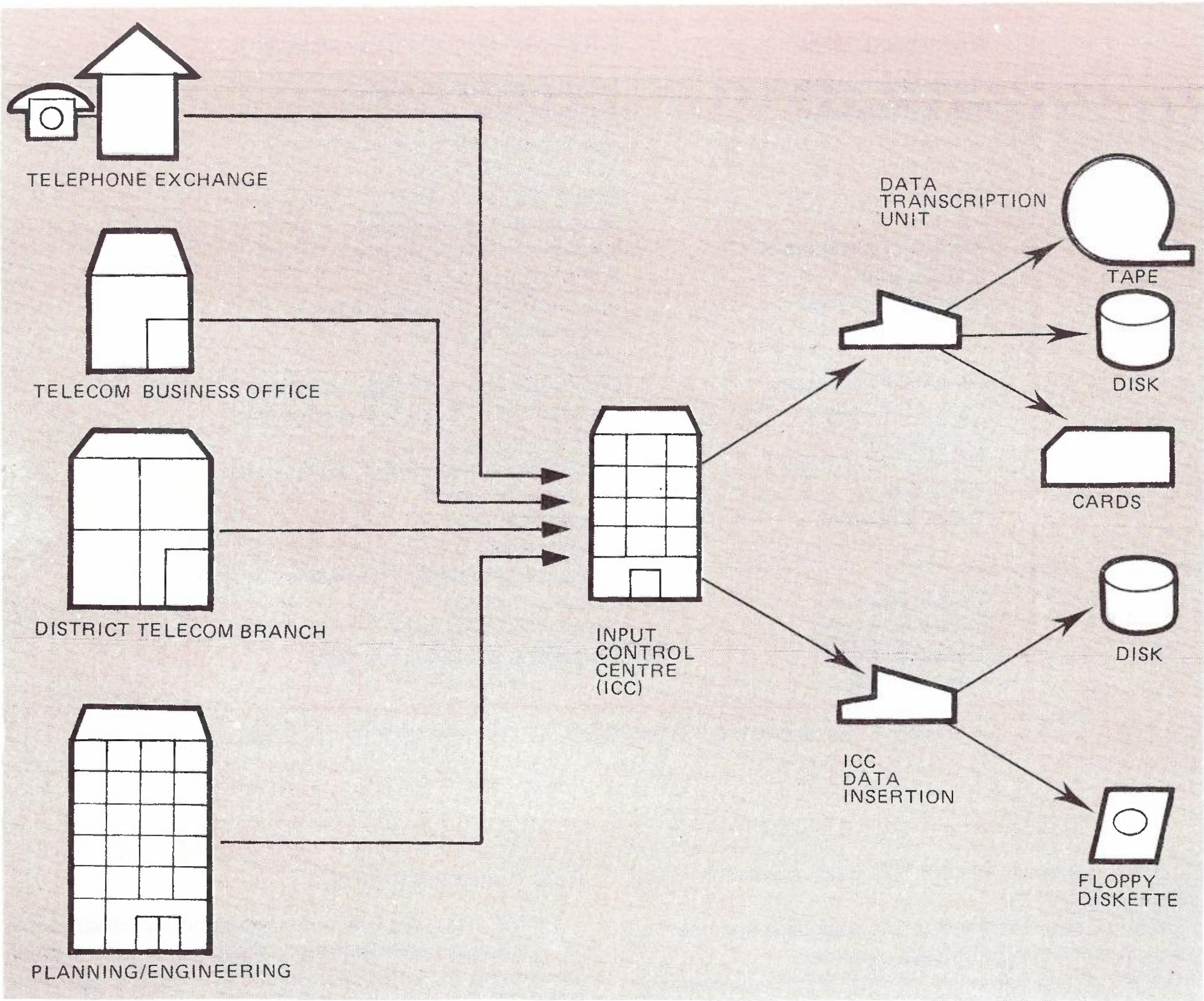


Fig. 2 ERF Data Collection Method and Data Sources.

During validation, certain elements of data on each transaction (card image record) are compared with the contents of a special validation lookup file. If all comparisons are acceptable, then the transaction is accepted for update of the data base. As data quality is of the utmost importance, special attention is paid to data validation.

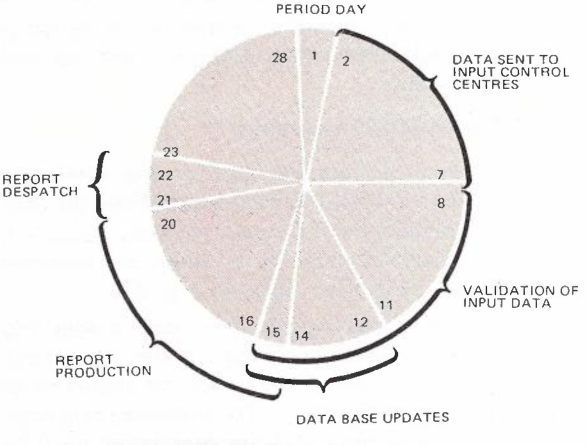


Fig. 3 ERF Production Cycle Timing.

When a State ICC has completed data validation for a particular stream, the ICC then informs the ERF Project Team in Headquarters, who will then initiate the appropriate actions to update the data base.

During each data base update run, the entire data base is saved on tape in case the Current Data Base is corrupted before or during the next update. These tapes are kept until the end of the production cycle when the Current Data Base (CDB) is again saved on tape as a backup and as a Historical Data Base (HDB).

ERF maintains a complete log of all CDB updates and related reports so that in case of either a computer system crash, or a software failure, restoration of CDB can be implemented with the minimum of effort.

Reporting

ERF produces a wide range of reports as part of its monthly production. These reports are presented in several different formats, namely, hardcopy, microfiche, permanent files and computer tapes as illustrated in **Fig. 5**. The State ICCs also produce reports locally which satisfy users in their State.

Other users of ERF may produce other reports either in an ERF provided standard format or to their own

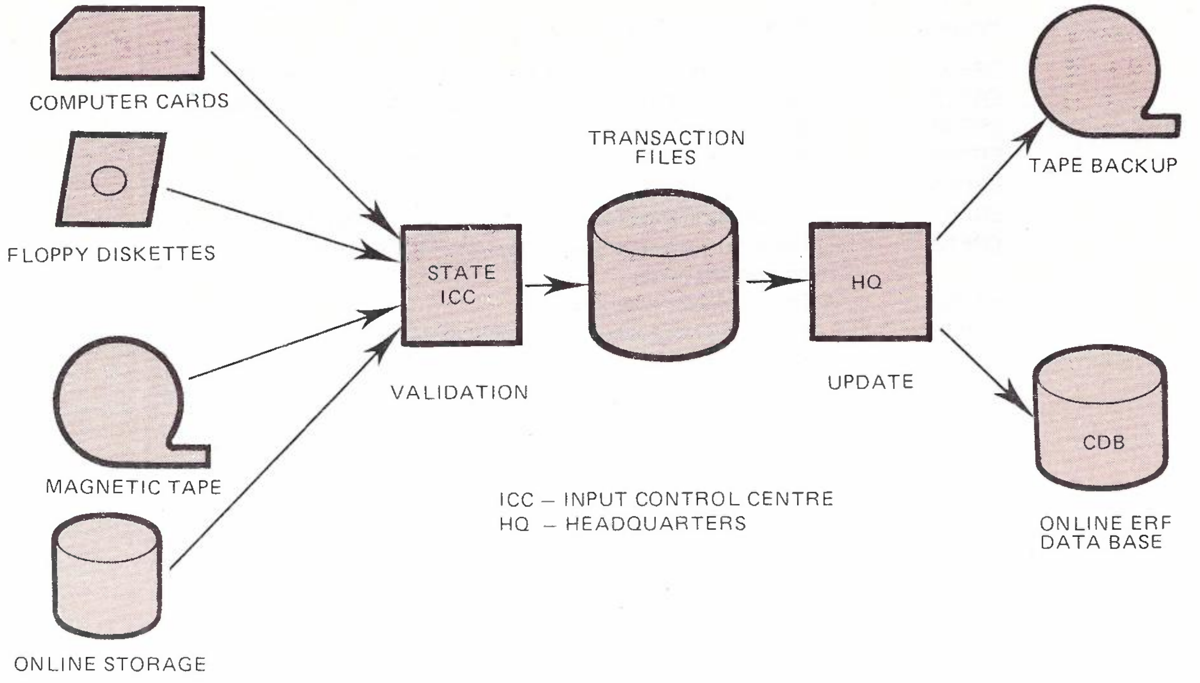


Fig. 4 ERF Data Validation and Update Sequence.

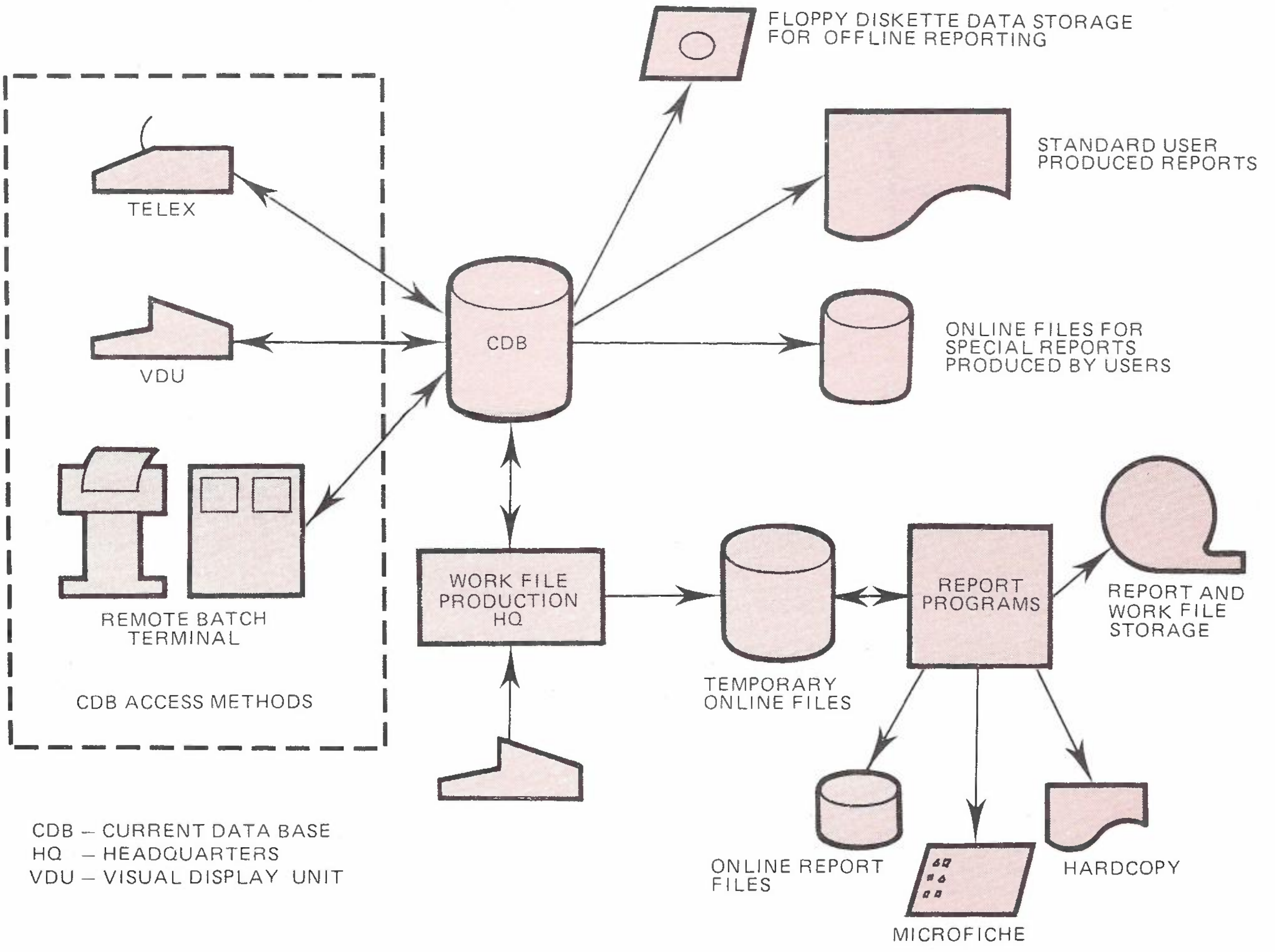


Fig. 5 ERF Reporting Method.

Report	Information Content
ERF01	Terminal exchange capacity and growth — full report.
ERF02	Terminal exchange capacity and growth — summarised.
ERF03	Subscribers' forecast data.
ERF04	Exchange administrative data — existing exchanges.
ERF05	Exchange administrative data — planned exchanges.
ERF07	Transit exchange information — input/output form.
ERF13	Terminal exchange switching stage and control equipment codes.
ERF22	Terminal exchange growth.
ERF25	Exchange occupancy and projected runout date graphs.
ERF27	Summarised exchange runout date information.
ERF29	Data used to produce ERF 25 and ERF 27 reports.

Table 2. ERF REPORTS PRODUCED ON MICROFICHE

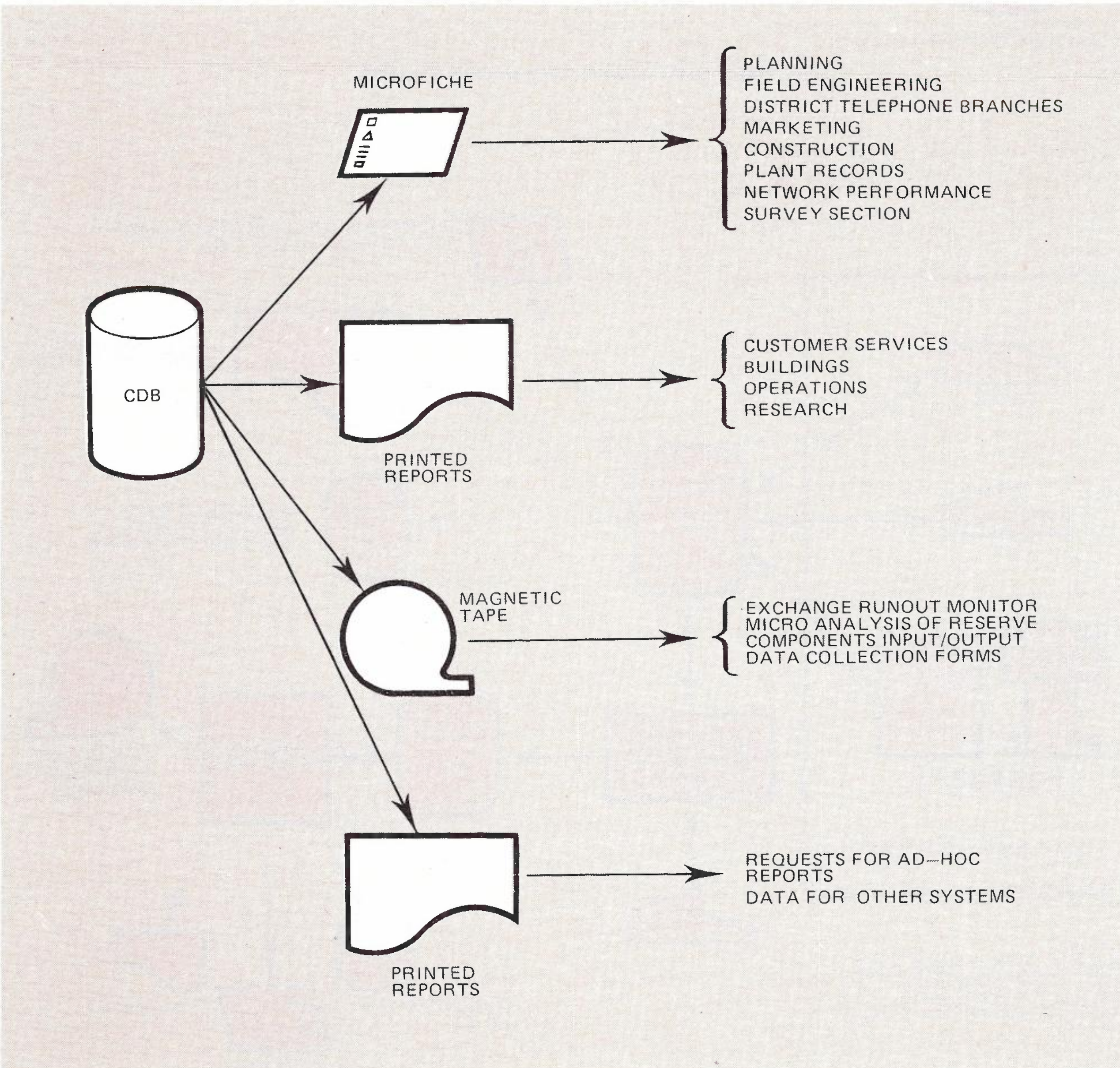


Fig. 6 ERF Report Usage and Distribution.

specifications. These reports are produced either by accessing an ERF work file or the data base directly. The major reports that are produced by ERF are copied onto microfiche. A summary of these reports is contained in **Table 2**. Samples of ERF reports are illustrated in the following page.

Impact of ERF on the Organisation

The information contained in ERF is used by a wide selection of branches in both State and Headquarters Administrations. The main users of ERF data, together with the report formats that they obtain, are listed in **Fig. 6**. ERF is now in its tenth year of operation and has gained recognition and wide acceptance in the organisation, not only in providing basic macro network capacity and growth statistics, but also in providing detailed micro statistics for use by State and Headquarters Planners in deciding future network strategies.

As more users access the data, the need for data quality gained universal recognition. The data base is now generally accepted as being accurate and comprehensive. It is also considered an essential part of most State operations. Clearly, from the data base, marketing studies for particular product promotion will be a relatively simple process of interrogating the data base and compiling specialised statistical reports. Engineering users can employ ERF for equipment penetration studies, exchange size distribution analysis, observation of capacity and growth of exchanges and other useful macro analysis.

In recent years, an Exchange Equipment Occupancy Monitoring System was developed. Using ERF as the main source of data, this system allows planners and managers to monitor the runout dates of individual exchanges. Because ERF contains the necessary information on installed equipment, services in use and forecasts, and because ERF has an established reliable network of information collection, the Exchange Occupancy Monitoring System has become quite successful. This development has now evolved into a Works Programming tool known as MARC (Micro Analysis of Reserve Components). A discussion about MARC will be reserved for a later paper.

The impact of ERF on the organisation is well recognised and ERF is fast becoming a data base which serves not only the planners as it was first envisaged, but also other sections of the community in Telecom Australia. Consequently a greater demand for ERF to collect and store exchange-related data now exists.

Conclusion

The Exchange Reference File has been operating successfully since 1972. It has been of major input to the planning processes of Telecom Australia.

This paper has briefly outlined the information contained in ERF, an overview of the operating procedure, the main methods of reporting and its impact on the organisation.

ERF in the future will be placing emphasis on increasing the data quality and the development of a more flexible data base system that will be able to meet the growing needs of all its users. The general thrust of placing the data base much closer to the end user is also gaining momentum.

References

1. J. Bridgford, G. Monsbourgh, K. Ray, J. Sewell, "Survey of Computer Applications in Telecommunications Planning." June 1971, Planning and Research Division, APO Headquarters.
2. ERF User Guide. Issued by Telecom Australia Headquarters, Planning Services Branch.

APPENDIX A

REPORTING OF STATISTICS ON A 4 WEEK BASIS

1. BACKGROUND

Service performance statistics relating to the operation of the telecommunication network are associated with service cost (man hours) statistics in a large number of operations-type reports. Statistics relating performance and costs need to be on a common time base.

The labour expenditure statistics are most conveniently brought to account at intervals integrally related to the fortnightly pay periods.

Hence, the performance statistics are presented on a 4 week period time base; annual results are derived from an aggregation of 13 such periods and quarterly results from 3, or in the case of the December quarter, 4 periods.

2. THE REPORTING YEAR CALENDAR

The reporting year always commences on or before July 1 and July 1st is always included in Period 1; when the closing date of a 13 period year would be such that this would not be the case (last day of the 'year' before June 3) a 14 period is added to that year so that period 1 of the following year can meet this condition. This next occurs in 1992/93.

3. QUARTERLY REPORTS

The term 'quarterly' as applied to performance reports does not refer to calendar quarters but to designated periods as follows:

Periods 1, 2 and 3	— September Quarter.
Periods 4, 5, 6 and 7	— December Quarter.
Periods 8, 9 and 10	— March Quarter.
Periods 11, 12 and 13	— June Quarter.

Extracted from Telecom Australia Engineering Instruction M0113.

ERF Sample Reports

EXCHANGE REFERENCE FILE — CAPACITY AND GROWTH SUMMARY - NATIONAL — REP-14 PERIOD 7 1984 — PRODUCED ON - 84/02/06 — ERF14

EQUIPT	METRO INNER :NO OF INST.	EQUIPD ENDS	SERVS	OCCUP %	METRO OUTER :NO OF INST.	EQUIPD ENDS	SERVS	OCCUP %	COUNTRY :NO OF INST.	EQUIPD ENDS	SERVS	OCCUP %	STATE :NO OF INST.	EQUIPD ENDS	SERVS	OCCUP %
AXE	4	9000	2843	31.59	4	13312	7168	53.85	0	0	0	I	8	22312	10011	44.87
ARE111	4	25400	23103	90.96	0	0	0	I	0	0	0	I	4	25400	23103	90.96
ARE113	119	1228400	1088532	88.61	30	267400	236375	88.40	14	111800	96178	86.03	163	1607600	1421085	88.40
ARE114	31	166800	139830	83.83	17	74600	62888	84.30	11	31400	26064	83.01	59	272800	228782	83.86
ARF101	0	0	0	I	0	0	0	I	1	9000	7714	85.71	1	9000	7714	85.71
ARF102	143	985800	879655	89.23	53	251800	212612	84.44	339	1242277	1067882	85.96	535	2479877	2160149	87.11
ARK511D	0	0	0	I	0	0	0	I	525	33130	20564	62.07	525	33130	20564	62.07
ARK511L	0	0	0	I	0	0	0	I	5	360	233	64.72	5	360	233	64.72
ARK511M	0	0	0	I	0	0	0	I	443	31930	20997	65.76	443	31930	20997	65.76
ARK521D	10	6200	4701	75.82	41	24800	19980	80.56	665	220749	171541	77.71	716	251749	196222	77.94
ARK521L	0	0	0	I	0	0	0	I	5	700	436	62.29	5	700	436	62.29
ARK521M	8	3950	3090	78.23	42	25710	18711	72.78	1231	499510	384640	77.00	1281	529170	406441	76.81
APOB	0	0	0	I	1	40	24	60.00	162	6480	3864	59.63	163	6520	3888	59.63
APOC	0	0	0	I	7	835	608	72.81	661	63733	43634	68.46	668	64568	44242	68.52
P2000	3	10000	9152	91.52	1	200	145	72.50	0	0	0	I	4	10200	9297	91.15
SRB-2F	36	142500	130382	91.50	6	24400	21993	90.14	44	142600	128985	90.45	86	309500	281360	90.91
SRB-2E	19	70200	63945	91.09	1	4000	3617	90.43	2	7000	5336	76.23	22	81200	72898	89.78
2000	100	633100	564065	89.10	15	11950	9132	76.42	38	89700	77628	86.54	153	734750	650825	88.58
CBM	0	0	0	I	0	0	0	I	3	190	179	94.21	3	190	179	94.21
CBNM	0	0	0	I	0	0	0	I	4	2200	2000	90.91	4	2200	2000	90.91
MAG	0	0	0	I	0	0	0	I	501	41281	28840	69.86	501	41281	28840	69.86
RCEE	0	0	0	I	0	0	0	I	201	1065	674	63.29	201	1065	674	63.29
RCMX	0	0	0	I	0	0	0	I	55	1345	570	42.38	55	1345	570	42.38
EMD	2	5200	4430	85.19	0	0	0	I	0	0	0	I	2	5200	4430	85.19
PENT	1	5000	4553	91.06	0	0	0	I	0	0	0	I	1	5000	4553	91.06
STCCOM	0	0	0	I	0	0	0	I	1	45	36	80.00	1	45	36	80.00
S17	3	16400	15012	91.54	0	0	0	I	0	0	0	I	3	16400	15012	91.54
S.P.C.	4	9000	2843	31.59	4	13312	7168	53.85	0	0	0	I	8	22312	10011	44.87
X-BAR	315	2416550	2138911	88.51	183	644310	550566	85.45	3239	2180856	1796249	82.36	3737	5241716	4485726	85.58
STEP	158	855800	767544	89.69	31	41425	35519	85.74	907	309513	259447	83.82	1096	1206738	1062510	88.05
MANUAL	0	0	0	I	0	0	0	I	764	46081	32263	70.01	764	46081	32263	70.01
OTHER	6	26600	23995	90.21	0	0	0	I	1	45	36	80.00	7	26645	24031	90.19
TOTAL	483	3307950	2933293	88.67	218	699047	593253	84.87	4911	2536495	2087995	82.55	5612	6543492	5614541	85.92

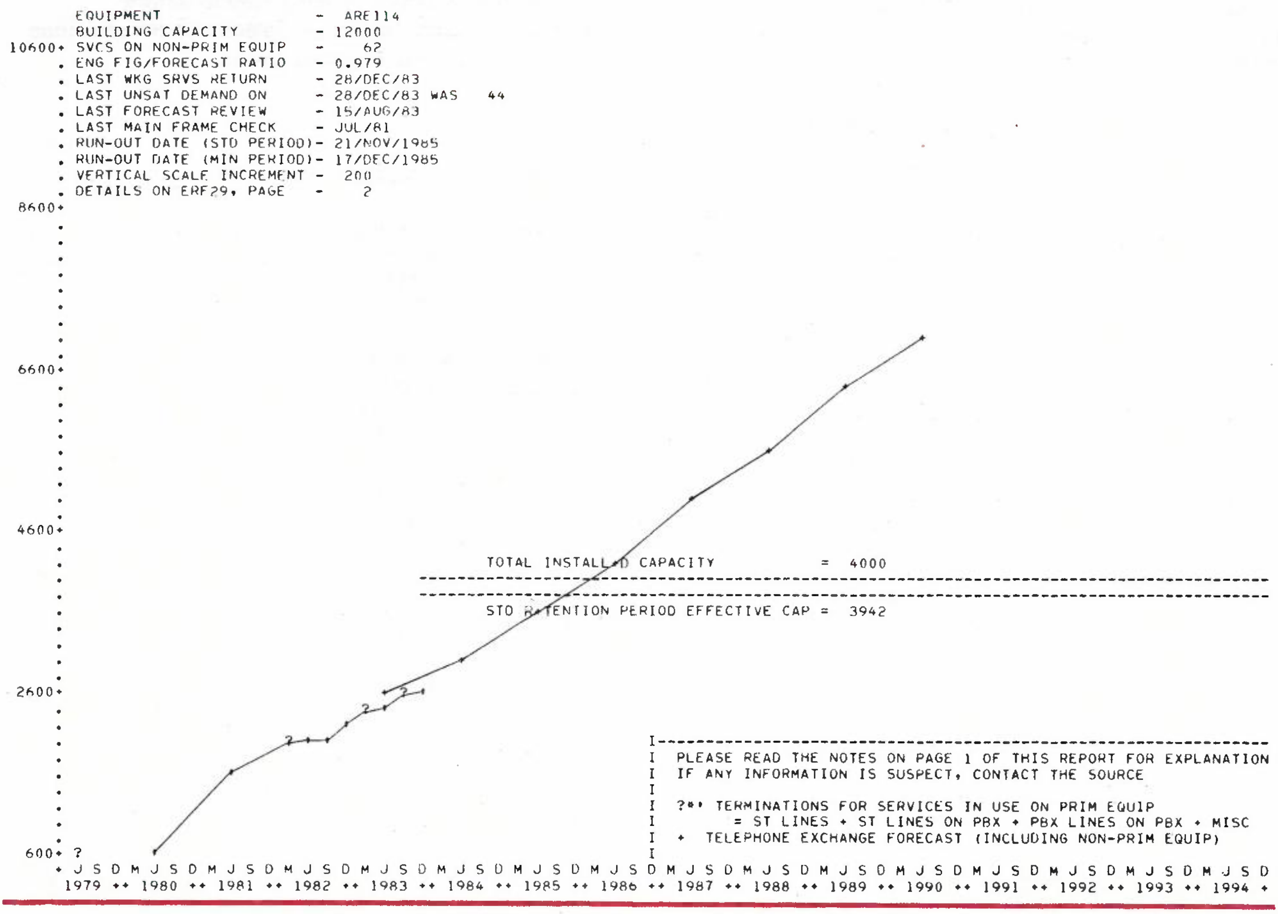
S.P.C. - AXE
XBAR - ARD591,ARE,ARF,ARK
STEP - APOB,APOC,P2000,SRB,2000
MANUAL - CBM,CBNM,MAG,RCEE,RCMX
OTHERS - EMD,PENT,STCCOM,S16,S17,S28,S-HMU

NOTE - TELEPHONE OFFICES AND PASTORAL EXCHANGES OMITTED

INSTALLATION =AN EXCHANGE OR PART OF AN EXCHANGE HAVING ONE EQUIPMENT TYPE
EQUIPPED ENDS=INSTALLED CAPACITY(S/L+PBX+I/C) ON PRIMIRY EQUIPMENT IE. EXCLUDING LARGE GROUP EQUIPMENT
SERVICES =S/L+S/L ON PBX+PBX ON PBX+I/C ONLY+O/G ONLY+ B/W LG.GRP.(ON PRIMARY EQUIPMENT)
OCCUPANCY =SERVICES/EQUIPPED ENDS (MANUAL EXCHANGES EXCLUDED FROM TOTAL OCCUPANCIES)

NSW — EXCHANGE DEVELOPMENT GRAPH — PRODUCED ON - 07/FEB/84

MENAI - EXCHANGE — DTO SUTHERLAND — DEC83 — ERF25 PAGE 7



Use of Plain Copper Conductors In Lieu of Tinned-Copper for Internal Cables

B. T. de BOER, K. G. MOTTRAM

In line with most Telephone Operating Administrations, Telecom Australia has specified and used tinned-copper conductors, with PVC insulation and sheathing, for most internal cabling within telephone exchanges and subscribers' buildings. Following some reported problems associated with solderability, an investigation showed that the current production tinned conductors in Australia were inadequately specified; however, the excellent performance of plain copper prompted a more detailed investigation which revealed that plain copper conductors (i.e., no tinning) were suitable for all current applications of internal cable. The study covered soldering, wire wrapping, and insulation displacement terminations. As a result of this work, Telecom Australia has adopted plain copper as the standard for internal cables. This decision has resulted in both improved performance in comparison with the previous tinned conductors (particularly in relation to solderability) and substantial cable cost reduction.

INTRODUCTION

Telecom Australia, like most Telephone Operating Administrations, has specified and used tinned-copper conductors for internal cables. Much of the reason for the use of tinned conductors can be traced back to the use of rubber insulation. Among the chemicals added to rubber to modify its properties was sulphur and, as sulphur readily attacks copper, it was necessary to provide copper conductors with a protective coating. The coating had to be readily applicable to copper wire, be corrosion resistant to sulphur, and be readily solderable. Tin had these properties and was probably originally applied to the copper wire by hot dipping, resulting in a reasonably generous coating thickness. With the change to PVC insulation, the tin coating on internal cable conductors was retained, presumably to maintain solderability. The tin coating is now commonly applied by electroplating, and, at least on products supplied to Telecom Australia, is very thin, averaging about 2 um thickness on conductors of 0.4 mm diameter. The tinning specification requirements are stipulated in AS 1574[1].

Following some reported problems associated with solderability of tinned conductors, an investigation was conducted using both tinned-copper and plain copper wires from current production cable.

SOLDERABILITY EVALUATION

The evaluation of solderability was performed using an extensive range of tinned-copper and plain copper wires from Australian manufacturers. Solderability was assessed according to Clause 2.8 of AS 1099 2 Ta Soldering[2]. An activated flux, as specified in Clause 2.8.2.3, was used for the solderability tests. (This flux was 25 percent by mass of colophony, 75 percent by mass of 2-propanol (isopropanol) with the addition of diethylammonium chloride to an amount 0.5 percent chloride. An activated flux was chosen because Telecom Australia uses activated resin-cored solder to AS 1834[3] for general electrical component soldering operations.) The principle of the test method is to measure the time elapsing between the moment a wire bisects a molten solder globule and that when the solder flows around, covering and wetting the wire. The shorter this period of time, the better the solderability of the wire. Immediately prior to each solderability test, the PVC insulation was stripped from each metallic wire. Ten samples from each wire designation were tested for solderability, and all quoted results are the average of these 10 individual measurements.

The initial solderability evaluations were conducted in December 1976 and May 1977 on wires in the "as received" condition (i.e., cable manufactured within the previous twelve months). Since the growth of intermetallic compounds[4-10] was suspected as the cause of solderability problems, solderability tests were also performed on samples of the tinned-copper wire, without insulation, which were artificially aged according to AS1099 2 Ba Dry Heat[2] (16 hours dry heat at a temperature of 155°C). In 1980, further samples of insulated wire from the original spools were again tested for solderability. These results represent approximately three years natural ageing in a mild laboratory environment, and again the insulation was stripped just prior to solderability testing.

Typical results of this solderability testing on many hundreds of samples are given in Table 1. The tests indicate that, on freshly stripping the PVC insulation, all plain copper wires soldered readily even after three years' natural ageing. Tinned-copper wires also generally soldered readily, although they exhibited larger variability

This paper was presented by the authors to the 32nd International Wire and Cable Symposium at Cherry Hill, New Jersey, USA on 15-17 November, 1983.

with occasional relatively high values. Natural ageing for three years had little effect on tinned-copper wire.

The artificially aged wires exhibited generally poor solderability and some wires became unsolderable.

METALLOGRAPHIC EXAMINATION

Cross-sections of a number of tinned-copper wires were prepared for metallographic examination. The examination revealed that, circumferentially and longitudinally, the tin coating was very uneven with typical thickness values between 0.5 um and 3.0 um. With the difficult-to-solder samples, diffusion had occurred between the copper base and the tin coating to form a copper-tin intermetallic compound. In cases where wires were unsolderable, the tin coating was completely consumed and only an intermetallic compound remained. Thwaites[4], Bernier[5], MacKay[6], Billot[7], and others all refer to solderability problems with the establishment and growth of copper-tin intermetallic compounds which occur during manufacture and ageing of tinned-copper conductors.

AS 1099 2 Ta allows for an artificial ageing test to assess susceptibility of tinned-copper wires to the growth of intermetallic compounds. In regard to artificial ageing, Ochs[8] considers that ageing of four hours at a temperature of 155°C is equivalent to three years' natural storage. This contrasts with the AS 1099 2 Ta requirement of 16 hours at 155°C, and supports our experience that the ageing requirement of As 1099 2 Ta is far too severe, since it would normally be expected that wires would be terminated within three years of manufacture.

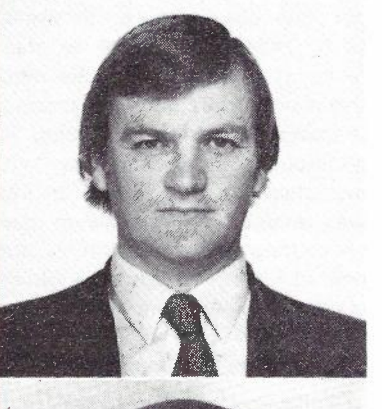
RECOMMENDATIONS FROM SOLDERABILITY STUDY

From our results, and from the literature, it is evident that there is a potential problem with respect to solderability of tin-coated copper wires. With thin tin coatings (less than 2 um) there is the risk that, either in manufacture and/or storage, the tin coating can be consumed by diffusion between the copper base and the tin coating to form difficult-to-solder copper-tin intermetallic compounds. Perhaps not unexpectedly, various investigators have recommended different values to reduce this risk. For long-term retention of solderability, the following authors have recommended these minimum coating values:

Bader and Baker[9]: 2.5 um solder, 5 um tin
Bernier[5]: 5 um tin
Cavanaugh GW and Lanagan J[10]: 7 um solder
Billot and others[7]: 2.5 um tin
Thwaites[4]: 8 um tin or solder

On the other hand, our results indicated that freshly stripped plain copper wire soldered as well, if not better, than tinned-copper wire. It was, therefore, quite possible that a superior performance could be achieved with plain copper wire, whilst at the same time, a substantial cost saving could be realised by the elimination of the tinning requirement.

A number of other factors, however, needed to be examined prior to any full-scale changeover to plain copper conductors. These included the evaluation of plain copper against other termination practices (i.e., wire wrapping and insulation displacement connections), and



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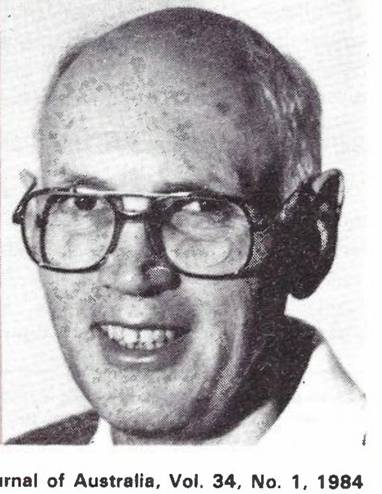

KEN MOTTRAM graduated in Metallurgical Engineering from the Royal Melbourne Institute of Technology in 1948. In 1949, he joined the Research Laboratories of Telecom Australia. He has been involved in the investigation of a wide spectrum of problems concerning materials for telecommunication plant. He is now Section Head of the Metallurgy and Electrochemistry Section at Telecom Australia.

TABLE 1. SOLDERABILITY EVALUATION OF TINNED-COPPER AND PLAIN COPPER CONDUCTORS

Designation Insulation Colour	Conductor Type	Soldering Time — (second)					
		As received 1977		Naturally Aged (approx. 3 years)		Artificially Aged	
		Mean	SD	Mean	SD	Mean	SD
Cable Sample Number 1							
Brown	plain copper	0.11	0.01	0.28	0.06		
Red	plain copper	0.12	0.01	0.37	0.09		
Orange	plain copper	0.12	0.01	0.31	0.06		
Green	plain copper	0.11	0.01	0.37	0.07		
Blue	plain copper	0.11	0.01	0.32	0.08		
Slate	plain copper	0.11	0.01	0.28	0.05		
White	plain copper	0.11	0.01	0.24	0.06		
Cable Sample Number 2							
Orange	tinned-copper	0.38	0.07	0.28	0.07	7.1	5.1
Green	tinned-copper	0.39	0.06	0.45	0.13	12.8	5.4
Blue	tinned-copper	0.30	0.05	0.37	0.07	2.2	2.3
White	tinned-copper	0.33	0.14	0.29	0.05	6.4	3.9
Brown	tinned-copper	0.39	0.11	0.38	0.06	11.7	7.6
Slate	tinned-copper	0.37	0.11	0.29	0.07	8.0	3.7
Blue/White	tinned-copper	0.46	0.13	0.31	0.05	12.2	13.3
Cable Sample Number 3							
Red	tinned-copper	0.44	0.11	1.01	0.52	67.4(a)	20.8
Orange	tinned-copper	1.08	1.17	0.96	0.41	44.1(b)	12.1
Green	tinned-copper	0.39	0.11	0.76	0.29	32.6(c)	23.1
Blue	tinned-copper	1.05	0.56	1.23	0.70	40.3(c)	34.4
White	tinned-copper	0.45	0.18	0.94	0.49	49.5(d)	21.3
Black	tinned-copper	0.44	0.11	0.34	0.06	14.9(e)	12.0

(a) Average of 6 samples; other 4 failed to solder in 100 seconds.
(b) Average of 7 samples; other 3 failed to solder in 100 seconds.
(c) Average of 8 samples; other 2 failed to solder in 100 seconds.
(d) Average of 5 samples; other 5 failed to solder in 100 seconds.
(e) Average of 9 samples; other 1 failed to solder in 100 seconds.

Note SD = Standard Deviation

the evaluation of all terminating practices, particularly solderability, after short-term ageing (usually less than six months) with insulation removed. This requirement results from the existing practices within Telecom Australia and some support industries, of pre-preparing and stripping wire harnesses for later mass installation.

The following criteria were therefore established to assess the suitability of plain copper wires for general use for internal cables:

(a) Since it is considered that wires will be terminated within 3 to 5 years after manufacture, the terminating performance of aged (3 to 5 years) and freshly stripped conductors must be guaranteed.

(b) Since at times wires prepared for terminating are left stripped of insulation for up to six months prior to installation, the terminating ability must be adequate under these conditions.

(c) Terminations and joints using plain copper wires must be shown to be completely suitable or at least equivalent to those made using tinned-copper wire.

For soldered terminations, the requirement of performance after ageing for freshly stripped conductors was satisfied by the previous evaluation given in Table 1. The requirements of (b) and (c) required further evaluation.

WIRE WRAPPING WITH PLAIN COPPER CONDUCTORS

To evaluate the performance of wire-wrap terminations, samples of plain copper and tinned-copper conductors were tested against the requirement of Telecom Australia Specification 1305[11]. This Specification was basically derived from IEC Publication 352. Brass posts 1.2 mm square, with maximum corner radii of

0.075 mm, and electroplated with 6 um of tin, were used in the tests. Plain copper and tinned-copper conductors of 0.40 mm diameter were used in the evaluation for comparison. The post dimensions, tin coating thicknesses, and diameters of the conductors were chosen as the most critical combination under the specification tolerances for material supplied to Telecom Australia. All joints were wrapped with an electrically operated Standard Pneumatic tool, model number 615 with a sleeve type 18840 432. Where unwrapping was required, a manually operated Gardiner tool 280 15 AA4 was used.

A range of mechanical, thermal and exposure tests, as specified in Telecom Australia Specification 1305, were conducted on the wire wraps. Each value quoted is the average of thirty individual tests. The details of the tests performed and the results obtained were as follows:

Stripping Force

This test was conducted according to the requirements of Clause 4.3 of Telecom Australia Specification 1305. Using a forked tool, the force required to strip the wire turns off a post was measured. For the size of post and wire used, the specification requires a minimum force of 22 N. As the average for tinned-copper wire was 42 N, and for plain copper wire 30 N, both combinations were satisfactory.

Vibration

Joints were vibrated according to the requirements of AS 1099 2 Fc[2]. This standard requires two hours vibration on three mutually perpendicular axes, with a frequency sweep from 10 to 500 Hz, and with the amplitude 0.75 mm peak or 10g, whichever is the greater. After vibration, the average change in resistance for the tinned-copper wires was 0.64 milliohm and for the plain copper was 0.11 milliohm.

Damp Heat

Joints were exposed for 56 days at a temperature of 40°C at a relative humidity of 93% according to the conditions of AS 1099 2 Ca[2]. After exposure, the average change in resistance for the tinned-copper wires was 0.18 milliohm and for the plain copper was 0.33 milliohm.

Hydrogen Sulphide Exposure

Joints were exposed for 21 days at a temperature of 25°C and a relative humidity of 75% with a hydrogen sulphide concentration of 10 ppm, according to the conditions of AS 1099 2 Kd[2]. After exposure, the average change in resistance for the tinned-copper wires was 0.56 milliohm and for the plain copper was 0.87 milliohm.

Rapid Change of Temperature

Joints were subject to thermal shock by alternating between one hour at a temperature of -55°C and one hour at 125°C according to the requirements of AS 1099 2 Na[2]. After 25 cycles, the average change in resistance for the tinned-copper wires was 0.38 milliohm and for the plain copper was 0.32 milliohm.

Stress Relaxation

Joints were exposed at a temperature of 125°C for a total of 1000 hours. The resistance changes observed are given in the following table.

Table 2. Average change in wire-wrap joint resistance associated with stress relaxation test.

Wire Type	Average change in resistance (mΩ) for the following times				
	200 h	400 h	600 h	800 h	1000 h
Tinned-Copper	0.55	0.49	1.55	2.07	2.40
Plain Copper	0.35	0.88	1.08	1.04	1.30

(10 hours at 125°C approximates to 1 year at 20°C)

Multiple Wrapping

The object of this test was to determine the effect on joint quality of consecutive wraps, each with a new wire on a single post. Multiple wraps are a common phenomenon in the real field environment. After 50 wraps, the joints were exposed to a hydrogen sulphide environment as specified above.

The results obtained were as follows:

Table 3. Change in wire-wrap joint resistance after multiple wraps.

Condition	Joint resistance (milliohm)	
	Plain Copper	Tinned-Copper
1 wrap	3.96	3.67
50 wraps	4.67	4.20
50 wraps + H_2S exposure	5.81	4.83

Results from Wire-Wrap Evaluation

Wrapped joints made with plain copper and tinned-copper conductors were subjected to a range of tests, aimed at determining compliance with quality requirements for wrapped connections. Both types of wire were considered satisfactory in all the tests; neither type of wire was superior in all the tests. As a result of this evaluation, it was considered that wire-wrapped joints using plain copper conductors and tin-plated posts to Telecom Australia specifications, were completely satisfactory for field use.

SOLDERABILITY PERFORMANCE OF EXPOSED PLAIN COPPER CONDUCTORS IN A TELEPHONE EXCHANGE ENVIRONMENT

To determine the effect on solderability of plain copper conductors left exposed without insulation, field experiments were established in four telephone exchanges in different parts of Australia.

Pre-stripped plain copper and tinned-copper wires of recent manufacture from two sources were exposed to the normal controlled exchange environment where the wiring harnesses would be stored prior to installation. The experimental sites were exchanges in Mackay, Port Kembla, Mildura and Port Pirie. See Figure 1. The sites were chosen because they offered a variety of atmospheric conditions due to climate and local industry activity.

Samples were tested for solderability after exposure for two, four and six months, and results are given in Table 4. In addition, nine individual tinned-copper wires from the two manufacturers' cables (as received) were mounted for metallographic examination. Nearly all samples had some area of tin coating thinner than 0.5 um; one wire had large areas with tin thickness less than 0.1 um. The intermetallic layer was approximately 0.4 um thick and the average thickness of tin from all samples was 2.4 um.

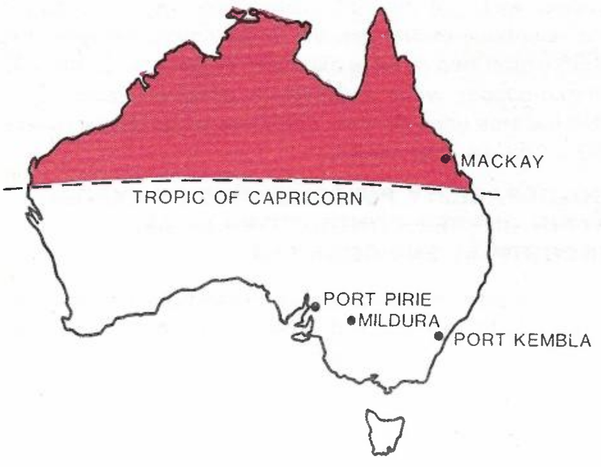

Fig. 1. Exposure Sites for Solderability Samples at Telephone Exchanges.

From Table 4, it can be seen that all "as-received" samples soldered in a reasonable time, but tinned-copper wires from manufacturer number 2 were the poorest and showed greatest variability. All plain copper wires, exposed at the four sites, soldered readily and showed little variability even after six months exposure. The tinned-copper wires generally exhibited poorer solderability and much greater variability than the bare

Table 4. Solderability performance of stripped plain copper and tinned-copper conductors (0.40 mm) exposed to exchange environment (air-conditioned)

Sample Exposure Environment	Soldering Time (second)							
	Plain Copper Wire				Tinned-Copper Wire			
	Manufacturer Number 1		Manufacturer Number 2		Manufacturer Number 1		Manufacturer Number 2	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
As received	0.63	0.20	0.53	0.25	0.62	0.08	1.81	0.84
Six days air conditioned office	0.50	0.09	0.50	0.11	0.49	0.08	1.50	1.20
Mackay								
2 months	0.56	0.10	0.54	0.08	0.49	0.12	0.54	0.31
4 months	0.69	0.24	0.71	0.19	3.22	2.82	1.10	1.13
6 months	0.84	0.26	0.82	0.32	0.85	0.63	1.10	0.92
Port Kembla								
2 months	0.34	0.08	0.42	0.10	4.09	5.58	1.92	2.58
4 months	0.56	0.13	0.66	0.58	—	—	—	—
6 months	0.58	0.31	0.84	0.55	2.62	1.26	5.39	9.81
Mildura								
2 months	1.49	0.80	0.50	0.08	1.39	0.64	0.70	0.50
4 months	0.39	0.09	0.50	0.11	1.79	1.16	7.02	10.4
6 months	0.42	0.04	0.44	0.10	4.93	10.4	7.70	14.9
Port Pirie								
2 months	—	—	—	—	—	—	—	—
4 months	0.63	0.15	0.87	0.26	2.37	2.37	1.85	0.98
6 months	0.51	0.08	0.50	0.13	2.15	3.20	1.03	1.21

Note SD = Standard Deviation

copper wires. Of the 220 plain copper wires exposed in the telephone exchanges, the longest soldering time was 3.58 s after two months exposure at Mildura. Of the 200 tinned-copper wires exposed in telephone exchanges, one became unsolderable, and three wires took between 30 s and 40 s to solder.

SOLDERABILITY PERFORMANCE OF EXPOSED PLAIN COPPER CONDUCTORS IN AN INDUSTRIAL ENVIRONMENT

A criticism of the previous evaluation was that the environment was too controlled, and, in some cases, may be more severe. In particular, if plain copper was proposed for use by equipment manufacturers, who also used the practice of pre-stripping wire sometimes well in advance of termination (particularly soldering), then the performance of plain-copper wires exposed without insulation in an industrial environment was required.

An additional set of field experiments was therefore undertaken with sites now chosen for realistic manufacturing environments. Two sites were established at equipment manufacturers' factories, whilst at the other two sites, the samples were sheltered, but freely exposed to outside air in highly industrialised areas.

Again the samples were tested for solderability after two, four and six months. The exposed conductors were also evaluated for wire-wrap performance, although the only test performed was initial joint resistance. The results of these evaluations are given in Table 5. As before, the solderability results are the average of ten values and wire-wrap results are the average of 30 measurements. Test procedures are as previously described.

In relation to solderability, the results again indicated the good performance of plain copper conductors, even though, in some cases, significant tarnishing of the surface had occurred. Even after six months exposure, the plain copper conductors had reasonable solderability times, although some degradation in performance was obvious. Tinned-copper conductors showed generally poorer solderability and greater variability after ageing. In the case of Field Site Number 1, extensive degradation of solderability performance for tinned-copper was observed.

The results of this solderability evaluation were strongly supported by an independent study performed by Standard Telephones and Cables Pty. Ltd. who are a major equipment supplier to Telecom Australia. Samples of both tinned-copper and plain copper conductors, with insulation removed, were aged in a number of factory environments and were tested for solderability after two, four and six months. The testing was performed using a GEC Meniscograph Wetting Balance, and evaluations used both activated and non-activated flux. All solderability testing was carried out at a temperature of 250°C. The results correlated strongly with our own evaluation, and again clearly showed that plain copper wire was in all cases as good as, if not better than, the current production tinned-copper wire.

The evaluation of wire-wrap performance of the exposed plain copper and tinned-copper conductors generally showed the insensitivity of this termination technique to the test conditions. Both conductor types showed no real change in joint resistance with conductor ageing time. This would be expected since the wire-wrap process, by nature, removed surface oxides, and whilst

Table 5. Solderability and wire-wrap performance of stripped plain copper and tinned-copper conductors (0.40 mm) exposed to industrial environment.

EXPOSURE		SOLDERABILITY TIME (second)				WIRE-WRAP JOINT RESISTANCE (milliohm)			
Site	Time (month)	Plain Copper		Tinned-Copper		Plain Copper		Tinned-Copper	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Factory Site Number 1	2	0.67	0.26	1.36	0.58	4.0	0.34	4.2	0.25
	4	0.84	0.37	1.23	0.64	4.0	0.40	3.9	0.32
	6	0.79	0.11	3.40	3.12	3.8	0.39	3.8	0.34
Factory Site Number 2	2	1.12	0.65	3.50*	7.30	3.9	0.38	3.9	0.27
	4	0.46	0.18	1.15	0.60	4.0	0.38	3.8	0.28
	6	1.06	0.33	1.79	0.75	3.9	0.40	3.9	0.41
Field Site Number 1	2	0.72	0.32	1.00	0.57	3.0	0.51	3.7	0.25
	4	1.94	0.91	2.71	2.10	3.9	0.36	3.9	0.35
	6	3.23	2.27	25.01	22.20	3.8	0.41	3.8	0.42
Field Site Number 2	2	0.98	0.34	1.01	0.49	3.9	0.34	3.8	0.33
	4	1.03	0.38	1.04	0.51	3.9	0.36	3.9	0.31
	6	2.95	2.22	2.97	2.45	3.7	0.43	3.7	0.30

Note SD = Standard deviation

* The average of 9 samples was 1.20 and the SD was 0.48. The tenth value was 24.24.

the intermetallic compounds are difficult to solder, they do not alter surface conductivity, or the ability to achieve the cold welding necessary for successful wire-wrap joints.

INSULATION DISPLACEMENT CONNECTIONS

Insulation displacement connection systems are now used extensively for terminating internal cables, and the use of these systems is expected to grow in future years. Extensive studies both world-wide and within Telecom Australia have resulted in the acceptance of this technique for joining plain copper conductors in external cables. Successful experience now extends over many years. An investigation aimed at examining the performance of tinned-copper conductors with insulation displacement systems is currently proceeding within Telecom Australia.

CONCLUSION

Following an investigation into solderability problems, it was found that current production tinned-copper conductors had tin coatings too thin to guarantee completely efficient solderability. Other investigators have reported this problem, and have recommended tin coating thicknesses significantly greater than were being provided by Australian manufacturers.

The investigation, however, indicated that the use of plain copper conductors may have been a suitable solution to the problem which would also achieve a significant cable cost saving.

Extensive studies were undertaken which resulted in the conclusion that plain copper conductors were entirely suitable as an alternative to tinned-copper conductors for internal cables. The studies covered solderability, wire-wrapping, and insulation displacement connections. Against significant popular belief, the studies also indicated that plain copper conductors, exposed without insulation in reasonable environments for periods up to six months, maintained satisfactory solderability with commonly used activated flux solders.

As a result of these investigations, Telecom Australia has adopted plain copper conductors as standard for internal cable and jumper wire designs. Although field experience with the new conductors extends for only six months, no problems or field dissatisfaction have been encountered.

The change to plain copper conductors for internal cables will have the following benefits:

(a) Improved solderability performance compared with previously inadequately specified tinned-copper conductors.

(b) Reduced cable cost due to elimination of tinning requirements.

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   2 Fc Vibration (sinusoidal)
   2 Kd Hydrogen sulphide test for contacts and connections
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   2 Ta Soldering
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Network Management: The State-of-the-Art

A complete review of telecommunications Network Management is being published in the February and March 1984 issues of the Telecommunication Journal. The Telecommunication Journal is the monthly periodical of the International Telecommunication Union (ITU).

One of the most fundamental advances in telecommunications in recent years has been the introduction of the automatic service which has allowed the user to dial calls directly without the assistance of an operator. This development, which started at the national level, was soon extended to international calls.

In a manual telecommunication network the operator provided a high degree of supervision and control over the flow of traffic and was able to respond to difficulties in operating the network in such a way that the subscriber was always assured of the best possible service. With the introduction of the automatic service, however, this supervision and the control were lost. This has led to the concept of "Network Management" and has encouraged many administrations to consider its introduction in both the domestic and international networks with a view to re-establishing supervision and control.

Network Management can therefore be defined as the function of supervising the network and taking action to control the flow of traffic so as to ensure the optimum utilization of the network in all situations.

In preparing this state-of-the-art review of Network Management the Telecommunication Journal has had the invaluable collaboration of the CCITT Working Party II/5 (Quality of Service and Network Management).

In Brief

AN INTRODUCTION TO INTEGRATED SERVICES DIGITAL NETWORKS (ISDNs)

At present, telecommunication services are generally provided on a dedicated basis, ie. different networks are designed to support different services. Examples of service-dedicated networks include: the Public Switched Telephone Network (PSTN), data networks and telex networks. Although the PSTN is mainly designed for telephony, it also carries a number of non-voice services (eg. data), provided that the signals associated with these services are converted into appropriate analogue signals suitable for transmission over defined frequency bands (eg. 4 kHz for voiceband). Specialised digital networks such as leased-line, circuit-switched and packet-switched data networks are more effective in catering for data services.

In recent years we have witnessed a rapid increase in the application of digital techniques in telephone networks, such as:—

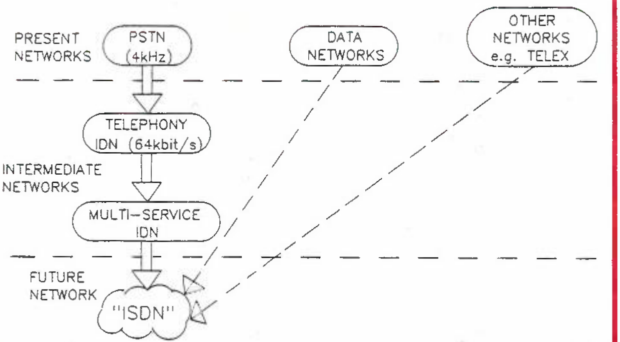
— digital switching in the exchanges;
— digital transmission between exchanges; and
— digital common channel signalling between exchanges for connection control and other applications.

With such a development, analogue PSTNs are evolving towards telephony Integrated Digital Networks (IDNs) operating at a nominal bit rate of 64 kbit/s, the rate at which a voice signal is encoded using the 8-bit Pulse Code Modulation (PCM) scheme.

The telephony IDN however, is increasingly being seen as a multi-service IDN in which a number of non-voice services can also be supported in addition to digital voice. Such a network evolution (see Figure) will lead to a general-purpose digital network, known as an ISDN or Integrated Services Digital Network. An ISDN will be capable of supporting (or integrating) a wide range of services (voice, data, text, image, etc.), using a small set of standardised multi-purpose, customer-network interfaces. A key difference between an ISDN and a telephony (and multi-service) IDN is the provision of a unified or integrated digital customer access (interfaces and associated signalling procedures or protocols) between the customer premises and the ISDN to support a multiplicity of different services.

The main motivations for the network development towards an ISDN telecommunication environment are the economies and flexibilities which the integrated nature of the network would foster.

From the customer's viewpoint, ISDN capability is recognised by the service characteristics available



EVOLUTION TOWARD ISDN

. PSTN : PUBLIC SWITCHED TELEPHONE NETWORK
. IDN : INTEGRATED DIGITAL NETWORK
. ISDN : INTEGRATED SERVICES DIGITAL NETWORK

through the standardised multi-service customer access interfaces, and not by the internal architecture of the ISDN.

The ISDN concept can therefore be regarded as a unified approach to the provision of present and future telecommunications services and facilities. Such a coordinated strategy would then allow independent developments in the customer's premises (such as terminal equipment) and in the network itself (such as transmission, switching and signalling equipment) within a common framework.

In order to reach early international agreement on a range of ISDN technical issues, standardisation activities are well under way within the International Telegraph and Telephone Consultative Committee (CCITT). In particular, CCITT Recommendations (or standards) for key ISDN customer access interfaces and protocols are likely to be achieved by the end of the current 1981-84 CCITT study period, thus paving the way for the development towards international ISDNs.

For further details on ISDNs, the interested reader is referred to the paper "Evolution towards Integrated Services Digital Networks" by N. Q. Duc and E. K. Chew, to be published in the next issue of this Journal.

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The evolution of ISDN is slowly but surely occuring. In the following issues of the Journal there will be a number of articles on ISDN. The above article serves as an introduction to a complex topic. Editor-in-Chief.

Planning for Digital Network Synchronisation

J. M. BURTON
J. A. BYLSTRA

This paper describes the need for digital network synchronisation and the planning of a synchronisation network for the Australian IDN.

INTRODUCTION

The cost effectiveness of digital systems and the convergence of digital switching and transmission technologies in the world telecommunication marketplace is leading towards the evolution of purely digital networks.

A major step in this evolution in Australia is the decision by Telecom to establish an Integrated Digital Network (IDN) on a national basis. Digital transmission will be provided to fully interconnect digital terminal exchanges where possible. Therefore, there will be a rapid growth of digital equipment and the IDN will tend to dominate the telephony network before the year 2000.

In order to ensure satisfactory performance of the IDN, it is necessary to accurately control the rate at which digital signals are transmitted and processed throughout the network. This will be achieved by "synchronising" the clocks controlling digital switches and transmission links, and some multiplexes.

In developing the network synchronisation plan, it is necessary to take into account the performance of international digital connections. Network synchronisation is currently being implemented in all overseas countries developing an IDN, and is an essential part of the evolution towards and preparation for an Integrated Services Digital Network (ISDN).

WHY SYNCHRONISE THE IDN?

If the rate of transmission of digital signals coming into an exchange is not synchronised with the rate at which the digital exchange processes the signals, some portion of the information will be recurrently lost or repeated. This phenomenon is known as "slip" and is a phenomenon peculiar to digital networks. Slips can occur at each switching point in a digital network if the incoming, outgoing and digital signal processing rates are not identical. A major source of slip is the frequency differences in unsynchronised clocks controlling digital signal processing. The effect of slip varies with the service being disturbed and varies from slight for telephony services to a serious impairment for data, facsimile and video services. These impairments typically can produce clicks in telephony services and errors in data traffic. By synchronising all clocks controlling digital signal processing — i.e. clocks controlling digital exchanges, transmission links and synchronous multiplexes — slip will not occur during normal network operation. Only during infrequent faults or abnormal operation will a degree of slip occur in such a synchronised IDN.

SYSTEM DESCRIPTION

Synchronisation of the IDN will be implemented by synchronising all exchange clocks to a single national reference clock by means of a master-slave system. Each exchange clock will be slaved to one or more clocks from a higher layer or the same layer in the clock hierarchy. The topology chosen for the synchronisation system is shown conceptually in **Fig. 1**.

To achieve a highly reliable system, the clocks will generally be interconnected by more than one synchronisation link, using diverse routes and transmission media where feasible. A single time reference for each clock is then derived according to the Prior-Assigned-Alternative-Master-Slave (PAAMS) algorithm, in which incoming synchronisation links are ranked in order of preference by the network designer and a switch within the clock automatically selects the link with the higher available rank.

The National Reference Clock (NRC) will be provided by the Telecom Research Laboratories in Melbourne. In order to enhance network performance during failure conditions, highly stable clocks are to be provided at selected digital trunk exchanges in each mainland State capital and at some other strategically located centres. At all other exchanges, standard exchange clocks will be adequate.

The distribution of synchronising information to exchange clocks will generally be achieved by using the timing information inherent in normal digital traffic bearers, thereby avoiding the need for dedicated synchronisation links and specialised operations and maintenance procedures. The primary timing reference will be 2048 kHz. All synchronising information will be extracted from the standard 2048 kbit/s digital stream. Three dedicated 2048 kbit/s links will be established between the NRC and the highly stable clocks in Melbourne, two links on diverse routes to Exhibition exchange, and one link to Windsor exchange which will also derive a second timing reference via a normal traffic bearer from Exhibition exchange.

The chosen topology ensures that switched digital traffic bearers can be utilised to provide timing information throughout the entire national network, except for the dedicated links from the NRC to the Exhibition and Windsor exchanges. A duplicated configuration will be used, so that in the case of failures of either the Exhibition or Windsor exchange the entire network will remain synchronised to the NRC.

SYSTEM PHILOSOPHY

The fundamental philosophy behind the synchronisation system is that the entire Telecom digital network should be synchronous, with no slips occuring on any national connection during normal operation. The synchronisation system will be developed initially to serve the IDN. Synchronisation of dedicated digital networks (such as DDN) will be progressively integrated into the IDN synchronisation system. Each DDN node will eventually be timed from the clock controlling the exchange building in which it is located, rather than maintaining a separate DDN synchronisation system. Private networks with digital access to the Telecom IDN will be able to derive synchronisation from the incoming bit stream and thereby eliminate slips between the private network and the IDN.

CLOCK HIERARCHY AND LOCATIONS

The existing Telecom network is hierarchical in structure as is the proposed clock synchronisation system. The introduction of the IDN will result in a network less hierarchical in nature, however this will not restrict the application of the hierarchial clock synchronisation system.

Synchronisation will be implemented using four different types of clocks in a five layer clock hierarchy as shown in **Fig. 1** and further details are outlined below.

Layer 1 is the uppermost layer of the clock hierarchy and incorporates the National Reference Clock (NRC) located at the Clayton Research Laboratories. To meet requirements for international digital working, CCITT recommendations require that the absolute frequency of a national network be maintained within $^{+}1 \times 10^{-11}$. To achieve this accuracy, Telecom has decided that the NRC will be provided by a triplicated caesium beam frequency standard. The NRC is the timing reference to which all other clocks are ultimately synchronised. A caesium based Back-up Reference Clock (BRC) will be available at a separate location for use in the event of a catastrophic failure of the NRC.

Layer 2 will consist of highly stable clocks heading synchronised regions and designated as Main clocks. Normally, one layer 2 clock per State will be provided and will be located in the capital city. The two clocks in Melbourne which are synchronised directly from the NRC, are also designated as layer 2. (As set out, this arrangement provides enhanced reliability for distribution of synchronising information to the other States.) Tasmania will derive its timing from the Melbourne Main clocks, while the Northern Territory will be timed from the Sydnay Main clock.

The clock to be provided for the Overseas Telecommunication Commission (OTC) will be designated as a layer 2 clock.

To enhance reliability and performance under failure conditions, additional highly stable clocks will be located at strategically important trunk exchanges in each State. These clocks will constitute layer 3 in the hierarchy. A layer 3 clock would generally be provided in the State capital, as a back up to the State Main clock, and a small number of additional clocks located at regional centres. Layer 2/3 clocks have triplicated crystal controlled oscillators together with an oven for improved long term stability.

Layer 4 of the synchronisation network will generally include all digital exchanges not equipped with layer 2/3 clocks. The clock used is the standard digital exchange clock module.

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During the last four years he has been a Special Rapporteur in CCITT Study Group XVI. In 1980 he received the M. Admin. degree from Monash University. He is presently a Principal Engineer in the Transmission Networks (ISDN) Section.

JOHN BURTON (Left) is a Supervising Engineer with Transmission Planning Branch in Telecom Australia Headquarters. After a period as a technician in Queensland and New South Wales, he joined the Telecom Research Laboratories in 1974 as an engineer, working on radio propagation studies. In 1979 he moved to Headquarters Planning Division and has since been involved with planning studies associated with the introduction of new technology into the subscriber and inter-exchange networks.

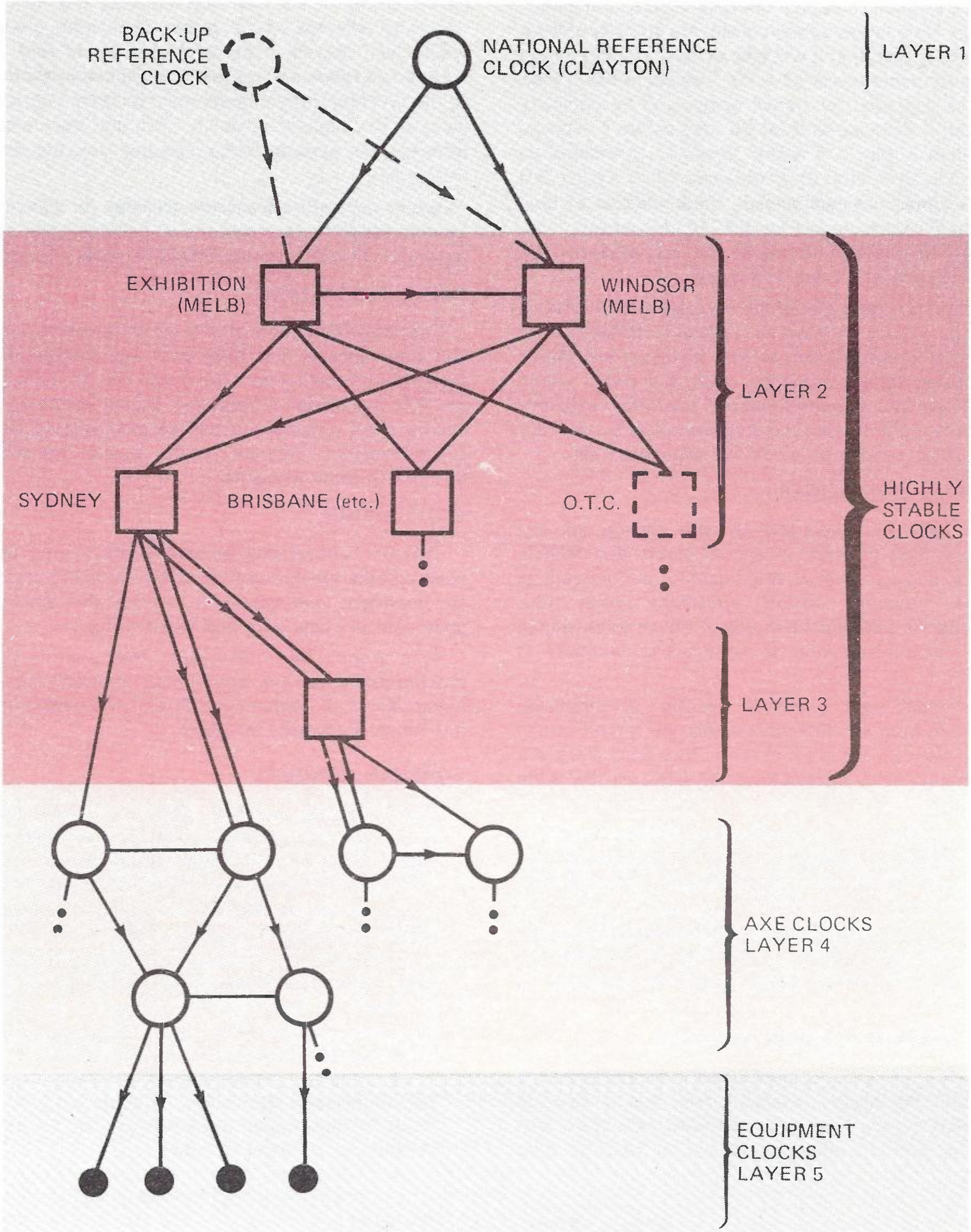

Fig. 1 Typical CBMS Implementation

Layer 5 includes the clocks provided as standard equipment in installations such as PABXs and digital concentrators. They are the lowest level in the hierarchy.

PERFORMANCE STANDARDS

To ensure that the network will continue to operate satisfactorily under a range of adverse synchronising situations, a number of important parameters have been set.

Hence, if a situation arises where all reference inputs to a clock are lost, the slip rate on a 64 kbit/s channel should not exceed:

- For layer 2/3, one slip during the first 3.8 days after the loss of reference.
- For layer 4, one slip during the first five hours after the loss of reference.

After these periods of time, the slip rate will gradually deteriorate and is determined by the relevant oscillator stabilities which are specified as: $\pm 2 \times 10^{-10}$/day for layer 2/3 clocks and $\pm 6 \times 10^{-8}$/day for layer 4 clocks. Maintenance action will prevent unacceptable slip rates.

In the case of layer 5 clocks, degraded operation may commence soon after the loss of all reference signals.

If a catastrophic failure of the NRC occurs, or if a layer 2/3 clock is no longer synchronised, the stability of layer 2/3 clocks is such that it will take at least 10 days before a frequency departure of $\pm 2 \times 10^{-9}$, stated in CCITT Rec. G.811 as degraded for transit nodes, will be obtained. Moreover, it will take at least 35 days before a slip rate worse than 1 slip in 5 hours, generally considered as degraded service (**Ref. 2**), is obtained when a layer 2/3 clock becomes unsynchronised. These periods of time will be sufficient to enable the BRC to be connected into the synchronising network, or to restore the synchronisation of a layer 2/3 clock.

It should be noted that in the infrequent event that an exchange clock becomes unsynchronised, the hierarchical area controlled by that exchange will still be synchronised to the exchange clock and traffic within that area will not experience slip. In the latter case, only traffic entering or leaving the area controlled by the "unsynchronised" exchange clock will experience slip.

PLANNING GUIDELINES

Care will be exercised in the design of the synchronisation network to ensure stable and reliable operation and to ensure that as much of the network as possible preserves normal operation under fault conditions. An additional aim is that the network should remain synchronised under as many failure conditions as possible.

Each clock will generally receive synchronising information from another clock within the same State in a higher layer or in the same layer. Thus each clock will ultimately be synchronised with the NRC via the State Main clock.

It is important that synchronisation links be chosen so that no loops are possible, that is no clock must ever receive a synchronisation reference which is derived from its own output. This condition must be satisfied for all primary and lower rank order synchronisation links, and all of their combinations. If this rule is violated, the synchronisation network could experience frequency instability.

ALLOCATION OF PAAMS PRIORITY

The time reference for each clock is derived from the input with the highest available rank and is selected automatically according to the PAAMS algorithm. That is, if the primary reference is lost or exhibits poor performance, it will be rejected and the secondary reference selected in its place. The same procedure would be followed in descending order of rank if the subsequent reference was lost. The allocation of priorities to the synchronisation inputs must be done with care to achieve the highest reliability with the best available transmission system being selected for the primary reference.

When ranking transmission facilities for selection as synchronisation references, the characteristics of system types or individual systems should be taken into account.

IMPLEMENTATION

The implementation of the synchronisation network will commence in mid-1984 with the establishment of the NRC and the network expansion will generally follow the AXE installation programme. Digital islands may occur for short periods, but will be incorporated into the synchronisation network when digital transmission facilities become available.

CONCLUSION

Telecom is developing an extensive IDN on a national basis and the synchronisation of such a digital network is an important component to ensure the satisfactory operation of voice, data and video traffic.

This paper has described the planning of a synchronising network appropriate to meet the future requirements of Telecom's IDN and the evolvement of this network towards an ISDN.

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The Effect of Slip

The object of network synchronisation is the minimisation of slip caused by interconnecting nodes in a network. Slip is the uncontrolled repetition or deletion of signal elements as a result of sampling a signal at a rate different from the signal rate.

The effect of slip varies with the service being disturbed and varies from slight for telephony services to a serious impairment for data, facsimile and video services. These impairments typically can produce clicks in telephony services and errors in data traffic.

Slip, apart from causing the above service disturbances, is also undesirable at a multiplex level as the multiplex frame alignment may be lost. Special measures are usually implemented to prevent the latter as otherwise temporary outages will occur.

A degree of slip may temporarily occur in a synchronised network during infrequent faults or abnormal operation. However, during normal network operation slip will not occur in a synchronised network.

The TELEX 2000 Premium Teleprinter

DAVID ROSS BE
KONRAD CIBIS Dip Eng.

The TELEX 2000 teleprinter provides Telecom with a telex terminal which is compatible with the requirements of the contemporary office environment. This article outlines how the TELEX 2000 performs the function of interfacing the existing Telex Service with the modern office as well as considering the impact of technological change on the evolution of telex teleprinters.

INTRODUCTION

In September 1983, Telecom commenced the marketing of its new premium telex teleprinter, the TELEX 2000. The TELEX 2000 has been introduced into Telecom's product range to expand the potential market for the Telex Service and to maintain Telecom's position in the telex terminal equipment market. The enhanced facilities offered by the TELEX 2000 over existing telex teleprinters have been developed to meet the requirements of high call volume customers and to interface the existing Telex Service with the developing needs of the modern office. Further, the TELEX 2000 maintains Telecom's position in the text communication market and provides an integrated approach to the development of the Teletex Service in the mid-1980s.

The TELEX 2000 provides customers with word processor capabilities for text preparation and enables more efficient and economical use of the Telex Service. The teleprinter has various modes of operation. Messages can be transmitted directly from the keyboard or from the internal memory. Transmission of text from the internal memory can be either sent under manual control of the operator or automatically by the teleprinter in accordance with delivery instructions provided by the operator. In the automatic transmission mode, the TELEX 2000 can initiate successive call attempts if the Telex network does not establish a connection to the called customer or if the interchange of answerbacks between both customers is not correctly received at the start and end of the transmission by the calling TELEX 2000. Received messages are printed on hard copy and can also be stored in the electronic memory. Full message logging facilities are available for ease of management of stored messages. The internal message capacity of the TELEX 2000 can be increased by the addition of a floppy disk unit.

THE AUSTRALIAN TELEX SERVICE

The TELEX 2000 interworks with the Telex Service which was initially established as a manually operated national Telex network in 1954. In 1966 the network was converted to fully automatic operation. The network uses L. M. Ericsson ARM and ARB crossbar exchanges and, more recently, AXB Stored Programme Controlled Exchanges. A modified CCITT Type B signalling system is used with International Telegraph Alphabet No. 2 and a transmission speed of 50 bauds. International access to and from Australian telex subscribers is provided by the Overseas Telecommunications Commission who operate the International Gateway exchanges in Sydney.

There are currently over 40,000 telex services in operation within Australia and over 1.5 million services world wide. Australian telex customers make over 45 million telex calls per annum nationally and over 12 million international calls per annum.

An essential aspect of the Telex network is its integrity of operation, both nationally and internationally. The TELEX 2000 complies with the following features of the Telex Service:

- The called party does not have to be in attendance to be able to receive a message. Because it is a 24 hour service it is convenient for sending messages to other time zones.
- Telex exists throughout the world and standards have been maintained to ensure the compatibility of telex signalling. Thus any telex customer can access any other telex customer in the world.
- Within Australia the Telex Service is automatic. This allows customers to key in the wanted customer's number on the teleprinter keyboard and obtain connection without intervention by an operator.
- Operator assistance and operator provided services are available.
- Automatic international access is also available to most parts of the world.
- All teleprinters of the Australian Telex network are fitted with an answerback code identifying the particular subscriber. The answerback code contains the subscriber identification, country identification, and subscriber's number in the form:-
  TELECOM AA 30146 (5 digit no.)
  TELPTS AA 134875 (6 digit no.)
- Printed service codes are provided when a call cannot proceed.

TELEPRINTER PRODUCT RANGE

Prior to the introduction of the TELEX 2000 to the Telex Service, Telecom's product range of telex teleprinters comprised:

Siemens Model 100 Series 1 (Fig. 1)

This teleprinter is an electro-mechanical type with a three row keyboard. Paper tape facilities were available as an addition to the basic send/receive terminal. This teleprinter is now obsolete.

Fig. 1 Siemens M100 Series 1 Teleprinter

Siemens Model 100 Series 2 and 2A (Fig. 2)

In 1970 the Series 2 was introduced to the Telex Service. It uses electro-mechanical technology similar to the Series 1 teleprinter. Tape facilities and the paper roll were included inside the metal cover which is much larger than in the Series 1. A four row keyboard is standard. During the 1970s a Series 2A was introduced with minor changes from the Series 2.

Fig. 2 Siemens M100 Series 2 Teleprinter

SAGEM TX20 (Fig. 3)

In 1978 Telecom introduced the SAGEM TX20 teleprinter. It is basically an electronic teleprinter employing a microprocessor and solid state memory. The keyboard operates reed switches as distinct from mechanical linkages employed in the older Siemens teleprinters. Printing is carried out by a seven element matrix print head. Extra operator facilities are offered by the TX20 which make it easier to operate than the other types. Tape facilities are included within the case except for the chad box. The paper roll is mounted on a holder above the case. The case is made of a strong flexible plastic rather than metal.

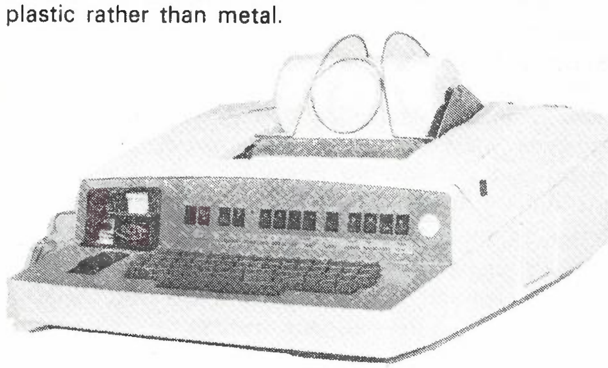
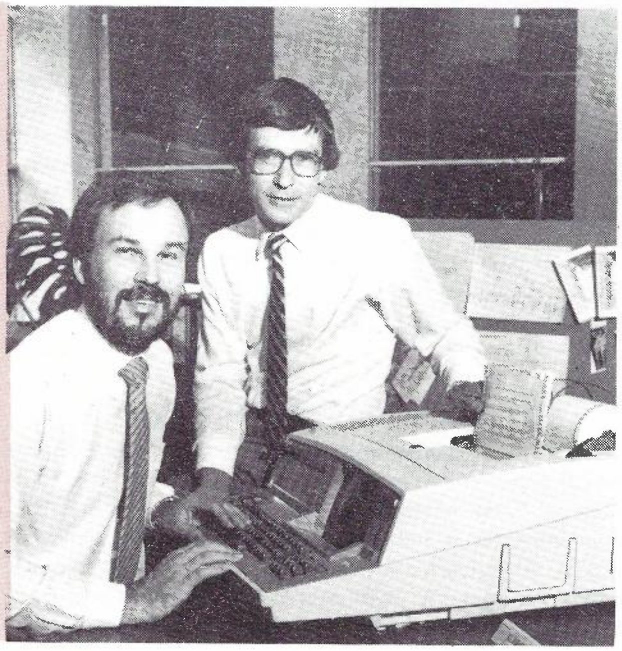


Fig. 3 SAGEM TX20 Teleprinter

DAVID ROSS (right) commenced with the Australian Post Office in 1965 as a Cadet Engineer. On graduating from the University of Melbourne, he spent 4 years with the Victorian Administration on external plant and metropolitan exchange service prior to transferring to Headquarters. At Headquarters David has worked on Telephone and Telex exchange equipment design, and as the Switching Equipment Design Co-Ordinator, prior to transferring to Commercial Services. He is currently the Supervising Engineer, Telex Terminals Section in the Text Services Division of Telecom Headquarters.

KONRAD CIBIS (left) graduated from the Preston Institute of Technology with a Diploma in Electronic Engineering (1974). He joined the Australian Post Office as an Engineer Class 1 and worked initially in the Telegraphs and Data Equipment Branch. His work with Telecom has involved him in a number of projects for Private Wire Telegraphs, the Public Telegram Service and Telex. He is now Senior Engineer with the Telex Terminals Section of the Text Services Division at Telecom Headquarters.



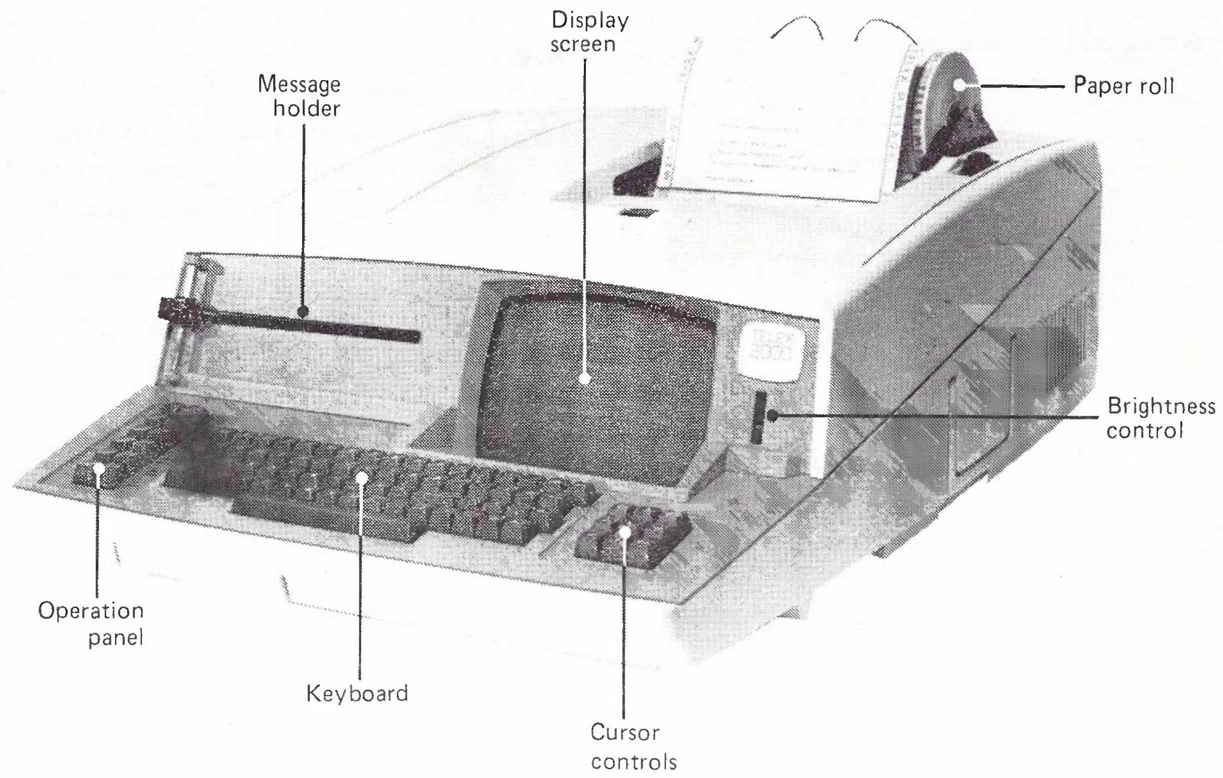


Fig. 4 TELEX 2000 Teleprinter

TELEX 2000

The TELEX 2000 (**Fig. 4**) has enhanced facilities and features which are not available with the above teleprinters. These facilities include:

- Visual Display Unit for ease of message preparation and editing.
- Electronic memory for message storage (32K characters).
- Long term or large volume message storage on optional floppy disk (115K characters).
- Automatic or manual transmission of messages (operator selectable).
- Automatic call re-try on unsuccessful calls.
- Multiple addressing of messages.
- Deferred delivery of messages (messages can be prepared and programmed to be transmitted up to 16 hours ahead).
- Abbreviated number calling (up to 20 often-called telex numbers can be stored).
- Protected format of text (in this mode prepared text cannot be altered).
- Directory log for all messages stored in memory.
- Answerback code verification (ensures messages are sent to the desired parties).
- Full tabulation facilities.

To elaborate on the benefit and ease of use of the additional facilities offered by the TELEX 2000, the operator interface is now discussed in more detail.

Operation Switches

The operation panel comprises ten operation keys dedicated to specific functions. These functions provide interaction with the internal memory to prepare, display, print, duplicate and erase messages. Further, the mode of transmission of messages and the use of the re-try facility is selected by specific keys. Other keys are provided for use in setting up the abbreviated number list and for use with the optional floppy disk.

Visual Display Screen

When a message is prepared for transmission and displayed by the TELEX 2000 the screen will look similar to that shown in **Fig. 5.**

Service Line

The first line on the visual display screen is the service line. The information displayed in this line is entered automatically by the teleprinter.

- Log Numbers.
  The first two characters in the service line represent the log number of the message as it will be recorded in the memory. The log number is used in conjunction with the operation switches to perform the required function on messages in memory.
- Service Messages.
  Service messages appear in the space following the log number to assist the operator in use of the terminal.
- Time and Date.
  Current time and date information is displayed.
- Memory Blocks Available.
  This display indicates the amount of internal message memory still available for use. The memory has 254 memory blocks, and each memory block contains 128 characters. When the number of blocks available

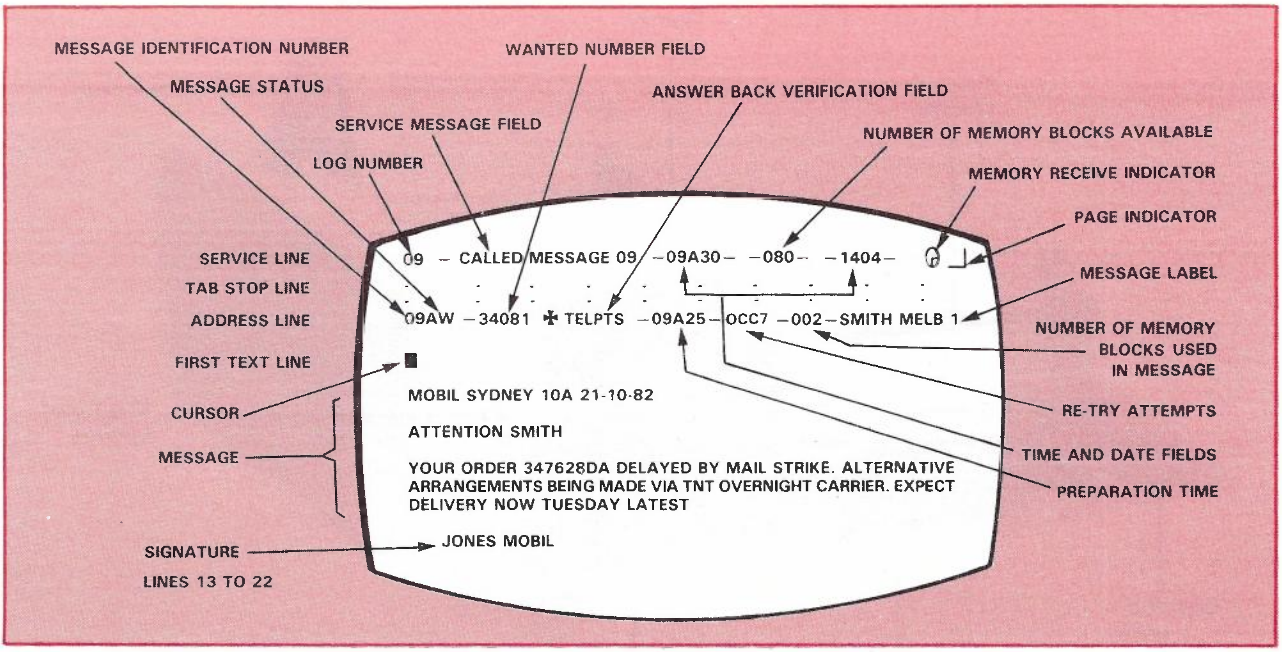


Fig. 5 TELEX 2000 — Display Screen

equals zero, MEMORY FULL is displayed on the visual display screen.

- Receive Memory Indicator.
  Incoming calls may be routed to the memory in addition to being printed automatically. This is indicated on the display.
- Page Indicator.
  When a long message containing more than 22 lines is being displayed the whole message may be moved up or down the screen by operation of the cursor keys. This page indicator shows what portion of the message is being displayed.

Tab Stop Line

The tab stop line may be set up for tabulation of parts of messages in a manner similar to typewriter tabulation.

Address Line

The following information may be displayed on the address line in the appropriate spaces or fields.

- Message Identification Number.
  The first three characters displayed on the address line indicate the identification number of the message as it will be recorded in the memory.
- Message Status.
  A fourth character is also displayed in association with the message identification number. This fourth character indicates the status of the message as defined by the following message status code:
  P = PREPARED — A message without a wanted customer number.
  W = WAITING — A message with a wanted customer number which has yet to be transmitted.
  S = SENT — A message which has been transmitted.
  R = RECEIVED — A message which has been received and stored in the memory.
  F = PROTECTED — A message with a protected format.
  J = REJECTED — A message which has not been successfully transmitted due to operator error or network difficulties.
- Wanted Customer's Number.
  Before a message may be transmitted automatically, it is necessary to enter the wanted customer's number in the address line. The number may be typed in full or, using an abbreviated address comprising a single letter.
- Answerback Verification.
  After the wanted customer's number is entered in the address line, the answerback codeword or number of the wanted customer may be entered. The teleprinter then automatically checks concurrence with the called number's answerback code. If a disparity occurs, the call is automatically cleared down.
- Preparation Time.
  The current time will be displayed in this field when the PREPARATION switch is operated. The re-try facility will use this time to initiate transmission of the message. If delayed delivery is required, the time shown in this field is altered to the time at which transmission is required.
- Re-try Attempts.
  This field will display the result of unsuccessful call attempts and indicate the number of re-tries remaining.
- Number of Memory Blocks Occupied.
  A three-digit display in the field after the answerback code verification field in the address line, indicates the number of memory blocks occupied by the message displayed on the visual display screen.
- Message Label.
  In the field after the memory block display in the address line, a label may be entered to help identify a particular message. Fourteen characters are available for this label. The label is stored in the memory with the message but is not transmitted.

TELEPRINTER DEVELOPMENT

The development in telex teleprinters has been brought about by the need to contain costs and increase efficiency. Advances in technology have allowed this to take place.

The electro-mechanical teleprinter performed the basic tasks required of a telex teleprinter. That is, it allowed traffic to be sent and received over the Telex network. Optional paper tape facilities were provided for message preparation and storage.

The major advantage that the first processor-controlled teleprinters had over electro-mechanical ones, was cost. Whilst the costs associated with electro-mechanical teleprinters were on the increase, the processor-controlled teleprinter utilising microprocessor technology, and developments in materials technology (especially plastics), enabled costs to be contained. At the same time operation of the teleprinter was made easier and its appearance made more suitable for an office environment.

The TELEX 2000 also utilises microprocessor technology. However, major developments in peripheral, interface and memory components have taken place since the first processor-controlled teleprinters were introduced into the Telex network. These developments have enabled the TELEX 2000 to be equipped with a large number of features in addition to performing the basic tasks of sending and receiving telex messages. These additional features enable significant improvement in operational efficiency. The telex operator is able to easily prepare and edit messages prior to transmission. Automatic transmission and re-try relieve the operator of a great deal of interaction with the Telex network. A 32K solid state memory and optional 115K floppy disk memory relieve the operator of paper tape handling problems and allow easy recall, editing and transmission of stored messages.

To illustrate the developments which have occurred, the principles of operation of the electro-mechanical and the processor-controlled teleprinters will now be outlined.

Electro-Mechanical Teleprinter — Principle of Operation

The principle of operation of an electro-mechanical teleprinter is shown in **Fig. 6.**

When coded signals are received from line the start signal causes the electromagnet armature to release. The receiver clutch is engaged and couples the drive section of the receiving selector to the driving shaft for one revolution. The driven camshaft in the receiver and the electromagnet responding to the coded signals set five levers in accordance with the code. The five levers then position five codebars in the codebar mechanism and printing mechanism. Near the end of the revolution of the receiving selector camshaft the mainshaft clutch is engaged. The stop pulse arrives and the receiving clutch is disengaged, allowing the receiving selector cam to reset; ready waiting for the next incoming signal. The previously engaged mainshaft clutch couples the printing mechanism and the correct type bar is selected and printing takes place.

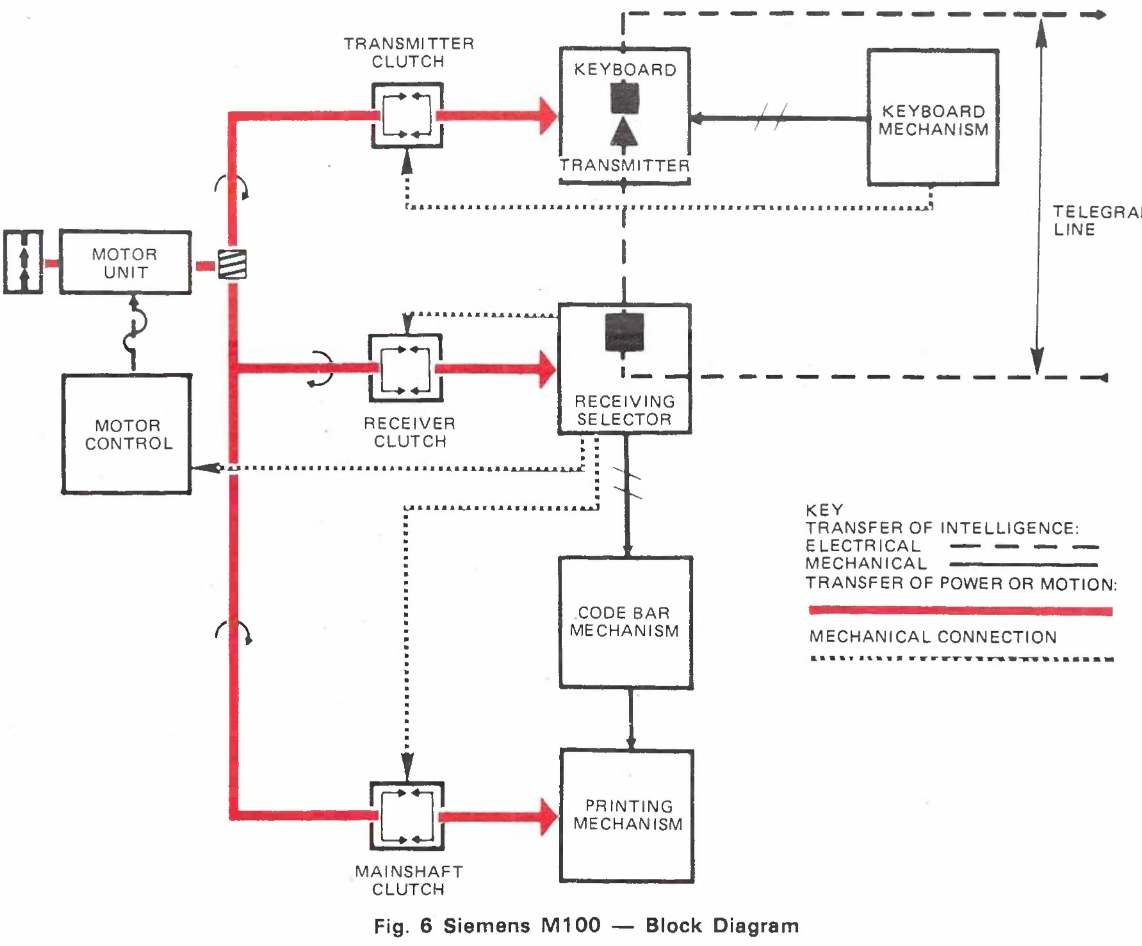


Fig. 6 Siemens M100 — Block Diagram

When the operator types a character on the keyboard five codebars are set simultaneously and the transmitter clutch is engaged. The driven camshaft revolves for one revolution only and the contact switch opens to send the start pulse to line, followed by five pulses representing the transmitted character. The stop pulse is then sent and the transmitter clutch disengages. The mechanism comes to rest ready for the next operator typing action.

The transmitter contacts and the receiving electromagnet are connected in series so the receiving selector responds to the transmitted signals in the manner described above. This ensures a page copy of the information being sent to line.

After a period of no signals the motor control turns off the motor in order to reduce wear.

Processor Controlled Teleprinter — Principle of Operation

Fig. 7 shows the principle of operation of the SAGEM TX20 teleprinter. The control logic comprises:

- a microprocessor
- a programme memory
- a temporary (storage) memory
- input-output circuits (Peripheral Interface Adaptors).

The input-output circuits interface the microprocessor with the peripheral devices:

- tape reader (reperforator)
- keyboard
- tape reader
- answerback unit
- abbreviated number store
- line unit
- real time clock
- facility switches
- printing unit.

Information is input from the peripheral devices to the microprocessor via the data bus. This information is then processed by the microprocessor in accordance with the programme and temporary memories and output to the relevant peripheral device. When the operator types on the keyboard the characters are sent via the data bus to the microprocessor. The microprocessor then processes the characters in accordance with the machine mode required. If the teleprinter is "on line" the microprocessor will send the characters to the printing unit and to line via the data bus.

Characters received from line are sent via the data bus to the microprocessor. The microprocessor processes the characters and sends them to the printing unit via the data bus.

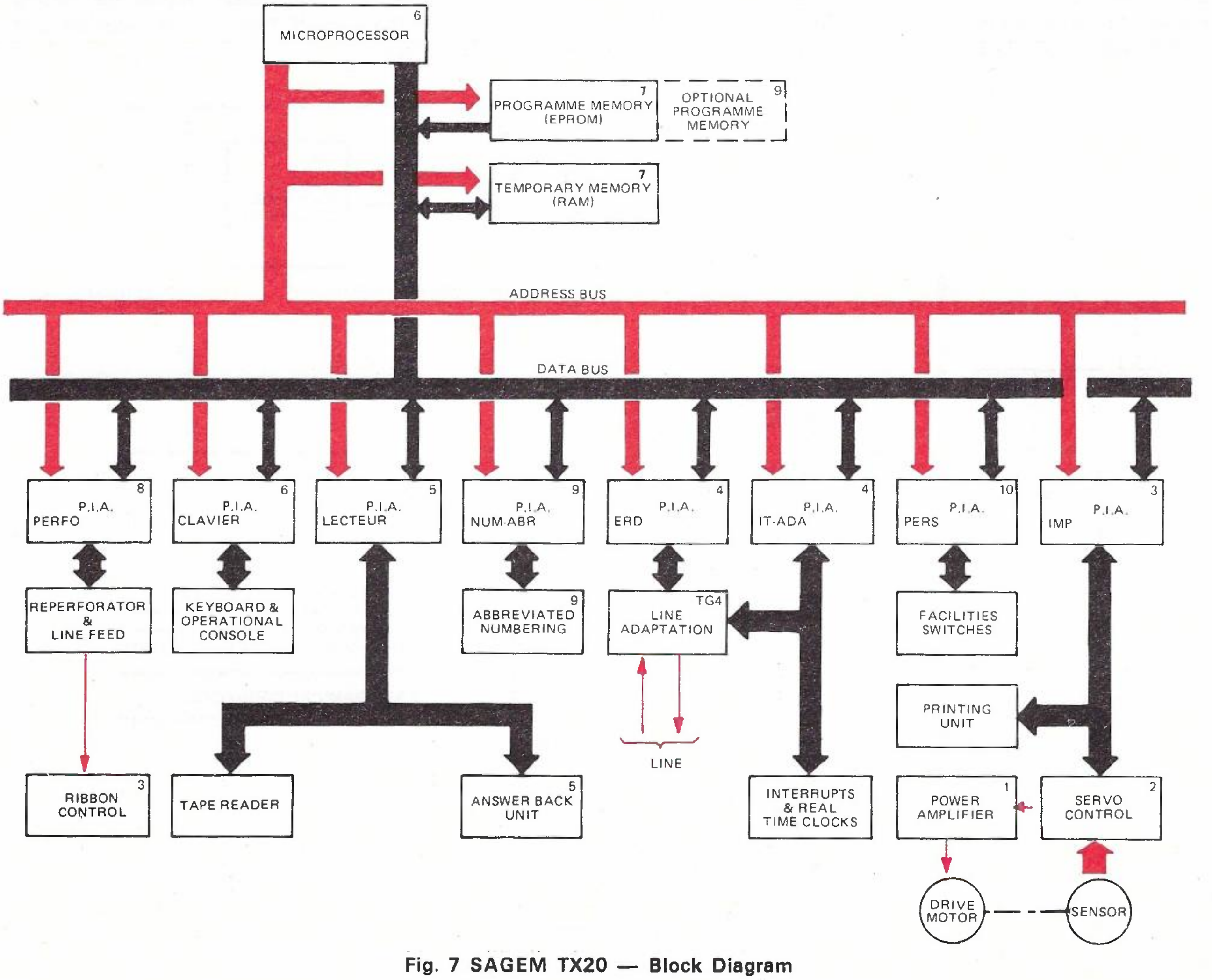


Fig. 7 SAGEM TX20 — Block Diagram

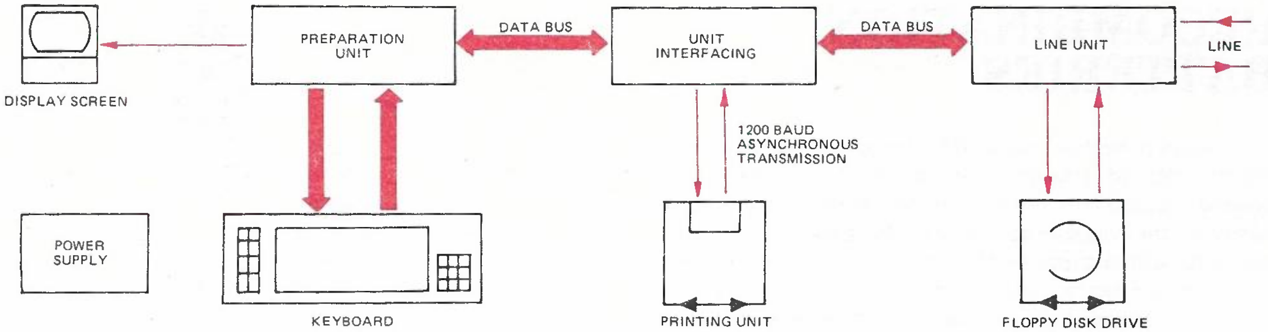


Fig. 8 TELEX 2000 — Functional Diagram

TELEX 2000 Teleprinter — Principle of Operation

As shown in **Fig. 8** the TELEX 2000 consists of three separate functional entities:

- line unit
- preparation unit
- printer unit.

Each unit employs microprocessor controlled logic circuitry similar to that described for the process controlled teleprinter. The line unit is the central or master unit to which the other two appear as peripherals.

Messages are prepared using the keyboard and visual display screen (ie. the preparation unit). Prepared messages are transferred to the line unit where they are stored and transmitted to line. Messages received from line are transferred to the printer unit via the line unit and may also be optionally stored in the line unit.

CONCLUSIONS

Initial user reaction to the TELEX 2000 has been most favorable. Simpler, quicker message preparation and transmission plus the TELEX 2000's extensive range of facilities and ease of operation, save time and money in operating a telex service.

The TELEX 2000 provides Telecom with a logical product link to the strategically important Teletex and Communicating Word Processor market.

RECOMBINATION BATTERIES

A range of sealed lead-acid batteries are now available which offer advantages over conventional batteries in selected telecommunications power applications. These batteries are available as one (2V), three (6V) or six (12V) cell units with a capacity of up to 150 Ah at the 10 hour rate. They are sealed and can be installed and operated in any position and pose no risk of electrolyte spillage.

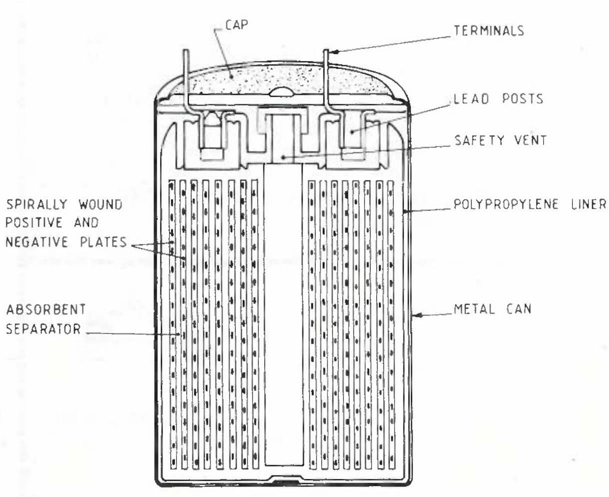
Transport and installation is simplified because there is no free acid in the battery. The sulphuric acid electrolyte is absorbed in microporous separators. This construction results in a low internal resistance and eliminates problems caused by electrolyte stratification. Any gases evolved during charging are electrochemically recombined. A pressure relief valve is provided in case excessive gas is generated under abuse conditions.

Recombination batteries are smaller and lighter than conventional wet batteries and are available at a similar cost. The recommended float voltage varies from 2.25 to 2.35 volts/cell, depending on the battery type. The manufacturers of these batteries predict a 10 year service life under float conditions.

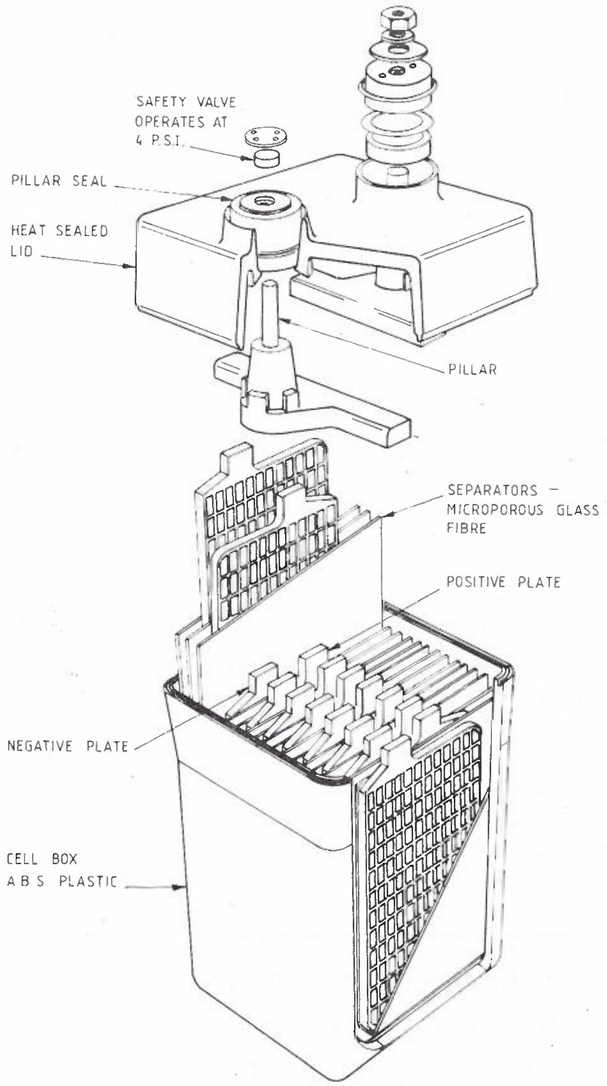
Recombination batteries being sealed do not leak acid or evolve explosive gases; special accommodation or ventilation is not required and they are office compatible. Power supplies can be fully integrated by installing recombination batteries and conversion equipment in one modular package. A technical article describing the application of recombination batteries in the Integrated Power Rack concept is being prepared for a later issue of this Journal.

Prepared by Telecommunications Power Section Headquarters, Telecom Australia.

Gates BC Cell



GATES CELL CONSTRUCTION



CHLORIDE POWERSAFE CELL CONSTRUCTION

Chloride Powersafe 3VB11

Computer Based Message Systems

IAN DAVIDSON BE
GRAHAM JENKINS ME, BSc.

Until recently, the business community has been well served by the traditional text communication services of Telex, facsimile and the Postal Services. Business is far more demanding today however, and requires faster and better communication facilities for handling its text based information. Telecom Australia is planning to meet this need by introducing two new text services, a message service and Teletex to operate in conjunction with the existing text services.

The message service, or Computer-Based Message System (CBMS) will cater for the less formal message communication requirements, whilst Teletex will provide the more formalised document transfer service desired by business.

HISTORICAL BACKGROUND

There can be little doubt that one of the most significant shifts in computing emphasis occurred during the latter part of the 1960s. Specifically, that period was marked by the entry of a number of time-share services in the computer bureau market-place. No longer did the programmer have to have his program punched on cards, then submitted over the counter, and returned to him a couple of hours later with a listing full of error messages arising, in many instances, from little more than a misplaced full-stop.

Service providers were not slow in embracing the range of opportunities offered through the availability of interactive access. Amongst the packages which became available on the time-sharing services were a number of message packages. These packages enabled a user to compose messages for other users to receive at their time of next access. Packages of this type tended to find their main application amongst co-workers within particular departments or institutions.

During the middle part of the 1970s, companies such as Tymnet and Telenet established public data networks which provided simplified data access to connected computer facilities for terminals located anywhere in the United States. Since that time, these networks have continued to grow, and links have been established to equivalent networks on other continents. In consequence, data communication facilities are now available between terminals and computers located virtually anywhere in the world.

In order that advantage might be taken of the potential world-wide customer-base now opened to them, the vendors of the early message services have extended and re-developed these services so that they more appropriately address the needs of user groups whose members may be widely dispersed. The historically different evolutionary paths for the various CBMS offerings today may be considered responsible in part, for the range of different facilities available on the different systems.

Services such as Quik-Comm and Intercomm have been developed by computer time-share bureaux and their message services are strongly intertwined with their traditional time-share services. Other services such as On-Tyme II and Telemail are very strongly linked in with their packet network services. Some companies, although having time-share or communication backgrounds have recognised the need for stand-alone systems, and services such as Comet and Easylink have emerged. Many of these vendors can make the software available for implementation in-house, on private systems.

IMPLEMENTATION

As previously indicated, many modern message systems have their genesis in predecessors implemented on general-purpose time-share computer systems. Accordingly, they tend to be implemented on computer systems of this type. In some instances, these systems still offer time-share computing and data-base (e.g. airline schedule, stock exchange) services in concert; in other instances, they have been implemented as single-function services.

The computers themselves range from traditional mainframe types down to 16-bit minicomputers. They may be organised as stand-alone systems, or in clusters; in the latter instance, provision is usually made for load-sharing or fail-safe operation so as to minimise the likelihood and extent of service interruption in the event of hardware and/or software malfunction.

A typical CBMS configuration is shown in **Fig. 1.**

CBMS OPERATION

Each subscriber on a public CBMS has allocated to him a conceptual mailbox to which mail items intended for him may be addressed. A subscriber, in this sense, may be an individual (e.g. G. K. Jenkins) or a corporate entity. Conceptual mailboxes are, in general, realised as computer disk files in which incoming mail items are stored in ASCII or equivalent form.

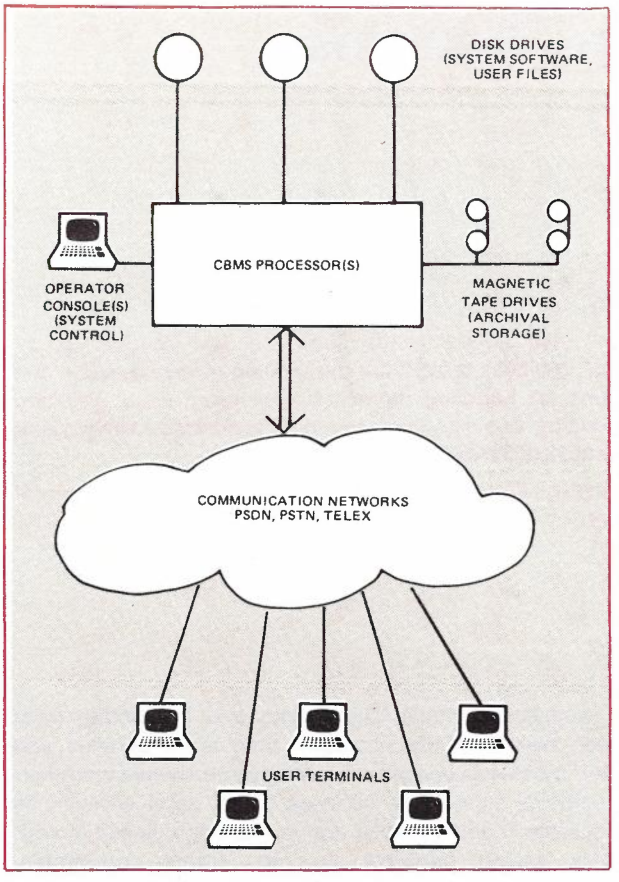


Fig. 1 Typical CBMS Implementation

A subscriber's access to the CBMS (and thence to his mailbox) is effected via a user number and password mechanism similar to that employed on most time-sharing and interactive information systems. This mechanism serves to identify a subscriber for the purpose of permitting access to his mailbox. It also enables him to be identified automatically when he is the originator of outgoing mail.

The actual process of **message origination** is illustrated in **Fig. 2.** Computer prompts have been shown in upper case so as to differentiate them from user entries. In the Figure, it will be apparent that once a subscriber has established telephone line connection (and in some instances entered a carriage return or other character to indicate the particular characteristics of his terminal), he is provided with a welcome message and invited to identify himself. Some systems require a user number (e.g. ABN017) at this stage; other systems will accept any unambiguous form of the user's name.

The user is then requested to enter his password, which is normally not echoed upon his display. An indication of the time at which his last session concluded is then provided so that he can ascertain whether some other person has illegally accessed his mailbox. An indication is also provided as to whether there is presently any incoming mail in his mailbox.

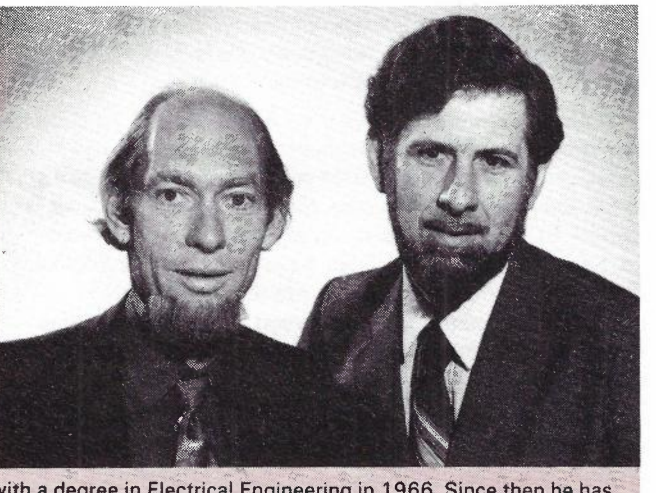
The user is then prompted ("CMD") to enter a command, and in this instance, elects to compose a new message. In this example, user commands have been shown in full; most systems allow the user to enter any one, two or three character non-ambiguous abbreviation of a command.

The user is instructed to enter, in turn, the name(s) of the recipient(s), and the names of any who will receive "carbon copies". As before, some systems allow the use of any non-ambiguous forms of name (so that in our example, it has been necessary to specify a first-name initial to resolve a potential ambiguity between Jenkins, whereas no such ambiguity is possible for the other names shown), whilst other systems require actual user numbers.

After entry of the intended recipient designator(s), the sender is invited to supply a subject heading. Such a heading enables recipients to easily scan the contents of

GRAHAM JENKINS (left) holds the degrees of Master of Engineering and Bachelor of Science from the University of Adelaide. He commenced work with Telecom Australia in 1966. In 1971, he moved into Telecom Australia Research Laboratories where he has worked in the Computer Applications and Techniques Section and the Customer Systems and Facilities Branch.

His recent work has involved a comparative study of the capabilities of the various available public Computer-Based Message Systems; as a result thereof, he is now working as a Principal Engineer within the Commercial Services Department on the implementation of such a System by Telecom Australia.



IAN DAVIDSON (right) graduated from Melbourne University with a degree in Electrical Engineering in 1966. Since then he has been with Telecom Australia working on aspects of data and Telematic services.

Over the past 18 months he has been involved in studies of text communication services, particularly Teletex and Computer-Based Message Systems (CBMS).

Ian is currently employed as a Principal Engineer in the Text Services Division of Commercial Services where he is actively involved in the specification and implementation of a CBMS service.

```
SAMPLE MESSAGE SYSTEM, ON AT 12:05 10-JAN-84.

PLEASE ENTER YOUR NAME: G Jenkins
PLEASE ENTER YOUR PASSWORD: $$$$$$

THANKYOU. YOUR LAST SESSION CONCLUDED AT 09:15 09-JAN-84.
YOU HAVE NO NEW MESSAGES.

CMD: Compose
TO:  Smith
CC:  Green, A Jenkins
SUBJECT:  New X.25 Teletex Machine
TEXT:
Hello John. We were intrigued to read of the new X.25
Teletex machine which your company is about to market.
— etc —
— etc —
Regards, etc.
.

CMD: Send
9857 12:46 10-JAN-84 MSG SENT

CMD: Logout
SAMPLE MESSAGE SYSTEM, OFF AT 12:47 10-JAN-84
```

Fig. 2 Message Origination

their mailboxes; it also assists in message filing and retrieval operations. Entry of the actual message text is then effected. As will be apparent in the Figure, there are no special format or protocol requirements for the text field beyond the condition that it should be displayable at the recipient terminal(s). In practice, many people tend to adopt a semi-conversational style lying somewhere between the terse brevity of a telex message and the stilted formalism of a conventional business letter. In our example, text termination is signalled by input of a line containing only a full-stop.

The user is again prompted to provide a command, and in our example, elects to send the message which he has just composed. A unique message identifier is printed along with the transmission verification; this identifier may be used internally so that the system need only keep one copy of messages with multiple destinations, or to facilitate backup and recovery operations.

At the next command prompt, the user elects to terminate his session through the use of a logout command. An appropriate sign-off confirmation is provided by the system.

Fig. 3 illustrates the **message reception** process; in particular, reception of the message that was prepared and sent in Figure 2. Sign-on is effected as discussed previously and the user is then informed that he has (in this instance) 2 new messages.

In response to the command solicitation, he enters "Scan", and is shown the time and date of message entry, originator, and subject description for each unread item in his mailbox. He then elects to read the first item shown in that scan list, and receives that message in full. Notice that the system has expanded all originator and recipient names into standard or preferred forms.

Once the message has been displayed, the user is again prompted to enter a command. In this instance, he elects to **file** the message for future reference. Most systems will provide the user with the option of creating a new file automatically if the nominated file does not exist.

EXTENDED USER CAPABILITIES

Most CBMSs offer a range of extended capabilities, so that the more experienced subscriber is able to more effectively employ his time spent at the terminal. It is convenient to group these capabilities into several categories.

Within the first of these categories, we might place those facilities associated with **delivery options.** One such option available on most CBMSs is that of directing that a carbon copy should be "blind"; in other words, the sender is able to specify that the address of such a blind carbon copy recipient should not appear in the address lists which are supplied to the other message recipients.

Another delivery option commonly encountered is the

```
SAMPLE MESSAGE SYSTEM, ON AT Ø9:35 11-JAN-84.

PLEASE ENTER YOUR NAME: Smith
PLEASE ENTER YOUR PASSWORD: $$$$$$

THANKYOU. YOUR LAST SESSION CONCLUDED AT 15:17 Ø9-JAN-84.
YOU HAVE  2 NEW MESSAGES.

CMD: Scan
1  12:46 1Ø-JAN-84  G JENKINS   NEW X.25 TELETEX MACHINE
2  Ø8:5Ø 11-JAN-84  I GOLDBERG  STAFF MEETING SCHEDULE

CMD: Read 1
To:      John SMITH
CC:      Gerald GREEN
From:    Graham JENKINS
Subject: New X.25 Teletex Machine
--------------------------
Hello John. We were intrigued to read of the new X.25
Teletex machine which your company is about to market.
— etc —
— etc —
Regards, etc.
--------------------------

CMD: File in teletex
FILED IN TELETEX

CMD: Logout
SAMPLE MESSAGE SYSTEM, OFF AT Ø9:41 11-JAN-84
```

Fig. 3 Message Reception

"receipt acknowledge" capability. When an option of this type is attached to the name of a recipient, an automatic acknowledgement message directed to the sender will be generated as soon as the recipient reads the message.

The timed delivery option enables a sender to specify one or more times at which delivery to his specified recipient(s) is to occur; in most systems which offer this capability, the sender is able to abort delivery up until the first specified time has elapsed. This capability might be used to remind the members of a committee of a regular meeting each fortnight.

In the second category of extended user capabilities, we might consider the set of **recipient processing facilities.** We have already encountered one such facility during our discussion of the message reception process; this was the message filing facility. Instead or as well as filing the received message, our recipient may elect to answer it immediately. Of course, he could start from the beginning, entering the name of the sender as his (new) intended recipient, and entering the subject line again. However, this information is already held within the computer, so that all he really needs to do is to enter the directive "Answer" as shown in **Fig. 4,** then proceed with his text entry.

Another available recipient processing facility enables a recipient to forward the entire received message to another person for subsequent processing. Upon entry of the directive "Forward", as shown in **Fig. 5,** he will be prompted to enter one or more names, then invited to enter any comments which he wishes to accompany the forwarded message.

NETWORKING

According to the manner in which a message service supplier calculates the comparative computing and communications costs, it may elect to service its entire customer base from a single (stand-alone or cluster) site, or it may establish a number of such sites interconnected through public packet data networks, or by private lines. A single-site operation offers evident advantages in terms of economies of scale in relation to computer support costs. Through exploitation of time-zone differences amongst its customer base, such an arrangement can also extend the effective revenue-generation period of a single installation towards twenty-four hours per day. On the other hand a multi-site arrangement can (depending on traffic patterns) offer a significant saving in communications costs. It also

```
CMD: Read 1
To:      John SMITH
CC:      Gerald GREEN
From:    Graham JENKINS
Subject: New X.25 Teletex Machine
--------------------------
Hello John. We were intrigued to read of the new X.25
Teletex machine which your company is about to market.
— etc —
— etc —
Regards, etc.
--------------------------

CMD: Ans
TEXT:
Thanks for your interest, Graham. I am air-freighting
a package of introductory brochures and manuals to you
today, and will be pleased to answer any specific
queries you may have after reading them.

Also, I shall be in Melbourne in about a fortnight, and
will arrange a demonstration whilst there if you wish.
Look forward to hearing from you soon.
.
CMD: Send
9863 09:50 11-JAN-84 MSG SENT
```

Fig. 4 Message Answering

enables some service continuity in the event of a major catastrophe at one site.

As shown in Figure 1, access from the CBMS may be achieved from a variety of communication networks. However, most terminals are connected via 300 bits/second asynchronous modems operating on the Public Switched Telephone Network (PSTN). This operating speed is sufficient for most applications, since few users are able to read and digest information appearing on a screen at any faster rate. The PSTN dial-up line may terminate directly in a modem rack at the CBMS processor site; this access route is convenient where the user is located in the same local telephone zone as the processor. Alternatively, it may terminate at a Packet Assembler/Disassembler (PAD) on a national packet data network, with calls being routed through it (and possibly through other interconnected national or international packet data networks) to the processor site.

INTERWORKING WITH OTHER CBMS

As in today's postal service there is a distinct advantage in being able to input a message to the system using a standardised address and "envelope" and leaving it to the network to firstly determine the correct destination system, and then to effect its delivery to the nominated mailbox. To achieve this today, the originator must have either direct access to the destination system or find his way through a maze of data networks which often have their own access codes and passwords.

The two standards setting bodies in this field, the International Federation of Information Processors (IFIP) and the Consultative Committee on International Telegraphs and Telephone (CCITT) are co-operating in the development of international standards for these services. Some re-development of the early message services has also been brought about through efforts to conform with the standards which are now emerging from these bodies. In the main, the standards produced to date address the need for standardised "envelope" formats which facilitate the transfer of messages between different services. A side-benefit has been the convergence of the meaning and presentation of commands on the different services, so that users familiar with one service tend to have little difficulty adapting to the use of another system.

INTERWORKING WITH OTHER TELEMATIC SERVICES

There is one electronic mail service which has operated internationally for several decades, and presently has a higher level of usage than any CBMS presently offered. We are referring, of course, to the Telex service. It is desirable that a CBMS operator be able to transmit messages to, and receive messages from, the users of the Telex service.

Several major CMBS suppliers offer facilities for Telex terminal addresses to be included (along with mailbox

```
CMD: Read 2
To:      John SMITH
From:    Ivan GOLDBERG
Subject: Staff Meeting Schedule
--------------------------
Hello John. Due to a clash in conference room bookings,
next Friday's staff meeting has been re-scheduled so as
to commence at 11:15. Would you please convey this to
those concerned, and let me know if there are any
consequent problems.
--------------------------

CMD: Forward
TO: Johnston, Brown
CC:
SUBJECT: Meeting Next Friday
TEXT:
Please see Ivan's message here-under, mail him direct
with drop to myself in event of conflict. See you there,
and please remember to bring your new slides.
.
MESSAGE ENCLOSED

CMD: Send
9896 10:02 11-JAN-84 MSG SENT
```

Fig. 5 Message Forwarding

addresses) in message destination fields. Messages addressed in this fashion are mapped to their upper-case equivalent forms, and pre-scanned for line-width and character-set compatibility. They are then routed into appropriate national or international Telex networks through interfaces which may be attached directly to the CBMS processors, or to data network PADs.

In a like manner, facilities are offered so that a message originating at a Telex terminal may be addressed to a CBMS Telex interface, and may contain a mailbox designator as a sub-address. The message is then placed automatically in the appropriate mailbox and may be scanned, displayed, filed and so on along with other messages therein.

It is intended that the Telecom Australia CBMS will have full Telex capabilities from its inception.

A number of national communications authorities (including Telecom Australia) are presently introducing a Teletex service intended to serve the high-volume communication needs of their business customers. It is desirable that the Teletex service also be able to interwork with the CBMS. Several major CBMS suppliers are presently developing Teletex interworking capabilities which are equivalent in both operation and implementation to the Telex interworking capabilities outlined above. It is expected that these Teletex interworking capabilities will become available to many CBMS users during the next eighteen months; Telecom Australia is committed to the provision of such capabilities at the earliest possible opportunity.

The recent widespread acceptance of Videotex services offers further opportunities for CBMS interworking. As far as can be ascertained, none of the major CBMS suppliers has thus far moved to embrace these opportunities.

TERMINALS

Public CBMSs are, in general, designed so that they may be accessed by the cheapest and/or most commonly available type of terminal. In practice, this "lowest common denominator" terminal turns out to be a non-intelligent ASCII display terminal, usually having 24 lines of 80 characters, although the exact screen capacity is unimportant. Such terminals are presently marketed in Australia from $600 upwards (according to quantity purchased, additional features, etc.).

It will be apparent that significant savings in user access effort can be achieved through application of a terminal having inbuilt dialling, modem and sign-on capabilities. Such "executive work-station" terminals (usually equipped with loudspeaking or hands-free telephones) are now marketed by a number of equipment manufacturers, and also by some overseas CBMS operators.

Some potential CBMS users already have their own communicating word processors, upon which they may effect message composition and storage and, in some instances, in-house message communication. Potential users in this category are catered for by allowing access through full-duplex 1200 bits/second asynchronous modems, with their word processors still appearing to the CBMS as non-intelligent ASCII terminals. Special commands are provided so that messages may be transferred to and from the CBMS in batches, without requiring intermediate message solicitations.

The intelligent personal computer is beginning to take on the tasks that directly support the office manager and white-collar worker. Functions such as forms preparation, detailed calculations, spreadsheet and of course text preparation are all available as computer packages.

Where an office worker already has a simple communication terminal for access to data bases and message systems it becomes logical to provide these additional office support functions in the CBMS making them available to the terminal user as a Value Added Service (VAS).

ENHANCED CAPABILITIES

Many vendors have realised the value in offering other time-shared services such as data-base access, specialised office automation software, intelligent interfaces and so on. A simple example might be a librarian who would access a master library data-base to locate a requested book. With the assistance of a simple forms generation program an inter-library loan request could be generated for transmission to the appropriate library via the CBMS.

Several other services offer further interworking possibilities. Amongst these are interfaces to the postal and courier services, where electronically originated mail is routed to a serving distribution centre for print-out and enclosure within window envelopes. It is then delivered conventionally through the postal or courier system. This service is presently offered on a couple of American and Canadian public CBMSs. It is possible that Telecom Australia will be offering such a capability in conjunction with Australia Post at some time in the future.

In the United Kingdom one public CBMS offers a radio-paging facility, which enables the originator of an urgent message to designate that its intended recipient(s) be paged and alerted to the fact that an urgent message requires their attention.

A NEW TELECOM SERVICE

Telecom has prepared a text services strategy in which Telex, Teletex and CBMS will be marketed as three related and complementary services. Telex has existed for many years and currently supports 40,000 users in Australia and 1.5 million world wide.

Telecom plans to introduce a CBMS into the Australian network by mid-1985 with universal access from anywhere in Australia via the Packet Switched Data Network (AUSTPAC). Access to AUSTPAC will be by direct connection or by local dial-up lines into AUSTPAC PADs.

Current plans also allow for interworking betwen the CBMS and the planned Australian Teletex service.

The CBMS will complement the Telex and Teletex services well. It is a message service and as such is less formal than Teletex yet is more personalised and easier to use than Telex. It enables simple and fast communication, overcoming time zone differences. Importantly, incoming messages are accepted when convenient to the recipient — they do not interrupt or demand attention. The CBMS is ideal for providing that informal yet essential written message service unavailable to Australian businesses today.

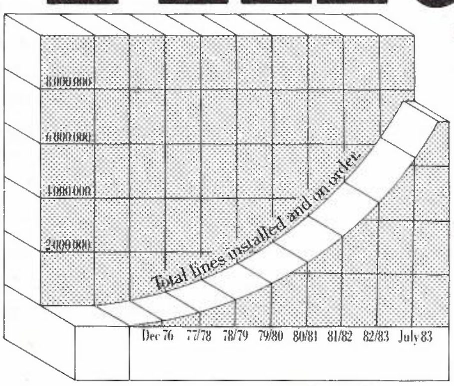
FUTURE SERVICES

If one regards the early experimental and in-house systems as the first generation CBMS then it follows that the currently marketed systems capable of supporting a public service are the second generation.

Third generation systems will allow full interworking between systems in different countries with the user's system taking full responsibility for routing and delivering the message to the distant mailbox. Now that interactive standards for Message Handling Systems are being finalised in the CCITT and IFIP, the implementation of third generation systems cannot be far into the future.

Computer based message systems can today, offer the business community a much needed service in the preparation and delivery of messages between busy executives.

SOFT TALK COMES THROUGH LOUD AND CLEAR



In telecommunications, the Software Age came into its own with the introduction of the AXE digital switching system. No other system in history has enjoyed a sales record as spectacularly successful as the revolutionary Ericsson AXE. Our graph shows how more than 80 telephone companies in 49 countries – including Australia – have chosen AXE over all other systems since 1976.

The word is soft.
The message is loud and clear.
Phone Ericsson: Melbourne (03) 309 2244.

ERICSSON

The New Microelectronics Revolution

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E. TIRTAATMADJA BE(Hons.), MIEEE
D. M. HARSANT BE(Hons.)

Microelectronics has been the dominating feature of technology for the past twenty-five years and integrated circuits are now found in a vast range of equipment for both commercial and domestic use. However the manufacture of these circuits has traditionally been a long and expensive process. This paper examines techniques which have been developed to exploit the expertise, which has been built up in the microelectronics industry, to realise more cost effective means of producing integrated circuits. These techniques are bringing the benefits of microelectronics to a vast range of new applications.

INTRODUCTION

The evolution and application of microelectronics has been the dominating feature of technology for the past twenty-five years. It is virtually impossible to consider any area of automation, communications, transport or domestic appliances which is not being influenced by the resources and expertise of the microelectronics industry.

A characteristic feature of microelectronics technology has been the explosive growth in the capacity for providing more and more functions on a single chip, accompanied by decreasing cost per function. Integrated circuits equivalent to tens of thousands of transistors are currently in production and chips containing hundreds of thousands will be available in the near future. As an example of the technology involved, the width of connections and other device structures on present chips is smaller than 3 microns (ie. .003 mm) with a reduction to 1 micron being projected. **Fig. 1** shows the complexity which is currently found in a large microelectronic circuit. This is a photograph of a Motorola MC1468705G2 single-chip microcomputer.

The detailed design of a large circuit, as shown in Figure 1, may involve many years of effort and require the use of very sophisticated computer aided design (CAD) facilities. The philosophy for such a design is to fit the entire circuit on the smallest possible chip and to optimize the layout and length of all on-chip interconnections commensurate with maximizing the overall circuit performance. This is a full custom (or hand-crafted) circuit and the designer has access to every mask level (perhaps 10 or more) of the fabrication process [1] together with a complex set of design rules specific to the particular process used. For more details of design and fabrication see [1-4].

The full custom approach requires the skill of experienced integrated circuit designers and this fact coupled with the CAD tools and long design time, results in very high design and development costs. A fully optimized product may cost in the order of hundreds of thousands of dollars to reach maturity. To justify this expense very large numbers of chips must be required, as in the case of standard components. This market is generally the province of the giant American and Japanese microelectronics companies.

In general, the larger and more complex circuits become, the more specialized are their applications and consequently the smaller the market. The cost of producing these circuits may not be a problem for the mainframe computer manufacturers who must use the latest and fastest chips available. However, for a vast range of industrial, commercial and domestic applications this forefront of technological sophistication is unnecessary and uneconomical. In addition, designers from any field may require smaller circuits to be developed in integrated form but find the cost of full custom design is out of the question. As a result, there is increasing worldwide interest and activity in exploiting the design and production expertise, which has been built up in the microelectronics industry, to find more cost effective means of realising integrated circuits. This has led to a range of integrated circuit design and fabrication techniques as illustrated in **Fig. 2.**

The main emphasis in this paper is the semi-custom approach, shown in the right hand column of Figure 2, which sets out to minimize the time taken for integrated circuit design. The time and costs associated with design are the major factors in the overall cost, rather than the final production of the circuit. This can be performed relatively cheaply on established and automated fabrication lines.

In the following section the two principal and well established methods of semi-custom design will be described first. These methods have several names but will be identified in this paper as the Uncommitted Array and the Cell Library. It will be seen that both these methods offer considerable advantages to a user who wishes to obtain microelectronic circuits tailor made for this application with the reliability and other benefits of standard semi-conductor devices.

Also noted in Figure 2 are a number of other branches of integrated circuit design, for example the multi-project-chip or MPC [5]. This is a form of custom design suitable for non-expert user designs and which allows for sharing of fabrication costs among a number of users. These factors lead to faster design times and lower costs per circuit than is possible with conventional custom integrated curcuits. The main use for the MPC would seem to be as an economical means of prototyping circuits in silicon. MPCs will also be discussed in more detail in the next section. Another branch to be mentioned later is field programmable devices. While these devices do not offer the same scope as the others, they are a useful tool for the designer.

These descriptions of design techniques will be followed by a comparison of their capabilities from the point of view of a designer who must choose one for a particular application. Future developments will also be discussed.

DESIGN METHODS

Semi-Custom Design

As mentioned, there are two principal methods for the realization of semi-custom integrated circuits, although future developments may merge the boundaries between the two. The two methods are compared and contrasted in Figure 3 which outlines the stages in the production of a complete integrated circuit.

The Uncommitted Array

Fig. 3 shows in broad detail the procedure for the Uncommitted Array. This employs an integrated circuit processed to every level except the final interconnection (metalization) layer(s). The chip is designed to consist of a large number of identical cells which the designer can interconnect for his specific application. Such an uncommitted chip can be fabricated on standard production lines in large numbers and stored as a standard item for future use. There are a number of descriptions for these circuits (eg. gate arrays, uncommitted logic arrays, masterslice arrays or masterchip arrays). However, the principal remains the

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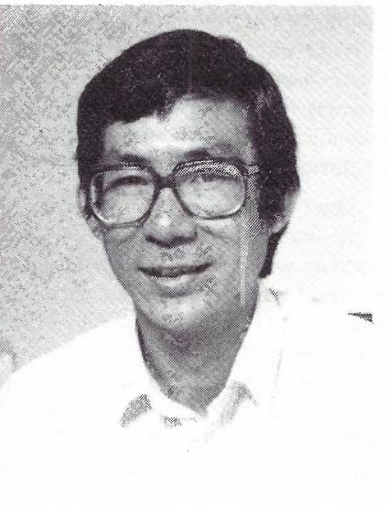
EDDY TIRTAATMADJA joined Telecom Australia's Research Laboratories on completion of Bachelor of Engineering degree from the University of Melbourne, in 1976. Since that time he has worked in the Switching and Signalling Branch and in the Customer Systems and Facilities Branch of the Research laboratories. His areas of study have included the assessments of the impact of new device technologies and the application of novel and complex design techniques in the design of telecommunications equipment. He is currently working on the study of the architectures of future exchanges, particularly, experimentation with a possible implementation of a multiservice digital exchange.



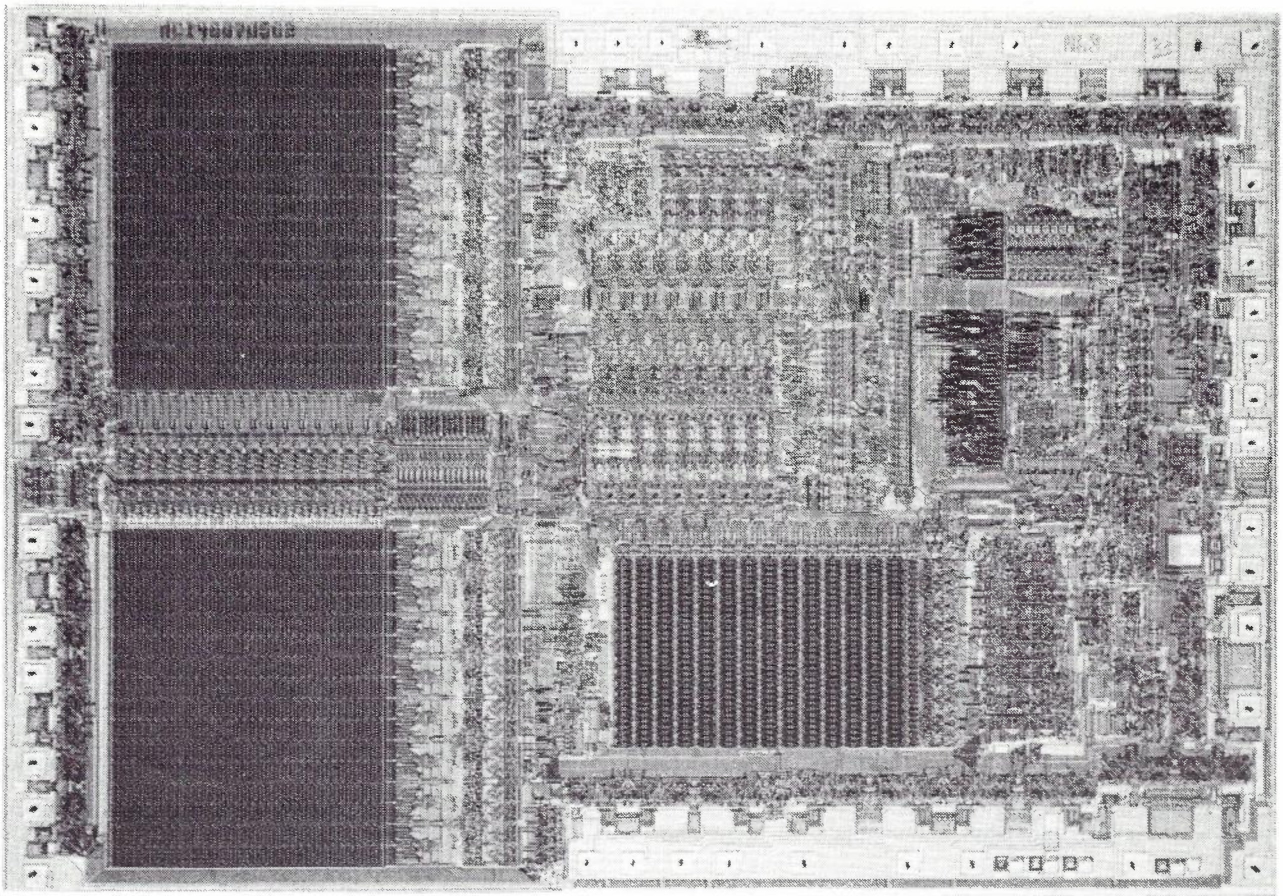


Fig. 1 Picture Of A VLSI Integrated Circuit, (Courtesy of Motorola Inc.). (MC1468705G2 chip photo)

same, ie. with the exception of the final interconnection layer the many levels of fabrication present in the manufacture of an integrated circuit are all standard, and may be committed to a variety of applications.

There are many variants of these arrays on the commercial market since the array design involves a number of decisions by the manufacturer. These decisions are as follows:—

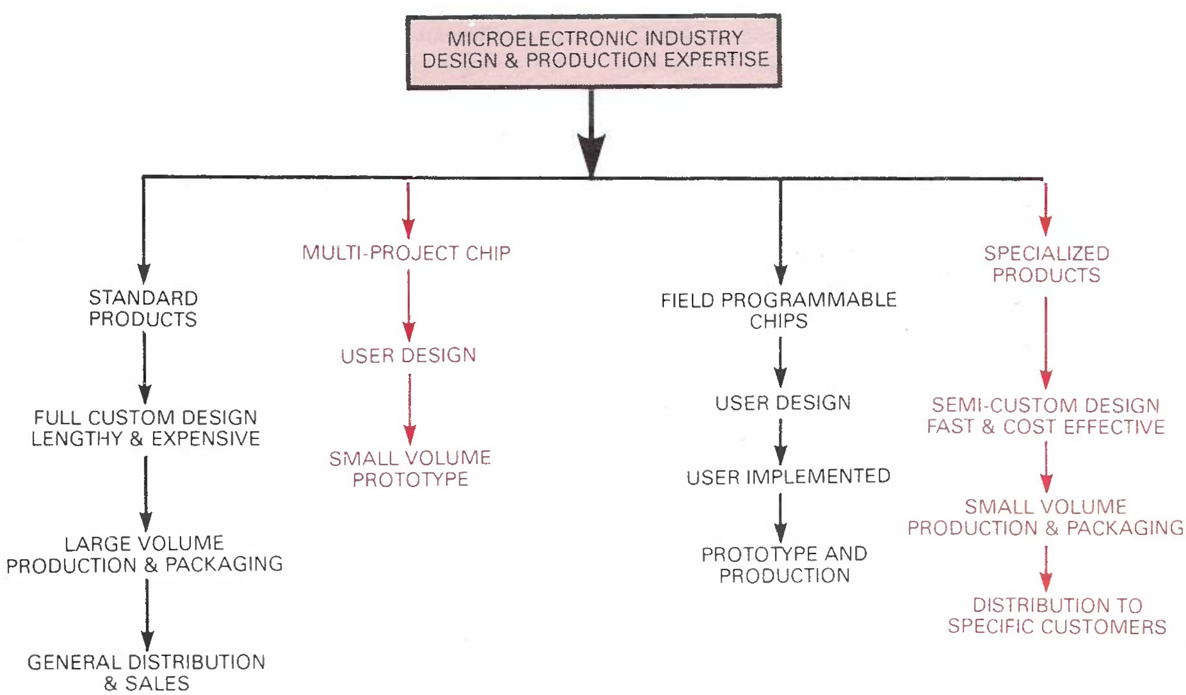


Fig. 2 Integrated Circuit Design Methods.

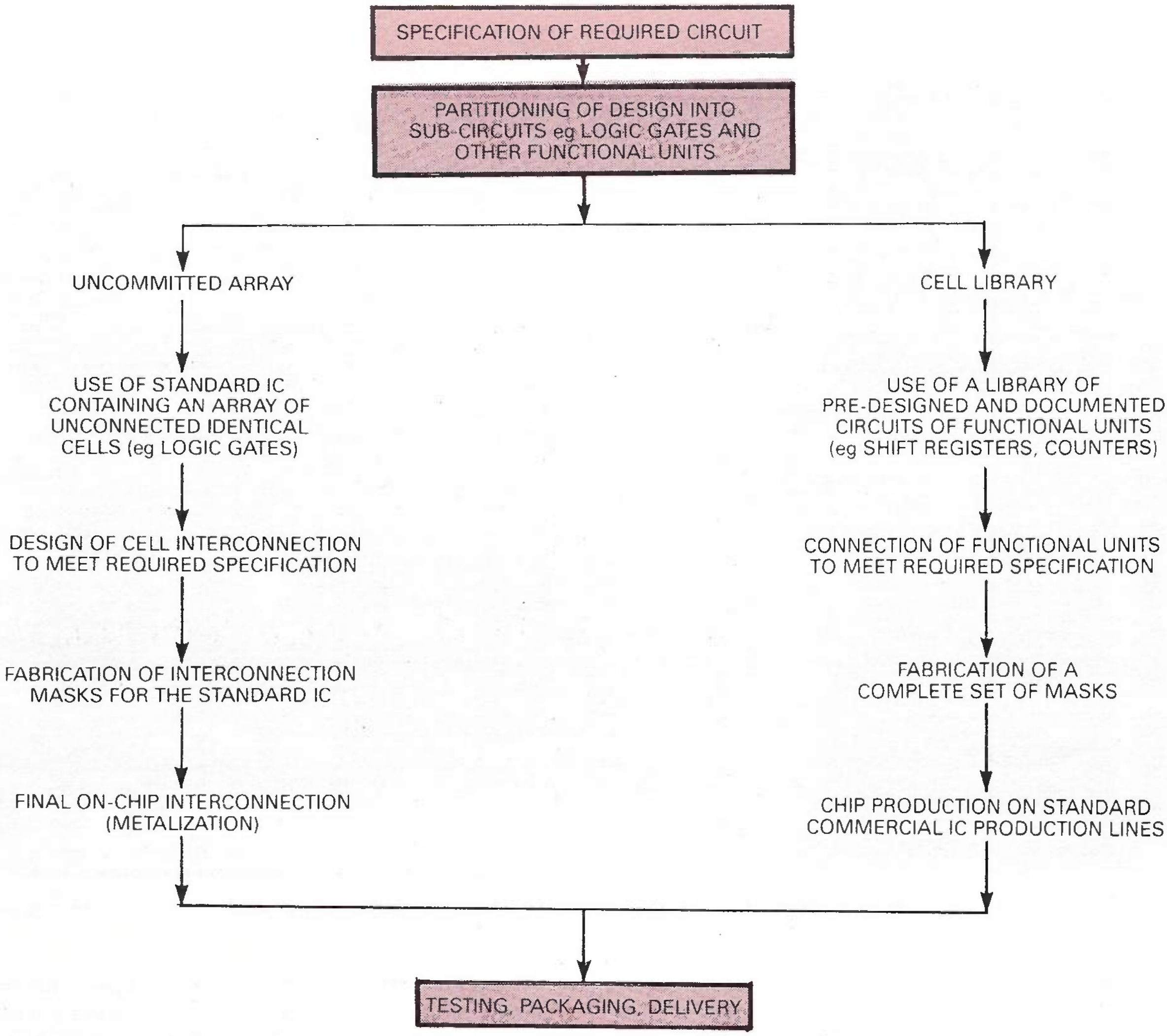


Fig. 3 Semi-Custom Design Approaches.

- The integrated circuit technology to be used [6] ie bipolar (TTL, IIL or ECL etc) or MOS (CMOS or nMOS). This choice simply reflects the range of options available for microelectronics products in general.
- The type of cell to be used on the chip. For example arrays may consist of separate items such as transistors and resistors or fully functional units such as NAND gates etc.
- The number of cells to be included on the chip. A range of sizes is available so that for a particular requirement the array used will not be underutilized. A cell utilisation of 70% would be considered satisfactory.
- The means of fabrication of the interconnection and in particular the number of layers used for this purpose. For small arrays one layer is sufficient, however, as the arrays become larger the use of two (or more) layers becomes necessary in some cases. This is similar to the use of double sided printed circuit board and the routing software used in both employs similar algorithms.

The design procedure for an uncommitted array firstly involves partitioning the given design specification into circuits corresponding to the particular cells on the chip. This is followed by the design of the interconnection pattern to connect as many cells as required to complete the overall circuit. This process will be familiar to many designers but in this instance the result will be fabricated on a single chip.

For small arrays, of the order of a hundred cells, the interconnection may be done by hand. However, as the arrays become larger the use of CAD tools becomes essential. The interconnection design is converted to the appropriate mask for the final fabrication stage which is the only unique operation in the manufacture of the circuit.

Fig. 4 is an illustration of a typical uncommitted array showing the rows of standard cells together with the final interconnection pattern. The input/output connections around the perimeter of the chip can also be seen. These will be bonded to the pins of the integrated circuit to complete the package. More details of uncommitted arrays can be found in [7-14].

The Cell Library

The second major stream of semi-custom design is based on the integrated circuit manufacturer having a CAD library of already fully designed and documented functional cells. These cells, called macros or primitives, generally correspond to the standard building blocks used by electronic designers in system formulation and

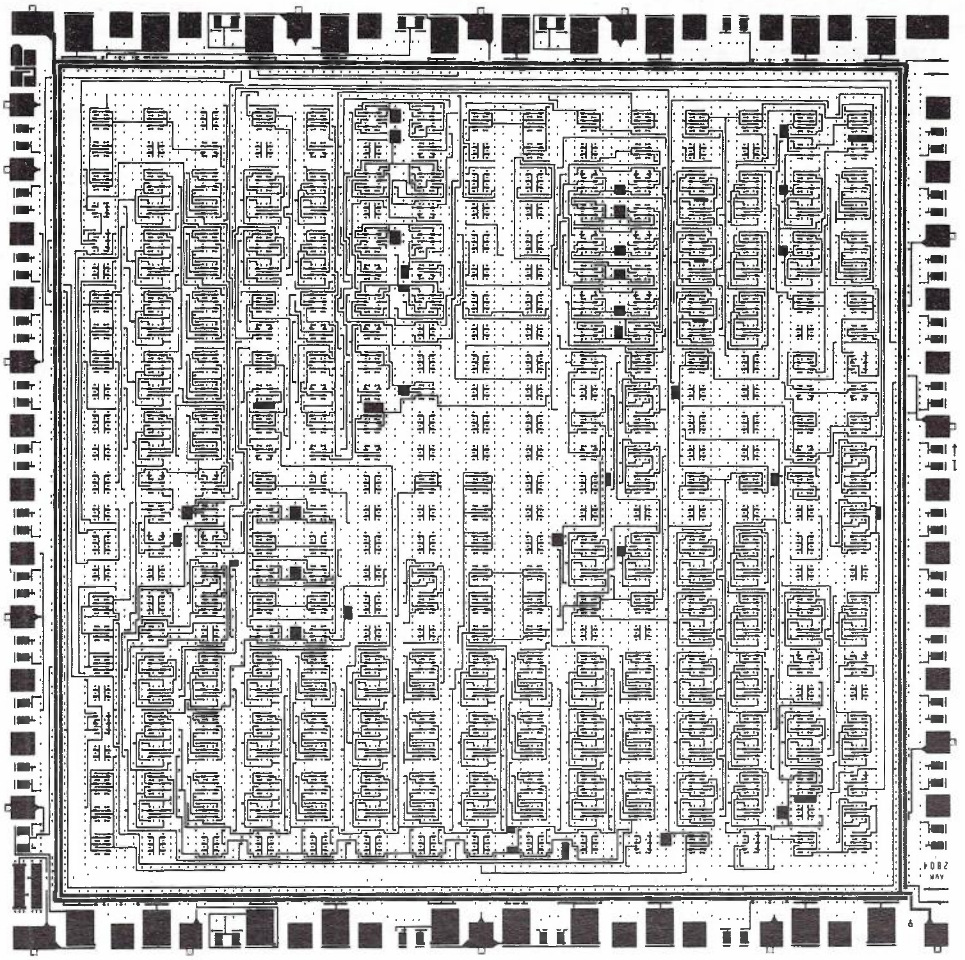


Fig 4 An Example Of An Uncommitted Array, (Courtesy of AWA — Microelectronics).

design. The range and scope of the circuits in each manufacturer's library may vary but will almost invariably contain such items as shift registers, full adders, counters, comparators and other similarly common circuits as well as the more simple multi-input logic gates.

In contrast to the cells of the uncommitted array, the library cells are not all the same physical size but vary according to the complexity of each circuit. However, for ease of subsequent chip design, individual manufacturers usually standardize on some fixed height of cell (macro) in their detailed silicon layout and vary the width to account for complexity. This method of fixed height, varying width cell design is often termed a "polycell" system. For ease of subsequent routing the terminal pitch for the connections to and from each cell is set on the same fixed grid spacing.

These pre-designed and fully characterized cells constitute the basis for the required semi-custom circuit. The design procedure is to partition the overall system into blocks corresponding to the macros available in the library and interconnect them to form the complete circuit. Similarly to the uncommitted array, it is possible for the user to design his own integrated circuit. This may be done by hand, using adhesive transfers to represent the individual macros and assembling them on a large sheet together with the interconnection details. Unlike the uncommitted array the cell library approach has no predetermined boundary and no fixed number of cells with which to work. The circuit contains only those macros needed for the particular application and hence there should not be any appreciable areas of unused silicon. Beyond some volume of production this is likely to be an economic advantage.

The options facing a cell library manufacturer include the choice of technology and most of the current manufacturers concentrate on CMOS. The fabrication of a cell library circuit is very different from that of the uncommitted array. Given the initial layout, the manufacturer must then go to the detailed silicon layout of every macro required, assemble them and add the detailed interconnection information. Thus a full integrated circuit fabrication procedure (as with a full custom chip) has to be followed. All the masks for each layer of the fabrication process have to be prepared. However, the need to do detailed chip design for the functional circuits themselves has been spared by the use of this approach. Further details of cell library design may be found in [12-16]. Table 1 shows in brief the relative advantages and disadvantages of the two semi-custom techniques.

The Multi-Project Chip

The multi-project chip, or MPC, is a means of producing custom circuits in integrated form at a relatively low cost per circuit. Under this scheme, as shown in **Fig. 5**, a number of small circuit designs are merged onto

TABLE 1: COMPARISON OF CELL LIBRARY AND UNCOMMITTED ARRAY APPROACHES

UNCOMMITTED ARRAY	CELL LIBRARY
Only one design and fabrication level (i.e. interconnect).	Full set of fabrication masks required.
Chips may be pre-fabricated in large numbers.	Devices fabricated individually.
Only one level to change if errors in design and fabrication.	Full set of masks may have to be remade if errors are found.
Cheaper (or smaller production quantities required).	Superior performance likely due to shorter interconnections.
Usage of silicon area not optimum.	No wasted space or chip.

Superior performance and reliability than produced by printed circuit board assembly, due to minimization of interconnection lengths and reduction of electrical assembly details.

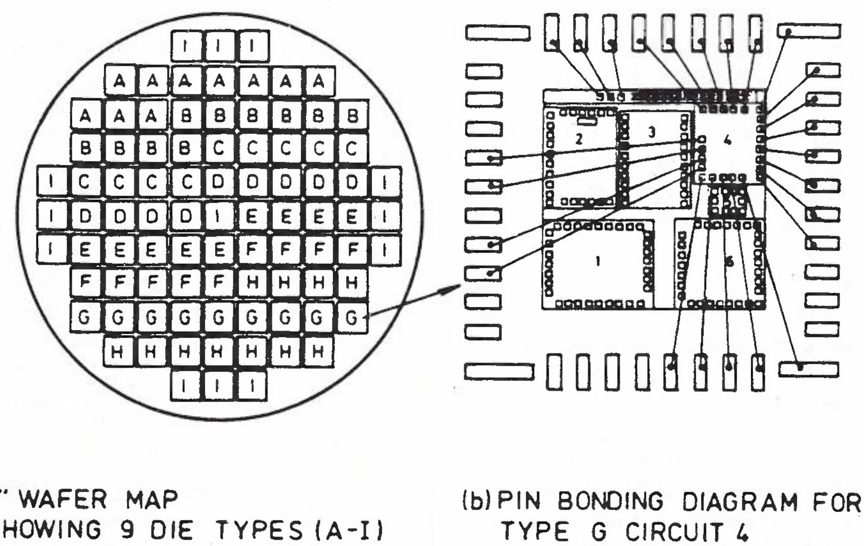
a single silicon die, forming one chip type containing several independent circuits. This die is repeated over a silicon wafer together with a number of different die types. After fabrication and packaging, each designer receives a small number of integrated circuits in which only his circuit is bonded to the package pins. This approach enables the total mask making and wafer fabrication costs to be spread over a number of projects, giving a much lower cost per circuit than is possible with conventional custom integrated circuits.

As stated earlier, the major costs in the development of integrated circuits are incurred before the circuit is manufactured. The MPC is considerably more economical in this regard as it is associated with a simplified design method developed by Mead and Conway [17] which enables designers who have little or no knowledge of semi-conductor physics to design their own custom integrated circuits relatively quickly. The technology used to fabricate MPC circuits is a self aligned nMOS depletion load process [17] which is a relatively straightforward process of only five mask levels and used by many manufacturers. The design method is based on a very conservative set of rules and very basic transistor models and because of this the circuits produced are not at the leading edge of technology. However, they are not far removed from having the line widths and density associated with VLSI chips. Design rules for CMOS MPCs are currently being developed in a number of Research Laboratories.

The MPC was originally developed as an educational tool, however, it is now seen, at least, as an economical means of prototyping circuits in silicon. A number of MPCs have been designed and fabricated in Australia since 1982. For more information see [18, 19].

Field Programmable Chips

These chips may be bought off the shelf and programmed by a user to perform his logic functions. There are two major types, programmable array logic (PAL) and the programmable logic array (PLA). They consist of regular arrays of AND gates and OR gates, combinations of which can realize any logical expression. The PLA permits access to both AND and OR functions while the PAL allows only the AND function to be



(a) 3" WAFER MAP SHOWING 9 DIE TYPES (A-I)

(b) PIN BONDING DIAGRAM FOR DIE TYPE G CIRCUIT 4

Fig. 5 Multi-Project-Chip Structure.

programmed, leaving the OR gates in a fixed pattern. The method of programming is to burn out the undesired connections by pulsing a large current through a specific interconnection. With the aid of relatively simple computer programmes users can design these chips to perform many low to medium complexity digital tasks (of the order of 30-100 gates). While not offering the scope of the other techniques, this is a quick and cheap solution offering a reduction in chip count of from 4:1 to 12:1. Further details may be found in [20-23].

COMPARISON OF TECHNIQUES

The alternative implementations available to designers are many and varied, as described in the previous section. A large number of commercial manufacturers and design houses are currently in the international market offering an expanding range of products and in this environment the designer is faced with choosing one of these competing techniques for his particular application. The choice of the most suitable implementation technique depends on a number of factors, some of which are interrelated. These factors include:—

- Requirement for digital or analogue circuitry or both.
- Size and complexity of the circuit.
- Circuit performance requirements, including operating speed and power supply limitations.
- Design time, including prototype evaluation.
- Cost, including design and production costs.

No one design approach will be superior for all these factors for a particular design. A designer will have to compromise and choose one for his application based on what he sees as the most important factors in his case. In this section the items listed above will be discussed to provide a general appreciation of the differences between the design techniques. A detailed comparison of the various techniques would doubtless be incomplete and rapidly become out of date as technology advances and the techniques refined. In addition to the above, users have to consider their long term aims bearing in mind the required volume of production and the need for repeat orders, availability and second sourcing.

Digital/Analogue Circuitry

Analogue circuit implementation requires that the designer has close control over the parameters of his circuit elements. The greatest degree of control and maximum design flexibility is found in the full custom approach where the manufacturer has considerable knowledge of his process capabilities and limitations. For the same reason the circuit performance can be pushed as close as possible to the limits of the technology being used.

Most of the currently available cell libraries provide digital building blocks corresponding to the familiar TTL 7400 series or the CMOS 4000 series. Standard analogue cell libraries are only recently becoming available [24], these contain a few common analogue circuits which can be sufficient for many applications. Typical elements include operational amplifiers, transistors, capacitors, zener diodes and resistors in various technologies [25]. Considerable research effort is going into this area and it is likely that extensive analogue and digital cell libraries will be available in the near future.

In uncommitted arrays where the cells consist of components (rather than logic gates) it is possible to commit the array for analogue functions. This is particularly so for bipolar arrays [26, 27] although further developments in CMOS technology are expected to provide analogue capability as well [28].

User designed circuits using MPC techniques generally perform poorly in analogue applications. Commonly available MPC design rules are intended for digital circuits and variations between the process parameters of different manufacturers hinders the development of standardized design rules for analogue circuits. A modular approach to analogue design for MPCs has been suggested [29] and this may be the first step in analogue MPC evolution.

Digital circuit implementation is catered for by all combinations of design approach (full custom, semi-custom, field programmable etc.) and technology (TTL, IIL, CMOS, nMOS etc.). The choice of the most suitable technique for a particular application depends on the factors described below.

Complexity

Highly complex circuitry can be realised in full custom form with the ultimate limitation being high development costs or technology limitations of the manufacturer's fabrication process (eg. VLSI). Similarly, cell library designs can be as complex as the manufacturer can process although the design time associated with such circuits is again likely to be a practical limitation.

Uncommitted arrays are now available in a range of sizes varying from one hundred cells to many thousand cells per array, the capability per cell also varying depending on the array family. For comparison purposes capacities are often quoted in terms of "2-input NAND gates equivalent".

Depending on the regularity of its design, an MPC can obtain up to 10,000 2-input NAND gates equivalent while field programmable devices are most suitable for low to medium complexity digital circuits containing between 30 and 100 2-input NAND gates equivalent.

Circuit Performance

Performance in this context includes circuit speed and power consumption. Because of the large number of alternatives for the implementation of each design approach only very general comments will be made.

As mentioned previously full custom circuits can be designed to achieve the highest possible performance due to the manufacturer's design expertise and knowledge and control of his processes. Cell library circuits will, in general, be less space efficient than the full custom equivalent and therefore have higher on-chip interconnection resistances and capacitances. Thus, cell library circuits will be inferior to full custom circuits in this regard. Due to the restrictions in its layout a circuit realised on an uncommitted array will in turn be inferior to a cell library equivalent.

MPCs typically use nMOS technology with conservative design rules as indicated above and as a result this approach does not provide the optimum performance from the technology. However, it may have a performance advantage over the uncommitted array and may approach cell library performance depending on the designer's expertise.

Any of the above will be superior to field programmable or standard component design in terms of both speed and power consumption due to the inclusion of most circuit interconnections on the chip. Off-chip connections slow the circuit speed considerably as well as consuming extra power in the buffer circuitry needed to drive signals off-chip and in dissipation in the unused area of the circuit.

Within each design approach, the choice of technology determines the performance of the circuit. The relative performance of the available technologies are well known, eg. ECL being the fastest, although it also consumes the most power; bipolar-TTL being faster than CMOS or nMOS, and CMOS having the lowest power consumption. Performance figures of these technologies are continuously being improved particularly in the CMOS area where considerable research is being carried out. The maximum speeds which are quoted in Table 2 may well increase in the near future.

TABLE 2: MAXIMUM CLOCK SPEED OF SOME COMMON TECHNOLOGIES

TECHNOLOGY	MAXIMUM CLOCK SPEED
ECL	50-500 MHz
Bipolar — TTL	20-100 MHz
NMOS	5-15 MHz
CMOS (Metal gate)	5-10 MHz
CMOS (Silicon gate)	10-40 MHz

Design Times

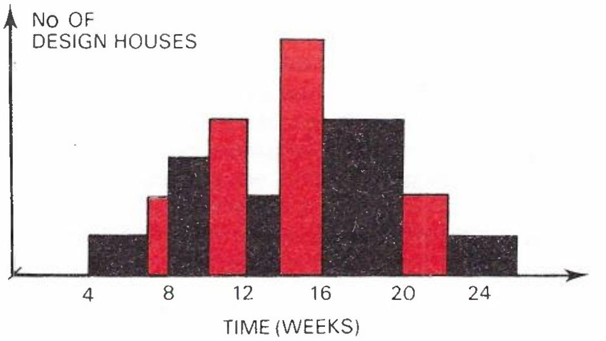
Design times for each design approach are clearly dependent on two major influences:—

- Size and complexity of circuit.
- Availability of CAD facilities and design expertise.

Because of the individual attention given to every circuit component, the full custom circuit has the longest design turn around time. Each step in the circuit implementation, ie initial design, mask making, sample fabrication, testing, refabrication and final verification are unique. Typically, full custom circuits will take one to two years to produce depending on circuit complexity. Turn around time for cell library circuits is approximately 30% of that of an equivalent full custom product, ie 4 to 8 months. Uncommitted array designs normally take around 15 weeks to realise.

Fig. 6 [30] shows typical design times quoted by a number of overseas semi-conductor manufacturers in 1982. The times shown are for design up to sample production and do not include testing and refabrication. Rerun times to cater for error found in the first prototype are of the order of 2 to 4 weeks for an uncommitted array and 4 to 8 for a cell library design.

Each MPC run (mask making, fabrication and packaging) can be expected to take between 10 and 15 weeks. The total design turn around time depends on the arrangements made among the designers who are sharing the manufacturing costs. For example some MPCs are processed only when enough designs have been submitted while others have prearranged timetables.



NOTE: (a) FUNCTIONAL TESTING OF PROTOTYPE CIRCUITS NOT INCLUDED
(b) RE-RUN TIME TO CORRECT FOR FIRST-RUN ERRORS NOT INCLUDED

Fig. 6 Quoted Average Development Times to Prototype Samples, (Courtesy of S. L. Hurst, 2nd Int. Conf. on Semi Custom IC's).

Costs

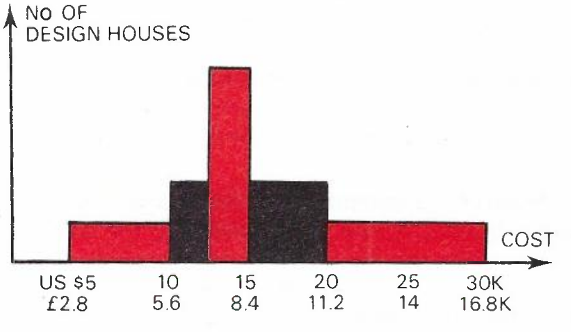
The two components of overall cost, development cost and production cost, will be treated separately.

The development of full custom circuits is very expensive because of the time, expertise and sophisticated CAD design tools required by the manufacturer. In the cell library approach this development cost is substantially reduced and users can design their own circuits using tools supplied by the manufacturer.

Makers of uncommitted array devices normally provide design assistance as well as final interconnection fabrication. However, a user with access to a "rear end" processing facility can design his own masks and buy arrays which he can subsequently process. The development cost in this case depends on how much consultancy is needed from the array manufacturer.

Fig. 7 [30] shows the result of a survey which sought development costs from sources of semi-custom devices.

Designers of field programmable devices depend on their own resources to realise a particular circuit. Development costs are low, perhaps less than a few weeks of designer effort.



NOTE (i) ADDITIONAL DESIGN CYCLE $1-3K FOR GATE-ARRAYS; $2-10K FOR CELL-LIBRARY DESIGNS
(ii) PROTOTYPE SAMPLES TYPICALLY BETWEEN 5-25 PACKAGED CIRCUITS
(iii) FUNCTIONAL TESTING OF PROTOTYPE CIRCUITS NOT INCLUDED

Fig. 7 Quoted Average Development Costs to Prototype Samples (Courtesy of S. L. Hurst, 2nd Int. Conf. on Semi Custom IC's).

Subsequent relative production quantity costs per chip are as follows; full custom, cell library, uncommitted array and field programmable devices. The full custom product is the most silicon efficient of these alternatives resulting in the smallest chip and consequently the lowest per unit cost. Manufacturers will vary their unit costs depending on the volume of the production. Complexity is also a factor and **Fig. 8** [30] shows typical costs of uncommitted array designs as a function of complexity for 1000 units production quantity. As indicated previously, the MPC was not originally intended as a production tool and its use for this purpose has not been established.

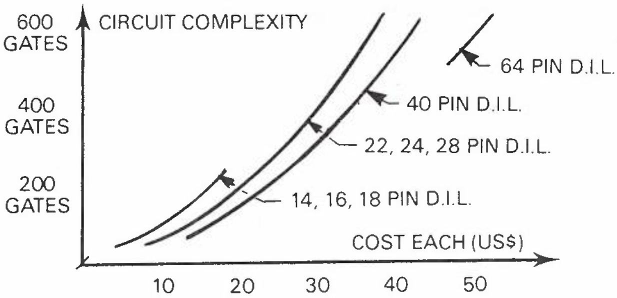


Fig. 8 Production Costs/Package (Plastic dil Packaging, 1000 off), (Courtesy of S. L. Hurst, 2nd Int. Conf. on Semi Custom IC's).

In general, fabrication costs are decreasing due to increasing demand, increasing expertise and improvements in technology and CAD. However, the cost of packaging must also be taken into account and as complexity and performance requirements increase this cost becomes more significant.

The overall economic consideration of the alternatives therefore depends not only on development cost, but also on production cost which is a factor of both complexity and volume. **Fig. 9** shows the total costs per unit as a function of volume production. It can be seen that the high costs of full custom curcuits render them unsuitable for low volume production. However, as the volume increases and the costs are shared amongst a larger number of devices the unit cost decreases. In the situation which is illustrated, field programmable devices are most economical for volumes up to 1000 units, uncommitted arrays are the best choice from 1000 to 20,000, cell library implementation is the cheapest from this level to 100,000 devices while full custom circuits are the most appropriate for production quantities above 100,000. This diagram however, only represents the situation for one particular circuit complexity. The total cost varies with complexity, not only the design costs vary but for the case of an uncommitted array the size of the array may vary giving a step function in the unit cost as the design moves from one array size to the next. In general the cell library becomes more economical than the uncommitted array at lower production volumes as complexity increases. Further information can be found in [31-33].

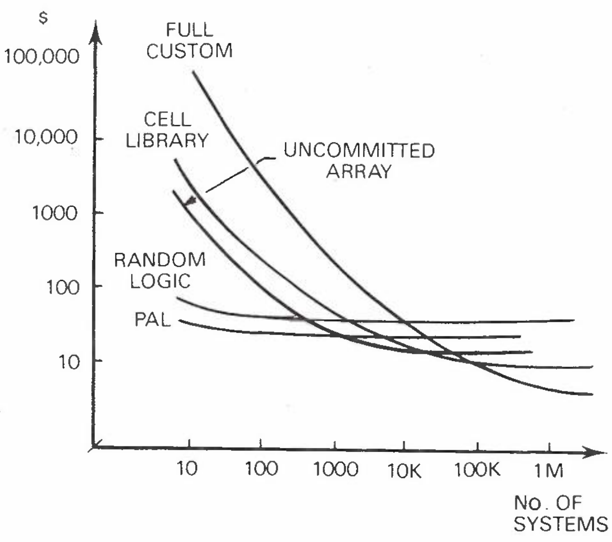


Fig. 9 Unit Cost As A Function Of Volume Production.

FUTURE DEVELOPMENTS

Although semi-custom design is not a new concept it has only recently become an area of increasing significance to both equipment manufacturers and integrated circuit suppliers. In 1982 there were nearly seventy companies worldwide offering gate array products and about twenty dealing in standard cells; this is a six fold increase on only two years previously. By 1986 semi-custom products can expect to have a 5% share of the total integrated circuit market [31]. There are several reasons for the upsurge of interest in this area. A major influence has been the increased availability at lower cost of CAD hardware and software, giving shorter design times and lower development costs. Increasing capacity for mask making and wafer fabrication, combined with decreasing production costs, has been another important factor. The important requirement of second-sourcing is also more realistic with the continuing standardisation of fabrication techniques between integrated circuit manufacturers.

The immediate future will see the increasing availability and use of custom and semi-custom microelectronics in all its forms. Continued developments in the following areas will prove to be significant factors in giving equipment designers access to these design techniques, which traditionally have been available only to designers within the semi-conductor fabrication houses.

Computer Aided Design Tools

The complexity of semi-custom circuits is increasing to such an extent that manual design methods are becoming impractical for the larger circuits. These methods are rapidly being replaced by the use of CAD tools. Current CAD tools consist of software packages for the placement of cells and circuit elements, and automatic routing of interconnect lines. These tools may be used in conjunction with interactive graphics systems. A large amount of worldwide research and development effort is currently being devoted to the CAD area. This includes the development of simulation packages for both logic and circuit stimulation and verification to prove the functionality of the design before fabrication, and test-set generation for final production testing.

Computer aided design of integrated circuits involves the processing of large amounts of data. Until recently, the processing power and memory capacity necessary for this type of function has been available only on large mini or mainframe computer systems, at a highly prohibitive cost. However, this situation is rapidly changing with the advent of the latest high performance microprocessor systems. There is now a trend towards the use of relatively cheap but powerful stand-alone CAD workstations, available on every system designer's desk. Such workstations have minicomputer capability incorporating interactive colour graphics and hard disk for efficient data storage and retrieval. A large amount of proprietary and non-proprietary software is becoming available to run on this type of system. This may often prove to be a viable alternative to the higher performance but considerably more expensive minicomputer running time-shared CAD workstations.

It is considered that the falling costs and increasing performance associated with microprocessor equipment, coupled with the more convenient access provided by a personal system, will cause a rapid increase in the use of stand-alone workstations for computer aided design of custom and semi-custom circuits.

Increasing Standardisation

The availability of second sourcing of custom or semi-custom integrated circuits is a major consideration of most equipment manufacturers. In order to satisfy this requirement, there must be a considerable degree of standardisation within the semiconductor industry.

At present, there is some degree of standardisation of fabrication processes and of mask making techniques within the industry. However, this is not sufficient to ensure that custom designers are readily interchangeable. Areas where standardisation is required include the design rules for semi-custom products, identification of mask orientations and the order of mask sets. There is also a need for standardisation of the test structures included on the masks for testing the validity of the different mask levels after chip fabrication. Standardisation of the uncommitted array approach is further complicated by the fact that most manufacturers have their own proprietary array structures, which ensures that any particular uncommitted array interconnect design is incompatible with the arrays of another manufacturer.

These and other factors indicate that there is a strong need for international standards in the custom and semi-custom microelectronics industry. It is likely that increasing pressure from equipment manufacturers will give rise to further standardisation in the future.

Technology Advances

Integrated circuit technology has advanced rapidly over the last decade. The continuing development of silicon fabrication techniques has resulted in steadily reducing silicon geometries, a trend which is expected to continue over the next decade. The effect of this trend is to increase circuit speed and density, and reduce power consumption per circuit function, with significant implications for custom and semi-custom technology.

The combination of technology and CAD advances will allow larger and more complex custom and semi-custom circuits to be economically designed and fabricated. Thus the range of application of these circuits will continue to expand, as development costs in particular continue to decrease. However, the decision to use this approach is not based solely on the cost of developing and fabricating custom or semi-custom chips. The chips form only part of the equipment cost. There are a number of other important advantages to be gained from the use of this technology, which may be listed as follows:—

- Enhanced circuit performance.
- Increased equipment reliability, due to fewer assembled parts.
- Reduced total equipment assembly size and power dissipation.
- Reduced production line assembly and test.
- Reduced inventory, documentation and spares.
- Enhanced commercial security, due to absence of standard parts and ease of copying.

It is for these reasons that custom and semi-custom circuit design is to become an increasingly viable alternative to traditional "standard parts" circuit design over the next decade.

CONCLUSION

In this paper we have presented the techniques which are currently available for the production of integrated circuits and have compared the methods which make it possible for designers with no experience in integrated circuit design to realize their circuits in integrated form. It is clear that the next decade will see giant strides in this area and make it even easier to produce these circuits economically and quickly.

These developments present an opportunity for companies who previously have been unable to use the technology developed by the major manufacturers. They will be able to use the benefits of integrated circuits to improve their competitive position. This will in turn build a separate industry serving these companies, providing design and manufacturing expertise and assistance.

This greater availability of integrated circuit technology will undoubtedly produce more innovation in the market place. However, because of the increased use of non-standard or proprietary devices it may also lead to difficulties with maintenance and faster obsolescence of products containing these devices. This is a problem which must be kept in mind by major consumers of microelectronics goods and equipment.

ACKNOWLEDGEMENT

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New President for AEIA

The Managing Director of Plessey Pacific Pty Limited, Mr Bruce Goddard, has been appointed the new president of the Australian Electronics Industry Association (AEIA).

He succeeds Mr Allen Deegan, Chairman and Managing Director of Standard Telephones and Cables Pty Limited, who did not seek Presidential re-election but will remain on the Board of Directors.

Newly elected vice-president of the association is Mr Cornelis Bossers, Managing Director of Philips Industries Holding Ltd.

Other executive appointments made at the Annual General Meeting were —

Telecommunications and Defence Division: Chairman, Mr Peter Lane (Standard Telephones and Cables Pty Limited); vice-chairman, Mr Arthur Gabb (Amalgamated Wireless Australasia Ltd).

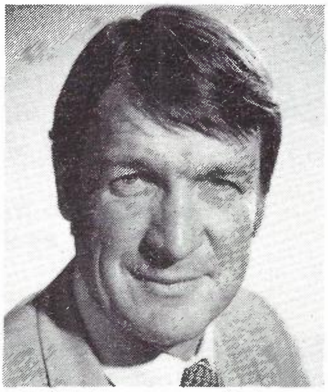
Components Division: Chairman, Mr Bob Gibson (Morris Productions Pty Ltd); vice-chairman, Mr Chris Tyree (Amtron Tyree Pty Ltd).

Mobile Radio Division: Chairman, Mr Terry Stanley (Motorola Electronics Australia Pty. Ltd); vice-chairman, Mr Ian McKenzie (Philips Industries Holdings Ltd).

Retirement of the Chairman, Council of Control

After a number of years as the Chairman, Council of Control of the Telecommunication Society of Australia, Mr Bob McKinnon, the General Manager, Engineering of Telecom Australia, retired from the Council. As the Chairman of the Council, he actively encouraged industry support to the Society. Prior to his retirement from the Council, he instigated an amendment to the Society Constitution, expanding the role of the Society to cover the Information Transfer segment as well as the traditional telecommunications topics. The Society acknowledges Mr McKinnon's leadership and thank him for his contributions. The Chief General Manager of Telecom Australia has appointed Mr Keith Barnes, Chief Planning Engineer to replace Mr McKinnon as the Chairman.

Retirement of Editor for Switching Design Topics



Leo Tyrrell has resigned from the Board of Editors after eight years as the Journal's switching editor.

Mr Tyrrell, BEE, MIE Aust. has recently been appointed as the Assistant Chief Engineer, Construction Telecom headquarters and is no longer directly concerned with switching developments. Prior to this, Mr Tyrrell has for a number of years been closely involved at Headquarters in the development and construction of the switching network.

Most recently he was head of the AXE Project Team which was established to integrate at Headquarters the activities of the various groups who were working towards the smooth introduction of the AXE switching system into the network.

New Production Assistant for the TJA.

The TJA recently announced the appointment of Mr Pat Carroll to the position of Production Assistant.

Pat, who works in Planning Division, Telecom, commenced with the PMG in 1950 as a Technician-in-Training in Victoria. He completed the course and transferred to the clerical ranks in 1957. He was with the Victorian Engineering Administration until 1968 when he was promoted to the Headquarters Engineering Planning Division. He has spent most of his time since then working in the Telephone Switching and Transmission Planning Branches and the Planning Division Secretariat, apart from some time with the Headquarters Personnel Department and the Headquarters Engineering Services Division. He is presently Information Officer with the Planning Division Secretariat; this position also carries out the functions of Secretary of the Headquarters Editorial Board which includes the production of the quarterly Headquarters Engineering Bulletin. His outside interests are more than adequately catered for; he is President of the Doncaster/Templestowe Musical Society.

The Data Communications Transport Service and Protocols

PAUL A. KIRTON B.E. (Hons), Ph.D.

The CCITT and ISO are currently developing international standards for a universal network-independent data Transport Service of uniform quality, and the Transport Protocols which will support it. This paper presents an introduction to the purpose and structure of the Transport Service and its relationship with communication networks. The Transport Service and Protocol standards being developed are also described.

INTRODUCTION

This paper gives an introduction to the Transport Service and Transport Protocols. The aim of the Transport Service is to provide a universal data transfer capability of uniform quality which can be used for data communication between different information processing systems attached to the same or different communication networks.

International standards are currently being developed by the International Organisation for Standardisation (ISO) and the International Consultative Committee for Telephone and Telegraph (CCITT) who are working in close cooperation. The draft standards (Ref. 1, 2, 3) are now very close to completion.

The presence of these standards will facilitate the development of distributed data processing systems.

This paper first discusses the need for a Transport Service, its structure and relationship with communication networks. Then, the Transport Service and Protocol standards are described, and finally an example of transport connection establishment is presented.

THE PURPOSE AND STRUCTURE OF THE TRANSPORT SERVICE

The Reference Model of Open Systems Interconnection (**Fig. 1**) (Ref. 4) provides the framework within which these standards are being developed. The upper three layers of the Reference Model support co-operation between two different end computer systems and the lower four layers provide data communications between the two systems. The lower three layers also provide relay and routing functions necessary to transfer data between the two end systems. The transport layer (layer 4) operates within the two end systems only, so the interfacing network is not aware of what is happening there. The transport layer is provided because there are many different existing networks which vary in quality. It enhances the quality of the underlying networks to produce a universal transport service of uniformly high quality for transporting data between end systems. The information processing application programs in the end systems are thus relieved of any responsibility for the reliable transmission of data.

Fig. 2 shows the underlying communications structure. The two users are in the session layer, but we can think of them representing the combined application, presentation and session layer entities from the point of view of transmitting data reliably between the two ends. The transport layer provides a network independent interface to the users. The transport entities communicate via the underlying Network Service. There could be several networks involved in transmitting the data (e.g. an international call or a call from a public network to a private network), but the users need not be aware of this. The different underlying networks could use different technologies. For instance, Network 1 may be an X.25 (virtual circuit) based packet switching network like Transpac in France or Austpac in Australia, Network 2 could be a datagram based network with connection oriented facilities provided by a network enhancement protocol, like Datapac in Canada, and Network 3 could be a circuit switched network. But irrespective of what type these networks are, the users do not want to be concerned with the different ways they operate. They merely require a consistent service.

The transport layer is built on the service provided by the underlying networks. It consists of a transport entity within each end system which implements the functions of the transport layer. These transport entities talk to one another via a Transport Protocol. The Transport Protocol is shown (Fig. 2) in dotted lines because it is a logical connection between these two entities. In reality it must use the connection services provided by the network service below to pass any data. The Transport Service is the facilities and functions provided to the user. The Transport Protocol is not visible to the user, but implements the functions between the two end systems necessary to provide the Transport Service on top of the underlying Network Service.

It may appear at first that the Network Service provides the same sort of functions that the Transport Service does. It provides the means for connection establishment and it provides facilities for transporting data. In that sense the two are similar, but the Transport Service may provide higher quality connections. For instance, with several different underlying networks as shown in Fig. 2, the quality of the resulting network connection between the two transport entities is no bet-

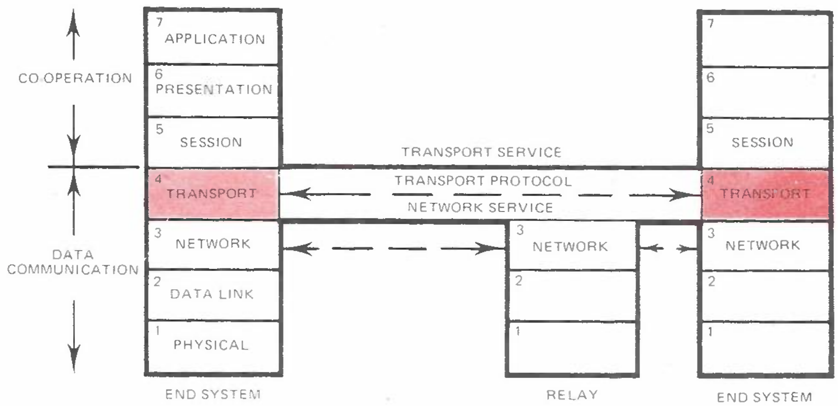


Fig. 1 How the Transport Service fits into the Reference Model.

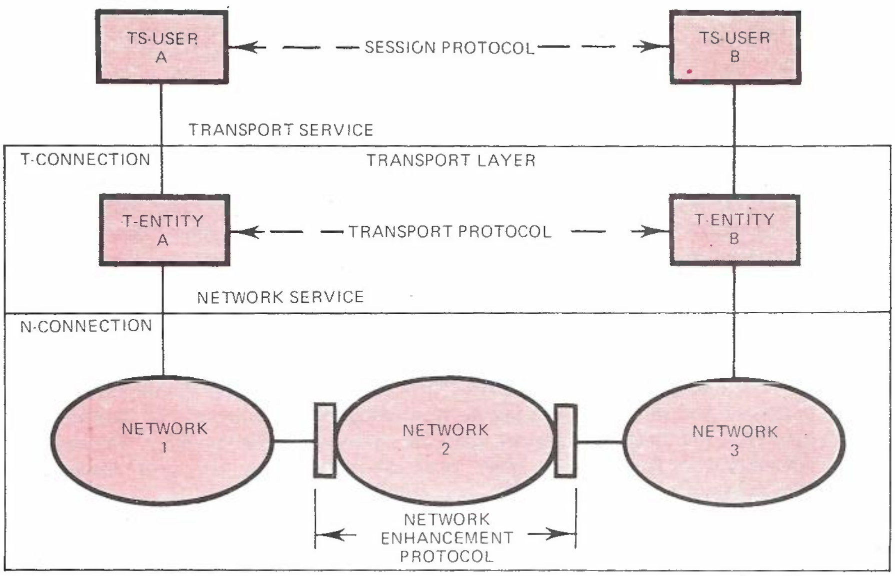


Fig. 2 Transport Service and the underlying network structure

ter than the quality of the poorest network. Typical quality service parameters are the reliability of the connection in terms of how long the connection will last before a failure occurs, and also the accuracy with which the data is transported. If the user would like a higher quality than provided by the network service, some sort of quality enhancement must be provided in the transport layer. For instance, additional error checking facilities and reconnect procedures could be provided. For the latter, if the network connection is disconnected, procedures could be provided within the transport entity to set up a new network connection without the users' knowledge. The users' transport connection remains established. The functions provided by each underlying network must be the same if they are to provide a consistent Network Service. If a network does not provide certain functions, a network enhancement protocol may be required as shown for Network 2 of Fig. 2. A typical example would be the provision of a connection oriented service using a datagram subnetwork. The network enhancement protocol operates between Networks 1 and 3 across network 2 and is considered to be a network layer function.

Another function of the transport layer is to optimise the cost of the network connection. For instance, some networks charge on the basis of call connect time (e.g. circuit switched networks), others charge for call connect time as well as for the number of packets sent. Therefore it may be advantageous to be able to multiplex serveral transport connections on top of one network connection. It may also be cost effective to be able to suspend a particular transport connection. For instance, the user may want to send data periodically to one particular party in another system. He may want to set up the transport connection and leave it set up for a long period of time, maybe for the whole of the working day. The transport entity could automatically take care of monitoring the level of traffic and disconnect the network connection if there has been no data for a certain time to reduce the cost.

In summary, the Network Service provides end-to-end connections between the transport entities in the two end systems, it provides the necessary addressing of the transport entities to set up the connection between the two, and it provides any routing and relay functions. The transport layer exists in the end systems. It provides any quality enhancement of the connection to build the network quality up to a standard required by the user. It also provides cost optimisation and another level of addressing for addressing different session entities.

At this point it is beneficial to clarify the distinction between the term "network" as defined in the Reference Model and "network" as commonly used to describe the services provided by an administration such as Telecom Australia. The ISO/CCITT Reference Model defines the network layer as a set of functions (e.g. routing) that are required to support data communications. This is an abstract description which is meant to be independent of any particular implementation. An Administration's "network" typically includes all the physical equipment such as computers and transmission media as well as operation support services such as network management, accounting and directory assistance. These include application layer functions for both internal use (e.g. network management) and external use (e.g. automated directory assistance). Thus an Administration would need to implement all layers of the Reference Model for certain applications.

THE TRANSPORT SERVICE DEFINITION

The Transport Service currently being defined is connection oriented. By connection we mean that a logical path is initially set up between two end users. Any data units which are then transmitted, follow the same path and stay in sequence.

Another form is the connectionless Transport Service. In this case each transport message is routed independently even for the same destination. Therefore messages may get out of sequence. This is a datagram type of facility and is "for further study." The connectionless service is useful in situations such as credit checking where only a limited amount of data is to be sent in each direction and the overhead in establishing a connection is not warranted.

Within the connection oriented service, there are three basic phases to a transport connection : the establishment phase, the data transfer phase and the release phase. The transport service provides specific services to the session entities which are the users of the transport service. These are the connection establishment service which provides facilities for the user to select the required connection quality, data transfer service which provides transparent transfer of data between the end systems, an expedited data service whereby a limited quantity of data can bypass the normal flow control (e.g. to abort an application that is not accepting data — this is similar to the interrupt packet in X.25), and a connection release service which will terminate a call irrespective of the current state of the call (e.g. partly established or during data transfer). The release is destructive. That is, once the release procedure has commenced any data that is in transit could be lost. It is up to the users of the transport service to ensure that all data is received prior to disconnection. Such a graceful release is one of the functions provided by the session layer.

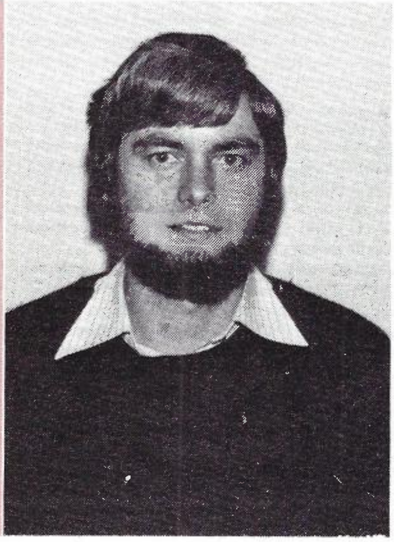
The Transport Service specification defines the interactions between the transport user and the Transport Service provider in terms of transport service primitives which are an abstract (i.e. implementation in-

Phase	Service	Primitive	Parameters
Connection Establishment	Connection Establishment	T-CONNECT request	(called address, calling request, expedited data option, quality of service, TS-user data)
		T-CONNECT indication	(called address, calling address, expedited data option, quality of service, TS-user data)
		T-CONNECT response	(quality of service, responding address, expedited data option, TS-user data)
		T-CONNECT confirmation	(quality of service, responding address, expedited data option, TS-user data)
Data transfer	Normal data transfer	T-DATA request T-DATA indication	(TS-user data) (TS-user data)
	Expedited data transfer (X)	T-EXPEDITED-DATA request	(TS-user data)
		T-EXPEDITED-DATA indication	(TS-user data)
Connection release	Connection release	T-DISCONNECT request T-DISCONNECT indication	(TS-user data) (Disconnect reason, TS-user data)

X) service provided only upon TS-user request

TABLE 1. TRANSPORT SERVICE PRIMITIVES

PAUL KIRTON graduated from Monash University Clayton, Victoria with B.E. and Ph.D. degrees in 1974 and 1981 respectively. While at Monash University he conducted research into linear phase filter approximation theory and microwave stripline filter design. In 1978 he joined the Switching and Signalling Branch of the Telecom Australia Research Laboratories in Clayton Victoria. There he worked on the development of instruments for monitoring the performance of computer controlled telephone exchanges. From 1981 he investigated the transport layer of the ISO/CCITT Reference Model of Open Systems Interconnection. He has also helped develop formal methods for specifying communication protocols and services. Currently he is working at the University of Southern California, Information Sciences Institute in Los Angeles under a Telecom Development Award. His main area of work there is multi-network interconnection.



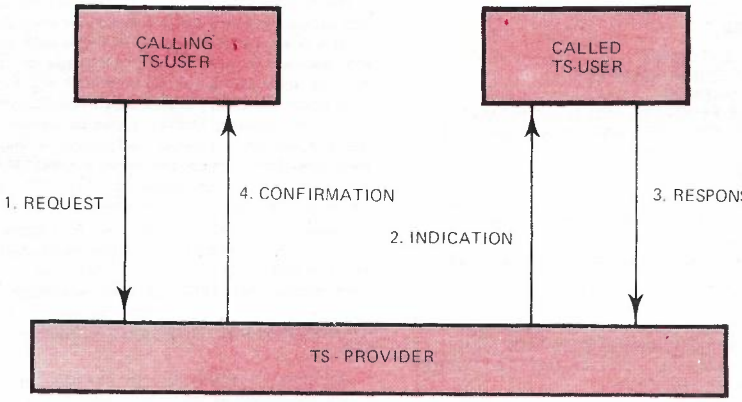


Fig. 3 The four variants of a service primitive

dependent) means of defining the commands and responses which go between the two. It also specifies the parameters associated with the particular primitives and the relationship between valid sequences of actions. Table 1 lists the Transport Service primitives and their parameters. There are four Transport Service primitive types: T-CONNECT, T-DATA, T-EXPEDITED-DATA and T-DISCONNECT, — one for each type of service. There can be up to four variants of a service primitive type, which will be illustrated for the T-CONNECT service primitive. **Fig. 3** shows the Transport Service provider and two users. A T-CONNECT request is a command from the calling user to the transport service provider requesting the establishment of a connection. A T-CONNECT indication is from the provider to the called user indicating that a connection has been requested. A T-CONNECT response from the called user to the transport service provider to the initiating transport service user completes the connection establishment. The service primitives have parameters which represent information transferred between the user and provider. The T-CONNECT request parameters are : the called address, calling address, whether expedited data is required, the quality of service that the user would like and also a limited amount of transport service user data. Specifying interactions in this manner does not specify the syntax or type of internal command that would be used in any implementation. We have an abstract description so that two different systems can represent their actions using common terminology.

The user data in the T-CONNECT is provided to help reduce the overall connection establishment delay overhead for all layers of an application connection by allowing some information about the session connection to be passed with the transport connection request.

Within the quality of service parameters there are performance parameters which indicate speed, such as establishment delay, transit delay and throughput; reliability, such as connection establishment failure probability; and accuracy such as residual error rate (the number of errors in the data being transported which go undetected). These are listed in Table 2.

The Transport Protocols are designed to enhance the reliability and accuracy of network connections but not their speed. From a user's point of view it may be desirable to group the quality of service parameters to reflect the requirements of typical applications. For example, real time transactions such as credit checking require low establishment and transit delays but high throughput is not necessary. Whereas for a large file transfer high throughput is required but establishment and transit delay are of less concern.

The relationship between the service primitives at the two ends of a connection must be specified. Time sequence diagrams can be used to do this in an informal manner. **Fig. 4** illustrates their use for a successful connection establishment. The arrows represent service primitives. The left vertical line represent time sequence within System A and the right vertical line that's in System B. The dashed lines indicate a casual relationship between events in the two systems.

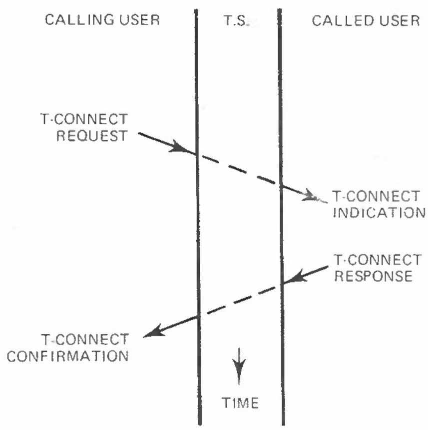


Fig. 4 Time sequence diagram for successful transport connection establishment

The above description methods for the Transport Service are informal as they rely heavily on natural language. In order to have a complete and unambiguous specification a formal description technique must be used as the authoritative specification. Suitable specification languages are currently being developed by both ISO and CCITT. They use a limited set of precisely defined language constructs so that a specification can only be interpreted in one way.

PHASE	PERFORMANCE CRITERION	
	SPEED	ACCURACY/RELIABILITY
ESTABLISHMENT	Establishment delay	Connection establishment failure probability (misconnection)
DATA TRANSFER	Throughput	Residual error rate (corruption, misdelivery, duplication/loss)
	Transit delay	Transport connection resilience
DISCONNECTION	Clearing delay	Disconnection failure probability

TABLE 2. CLASSIFICATION OF PERFORMANCE QUALITY OF SERVICE PARAMETERS

THE TRANSPORT PROTOCOL

The Transport Service is composed of a Transport Protocol sitting on top of the Network Service. It is the Transport Protocol that implements the functions of the transport layer. The functions of the Transport Protocol are listed in Table 3. During the connection establishment phase, the Transport Protocol must select the appropriate Network Service. There could be several networks via which one user may call another, and a given network may offer a range of different service qualities. The network service which best matches the request from the user should be selected. A decision must be made whether or not to multiplex the transport connection onto an existing network connection. This is based on cost optimisation and performance factors. The appropriate transport protocol data unit size must be selected. The size of a Transport Service Data Unit (T-SDU) being passed from the Transport Service user is independent of the size of the Transport Protocol Data Unit (TPDU) transmitted over the network connection. The transport address must be mapped to the appropriate underlying network address. This implies that directory and address translation functions exist within the transport entity. We would like these to be transparent to the user. For instance a user may be able to address a remote entity by name. The transport entity translates this to a network number internally without the user having to do so.

Connection phase:

- select network service
- decide whether to multiplex
- select optimum TPDU size
- select data phase functions
- map transport address to network address
- distinguish between T-connections

Data transfer phase:

- concatenation
- segmenting
- TSDU delimiting
- multiplexing
- T-connection identification
- flow control
- error detection
- error recovery
- expedited data

Release phase:

Disconnection regardless of current state.

Additional functions:

- protocol version identification
- security checks
- encryption
- checksum
- priority
- accounting
- quality of service monitoring

TABLE 3. TRANSPORT PROTOCOL FUNCTIONS

Within the data transfer phase, blocking, segmenting and concatenation functions are provided. Because the TSDU and TPDU size may be different several TSDU's may be blocked into a single TPDU or a single TSDU may be segmented and transferred by several TPDU's. Similary several TPDU's may be concatenated into a single Network Service Data Unit (NSDU) When multiplexing several transport connections onto a single network connection means of identifying the individual transport connections must be provided. Flow control is provided to match the data receiving rate and sending rate at the two ends. Error detection and recovery functions may be needed in cases where the network service quality is not sufficient. Also an expedited data transfer service is provided.

Release functions can be invoked irrespective of the current state of the connection.

There are certain additional functions which have not been completely specified as yet, but are recognised as being valid transport layer functions. Examples are security checks on users, data encryption, connection priority, accounting functions and quality of service monitoring. Some of these functions may be provided by other layers.

Service primitives provide the interactions between the users and the transport service provider, i.e. between adjacent layers. The units of interaction between the transport entities within the transport layer are called transport protocol data units and are listed in Table 4.

CONTROL
CONNECTION REQUEST AND CONFIRM
DISCONNECTION REQUEST AND CONFIRM
DATA ACKNOWLEDGEMENT
EXPEDITED DATA ACKNOWLEDGEMENT
REJECT
TPDU ERROR
DATA
DATA
EXPEDITED DATA

TABLE 4. TRANSPORT PROTOCOL DATA UNITS

They are divided into two types, control and data. The control TPDU's provide connection establishment and release. There are also Data Acknowledgement and Reject TPDU's to support error recovery procedures. The Reject TPDU requests a retransmission when loss of data is detected. If a TPDU cannot be recognized an Error TPDU is returned. The Data and Expedited Data TPDU's transport the data and expedited data of the user.

There are many functions provided by the Transport Protocol. Depending on the quality and cost of a network connection not all of them may be required. To facilitate interworking the possible functions have been organised into five classes with options. A class is a specified set of functions. Thus users can implement a specific class and know that the same functions will be implemented by a correspondent user of the same class. The five classes are: simple class (which corresponds to Teletex), basic error recovery class, multiplexing class, error recovery and multiplexing class, and error recovery and detection class.

The choice of which class to use is based on the quality of service required by the user and the quality of the network connection that has been established. Different network connections are classified broadly into three categories. A type A network connection is one where the residual and signalled error rates are satisfactory to the user. Residual errors are the errors that go undetected by the network such as bit errors, out of sequence TPDU's and lost TPDU's. Signalled errors are those that the network has detected but cannot recover from. There are two types of error signals from the network. A RESET indicates that data may have been lost but the connection is still intact and a DISCONNECT indicates that the connection has been lost and possible data lost also. Any recovery must be done by the Network Service user. A type B network connection is one where the residual error rate is satisfactory but the signalled error rate is unsatisfactory. For instance, the network connection may collapse too often and the user doesn't want to be concerning himself with re-establishing the connection all the time. We would like the transport entity to look after this automatically. Finally the type C network connection is one where the residual and the signalled error rates are unsatisfactory to the user. To use a type C networks the user could require a more complex transport protocol capable of automatically detecting and recovering from errors.

The matrix of Table 5 shows the relationship between the different types of network connections (N-connections), the different Transport Protocol classes and whether or not multiplexing is provided. Classes 0 and 1 have no multiplexing or end-to-end flow control, whereas Classes 2, 3 and 4 provide multiplexing and flow control (optional in class 2). Classes 0 and 2 provide neither error recovery nor detection and hence are only suitable for use over Type A network connections. Classes 1 and 3 provide error recovery and are hence suitable for use over Type B network connections and class 4 provides error recovery and detection and is hence suitable for use over a Type C network connection.

In order to avoid duplicated effort in developing these protocols the CCITT is taking prime responsibility for Classes 0 and 1 and the ISO for Classes 2, 3 and 4.

The Class 0 Transport Protocol is the same as CCITT Recommendation S.70 for Teletex. Teletex is a high speed (2.4 kb/s) enhanced form of Telex designed for communication between word processors. This will provide a first sort of electronic mail facility between different business offices whereby documents that are typed up on one word processing system can be transmitted directly to another. The Teletex Recommendations also include Session (S.62) and Presentation Layer (S.61) procedures required to support document transfer. The Class 0 Transport Protocol only includes the transport layer functions of the Teletex procedures. The functions of the Class 0 Transport Protocol are summarised in Table 6. The Class 0 Transport Protocol only provides connection establishment and data transfer services. It does not provide explicit disconnection, i.e. using a Disconnect TPDU; but relies on the release service of the network layer to inform the remote transport entity of disconnection. It does not provide expedited data or user data during a connection establishment, and therefore does not support the full Transport Service. Other functions not provided include multiplexing, end-to-end flow control, error recovery and error detection. End-to-end flow control refers to explicit credits passed between the Transport entities indicating the number of TPDU's that may be sent. In the absence of this function the Class 0 protocol relies on backpressure flow control. That is, when a transport entity cannot receive any more data it applies local flow control at the network connection interface. As the buffers within the network connection fill up the correspondent transport entity will then be informed by its own network interface that the connection cannot accept more data.

5 CLASSES

0 : SIMPLE (TELETEX)
1 : BASIC ERROR RECOVERY
2 : MULTIPLEXING
3 : ERROR RECOVERY AND MULTIPLEXING
4 : ERROR RECOVERY AND DETECTION CLASS

CHOICE BASED ON:

— USER REQUIREMENTS QUALITY AND COST
— QUALITY OF NETWORK CONNECTION

NETWORK CONNECTIONS CLASSIFIED AS:

TYPE A RESIDUAL & SIGNALLED ERROR RATES O.K.
TYPE B RESIDUAL ERROR RATE O.K. — SIGNALLED ERROR RATE TOO HIGH
TYPE C RESIDUAL AND SIGNALLED ERROR RATES TOO HIGH

NETWORK TYPE	CLASS WITH NO MULTIPLEXING	CLASS WITH MULTIPLEXING
A	0	2
B	1	3
C	—	4
	CCITT	ISO

TABLE 5. TRANSPORT PROTOCOL CLASSES

SIMPLE CLASS (0)

- CCITT Rec. S.70 — telex
- Use with type A network-connection

- **Provides:**
- connection establishment
- data transfer with segmenting
- protocol error reporting

- **Does not provide:**
  - — multiplexing
  - — explicit disconnection
  - — flow control
  - — error recovery
  - — expedited data
  - — user data in connection establishment

BASIC ERROR RECOVERY CLASS (1)

- Use with type B networks (typically X.25 based)
- Recovery from network disconnect and reset
  - — TPDUs have sequence numbers
  - — copies retained until acknowledged
  - — REJECT command
- User data in connect
- expedited data
- explicit disconnection
- no flow control or multiplexing

TABLE 6. TRANSPORT PROTOCOL CLASSES 0.1

The functions of the Class 1 Transport Protocol are also summarised in Table 6. Class 1 has been designed to recover from network signalled errors such as resets and disconnects and to take advantage of Network Services such as Receipt Confirmation and Expedited Data which are usually provided by networks with X.25 access. The recovery function works by allocating each TPDU a sequence number and saving a copy until acknowledged by the correspondent transport entity. On receipt of a reset or disconnect from the network, retransmission can be commenced from the last unacknowledged TPDU. In the case of a disconnect a new network connection must first be established. TPDU acknowledgement can either use a Data Acknowledgement TPDU or take advantage of the Network Receipt Confirmation Service if available. Retransmission may be requested by sending a Reject TPDU.

The Class 1 protocol also provides user data transfer during connection establishment, expedited data (using either the Expedited Data TPDU or the network Expedited Data Transfer Service) and explicit disconnection using the Disconnect TPDU. It does not provide multiplexing or end-to-end flow control.

The function of the Class 2, 3 and 4 Transport Protocols are summarised in Table 7. Classes 2, 3 and 4 form a hierarchy in that all functions of Class 2 are provided by Class 3 and all of Class 3 are provided by Class 4. They all support multiplexing of several transport connections onto a single network connection. The individual transport connections are identified by a Destination Reference number in the header of each TPDU. To prevent domination of the network connection by any one of the multiplexed transport connections these classes also provide end-to-end flow control (optional in Class 2). The detail of the flow control mechanism varies for each class but broadly works as follows. The data TPDU's are sequentially numbered for each direction of transmission. The receiving entity indicates the next expected sequence number in the Data Acknowledgement TPDU together with a credit which indicates the number of additional data TPDU's the entity is prepared to receive. The sending entity may send TPDU's with sequence numbers up to the next expected plus the credit, but must then wait for further acknowledgement and credit. Class 2, 3 and 4 all provide expedited data which has separate flow control from normal data. However only one Expedited Data TPDU may be unacknowledged at any time and the quantity of user data is limited to 16 octets. Expedited data allows the normal data flow control to be bypassed. For example, consider a text file transfer from a computer system to a remote printer. Because the printer is much slower than the computer the printer would accept a block of data and then use flow control to prevent the computer from sending further data until it is ready. Consider the case where the sending user decides to abort the file transfer. Without expedited data the user's abort command would not be received until the previously sent text had all been printed, but expedited data allows this flow control to be bypassed and the abort command to be passed on immediately.

MULTIPLEXING CLASS (2)

- Use with type A network connections
- Multiplexing — uses destination reference
- Flow control optional
  - — transmit window provided using sequence numbers and credit
- No error recovery
- expedited data allowed

ERROR RECOVERY & MULTIPLEXING CLASS (3)

- Use with type B network connection
- Class 2 functions included
- Error recovery similar to class 1

ERROR RECOVERY & DETECTION CLASS (4)

- use with type C network connection
- class 3 functions included
- detects loss, out of sequence, duplicate TPDU's by use of sequence numbers, retransmission on time out
- checksum option

TABLE 7. TRANSPORT PROTOCOL CLASSES 2, 3 AND 4

Class 2 provides neither error recovery nor detection. Class 3 provides error recovery similar to that provided in Class 1 and Class 4 provides error detection as well. The error detection function utilises the sequence numbers of data TPDU's to detect out of sequence and duplicate TPDU's. Time outs on acknowledgements are used to detect lost TPDU's which are then retransmitted. A checksum may optionally be added to TPDU's if bit errors are considered a problem. Most public data networks have a satisfactory residual error rate so that Class 1 or 3 protocols will probably be the most commonly supported. Many North Americans tend to favour Class 1 as it can take full advantage of existing network facilities, while European manufacturers are giving more support to the Class 2, 3 and 4 hierarchy because they are more network independent, provide multiplexing, which suits the European tariff structure, and can be implemented in a unified manner.

To facilitate Open Systems Interconnection it is desirable to have a common protocol class implemented within all open systems. Class 0 has been proposed by CCITT because it is the simplest class. However, it does not support the full Transport Service.

TRANSPORT CONNECTION ESTABLISHMENT EXAMPLE

In this section the different functions are put together to see what happens when a transport connection is successfully established. the different signals that pass between the users, between the transport entities and to the network service will be described.

Fig. 5 shows two transport service users who wish to communicate with one another. Their respective transport entities and the network which does all the routing and relay functions between the two end systems are also shown.

The first thing that happens is that transport user-A, who is requesting the connmection, sends a transport connection request command (1) to his transport entity (A). This command will include the necessary addressing information and any quality of service requirements of the user. The first thing the transport entity must do is to examine the addressing information to determine the network address of the called transport entity. A directory function may be utilised. The quality of service and cost requested by the user must be examined in order to decide whether to multiplex onto an existing network connection or set up a new network connection.

Assuming that a new network connection is required a network connect request command (2) is sent to the network service to set-up a network connection to the transport entity (B) at the other end. The network does all the necessary routing functions and then notifies transport entity B that there is an incoming network connection (3). Transport entity B can accept the network connection with a network connect response (4) which results in a network connection confirmation (5) at transport entity A. At this point in time a network connection is set up between the two transport entities and that means that we can now transfer information between the two end systems. The network service informs transport entity A about the network connection quality using parameters of the N-CONNECT-Confirm.

Transport entity A now knows the quality requested by the user and the quality provided by the underlying network so that any difference in quality must be provided by appropriate transport layer functions. Transport entity A can now select the appropriate class of Transport Protocol to build the quality up to that requested by the user. Let us assume Class 1 is selected. This information is included in a connection request TPDU (6) and sent from entity A to entity B via the network connection. On receipt of this TPDU entity B notes the protocol class requested and decides whether it can support that particular class or must negotiate the use of a lower class.

Let us assume that entity B only supports Class 0 and is prepared to accept the connection. It must determine the resultant transport connection quality on the basis of a Class 0 protocol using the previously established network connection. It notifies Transport Service user B of the incoming connection by sending a Connect Indication (7) which includes the quality of service as parameters. Note that the quality of service indicated to user B is that determined by entity B not that requested by user A. The former will be less than the latter because of the reduced protocol class.

User B can decide to accept the connection, in which case he responds with a connect response command (8), or not to accept the connection, in which case he would respond with a disconnect response command including an appropriate reason. Assuming he accepts the request, entity B then sends a connect confirmation TPDU (9) over the network connection to entity A indicating the reduced protocol class and service quality. At this stage, note that the only interaction between transport entity A and transport user A has been the submission of a Connect Request. All other interactions are completely transparent to the user. The user doesn't have to be concerned with how the addressing and negotiation of quality of service is achieved.

The final signal in establishing the connection is the Connect Confirmation response (10) sent by transport entity A to Transport Service user A. The Connect Confirmation includes parameters specifying the actual quality of the established transport connection. This quality will be less than the quality requested by user A because of the reduced protocol class. It is, to user A whether he will accept this or reject it by issuing a disconnect request.

This example provides a summary of the interactions involved in establishing a transport connection and how the transport service makes many of the functions transparent to the user.

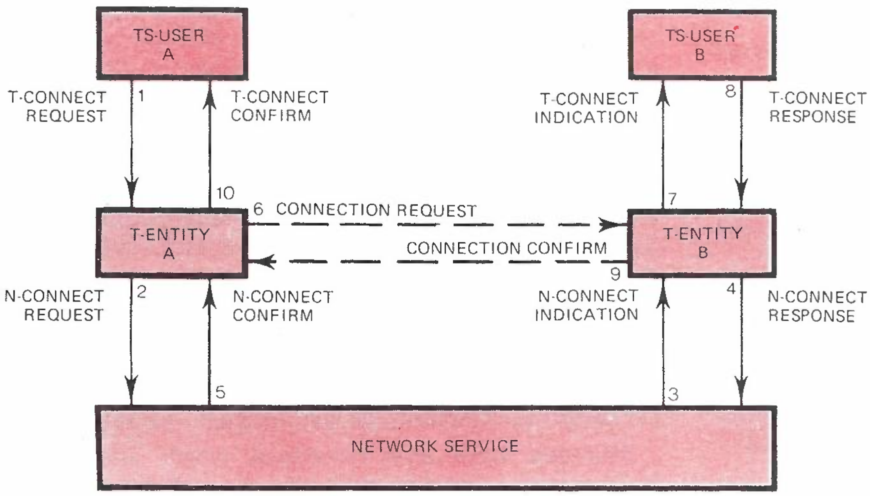


Fig. 5 Transport Connection establishment

FURTHER WORK

Because the transport protocols are implemented in end systems many different implementations throughout the world will need to interwork. It is therefore necessary to formally specify the Transport Service and Protocols in a complete and unambiguous manner so that different implementers will interpret the specifications identically. Some of the protocol procedures are quite complex. It is necessary to verify these procedures against the service specification. It is also desirable to analyse the performance of these protocols under a variety of operating conditions.

The ultimate test of any standard is experience with implemented systems. It is desirable to conduct interworking experiments between different systems across multiple networks to see what the real performance of these protocols is.

CONCLUSION

The implementation of an international standard data Transport Service will open the way for the rapid development of distributed data processing applications and for universal data communications between businesses and eventually households.

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This article was first published in Vol. 33/3, 1983. Due to a production error, a number of diagrams were incorrectly referenced and positioned. For the benefit of our readers, the errors have been corrected and this article is reprinted in full. We regret any inconveniences caused.

In 1983, Refresher Courses were introduced into the range of TJA features on the suggestions from several readers. The first in the series was Optical Communications and this is now followed by a group which encompasses Data Communications. In each case we are indebted to the Information and Publicity Office of Telecom for supplying the original material.
Editor-in-Chief

From Morse to Telex

In 1844, an American called Samuel Finley Breese Morse sent the first message over a telegraph line between Baltimore and Washington in the United States, using a signalling code of his own invention. The message read "What hath God wrought?"

There had been other telegraph systems before Morse; in particular the Englishman Charles Wheatstone had developed a system using the deflections of a needle which was used in railway signalling. Both Wheatstone and Morse were indebted for their basic ideas to the American, Joseph Henry, who, however, did not patent his inventions.

But what made Morse's system different, and what caused it to be the telegraph system universally employed, were two factors; firstly, Morse's ability to lobby the United States Congress and convince them to pay for the construction of the first commercial telegraph line; and secondly, the simplicity and ease of the "Morse Code." Skilled operators could eventually send messages in the code at up to thirty words a minute.

Morse's basic telegraph system was extremely simple: the operator opened or closed a switch (known as the "key") to send electricity from a battery along the telegraph wire: the return path for the current was through the ground. At the receiving end, the pulses of current operated a pen which marked a strip of paper (later known as "ticker-tape") whenever current was present. Later, skilled operators found they could spell out the message just listening to the sound that the pen made; and eventually the marker was replaced by a mechanism to amplify the sound.

The problem was how to use these pulses of electrical current to represent the letters of the alphabet and to spell out a message.

Morse decided that the best way was to use two different kinds of electrical pulse: one short and one long; a dot and a dash. By combining these two kinds of pulses, it was possible to represent every letter in the alphabet by a code of four pulses or less.

He made a careful study of the frequencies of different letters of the alphabet used in printing, by examining the numbers of each letter kept in typesetters' print trays. He then gave the letters which were most frequent the shortest codes. In this way, the number of pulses that had to be sent to communicate an average sentence in English could be kept to the minimum.

Thus the letter "E," which is the most commonly used in English, was given a Morse code of a single dot. The next most common letter, "T," was represented by a single dash. Less common letters were combinations of dots and dashes. Numerals and punctuation marks were made up of combinations of five and six pulses respectively.

There was a strict set of rules governing how to send messages in Morse Code. A dash was to last as long as three dots. A space as long as one dot was left between the pulses making up the same letter. A space as long as one dash was left between different letters, and a space as long as five dots was left between different words.

Although all this starts to sound very complicated, in practice the operators soon found they could send and receive the messages with increasing speed and reliability. In a very short time, Morse's telegraph system became adopted in almost every industrial country in the world.

The first telegraph line to be erected in Australia was in 1854, between Melbourne and Sandridge (now Williamstown). Other lines in other colonies quickly followed.

By the turn of the century, the manual Morse system in Australia covered some 20,000 miles. With trunk telephony still on the horizon, and interstate trunk calls still 20 years in the future, the demand for telegraph transmission was increasing rapidly. An operator was only capable of transmitting an average of 40 words per minute. To fully utilize the carrying capacity of these single-wire earth return circuits, a speedier system was needed.

About 1900, Wheatstone invented an automatic Morse transmitter which would transmit up to 400 w.p.m. on a good line. Operators at keyboard paper tape punching machines prepared tapes which were punched in Morse Code and converted to electric pulses by the transmitter or reader. At the receiving end, an improved high speed inking register was installed on the line. The tapes, marked in Morse Code, were then handed to operators to decode. Driven by weights or battery powered DC electric motors, this system was in use in the Australian telegraph service for many years.

As telegraph traffic increased, engineers looked for other means to increase the message carrying capacity of the telegraph lines. Many methods were proposed, but only the more worthy survived. A French inventor, Baudot, contrived a character code better suited to automatic operation, consisting of five units. This new code enabled the manufacture of page printed telegraph machines which resembled the typewriter, and reduced the amount of training required for the operator — but increased the complexity for the telegraph mechanic.

Methods were also developed which enabled 'multiplexing' — sending more than one message along the same line at the same time. Two, three or four channels could be combined by transmitting the code for one character from the first channel, then one from the second, and so on. At the receiving end, these signals were sorted out in correct sequence by equipment in exact synchronism with the sending equipment.

Such methods were used on heavy traffic telegraphic lines in Australia until the early 1950s.

The increase in telegram traffic between post offices and the growth in private line telegraph services between business houses, generated a demand for a page printing telegraph machine which could be operated without knowledge of special codes and procedures. The Teletype Model 12 System used a Morkrum Printer as a receiver in an early attempt to build a direct printing, keyboard operated, page printing system. By late 1920, more sophisticated versions from Teletype and Creed Companies became so well known that these trade names have passed into the language. The general name for this kind of equipment is the 'teleprinter'.

By the 1950s, the Teleprinter was the main telegraph terminal device in use. There was then a growing need for post offices to be able to communicate direct with each other, in order to handle the growing telegram traffic. To this end, the Australian Post Office instituted a message switching system called the Teleprinter Reperforator Exchange Switching System (TRESS) in 1959. By this system a series of automatic switching centres directs each message to its destination for printing out on the receiving teleprinter.

To send a telegram by TRESS, an operator types out the correct address code at the start of the message on the teleprinter, and completes the telegram. At the switching centre, equipment recognises the address, stores the message and transmits the telegram to the receiving teleprinter when the line is free.

The Creed model teleprinter, based on a printing telegraph developed by the Creed brothers in England early this century, can transmit approximately 66 w.p.m. which compares with an experienced typist's average speed of 50 w.p.m.

Morse code had long been replaced on main line routes, but the nationwide introduction of TRESS over the next few years marked its disappearance entirely from country and surburban lines by the early 1960s.

There is a rapidly growing worldwide demand for the transmission of business and commercial messages with a written record. The business world recognised the usefulness of the telegraph printer for this purpose, and many point-to-point services were established. Telecommunications administrations throughout the world, and in this country, recognised the advantages of connecting telegraph machines together over a network of switching points and connecting paths, so they instituted a fully automated teleprinter exchange service called 'telex' in 1954.

The Australian telex network operates in a similar manner to the telephone service, with connection possible to telex subscribers anywhere in Australia or the world for 'talking in type'.

A telex subscriber merely types out the telex number or code for the called party, awaits an acknowledgement from the called machine and then transmits even if the called teleprinter is not staffed. The call can operate as a 'conversation,' each subscriber being able to answer the other during the call.

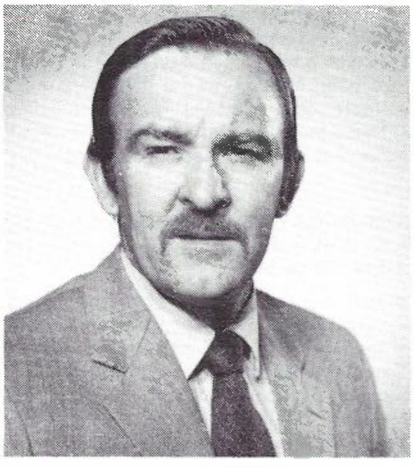
Auxiliary to telegraphy are various machines for the facsimile reproduction of drawings, documents and photographs. In the past, the transmission of photographs by news agencies, and of meteorological information in the form of weather charts, has proved very successful but too expensive for general use.

Only recently has the idea of using facsimile transmission for ordinary business gained momentum, due largely to the development of cheaper equipment. All business facsimile machines work on the same basic principle. In each case a reader of some kind converts the optical information on a document into an electrical signal which is then transmitted down a telephone line to a receiver at the other end. The signal is essentially the same as that used to carry speech between conventional telephones. At the receiving end it is used to reproduce an exact copy of the original document by any of a number of copying techniques.

Growth in the general acceptance of facsimile transmission, however, is slow but during the next few years most business facsimile units are expected to be installed as part of a single, simple system linking perhaps only two locations and expanding in due course to corporation-wide networks, and eventually into national and international networks similar to today's telex networks.

Telegraph-type communication has been the forerunner of information transfer for well over a century and in its latest form, digital transmission, its life will extend well into the future.

Information Transfer News Item



Telecom Senior Appointment

Dr Laurie Mackechnie will be promoted as Telecom's General Manager, Commercial Services as from 15 April, 1984. He succeeds Mr Mel Ward who will become Chief General Manager, Telecom from that date.

Dr Mackechnie is currently Chief Development Engineer at Telecom Headquarters. A member of the Australian Institute of Management, he is a B.E. Hons, M. Eng Sc (Melb), M. Admin (Monash) and a PhD (Notre Dame USA).

Aged 38, he began his career as a Cadet Engineer in the PMG's Dept. After 8 years in the PMG's Research Laboratories, he headed up Telecom's Computer-Co-ordination (1975-77), and Radio Communications Construction (1977-1980) prior to promotion to Assistant Chief Engineer Construction (1980-83).

ABSTRACTS: Vol. 34 No. 1

THE NEW GOLD TELEPHONE FROM TELECOM AUSTRALIA: J. C. Mitchell, Telecom Journal of Aust. Vol. 34, No. 1, 1984, Page 3.

The Gold Phone is a new coin telephone intended for the generally supervised small business market. As a successor to the familiar Red Phone it will provide a service to customers and an attractive source of revenue for the business. This paper looks at the reasons for the development of the Gold Phone and discusses its basic features and many new facilities including STD/ISD access, electronic coin validation and display of remaining credit.

LOW COST POWER SUPPLY SYSTEMS FOR RURAL TELECOMMUNICATIONS NETWORKS: N. K. Thuan and M. R. Mack, Telecom Journal of Aust. Vol. 34, No. 1, 1984, Page 13.

There are many problems and issues which power supply designers must resolve in the powering of a rural and remote telecommunications network. This paper examines the issues, problems and some fundamental principles concerning the provision of reliable low-cost power supplies to meet the demands of both new transmission technology and the unique Australian environment.

FATIGUE CRACKING IN ORMAT ENERGY CONVERTERS: R. J. A. Mason, Telecom Journal of Aust. Vol. 34, No. 1, 1984, Page 27.

The failure of several Ormat Energy Converters which provide power on the Moomba-Sydney gas pipeline was found to be due to fatigue cracking of the boiler area immediately above the gas burners due to the flame impingement heights within the burners being too low. A relatively simple and inexpensive modification to overcome this problem has been carried out on each of the converters in the field, but further cracking can be expected because of the already accumulated fatigue damage. Any further cracking however, is not expected to be of a serious nature and may be repaired quickly on-site.

CALL CHARGE ANALYSIS SYSTEM: G Conroy and R. G. James, Telecom Journal of Aust. Vol. 34, No. 1, 1984, Page 31.

Telecom Australia is now installing the Call Charge Analysis System (CCAS) in all State capitals to provide greatly improved facilities for the investigation of the metered call component of customer accounts and also to provide automatic surveillance of the metering system. This article describes the equipment and the facilities of CCAS.

EXCHANGE REFERENCE FILE: M. Chin and R. Truscott, Telecom Journal of Aust. Vol. 34, No. 1, 1984, Page 37.

This article briefly traces the development of the Exchange Reference File date base and broadly describes the major components of the system.

USE OF PLAIN COPPER CONDUCTORS IN LIEU OF TINNED-COPPER FOR INTERNAL CABLES: B. T. de Boer and K. G. Mottram, Telecom Journal of Aust. Vol. 34, No. 1, 1984, Page 45.

Telecom Australia has specified and used tinned-copper conductors, with PVC insulation and sheathing, for most internal cabling within telephone exchanges and subscribers' buildings. Following some reported problems associated with solderability, an investigation showed that the current production tinned conductors in Australia were inadequately specified; however, the excellent performance of plain copper prompted a more detailed investigation which revealed that plain copper conductors (i.e. no tinning) were suitable for all current applications of internal cable. As a result of this work, Telecom Australia has adopted plain copper as the standard for internal cables.

PLANNING FOR DIGITAL NETWORK SYNCHRONISATION: J. M. Burton and J. A. Bylstra, Telecom Journal of Aust. Vol. 34, No. 1, 1984, Page 53.

This paper describes the need for digital network synchronisation and the planning of a synchronisation network for the Australian IDN.

The TELEX 2000 Premium Teleprinter: D. Ross and K. Cibis, Telecom Journal of Aust. Vol. 34, No. 1, 1984, Page 57.

The TELEX 2000 teleprinter provides Telecom with a telex terminal which is compatible with the requirements of the contemporary office environment. This article outlines how the TELEX 2000 performs the function of interfacing the existing Telex Service with the modern office as well as considering the impact of technological change on the evolution of telex teleprinters.

COMPUTER BASED MESSAGE SYSTEMS: I. Davidson and G. Jenkins, Telecom Journal of Aust. Vol. 34, No. 1, 1984, Page 65.

Until recently, the business community has been well served by the traditional text communication services of Telex, facsimile and the Postal Services. Business is far more demanding today however, and requires faster and better communication facilities for handling its text based, information. Telecom Australia is planning to meet this need by introducing two new text services, a message service and Teletex to operate in conjunction with the existing text services.

The message service, or Computer Based Message System (CBMS) will cater for less formal message communication requirements, whilst Teletex will provide the more formalised document transfer service desired by business.

THE NEW MICROELECTRONICS REVOLUTION: Telecom Journal of Aust. Vol. 34, No. 1, 1984, Page 73.

Microelectronics has been the dominating feature of technology for the past twenty-five years and integrated circuits are now found in a vast range of equipment for both commercial and domestic use. However the manufacture of these circuits has traditionally been a long and expensive process. This paper examines techniques which have been developed to exploit the expertise, which has been built up in the microelectronics industry, to realise more cost effective means of producing integrated circuits. These techniques are bringing the benefits of microelectronics to a vast range of new applications.

THE DATA COMMUNICATIONS TRANSPORT SERVICE AND PROTOCOLS: P. A. Kirton, Telecom Journal of Aust. Vol. 34, No. 1, 1984, Page 85.

The CCITT and ISO are currently developing international standards for a universal network-independent data Transport Service of uniform quality, and the Transport Protocols which will support it. This paper presents an introduction to the purpose and structure of the Transport Service and its relationship with communication networks. The Transport Service and Protocol standards being developed are also described.

THE MICROWAVE NETWORK WITH MAXI-BACKUP: THAT'S OKI, FROM PLESSEY AUSTRALIA.

OKI microwave communications are proven worldwide, including Australia. For instance the State Rail Authority of NSW - 1.5 GHz 60 channel system has been operating successfully from South Grafton to Broadmeadow for some 5 years - the final stage a 7 GHz 300 channel system to Sydney was completed in December 1983.

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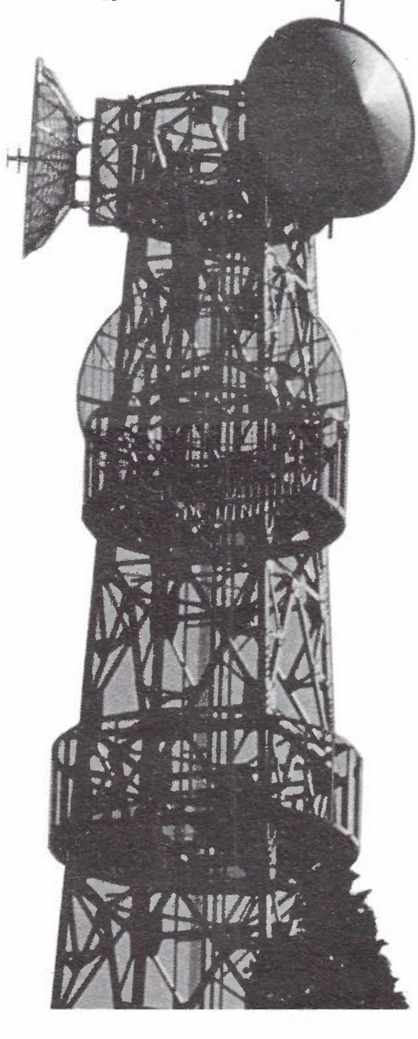

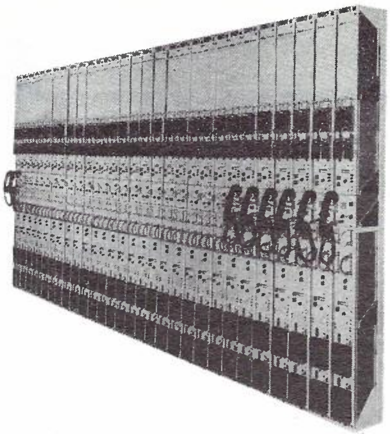

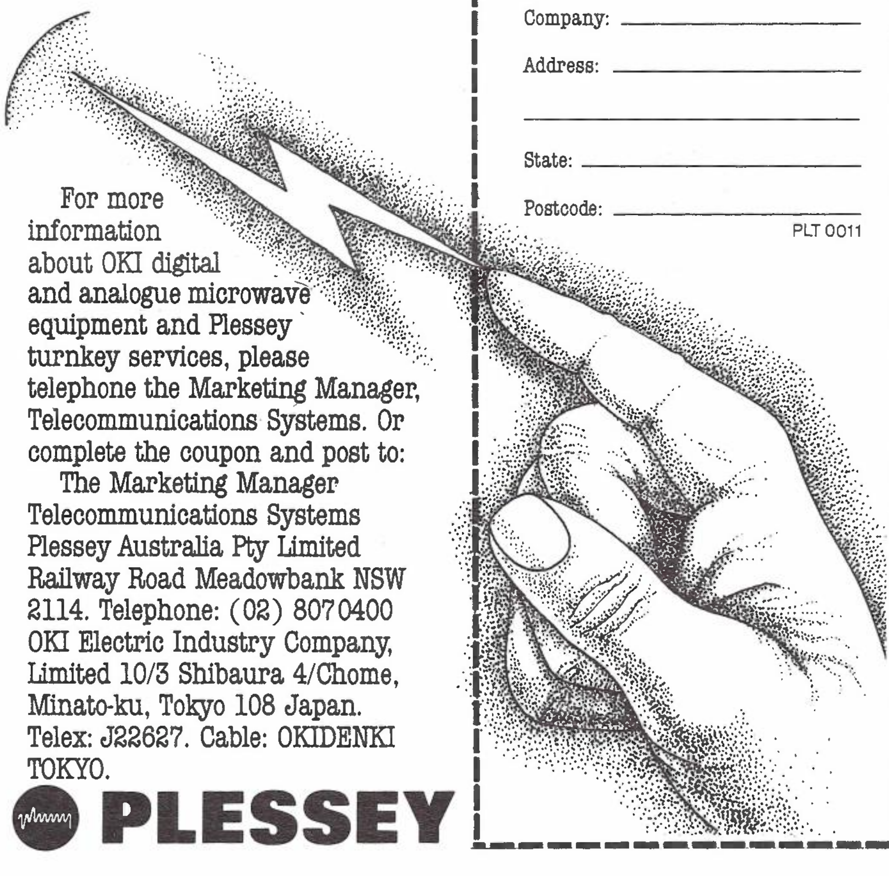

For more information about OKI digital and analogue microwave equipment and Plessey turnkey services, please telephone the Marketing Manager, Telecommunications Systems. Or complete the coupon and post to:

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Telecom introduces a pay-phone so brilliant it could only be called Gold Phone.

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Incorporating the latest advances in technology, the new Telecom Gold Phone offers features and benefits previously unavailable in a pay-phone.

Benefits

- Multi coin capability reduces the need to provide change
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- Warning before STD and ISD calls terminate
- Lockable metal coin compartment
- Bench, shelf-mounted, or free-standing
- Use as normal phone with operator key
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If your reputation could be enhanced by providing a first-class telephone service to customers and staff alike, ask for a demonstration of the Gold Phone at your nearest Telecom Business Office today.

No one knows more about phones.

Telecom Australia
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THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

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