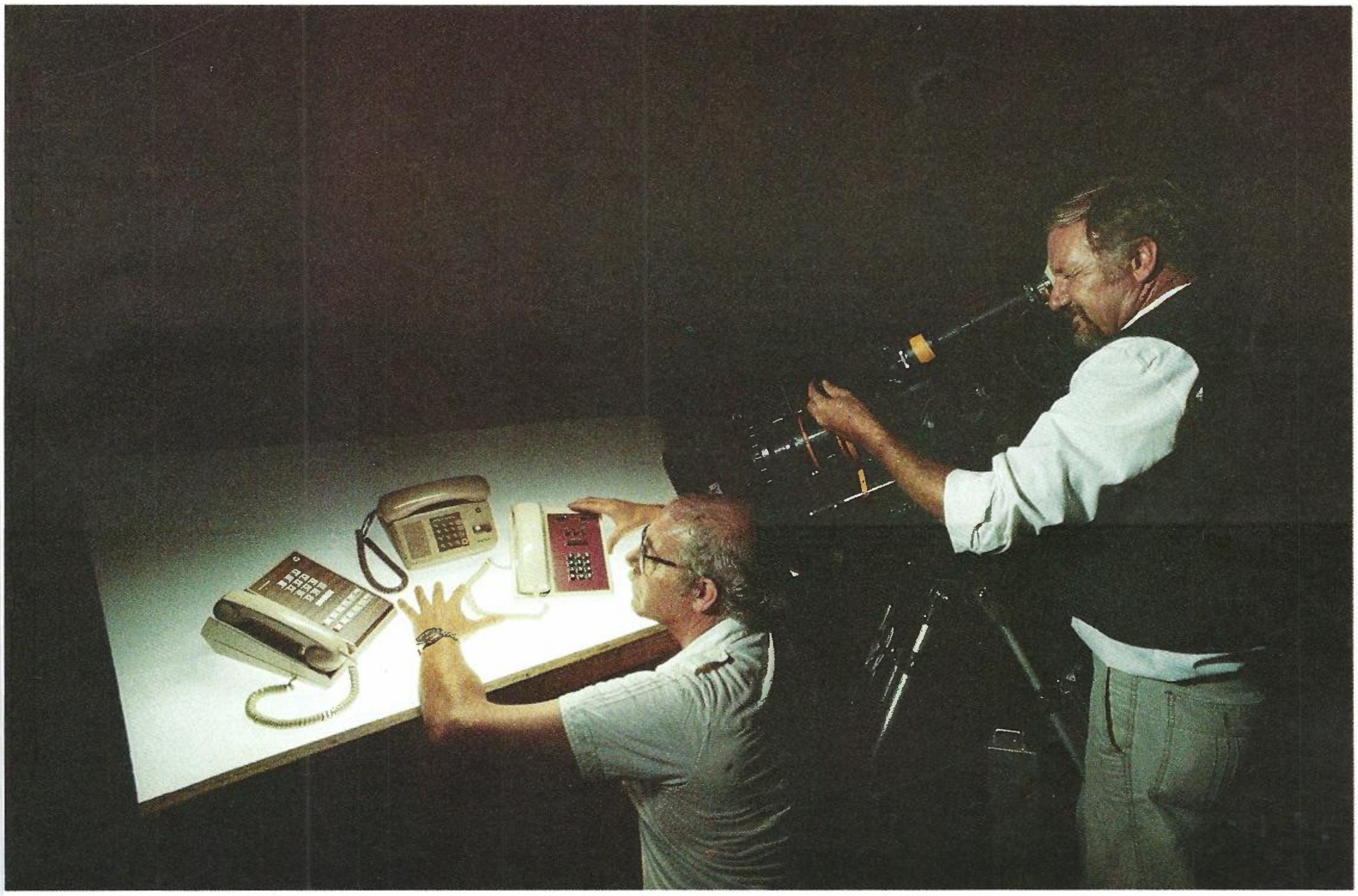
Volume 34 No. 2, 1984

the telecommunication journal of Australia



FEATURED IN THIS ISSUE

34/2

TELECOM COMMANDER T.

A great way to upgrade your business communications.

At the push of a button you can

- answer or make calls from any one of up to five Telecom Commander T extensions
- call any extension on the built-in intercom
- place callers on hold
- page one or all extensions
- dial without lifting the handset
- set up a group conference so that one or more extensions can join in your conversation
- redial the last number you called.

Not to mention that Telecom Commander T comes with six variable face plate colours to match your decor.

Commander T is perfect for the executive/secretarial situation, as a one-line business system, or even for your home. You can buy your Telecom Commander T system, or rent it from as little as $18* per month.

Find out how a Telecom Commander T can improve your efficiency and make business communications easier.

Call in to your local Telecom Business Office now.

*Rental of Commander T with 2 extensions, excluding installation and line rental.

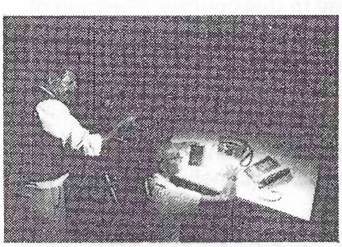
Telecom Australia
The Vital Connection

TAT 280

THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

ISN 0040 2486

Volume 34 No. 2, 1984



Cover shows Telecom Commander Stations on location for a television advertisement to be screened in 1984. See article in this issue.

CONTENTS

OTHER ITEMS

Editorial

Mr B.R. Goddard
President, AEIA
Managing Director,
Plessey Pacific Pty. Ltd.

The Australian Electronics Industry Association (AEIA) represents forty seven (47) principal companies in the communications, electronics and data processing fields. It was born from the marriage between three older Associations in 1981, namely the Australian Telecommunications Development Association (ATDA), the Australian Electronic Component Manufacturers Association (AECMA) and the Australian Electronics Industry Council (AEIC).

In January, 1984 the Association joined with the Australian Electrical and Electronics Manufacturers Association (AEEMA) to finalise the merging of the complete electrical and electronics industries.

Approximately 70% of the telecommunications industry sales are to Telecom Australia.

In the 1983/84 financial year Telecom has spent $1,000M with Australian industry and continuing orders of this size, in real terms, are expected to continue.

This dual support given over the years has resulted in Australia having a telecommunications network equal to any country in the world.

The industry world-wide is now in a state of flux as changing technologies shorten product life cycles and the increasing costs of development of major telecommunication systems are becoming more and more expensive.

Limitations of scale in the Australian economy combined with the rapid introduction of labour saving devices make it increasingly important to enter export markets. With the European and North American markets facing saturation it is becoming more apparent that Australia's most promising area for export is the emerging South East Asian market which is becoming the focal point for increasing world-wide sales.

Therefore, it is now essential that Telecom and industry should continue to have a meaningful working relationship. Mr Brack's statement that "Telecom has a role to play in fostering Australian manufacturing and assisting it to engage in technological development" has come at an opportune time in the restructuring of Australian telecommunications manufacturing abilities.

Without the support of Telecom, industry could not be involved in research and development projects demanding long time horizons, heavy investments in research equipment and manpower, and with uncertain commercial outcomes.

Co-operation in the future must be centred around the high growth areas of telecommunications such as Videotex, optical fibre, cellular radio, satellites, application software as well as the various data networks.

Joint technical liaison between Telecom and particular companies on particular products would not only share the costs and risks, but, also the benefits of projects that would otherwise not be contemplated.

Australia cannot obviously become involved in development of all the telecommunications requirements of the nation, but, we (AEIA) should be involved in all facets of particular items of equipment.

Being fully aware of Telecom's requirements from joint working groups would also ensure that the local industry is completely aware of the particular network problems usually caused by peculiar difficulties to this country. Planning of this co-operation has already begun.

Although this is only a start it is certainly a step in the right direction and provides an excellent forum for discussion and future tender negotiations. This attitude will help to ensure that Australia retain a telecommunications network at least as modern and efficient as other leading countries.

Telecom, a share holder in the Australian satellite, will be a major user and the potential demand by users of the satellite has risen above all expectations so much so that the third satellite which was due to be launched in 1988 will be launched in 1986.

By continuing the policy to purchase equipment manufactured in Australia, Telecom will play a major part in the growth of the Australian manufacturing industry.

The AEIA commends the Telecommunication Society of Australia on the high standard of the Journal, bringing to the forefront new technology developments and the meetings conducted by the Society provide a forum for the dissemination of knowledge to and from the Information Transfer Industry.

The Introduction of Telecom Commander

E. BLAKE B. Comm., Dip. P.A.

The launch in late 1981 of the first of the current range of Commander small business telephone systems signalled both a revitalisation of an important part of Telecom's product line, and the commencement of a more commercial approach by Telecom to this area of the market place. This article examines the introduction of Commander in terms of its commercial impact. Articles to be included in subsequent issues will deal with the technology of Commander.

INTRODUCTION OF TELECOM COMMANDER

A significant part of Telecom's role is to meet customer needs for small and medium sized multi-line telephone systems. Nearly a quarter of the telephones associated with the Australian Telephone Network are connected via small business telephone systems.

In 1979, Telecom's small business systems product line comprised:

- Small single line intercoms with one or two extension telephones — known as 1/2 and 1/3 systems.
- Larger intercoms with up to 4 lines and 11 extension telephones, known as 2/6 and 4/11 systems. These had the advantage of allowing users access to exchange lines at any extension telephone as well as to make intercom calls directly without the need for an operator. However, the technology of the systems required the use of large 25 and 50 wire cabling and the mounting of a bulky wall connector unit near each extension telephone.
- Manual operator switchboards known as PMBXs (Private Manual Branch Exchanges). The range included 4 sizes of table-top key operated units, and two sizes of floor mounted, cord operated units offering capacity up to 15 lines and 80 extension telephones. A major disadvantage with the manual switchboards was the need for an operator to handle all internal and external calls.
- A range of multiwire products called Multicom. The range included a number of specialised types of equipment for executive use, for use in multiple line answer situations (eg., order departments) and centralised answering situations (eg., to answer unattended phones in large offices).

In addition, Telecom continued to service a number of obsolescent types of intercom and PMBX equipment of early design.

Technological progress in the 1970s had led to the development of new micro processor-based small business telephone systems which could provide the advantages of an intercom system combined with slim station wiring (4 conductor). In addition, the systems could offer a host of additional customer facilities and support a wide variety of hardware options.

In 1979, Telecom invited tenders for the supply of new generation small business systems. In November 1981, the first range of the resulting new products was launched in Melbourne and Brisbane. In 1980, Telecom invited offers for the supply of a basic one line system. By July 1983, there was a total of 8 new models available to Telecom customers.

THE TELECOM COMMANDER RANGE

The range of new systems is marketed under the name "Telecom Commander".

The models in the Commander range are:

N308)	
N616)	Launched in Melbourne,
N1236)	Brisbane November 1981 —
N2260)	nationally March 1982
S207)	Launched nationally
S416)	July 1982
S620	Launched nationally June 1983
T105	Launched July 1983 (NSW August 1983)

Note: The number indicates the capacity of the system eg., N308 is a 3 line and 8 extension capacity; N1236 is a 12 line and 36 extension capacity.

Fig. 1. outlines a typical Commander (N308) system.

SELECTION OF THE PRODUCTS

In choosing the main range of products, that is, systems with more than one outside line, Telecom elected to provide a dual product range. The two ranges selected, now known as the Commander N series and the Commander S series, appeared to cater for different needs and tastes, and this has proven to be the case in practice. In addition, the Commander N series had the benefit of having already been in use in the USA and Japan and was already well established as a good performer in both marketing and technical terms. The Commander S series was not yet in production but incorporated the latest in system technology.

Commander N series systems designed by Nitsuko (Japan) and supplied to Telecom by STC, are typical in design of systems currently in use in the Japanese and North American markets, and are characterised by the style and the multi button method of system operation. See **Fig. 2.**

The Commander S series systems designed and supplied by Siemens are quite different. Extension telephones have the usual telephone key pad plus only 4 additional special function keys and 6 line lamps. See **Fig. 3.**

Both systems offer the same basic facilities, namely:

— The ability to make and receive calls on any outside line at any extension telephone directly without the need for operator assistance.

— The ability to make and receive intercom calls to or from other extensions directly without the need for operator assistance.

In addition, both systems provide a considerable range of facilities such as abbreviated dialling memory, optional "hands free" telephones, conference call facilities, etc. Significant differences in the facilities are that N series systems incorporate in-built intercom paging facilities while Commander S series systems have greater customer choice in terms of directing outside calls to particular extensions during normal and night service conditions.

Marketing experience has shown that Australian customers tend to have a marked preference for one style of product or the other and appreciate the ability to choose.

Although this choice of systems means that two firms, STC and Siemens, share the supply of multi line Commander models, the production volumes available to each were still sufficient to justify the setting up of local manufacture of the respective products.

In the subsequent choice of a single line product, one product, now known as the Commander T, was selected. This product provides similar facilities to the larger systems at low cost. The system provides a door answer in-

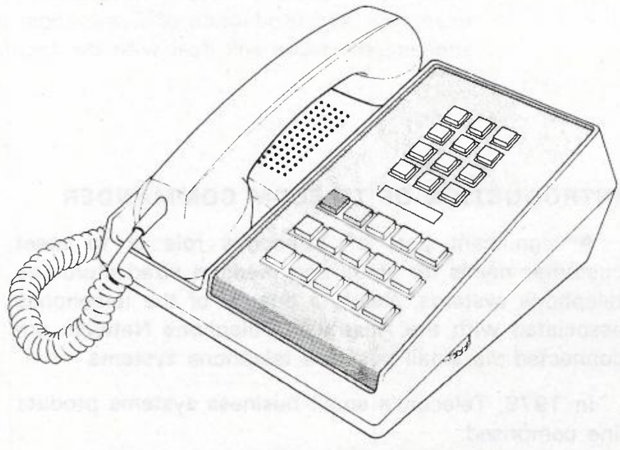


Fig. 2. Typical Commander N telephone.

ED BLAKE joined Telecom's Customer Relations area in Victoria in 1967. He completed the Traffic Officer Course during 1969/70 and worked in Victoria as a Traffic Officer in the Service Advisory and Works and Equipment fields until 1973. Ed was a Customer Services training officer in Victoria for several years before joining the newly formed Customer Services Product Planning Branch at Telecom HQ in 1977. In the product planning field, he was associated with network product planning including the Inwats 008 Service. Ed was Manager, Record Services, from 1979 to 1981, and was responsible for Telex and Teletex marketing. He has been Manager Small Business Systems Marketing since mid-1981. Ed (centre) is pictured with Mr Phil Solman (right), Executive Director and Mr Wayne Lotherington (left), Telecom Account Supervisor of USP Needham, the advertising agency for Commander.

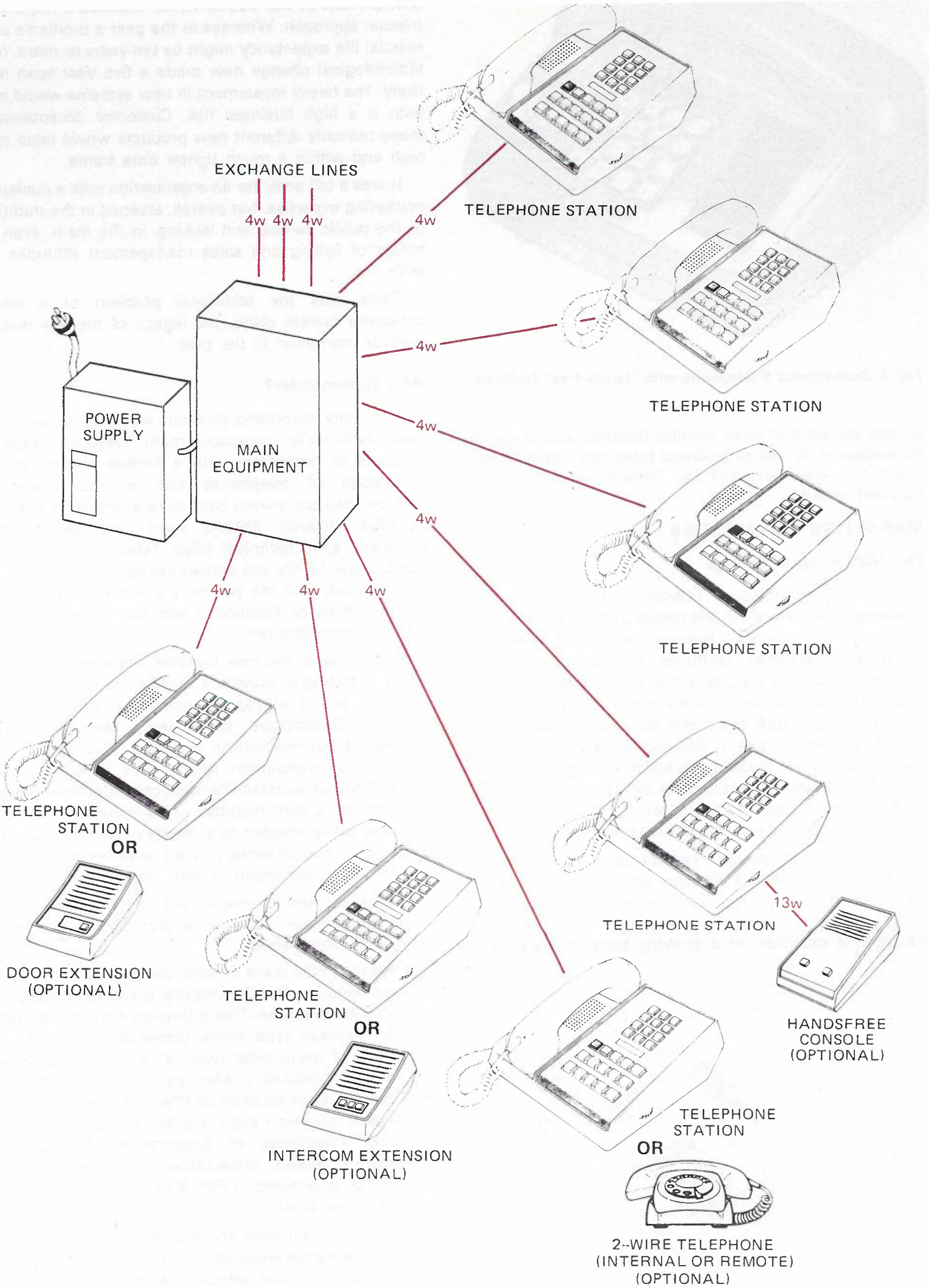


Fig. 1. Typical Commander System.

Fig. 3. Commander S telephone with "hands free" facilities.

tercom station and room monitor facilities, and is suited to residential as well as business telephone needs. Commander T was designed by Tamura, Japan, and is supplied by AWA.

MARKETING COMMANDER

The Marketing Challenge

Commander presented Telecom with a number of challenges. Some were in the nature of the product itself. A typical Commander system comprises over 30 significant customer facilities. It may involve 20 customer hardware options alone. It involves tailoring a system to meet customer needs but on a giant scale — by the end of 1984 there will be over 50,000 Commander systems in use in Australia. This would involve the adaptation of existing Telecom management systems to cope with a considerable increase in complexity in forecasting, distributing, selling, installing and servicing small business telephone systems.

However, Commander represented a significant departure from previous Telecom practice in that Telecom elected to apply to Commander the methods of marketing usually associated with the private sector. This was both a reflection of a growing body of marketing

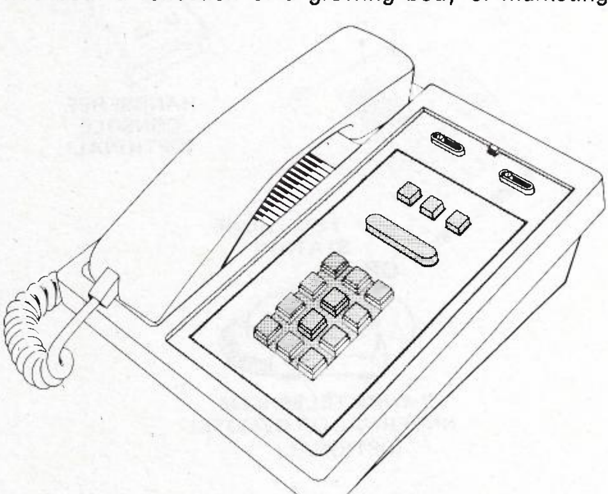


Fig. 4. Commander T telephone.

expertise within Telecom and a reaction to the marketing environment of the 1980s which required a more commercial approach. Whereas in the past a product's commercial life expectancy might be ten years or more, rapid technological change now made a five year span more likely. The heavy investment in new systems would carry with it a high business risk. Customer acceptance of these radically different new products would need to be high and within a much tighter time frame.

It was a tall order for an organisation with a nucleus of marketing expertise, but overall, steeped in the traditions of the public service and lacking, in the main, even the basics of selling and sales management attitudes and skills.

There was the additional problem of a largely untutored market place, the legacy of the low level of product promotion in the past.

Why Commander?

A primary marketing problem was how to present a new, technically complex, multi featured range of products to customers with a limited interest in and knowledge of telephones and telephone systems. Telecom had not always paid close attention to branding its past systems. PMBXs were described by their enigmatic semi technical titles. Telecom's larger intercoms of the 1970s still carried the light green hue of the manufacturer and the yet more enigmatic letters 'T&N' — the initials of Telefonbau and Normalzeit, the West German manufacturer.

In the case of the new systems, there was a need for strong branding to provide a title for the diverse product grouping and a strong Telecom association with the product. Descriptive titles (eg., Multicom) were considered but rejected. In any case, it was difficult to find an apt description. Many sets of names were researched but rejected. Paradoxically, Commander was proposed by a staff member — its appeal being that it could be easily adapted to a variety of promotional uses, but with the overall sense that is true of the product "that it puts you in command of your telecommunications".

Further marketing research led to the adoption of the initial Commander brand name promotion "Graduate to the Clever Commander".

After the initial wave of advertising using press as the principal medium, the Commander brand advertising was extended to television. This television advertising used a Marcel Marceau type mime character to act out the difficulties of using older types of telephone equipment and then introduced customers to Commander. The advertisement proved to be an effective attention-gaining device and television soon eclipsed all other sources of customer knowledge of Commander. Paul Russell, Melbourne based entertainer appearing in the advertising, is pictured in **Fig. 5** in his role as the Commander mime artist.

While television soon showed that it had a capability to rapidly advance knowledge of the Commander brand name, this was most effective with larger businesses who had a better appreciation of telephone systems in general. In 1984, Commander will return to television screens using a more educational approach designed to improve small business appreciation of the product.

Fig. 5. Paul Russell advertising Commander.

Owning your own Commander

Until the mid-1970s Telecom provided terminal equipment on the same basis as it did its telephone service — by subscription rental. This method was appropriate at a time when Telecom could use recycled systems to keep its costs down. In the late 1970s and 1980s, Telecom's ability to finance customer rental was greatly reduced as interest costs rose. In addition, the economic life expectancy of systems was considerably reduced. In the case of Commander, Telecom elected to sell a significant proportion of its systems. The offering of a customer choice of purchase or subscription rental increases the overall customer benefits by catering for those customers who have ready access to funds and are able to purchase, as well as providing "no strings attached" rental finance to others, typically the smaller business with less access to funds.

Introducing the purchase option also provided customers with the opportunity to arrange their own lease finance. While many customers already lease Commander, in 1984 Telecom will introduce selling procedures which cater specifically for leasing companies' formal requirements as well providing point of sale information designed to facilitate customer access to interested leasing organisations.

Making Commander Simpler

As expected, providing modular systems in high volumes has created logistical problems. Explaining 30 facilities and taking orders for 20 items of hardware is a problem for both the customer and the sales person. Consideration is being given to offering customers certain fixed pre-packaged facilities, thereby simplifying the whole logistical process from forecasting through to distribution of the product. However, customers will still be free to order a system configured to their individual needs.

Selling Commander

The selling of Commander proved to be a major problem for Telecom given the largely passive mode of selling used previously. Telecom staff had good product skills and possessed a strong service orientation. However, the customer communication skills needed to motivate customers to purchase a radically new product were generally lacking, as were the basic sales management skills typical of commercial organisations. The early difficulties with selling Commander were perceived and, as a result, new initiatives were set in motion to create an improved national sales force capable of operating efficiently in the market place.

To fit in with the passive selling style, initial Commander merchandising relied upon customer response to press advertising. Active selling concentrated upon the use of customer seminars supplemented by small sales forces in some major cities.

In order to make the transition to a more effective and productive sales force for Commander and a growing range of new Telecom products, in 1982 Telecom set up a new National Sales organisation within its Headquarters Commercial Services Department, with sales forces operating within the Operations Department in each State. The formation of the new sales forces is already well advanced at the time of writing.

Commander has thus provided a catalyst which will have profound long term effects upon Telecom's commercial efficiency.

Retiring the older products

Commander has effectively replaced the intercoms of the 1960s and 1970s and these are no longer available to customers. The PMBXs remain in the product line but demand for this earlier generation of equipment is rapidly declining. However, Telecom still continues to service intercom and PMBX units of a still earlier generation including single line "Tele-Intermediate" and A5 intercom systems, and multiple line A10 intercoms and the 2+4 and 3+12 tabletop PMBX systems. Customers with these systems have been offered generous terms to convert to Commander. In any event, the withdrawal of the maintenance service for these units will be completed by June 1985.

Ongoing Developments

The Telecom Commander range is constantly being updated as the need for new facilities is perceived. Current developments include:

— Introduction of a 'package' of new facilities which will be available on new Commander N series systems, except N308 models, from mid-1984. The package will include a call details recorder facility which can print out call details automatically.
— Headset facility for Commander N series users — particularly useful where the system is used in locations such as an ordering department.
— Upgraded appearance of small models N308 and N616.
— Introduction of a new Commander T station which allows connection of a second non-system line.
— Introduction of a new model station for executive use on Commander T systems.

COMMANDER IN THE 80s

Commander has been an important event for Telecom. It has been an outstanding commercial success, and it has shown that Telecom can adapt to the demands of the 1980s. Within a two year period Telecom has acquired a new level of marketing skill, which new initiatives, particularly in the sales area, will continue to refine.

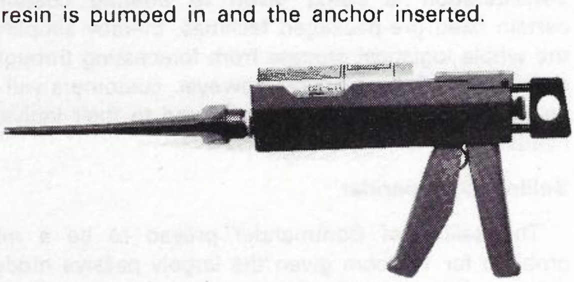
While there are now a number of other new products in the Telecom product line which can also lay claim to significant contributions to this process, Commander represents a significant turning point in Telecom's history.

Information Transfer News Item

Injection System for Reliable Fastenings in Any Base Material

Hilti has released its HIT system which enables safe fastenings into concrete, all types of brick, hollow block, old and porous material or irregular holes.

The system is simply that once the hole is drilled resin is pumped in and the anchor inserted.



Components are a dispensing gun with twin pistons for the cartridge system; an injection piston with a scale to give the right filling for each hole and a two-component cartridge of adhesive mortar. A special sieve is provided to ensure optimal keying in hollow brick.

Both male and female threaded fastenings are available from M8 to M16.

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Phone 648 4466.

Telecom Premium Telephones

A. A. RENDLE. B.A.(Cantab.)

The emergence of LSI technology has enabled the production of relatively cheap telephone instruments with many facilities beyond those offered by the traditional basic telephone. Telecom Australia is offering a selection of these new telephones to customers, but is faced with the problem of maintaining a competitive range in an environment where many new instruments are becoming available all the time.

BACKGROUND

Worldwide, telephone instrument design remained fairly static from the early sixties to the mid seventies, when emerging LSI technology made replacement of the rotary dial by push buttons economically feasible. Telecom Australia responded to this by introducing the Touchfone, a push button version of the standard 800 series telephone, in 1977.

Since then, two factors have had a profound impact on telephone instrument design:

- continuing progress in semiconductor technology leading to low cost LSI devices and microprocessors.
- deregulation of the North American telephone terminal market.

The competitive North American market, combined with the technological means to provide a wide range of new customer facilities, has stimulated the development of an avalanche of new customer terminal products.

Telecom has a charter to provide its customers with new facilities, as they become available. Permits have been given, for several years in Australia, for telephones with special facilities to be marketed by private suppliers; so that Telecom is already in competition in this area of the telephone market. To meet these market conditions, Telecom decided to launch a range of Premium telephones.

Fig. 1: Gondola.

Telecom has also decided to market a range of Decorator telephones, which will be the subject of an article in a later issue. Also, the launch of premium telephones had some associated technical problems to overcome, and these matters are discussed in another article in this issue.

INITIALLY FOR RENT

The first product offered was the Gondola, **Fig. 1**, which was launched in October 1981, at a premium rental. The style follows the famous Henry Dreyfuss "Trimline" design for the Bell System. The "Trimline" was a major innovation when it was introduced, because it shifted the dial from its traditional position, on the body of the telephone, to the handset. Although we have become familiar with this concept since, a real leap in imagination was needed to create it. In doing so, Henry Dreyfuss created one of the classics of telephone design. The Gondola was initially sourced from SESA in Spain, through Standard Telephones & Cables (STC), but it is now assembled in Australia by STC. The Gondola is available in decadic and DTMF versions, table and wall models, and in a range of colours.

SALE RANGE OF TELEPHONES

Although the Gondola was introduced as a rental telephone, further analysis of the market indicated that other products in the premium range should be offered only for outright sale to the customer. New policies and procedures had to be established for selling, as opposed to renting, telephones. Perhaps the major innovation is that the customer now has the choice of self-installing the telephone into an existing socket, or arranging optional installation by Telecom.

WARRANTY

The telephones mostly carry a warranty for two years, with a fee for repair beyond the warranty period. Alternatively, the customer has the option to enter into a maintenance agreement with Telecom.

RETAIL OUTLETS

Telecom Business Offices have been adapted, with consultant designed product displays, for over-thecounter sales of small quantities. The telephones are also available through Account Managers and the Business Sales Force. Separate arrangements are made for the delivery of bulk orders.

THE PRODUCTS

The current sales range of telephones is:

Digitel

The Digitel, **Fig. 2,** was developed in Denmark by the Jutland Telephone Company and KIRK. The industrial design was by Jakob Jensen, also well known for the Bang and Olufsen range of Hi-Fi equipment. There are a number of different Digitel models:

Digitel Courier: basic facilities and recall. Last number redial (decadic only);

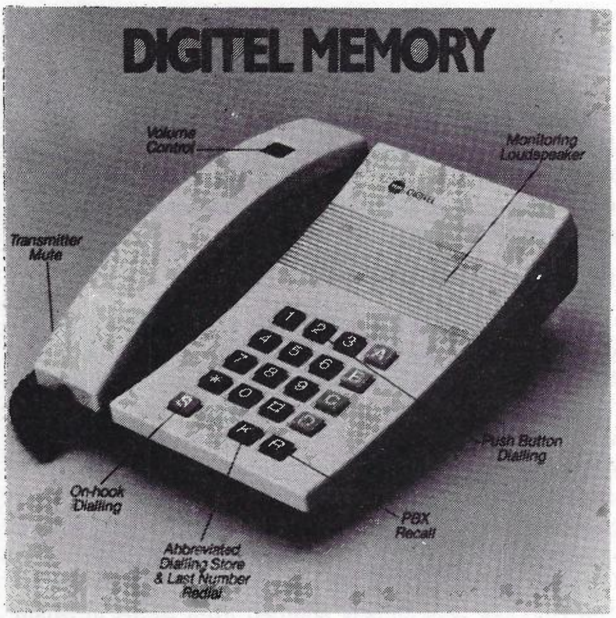


Fig. 2: Digitel.

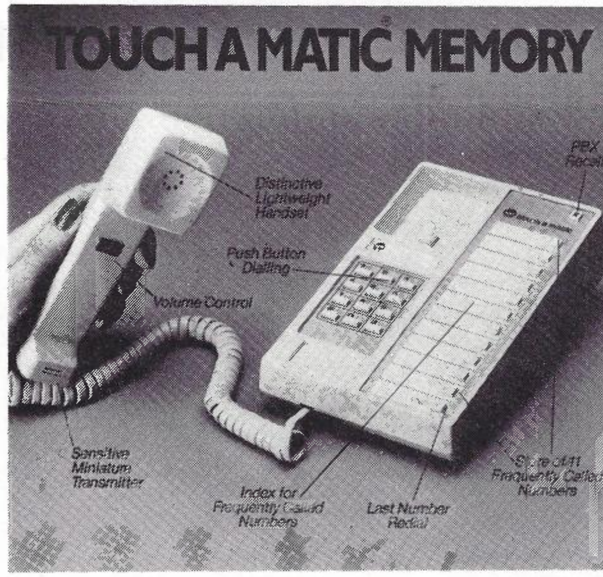


Fig. 3: Touch-a-Matic.

Digitel Monitor: monitor loudspeaker;

Digitel Memory: monitor loudspeaker and abbreviated dialling;

Digitel Conference: voice switched hands-free;

Digitel Two Line: monitor and 2 lines.

All models are available in decadic or DTMF versions. A range of six colours is available; the colour is easily changed, by replacing the telephone and handset covers.

Touch-a-Matic Memory

This telephone, **Fig. 3,** incorporates a repertory dialler, so that eleven stored numbers, plus the last number dialled, are all available at the touch of a single button. The Touch-a-Matic was developed by Western Electric in the USA and is supplied to Telecom via AWA. It is available in table and wall models, and decadic or DTMF dialling versions.

TONY RENDLE is currently Manager, Telephone Engineering Branch in the Commercial Services Department of Telecom Australia, Headquarters. He graduated from Cambridge University and worked on aircraft antennae systems and measurements with Standard Telephones & Cables Ltd., before migrating to Australia in 1962. His career in Telecom has been mainly in the telephone terminal area.

Fig. 4: Flip-Phone.

Flip-Phone

The Flip-Phone, **Fig. 4,** was the fore-runner of the flood of one piece electronic telephones which have appeared in vast quantities in recent times. However, none of the imitations have improved on the ingenious fold up concept of the Flip-Phone. Also available is a simple and effective wall holster, which allows the telephone to be stowed away tidily when not in use. The Flip-Phone is available only in a decadic version. The Flip-Phone was developed by GTE in the USA, and is supplied to Telecom by GTE Australia.

Transit

The styling of the Transit range, **Fig. 5,** which is already familiar in Commander "S" stations, is of West German origin. The telephones are supplied by Siemens Australia, initially imported, but later from Australian production. The following models are currently available:

Transit Conference: voice switched hands-free, decadic and DTMF versions;

Transit Conference + 10: voice switched hands-free and abbreviated dialling, decadic only;

Transit Courier: basic telephone with PABX recall. DTMF version available with timed loop break, decadic version has last number redial.

Fig. 5: Transit.

FUTURE PRODUCTS

With continuing rapid advances in semiconductor devices, and the competitive nature of the market, there will be continual changes to the product range. This creates headaches for everyone concerned, especially for a supplier pledging continuing support for products. But once the tiger has been caught by the tail, one has to hold on! Already, the products described above have been reviewed; some of the existing range will be dropped, and new ones added. A continuing trend will be that more and more facilities will be expected at lower and lower prices.

Information Transfer News Item

Satellite Communications

Spacetel, a Satellite Communications System developed by Microtel of Canada, solves the problem of providing reliable voice and data communications to remote communities and resource-based camps.

Originally conceived by British Columbia Telephone Company to cope with the problems of providing telecommunications to remote settlements and fast-developing mining and logging camps of Canada's west coast, Spacetel was designed and developed by Microtel Pacific Research and is manufactured and marketed by its parent company, Microtel. The mobility and portability of the thin-route, single channel per carrier (SCPC) system, as well as its security features, also make it very suitable for private business networks.

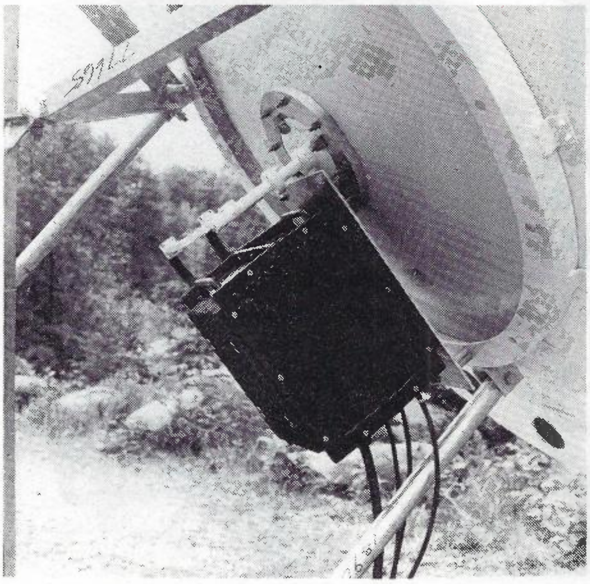
Spacetel is based on a star configuration which results in a complex Central Control Station (CCS) capable of handling up to 1,000 remote earth stations. Normally, the CCS is situated in a metropolitan area, interfacing directly to a Central Office of a public switched network. This interface, which is totally transparent to both the operating company and to the Spacetel user, provides the remote user with a level of service equivalent to that enjoyed by metropolitan users.

No specialized electronic skills are needed to operate the equipment which is light-weight, easily transported and can be delivered to a remote site by a light vehicle or aircraft.

Remote terminal antenna sizes are kept to a minimum through the use of 14/12 GHz (gigahertz) band and a large central control station (CCS) antenna. Demand assignment multiple access (DAMA) reduces satellite transponder bandwidth requirements. This reduces costs. The system is integrated with the voice network on a subscriber loop basis, simplifying the use of the CCS. A user-sensitive billing system is included, and the CCS is equipped with elaborate maintenance, testing and alarm reporting systems.

The Spacetel system extends the subscriber services available at a central site to any location within the appropriate satellite footprint. High quality voice transmission is provided using 32 kilobits per second (32 kb/s) digital encoding and QPSK (quaternary phase shift keyed) modulation. Excellent data performance is assured through direct digital modulation and forward error correction (FEC) coding techniques.

Field evaluation in 1982 by Microtel and British Columbia Telephone Company considered a number of factors, such as: portability of the dish antenna, required installation times, effect of climate and various terrain on signal quality, durability and reliability of the equipment when faced with frequent transportation over bumpy roads, level of customer satisfaction, and billing procedures. The field trial was extremely successful.



Microtel began manufacturing Spacetel in the summer of 1983 and the first multi-channel Spacetel units which can provide from two to 12 channels were shipped from the Microtel factory in February, 1984.

Microtel is a major Canadian manufacturer of a broad line of telecommunications equipment based in Burnaby, British Columbia. From its factories in Burnaby, Saskatoon, Saskatchewan and Brockville, Ontario and its network of sales offices in Canada and in Atlanta, Georgia, and its affiliation with GTE, Microtel generated sales of over \$206-million in 1983. The company's research and development arm, Microtel Pacific Research, is the largest organization of its kind in Western Canada.

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Technical Aspects of Premium Telephone Introduction

W. TREBILCO — A.R.M.I.T.
W. LEW — B.E.

When Telecom decided to enter the premium telephone market with telephones of overseas origin, a number of technical problems had to be overcome so that these telephones would comply with Australian specifications and also be compatible with the existing customer installation plans. This article describes how these problems were overcome, and the changes introduced into the standard installation plans to allow parallel working between these new telephones and the 800 series telephones.

INTRODUCTION

Elsewhere in this issue, an article by A. A. Rendle, "Telecom Premium Telephones", describes how Telecom Australia entered the market for premium telephones, and details the telephones which comprise Telecom's initial product range.

This complementary article discusses the more interesting and novel technical aspects of Telecom's entry into the premium telephone market.

Following its decision to enter the market for premium telephones, Telecom Australia invited tenders for suitable instruments in August 1980 and, after tenders closed in October 1980, a number of telephones were selected for their marketability, based on customer appeal, facilities and cost. This short list of telephones was then subjected to technical evaluation, particularly for:—

- Transmission Performance.
- Electrical Performance.
- Interworking with other Telephones and the Network.
- Reliability of Components.
- Environmental Performance.
- Adverse Electrical Conditions.
- Rejection of RF and EMI Signals.

The main design problems encountered during this evaluation included low transmission, radio frequency interference, loss of memory storage, breakdown to high voltage, and low sound pressure level output from ringers.

It became apparent during testing that none of the premium telephones, as offered, would meet all the specified requirements for working off the Australian network. This was the result not of fundamental deficiencies, but of the telephones having been designed for conditions other than in Australia.

Generally, the design problems encountered were overcome by negotiating with suppliers to modify their telephones. In some cases, it was not practicable to change the design because of additional costs; this applied particularly where additional facilities were involved, or where the life expectancy of a component did not quite meet specified requirements.

Further, because the telephones offered were designed to suit the requirements of their country of origin, the following interworking problems occurred when the premium telephones and the 800 series telephones were connected in parallel:—

- The premium telephone ringer circuits were designed for 2-wire operation and therefore would not operate in parallel with 800 series telephones without causing bell tinkling on associated telephones or impulse distortion when dialling out. This followed from the 800 series telephone having been designed for 3-wire operation.
- The low impedance 800 series telephone bell circuit shunted the ring current from the high impedance tone ringer of the premium telephones, resulting in impaired performance of the premium telephone ringer.
- Many of the premium telephones offered, particularly those of European origin, had a much higher dc resistance than the 800 series telephones. Consequently, unequal battery feed current sharing occurred to the extent that transmission failed on long lines, when two telephones in parallel were in use at the same time.

To expedite the availability of premium telephones to Telecom customers, it was necessary to purchase telephones requiring minimal design changes for Australian conditions. Accordingly, it was decided to adapt the 800 series telephone to work as a 2-wire telephone when connected in parallel with premium telephones. This approach was to be adopted as an interim measure until a standard 2-wire telephone was available to replace the 800 series telephone.

To enable the 800 series telephone to be associated in a 2-wire mode with other telephones required the development of:—

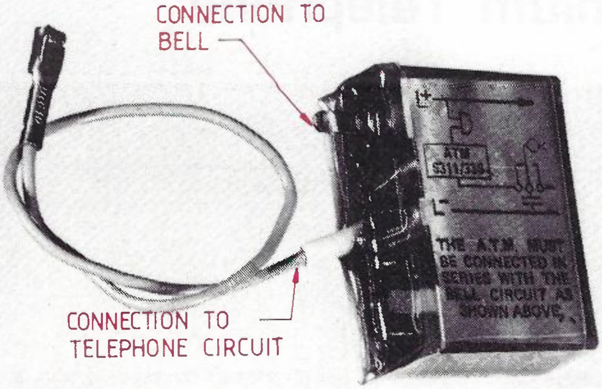

Fig. 1. Anti Tinkle Module.

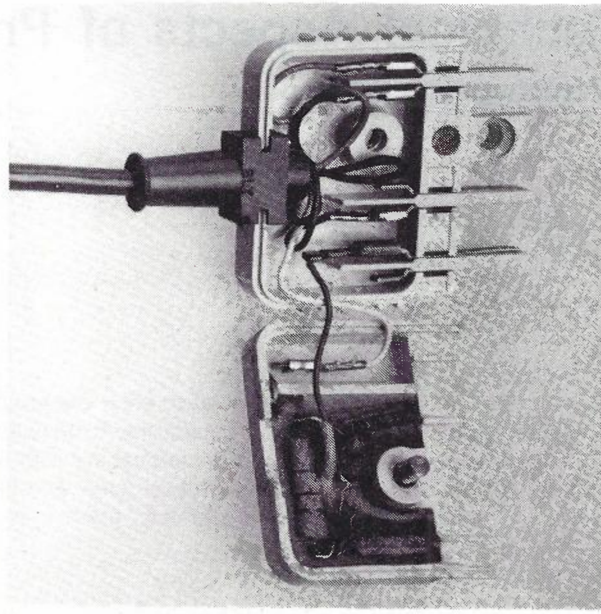

Fig. 2. Current Sharing Module.

- An anti tinkle module (ATM) (**Fig. 1**), and
- A current sharing module (CSM) (**Fig. 2**).

Fig. 3 shows where the two modules are fitted in an 800 series telephone.

In summary, to permit the early introduction of premium telephones, Telecom needed to overcome some basic design problems which rendered the telephones incompatible with Australian conditions. Also, Telecom needed to effect some original basic design work on ATM and CSM modules. All of these aspects will now be discussed in detail.

DESIGN PROBLEMS

- **Radio Frequency Interference**

Most of the telephones offered had a number of semiconductors and amplifying elements which caused demodulation of AM radio signals, which then appeared as interference in the telephone. Installations where this occurred were up to 4 km from radio transmitter masts,

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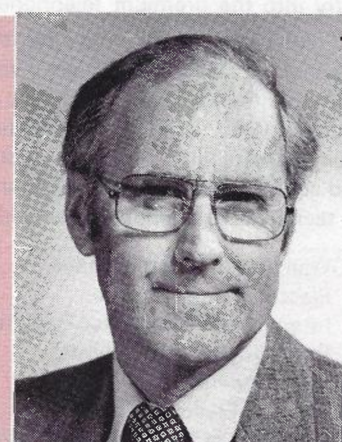
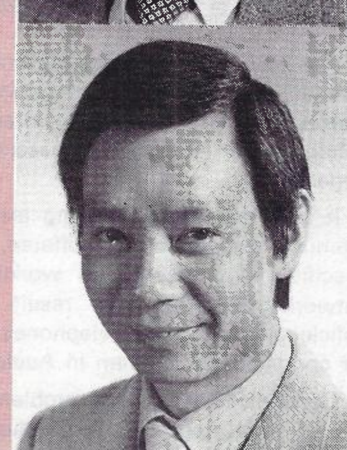


W. LEW graduated from Monash University with a degree in Electrical Engineering in 1977. He started working with Telecom Australia as a Telecom Assistant. In 1979 he joined Customer Equipment Branch, Headquarters as an Engineer Class 1. He is currently working in the Telephone Engineering Branch, Commercial Services Department, Headquarters.



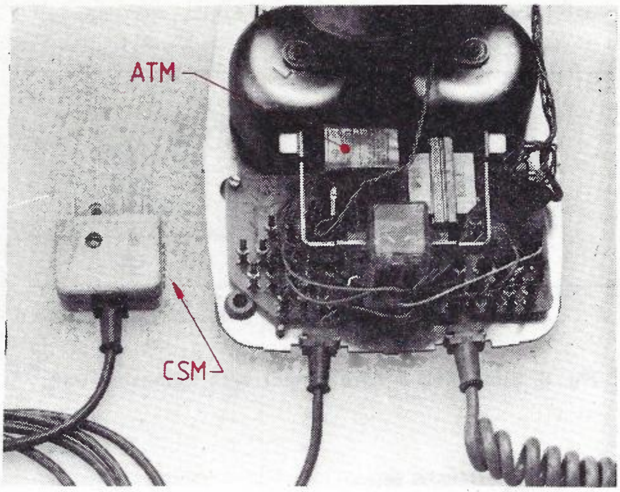


Fig. 3. Telephone with ATM and CSM Fitted.

and were typically served by aerial drop wire, or had lengthy wiring in the house. This wiring acted as a radio signal aerial to the telephone, and the user provided the ground by capacitive coupling to the handset. Methods used to reduce this interference to acceptable levels included a metal foil shield in the handset of one-piece-telephones, as shown in **Fig. 4**, and RF by-pass capacitors across selected semiconductors in the circuit of other telephones. In all required cases, it was possible, by these means, to reduce RF interference to acceptable levels.

- **Low Transmission**

The send and receive performance of some telephones was lower than required for Australian conditions. As most of the telephones had active amplifier transmission circuitry, adjustments could be made to meet Australian requirements. Most of the telephones had electronic transmitter circuitry, and therefore good frequency response.

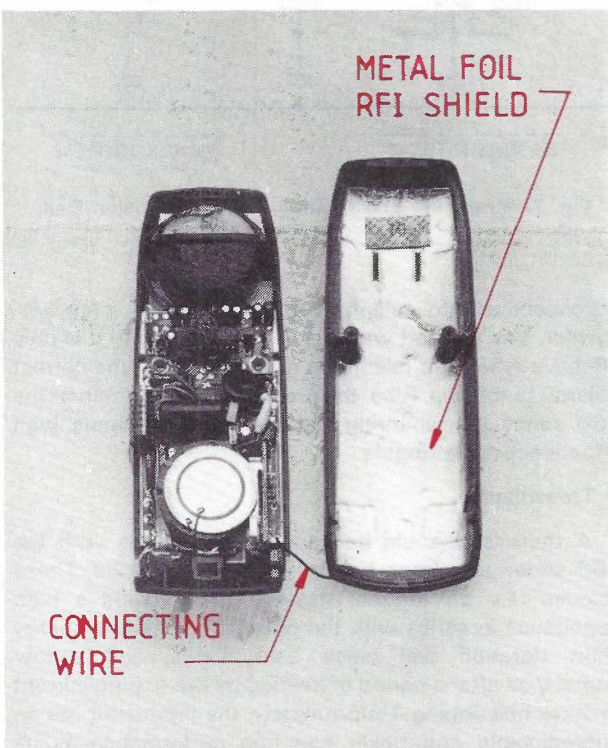


Fig. 4. Metal Foil RFI Shield in One Piece Telephone.

- **Memory Loss**

High voltage back EMFs or line breaks may occur on exchange or PABX lines during:—
— Dialling.
— Replacing the handset of telephones with poorly sequenced gravity switches.
— Equipment switching.
— Rearrangement of line or exchange equipment by Telecom staff.

These high voltage spikes caused the stored memory of repertory numbers in some telephones to be lost, or the last number redial store to be reset, and effectively lost, in others. These problems were overcome in various ways depending on the telephone design. In some, circuit changes were made, and in others voltage dependent resistors or small inductors were connected in series with the line.

- **Ringer**

It was necessary for some telephones to have improved ringer adjustments or resonators fitted to provide the ring level required. On some telephones, the tone ringers needed to be desensitized to meet the anti tinkle requirement when dialling out from another telephone in parallel.

- **High Voltage Breakdown**

Telephones were tested to withstand a functional surge test of 2 kV 10/700 μS after which the telephone was to be still fully operational. They were also tested to a protective voltage of 3.5 kV rms to SAA double insulation requirements to protect the user against the possibility of a voltage rise between line and local earth, such as 240 V power wires contacting the exchange line. Most telephones passed the functional surge test and those which failed were improved by the addition of surge protectors.

Failure due to protective voltage tests usually occurred because metal parts on the surface of the telephone were connected, or in close proximity to, the telephone circuit board. Solutions were dictated by the circumstances of each case; for example, in one telephone the metal dial surround plate was changed to a plastic "metal look" plate. In another telephone, a mylar spacer was used to separate the metal base from the circuit board.

- **Reliability**

Life tests were carried out on selected components such as gravity switch and dial, and complete telephones were environmentally tested. As mentioned earlier, where the telephones did not meet specification, some changes to improve the performance could not be justified because of the additional cost. This occurred in life tests on two dials which did not meet the one million operations per button specified.

NEED FOR ANTI TINKLE AND CURRENT SHARING MODULES

Because of the need to expedite the availability of premium telephones to Telecom Australia customers, it was desirable to purchase telephones that were already in world production, and which would require a minimum of modification to satisfy Australian requirements.

Most telephones offered were designed for 2-wire working, whereas the Australian standard 800 series telephone is a 3-wire device. The association of 2-wire and 3-wire telephones leads to bell tinkling during dialling, a problem which needed to be overcome. Modification of the 2-wire telephones would have involved extensive redesign and inevitable supply delays. It was decided to adopt the 2-wire connection system, and to develop locally a device to be used as required to prevent bell tinkling on associated telephones. The device has become known as the Anti Tinkle Module (ATM), a full discussion of which follows.

In a similar manner, a local solution was required for the situation in which the association of some different telephones can result in insufficient current being available to the transmitter of one of the telephones when the use of both telephones at the same time is attempted. Telephone and network design does not envisage the use of telephones jointly in parallel, but this has become an expectation of users even if only to supervise the effective transfer of a call from one telephone to the other. In some cases, use of the new telephones would result in current being totally starved from one transmitter and therefore no speech at any level being possible. The solution for this situation is by the use of a Current Sharing Module (CSM), a full discussion of which follows.

THE ANTI TINKLE MODULE (ATM)

The first parallel telephone services installed in the 1920s were in fact 2-wire working but these services were only permitted if both telephones were in the same room. The bell in the second telephone was disconnected but tinkling still occurred in the first telephone when dialling out from the second.

To overcome bell tinkling and allow the bell in the second or third parallel telephone to operate, a third wire was added so that all telephones shared a common capacitor in the first telephone via their respective gravity switch contacts (**Fig 5**). This arrangement also provided for spark quenching of dial contacts and prevented impulse distortion if the bell circuit of the second or third telephone was across the line during dialling.

In 1975, a fourth wire was added to the 800 series telephone cord to simplify the wiring of parallel services with extension bells (**Fig. 6**).

As discussed earlier, it was decided to go to 2-wire parallel operation of the 800 series telephone (**Fig. 7**) so that it would be compatible with the premium telephones. However, before design work started on the ATM two existing methods of preventing bell tinkling were considered.

- **Bias Spring**

The bias spring method used in the USA relies upon a wire spring holding the bell striker arm against one gong to desensitize the bell against operation to the low energy back EMF produced during dialling. This method was rejected because of mechanical redesign involved and the obvious difficulty in applying the solution

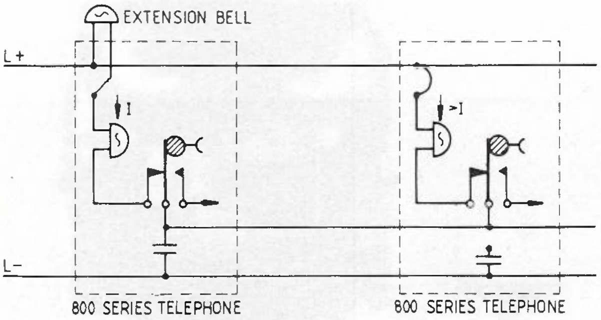


Fig. 5. Simplified 3-Wire Circuit with Extension Bell.

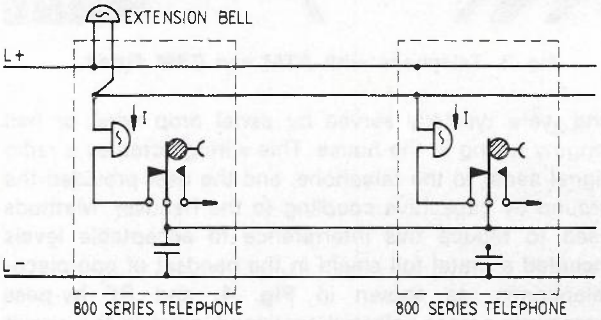


Fig. 6. Simplified 4-Wire Circuit with Extension Bell.

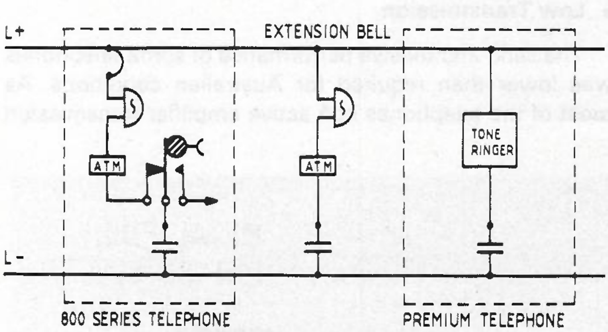


Fig. 7. Simplified 2-Wire Circuit with Extension Bell.

retrospectively to telephones in customers' premises. Further, this method was not favoured because it is only effective when the telephone is connected in the correct polarity to the line. Also, the problem would remain of the 800 series bell shunting the premium telephone high impedance tone ringers.

- **Thermistor**

A thermistor could be connected in series with the 800 series telephone bell to provide anti tinkle. These devices rely on thermal hysterisis to provide a high impedance in series with the bell during the low energy short duration dial pulse back EMFs, and a low impedance after a period of heating by the ringing current to allow bell ringing. Unfortunately, the thermistor has an unpredictable anti tinkle and ring performance as its resistance is subject to the ambient temperature, which varies widely throughout Australia.

ATM Design Parameters

The ATM was designed to meet the following parameters:—

- Prevent bell tinkling off all types of exchanges and PABXs.
- Provide ring current sharing for all combinations of telephone types in parallel with 800 series telephones, including extension bells.
- Respond to ring signals from 17 Hz to 50 Hz with amplitudes of 40 V rms to 100 V rms.
- Operate over the temperature range -10°C to +55°C.
- Withstand 2 kV 10/700μS voltage surges.
- Allow line testing for the bell capacitor from remote test centres.
- Prevent dial impulse distortion.
- To be fitted inside 800 series telephone.

The ATM (**Fig. 8**) was first designed to simulate in electronic form the characteristics of the thermistor. It was soon found that the average voltage of dial pulses on a zero resistance line off a step by step exchange, as seen by the ATM, was higher than the average voltage of minimum ring signal. Fortunately, the transition between the break and make of the dial pulse is faster than the maximum rate of voltage change of the 100 V rms 50 Hz ring signal. A dial pulse detection circuit was then added to the initial circuit. Further testing showed that when highly inductive extension bells were connected to the telephone service, voltage spikes were detected by the ATM as dial pulses, and the ATM went into the high impedance dial pulse detection state. To overcome this condition, a dial pulse detector enable switch was added to the design to disable the dial pulse detection circuit once the ATM is in the low impedance state.

The first versions of the ATM for field trial were constructed on a PBA which mounted under the telephone bell gong fixing screws. This method of construction was unsuitable for general use as it occupied too much space in the telephone and was therefore limited to the basic 800 series telephone.

Following discussions with manufacturers, it was found to be possible to economically produce the device by potting the components together in an expoxy resin using the same techniques used to manufacture certain capacitors. This method allowed production of a robust single small component which would fit the 800 series, Gondola and Ericofon telephones, which would need to use the device. To avoid special mounting arrangements, one side of the ATM was covered by a piece of double sided adhesive tape. This allows the technician to simply peel off the backing paper and fix the ATM onto the top of the bell circuit capacitor (Fig. 3).

After the initial production of some 20,000 anti tinkle modules, it was found that the spread of component tolerances in production resulted in many anti tinkle modules not meeting specification. This problem was overcome by the change of some component values. By March 1984, 30,000 ATM had been supplied and these have performed satisfactorily in service.

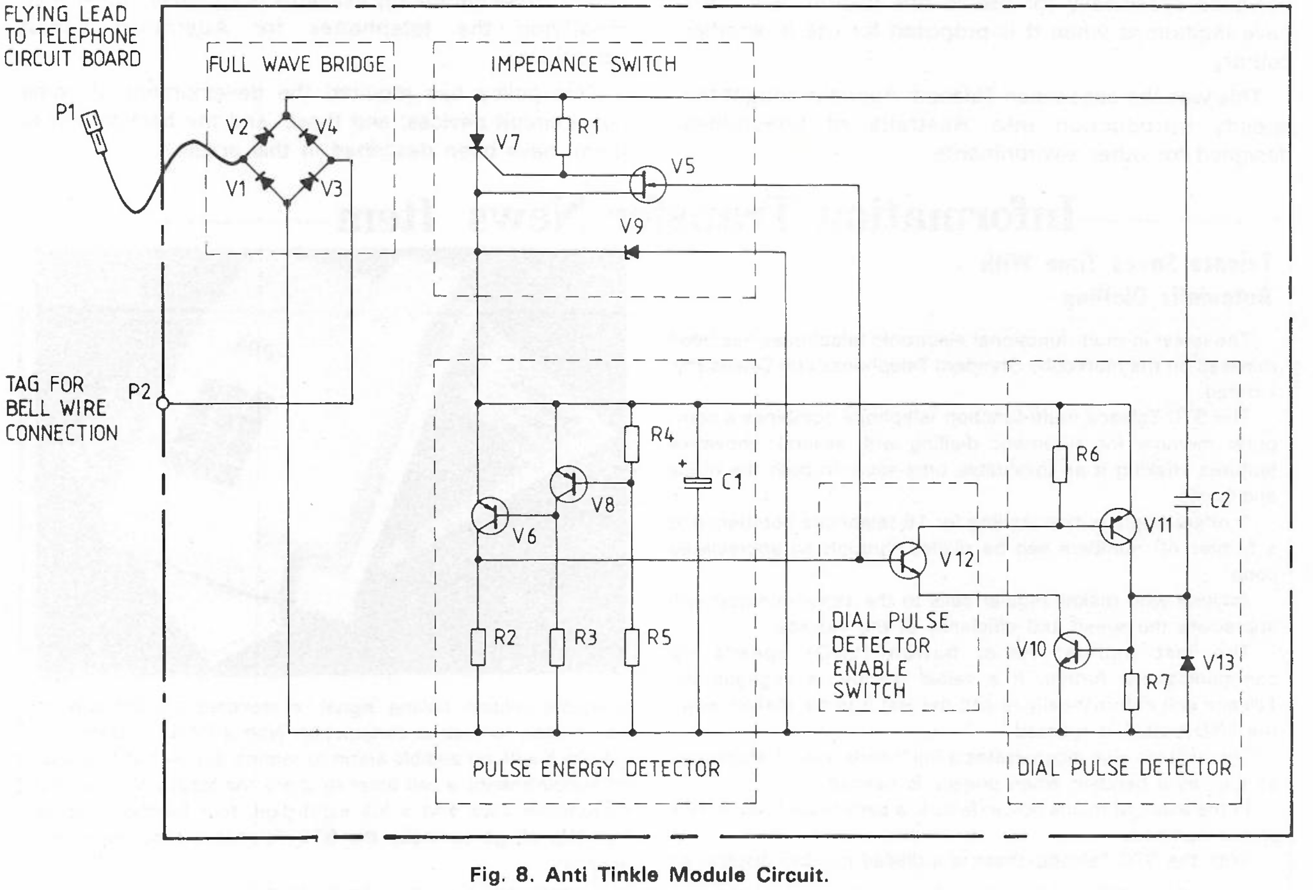


Fig. 8. Anti Tinkle Module Circuit.

THE CURRENT SHARING MODULE (CSM)

CSM Design Parameters

The CSM was designed to meet the following parameters:—

- Provide current sharing between two telephones of different impedance when both are in the off-hook condition.
- Low voltage drop across the CSM when only one telephone is off-hook.
- Low impedance to speech transmission and incoming ring.
- Operate over the temperature range -10°C to +55°C.
- Withstand 2 kV lightning surge tests.
- Can be retrofitted to any telephone.

To allow the high and low impedance telephones to share the transmitter current equally, it was simplest to increase the dc resistance of the lower resistance telephone. The CSM is placed in series with the line of the low impedance telephones in a parallel service. The circuit of the CSM (**Fig. 9**) shows the added resistance and a capacitor to provide a low impedance path for speech and ring currents. The zenner diodes protect the capacitor. Some telephones, such as the one piece type, did not have sufficient space inside the telephone case to mount a CSM, and it was necessary to locate the CSM outside the telephone in the line plug as shown in Figure 2. This external mounting has been adopted as standard for all cases.

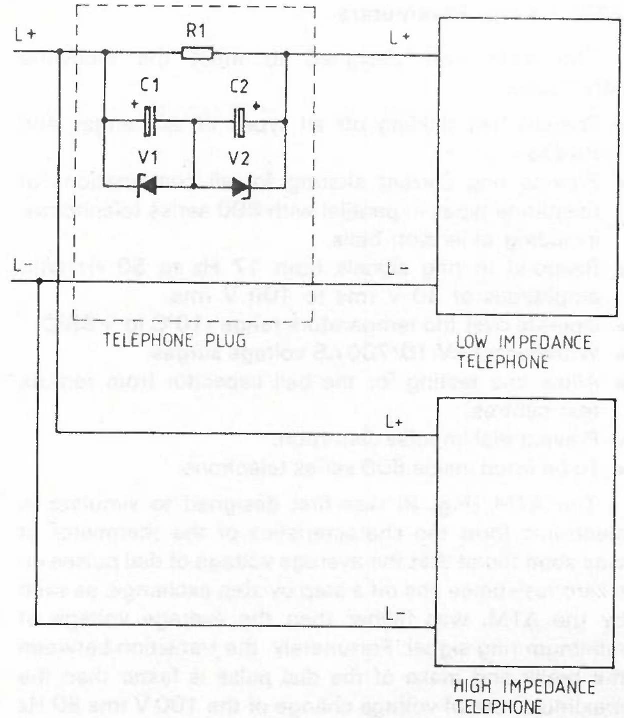


Fig. 9. Current Sharing Module Circuit.

SUMMARY

Each telephone system around the world has its own particular characteristics. A telephone instrument designed specifically for use in one country will often have limitations when it is proposed for use in another country.

This was the case when Telecom Australia sought the speedy introduction into Australia of telephones designed for other environments.

Telecom is a relatively small user of telephones available throughout the world. Consequently, should Telecom consider the future use of telephones from around the world, it would seem more appropriate to tailor Australian wiring and connection arrangements to accept these commonly available telephones, rather than modifying the telephones for Australian circuit conditions.

This policy has required the development of some novel circuit devices, and these, and the background to them, have been described in this article.

Information Transfer News Item

Teleace Saves Time With Automatic Dialling

The latest in multi-functional electronic telephones has been released on the market by Standard Telephones and Cables Pty. Limited.

The STC Teleace multi-function telephone combines a computer memory for automatic dialling with several innovative features, making it an invaluable time-saver in both the office and home.

It offers single button dialling for 16 telephone numbers and a further 40 numbers can be dialled through an abbreviated code.

Anyone who makes regular calls to the same numbers will appreciate the speed and efficiency of the Teleace.

The last number redial button (LND) speeds up communications further. If a called number is engaged the Teleace will automatically re-call the last number dialled when the LND button is pressed.

The Teleace also incorporates a full 'hands free' loudspeaker, as well as a handset when privacy is needed.

In the event of mains power failure, a battery back-up retains stored numbers.

With the STC Teleace, there is a dialled number display, an adjustable volume calling signal, a standard keypad and an earth button for use in conjunction with a PABX system.

A clock with an audible alarm to remind the user of meetings and appointments, a call timer to check the length of trunk and international calls and a full eight-digit, four function display calculator all go to make the STC Teleace a most attractive package.

Local Area Networks

P. F. FRUEH B.E. M.Eng.Sc.

This article describes a relatively new form of telecommunications network, the Local Area Network, which is finding increasing application for office communications. As well as examining the underlying technology and techniques, the article considers standardisation, applications and interworking aspects.

INTRODUCTION

One of the fastest developing areas in telecommunications is office systems, particularly those used to support services such as electronic mail, voice mail, database access, etc. These systems provide a range of voice and non-voice services to users within an organisation who are located within a single geographical site. While recent developments in PABX technology and techniques allow them to support some of these services, this article concentrates on the more fundamentally new Local Area Network (LANs).

LANs are high speed networks which can interconnect a range of devices (see **Fig. 1**) within a single site. Although the name LAN is most commonly used, alternative names such as Local Area Computer Network or Local Computer Network are sometimes used, signifying that these networks were originally developed for distributed data processing.

There is no precise definition of a LAN but they are generally characterised by:—

— Single site, often an office building or group of buildings in a campus environment, typically of 1-2 km range;

— high data transfer speed, typically 1-20 Mbit/s;

— low error rate, typically much less than 10^{-8}.

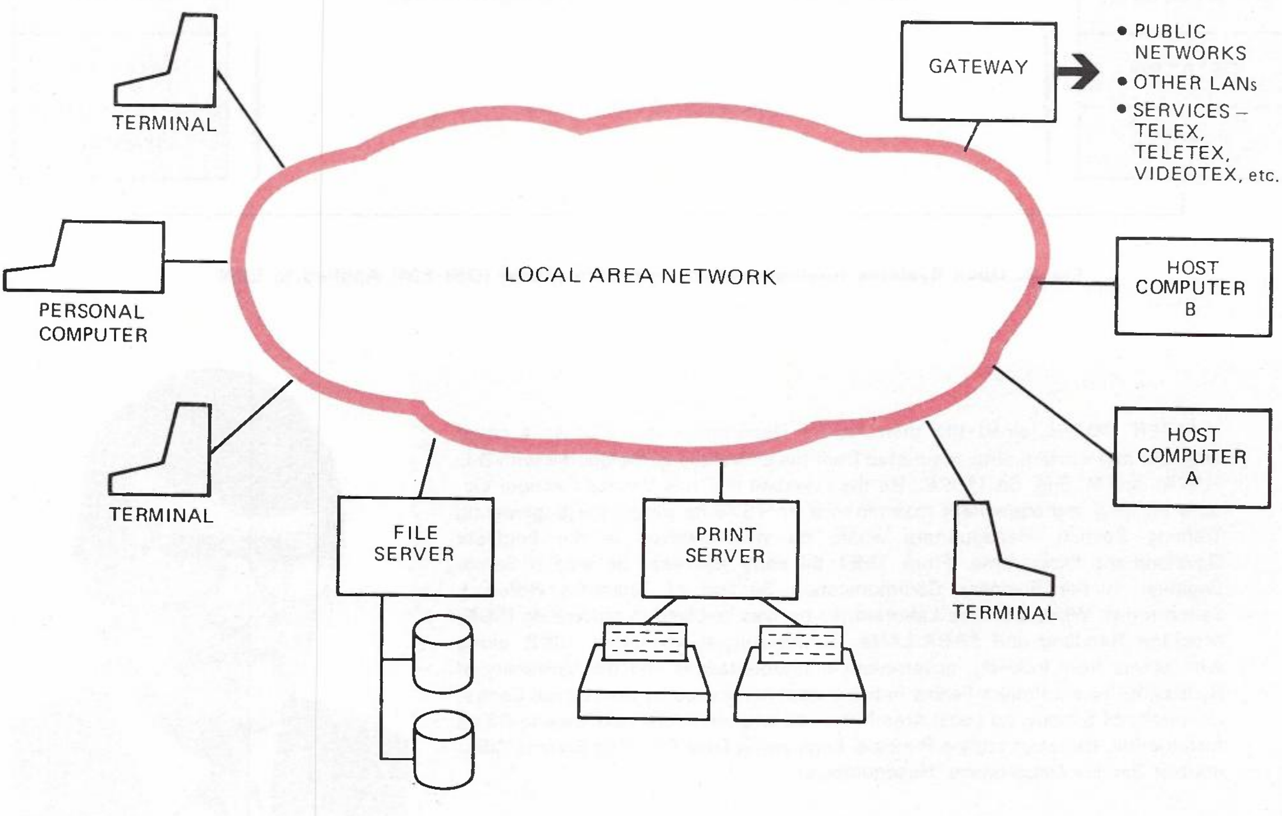


Fig. 1. Functional View of a Local Area Network

Fig. 2 illustrates the operating region of LANs in relation to more traditional data communication techniques. It can be seen that in effect LANs geographically extend the computer bus, allowing computers and intelligent workstations to operate in a distributed manner, exchanging files at high speed (M-bit/s) and sharing resources such as mass storage and printers.

It is useful to consider LANs within the framework of the Open System Interconnection Reference Model (OSI-RM) as shown in Fig. 3. The OSI-RM partitions communications tasks into seven layers. Within each layer a defined set of procedures, termed a protocol, is used to facilitate the efficient completion of the tasks associated with that layer. These layers are additional to the physical transmission medium used to carry the information. The bottom three layers are involved in managing a communication path across a single network. The fourth layer, the Transport layer, is used to isolate higher layer protocols from network specific aspects and provide a uniform quality of service. The

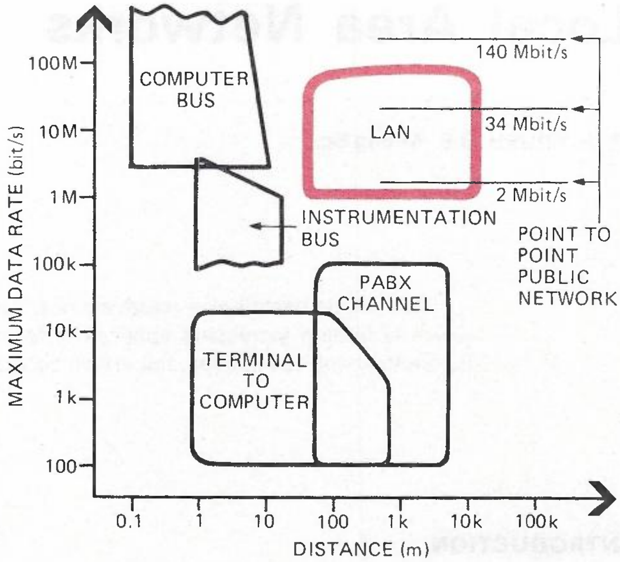


Fig. 2. LANs Compared to other Networks

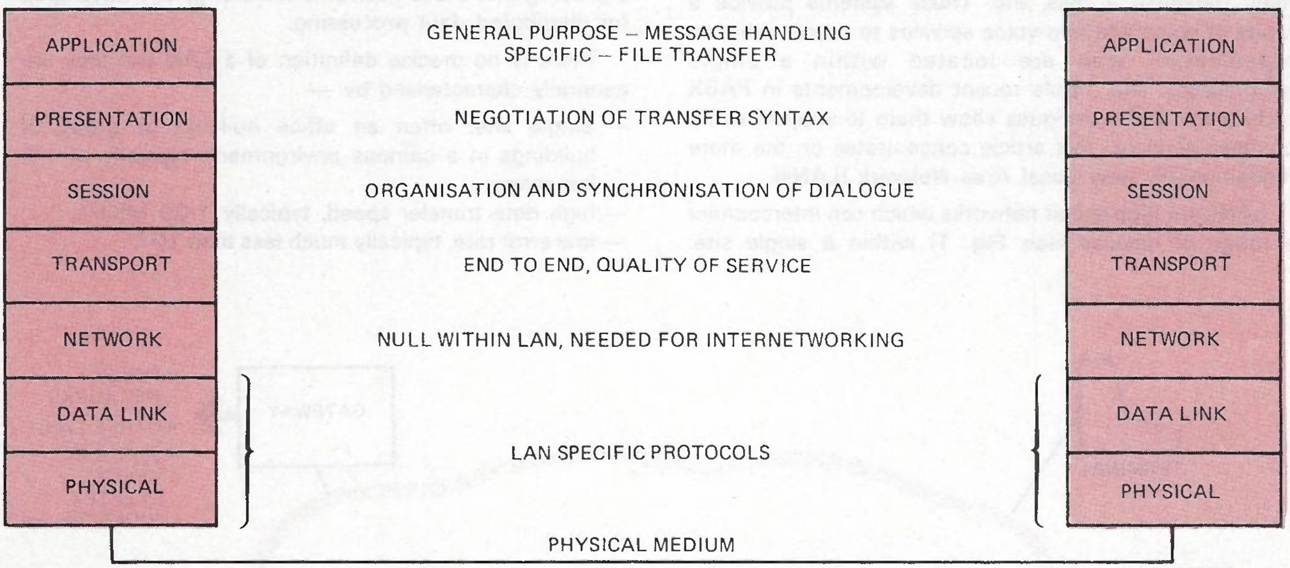
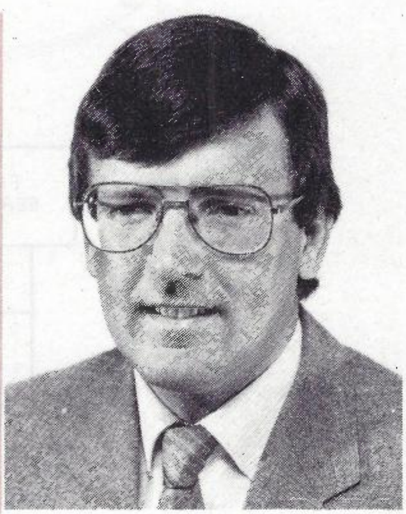


Fig. 3. Open Systems Interconnection Reference Model (OSI-RM) Applied to LAN

PETER FRUEH joined the then PMG's Department in 1972 as a cadet engineer and subsequently graduated from the University of Melbourne with B.E. (1974) and M. Eng. Sc. (1976). He then worked in Trunk Service Section, Victoria on long line equipment maintenance. In 1978 he joined the Engineering Training Section, Headquarters where he was involved in the Engineer Development Programme. From 1981 till early this year he was a Senior Engineer in the Business Communication Section of Telecoms Research Laboratories. While with the Laboratories he was involved in studies on ISDN, Message Handling and PABX/LANs. During August-November 1983, along with others from industry, government instrumentalities and the University of Sydney, he was a Project Fellow in the project conducted by the Warren Centre, University of Sydney, on Local Area Networks with particular reference to Office Automation. He is currently a Principal Engineer in Data Planning Branch, Commercial Service Department, Headquarters.



Transport layer is the first protocol which operates from end device to end device, across multiple networks. Layers 5 to 7 are used to provide for common application oriented user requirements such as managing the session, negotiating the presentation of information and providing messaging and file transfer capabilities.

When considered from the OSI-RM viewpoint, LANs may have functions spread throughout these seven layers. However the essential differences between LANs and other networks are most evident in the bottom three layers.

LAN ARCHITECTURE

When considering the types of available LANs, one thing becomes clear — they are characterised by diversity.

The aim of this section is to identify different parameters such as network topology, transmission media, etc., which can be used as a framework for consideration of specific LAN products.

NETWORK TOPOLOGY

Network topology refers to the manner in which the network provides interconnection paths between devices connected to it. The four basic topologies are star, bus, ring, and mesh, as shown in **Fig. 4**.

In practice a combination of these topologies is often employed. For example nodes on a ring network may actually connect a number of devices which are connected to the node in a star configuration.

Star

In the star topology a central switching node is used to which each device is connected. All traffic passes through the central node. The switching technique used within the node can be:

CIRCUIT SWITCHING — dedicated and fixed transmission capacity is allocated to intercommunicating devices for the duration of a communication session. The circuit connection passes through a number of phases — call establishment, information transfer and call cleardown. Circuit switching is used in all modern PABXs for the provision of voice and data communications;

PACKET SWITCHING — finite length packets of information are passed between the network and communicating devices;

MESSAGE SWITCHING — the entire message of the sending device is transmitted to the central node where it is stored for later retransmission to the receiving device or devices.

Bus and Tree

In a bus topology all devices are directly connected to a single transmission medium. (Although a simple bus is shown in **Fig. 4**, a physical tree topology is often used in practice. The tree may be formed from a number of bus sections interconnected by repeaters.) Other LANs, particularly broadband LANs, directly use a physical tree topology. However these LANs are generally also termed "bus" systems as all devices are logically connected in a bus topology.

Use of the transmission medium is shared between all devices, using a variety of techniques which are described later.

Ring

In a ring topology network nodes are connected together with transmission links to form a closed ring. The transmission links are normally used unidirectionally with information flowing from the source node to the destination node. A monitor station is often included in the ring to ensure that proper operation occurs and to alert the system administrator of faults. The information generally takes the form of packets of data. Responsibility for removing used packets from the ring may lie with the source, destination or monitor station nodes, depending on the protocol used. Nodes may be individual devices or concentrators which are in turn connected to a number of devices.

Mesh

In the mesh topology devices are interconnected to one another directly. For small number of devices this technique is quite effective, but the number of links required rises rapidly as the number of devices increases. Mesh topology is often used jointly with other topologies such as star. In this case devices may connect in a star topology to a switching node and a mesh topology is used between switching nodes.

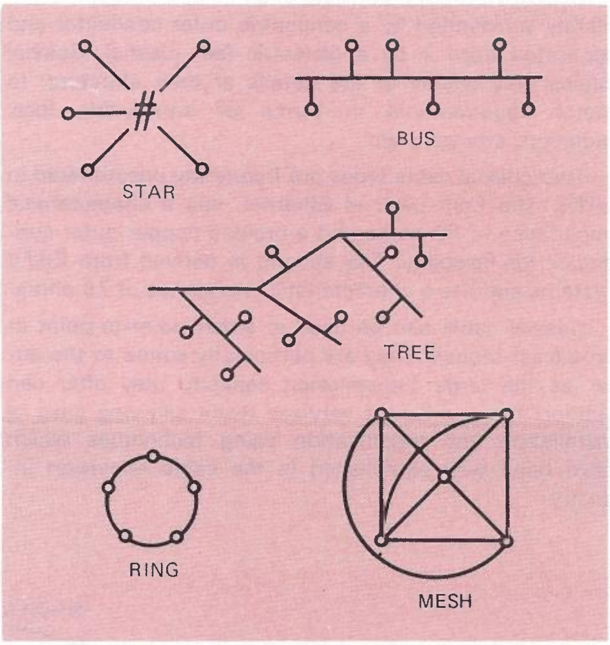


Fig. 4. LAN Topologies

TRANSMISSION MEDIA

The transmission medium provides the physical connection between devices attached to a LAN. It may take the form of twisted pair cable, coaxial cable, optical fibre cable and free space (for radio or infrared transmission).

Some factors which influence the choice of a particular LAN medium include:

— desired transmission capacity over the medium expressed either in terms of information capacity (measured in terms of bit/s for digital signals) or bandwidth (measured in Hz for analogue signals);
— physical range of the LAN required, while maintaining the full transmission capacity. This may range from a few hundred metres to several kilometres;
— variety of services to be supported by the LAN eg. data only or a combination of data, voice or video;
— noise immunity;
— signal radiation from the medium;
— total system costs including those for installation, commissioning and maintenance through the system lifetime.

Each of the LAN media differs in the various factors listed above. In this section each medium is briefly described.

TWISTED PAIR CABLE consists of individually insulated wires which are twisted together in a helix. A number of pairs may be bundled together to form a multipair cable. Twisted pair cable is low in cost and very widely used for telephony. Depending on the environment and the encoding technique used they can be employed to transmit digital signals over several kilometres at rates up to several hundred kb/s. With signal regeneration at repeaters they can be used at several Mb/s. Twisted pair cable can be used in either broadcast or point to point mode, and are most commonly used in a star topology.

COAXIAL CABLE consists of an inner conductor completely surrounded by a concentric outer conductor and separated from it by a dielectric (air, plastic). Coaxial cables vary widely in the details of their structure, to match requirements in terms of bandwidth, loss, radiation, strength, etc.

Two coaxial cable types are frequently encountered in LANs. The first, used in Ethernet, has a characteristic impedance of 50 ohms and a braided copper outer conductor for flexibility. The second is derived from CATV systems and has a characteristic impedance of 75 ohms.

Coaxial cable can be used in either point-to-point or broadcast modes. They are particularly suited to the latter as the large transmission capacity they offer can support many different services while allowing ease of installation and modification using techniques which have been well established in the cable television industry.

OPTICAL FIBRE CABLE. Communications is achieved by transmission of light through an optical fibre and appropriate electrical/optical conversions at each end. The light is contained within the fibre core by total internal reflection.

The dominant light sources are semiconductor lasers and light emitting diodes (LEDs) while photodiodes are generally used as the light detectors.

Optical fibre systems are normally used as high speed baseband digital transmission systems at speeds of from one to several hundred Mb/s. Ring and star topologies predominate for optical fibre LANs.

As optical fibre systems evolve, transmission capacity, range and reliability are expected to increase while costs continue to decrease.

FREE SPACE (FOR RADIO AND INFRARED). There are a number of significant disadvantages in using free space as a LAN medium, including:
— limited availability of frequency allocation in the electromagnetic spectrum;
— modest bandwidths supported;
— restricted geographical range of terrestrial systems;
— noise and interference.

To maximise the use of the limited bandwidth available, packet transmission techniques and a variety of modulation schemes are used. The limitations of radio as a transmission system (for example high error rates) impact heavily on the protocols used for information transfer.

MEDIA ACCESS CONTROL

Where a number of devices are connected to a common transmission medium in a LAN, some form of media access control technique is needed to ensure that the medium is shared satisfactorily. This can be achieved in a wide variety of ways (see **Fig. 5**) and the particular technique chosen generally reflects both the characteristics of the medium and the network topology. A number of common media access techniques and applications for which they are suited are described below.

FREQUENCY DIVISION MULTIPLEXING (FDM). A transmission medium may have its total bandwidth subdivided into a number of channels of lesser bandwidth. These channels may then be used for a par-

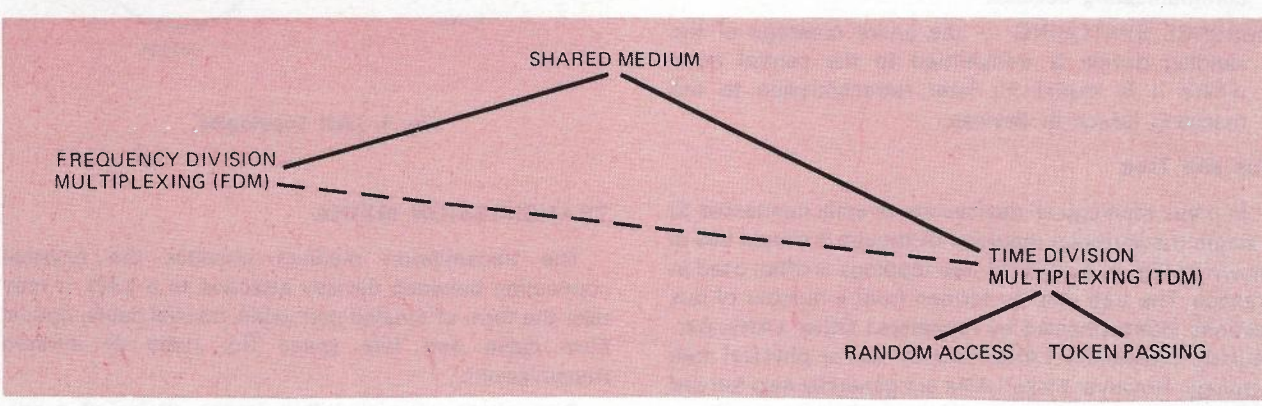


Fig. 5. LAN Media Access Techniques

ticular service or they may be further sub-allocated using some of the other techniques described below.

FDM has traditionally been used for the analogue transmission of services such as telephony and video. In particular, broadband LANs, utilising CATV technology, use FDM to split the large available bandwidth (50 = 50-350 MHz) into smaller channels.

TIME DIVISION MULTIPLEXING (TDM) techniques rely on making the full capacity of the medium available to individual devices but sharing the time available. For example fixed timeslots may be allocated to each device whether it has information to transmit or not. This technique is efficient for high traffic levels and where the service requires fixed capacity for long periods. For low traffic levels and for bursty traffic other techniques are more suited.

TOKEN PASSING techniques allow a device to transmit only while it possesses a token. This token is then passed on to other devices. A number of algorithms for the transfer of the token may be used and these can be tailored to suit the application. In essence, token passing is a deterministic media access control technique. As such it is very well suited for applications with a specific real-time requirement, for example telephony or industrial process control. For high speed and high traffic networks this method is also more efficient than Random Access schemes. While token passing is conceptually simple, in practice it can be rather complex to implement due to the need to provide specific mechanisms for startup, to overcome loss of a token, to prevent duplicate tokens and to allow for devices to enter and leave the network.

RANDOM ACCESS SCHEMES (ALOHA, CSMA, CSMA/CD). These techniques apply distributed control, where each device has associated with it media access control rules which govern the sharing of the medium. This allows the situation to arise where two or more devices are contending for access to the medium at the same time. As a result contention resolution techniques may need to be used. Random Access schemes are generally suitable for applications where many devices access the medium but only infrequently. Another limitation is the fact that the information transfer delay is probabalistic rather than deterministic and this can limit their use in critical real-time applications.

(CSMA) Carrier Sense Multiple Access. CSMA requires that devices listen before transmitting. If another device is transmitting, the listening device defers to it, either by backing off for a period of time or by monitoring and transmitting when it is clear. CSMA is efficient for networks whose propagation delay is small compared with the transmission time of the message. At very high traffic levels some instability is evident.

(CSMA/CD) CSMA with Collision Detection. CSMA/CD is similar to CSMA with the extension that the transmitting device monitors the medium to detect whether another device has also attempted to transmit (resulting in a collision of information signals). Obviously this technique is only possible for a logical bus topology and for media which allow detection of collisions. After a collision has occurred, transmitting devices back off for a random period before attempting retransmission. To prevent overload this random period can be extended when repeated collisions are encountered. As such CSMA/CD is a robust technique which is efficient (at modest speeds) and stable under overload.

LAN PROTOCOLS

The protocols used in a LAN are the formal set of procedures adopted by communicating devices to effect information transfers. Ideally these protocols would be:

— simple, to aid implementation, verification and understanding;
— robust, to cope with network degradations;
— standardised for universal applicability;
— efficient for a wide range of services;

In practice some of these requirements are contradictory and, as in other areas, design choices must be made. A large number of different protocols are in fact in use, although the trend is towards standards.

A major division of LAN protocols is between those providing connectionless services and those providing connection-oriented services.

A connectionless (datagram) service delivers packets of information individually. These packets may have been formed by packetising a continuous data stream or they may be self-contained messages of limited length. As packets are handled individually the network does not need to maintain connection information and this can lead to more efficient dynamic traffic routing and simplicity in implementation, particularly for interconnected LANs. Depending on the network's topology, packets may be delivered out of sequence or not at all. As a result, where connectionless protocols are used in the data link layer, higher layer protocols (typically transport layer) are normally employed to ensure error free end-to-end communication. In LANs where error rates are normally very low and where (depending on the topology) packet sequence integrity may be ensured, connectionless protocols at the data link layer are generally used.

A connection-oriented (virtual circuit) service allows communicating devices to establish a logical connection over the network for the duration of a session. Connection-oriented protocols provide a smooth, in sequence, flow of information which makes them suitable for applications such as terminal-to-host-computer communication and as a delivery service for existing protocols such as X25. In public X25 data networks connection-oriented (virtual circuit) service is normally provided.

IMPACT OF VLSI TECHNOLOGY

For LANs to find widespread application it is necessary for the cost of LAN interfaces to be reduced through the use of Very Large Scale Integration (VLSI) technology.

An example of a LAN interface implementation is shown in **Fig. 6**.

Most of the interface electronics is contained in the controller card. Due to the moderate complexity of the media access and logical link control procedures used a current implementation typically requires 50 to 100 Small and Medium Scale Integration (SSI/MSI) Integrated Circuits (ICs). As a consequence the cost of interfacing has been well over $1,000 per device.

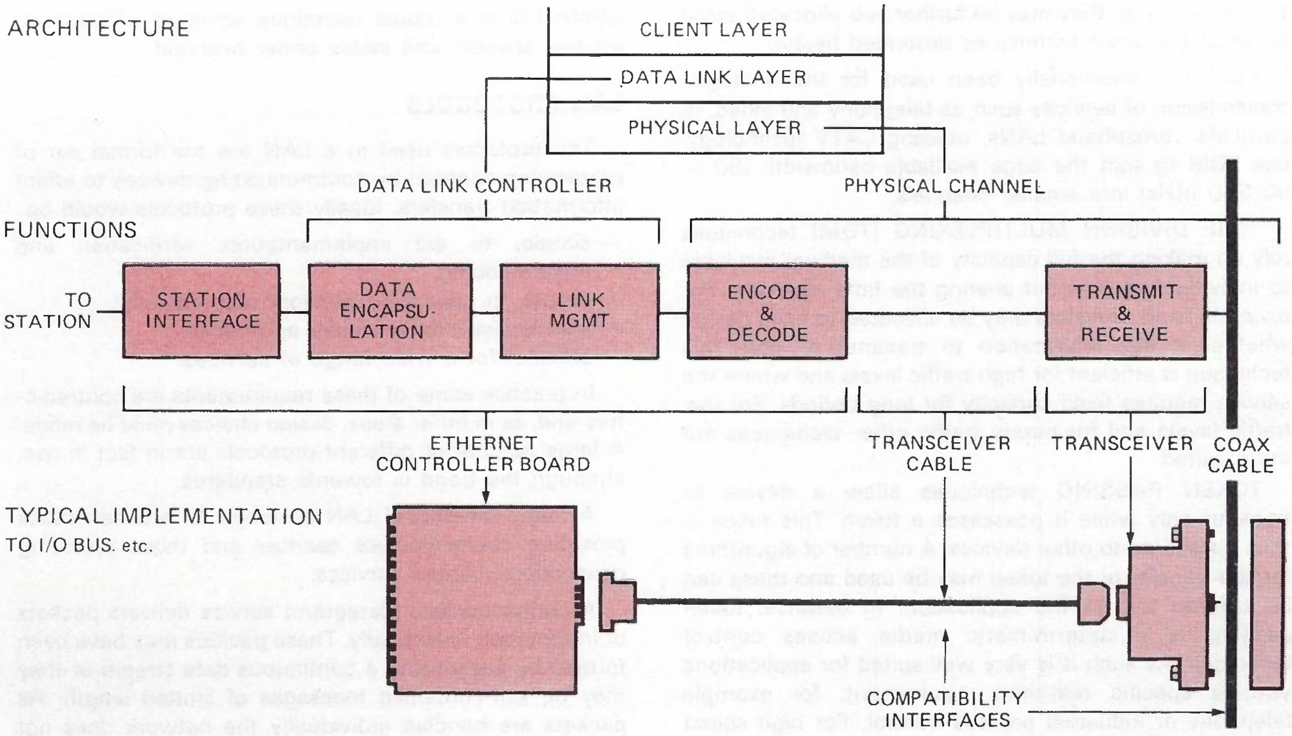


Fig. 6. Typical LAN Interface Implementation (Ethernet)

As standards such as the IEEE 802 standards and de facto standards, for example Xerox's ETHERNET and Datapoint's ARCNET, become established, IC manufacturers are beginning to implement them in VLSI. Typically one or two devices contain most of the interface circuitry, although an additional 10 to 20 devices may be required. Using these VLSI devices brings the cost of interfacing down to approximately $500.

Although the primary aim in implementing LAN interfaces in VLSI is to reduce costs, a number of important secondary benefits are derived, including:

- — small size of printed circuit board used. This allows LAN interfaces for existing Input/Output slots, for example in Personal Computers. For new designs the LAN interface may be incorporated as a small section of the main circuit board, further reducing costs;
- — lower power consumption, reducing demands on system power supplies;
- — enhanced reliability through the much reduced number of components.

STANDARDISATION

The dilemmas of standardisation are very evident in LANs. To what extent and when to standardise?

- — too much or too soon stifles innovation and inhibits market forces;
- — too little or too late can leave manufacturers with a fragmented and limited market, and users with confusion and incompatible equipment.

As is evident from the previous sections, the range of design choices (media, media access, topology, etc) open to manufacturers is enormous. Moreover, the wide range of applications justify a variety of different LAN types. As a result it is impossible to achieve a single standard for LANs which would suit all applications or recognise the different major market forces.

The major work in standardisation of LANs has been by the Institute of Electrical and Electronics Engineers (IEEE) which formed its 802 Committee in 1980. Initial efforts in standardisation concentrated on the bottom two OSI-RM layers. Higher layer protocols are only beginning to receive attention.

The IEEE 802 Committee found it useful to sub-layer the bottom two OSI-RM layers into three layers as shown in **Fig. 7**. One difference between LANs and other networks is that devices often share a common medium rather than having dedicated media. As a result, while there are recognizable Link and Physical layer functions there is an additional Media Access Control (MAC) function. This function requires a protocol to be specified between devices which regulates access to the common shared medium.

The need for a variety of different LAN types has led to the IEEE developing a family of standards as shown in **Fig. 8**. Three major categories of LAN, the CSMA/CD, Token Bus and Token Ring are specified. For each of

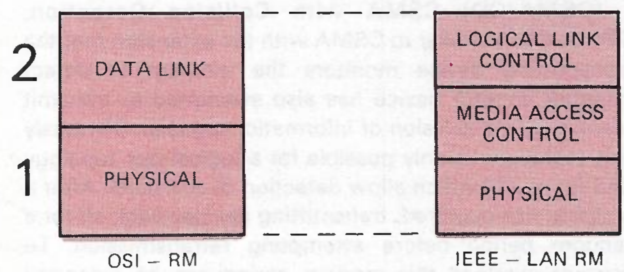


Fig. 7. IEEE Reference Model Sub-layering

these categories a number of optional implementations are described, for example baseband and broadband, various speeds (1, 5, 10 and 20 Mbit/s), etc. One of the CSMA/CD types is almost identical with Ethernet. The Token Ring standard is being primarily progressed by IBM and reflects their preferred LAN techniques.

A major new area under consideration is Metropolitan Area Network (MANs). These networks would apply LAN techniques over city wide areas (10-50 km). Although MANs are potentially very important it is not clear that there are strong forces for standardisation yet or if IEEE is the appropriate body for this type of standard.

Each category of LAN shares a common logical Link Control (LLC) standard. This is a major achievement of the IEEE 802 Committee, allowing a variety of LAN techniques to be used while maintaining a common interface for system integration. Two alternative LLC protocols types are supported:—

Type 1 (Connectionless)
Type 2 (Connection Oriented).

The current status of these standards is that 802.2, 802.3 and 802.4 are complete. 802.5 is still at draft stage and a standard for 802.6 is some time off, if it does indeed eventuate.

802.1 is an overview document which defines the objectives of the standards, relationships between the standards and to the OSI-RM. It will also define what is implied by compliance to the standards, what form of internetwork addressing and network addressing is adopted. As an overview document, 802.1 is being held in draft form until the other standards are completed.

Some preliminary work examining the networking implications of LANs has been undertaken within the International Organisation for Standardisation (ISO) and the International Consultative Committee for Telephone and Telegraphs (CCITT).

APPLICATIONS

Proprietary

Some LANs (eg. Datapoints ARCNET, Wangs WANGNET) have been developed by manufacturers to interconnect their particular equipment. Devices connected to these proprietary LANs may communicate at high speed (Mbit/s) to exchange files (programs, data, voice, image), share mass storage, etc. To support these applications, devices must use the same proprietary higher layer protocols. This restricts users of this type of LAN to a single manufacturer, unless cross-licensing agreements between manufacturers exist (eg. Datapoint/Radio Shack). Some manufacturers make available their protocols in an attempt to have them become defacto standards (eg. Xerox Network Systems protocols).

Networking of Existing Equipment

Many organisations currently have a range of different Data Processing (DP) equipment and use a number of different data communication techniques. Point to point links are commonly used between terminals and host computers and to a lesser extent concentrators and multiplexors which reduce the wiring involved. Problems with this approach are:

— the total amount of wiring involved is often considerable. Given the need for rapid expansion and change in DP installations, wiring can be a major headache, particularly in older buildings.
— terminals are associated with particular hosts and operation on multiple hosts depends on the availability of special inter-host software or cumbersome manual patching techniques.

LANs can partially solve these problems (see **Fig. 1**) by allowing terminal users to log on to a number of different hosts and by lessening wiring difficulties. Links provided by networking LANs are generally low speed (up to 19.2 Kbit/s) for terminal interconnection. Higher speed links (up to several Mbit/s) are possible between hosts using networking LANs but this may require the development of host specific software. Networking LANs (eg. Ungermann-Bass Net/One, Sytek Localnet 20/40/50) are suitable for medium to large users with significant installed DP and data communication equipment.

Future Networking

As standards, both open standards (eg. IEEE 802) and defacto standards (eg. IBM, Ethernet), emerge and as the use of VLSI brings down implementation costs, we can expect to see LAN interfaces directly incorporated into equipment. Future intelligent workstations will use a LAN

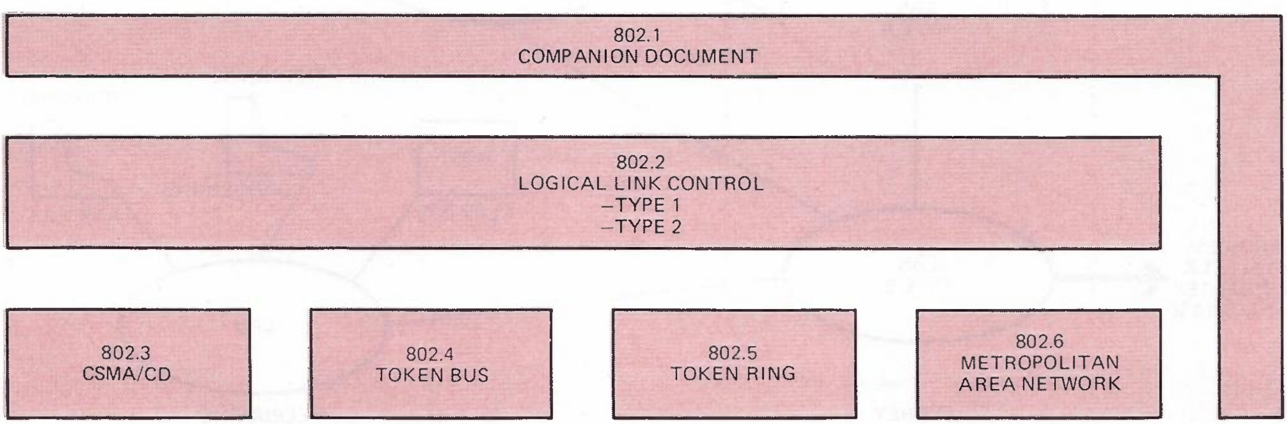


Fig. 8. Structure of IEEE LAN Standards

interface in the same way that terminals currently use RS 232C interfaces.

LAN INTERWORKING

While a LAN provides communications within a site, many users will wish to communicate through the LAN to other sites within the same organisation and to other organisations. To achieve this LANs need to be interworked with other networks (see **Fig. 9**).

Within Australia a number of current Telecom Australia services can be used for interconnection (see Table 1). Potentially Aussat may also be used for LAN interconnection. Overseas links can be achieved using the services provided by the Overseas Telecommunications Commission (OTC). Careful analysis of requirements is needed to establish the optimum mix of interconnection methods.

The device which interfaces between a LAN and another network is called a gateway and its function is to resolve differences between the networks sufficiently to allow interworking. Gateways can be either network or end user service gateways. Using the OSI-RM, network gateways resolve layers 1 to 3. Service gateways provide access to end user services for example Teletex or Videotex, and must implement appropriate upper layer protocols (Layers 5-7) as well as lower layers.

Among the gateway functions which need to be performed are:—

— SPEED CONVERSION, BUFFERING AND FLOW CONTROL. LANs typically operate at Mbit/s speeds internally and to interconnect to lower speed networks the gateway must adjust the speed accordingly. Buffers are required to take information at the higher speed and temporarily hold it for transfer at the lower speed. To prevent the buffers from overflowing flow control is employed. This involves temporarily halting devices transmitting at the higher speed while full buffers are emptied.

PERMANENT CONNECTIONS	
Datel	300 bit/s-48 kbit/s
Analogue Data Service (ADS)	Up to 1200 bit/s
Digital Data Service (DDS)	2.4,4.8,9.6 and 48 kbit/s
2Mbit/s Cable	2 Mbit/s
Digital Radio	2,8,34 Mbit/s
SWITCHED CONNECTIONS	
Datel	300 bit/s — 9.6 kbit/s
ADS	User selected
Austpac — Asynchronous	
Character Mode	110-300,1200 bit/s
Packet Mode	2.4,4.8,9.6 and 48 kbit/s

TABLE 1 CURRENTLY AVAILABLE TELECOM AUSTRALIA SERVICES FOR LAN INTERCONNECTION

— PROTOCOL CONVERSION. Where the networks use different protocols the gateway must act as a translator, converting between the protocols.

— ADDRESSING. LANs often use different addressing schmes to other networks. The gateway must be able to translate addresses from one network to the other.

— ROUTING AND ACCESS CONTROL. If the gateway has available alternate routes to the destination it may dynamically determine the optimum route, depending on a number of variables. Access controls may be required to restrict user access to particular destinations.

CONCLUSION

Although currently in their infancy, LANs can be expected to find rapidly increasing application in Australia. LANs lie at the centre of the office automation, computing and communications triangle. Through their high speed communication paths, LANs can support new forms of distributed processing and innovative office automation services.

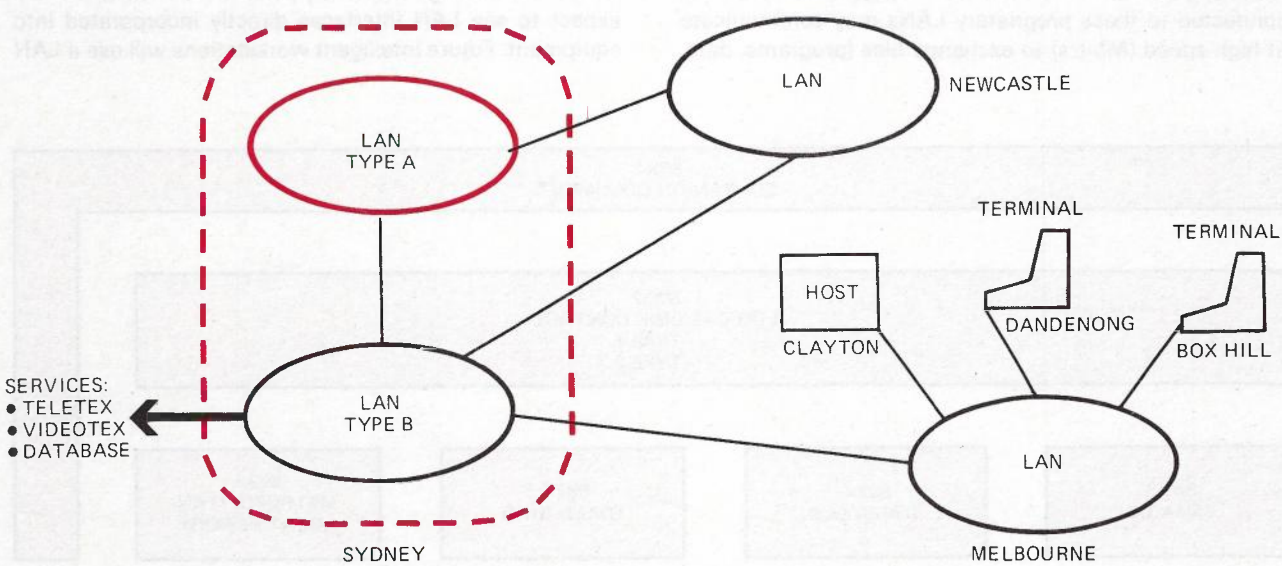


Fig. 9. Example of LAN Interconnection

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A major source of reference material on LANs in Australia is "Local Area Networks: with particular reference to office automation," which is a report of a project at the Warren Centre for Advanced Engineering at the University of Sydney, 1983.

Other general references include:

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Information Transfer News Item

COMPACT DIGITAL SWITCHBOARD FROM PLESSEY COMMUNICATION SYSTEMS

Plessey Communication Systems Pty Ltd, have announced technical details and product features of their latest fully computerised digital switching system — designated CDSS — which has its own built-in self-testing program.

The CDSS system was developed in the United Kingdom and, since its introduction several years ago, more than 12,000 systems have been sold world-wide. Earlier this year the system, carrying the model designation "Monarch 120" in the U.K., was one of the award winners of the Duke of Edinburgh's designer prize.

Aimed at the small business segment, CDSS is the new generation of compact, computerised switchboard systems. If offers no less than 57 systems, operator and extension features and three additional optional features. The system is available in 61 and 117 extension configurations. The new operator's console, with its touch-sensitive keys, weighs seven kilos, while the equipment cabinet for the 117 extension system weighs 66 kilos.

The CDSS system has been designed for installation in a typical air-conditioned office environment and it removes the expense of a separate switching room, necessary with the previous generation of switchboards.

A wide range of facilities is provided in each CDSS system including a stored directory of most often called numbers, conference calls, on request automatic re-dialling of an engaged extension, 'classing' of extensions enabling or preventing the making of trunk calls and many other facilities.

In normal operations the CDSS self-test program constantly monitors system performance and any problem is indicated at the operator's console on an LCD display.

The operator is therefore able to advise the Telecom service engineer exactly which problems are being experienced. Defective items can generally be replaced without interrupting other system operations.

The modular equipment design simplifies expansion. By adding a second equipment cabinet the 61 extension configuration may be expanded up to 117 customer useable extensions.

The complete system is extremely user-friendly. It constantly monitors its functions and advises the operator precisely what is happening.

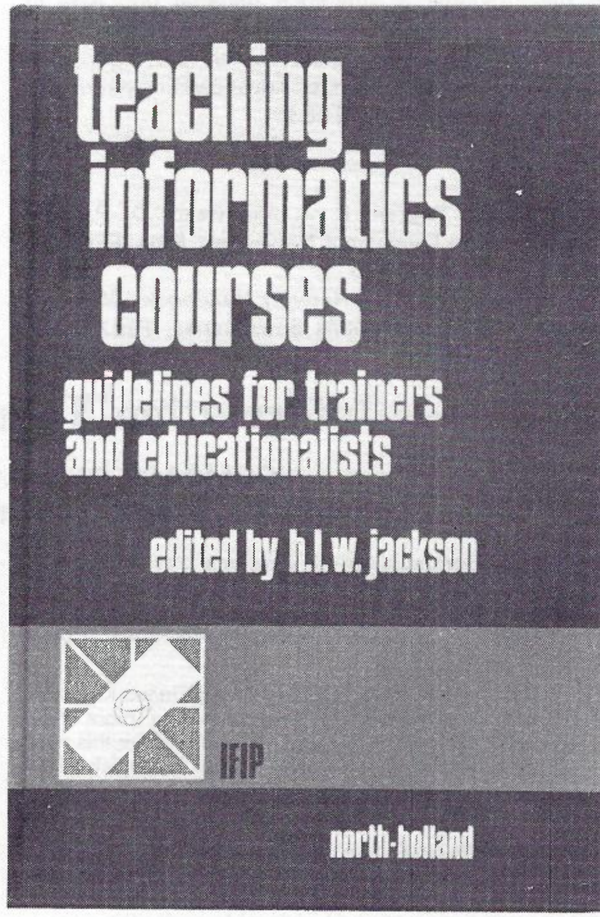
One unique aspect of CDSS is that an extension can be allocated two numbers. A company internal telephone directory may list one number against the title of the extension user and another against the person's name. Should the person move to another position in the organisation, the internal telephone number may be retained for use at a different extension. The telephone number listed against the title remains unchanged.

A feature of the CDSS system which will appeal to new switchboard operators and extension users is the automatic tone demonstration. By sequentially dialling a preassigned set of numbers, each of the tones produced by the system to indicate call or extension status, is individually demonstrated.

Issued by: **Plessey Communication Systems Pty Limited, Sydney**. Further Information: **Plessey — Adrian Seward — (02) 923 6333.**

BOOK REVIEW

TEACHING INFORMATICS COURSES
Guidelines for Teachers and Educationalists
Edited by H.L.W. Jackson
Published by North Holland 1982
xii + 270 pp. Price: $US39.50, hard back.



This book contains the proceedings of the IFIP WG 3.4 Working Conference on Teaching Informatics Courses, held in Vienna, Austria, 21-24 July, 1981.

The contributors to the Conference numbered 13 authors of papers, 6 Chairmen of Working Groups, and 30 Invited Conference members drawn from all over the world.

The book is in four parts — Introduction, Background Concepts, Working Group Reports, and Final Discussion and Recommendations.

Attached to some papers are long lists of references, while other papers list no reference material whatever.

Some lack of uniformity of typeface used in the original typescript is evident, but it does not detract significantly from the overall presentation, which is well-edited.

The Introduction explains the motivation and structure of the Conference, the most crucial element of which was the concept of working out specific ideas in small working parties. Undoubtedly this objective was achieved, and the outcomes of the Conference are presented effectively.

Readers who are concerned with Educational Methods will appreciate the excellent group of papers centred on the teaching of programming and the improvement of computer literacy; for instance, by the sensible use of flow-charting, and of CPU state transition diagrams. Two papers in a section on Developing Countries, while a little out of the context of the title of this "book", make the relevant point that well-intentioned efforts to develop information systems in less developed countries (LDCs) run a high risk of failure through shortages in a range of skills.

But a focal point of the book stands out in the third of the background concepts, dealing with organizational and social content.

The reader here encounters two papers which give two separate definitions of "Informatics", but both are explanations rather than definitions. In one of these two papers the author relates Informatics with Systems Science and Cybernetics and claims that this approach to teaching enables students, drawn from a wide range of fields, to reach a stage of development when they "can think (for) themselves". They work "with better overview", they can "see reasons instead of symptoms", and, importantly, "they can deal with genuine real world problems". These claims will ring true with those readers who have taught or practised the discipline of Systems Engineering. Complementing these observations is a companion paper dealing with the difficulties of implementing computer-based information systems. This paper provides a model of the implementation process, listing the barriers to implementation, the risk factors, and 78 useful references.

The Working Group Reports — undoubtedly the most crucial element of the conference — document ideas in such a way that they will be of direct use to teachers who are designing and running courses. Several examples can be cited. For instance, Information Systems design is reviewed with clarity and teaching syllabi are offered. Convincing case studies are presented and experience with their use in teaching is discussed. An excellent teacher's guide for introducing programming to students, together with a detailed simulation, is presented, while LDCs are catered for by the outline of a self-instruction manual for use by computer experts with no training in teaching.

The book meets it aim of bringing together materials which will be of direct use to teachers preparing courses in a range of computer-related topics and participative systems design, with specific hints on how to teach the new informatics topic. But it does more than this. It documents the degree of maturity that has emerged in this area; the impact of the speed and consequences of technological change, and the wide range of environments and outlooks that are involved. Depressingly, it confirms, in a sober judgmental context, a continuing shortage of adequate "computer people".

The Conference formal recommendations echo these sentiments by seeking to focus the attention of the relevant national agencies, and IFIP itself, on the need for devising a mechanism to deal with education and training in industrial automation; for educational research in the field of informatics education; and for support of training courses for teachers of informatics in developing countries.

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Automatic Transmission Loss Checker

A. A. MORKANS.

Telecom Australia has recently acquired new transmission testing equipment for telephone circuits. Whilst a comparison with some older equipment is inevitable, the Automatic Transmission Loss Checker provides facilities heretofore unavailable to maintenance staff.

This article is a description of the Automatic Transmission Loss Checker and its role in the Australian network.

THE ATLC

The Automatic Transmission Loss Checker (ATLC) is a new transmission testing device built for Telecom Australia under contract from Electronic Design Laboratories (Australia) Pty. Ltd. It is designed to perform transmission testing on telephony circuits; primarily on an end-to-end basis, being connected to a customer's appearance and interworking with a Test Call Answer Relay Set (TCARS) at the distant end.

The emphasis on transmission testing is changing due to the large scale introduction of solid state equipment in the broadband network. This equipment, with its inherent stability, has reduced the need for regular broadband network transmission testing. The broadband network however, forms only part of the overall connection between two customers. The critical word in the last sentence is "overall"; for the quality of service perceived by the customer depends on the overall transmission loss. The demands on transmission quality are increasing due to greater customer awareness and the greater penetration of non-voice services into the network.

Having established an a priori case for doing transmission testing on overall connections, what could be done about it? The ATLC has now provided Telecom with the means to readily perform this type of testing. It is acknowledged that there are other available instruments capable of performing transmission tests. This article will however explain why the ATLC is uniquely suitable for this particular role.

The purpose of this article is not to provide a board-level description of the ATLC but rather to give the reader an appreciation of its facilities and operation. To put the ATLC into its proper context, it is intended to examine the background that led to its development and also to compare it to other available transmission testing equipment.

WORKING PARTY

History

A working party with representatives from three States and Headquarters, was established in 1976 to determine the requirements for a national system for automatic transmission testing of telephone circuits. Resulting from this Working Party was a national project to be undertaken by New South Wales Trunk Network Service.

The national project covered the study of the requirements for automatic testing of country and metropolitan networks. It was also to determine the optimum economic mixture of available techniques — for example, individual circuit testing and random circuit testing of groups of circuits.

Recommendations

The Working Party instigated a field trial of the J. N. Almgren Automatic Transmission Level Checker and Automatic Dialling Unit. Pending the full results of the national project, it was decided that there was an immediate requirement for similar equipment. This equipment was to fulfill the functions of a local network tester, both network performance and plant performance, and fault indicator.

Introduction of the ATLC

As a result of the Working Party, tenders were opened for the purchase of an ATLC-type instrument. A decision was made to equip each District Telecommunications Branch (DTB) with one unit. The contract was ultimately awarded to Electronic Design Laboratories Pty. Ltd.

After extensive development and field-trials, the ATLC was released for field use late in 1983. Whilst the fine-tuning is still ongoing, the ATLC is essentially now available for field staff use.

DESIGN PHILOSOPHY

The basic philosophy behind the design of the ATLC was to produce an instrument that was simple to use but also powerful enough to accommodate rapid changes in technology. In order to meet this criterion it was deemed necessary that the ATLC had, inter alia, the following attributes:

User-Friendly

It was envisaged that many of the staff operating the ATLC would not have extensive knowledge of transmission theory. This led to a design that made the unit easy to control and reduced the need for interpretation of the results. To simplify the interpretation of results, the following decisions were made:

— to apply limits which are almost universally applicable without corrections for local circumstances.
— remove dBr and dBmO terminology from testing.
— remove the need for statistical analysis.

It was considered that, for maintenance staff, there was no necessity for mean and standard deviation calculations etc., as these are not really important if the overall performance is within prescribed limits. The ATLC still however, had to provide the information for full analysis if required by a specialist group.

Flexibility

Since the ATLC was expected to cope with a wide range of testing environments, and philosophies, it was important that the unit be as flexible as possible. What actually constitutes "flexibility" is difficult to define, but following attributes were considered necessary:

- The unit had to be easily portable because of the decision not to supply each exchange with an ATLC.
- Both local and remote operation, via data link.
- Once the ATLC was programmed it had to be capable of unattended operation. This inferred, inter alia, storage of results either in memory and/or hard copy.
- Whilst the primary application of the ATLC was to determine plant performance, it also had to have the facility to identify and hold faulty circuits.
- Because of the many different types of exchanges in our network, the ATLC had to be exchange independent.
- The ATLC had to be capable of functioning in a network that, in realistic terms, does not always operate to specification. Variances in tone levels and frequencies, pre- and post-dialling delays, level of circuit noise etc., all had to be anticipated and allowed for.

OPERATIONAL OVERVIEW

The EDL ATLC (**Fig. 1**) is a microprocessor based instrument for performing primarily transmission tests. It automatically dials a series of distant exchange TCARS

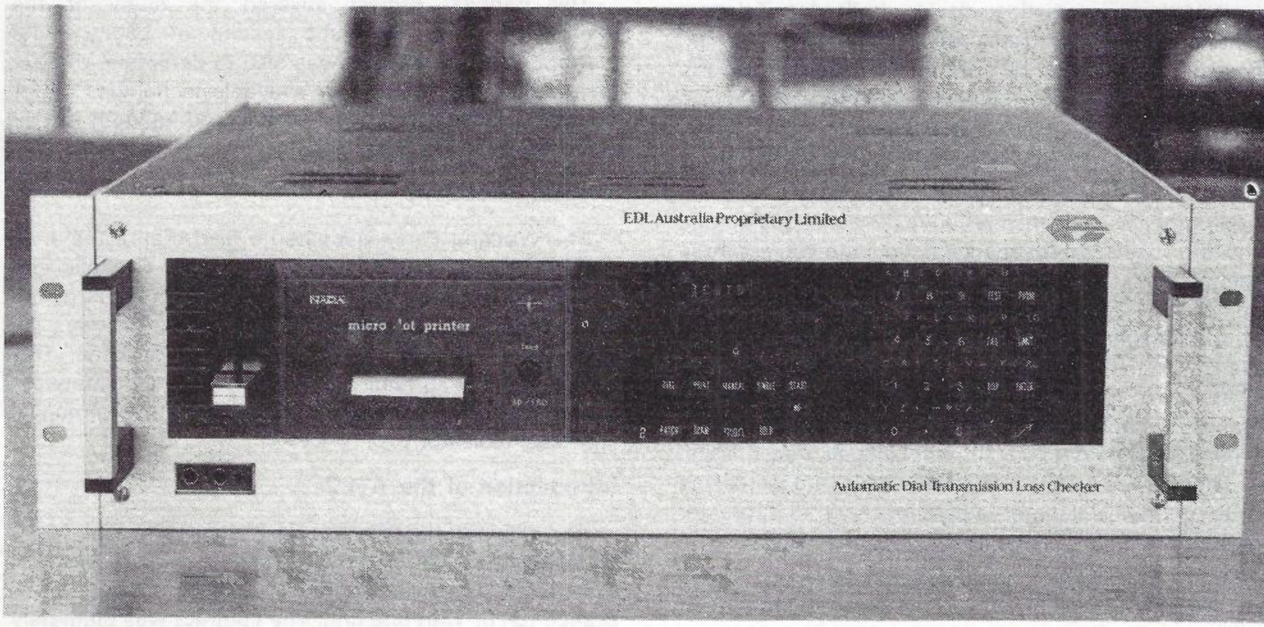


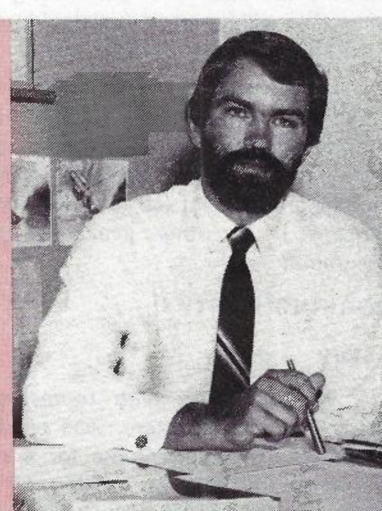
Fig. 1. Automatic Transmission Loss Checker.

AL MORKANS graduated in 1978 with a Diploma of Engineering (Electronics) from Caulfield Institute of Technology (Victoria).

In 1979 he joined the Commission and worked in Field Engineering. One of his major responsibilities was the Mobile Telephone Service (MTS).

Al was promoted to Engineer Class 2 in 1981 and joined Network Operations Branch in Headquarters. He continued his involvement with the MTS which included, inter alia, the writing of the MTS Operations and Maintenance Manual. It was in this area that Al had the responsibility for the ATLC from the pre-prototype stage to field introduction of the final version.

Al is now a Senior Engineer with the Network Management Project Team (HQ).



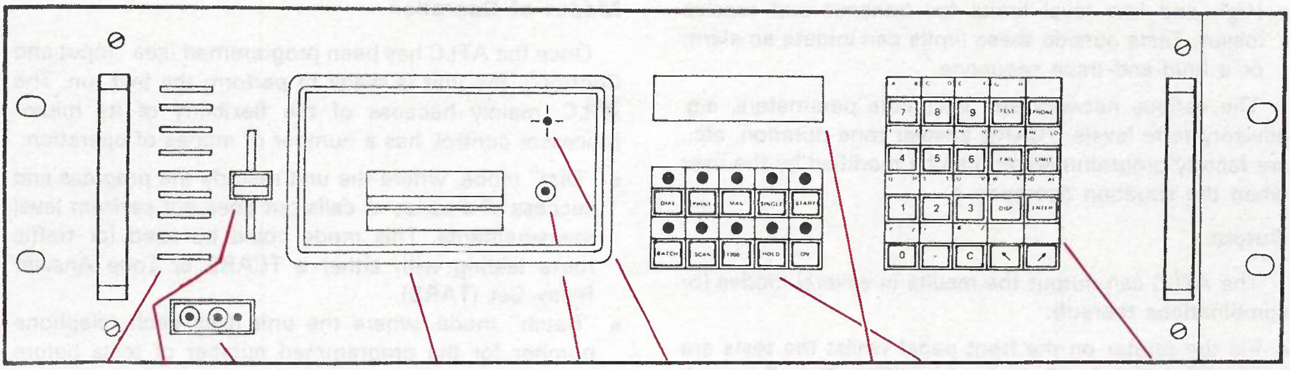


Fig. 2. ATLC front panel layout.

relay sets, calculates and stores the line loss in both directions for each route.

The ATLC enables measurements to be made on telephone circuits without the need for staff at either end. In addition to line loss, the unit checks and records other parameters of network performance, viz. busy circuits, no answer, advisory tone levels and frequencies, and TCARS faults.

The ATLC can be programmed to automatically perform up to 999 tests to each of ten different destinations. At the end of the series of tests, or when it reaches a preset number of out-of-limit tests, the unit outputs a summary of circuit performance on each route.

The ATLC also has three serial input/output ports to enable it to be integrated into automated data acquisition systems or for long line remote control and monitoring, e.g. in unattended locations. To allow for possible future requirements, the ATLC has been fitted with the hardware necessary (apart from the integrated circuits) to interface with the IEEE 488 general purpose instrumentation bus.

FACILITIES AND OPERATION

Input and Control

The ATLC can be programmed, and hence controlled, by the keyboard on the front panel (**Fig. 2**) or via the input/output ports on the rear (**Fig. 3**) of the instrument.

When first powered up, the ATLC must be programmed by the user with the information necessary for it to perform the desired test sequences. This information includes:

- Time and date.
- Time and date the test run is required to start.
- The number of tests to be performed on each route.
- The number of out-of-limit tests allowed before an alarm is raised.
- Up to ten telephone numbers (of the TCARS) together with alphanumeric codes to describe the routes.

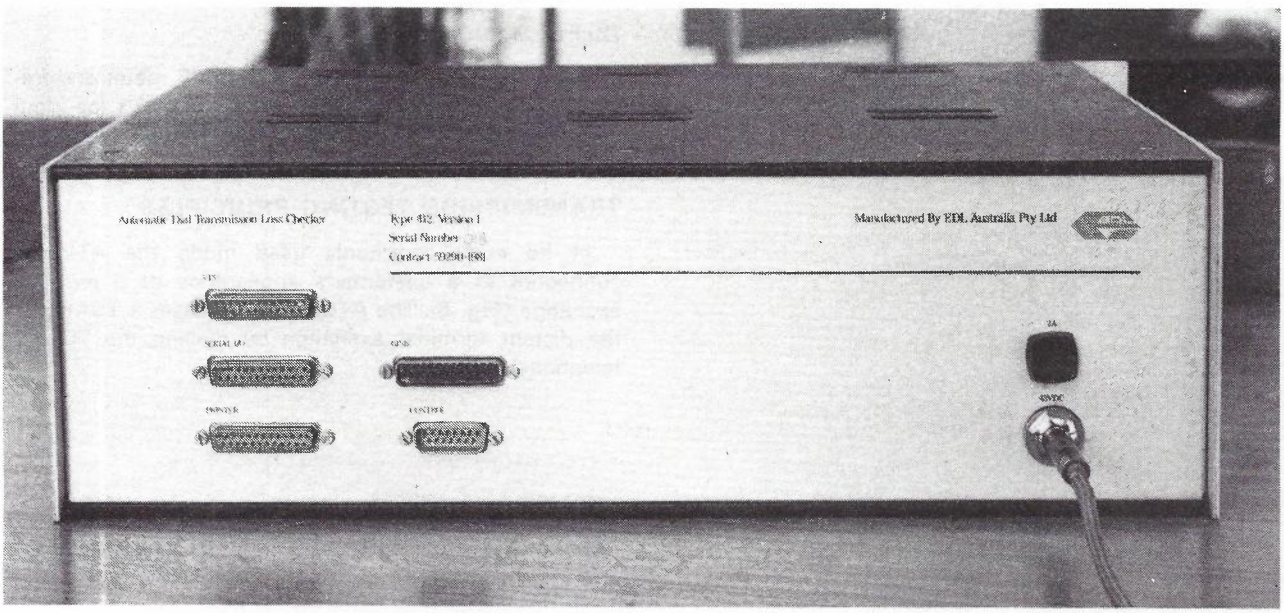


Fig. 3. Rear panel showing input/output ports.

- High and low level limits for transmit and receive losses. Tests outside these limits can initiate an alarm or a hold-and-trace sequence.

The various network and exchange parameters, e.g. advisory tone levels, TCARS answer tone duration, etc., are factory programmed but can be modified by the user when the situation demands it.

Output

The ATLC can output the results in several modes (or combinations thereof):

- Via the printer on the front panel whilst the tests are occurring. This is referred to as a "Real-Time Printout" (**Fig. 4**).

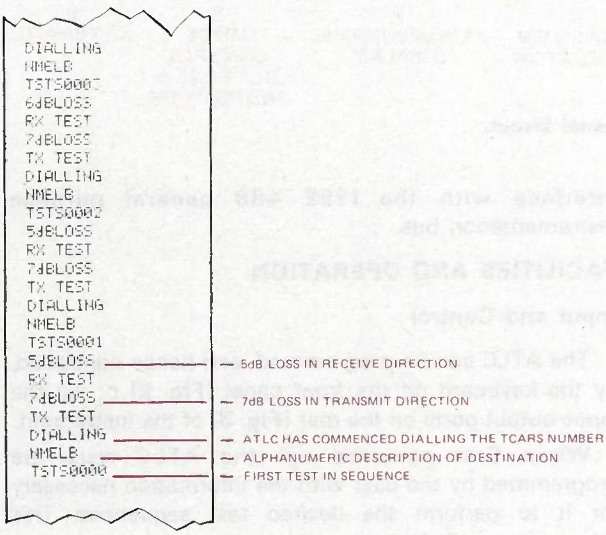


Fig. 4. Real-time printout.

- At the conclusion of the test run the printer can output a "Summary Printout" (**Fig. 5**).
- Both real-time and summary information can be displayed on the LED display on the front panel.
- Similarly the test results can also be output via the input/output ports on the rear panel.

In addition to test results, the ATLC can activate an alarm if the preset limits are exceeded. There is both an internal alarm and relay contacts, connected to a socket on the rear panel, that can activate an external alarm.

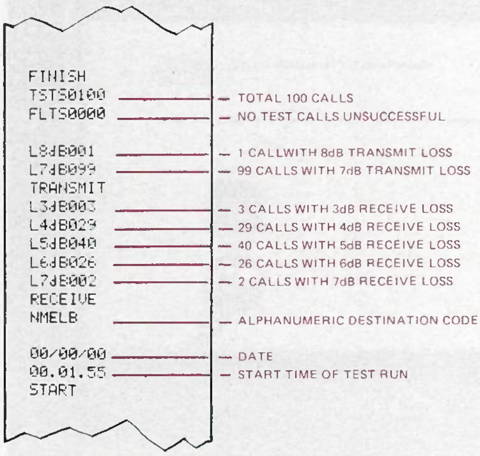


Fig. 5. Summary printout.

Modes of Operation

Once the ATLC has been programmed (see "Input and Control"), the unit is ready to perform the test run. The ATLC, mainly because of the flexibility of its microprocessor control, has a number of modes of operation:

- "Dial" mode, where the unit records the progress and success of a series of calls but does not perform level measurements. This mode could be used for traffic route testing with either a TCARS or Tone Answer Relay Set (TARS).
- "Batch" mode, where the unit dials each telephone number for the programmed number of tests before proceeding to the next telephone number.
- "Sequential" mode, where the unit dials each programmed telephone number in turn, then repeats the sequence the programmed number of times.
- "Single Number" mode, where the unit carries out tests to one number only.
- "Manual" mode, where the unit waits for the operator to press Start to step through each test of the test sequence.
- "Single Test" mode, where the unit stops and holds the test call at the end of the call sequence. In this mode, the user can repeat the level measurement sequence or release the unit to carry on with its test sequence.
- "Hold and Trace" mode, where the unit holds the test call and raises an alarm at the end of a test where the transmit or receive losses were found to be outside the pre-programmed limits.

Real-Time Clock

The ATLC is equipped with a real-time clock that also includes the date. This clock will remain active as long as the ATLC is connected to a power supply. The clock facility has two main uses; firstly, to identify printouts with time and date information. Secondly, the real-time clock enables the ATLC to be programmed to start a test run at a preset time on a particular day or on a consecutive number of days. This is a particularly useful option since unattended testing is possible at night during light traffic periods.

Digital Meter

The ATLC can be used as a digital dB meter and frequency meter. In this mode the ATLC displays the input level from -39 dBm to +10 dBm and the input frequency from 0 to 999 Hz.

TRANSMISSION TESTING PRINCIPLES

In its most commonly used mode the ATLC is connected to a customer's appearance at a terminal exchange (**Fig. 6**). The ATLC then accesses a TCARS at the distant terminal exchange by dialling the TCARS telephone number.

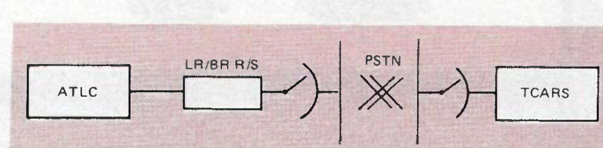


Fig. 6. Typical test configuration.

The TCARS contains a level sensitive tone receiver which operates when the level of 820Hz tone, at its input, reaches -20 dBm. Operation of the receiver causes the TCARS internal oscillator to trigger and send an 820 Hz tone, at 0 dBm at the exchange reference point, back to the testing end.

In operation, the TCARS answers the far end line after receipt of ringing current, and then after a delay, transmits 2 bursts of 820 Hz identification tone. The TCARS then waits for a level of tone to trigger it, responding with 5 seconds of 820 Hz tone. This tone test sequence may be repeated until the TCARS releases the line when the test call is terminated.

By taking account of the TCARS receiver trigger level (-20 dBm) and TCARS send level (0 dBm), the ATLC is able to automatically determine the line loss for each test circuit in both directions.

The ATLC then stores the test result and moves on to the next test, according to the selected mode of operation.

USE OF THE ATLC

As can be gathered from previous sections, the ATLC has many testing options. The best utilisation of all of these facilities has yet to be defined. This section illustrates typical methods of using the ATLC. As overall network testing methodology evolves there seems little doubt that transmission testing, and hence use of the ATLC, will also reflect these changes.

Test Types

In a macro sense, the ATLC can perform three different types of tests. The choice of the test type will depend very much on the needs of the area that is performing the tests. Each type has a specific use and this should be considered before a test programme is compiled.

Network Performance Tests

Network performance testing is not restricted to single circuit groups and does not require the identification of the route taken. It is however, usually restricted to testing from terminal exchange to terminal exchange (**Fig. 7**).

This type of testing would normally be carried out by State based groups, such as the Network Performance and Analysis Centre (NPAC). Network performance testing gives an overall picture of how the network is performing. Subsequent analysis of the data will indicate where further examination might be required. Since this type of testing does not isolate the problem to specific circuit groups, its use in maintenance areas is of limited value.

Plant Performance Testing

Plant performance testing is restricted to a single circuit group and the route taken must be identified but not necessarily the individual circuit group position (**Fig. 8**). Fault location usually requires the individual circuit group position to be identified.

The main purpose of this testing is to ascertain how the originating routes, from a given exchange, are performing. This purpose infers that plant performance testing would usually be used by exchange maintenance groups. This testing could be used as a prelude to "fault location" by isolating the routes that exhibit poor transmission performance.

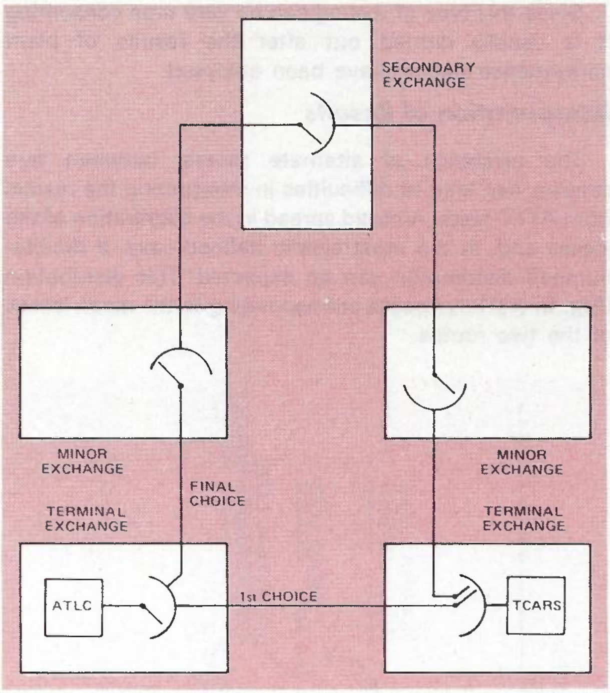


Fig. 7. Network performance testing.

Fault Location Testing

Fault location, using the ATLC, is achieved by setting the instrument into "Hold and Trace" mode (as described earlier in this article). The purpose of this testing is to hold and subsequently identify the faulty circuit/s. Steps can then be taken to rectify the cause of the poor transmission performance.

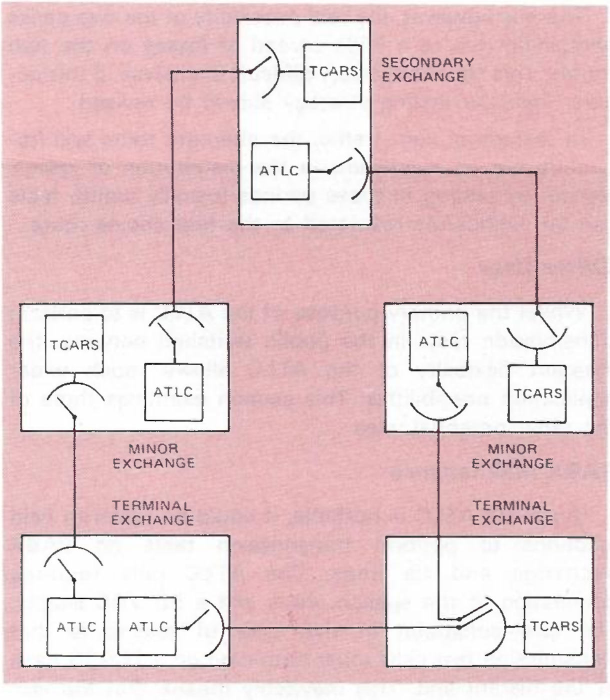


Fig. 8. Plant performance testing.

Since this type of testing can be very time consuming it is usually carried out after the results of plant performance testing have been analysed.

Interpretation of Results

The existence of alternate routes, between two centres, can lead to difficulties in interpreting the results from ATLC tests. A broad spread in the distribution of the losses and, in the most clearly defined case, a double-humped distribution can be expected. This distribution (**Fig. 9**) will have peaks corresponding to the mean losses of the two routes.

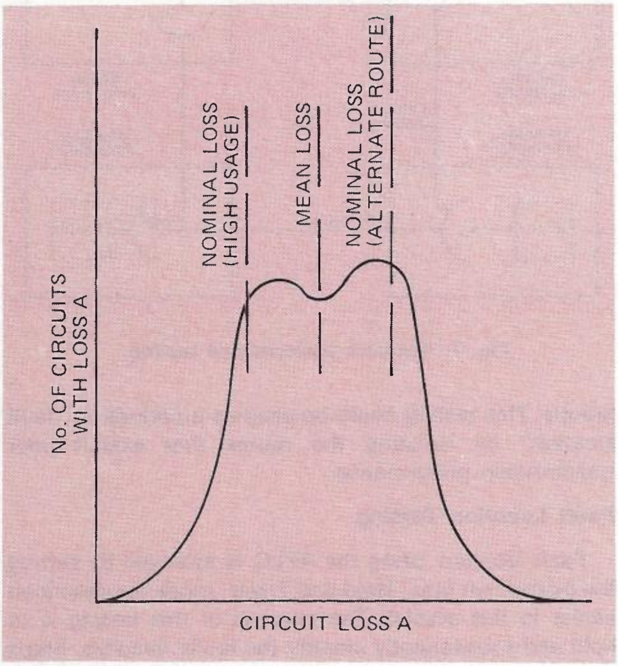


Fig. 9. Distribution of losses due to alternative routing.

There is however, the real possibility of the two peaks combining due to a wide spread of losses on the two routes. This situation is very difficult to analyse. If this occurs, then the testing strategy should be revised.

In periods of light traffic, the alternate route will frequently not be significant in the distribution of losses. Hence, by testing in these periods (usually night), tests can be confidently restricted to the first choice route.

Other Uses

Whilst the primary purpose of the ATLC is to perform transmission tests in the public switched network, the inherent flexibility of the ATLC allows much wider application possibilities. This section examines three of the other potential uses.

PABX Maintenance

Since the ATLC is portable, it could be taken to field locations to perform transmission tests on PABX exchange and tie lines. The ATLC only requires connection to the speech wires and a 50 VDC supply. The one constraint in this type of testing is that transmission test calls must terminate on a TCARS base at the distant end. This inevitably means that the test calls must be directed to the parent exchange.

Traffic Route Testing

The transmission testing utility of the ATLC can be disabled via the keyboard. In this mode the ATLC will perform connection tests only, i.e. emulate a Traffic Route Tester (TRT). Whilst it is not suggested that the ATLC is a replacement for the TRT; there may be occasions when it is advantageous to use the ATLC in this mode. This could occur in small country exchanges with no fixed TRT facilities.

Commissioning Circuits

When commissioning new circuits and/or circuit groups, the ATLC could be used to ascertain whether their performance meets the specified targets. Because connection tests are intrinsic to transmission tests, a measure of both switching and transmission performance could be obtained simultaneously. It must however, be remembered that the ATLC is a network-type device hence the testing period should be chosen to ensure that the selected circuits are tested.

OTHER TRANSMISSION TESTING INSTRUMENTS

Whilst this article is primarily on the ATLC, it is interesting to compare it to the other available transmission testing instruments. It must be remembered that some of the following instruments are very old, in a technological sense, hence a direct comparison with the ATLC is not always possible. Specialised broadband test equipment will not be considered here.

J. N. Almgren ATLC

The J. N. Almgren ATLC, type AS29, is the predecessor to the current ATLC. The AS29 does not have an in-built dialling unit hence it is usually used with an Automatic Dialling Unit (ADU, type AS17A). To avoid confusion, only the EDL version is referred to as the "ATLC", in this article.

The AS29 performs the same basic functions as the ATLC and in a similar manner. The major difference is that the ATLC has extra facilities and options, mainly by virtue of the flexibility of software-control.

The AS29 was acquired, in limited quantities for the field trial (See the Section labelled "Working Party"), and no further purchases are envisaged. Undoubtedly the units will remain in service, until the end of their useful life, to supplement the ATLC in the field.

Automatic Transmission Test Unit

The Automatic Transmission Test Unit (ATTU), in conjunction with a suitable access device such as a Trunk Routiner, TRT or Automatic Exchange Tester (AET), allows automatic transmission testing in both the transmit and receive directions. Like the ATLC it has to interwork with a TCARS. Unlike the ATLC however, the ATTU provides only a "Go-No Go" result.

The nominal go and return loss of each route must be known as the ATTU carries out limit testing only, with the limits on either side being selectable. This is probably the ATTU's worst comparative disadvantage since it is not necessary to have the same information to achieve meaningful results with the ATLC. Furthermore, if the results are spread over a large range, ATTU-type testing can be time consuming.

One principal advantage of the ATTU is that, in conjunction with an AET or similar, the testing can be readily confined to a single circuit if required. In other words the ATTU is a circuit testing device rather than the ATLC which is essentially network based.

Transmission Level Checker

The A205 Transmission Level Checker (TLC) is a manual instrument for performing transmission tests in conjunction with a TCARS. The instrument is considered "manual" because both the dialling, via an in-built rotary dialler, and the actual transmission test are performed manually on a single call basis. This mode of operation is the TLC's main drawback, and severely limits its usefulness when large numbers of test calls must be made. It is not likely that the TLC will play a major role in future transmission testing.

Transmission Measuring Set

The A215 Transmission Measuring Set (TMS) is quite different to any of the above instruments in that it can send and also measure a range of frequencies. It is a manual instrument, like the TLC, but the TMS is not equipped with a dialler. To gain access to trunk circuits, the TMS is often associated with a test desk or ARM AET.

The advent of the ATLC-type instruments has limited its use in routine transmission testing of telephone circuits. The TMS is still used for checking items such as channel synchronisation and frequency response. It can also be used as an adjunct to the ATLC for locating the actual fault on a circuit "captured" by the ATLC.

It is these latter uses that should see a continuing need for the TMS, or equivalent type instrument.

WHERE TO NOW?

It seems that Telecom has only begun to proceed along the learning curve on transmission testing. Very little has yet been done on routine checking of overall circuit transmission performance. Transmission testing was always thought of as belonging to specialists in broadband maintenance areas. Perhaps this occurred because much of the early equipment often required fairly extensive knowledge of transmission aspects before the results became meaningful. Not many people in the switching maintenance areas had that specialised knowledge.

The past few years have seen greater penetration of non-voice services, especially those utilising terminal equipment built by outside manufacturers, into the telephony network. There are also signs that our customers are expecting better standards of service from their communications facilities. In the first case transmission performance, to specification, is virtually essential. In the latter case it could be considered as "very desirable".

The ATLC has provided us with the means of resolving the above, apparently conflicting, problems. The instrument provides sophisticated and powerful testing facilities but at the same time is easy to use. The design of the software and hardware are such that upgrades in both are readily possible if changes in technology demand them. The ATLC will not render all other transmission testing equipment obsolete overnight but is certainly a quantum leap forward on what is currently available.

The challenge of designing the ATLC is now over. The challenge of best defining the testing methodology and utilisation, of all its facilities, has just begun.

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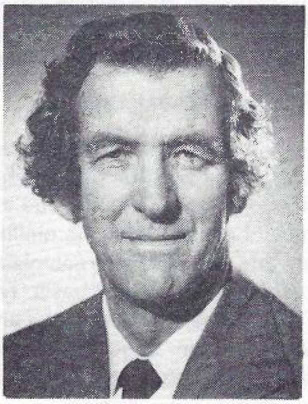
Personalities

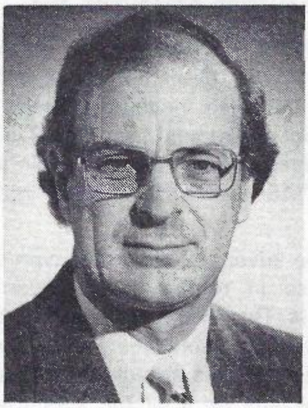
Retirement from the Board of Editors



George Moot joined the Editorial Board in 1966 as the Editor for Telephone Exchange Equipment. He was appointed Editor In Chief in 1972 following the retirement of Mr Vin White from this position. George served as Editor In Chief up to 1977, after which he resumed as Editor for Network Performance and Operations. During his term as Editor In Chief, the Journal was changed into the present format, with the introduction of colour. George has contributed Journal articles dealing with qualitative maintenance, service standards and the organisation of Telecom. The Telecommunication Society of Australia acknowledges George's valuable contributions.

Mr Bob Lewis has been appointed by the Society to take over George's role as the Editor For Network Performance and Operations.

Appointment to the Board of Editors

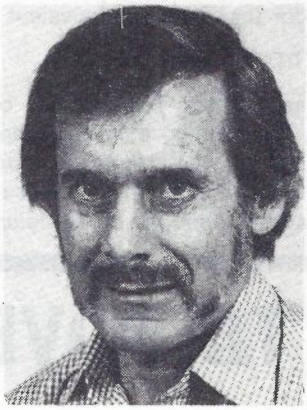


The Telecommunication Society of Australia announced the appointment of Bob Lewis to the Board of Editors.

Bob started his engineering career with Telecom Australia in 1960. Initially he was employed in the Victorian Administration where his work involved the installation of major cables, and maintenance and operational aspects of the external plant network.

In 1971 he was promoted to Headquarters where he has held positions with responsibilities for design, installation and service aspects of line plant. He has also worked in the Design Co-ordination Secretariate, and is currently Supervising Engineer Lines Service Section in Network Operations Branch at Headquarters.

New State Representative to the Board of Editors

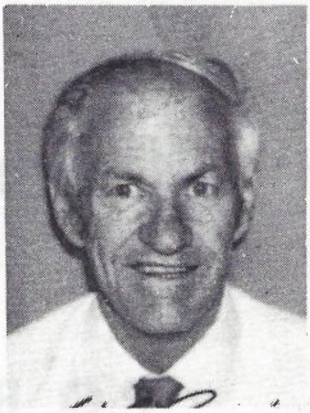


Alan Haime joined the PMG Department as a Technician-in-Training in 1958 and qualified as a Senior Technician in 1965. During 1966 he worked for the Muirhead group of companies in London, England. He became a Cadet Engineer in 1968 and completed degrees of Bachelor of Engineering and Master of Engineering Science at the University of Western Australia in 1971 and 1977 respectively. He was awarded the 1970 IREE Fisk prize.

Alan has had a wide range of experience in the design and operation of radio communications and broadcasting facilities in Western Australia. He is a member of the Institute of Engineers (Aust.) and is currently the Supervising Engineer, Radio Section, Perth.

Alan has published papers in the Telecommunication Journal of Australia and the Australian Telecom Research Journal. He is the State Representative of the Editorial Board and Convenor of the Lecture Sub-Committee of the Western Australia Division of the Telecom Society.

Appointment of Chairman, Western Australia Division



The Telecommunication Society of Australia, Western Australia Division announced the appointment of its new Chairman for the Division, Mr G. White.

Geoff White joined the PMG's Department as a Technician-in-Training in 1947 and qualified as a Senior Technician in 1954. He became a Trainee Engineer in 1961 and completed his Associateship in Communications Engineering in 1963.

Geoff has had a wide range of experience in both Metro and Country Districts, planning and resources. He is currently the Deputy Superintending Engineer, Programming and Resources in Regional Operations Branch and is a member of the Institution of Engineers (Aust.).

Geoff was Secretary of the WA Division of the Telecommunication Society from 1972 and State representative on the Editorial Board from 1977.

Barrage Testing for 2 Mbit/s Pair Cable Routes

M. JINMAN B.Sc., MIEE

Barrage testing is a method for measuring the effects of crosstalk on digital pair cable systems, by simulating the working conditions. This paper relates the Australian experience in developing barrage test sets for 2 Mbit/s line systems.

BACKGROUND

When the housings for a new set of 2 Mbit/s systems are installed on a cable, it is not often practicable to install all the systems at once, to make certain that they will all work satisfactorily. Even if this could be done, one vital piece of information would be missing — the margin against excessive crosstalk for each regenerator section on the cable.

Measurements of this margin are vital for three reasons:—

1. To ensure that there is a "safety margin" to guard against minor changes in service, such as repeater replacements and cable diversions. Regenerator sections with an adequate safety margin are accepted for service.
2. To identify any regenerator sections on which the safety margin is too small, or on which crosstalk is already excessive. These sections are not used in service, unless put right or replaced.
3. To provide data on the distribution of the margins, on the cable and housing installations tested. This data is used to correct the route design rules, when necessary, so that future installations on similar cables can be designed more safely (if the measured margins are too small) or more economically (if the measured margins are larger than needed).

The easiest and safest way to measure the margins is to load the cable with simulated line signals on all relevant transmit pairs, and measure the resulting crosstalk noise on each of the receive pairs. If the simulation is correctly done, this noise is the same as would be experienced in service, with all systems operating. Comparison of the measured noise with the permissible noise level for the regenerator section being tested yields the margin.

This process is known as barrage testing. The origin of the name is not known — presumably, the image of many noise sources, all firing at once, appealed to someone with a military background.

Barrage test sets have been built by several other administrations. However, the use of barrage testing has not been widespread, because most countries had already established primary PCM networks, before the technique was developed. These countries use conservative design rules, which avoids the need for barrage testing but is more expensive in the long run, unless the national network is small.

AUSTRALIAN DESIGNS

Mark 1 (1978)

The first Australian barrage test set was built by Transmission Branch, Research Department (TR). Its purpose was to check the accuracy of a computer algorithm developed by TR, to produce design rules by processing crosstalk data for pair cables. It was not intended for field use.

At this time, it was already known that the crosstalk limits on many cables were set by near-end crosstalk (NEXT) and third-circuit crosstalk (3CXT). In these cables it is not often necessary to measure far-end crosstalk (FEXT) nor the pair section loss (LOSS).

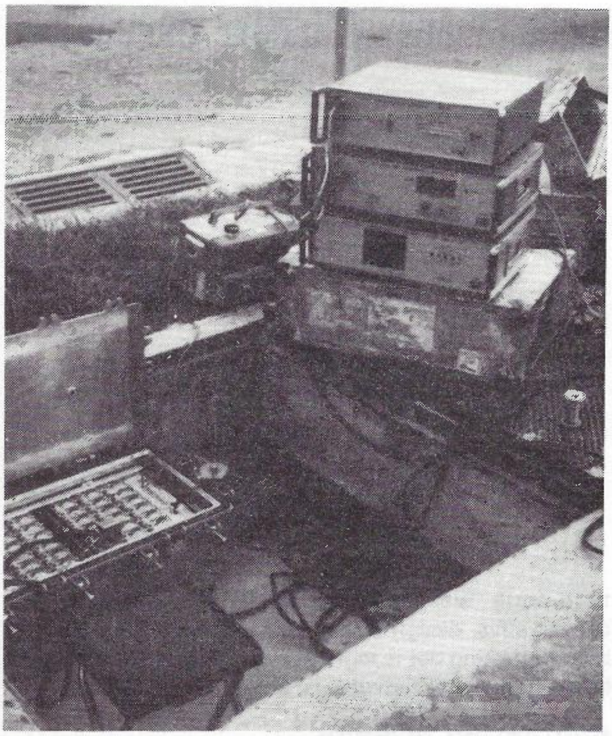
The noise on the receive pairs was measured by the RMS voltage at the decision point of a modified regenerator, a method still used by British Telecom.

The physical format used was followed in all later designs. The control unit provided power supplies and all measurement functions. A set of test modules, which plugged into the PCM housing in place of the line repeaters, contained the PCM signal generators and provided test access to the receive pairs.

Mark 2 (1980)

The original approach to route design for 2 Mbit/s systems was to "characterise" the cable network by crosstalk measurements. By 1980, it had become clear that this approach was unworkable. The only practicable access to cable pairs was through newly installed PCM housings. This limits the rate at which crosstalk data can be obtained, especially for the less commonly used cables. At each housing a large number of crosstalk readings is needed to avoid unacceptable sampling errors. With the available resources, characterisation by this means could not have been completed until it was too late to matter, and would have been very expensive.

A barrage test set, in effect, makes a large number of broadband crosstalk measurements simultaneously, so



Mark 2 Barrage tester in use.

that the data produced has a much smaller sampling error. Thus the barrage test set can be used to characterise the cable as well as to perform commissioning tests. Moreover, the margin measurements produced can be used more directly to formulate route design rules — avoiding the need for the computer algorithm, and several uncertain assumptions involved in processing crosstalk data.

Consequently, two new barrage sets were built, mainly for characterisation purposes but also for commissioning tests on critical or doubtful routes. These sets were originally called Cable Characterisation Instruments, but are now usually known as Barrage Test Sets.

To avoid some assumptions necessary in noise measurement at the decision point, and also some practical problems, a new measurement technique was adopted for these units. An unmodified line repeater was used, with its equaliser set by a PCM signal through a variable artificial line. Crosstalk noise from the cable pair under test was added to this signal at the regenerator input, and the limiting noise level was identified by measuring the bit error ratio (BER). The general arrangement is shown in **Fig. 1.** The margin is measured by comparing the artificial line setting for the limiting BER with the loss of the pair section under test: the margin should be at least 3 dB. As far as NEXT and 3CXT are concerned, this arrangement simulates the real case very closely.

These two sets are still in service, after many thousands of kilometres by air freight and road transport, and much hard use in rough conditions. This is greatly to the credit of Transmission Branch which was responsible for their design and construction.

INTERLUDE: FIELD OPERATIONS

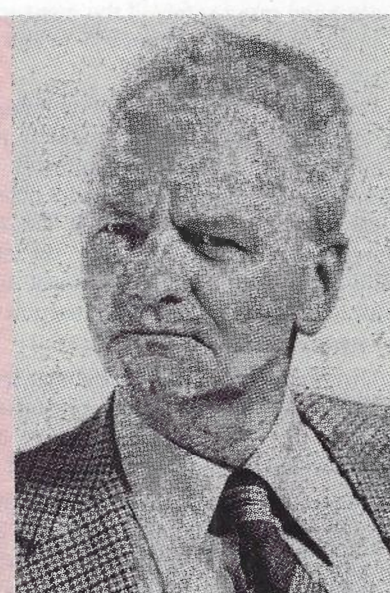
The two Mark 2 sets have proved their value in a number of ways, including:—

1. Confirming that barrage testing of large PIUT cables is not usually needed, provided that the design rules are observed.
2. Detecting "3CXT peaks" which are drastic increases in 3CXT on certain PIQL cable pairs. Barrage testing is the only reliable way to detect this effect. About 10% of PIQL cables are affected, often severely.
3. Checking for FEXT in PIQL cables — resulting in new pair selection rules for PIQL.
4. Proving route designs for unusual cables, for which little or no data is available.
5. Providing reliable data for refining the design rules.

Mark 3 (1982)

In mid-1981, the Research Department arranged an Industry Research and Development contract with

MICHAEL JINMAN was born and educated in the UK, and graduated in 1953 with first class honours in electrical engineering. He then worked in the research and development laboratories of two large and one small UK companies, mainly on the design of microwave components and systems. Seven patents were filed during this period, in several different fields. In 1971 he joined the Australian Post Office, in the Long Line Equipment Branch at Headquarters. In 1975 he was appointed to the new Transmission Network Design Branch of Telecom Australia, and began the exploratory work on primary PCM transmission which led, eventually, to the formulation of the route planning rules.



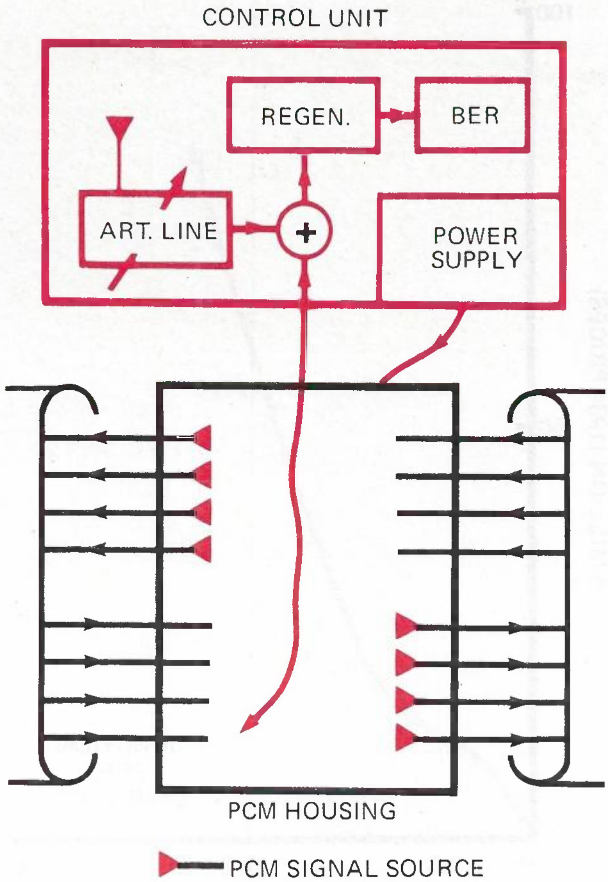


Fig. 1. General arrangement of Barrage Tester (Mark 2).

Jacobs Radio Australia Pty. Ltd., for the development of a barrage test set with microprocessor control, to conclude with the production of a prototype unit.

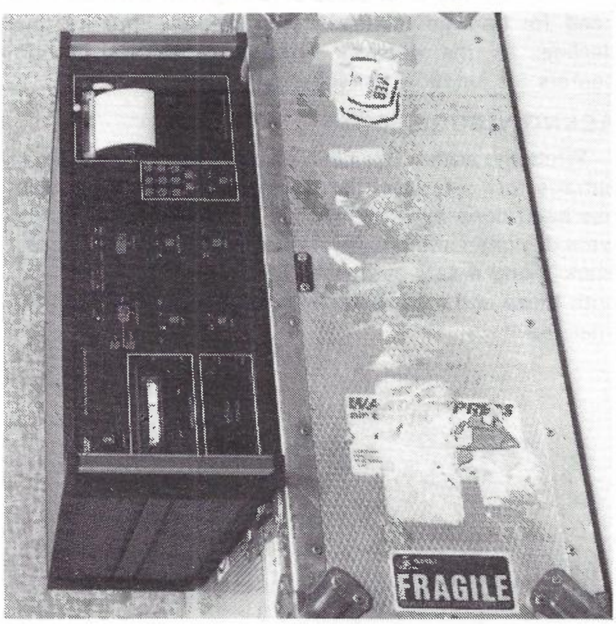
One aim of this contract was to eliminate the manual adjustment of the artificial line in the Mark 2 design. This is a tedious process, and also involves heavy wear on moving parts not designed for field use — a potential reliability problem. Another aim was to find out to what extent microprocessor control could be usefully applied for other purposes.

Good points of this design were:—

- The light weight single box control unit (compared with three boxes in the Mark 2).
- New design test modules, taking much less current and with inbuilt stabilisers. This is a great advantage for FEXT testing, since a group of modules at the far end of the section can be powered from batteries.
- An audible cue signal in the module connector, to tell the operator in the manhole when to move to the next module.

On the other hand, the inbuilt printer, which was needed for most of the more elaborate microprocessor functions, proved not reliable enough for field use. This did not matter much, since most of these functions turned out to be unnecessary.

However, the building and field testing of this prototype can now be seen as an essential step towards the final design. Most of the faults discovered and corrected could not have been found in any other way.



Mark 3 prototype Jacobs Radio JCC-1 PCM Cable characteriser.

Mark 4 (1983-4)

Early in 1982, a new approach to barrage testing was proposed, using two sets to simulate all the working conditions on a repeater section. The extra cost could be recovered by eliminating the preliminary dc, pulse echo and insertion loss measurements needed if only one set is used. With microprocessor control, it was obviously possible to design barrage sets which would operate either alone, measuring NEXT + 3CXT only, or in pairs, measuring NEXT + 3CXT + FEXT + LOSS. This principle was adopted for the design of the production barrage test sets.

Most of the other features made possible by full use of the microprocessor were abandoned, for one reason or another. Most of these features need peripheral equipment, such as a printer, which is not reliable enough. Australian field conditions can be very harsh and the worst conditions are found in places a long way from repair facilities or replacement units. The conclusion was that reliability and simplicity of operation were the paramount requirements, and that nothing should be added which might detract from these. It is interesting that British Telecom design has moved in the same direction, even though their environmental and logistic problems are less severe.

Several other design changes were made in the light of field experience with the Mark 3 prototype. LED indicators proved hard to read in sunlight, and were replaced by an LCD display. The number of push button controls was reduced, and the push buttons themselves changed to a contactless version. Fan cooling has been dropped, to avoid dust and reliability problems: this may prevent operation in extreme heat, but the trade-off is well worth while. The separate control unit transit case has been replaced by an integrated case, which will be more convenient in many field applications.

In the single station mode, the basic design is that used in Mark 2 and Mark 3, with a few refinements. In the two-station mode, the PCM signal to the reference regenerator is sent from the far-end station, along the pair being tested. To allow for negative margin measurements in this mode, there is a facility for adding 10 dB gain at the sending end of the test pair, and 10 dB loss at the receiving end: in effect, this reduces the noise level by 10dB, while leaving the signal level unchanged. There is also a facility for measuring the LOSS of the pair section being tested.

In the two-station mode, a data link between the two control units is needed, so that the two microprocessors can co-ordinate their actions. Since only a low speed link is needed, and there is no need for communication while a measurement is in progress, this has been provided by modulating the PCM signals on the test pair, and on the return pair for the same system. This avoids the need for a separate data link. Either of the two stations may be set up to control the measurements, which can then be made in both directions: both stations display the results.

In single-station mode, only the combined effects of NEXT and 3CXT can be measured. No attempt has been made to separate these, since dominant 3CXT is usually caused by the "3CXT peaks" effect which has an easily recognised pattern of results. In the two-station mode, NEXT/3CXT, FEXT and LOSS effects can be measured, separately or all together.

Every effort has been made to design a reliable equipment which is simple to operate. Most of the design work has been done by Jacobs Radio under an extension of the contract for the Mark 3 version, in collaboration with TND and TR Branches of Telecom Headquarters.

COST CONSIDERATIONS

Fig. 2 shows a graph of the actual projected cumulative cost of a 2 Mbit/s line equipment for the junction networks, based upon repeater housing orders. This is the "committed cost", which is not paid in full until the housings are filled, but to which we are committed as soon as the first housings are installed on each cable. The increasing use of optical fibre cable will not make much difference to this graph: the two forms of transmission are mainly complementary, not competitive. The curve is expected to level out to a final value between 100 and 200 million dollars.

(This estimate is much higher than used in a previous paper in this Journal — "Route Planning Rules for Primary PCM" Vol. 30, No. 1, 1980. At that time, it would have been thought rash to consider PCM as more than a cheap way to carry analogue telephone traffic. We have come a long way in four years!)

It is difficult to estimate how much larger the final cost would have been without barrage testing, but the difference is probably at least 2%, in addition to the savings made by avoiding crosstalk measurements. This means that the barrage test sets will pay off about ten times their cost.

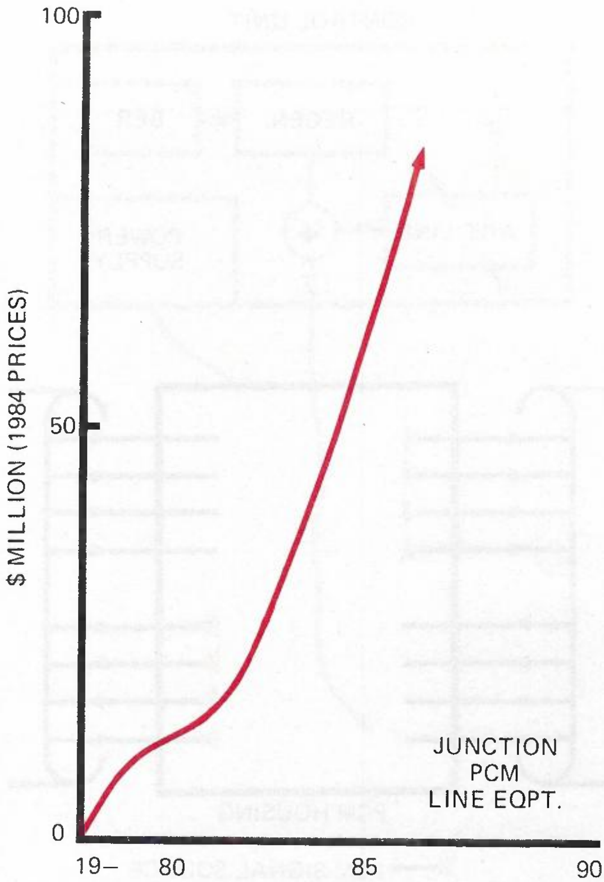


Fig. 2. Actual and Projected Cost of the 2 Mbits pair cable Junction Network for Telecom Australia.

The Mark 4 barrage test set is likely to be the last of its line. The shape of the graph suggests that the rate of installation on new PCM cables is likely to peak about 1985. Demand for barrage testing will peak later, but the production units should be able to cope without much difficulty. By the time these sets begin to wear out, the need for barrage testing should be well into its final decline, as the network turns towards optical fibre bearers for junction transmission.

ACKNOWLEDGEMENTS

While the author has been involved with the design of barrage test sets from the beginning, most of the work has been done by other people. The Mark 1 and 2 sets were designed and built by Transmission Branch, and the Mark 3 and 4 sets by Jacobs Radio. Original ideas from both these and other sources have all contributed to the final result.

Evolution Towards Integrated Services Digital Networks

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ENG K. CHEW, B.E., M.Eng.Sc., Ph.D., Grad IE(Aust)

This paper briefly outlines the evolution of public telecommunications networks towards Integrated Services Digital Networks (ISDNs). Such a network may be regarded as a general-purpose digital network capable of supporting a range of voice and non-voice services through a small set of customer-to-network interfaces.

The International Telegraph and Telephone Consultative Committee's (CCITT) current effort in formulating a series of ISDN Recommendations (or standards) is described. Emphasis is placed on ISDN customer access interfaces and protocols.

Examples of ISDN field trials are mentioned and some possible future directions in ISDN standardization activities are indicated.

1. INTRODUCTION

At present, public switched telephone networks are generally becoming more digital in nature, with increasing use of 64 kbit/s Pulse Code Modulation (PCM) transmission and switching. This trend will produce, initially, a telephony-based Integrated Digital Network (IDN) and, later, a multi-service IDN in which customer-to-customer digital connectivity exists and through which a multiplicity of services (voice and non-voice) are accessible by the customer.

The telephone IDN however, is increasingly being seen as a transitory step towards a so-called Integrated Services Digital Network (ISDN) which, conceptually, can be regarded as a general-purpose network capable of supporting (or integrating) a range of different services (telephone, data, text, image, etc.) using both circuit and packet switching techniques via a small set of standard multi-purpose customer-to-network interfaces. The main motivations for network development towards an ISDN environment are the economies and flexibilities which the integrated nature of the network would foster (see, e.g. Dorros, 1981, 1983; Kennedi, 1981).

Economies can be achieved by combining many new and emerging services (which are digital in nature) with existing services and by utilizing an integrated information transportation (or carriage) capability at a significantly lower overall cost than it would take for each service to utilize a separate transportation capability. Since we cannot yet envision all the services which may be carried by an ISDN, flexibilities can be achieved by the use of digital transport which in general, is insensitive to the services carried, despite possible differences in traffic characteristics.

The ISDN concept can therefore be regarded as a unified approach to the provision of present and future telecommunications services and facilities.

This paper introduces the evolution towards ISDNs. Several possible network architectures can be conceived for this evolution. The actual structure would, however, depend on the present infra-structure of national networks.

Standardization activities are well under way within the International Telegraph and Telephone Consultative Committee (CCITT) with the objective of reaching early international agreements on a range of ISDN technical issues. In particular, CCITT Recommendations (or standards) on ISDN customer access interfaces and protocols are likely to be achieved by the end of the current 1981-84 CCITT study period.

In parallel with the above standardization effort, ISDN field trials are being prepared in a number of countries ahead of CCITT Recommendations in order to gain valuable early experience and possibly a commercially advantageous position. Examples of these field trials are briefly mentioned.

The paper also indicates some possible future directions in ISDN standardization activities.

Further details on the topics covered in this paper and related aspects can be found in DUC (1984).

2. THE ISDN APPROACH

In recent years, we have witnessed a rapid increase in the use of digital techniques for telephony and data communications services. Service-dedicated digital networks have been and are being implemented using both digital transmission and switching techniques. This approach is known as integration of transmission and switching, and the resulting networks are referred to as Integrated Digital Networks (IDNs).

Examples of service-dedicated IDNs are:

— IDN for telephony, based on transmission and circuit switching of 64 kbit/s Pulse Code Modulation (PCM) voice channels, and on common channel signalling for connection control and other applications.

— IDNs for data, based on transmission and switching of customer data streams (e.g. at rates of 1.2, 2.4, 4.8, 9.6, 48 kbit/s) using circuit switching or packet switching techniques. These data networks are commonly referred to as circuit-switched and packet-switched data networks, respectively.

The telephony IDN however, is increasingly being seen as a multi-service IDN in which customer-to-customer digital connectivity exists and through which a multiplicity of services are accessible by the customer. This evolution is generally regarded as leading to the so-called Integrated Services Digital Network (ISDN), a general-purpose public network capable of supporting (or integrating) a range of different services (voice and non-voice) via a small set of standard multi-purpose customer-to-network interfaces (**Figs. 1 and 2**).

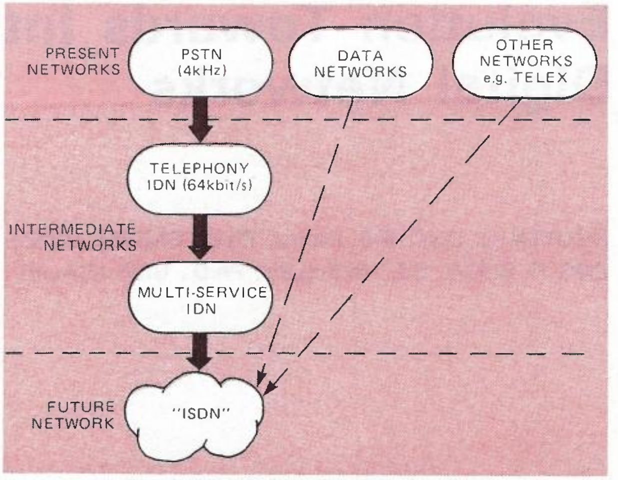


Fig. 1: Evolution Toward ISDN.

— PSTN: Public Switched Telephone Network.
— IDN: Integrated Digital Network.
— ISDN: Integrated Services Digital Network.

NGUYEN QUANG DUC was born in Gia Dinh, Vietnam, on June 23, 1947. He received the B.E. (Honours) and the Ph.D. degrees in Electrical Engineering from the University of Queensland, Brisbane in 1969 and 1973 respectively, studying under an Australian Colombo Plan Scholarship and a Radio Research Board Grant.

Subsequently, he joined Telecom Australia Research Laboratories working on digital line systems and data communications in Transmission Branch. Between June 1976 and July 1977, through his previous doctorate work in coding theory, he was invited to Syracuse University (Syracuse, New York State) as a Visiting Associate Professor at the School of Computer and Information Science. On his return to the Laboratories, he led studies on data switching networks, Open Systems Interconnection (OSI) and Integrated Services Digital Networks (ISDNs) in Switching and Signalling Branch.

In 1981 he was appointed founding Head of Customer Access Section in Customer Systems and Facilities Branch. This Section conducts research into a range of topics associated with multi-service telecommunications environment (including access to ISDNs and interworking between private and public networks).

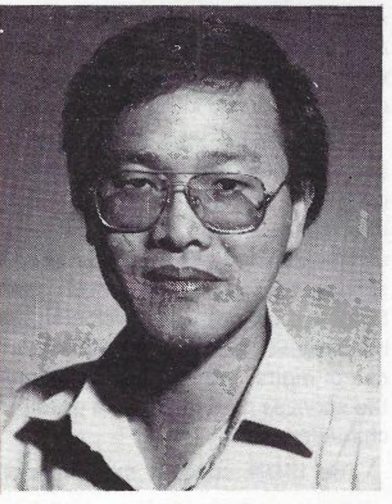
Dr Duc is an active contributor in the development of CCITT ISDN standards and has served as Drafting Group Chairman for Draft Recommendation I.310: ISDN Protocol Reference Model.

ENG KIANG CHEW received the degrees of B.E. (Elec.), 1972 from the University of Melbourne; M.Eng.Sc., 1975 and Ph.D., 1981 from the University of Sydney. After working for a year with Telecom Australia, he attended the University of Sydney, in 1973, where he also worked as a Tutor in Electrical Engineering. His Ph.D. work (1975-79) was on the modelling and analysis of stored program controlled (SPC) telephone switching systems.

Since joining Telecom Australia Research Laboratories in 1979, he has worked on aspects of SPC switching operations and maintenance, modelling and analysis of the CCITT No. 7 Common Channel Signalling System.

In 1982 he became a Senior Engineer with Customer Access Section where his work was centred on the interconnect arrangements between customer systems, networks and the public networks, especially in an Integrated Services Digital Network (ISDN) environment.

Dr Chew is currently a Principal Engineer with Business Communication Section where he leads a project on application-oriented services with emphasis on naming, addressing and directory facilities.



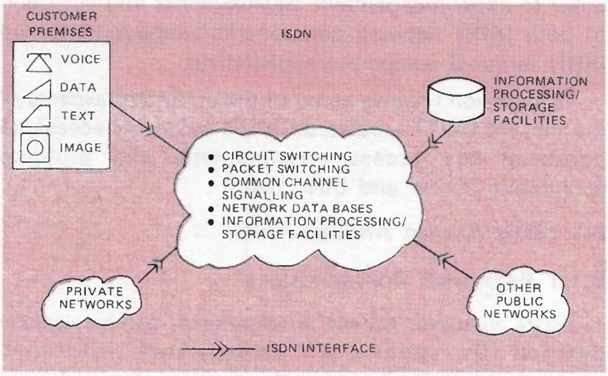


Fig. 2: ISDN Environment.

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

A key element of this unified service provision or service integration is the provision of a common access between the customer premises and the network for a range of different services.

Within the CCITT discussions, the integrated customer-to-network access refers to common access signalling procedures and protocols used over a small set of standardized customer-to-network interfaces.

In summary, integration in a multi-service telecommunication environment implies integration of three fundamental components:

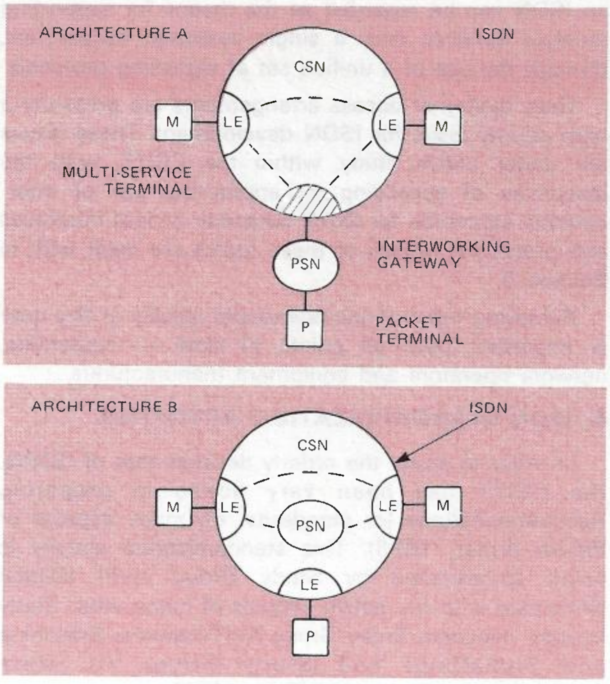
(a) **customer services** (e.g. with respect to features and facilities, terminals, service interworking)
(b) **network resources** (e.g. with respect to transmission, switching, signalling, network interworking, network management)
(c) customer-network access (e.g. with respect to signalling procedures, protocols and functional interfaces).

3. ISDN ARCHITECTURES

In dealing with a range of voice and non-voice services having diverse requirements, two complementary switching techniques, namely, circuit switching and packet switching are used in the ISDN development (Duc, 1980). Circuit switching is generally preferred for supporting services such as real time communications and bulk information transfer. Packet switching on the other hand, is generally preferred for services of bursty traffic characteristic such as interactive data applications.

Depending on how these two switching techniques are used within the emerging ISDNs, two possible ISDN architectures can be conceived for the network evolution (**Fig. 3**) (Duc and Chew, 1983).

Architecture A assumes the pre-existence of a packet switched network (PSN) before an ISDN is developed. The ISDN in this case is regarded as a multi-service circuit-switched network (CSN). The PSN is therefore treated as a separate dedicated network, **external** to the



LE : LOCAL EXCHANGE
CSN : CIRCUIT SWITCHED NETWORK
PSN : PACKET SWITCHED NETWORK

Fig. 3: Two Possible ISDN Architectures.

ISDN. Multi-service offerings (circuit and packet switched) are provided to ISDN customers via a single customer-to-network access line. The only support the ISDN gives to packet calls is a physical 64 kbit/s channel between the local ISDN exchange and the appropriate PSN port of an internetworking gateway. Such an approach has been adopted by British Telecom in the development of its ISDN (Partridge, 1983).

Architecture B is based on the premise that the local ISDN exchanges perform packet switching functions as well as circuit switching functions. This approach allows the ISDN to integrate both circuit and packet switching facilities. It also allows the separate development of a dedicated PSN, if economically justified. In this case, packet handlers in the ISDN will interwork with the PSN via CCITT Recommendation X.75, the protocol interface standard for interworking between public packed switched data networks. Such an approach has been adopted by Italy in the development of its ISDN (and PSN) (Mossotto and Di Pino, 1981).

In the very long term, it is expected that both circuit and packet switching will be fully integrated in the ISDN.

It is clear from the above discussions that there is no unique direction for ISDN network development or evolution. The direction chosen will depend very much on the existing infra-structure of the national networks.

It is generally accepted that the transition from existing networks to a comprehensive ISDN may require a period of time extending over one or two decades. During this period it is expected that the evolving ISDN will need to interwork with existing dedicated networks.

However, from the customer viewpoint, an ISDN is only seen through the customer access interface; that is, an ISDN can be regarded as the means for supporting multiple services over a single customer access link, through the use of a unified set of signalling protocols.

Thus, customer access arrangements are presently a high priority issue for ISDN development. These issues are under active study within the CCITT, with the objectives of specifying an appropriate set of international standards for ISDN customer access interfaces and protocols. Details of these topics are dealt with in Section 5.

Achieving international standards quickly in this area is important from all points of view — customers, network operators and equipment manufacturers.

4. ISDN STANDARDIZATION ACTIVITIES

In order to assist the orderly development of ISDNs, the CCITT has been very active in preparing Recommendations (or standards) on many aspects of ISDNs (Irmer, 1983). This standardization activity is being co-ordinated by Study Group XVIII (Digital Networks) with the active support of many other Study Groups, including Study Group XI (Telephone Switching and Signalling) and Study Group VII (Data Communication Networks) (Duc, 1980).

In particular, Study Group XVIII is proposing the establishment of a new CCITT Recommendations series called the I-series, to cover all ISDN-related topics such as the following:

— the ISDN concept and associated principles;
— service capabilities;
— overall network aspects and functions;
— user-to-ISDN interfaces;
— internetwork interfaces.

(In this paper, the terms "user" and "customer" are used interchangeably, and they have a general meaning to include terminals and systems in the customer premises.)

Appropriate references will be made to other relevant (current and new) CCITT Recommendations series, such as the X-series on data network aspects from Study Group VII and the Q-series on telephony network aspects from Study Group XI.

5. ISDN CUSTOMER ACCESS

As mentioned earlier in Sections 2 and 3, the technical aspects related to customer-to-network access are currently a most urgent issue of ISDN studies. Early international agreement is being sought within the CCITT in order to allow independent developments and evolution of both ISDN network components/configurations and ISDN terminal equipment/applications.

This section reviews some of the important aspects of the current CCITT studies on ISDN customer access, in particular the access arrangements and protocol achitecture (Chew and Duc, 1983).

5.1 ISDN Access Arrangements

5.1.1 Reference Configurations

ISDN customer access arrangements can be usefully defined by means of **conceptual** reference configurations. In these configurations user premises equipment, network transmission and exchange equipment are partitioned into generic functional groupings separated by well-defined logical reference points (some of which correspond to physical interfaces). **Fig. 4** shows a typical reference configuration for ISDN customer access, comprising the following generic functional groups:

— TE1 — Terminal Equipment Type 1 (or ISDN Terminal);
— TE2 — Terminal Equipment Type 2 (or Non-ISDN Terminal);
— TA — Terminal Adaptor;
— NT1 — Network Termination 1;
— NT2 — Network Termination 2;
— LT — Line Termination;
— ET — Exchange Termination.

TE1 includes functions associated with ISDN terminal equipment complying with new ISDN Interface (e.g. S or T) Recommendations. Examples of TE1 are new generation terminal equipment including digital telephones, data equipment and integrated services (e.g. voice, facsimile, data, video etc.) terminal equipment.

TE2 includes functions associated with current-generation terminal equipment complying with, for example, the X-series Recommendations (e.g. X.25, X.21).

TA includes interface and protocol adapting functions which allow TE2 terminals to be connected at the ISDN customer-to-network interfaces (i.e. S or T).

NT1 provides functions for the proper physical and electrical termination of the network. These functions belong broadly to the Physical Layer (Layer 1) of the Open Systems Interconnection (OSI) Reference Model (Duc, 1982). (The OSI model defines a seven-layered

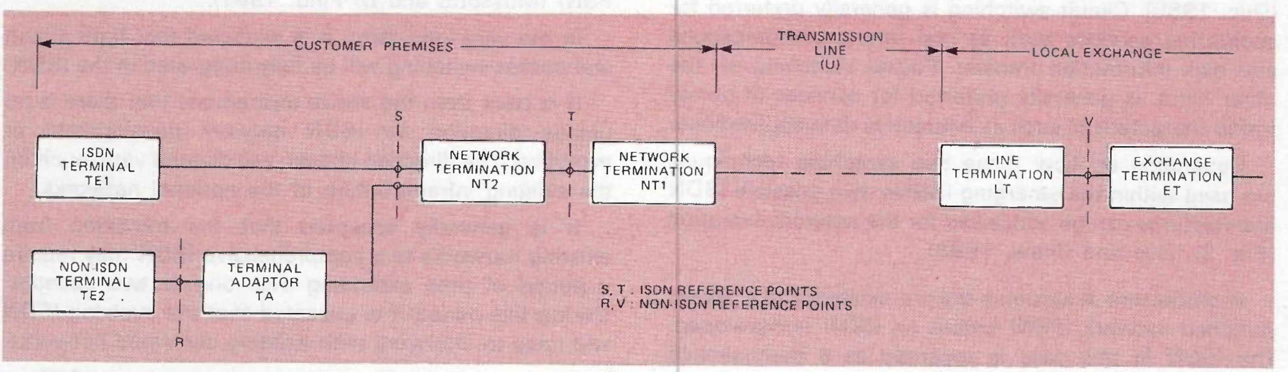


Fig. 4: ISDN Digital Customer Access Reference Configuration.

protocol architecture and serves as framework for the development of communication protocol standards).

NT2 includes functions broadly belonging to Layer 1 and to higher layers of the OSI model, such as Layer 2 (Data Link) and Layer 3 (Network). The actual functions performed by NT2 would depend on its physical configuration. PABXs, Local Area Networks (LANs) and Terminal Controllers are typical examples of equipment or combinations of equipment that can provide NT2 functions. In these cases, NT2 is said to be non-transparent or intelligent as it may handle protocols at OSI Layers higher than Layer 1. Distribution models for non-transparent NT2 are still under investigation within CCITT and their specifications have been deferred until the next CCITT 1985-88 study period. In the remainder of this paper only transparent NT2 (i.e. with Layer 1 functions only) will be considered.

ET and **LT** represent exchange equipment/functions.

The reference configurations are intended to be implementation-independent. The functions which compose the functional groups TE1, TE2, TA, NT1 and NT2 can therefore vary with the physical implementation method used for the access. For example it is possible to combine NT1 and NT2 as one functional block in a physical realisation. Other combinations are also possible (Decina, 1982). Furthermore, it is possible to connect directly multiple TE1s (or TE2s and TAs) to NT1 using a multidrop arrangement (e.g. a bus).

5.1.2 Interface Structures

In order to minimise the variety of standard ISDN customer-network physical interfaces, CCITT has defined small sets of both channel types and structures for such interfaces.

A **channel** represents a portion of the information-carrying capacity of the interfaces through which information is carried. Channels are classified by **channel types,** having common properties. Channel types are further combined into **interface structures** which define the total digital information-carrying capacity across a physical interface.

The following essential channels have been defined and studied by CCITT: B-channel (64 kbit/s) and D-channel (typically 16 kbit/s) (CCITT Study Group XVIII, 1982). A B-channel may be used to carry a variety of digital information streams (e.g. voice, data) on a dedicated, alternate, or simultaneous basis, consistent with its capacity and the applicable service capabilities. A D-channel is used to carry signalling information and may be used also to carry telemetry and packet-switched data. Digital information in this channel is transferred using a frame-oriented link access procedure (LAP), known as LAP-D protocol.

CCITT has further defined several interface structures which must be complied with at the ISDN customer-network physical interfaces. The most important ones are:

- **Basic access** interface structure comprising two B-channels and one D-channel. The following basic access capabilities are therefore possible: 2B+D; B+D; or D, where B=64 kbit/s and D=16 kbit/s (**Fig. 5**).
- **Primary rate access** interface structures comprising for example (23B+D) or (30B+D), where B=D=64 kbit/s.

At present, most of CCITT's effort is centred on the development of signalling protocols for the (2B+D) basic access arrangement, particularly the D-channel protocols. It is anticipated that these protocols will be flexible and form the basis of future protocol developments for other interface structures (e.g. for nB+D). In this way, the number of different customer-network interfaces required could be minimised. This would hence maximise user flexibility through terminal compatibility, and would reduce costs through economies in production and operation of both the ISDN and user equipment. In the following, the basic access protocol architecture will be treated in detail.

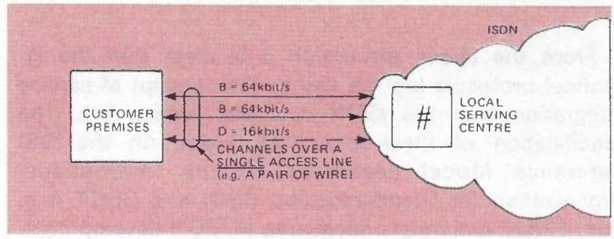


Fig. 5: ISDN Basic Access Interface Structure.

5.2 ISDN Access Protocol Architecture

5.2.1 General

In the basic access arrangement, the main role of the D-channel is to provide "out-slot" or common channel signalling functions for call control of the two B-channels (or circuits). This means that when a user wants to use a B (64 kbit/s) circuit for communication with another user in a remote part of the ISDN, the signalling procedures (or protocols) for setting up (and subsequently clearing down) of the B-circuit are conveyed via the D-channel (hence out-slot signalling) (**Fig. 6**).

This separation of signalling path (D-channel) from the user information path (B-channel) facilitates the specification of a flexible, universal signalling protocol which is capable of supporting both voice and non-voice services. This signalling technique for the ISDN basic access is quite similar to that of CCITT Common Channel Signalling System (CCSS) No. 7 (e.g. Chew and Subocz, 1982). It is the alternative to the "in-slot" signalling technique adopted in X.25 and X.21 access protocols where the signalling information is conveyed over the same path as the user information.

As mentioned earlier, the characteristics of the B- and D-channels are quite different: the former (64 kbit/s) is based on circuit switching; the latter (16 kbit/s) on packet switching mode of operation. Noting the capacity of the D-channel, CCITT Recommendations also allow telemetry (t-type) and slow speed packet (p-type) information to be message-interleaved (or statitistically multiplexed) with the signalling (s-type) information over the same D-channel.

It should be realised that **within** the D-channel itself an in-slot signalling technique (similar to X.25) is used to set up logical connections for conveying s-type, p-type or t-type information between the user ISDN terminal (TE1) or terminal adaptor (TA). This should not be confused with the **purpose** of the s-type information in the context of the 2B+D basic access arrangement.

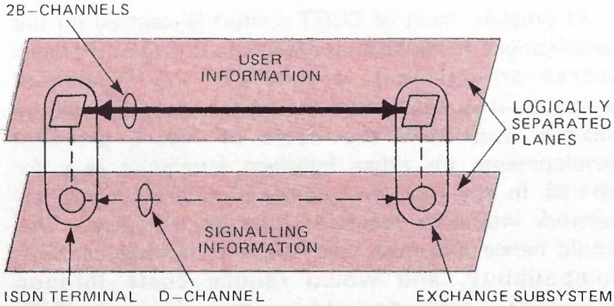


Fig. 6: An Example of "Out-Slot" or Common Channel Signalling.

From the above discussion it is clear that the D-channel protocols are the key to the concept of service integration over the ISDN customer access link. The specification of these protocols, based on the OSI Reference Model developed by the International Organisation for Standardization (ISO) and CCITT (e.g. Duc, 1982), is a most critical area of ISDN development. It is also an area of intense CCITT activity, which has the aim of producing international standards by the end of the 1981-84 study period.

The following presents a brief review of the current developments of the D-channel protocol layers.

5.2.2 D-Channel Protocol Layers

Currently, D-channel protocols have been defined as comprising the lower three layers of the OSI model, namely, Physical, Data Link and Network Layers (CCITT Study Group XVIII, 1982; CCITT Study Group XI, 1983). The Physical and Data Link Layers specification align closely with the Open Systems Interconnection Reference Model. However, some issues remain unresolved regarding the OSI representation of the s-type protocol in the Network Layer. These protocol layers are described below:

Physical Layer (Layer 1):

This layer provides the basic transmission capability for bit streams, including the line coding, timing and synchronisation functions. Other functions include power feeding and maintenance. It also provides the necessary signalling procedure to access the transmission medium. The media access procedure is critical for the support of multidrop customer in-house installation, such as a bus arrangement. It is required to resolve contention between multiple terminals seeking to access the common D-channel simultaneously. This issue is similar to that encountered in LANs.

At present the definition of the physical, electrical and functional characteristics of the S and T interfaces have been based on a 4-wire approach. The contention resolution mechanism adopted by CCITT is based on a CSMA/CD (carrier sense multiple access with collision detection) scheme, incorporated with a priority assignment mechanism allowing some messages to have priority over others for D-channel access.

Data Link Layer (Layer 2):

LAP-D protocol, the Link Access Procedure in the D-Channel at Layer 2 uses frame structures comprising frame delimiters (flags), zero insertion/deletion and cyclic redundancy check. The specification is largely derived from X.25 LAP-B procedures. However, LAP-D differs from LAP-B in one significant aspect — LAP-D is required to support multiple parallel logical links (i.e. multiple LAP's). Multiple logical links allow several terminals to communicate concurrently with the exchange. Furthermore, different LAP's may be required to access different Layer 3 protocols for s-type (signalling), p-type (packet data) and t-type (telemetry).

To support multiple LAP's over a single physical link a new Layer 2 addressing scheme has been developed. The scheme uses a **Data Link Connection Identifier (DLCI)** to identify uniquely both end points of a logical link. The DLCI consists of two parts: **Terminal Endpoint Identifier** (TEI) and **Service Access Point Identifier (SAPI).** The TEI identifies a particular terminal, while the SAPI is used to identify the particular Layer 3 protocol entity required.

The multiple logical link concept is an essential part of the LAP-D protocol. Recent progress has enabled this concept to be represented unambiguously in terms of the standard OSI concepts and definitions (Australia, 1982a).

Multiple terminal arrangements will be prevalent in the customer in-house installation. A basic requirement of these arrangements is that the local exchange should not need to know of the terminal configuration in the customer premises. Further, terminals must be universally portable, i.e. they can be moved from one ISDN interface to another. Associated with these requirements is, firstly, the need to devise a scheme for allocating a TEI value to a terminal. Both fixed and dynamic TEI assignment mechanisms have been proposed. From the viewpoint of flexibility, and terminal portability the dynamic scheme is generally favoured. Secondly, there is a need for the exchange to broadcast an incoming call to the terminals, and any compatible terminal may answer the call. (The answering terminal must then inform the exchange of its TEI value.) Thus LAP-D protocol possesses a broadcast facility, the detailed specification of which has been defined.

Network Layer (Layer 3):

At present Layer 3 has been defined to manage the establishment and termination of both circuit-switched connections (using s-information type) and packet-switched (t- or p- information type) connections. However, only the s-type protocol has been defined (CCITT Study Group XI, 1983). This protocol has a large degree of similarity with the User Parts of the CCSS No. 7. Indeed, in order to facilitate its interworking with the ISDN User Part of the CCSS No. 7, the two protocols must be closely aligned.

Recent results from Working Party XI/6 Melbourne meeting (CCITT SG XI, 1983) support the three-layer architecture for D-channel signalling functions, with the Layer 3 subdivided into Layer 3-Upper and Layer 3-Lower. Layer 3-Upper deals with call control functions, while Layer 3-Lower would allow the incorporation of future functions (such as signalling reliability which may be required for PABX access and other applications).

However, for placement of the functions **not** related to call control, such as those needed for changing from one service (e.g. voice) to another (e.g. data) during a call, no agreement has been reached within CCITT. Further details can be found in Duc and Chew (1984), Chew (1984).

6. ISDN EXPERIMENTS AND FIELD TRIALS

As part of their network developments towards an ISDN, a number of countries have already embarked on ISDN-related experiments and field trials.

While CCITT Recommendations (or standards) on ISDNs are being formulated (with end of 1984 as target date), the experimental activities will encompass, in early stages, proprietary techniques which may or may not be consistent with the emerging international standards. Although such a situation is awkward for the organisations concerned (e.g. network operators, equipment manufacturers), the experiments and field trials will provide them with valuable early experience on ISDNs and possibly a commercially-advantageous position at a later stage. In any case, it is expected that CCITT ISDN standards will be adopted and incorporated in final designs where applicable. The following paragraphs illustrate some of the above ISDN activities.

United Kingdom

British Telecom plans to introduce an ISDN pilot service (and not a field trial) based initially on a System X digital local exchange in central London, with opening to the public due in mid 1984. The pilot service is aimed at business customers and hence there is emphasis on providing ISDN customer access in all the major business centres. It is expected that the service will be extended to Birmingham and Manchester during 1984-85. CCITT ISDN standards will be incorporated at a later date (around 1986). Further details on the UK ISDN activities may be found in Partridge (1983).

Italy

Two ISDN field trials are being prepared jointly by the Italian network operators and two manufacturers (namely, Italtel and the multinational ITT, International Telephone and Telegraph Corporation):

- mid 1984 in Florence using Italtel UT10/3 digital exchange;
- mid 1984 in Bologna using ITT 1240 digital exchange.

Further details on the Italian ISDN activities may be found in Mossotto and Di Pino (1981).

Belgium

The plans for ISDN activities in this country are as follows:

- late 1984 in Namur using ITT 1240 digital exchange;
- 1985 in Brecht (Antwerp) by updating the current ITT1240 which has been used to carry voice only since 1982;
- also 1985 the two ITT1240 exchanges in Namur and Brecht are expected to be interconnected.

Sweden

Ericsson, the Swedish manufacturer will conduct an ISDN demonstration in mid 1984 in Venice (Italy) using its modified AXE-10 digital local exchange. CCITT basic access standards will be incorporated (end 1986) and the ISDN service will be introduced by the Swedish Telecommunications Administration Televerket in 1987.

Germany

The German Post Office (Deutsche Bundespost) ISDN field trials will start in 1985 using up to two types of exchanges selected from three different manufacturers. CCITT ISDN basic access standards will be later incorporated in 1987. (Irmer, 1983).

France

The French Administration is currently waiting for CCITT ISDN standards to become available (end 1984) before starting their ISDN field trials in 1986. It is noted, however, that a major multi-services project will take place in mid 1984 using the French-developed Telecom 1 satellite.

Japan

Nippon Telegraph and Telephone (NTT) has recently embarked on a 20-year network development plan to construct in several stages the Japanese ISDN known as the Information Network System (INS). An INS model is being constructed in the Musashino/Mitaka area, a Tokyo suburb, and will be operated on a test basis for a period of five years (until 1987) to train personnel and to test various INS techniques and technologies. In addition, INS will be displayed and demonstrated at the International Science Exposition in Tsukuba Science City in 1985. Commercial service will also be offered to customers in that area. Further details about the INS may be found in Kitahara (1983).

7. ISDN FUTURE DIRECTIONS

Most of the ISDN standardization activities have been conducted within the CCITT and this situation is expected to remain in the foreseeable future.

The current international standardization effort on ISDNs has been towards the formulation of CCITT Recommendations by the end of 1984. A great deal of emphasis has therefore been placed on the provision of an ISDN customer basic access structure of 2B+D (where B=64 kbit/s and D=16 kbit/s). Such a structure and its associated signalling and protocols will form a fundamental basis for the development of other customer access structures. Examples of these are: the primary rate access 30B+D or 23B+D (where B=D=64 kbit/s) and its alternative in which an E-channel is used instead of D-channel. (The difference between D and E channels lies in their protocol characteristics).

In the next CCITT study period (1985-1988) it is expected that the emphasis will be placed on many of the important issues that have been raised but not yet studied because of lack of time in this study period. Such topics would include the following:

- switched connections at bit rates less than 64 kbit/s; e.g. encoded voice at 32 kbit/s or 16 kbit/s;
- switched connections at bit rates greater than 64 kbit/s; e.g. encoded stereo sound and digital video;
- provision of so-called multi-media calls involving more than one type of services; e.g. simultaneous voice and video, or voice and facsimile;

— interfacing between ISDN and Local Area Networks (LANs)/PABX;
— incorporation of LAN/PABX-like features in the customer in-house multi-terminal arrangements (such as local communications between terminals in a given customer premises) (Australia, 1983b).

The results of the CCITT discussions on ISDN matters in the current study period and subsequent ones will greatly assist the development of telecommunications networks in supporting a wide range of current and emerging services in an orderly manner.

8. CONCLUSIONS

This paper has briefly described the ISDN approach, a fundamental concept in the development of future telecommunications networks. The ISDN is characterized by the provision of digital end-to-end connectivity between communicating parties for a wide range of voice and non-voice services through a small set of customer-to-network access interfaces.

Such an approach would allow the independent development of equipment and associated techniques used in both the customer premises and the networks.

Much of the achievement made on ISDN studies has been produced by the enthusiastic effort and co-operation of CCITT member organisations. The aim of the current activities is to standardize the interfaces and protocols for the (2B+D) basic access arrangement by the end of the 1981-84 study period. Based on the current progress, this objective is likely to be achieved. The results will provide an important foundation for the studies of other ISDN customer access structures and issues. More importantly, they will also provide much needed internationally agreed standards in the worldwide network development towards ISDNs.

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An Introduction to the Integrated Services Digital Network User Part of the CCITT CCSS No. 7

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Various User Parts for the CCITT Common Channel Signalling System No. 7 have been defined e.g. the Telephone User Part and the Data User Part. The specification of the Integrated Services Digital Network User Part (IUP) intended for use with both voice and non-voice services is about to be specified by the CCITT. This paper gives an overview of the IUP, listing the services currently offered and some of the proposed services describing the basic call control and signalling procedures necessary for the establishment, maintenance, alteration and the termination of call connections in an Integrated Services Digital Network (ISDN) environment. A description of the basic procedures using the CCITT Specification and Description Language (SDL) is also included.

1.0 OVERVIEW OF THE INTEGRATED SERVICES DIGITAL NETWORK USER PART

The Integrated Services Digital Networks User Part (IUP) of the CCITT Common Channel Signalling System (CCSS) No. 7 [1, 2] is a multi-service call control facility [3]. It provides for a wide, open-ended range of signalling functions that permit circuit switched services to be established for voice and non-voice applications in an integrated services environment. It replaces traditional Line and Information signalling and is suitable for national and international applications. In the future it is intended that the IUP will be developed to cater for packet switching services as well.

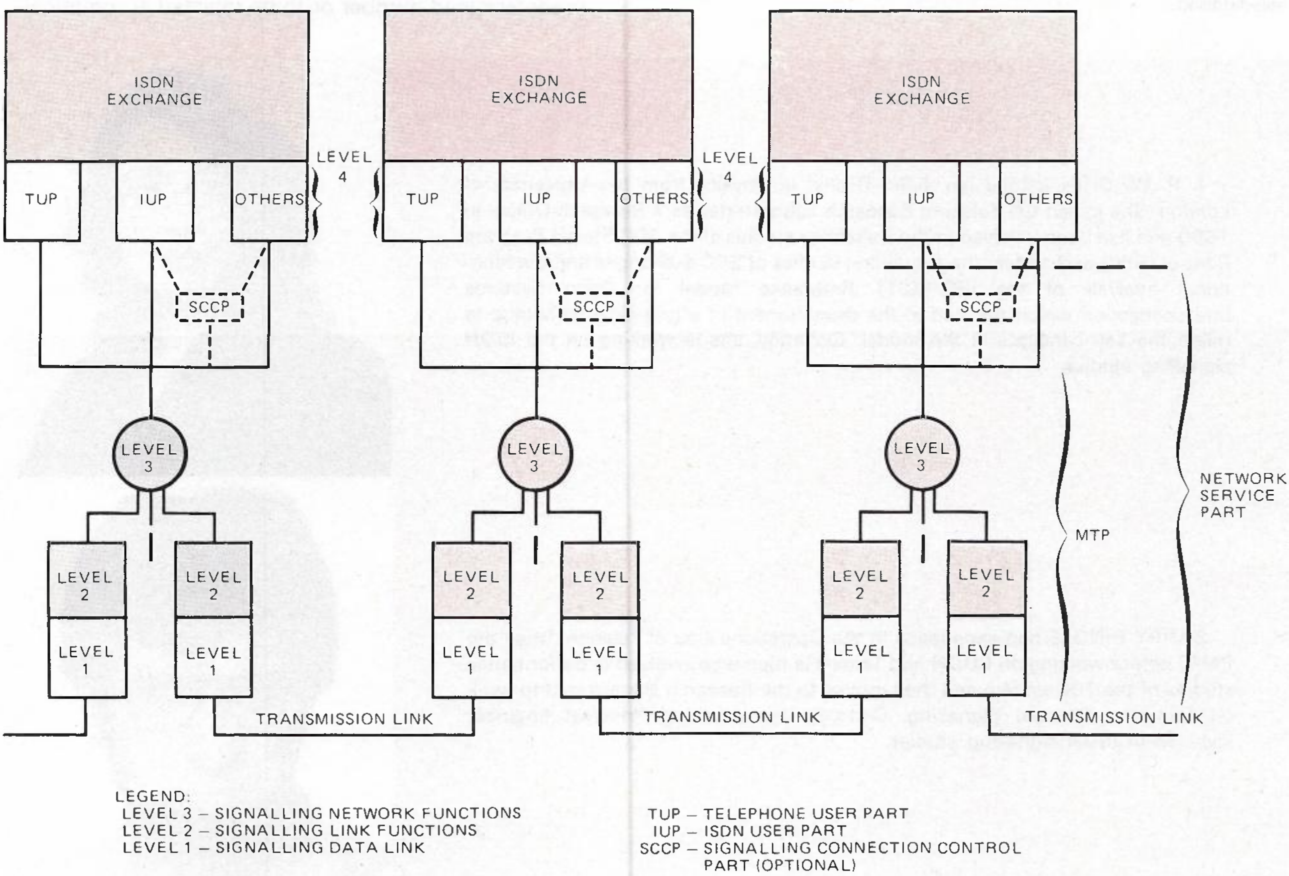

Fig. 1 The interrelationship of the IUP, the No. 7 network and the exchanges.

The network connections can be either 64 kbit/s transparent or 64 kbit/s non-transparent. The 64 kbit/s transparent connection is used to carry any one of the standard user classes+ whereas the 64 kbit/s non-transparent is used primarily for voice communication where the connection may include bit manipulating devices such as echo suppressors. Additional connection types such as sub-rate channels, which may be subject to future standardisation, are also catered for. **Fig. 1** shows the interrelationship of the IUP, the No. 7 network and the exchanges.

2.0 SERVICES OFFERED BY THE IUP

2.1 Basic Services

The Basic services offered to the user are the signalling functions required to establish, maintain and release circuit switched connections for voice and non-voice services in an ISDN. They include most of the services offered by existing signalling systems. (Note: the term 'User' in CCSS No. 7 terms usually refers to the exchange in which the User Part resides. It does not usually refer to subscribers or customers but where it does, this will be identified.)

2.2 Supplementary Services

In addition to the Basic services, the IUP also supports a wide variety of Supplementary services.

+ a user class is a category of data transmission service provided by a communication system, such as data network, in which the data signalling rate, the data terminal equipment operation modes, the data code structure, and other feature facilities and services are standardised.

Examples of Supplementary services or subscriber facilities are listed below:

(A) "Closed User Groups (CUGs)" enable subscribers with one or more of the following facilities to form a group with controllable access restrictions. The facilities are:

(i) CUG with outgoing access to the network at large;

(ii) CUG with incoming access from the network at large;

(iii) Incoming calls barred within the CUG (applied per subscriber).

(iv) Outgoing calls barred within the CUG (applied per subscriber).

These facilities permit the creation of sub-networks with controllable access.

(B) "Subscriber access to the calling party address identification" allows a subscriber to be informed of the ISDN number of the calling party before accepting incoming calls, except when the calling party has the calling party address presentation restricted or when the complete number of the calling party is not available to the destination exchange;

(C) "Subscriber access to the called party address identification" enables a caller to be informed of the identity of the called party when outgoing calls are attempted. This is useful when calls are redirected and as a confirmation before answer of the called number;

(D) "Redirection of calls" enables calls to a specific ISDN number to be either redirected to another predetermined number or to be rejected automatical-

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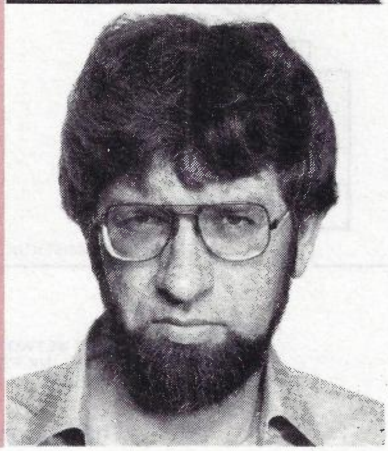

ly during a specified period when the facility is activated;

(E) "Connect when free and waiting allowed" allows a calling subscriber who has the "waiting allowed" facility to have his call queued at the destination exchange if the call encounters a busy access line(s). The call connection is maintained to the local exchange until the called party becomes free;

(F) "Completion of calls to busy subscriber" facility is similar to the "connect when free and waiting allowed" facility except that the caller does not enter a waiting period. Instead, the caller activates this facility in his local exchange which in turn causes the called party exchange to periodically test the status of the called party for a limited period. When the called party becomes free, the calling party is called and when that party answers, the called party is alerted. In this way, the call is completed automatically without repeated dialling; and

(G) "Network access to the calling party address identification" facility which is a capability of the network to obtain the calling party address inside or outside its own network.

2.3 End-to-End Signalling

In order to make information transfer between endpoint IUPs (i.e. originating and destination exchanges) more efficient, an End-to-End signalling facility has been included in the IUP. There are two methods of End-to-End signalling specified which can co-exist in the same network:

(a) the pass-along method; and

(b) the Signalling Connection Control Part (SCCP) method.

The pass-along method relies on the existence of a circuit-switched connection between two endpoints while the SCCP is independent of any switched connections.

The pass-along method makes use of the link by link signalling connection that is established during call set-up. A message from the originating IUP endpoint is sent through intermediate IUPs (like any call control message) to the destination IUP. The contents of the End-to-End message is not evaluated but the message is simply re-addressed to the IUP in the next exchange along the circuit connection. Eventually it will reach the destination endpoint where it will be processed. Clearly this is a simple extension of the present use of the CCSS No. 7.

The SCCP method makes use of an additional functional block called the SCCP [4]. The SCCP provides additional functions to the standard Message Transfer Part (MTP) of No. 7 so as to provide a standard Network Service as specified in Chapter 4.5 of [5]. This permits information transfer between two endpoint exchanges without a circuit having to be established as in the pass-along method. Instead, a logical connection is established. (The SCCP also permits information transfer between exchanges and data bases as it provides many of the features of an X.25 type packet network. It will facilitate the connection of exchanges to Operations and Maintenance Centres, charging centres, routing data bases etc., and so provide for such services as traffic monitoring, dynamic network management, network fault reporting, automatic transfer of charging data for billing purposes and the transfer of software updates to exchanges.)

The SCCP method allows End-to-End signalling message to be routed through the No. 7 network in the most direct way. At no time do the messages need to be processed by any intermediate IUP. However, the SCCP does require knowledge of all CCSS No. 7 network addresses unlike the exchange using pass-along method that only needs to know the addresses of exchanges to which they are connected by circuits.

In order to associate a particular End-to-End message with a particular call, a Call Reference is necessary. The pass-along message uses a different reference between each IUP as does a normal signalling message. It uses the address of the IUP exchange it is leaving (the Originating Point Code), the address of the next IUP exchange (the Destination Point Code) and the number of the circuit to which it is related. The SCCP method needs a separate call reference which must be allocated under the control of the initiating IUP.

3.0 CALL CONTROL PROCEDURES

The basic call control procedure of the IUP are very similar to the setup of MFC (Multi-frequency Code) controlled calls. They can be divided into three phases: the call set-up, the conversation (or data transfer) and the call cleardown phases.

Each phase of a call is characterised by a group of messages. These messages contain information about the calls and they are sent either in response to a caller's actions or to another message. The call control procedures specify what will be sent and when it will be sent. The advantage of No. 7 is that it can send more information more rapidly than older signalling systems. This enables the additional facilities to be provided whilst decreasing the call setup time. In order to improve its usefulness in a wide range of applications the IUP also has many options. However, this also increases the complexity. Two such options are the alternative call setup signalling procedures: the En-bloc and Overlap procedures. The En-bloc procedure is one in which all the address digits are sent at the same time in the Initial Address Message (IAM). In the Overlap procedure only some of the address digits are sent forward in the IAM and the remaining address digits sent later in one or more Subsequent Address Messages (SAMs).

The call control procedures will be illustrated by describing the messages and then showing a typical call control procedure.

3.1 Message Descriptions

The first message sent in a call set-up attempt is an IAM. All IAMs consist of:

(a) a Service Identification field which indicates the type of service requested;

(b) a Nature of Connection Indicator field which indicates whether satellites are permitted, whether circuit continuity checking is required (depending on the type of transmission system used for telephone circuit) and whether an outgoing echo suppressor has been previously included in the circuit;

(c) a Forward Call Indicator field which indicates if the call is national or international, if End-to-End signalling is permitted (and which type) and if the connection is controlled by IUP at every exchange;

(d) a Calling Party Category field which indicates if the caller is an operator (and the language to be spoken), a priority call, a data call, a test call or an ordinary subscriber call;

(e) the Called Party Address which is the number of the party to which a connection is requested.

There are other optional fields which can be found in [6].

Apart from IAMs and SAMs, other type of messages are:

(i) the Address Complete Message (ACM) — used after a set-up message is sent to the called party and the called party has indicated that it is willing and able to accept the call by responding with an Alerting message. In a simple telephone call, the ACM has a similar function to the currently used Ring Tone;

(ii) Answer (ANS) message — used when a called party answers. It can also remove ringing tone, if applicable, and will cause the transmission path to be connected through at the destination exchange;

(iii) Continuity Check Request (CCR) message — used to initiate checks that a transmission path exists, particularly on analogue circuits. In non-Common Channel signalling systems, the signalling itself is the Continuity Check;

(iv) Call Modification Request (CMR) message — when a CMR is received by an exchange, it prepares to modify the call as requested (if possible). For example, a data call could be modified to a voice call with echo suppressors, or vice versa. A CMR is then sent to the next exchange. When the last exchange is ready to modify the call, a CMC is sent back through the preceding IUPs;

(v) Call Modification Complete (CMC) message performs the call modification initiated by a CMR and acknowledges the modification to the initiator;

(vi) Reject Connection Modification (RCM) message used when an exchange is unable to change the resources requested by a CMR. This type of message is usually accompanied by the reason for the rejection;

(vii) Call Supervisory Message (CSM) — used at any time during call set-up when the connection cannot be completed. This type of message usually contains the reason for the call refusal as well;

(viii) Delayed Release Signal (DRS) message — generated by the network in response to a Disconnect request from a subscriber if the network is applying a hold to the connection;

(ix) Release (REL) message — used to request the disconnection of a transmission path;

(x) Released (RLSD) message — indicates that the switchblock connection has been removed; and

(xi) Release Complete (RLC) message — used to inform the preceding exchange when a RLSD message has been received and the transmission path has been released. It signifies that the circuit is now available for use on other calls.

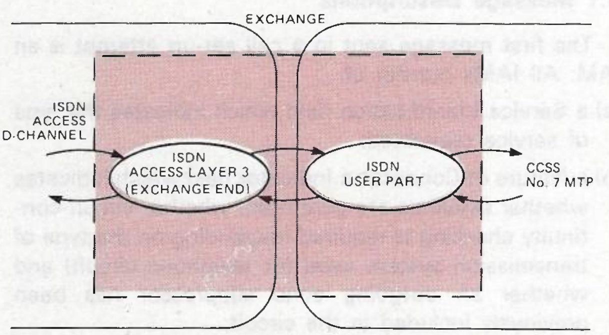

Fig. 2 IUP relationship with ISDN Access (D-channel) signalling.

The IUP messages are related to the ISDN Access signalling messages as shown in **Fig. 2** and more details of ISDN access signalling procedures are available in [7].

The following paragraphs depict the relationship and the sequence of events in a typical call as shown in **Fig. 3**.

3.1.1. Establishment of Call —

To initiate a call the customer sends a Call Set-up message to the originating exchange. The following actions result:

1. at the originating exchange:

(i) a check is made that the call is to be routed to another exchange;

(ii) an IAM (in the case of En-Bloc) is sent or IAM plus SAMs (in the case of Overlap) are sent to the succeeding exchange;

(iii) the calling party's call set-up request is acknowledged with a Call Sent message; and

(iv) the connection of switchpath between the originating exchange and the succeeding exchange is initiated.

2. at an intermediate exchange, actions (i), (ii) and (iv) above are performed.

3. at the destination exchange, a set-up message is sent to the called party.

3.1.2. Call Accepted —

If the call can be accepted by any terminal, each of the accepting terminals returns an Alerting message to the destination exchange which in turn sends one Address Complete Message (ACM) backwards to the originating exchange. The originating exchange then alerts the calling party using an Alerting message.

3.1.3. Called Party Answers —

When one terminal or customer answers, it becomes the called party and sends a Connect message to the destination exchange. The switch path is then connected and an Answer message is passed backward to the succeeding exchanges until the message is received by the originating exchange. A Connect message is sent to the calling party and conversation begins. The Answer message usually will initiate Charging.

3.1.4. Release of Call —

When the call is finished and when the call release is

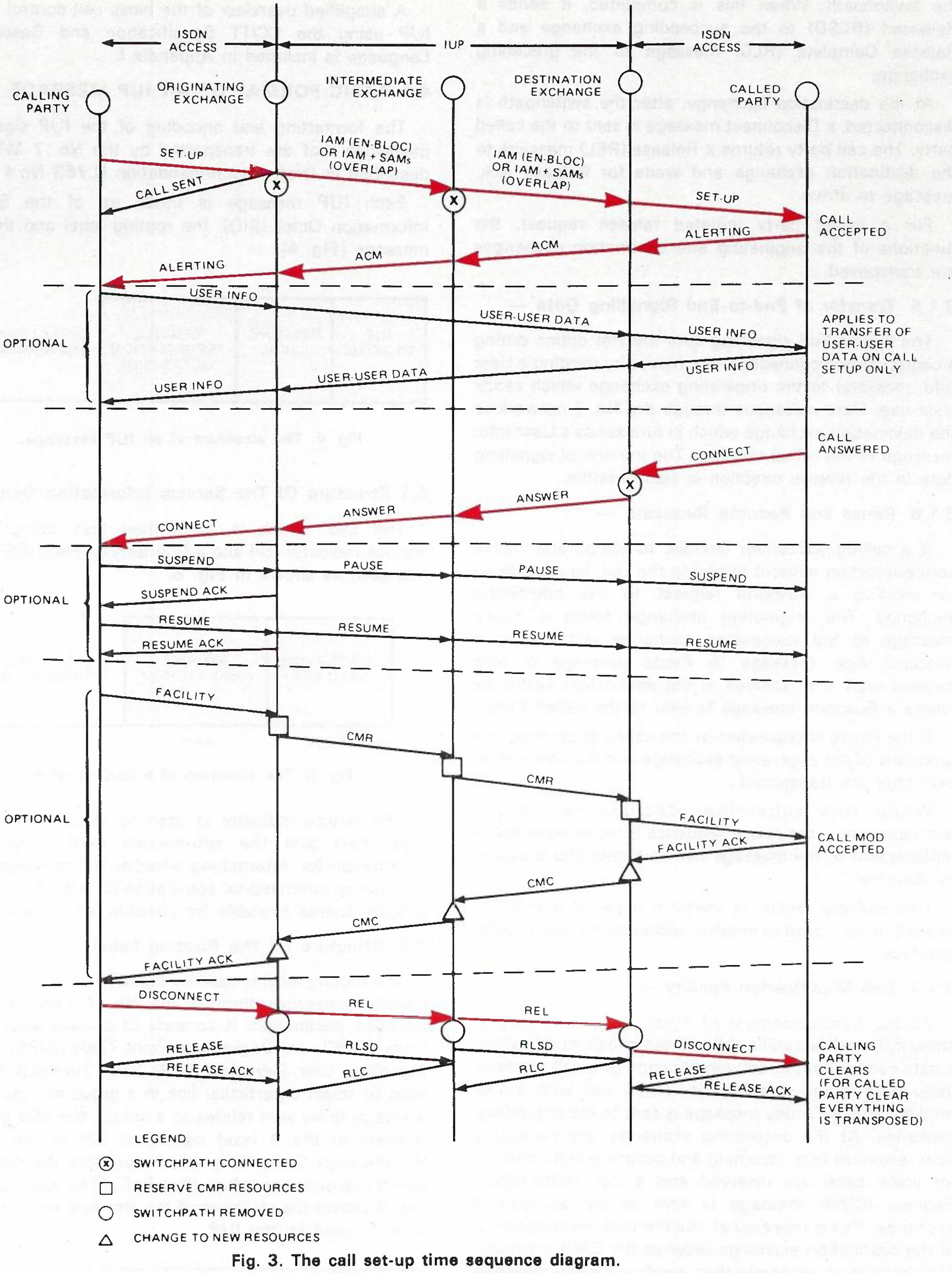

Fig. 3. The call set-up time sequence diagram.

initiated by the calling party, a Disconnect message is sent to the originating exchange.

At the originating exchange:

(i) a Release (REL) message is sent to the succeeding exchange;

(ii) the removal of the switchpath is initiated;

(iii) a Released (RLSD) message is sent to the succeeding exchange on completion of the removal of the switchpath; and

(iv) a Release (REL) message is sent back to the party who initiated the release. (This is acknowledged with a Release Ack. message).

When a Released (RLSD) message is received by an intermediate exchange, it sends a Release (REL) message to the succeeding exchange and disconnects the switchpath. When this is completed, it sends a Released (RLSD) to the succeeding exchange and a Release Complete (RLC) message to the preceding exchange.

At the destination exchange, after the switchpath is disconnected, a Disconnect message is sent to the called party. The call party returns a Release (REL) message to the destination exchange and waits for Release Ack. message to arrive.

For a called party initiated release request, the functions of the originating and destination exchanges are transposed.

3.1.5. Transfer of End-to-End Signalling Data —

The End-to-End signalling data transfer option during a circuit related connection is achieved by sending a User Info. message to the originating exchange which sends User-user Data messages through the No. 7 network to the destination exchange which in turn sends a User Info. message to the called terminal. The transfer of signalling data in the reverse direction is also possible.

3.1.6. Pause and Resume Requests —

If a calling subscriber decides to temporarily cease communication without releasing the call, he may do so by sending a Suspend request to the originating exchange. The originating exchange sends a Pause message to the succeeding exchange and returns a Suspend Ack. message. A Pause message is sent forward until it is received at the destination exchange where a Suspend message is sent to the called Party.

If the Pause is requested by the called subscriber, the functions of the originating exchange and the destination exchange are transposed.

When this subscriber decides to resume communication, the above sequence is repeated with the replacement of the message names Pause and Suspend by Resume.

This optional facility is useful if a called terminal is needed to be moved to another socket on the same ISDN interface.

3.1.7. Call Modification Facility —

At the commencement of a call, it is necessary to know if the call is a voice call without in-call modification, a data call without in-call modification or a call (voice or data) with in-call modification. For a call with in-call modification, a Facility message is sent to the originating exchange. At the originating exchange, the necessary new resources (e.g. incoming and outgoing echo devices for voice calls) are reserved and a Call Modification Request (CMR) message is sent to the succeeding exchange. This is repeated at intermediate exchanges until the destination exchange receives the CMR message. The destination exchange then sends a Facility message to the calling party. When the call modification is accepted, the called party returns a Facility Ack. message to the destination exchange. The destination exchange resources are changed from reserved status to in-service status and a Call Modification Complete (CMC) is sent to the succeeding exchange. This is repeated at the intermediate exchanges. At the originating exchange, a Facility Ack. message is sent back to the calling subscriber. This facility is also optional.

A simplified overview of the basic call control of the IUP using the CCITT Specification and Description Language is included in Appendix I.

4.0 BASIC FORMAT OF AN IUP MESSAGE

The formatting and encoding of the IUP signalling messages that are transported by the No. 7 MTP are described in Draft Recommendation Q.763 No.4 [6].

Each IUP message is made up of the Service Information Octet (SIO), the routing label and the IUP message [**Fig. 4**].

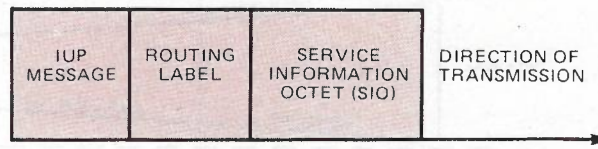

Fig. 4. The structure of an IUP message.

4.1 Structure Of The Service Information Octet

The SIO, which is transmitted first, comprises a Service Indicator (SI) and a Sub-Service Field (SSF) of 4 bits each as shown in **Fig. 5.**

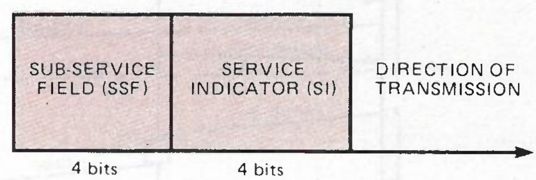

Fig. 5. The structure of a routing label.

The service indicator is used to identify the source User Part and the sub-service field consists of information for determining whether the message is for national or international application (2 bits). The other 2 bits are spares available for possible future needs.

4.2. Structure Of The Routing Label

The routing label is used by the MTP of CCSS No. 7 to transfer messages through the No. 7 network to its intended destination. It consists of a Destination Point Code (DPC), an Originating Point Code (OPC) and a Signalling Link Selection (SLS) field. The SLS field is used to select a particular link in a group of links. If the message to be sent relates to a circuit, the SLS actually consists of the 4 least significant bits of the Circuit Identification Code (CIC) which specifies the circuit to which this message refers. (See Ref. [1] for more details). **Fig. 6** shows the structure of the standard No. 7 routing label as used by the IUP.

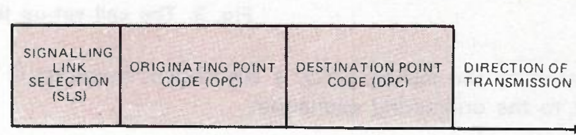

Fig. 6. The structure of a Service Information Octet.

4.3 Structure Of IUP Messages

An IUP message may be made up of a number of

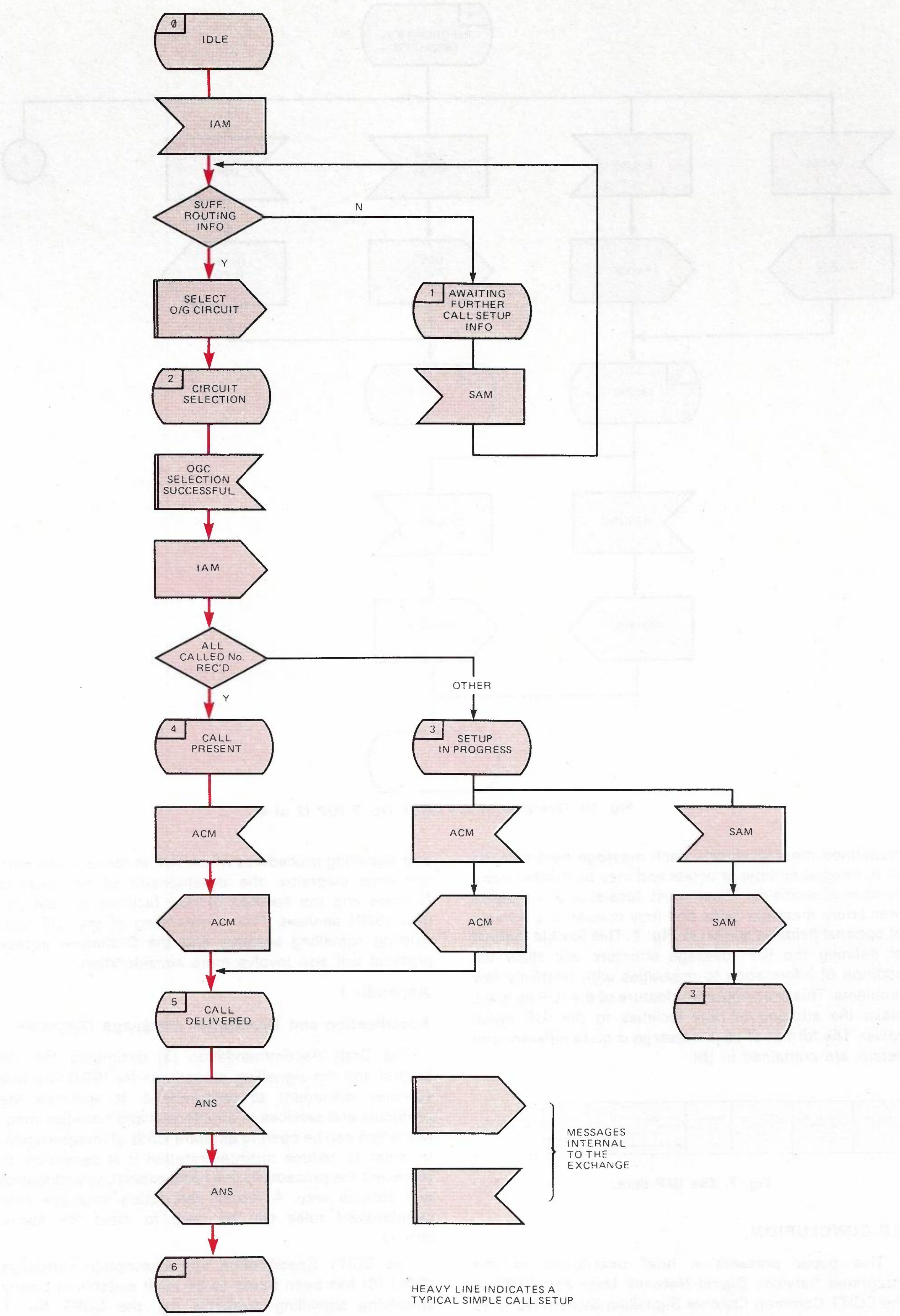

Fig. 9. Overview of the CCSS No. 7 IUP (1 of 4).

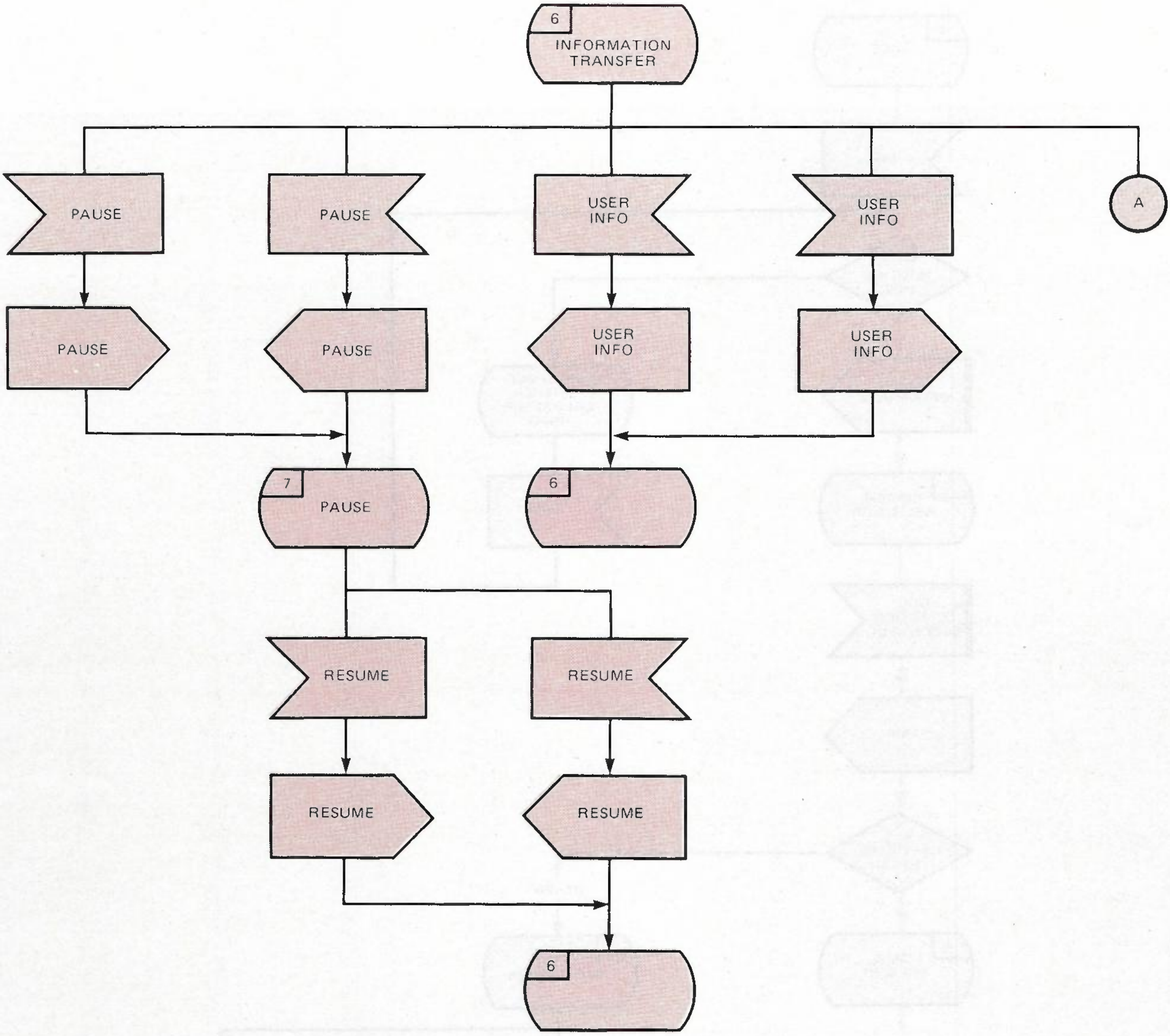

Fig. 10. Overview of the CCSS No. 7 IUP (2 of 4).

predefined message fields. Each message field consists of an integral number of octets and may be divided into a number of subfields. These must consist of a number of mandatory message fields and may consist of a number of optional fields as shown in **Fig. 7.** This flexible method of defining the IUP message structure will allow the addition of information to messages with relatively few problems. This is an important feature of the IUP as it will make the addition of new facilities to the IUP much easier. The format of each message is quite different and details are contained in [6].

Fig. 7. The IUP data.

5.0 CONCLUSION

This paper presents a brief description of the Integrated Services Digital Network User Part (IUP) of the CCITT Common Channel Signalling System No. 7 as specified to date and demonstrates the basic call control and signalling procedures of the IUP in terms of the time sequence diagrams, the development of the existing facilities and the addition of new facilities to cater for new ISDN services. The interworking of the IUP with existing signalling systems and the D-channel access protocol will also involve more consideration.

Appendix I

Specification and Description Language Diagrams

The Draft Recommendation [3] describing the call control and the signalling procedures for ISDN use is a complex document to comprehend. It specifies the protocols and services in an informal and narrative manner which can be open to different kinds of interpretation. In order to reduce misinterpretation it is necessary to represent the procedures in a more explicit, unambiguous and concise way. A formal description language with standardised rules can be used to meet the above criteria.

The CCITT Specification and Description Language (SDL) [8] has been found to be most suitable in clearly specifying signalling protocols e.g. the CCSS No. 7 protocols. In this paper, a simplified overview of the basic

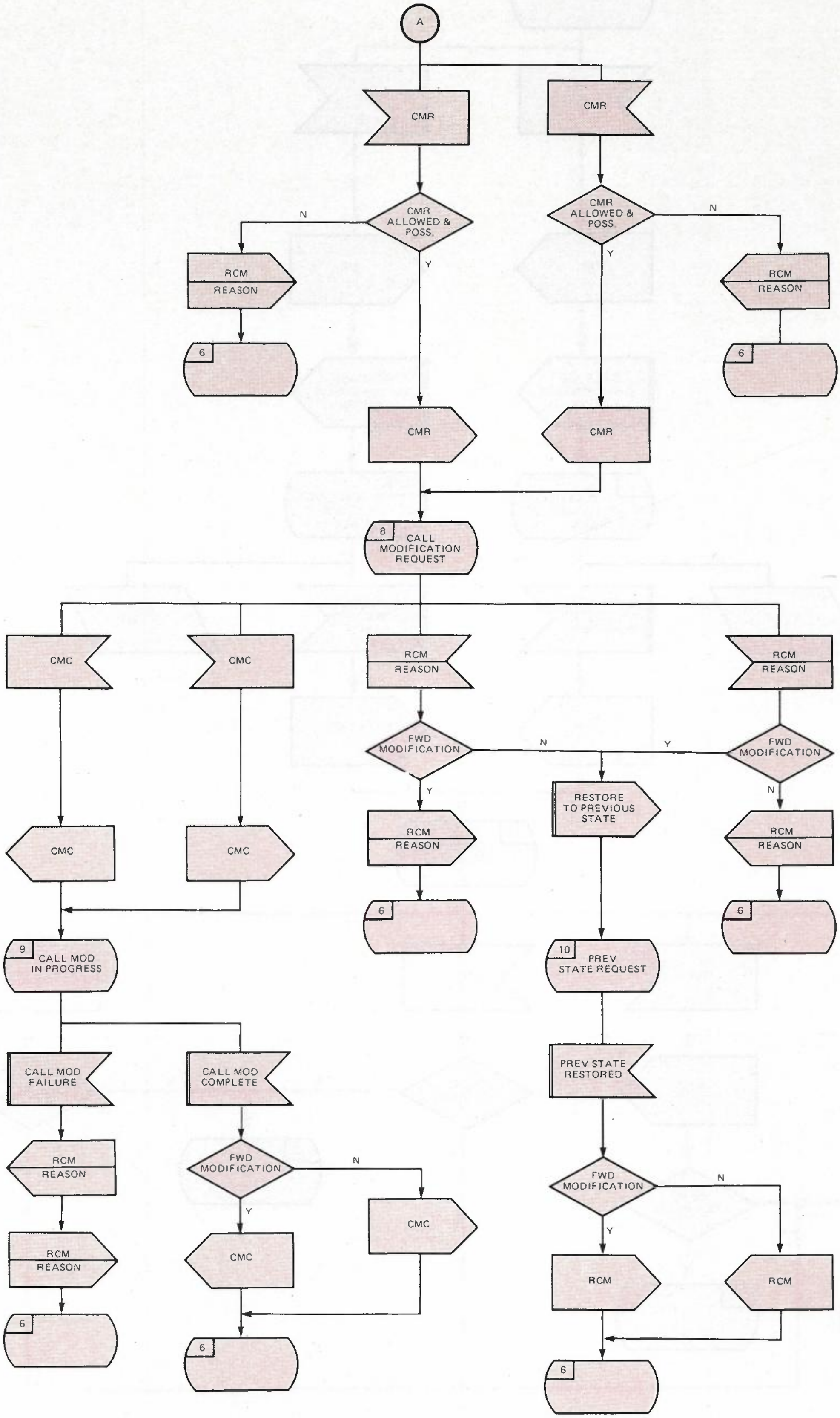

Fig. 11. Overview of the CCSS No. 7 IUP (3 of 4).

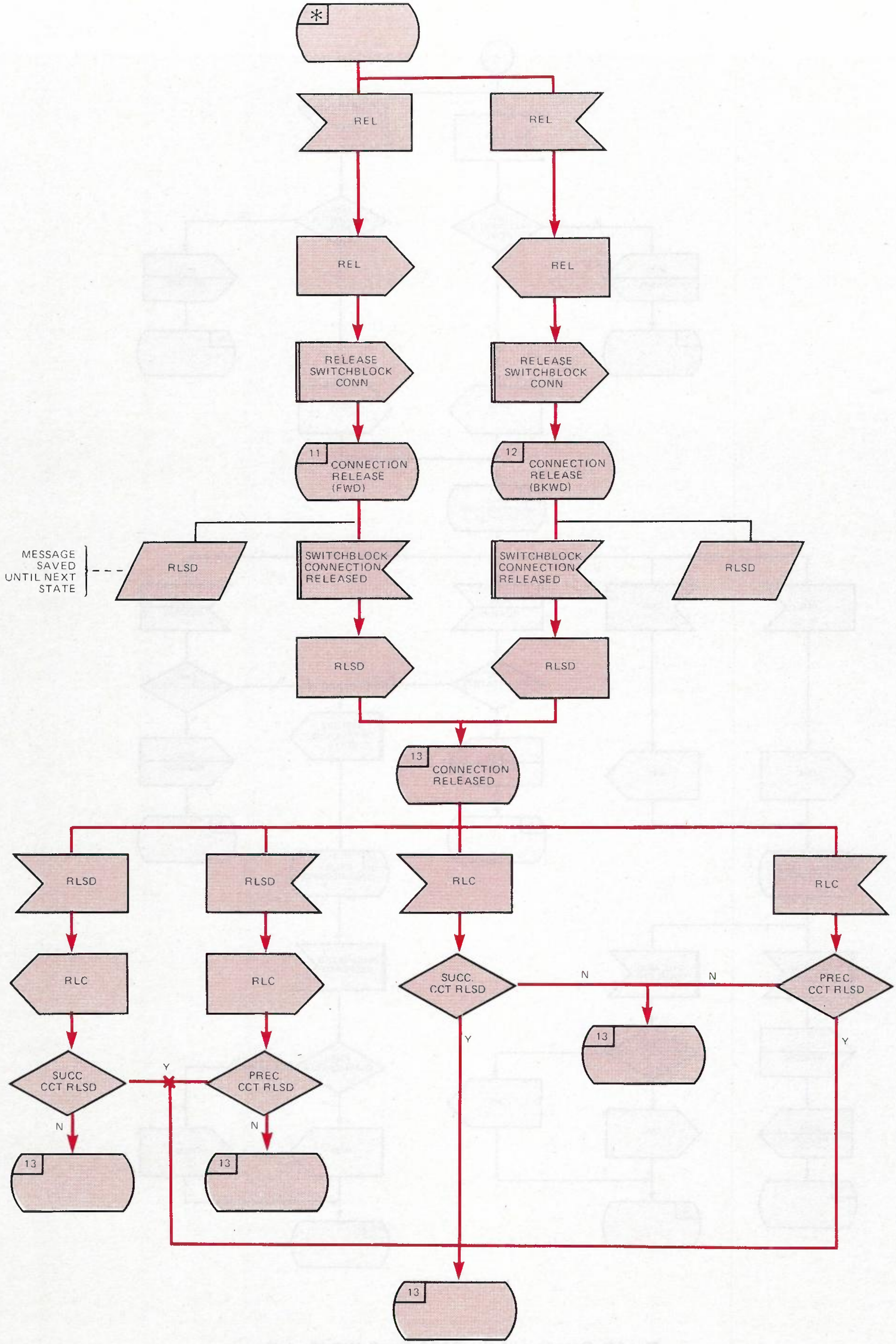

Fig. 12. Overview of the CCSS No. 7 IUP (4 of 4).

call control of the IUP is given in SDL (see **Figs. 9-12**) and covers only the basic messages flowing in and out of the exchange. For a more detailed SDL description of the procedures, readers should refer to [9].

Several assumptions have been made in the descriptions, namely:

— all variables are cleared (to 0) when State 0 is entered;

— the State marked "*" is a generalisation of the initiation of call release. It saves having to repeat message inputs in many states.

The relationship of Call Originating, Intermediate and Call Destination exchanges is shown in **Fig. 8.** Note: no D-channel signalling messages are included in these diagrams.

Fig. 8. Exchange relationship assumed in SDL description.

The message flow of inter-exchange messages follows this relationship i.e. forward messages are sent as " " and received as " " whereas backward messages are sent as " " and received as " ". This is consistent with the time sequence diagrams.

There are fourteen states in the SDL diagrams. These are shown in **Table 1** below.

State No.	State Names
0	Idle
1	Awaiting further call set up information
2	Circuit Selection
3	Setup in progress
4	Call present
5	Call delivered
6	Information transfer
7	Pause
8	Call modification request
9	Call modification in progress
10	Previous state request
11	Connection release (Forward)
12	Connection release (Backward)
13	Connection released
*	All states except 0, 11, 12 & 13

Table 1. States used in the SDL diagrams

Abbreviations

ACK	ACKnowledgement
ACM	Address Completed Message
ANS	ANSwer
CCITT	International Consultative Committee on Telephone and Telegraph
CCR	Continuity Check Request
CCSS	Common Channel Signalling System
CIC	Circuit Identification Code
CLI	Call Line Identity
CMC	Call Modification Complete
CMR	Call Modification Request
CSM	Call Supervisory Message
CUG	Closed User Group
DPC	Destination Point Code
DRS	Delayed Release Message
IAM	Initial Address Message
ISDN	Integrated Services Digital Network
IUP	Integrated Services Digital Network User Part
MTP	Message Transfer Part
OPC	Originating Point Code
RCM	Reject Call or Connect Modification
REL	RELease
RLC	ReLease Complete
RLSD	ReLeaSeD
SAM	Subsequent Address Message
SCCP	Signalling Connection Control Part
SDL	Specification and Description Language
SI	Service Indicator
SIO	Service Information Octet
SSF	Sub-Service Field
SLS	Signalling Link Selection
UP	User Part

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Leopard — A Computer Based System for Processing Telephone Service Difficulty Complaints

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OWEN J. BRISBANE.

Telecom has developed and largely implemented a major computer based system to support the processing of telephone service difficulty complaints and the repair function. This system, called LEOPARD, not only improves the efficiency of these functions but also ensures that customers are provided with a better standard of repair service. This article describes the functions of the system.

CAN IT CHANGE IT'S SPOTS?

Telecom's LEOPARD is not a yellow animal with black spots from Africa, but a computer system from Australia designed to eliminate 'spots' of poor performance in Telecom's telephone maintenance service.

LEOPARD (Local Engineering Operations Processing Analysing and Recording of Data) replaces the traditional paper records and manual record handling procedures in Service Assistance Centres (SACs) and Fault Despatch Centres (FDCs) with computer records and Visual Display Unit (VDU) transactions. The term Fault Despatch Centre (FDC) will be used here to describe the various centralised telephone maintenance centres in Telecom's operations in different states, alternatively known as Subscribers District Centres and Subscribers Equipment Groups. LEOPARD, the first major system in Telecom to provide staff at the workface with on-line access to the power of the computer, improves both the efficiency of their operations and the quality of the service provided to customers. This article describes in general terms the significant aspects of the LEOPARD system's operation.

The LEOPARD project is an immense system and one which impacts on many areas of Telecom's customer operations. It was designed and developed entirely within Telecom. The specification and design of the system, and the design and development of the software system being undertaken by Headquarters Engineering and Information Systems Departments respectively. The extensive commissioning work was performed mainly by the state Engineering Departments assisted by other state and headquarters personnel. Many people have contributed significantly to the above activities, and the success of the project is a reflection of the dedication and the teamwork displayed by those concerned.

The introduction of this system has been very successful. The excellent level of staff acceptance is believed to be attributable to a number of deliberate factors in the design. The first was the adherence to the philosophy that the system had to be designed from the workface upward i.e. it had firstly to give these staff access to the information and facilities required to do their work more efficiently and more confidently; and then to provide each successive level of management with the facilities to monitor and control their operations efficiently. The second major factor was the close attention paid to industrial relations aspects from the conceptual stages of the project onward. In conjunction with Industrial Relations Department views of staff and staff associations were sought and considered, and these people were kept informed of intentions and developments as the project progressed.

Considerable attention was also given to making the system easy to use and to improving the working environment. To these ends VDUs were specially selected and modified for ergonomic comfort and ease of use, and furniture and lighting specifically designed for the function were installed. See **Fig. 1** and **2**.

THE PRE-LEOPARD HANDLING OF CUSTOMER COMPLAINTS

The principal features of the pre-LEOPARD procedures for handling customer telephone service difficulties are:—

- Customer service difficulty complaints are received at the Service Assistance Centre (SAC) (service code 1100);
- SAC operators record the particulars of each complaint on a docket;
- The trouble report and technical assistance report dockets are passed to a teleprinter operator for sorting and transmission to the appropriate Fault Despatch Centre (FDC), or Network Performance Analysis Centre (NPAC) respectively. (The FDC staff do not see the technical assistance reports.)

Fig. 1. The Working Environment in a LEOPARD Fault Despatch Centre. Homebush FDC, New South Wales.

- At the FDC, the fault docket is associated with the customer's master card and passed to the test desk;
- The service is tested and appropriate details are entered on both the master card and the fault docket;
- If a faultman is required to attend, the fault docket and master card are passed to the plotter/programmer who assigns the fault to a repairman;
- The programmer passes these dockets with details entered to a despatcher who arranges for despatch to the nominated repairman;
- When the fault has been cleared, the repairman reports details back to the despatcher who enters them on the master card and fault docket. The fault docket is filed so that the various statistics on faults handled can be compiled manually, at a later time;
- A customer reporting to the SAC and needing to know the progress on a previously reported fault, is kept on the line while the operator or a supervisor rings the FDC, and until someone in the FDC can track down the fault docket and report back.

IAN RIDGE (left) worked as an engineer in private industry prior to joining Telecom's Research Laboratories in 1971. At the Research Laboratories he developed a high speed computer controlled data logger for radio propagation studies. Following a period in Engineering Computer Coordination he joined the LEOPARD project team in 1977. Initially responsible for developing the implementation practices and procedures used in the project, he has been Project Manager since 1981.

OWEN BRISBANE (right) commenced with the Post Master General's Department as a technician in training in 1959. After service with Metro Operations area in Victoria he was outposted to the HQ LEOPARD team to help develop the project implementation practices. He returned to Victoria to complete the implementation of the first FDC. From there he was promoted to his present position as STO3 with the HQ LEOPARD project team.

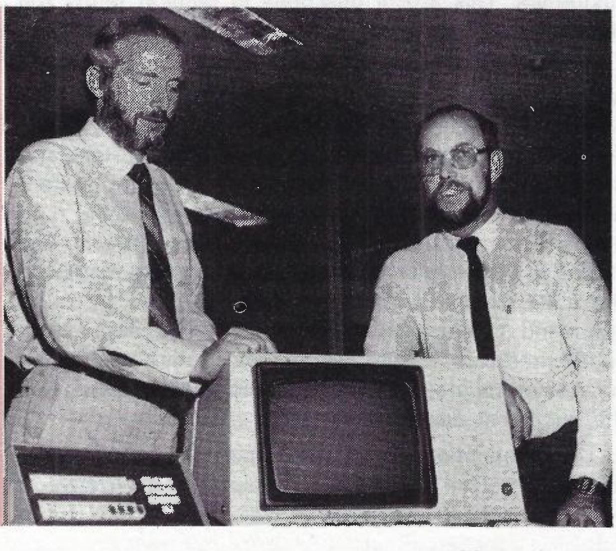

Fig. 2. The LEOPARD Environment at Hawthorn FDC, Victoria.

AN OVERVIEW OF LEOPARD

The key features of LEOPARD operation are summarised below. Refer also to **Fig. 3**:—

- LEOPARD is an on-line real time system in which the customer's master cards (service records) are replaced by the LEOPARD Service File records which can be accessed by staff in the FDC from VDU terminals;
- Customer reports are received at the SAC by an operator, who handles them in one of two ways. Initially the operators will not each have a VDU and will write a docket for each report, as for the manual system. This docket is passed to the teleprinter room where it is entered into a LEOPARD VDU. Enquiries on the progress of repairs are answered by referring these calls to an operator who has a VDU. Ultimately each operator will have a VDU and will enter reports and make enquiries directly, with the customer getting almost instant response to queries.
- Trouble report details are associated by the processor with the essential details of the service and this information is placed in a waiting test queue for the appropriate FDC. Technical assistance reports are directed to a printer at the NPAC. Manual sorting of trouble reports by FDC and separation from technical assistance reports is not required.
- The trouble report is retrieved by a tester at the FDC who tests the service, calling for other information as necessary, and records the result of test (ROT) via the VDU;
- If the attention of a faultman is required, the tester nominates the repair discipline and urgency, and the report is presented to the programmer who allocates it to an appropriate repairman;
- When the nominated repairman calls for a fault, the despatcher retrieves the report, via a VDU and passes on the necessary details;
- When the repair is completed, details provided by the repairman are entered into the computer record by the despatcher for subsequent updating of the customer's fault history record and statistics collection;
- LEOPARD provides staff with ready access to a wide range of information and facilities, including those which assist the officer-in-charge (OIC) and the supervisors to monitor the status of all work passing through the FDC.

THE LEOPARD COMPUTER ENVIRONMENT

LOEPARD uses the two computer centres of Telecom Australia's computer network (TACONET); one in Melbourne serving Victoria, South Australia, Western Australia and ultimately Tasmania, and the other in Sydney serving New South Wales and Queensland.

LEOPARD represents a significant load on this network. The program of metropolitan installations to be completed by July 1984 requires processing resources equivalent to that of 2 Honeywell DPS8 processors; disk storage capacity equivalent to 40 disk drives of 157 megabytes capacity; and front-end capacity and ports for about 800 VDUs on about 180 high speed data lines. It is a transaction driven system using about 200,000

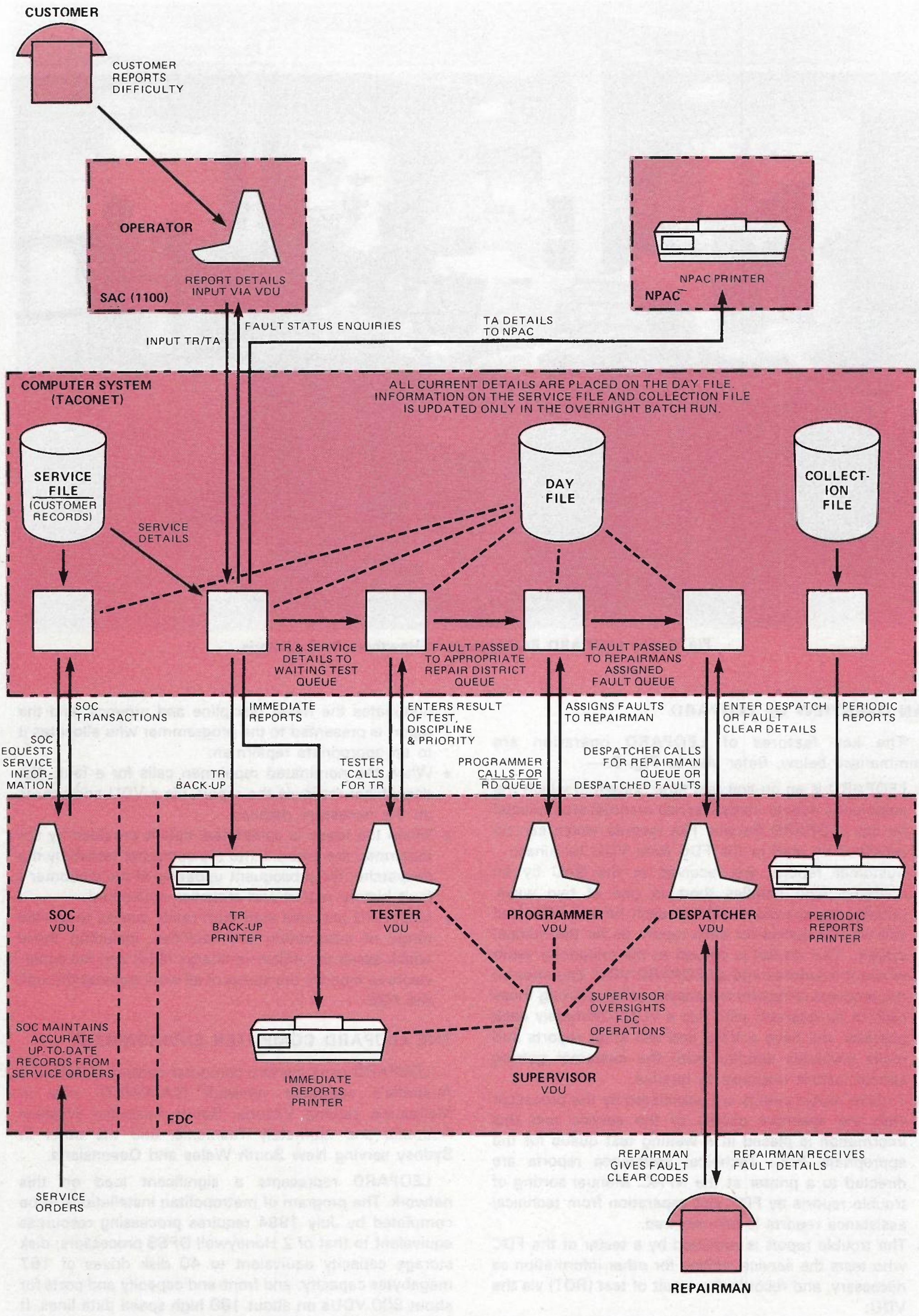

Fig. 3. LEOPARD — On-Line Information Flow in the Processing of Customer Reports.

transactions per FDC in each four week period, or over 6 million transactions per four week period in total.

Particular attention was paid in the design of the system software to security, flexibility of future processing and good system recovery characteristics.

To suit the processing used, and as shown in Fig. 3, the LEOPARD system is based around three major database files:—

- The Service File — this file is updated only in batch mode (overnight) and contains the details of each service, including the service number, customer name and address, equipment type and installation details, together with service order history and a history of complaints lodged and faults repaired on that service.
- The Day File — this file contains the details of all current actions against each service i.e. service order activity and customer complaints. In the overnight batch run, service order transactions and completed repair activity details are used to update the Service File and Collection File records.
- The Collection File — this file is used to hold the progressive accumulation of operational statistics from which the various periodic reports are produced.

INFORMATION PROCESSING WITH LEOPARD

The LEOPARD system was designed around the centralised FDC type of operation where each person generally performs a specific function. Each VDU is identified to the processor as having a particular function which then restricts the specific transactions which can be entered from that VDU.

The flow of information as work progresses through the SAC and FDC is illustrated in Fig. 3 and described in the following sections:—

Service Assistance Centre (SAC)

When the SAC receives a customer's service difficulty report, the operator determines whether it is for:—

- Non-Technical Assistance (NTA), e.g. enquiry regarding meaning of a service tone.
- Technical Assistance (TA), e.g. network related conditions such as congestion or no progress.
- Trouble Report (TR), i.e. a report relating to a condition on the customer's service requiring the attention of testing staff for testing and possibly repair.

For both Technical Assistance (TA) reports and Trouble Reports (TR), the SAC operator enters the appropriate command code, service number and report details into the processor via a VDU.

When a trouble report is entered, the processor checks the Service File to determine whether the number is on file. If the number is not on file the processor does not accept the report, referring it back to the operator with an appropriate error message. If the number is on file, the processor extracts relevant information from the Service File and associates this with the report details, and this information is placed in a waiting test queue for the appropriate FDC. The operator then receives an acknowledgement that the report has been accepted.

If the report is a Technical Assistance report, the processor causes a printout to occur on a printer at the Network Performance Analysis Centre (NPAC) and, for each of the originating or terminating numbers involved which is held on its files, records the TA details against their fault histories.

The LEOPARD system allows the SAC operators to enquire about the progress of any fault clearance in the system via a VDU transaction. When each operator is provided with a VDU to access LEOPARD, this same VDU can be used to interactively access SULTAN (Subscribers Line Test Access Network) testing facilities.

Screening of Trouble Reports by Computer

To reduce unnecessary work at the FDC the processor does some initial processing on the trouble reports (TRs) before they are passed to the FDC:—

- Busy out of Order (BYO) and Did not Answer Faulty (DAF) reports, the processor will hold back the initial report from the waiting test queue. If a subsequent report is received before the close of business the following day, the report will be passed on to the test queue; otherwise the processor clears the initial report from the system, but records this fact on the fault history.
- Coins no Service (CNS) reports on public telephones are examined by the processor. Only when a predetermined number has been received in a preset period on any one service is the fault directed to a repairman. Otherwise the reports are recorded against the service's fault history but no action is taken. In neither case is action by the tester required.
- For second and subsequent reports on a service already the subject of a TR, the processor records this so that the FDC staff can upgrade the repair priority. Excessive subsequent reports cause an immediate printout for the supervisor's attention, **Table 1**.
- All other types of TRs are directed to the waiting test queue of the FDC responsible for that service.

Queues for Trouble Reports

There are two types of test queues which hold new TRs ready for the tester to action in turn. The two test queues are:—

- — The Waiting Test Queue — TRs on all except Public Coin Telephones appear in this queue.
- — The Public Coin Telephone (PT) Queue — ;This is a special queue for PTs which, recognising that they have a quite different reporting pattern to other services and also that they are often handled by different staff, allows them to be treated separately.

The TRs in these queues are listed in time of arrival order within a priority based on the type of service. The tester, when he calls for the next TR, will therefore be presented with the oldest, most urgent fault in the queue. For the Waiting Test Queue these priorities are Urgent, Prompt Business, Minor Business, Prompt Domestic, Minor Domestic, while for the PT Queue they are Prompt PT and Minor PT.

For situations in which the tester can not immediately action reports, two further queues are provided to hold these TRs in abeyance.

- — The Park Queue: for faults that are incipient, and need to be tested again, or for faults on which the tester may wish to speak to a customer when available. These TRs may be requested from the queue at any time. The TRs remaining in this queue overnight are automatically returned to the waiting test queue next morning, to ensure that they are not overlooked.

— The Volume Hold Queues: for TRs which are known to have a specific cause preventing their immediate clearance, e.g. cable faults or exchange group equipment faults. The tester can direct these TRs to the appropriate volume hold queue so that they may be cleared once the fault has been rectified.

Volume hold queues are created by the supervisor as the need arises. Parameters are defined for each queue so that only services meeting these parameters can be accepted.

FDC Testing Officer

The tester calls for a TR from the Waiting Test Queue or the Public Telephone Queue by input of an appropriate VDU command. The TR with the relevant service details will appear as a form on the screen, see **Fig. 4**. LEOPARD greatly improves the facilities and information available to the tester, recognising that the quality of testing has a significant impact on the quality of the repair service provided by the FDC. The tester can call up a variety of information to assist in the fault diagnosis, such as a full fault history (including all technical assistance report details), and lists of 'associated lines' or extensions of that service. Should it be necessary, a report can be easily transferred to another service by entering the new service number and the appropriate command code.

The line is tested if necessary, using the available test facilities (test desk or SULTAN). Any further action depends on the Result of Test (ROT). If the service is Right When Tested (RWT), the tester enters appropriate codes on the form. The TR is cleared from the system and the service's fault history, held by the processor, will be updated accordingly.

If the service is found faulty, the tester enters the result of test code, an assignmment priority to indicate the degree of urgency to the programmer, and allocates the fault to one of the following Repair Disciplines using the code shown:—

- Technicians, or substation (T);
- PABX (P);
- Lines (L);
- Exchange (E); or
- Other FDC (Z).

The processor identifies and directs the TR to the service's preassigned repair district for that discipline, for further action by the programmer and/or despatcher. The tester can also enter appointments for repairman visits which are then monitored by the programmer and the system.

The tester may not be able to test the service immediately in which case he may direct it to the park queue or a volume hold queue, dependent on the particular circumstances, as described earlier.

Programmer

The programmer's (or plotter's) task is to assign work to individual repairmen and to ensure that the work is balanced across the available staff.

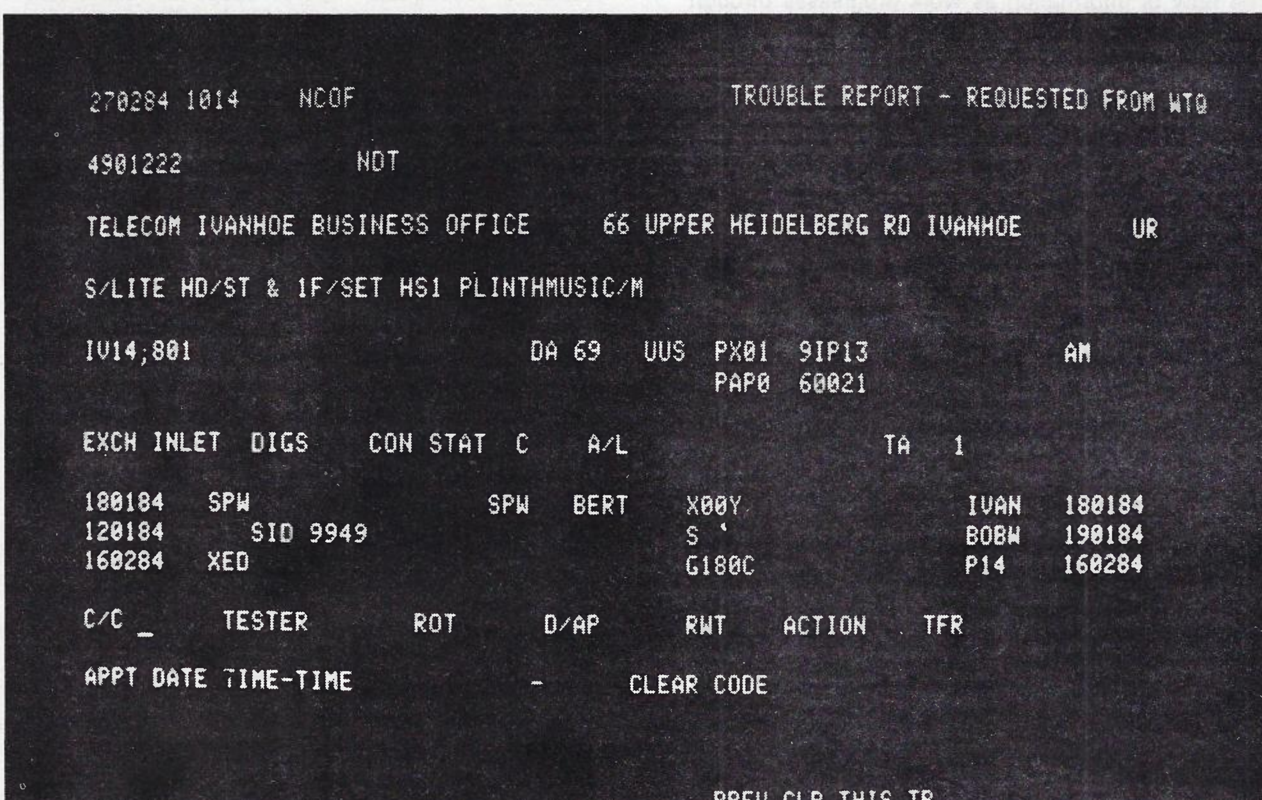
270284 1014 NCOF TROUBLE REPORT - REQUESTED FROM WTQ
4901222 NDT
TELECOM IVANHOE BUSINESS OFFICE 66 UPPER HEIDELBERG RD IVANHOE UR
S/LITE HD/ST & 1F/SET HS1 PLINTHMUSIC/M
IV14;801 DA 69 UUS PX01 9IP13 AM
PAP0 60021
EXCH INLET DIGS CON STAT C A/L TA 1
180184 SPW SPW BERT X00Y IVAN 180184
120184 SID 9949 S ' BOBW 190184
160284 XED G180C P14 160284
C/C _ TESTER ROT D/AP RWT ACTION TFR
APPT DATE TIME-TIME - CLEAR CODE
PREV CLR THIS TR
REMOTE FORMS

Fig. 4. Trouble Report and Service Details as Presented to the Tester.

As indicated previously, the tester allocates each fault to the appropriate repair discipline (technician, lines, PABX, exchange or other FDC), and allocates an assignment priority which determines the fault's position in the repair district (RD) queue presented to the programmer.

The repair district (RD) is a geographical area unit for each discipline, defined by a group of lines distribution areas (DAs) selected such that for each discipline it produces 20-30 faults per day. The RDs for each discipline will therefore be of different geographical size — an FDC may have say eight technician RDs but only four for Lines or PABX. Any specific service will thus have allocated an RD for each of the four repair disciplines, which are determined by the lines DA in which it occurs and recorded on the service record. The concept of the repair district assists FDCs in the control of their repairmen, and gives the programmer faults already arranged geographically and by discipline. It is possible to have multiple programmers each working on separate disciplines, and in fact lines and PABX are often handled separately.

The programmer nominates on the VDU the RD to be reviewed. The programmer reviews that RD and assigns each fault to a repairman, taking into account knowledge of the repairmen working in that RD, the faults they already have in hand, and their skills appropriate to each fault or equipment type. The programmer may accept the assignment priority allocated by the tester, or alternatively allocate a different despatch priority which then determines the position of the fault in the repairman's queue. The processor places each fault in the repairman queue, in priority order, ready for the despatcher to pass them to the repairmen. Faults allocated to an EXCHANGE or OTHER FDC discipline do not require any programmer action, going directly to a "repairman's queue" and to the despatcher.

Despatcher

Each repairman contacts the despatcher to obtain details of faults assigned to him. The despatcher will request the assigned faults for that repairman. From the VDU display the details are read to the repairman, and each fault is marked as despatched. The processor transfers these faults to that repairman's despatched faults queue.

For EXCHANGE and OTHER FDC faults the despatcher must review the assigned faults from time to time and initiate contact with these areas to despatch these faults. At the time these faults are marked as despatched, an exchange sequence number can be recorded if required.

When a repairman (including EXCHANGE or OTHER FDC) has cleared the faults in hand, he will ring the despatcher to clear them off. The despatcher updates the despatched faults display with details of the fault clear codes. When the fault has been cleared, the processor removes the fault from all active queues (in the Day File). In the overnight batch run the fault clear details will be recorded on the fault history, and statistics on the fault added to the Collection File counts for statistical reporting.

If the fault clear code indicates the service is waiting parts, the processor will cause a waiting parts report to be printed so that the parts may be obtained. The fault can be cleared, following reassignment, once parts are available. If the repairman advises the despatcher that another discipline e.g. lines, is required to perform, or complete, the repair, the despatcher adds a change of discipline clear code. This causes the processor to pass the fault to the RD of the other discipline, for further assignment and despatch. The fault is cleared from the system once it has a final fault clear code.

It can be seen that with LEOPARD all decisions in the handling of faults are made by the FDC staff. The processor only provides a fast orderly transfer of information and ready access to information and facilities not available in a manual situation. To achieve this the staff must however, use correct input, test and clear codes.

Service Order Cell

Service Order Cell staff maintain the Customer Service Records for the FDC by creating, disconnecting, dismantling and amending service records according to the Service Orders and other advices received. Again, transactions are recorded on the day file for updating against the Service File in the overnight batch run. Statistics on the numbers of each type of service maintained are also generated.

Two of the major problems in a manual record system are:— being able to find any record when you want it, and ensuring that data in any record is consistent with that in any related record e.g. between the records of the various lines terminating on a switchboard, and between the records of extension and their switchboard lines. LEOPARD overcomes both of these by ensuring access to any service record is always available (every VDU in an FDC could be viewing the one service record at once, if they needed to), and secondly by applying rigorous editing and cross checking when any record is created or altered. This latter feature, together with the confidence staff gain in the accuracy of the records, ensures that the LEOPARD files grow in accuracy, and value, as time passes.

This rigorous editing and validation undergone by every record created also accounts for the considerable effort expended in converting an FDC to LEOPARD. Sufficient of the errors in the existing manual records have to be eliminated to allow this data to be loaded! The cost of this error correction and keying of the data on to diskettes prior to conversion of a centre is about a dollar per record, and while not easily proven in figures, the increased value of the records probably more than compensates for this; particularly since the on going operation ensures that the accuracy is maintained and improved.

Supervisor/O.I.C.

The LEOPARD system provides the supervisor with facilities for monitoring and controlling the day to day operations of the centre.

The following are examples of the supervisor's responsibilities and of the supervisor facilities available in LEOPARD:—

— Special Inspection (SI) Procedures

Special inspections (EM52s) are invoked for services having excessive faults. They are presented in the form of special inspection dockets (SIDs) printed each morning in the FDC.

Efficient special inspection procedures are critical to the elimination of fault prone equipment and ineffective repair practices. To a significant degree the success of LEOPARD depends on its success in improving these procedures. Considerable effort has been expended to ensure that the LEOPARD procedures are effective.

In LEOPARD, each time a trouble report is placed in a waiting test queue the processor checks the fault history for the service. If in the preceding 30 days two TRs have been cleared as faults, this report will be flagged as it is processed through the system as "SI possible". This alerts those staff handling it to be alert for possible causes. During the overnight batch run the processor examines the fault clear codes and, if the TR has been cleared as a fault, a Special Inspection Docket is submitted to the supervisor next morning. Certain faults are excluded from consideration in this processing e.g. BYO and DAF reports that do not reach the tester and minor faults such as switchboard lamps or cords. The SI docket gives the supervisor sufficient detail, including fault histories, to assist in the decision to initiate a special inspection visit or take other appropriate action.

— Public Telephone Fault and Coins-No-Service Parameters

Public (Coin) Telephones (PTs) are not subject to the SI procedures explained above because those parameters are not appropriate. Instead if the number of faults cleared within the month for any particular PT exceeds a preset number for the FDC, details of that PT are included in the PTs with Excessive Faults report. The supervisor can examine this report and other information available in LEOPARD to determine if corrective action is required.

The supervisor may change this parameter at any time (e.g. holiday periods when PTs are subject to a non-standard usage rate) to ensure that only those PTs with a non-typical fault pattern are highlighted for special attention. The overall performance of PTs can thus be gradually improved.

The Coins-No-Service (CNS) parameter for a PT is decided when the service record is created or amended. If necessary the supervisor can change the CNS value for all PTs for a particular day by adding to the number of reports required to initiate a visit. The CNS parameter is changed back to the preset value during the overnight batch run.

— Work Flow Monitoring and Control

LEOPARD provides the supervisor with various facilities to monitor the workload in the FDC. The total faults display (technician or substation) **Fig. 5**, shows for each repair district the total faults within each assignment priority, as well as the total faults waiting assignment (WA). This display highlights any repair

TOTAL SUBSTATION FAULTS

—	TA	TB	TC	TD	TE	TF	TG	TH	TI	TJ	TK	TL	TM	TN	TO	TP	TQ	TR
NON CTP																		
A1	1			1	1	1		1									1	
B1																		
A2																		
B2																		
A3														1				
B3	1		1	1			2	1			1							
A4		1			2			2			3				1	1	2	2
B4	5	3	3	2	2	1	5	5	2	2	5	1	4	1	7	3	1	1
TOTAL	7	4	4	4	5	2	7	9	2	2	9	1	4	2	8	4	4	3
WA	3		1	1	3		1	5	1	2	3	1			2	1	2	
CTP																		
TOTAL																		1
WA																		
RD																		
TOTAL	7	4	4	4	5	2	7	9	2	2	9	1	4	2	8	4	4	4

CTP GRAND TOTAL 1 B GRAND TOTAL 60 RD GRAND TOTAL 82
REMOTE

Fig. 5. Total Faults Display for Substation (Technician) Faults. Repair Districts TA to TR are Shown With the Fault Numbers in the Various Priority Categories; A = Domestic or All Hours Access, B = Business Hours Access. Waiting Assignment (WA) and Coin Telephone Public (CTP) Totals are Shown Separately.

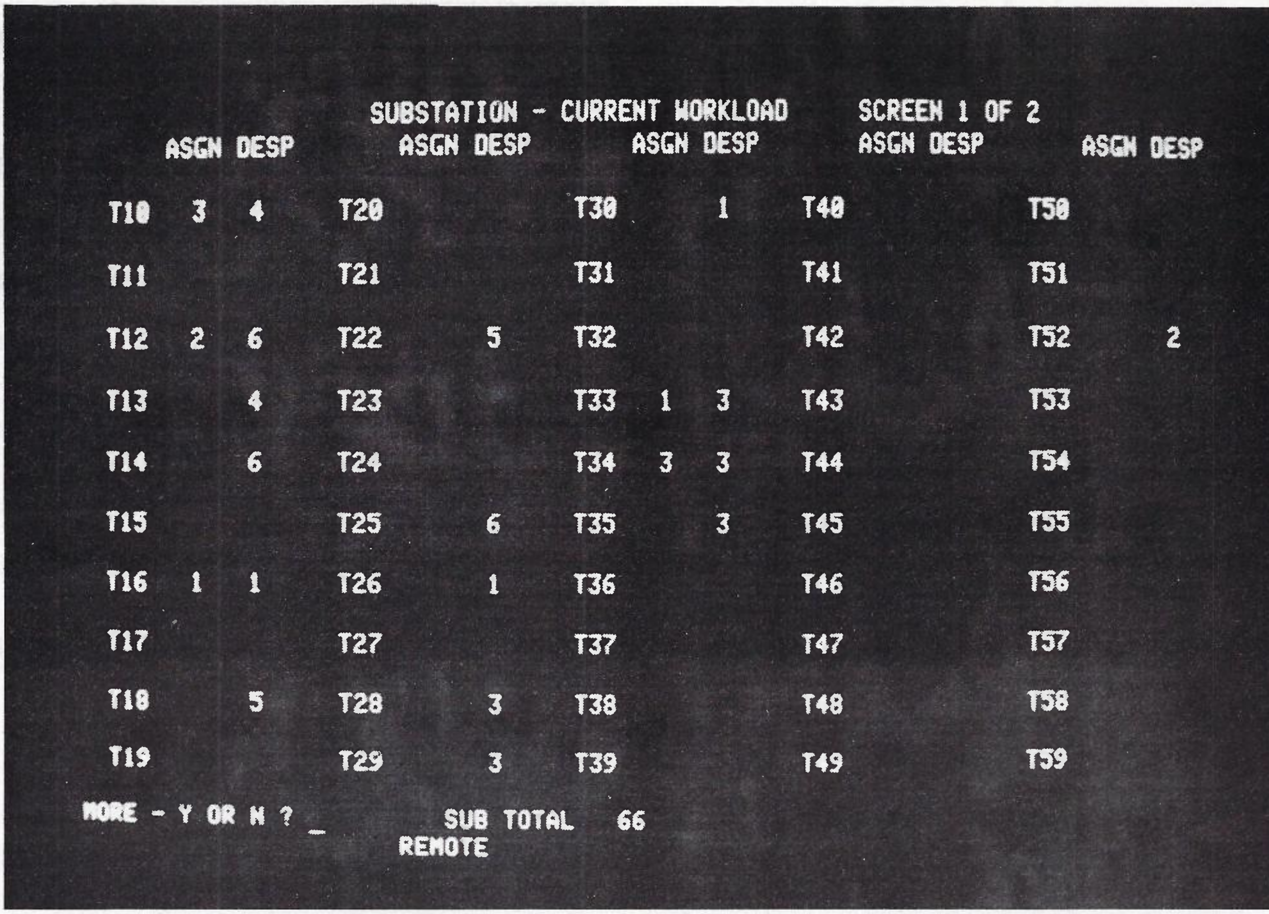

Fig. 6. Current Substation (Technician) Workload Display. Faults Despatched and Those Assigned But Not Yet Despatched are Shown Separately for Each Technician T10 to T59.

district (RD) requiring particular attention. The workload of each repairman in a discipline is also readily available from the Current Workload display for that discipline, **Fig. 6**.

An overhead display shows, in enlarged numbers, the four counts of the number of reports in the two waiting test queues, park queue and volume hold queues. The use of these displays enables the supervisor to monitor the workload in the FDC and to ensure that the workload is balanced across the available testers and repairmen. Other displays are available to provide finer detail when required.

The supervisor's role in the control of work passing through the testing queues is important to the efficient operation of an FDC. The following descriptions show how LEOPARD makes it simple for the supervisor to examine the work in these queues, as part of this function.

Test Queues

The supervisor can review the waiting test and PT queues to examine each report waiting test and can, if required, take action on any TR such as passing it to a repair district for programmer action, or transferring it to a volume hold or park queue.

Volume Hold Queues

Volume Hold Queues are for faults that may affect a number of services and generally have a known cause such as a cable or exchange equipment faults. They are created by the supervisor when the need arises. There are three types of Volume Hold Queues with parameters defined which control the services which will be accepted into them. viz:—

For Cable Faults — specified by the exchange and Lines DAs affected.

For Exchange Faults — specified by the exchange and number range affected.

For Miscellaneous Faults — specified by the exchange area affected.

The supervisor can create up to 20 Volume Hold Queues which can be any mixture of the above types. When the particular fault is rectified, and all the TRs have been cleared from the queue, the supervisor can dismantle that Volume Hold queue.

Park Queue

This is for faults that the tester wishes to test at some later time. While these TRs will be automatically returned to the Waiting Test queue if left overnight, the supervisor can also review this queue at any time and action the TRs or return them to the Waiting Test queue.

Reports for Operations and Management

The LEOPARD system provides various immediate, daily and periodic printed reports that assist in the running of the FDC and enable the supervisor and OIC to monitor the operation of the SAC and FDC, as well as providing management summaries of performance and statistics. **Tables 1** and **2** list all but a few of these reports.

REPORTS INITIATED BY ENTERING A TROUBLE REPORT

- **TR on a Service Which is Waiting Parts.**
- **TR on a Service Which has Special Inspection Current.**
- Subsequent TR on a Service. Produced for every third TR entered while fault current.
- **TR on Which the Service Number is Unknown or Not on File.** Supervisor arranges for processing as required.
- **TR Backup.** For each TR entering a test queue, includes abbreviated details of the service.

REPORTS INITIATED BY ENTERING PARTICULAR CLEAR CODES

- **Attention Outside Authority.** Used to follow up with e.g. Workshops, Harbour Trust.
- **Rewire Required.** Service restored but recabling required, docket goes to rewire team.

REPORT INITIATED BY ENTERING A TA REPORT

- **TA Report.** Printed at the NPAC.

Table 1. LEOPARD — Immediate Reports.

Telecom's standard monthly reporting period is the 28 day period coinciding with the Network Performance Analysis Centre (NPAC) reporting period. The various periodic reports are available on the morning following completion of the period.

LEOPARD was implemented as a standard system for all FDCs. The system extracts its counts from the every-day operations performed by the staff and, by using standard calculations, ensures that the statistics for every FDC are derived in exactly the same way. The variation in counts caused by different interpretations of the calculation methods have therefore largely been eliminated. This adds tremendously to the value of the statistics in that true comparisons can be made.

Operational Experience with LEOPARD

LEOPARD has been operational at Footscray FDC and Russell SAC in Victoria since April 1979. Bankstown FDC and Ashfield SAC followed in April 1980. The program to convert the rest of the mainland metropolitan areas and Canberra got underway in 1981, and this program should be completed during July 1984. The provision of a VDU to each SAC operator will take a little longer, as this facility needs to be coordinated with other projects such as SULTAN and the National Automatic Call Distribution (NACD) Queueing system.

The system has lived up to expectations in terms of providing an extremely efficient system for handling customer trouble reports. Real benefits are flowing from the ready identification of customers receiving substandard service, and the follow up monitoring on the special inspections. Equally importantly, the system has been readily accepted by staff as it enables them to do

DAILY REPORTS — For Operational and Monitoring Purposes.

- Special Inspection Dockets.
- Completed Repairs — Summary by Repairman.
- Fault Report Duration. Percentage of reports cleared against target time periods.
- Ineffective Actions. Counts of change of discipline, found OK and not-in-attendance clears.
- Unworkable Faults not Cleared within 24 Hours of Report.
- Current Workload. In hand yesterday, processed yesterday, and resulting in-hand today.
- Waiting Parts. Storeman's advice of parts required.
- SAC Statistics. For SAC supervisors, shows the work their SAC generated and its disposition.

WEEKLY REPORTS — Part of Special Inspection Follow Up Procedures

- Resubmitted Special Inspection Dockets. Produced for SIDs on which no action has been taken.

MONTHLY REPORTS — For Management and Supervisory Purposes

- PTs With Excessive Faults.
- Faulty Within One Month of Connection.
- Special Inspections Summary.
- Services Disconnected and Still In-Place after 12 weeks.
- Faults Affecting Metering. Lists service numbers and relevant clear codes — in case of account queries.
- Services on Which Connection Completion Advice is Overdue.
- Telephone Customer Equipment Counts. Station and service statistics within terminal equipment types.
- Telephone Customers Fault Analysis. Complete summary by terminal equipment, time periods, disciplines etc.
- Special Services Equipment Counts.
- Telephone Lines and Stations Counts Within Each Exchange.

Table 2. LEOPARD — Representative Periodic Reports.

their job more efficiently and confidently, and it provides a much better work environment.

A very important benefit of LEOPARD is obtained through providing the SAC operators with on line access to progress on fault clearance. LEOPARD not only enables a better standard of repair service to be provided, but ensures through this facility that customers are given a better perception of the level of service being provided.

Adaptation of LEOPARD to Telecom's Changing Environment

The time since LEOPARD development commenced has been one of rapid change for Telecom Australia. New generations of terminal and PABX equipment have been introduced; major computer projects in related areas have been undertaken; major reorganisational arrangements have been introduced; and Telecom has taken a much more commercially oriented profile. All of these activities impact on the maintenance area and the LEOPARD system, which has had to adapt to the changes. The adaptations required, often involving major redevelopment, have been introduced successfully.

While the number and magnitude of these developments seems to be increasing as time goes on, it is expected that these changes will continue to be catered for successfully.

Future Extensions

The LEOPARD system has proven so successful that there are requirements to extend the coverage of the system. The addition of Melbourne's three outer metro districts is already underway, and consideration is being given to the addition of Hobart and larger country centres.

TELECOMMUNICATION JOURNAL OF AUSTRALIA

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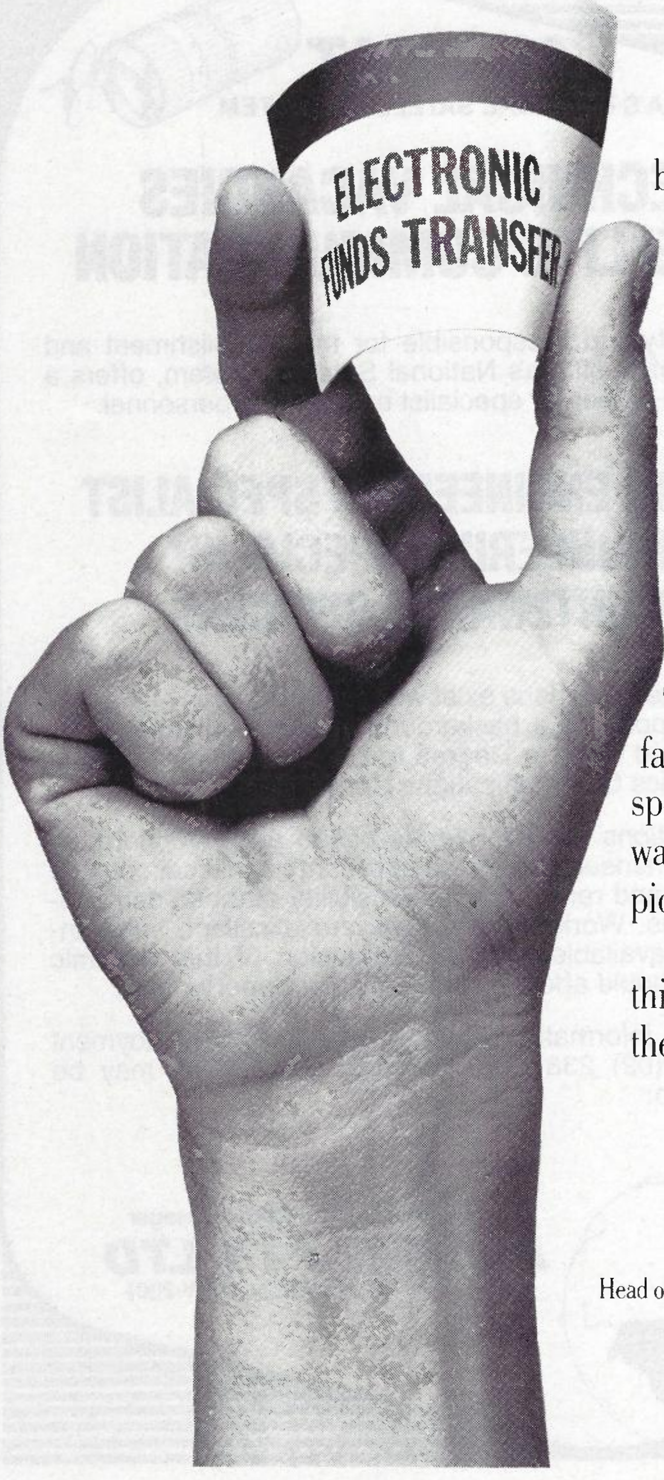

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An Analysis of Press-Fit Technology

Ram P. Goel AMP Incorporated Harrisburg, Pennsylvania

Press-Fit Technology is finding more and more applications in the telecommunications industry, particularly in areas where very high pin counts must be inserted into printed circuit boards, but where the disadvantages of the use of solder baths must be avoided. This article provides an analysis of press-fit pin technology.

An analysis of press-fit pin technology has been presented. Limitations of the rigid pin technology have been discussed. It has been shown that the rigid pin is inherently not amenable to press-fit pin technology.

The two commonly available compliant pin types, namely, the crescent and the split-beam types have been analyzed. It has been shown that the shape of a crescent type is only an illusion of making a contact over the entire length and circumference of the pin. The deformed shape is much different from the undeformed shape. On the other hand, split-beam-type pin technology is based upon setting up lower stress in a PC board and the undeformed shape of the pin gives a good measure of the contact area that will be obtained upon inserting the pin in a PTH.

INTRODUCTION

Various methods of interconnecting electrical components have been developed over the last few decades. Initially, soldering was perhaps the most widely used method in making a reliable and long lasting connection system. With the advent of solderless wrap technology, and the significant economic advantages (without any detriment to the reliability and life of the connection) that it brought about, pressure connections have been gaining wider acceptance in many areas of interconnection systems. For example, quick connects of split beam type for terminating electrical conductors, press-fit pins in printed-circuit boards, etc. are now finding their way into almost all new equipment designs in the telephone and the computer industries.

A pressure connection is based on the principle of providing an adequate metal-to-metal contact area by pressing together the two connecting components initially and continuously during the expected life of the connection. The elastic energy, necessary to maintain the pressure at the interface during the life of the connection, is stored in one or both of its elements.

Ease in manufacturing, assembly, field repairs, and changes, etc. make pressure connection technology highly effective. Furthermore, absence of problems associated with soldering, namely, contamination, localized heating, solder splashes, wire clippings, etc. help realize bigger economies and better reliability by the use of such a technology. In the following, we shall present an analysis of the press-fit pin connection technology and discuss the advantages and disadvantages of each type of pin that are commonly used in the industry.

There are two characteristically distinct pin technologies and three distinct pin geometries that are widely available in the market place. The different technologies can be categorized as rigid (solid) and compliant pin technologies while the various geometries can be labeled as solid, crescent, and split-beam type pins (Figure 1). First, an analysis of a rigid pin connection will be presented. Its disadvantages over the now available compliant pin technology will be discussed. It will be followed by an analysis of the two compliant pin technologies along with a relative comparison of the basic concepts of each.

RIGID PIN TECHNOLOGY

As described above, a press-fit pin connection is a pressure connection system. The connection is made by inserting a pin in a plated-thru-hole (PTH) such that the diagonal of the pin is greater than the diameter of the PTH. No soldering should be required to obtain a mechanically and electrically stable connection.

A solid pin is usually of rectangular shape while the hole is a circular one. As the name implies, solid pin does not deform during insertion. Since the hole diameter is smaller than the diagonal of the pin, the hole must expand to accommodate the pin. Thus, the entire elastic strain energy of the connection is stored in the board. The quality of the connection will primarily depend upon the amount of strain energy stored in the board. Following simple analysis will yield the information on the stored energy in the connection system.

Consider the case of a thin plate with a central hole of initial radius, a, and subjected to a uniform radial pressure, p, at the inside of the hole. In general, there are several pins mounted on a single board and the stress distribution in the plate will be complex. However, for simplicity, we will neglect the effect of adjoining pins on the stress distribution of a connection. This simplifying assumption will not affect our conclusions in any way.

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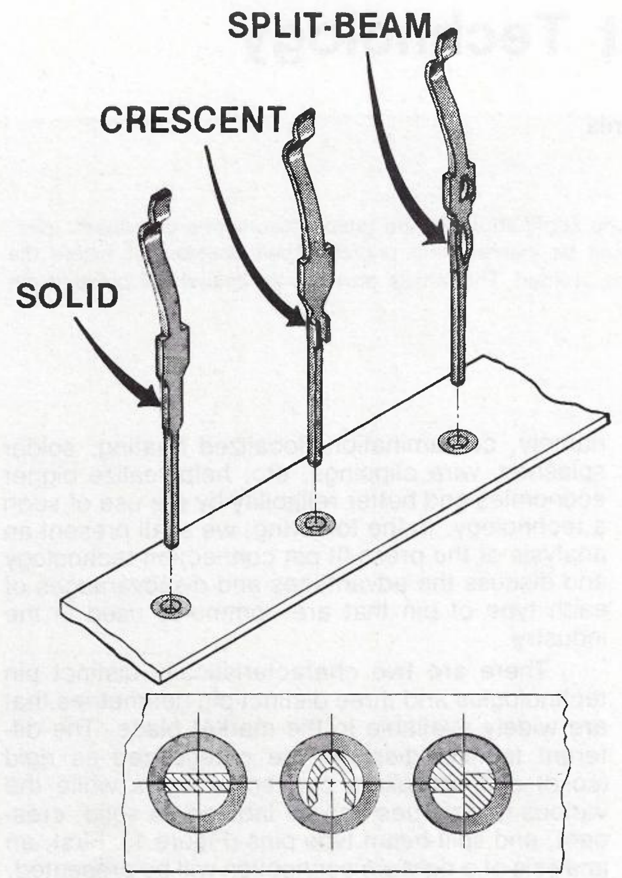


Figure 1

The elastic radial deformation and pressure relationship at any point in the plate can be easily obtained by applying elementary principles of the theory of elasticity especially if we assume the case of plane stress and small strains. Then at any point in the plate we have,

$$p = \frac{2G}{a^2} ur \qquad (1)$$

where u is the elastic deformation in the radial direction of a point at a radius r and G denotes the shear modulus of the material of the plate. The above relationship can be used to develop retention force information for the case of a press-fit pin connection. Retention force is defined as the amount of axial force required to push the pin out of the hole. If P denotes the retention force, it can be given as,

$$P = \mu\,(2\pi a)\,\frac{2G}{a^2}\,u_0 a = 4\pi\mu G\,u_0 \qquad (2)$$

where μ represents the coefficient of friction between the pin and hole surfaces and u_0 is the radial displacement at the inner surface of the hole. The above results are applied to estimate the retention force of the solid pin as follows.

Example

Consider the case of a 0.100 in. thick PC board with a hole range of 0.0345 in. to 0.0415 in. and press-fitted with a rigid pin of a diagonal of 0.046 in.[1] Since the pin is assumed to be rigid, the range of radial displacement at the inner surface of the hole for this case will be $u_0 = 0.0045$ in. to 0.0115 in. From Equation (2), the retention force per mil (0.001 in.) interference for the PC board under consideration (0.100 in. thickness) will be 75.4 lbs., assuming a coefficient of friction = 0.3 and the shear modulus of the PC board material = 2×10^5 psi. However, the total interference is 4.5 to 11.5 mils. Therefore, if the deformations are elastic, one would expect the retention forces to vary from 339 lbs. to 867 lbs.

The above values are much higher than are reported in the literature on solid pins.[1] Obviously, it is because much of the deformation is plastic and only a small fraction is elastic. Therefore, much of the insertion force is required to permanently deform the board and does not contribute to the stored energy.

If the deformation is large, or if the board is very thin, it may even damage the board. In the case of a rectangular pin, there is usually a localized deformation of the hole, i.e., cutting of the hole occurs and only a small interference, if any results. In many cases, if there is no interference, it could result in a loose pin.

In summary, one can draw the following conclusions for rigid pin connections.

1. Insertion forces are very high. Much of the forces are needed to deform the board plastically and possibly causing a damage to the otherwise expensive board.
2. Damage to pins may occur due to buckling.
3. To keep the insertion forces lower, only smaller interferences are desirable. It would imply a tighter tolerance on the plating thicknesses which in turn would imply an expensive plating process.
4. Retention forces will depend upon the amount of effective interference. If the cutting of the board is excessive, it may result in low retention forces and vice versa.
5. Because of the large variability in the retention forces, repairability becomes difficult and expensive.
6. For high reliability applications, these connections need to be soldered. It would probably represent the worst case because it combines the disadvantages of soldering and press-fitting.
7. Above all, press-fit pin connection technology is not amenable to rigid pins. As is clear from the above analysis, a PC board is nearly rigid in the plane of the board and the pin is rigid as well. Then it is obvious that two rigid components can not store elastic energy and thus a press-fit pin connection can not result.

COMPLIANT PIN TECHNOLOGY

Because of the aforesaid limitations of the rigid pin technology, a need for a new technology that would overcome, at least partially, these limitations arose. A new objective was set. It was comprised of designing a pin with the following characteristics:

- Lower insertion forces such that mass insertion is feasible; smaller permanent set, if any, occurs to the holes; lower local stresses are set up and thinner PC boards can be considered.
- Elastic strain energy is largely stored in the pin.
- If there exists any possibility of damage during insertion, it should only occur to the pin that is relatively inexpensive and not to the PC board.
- A pin should be able to be used over a wide range of hole sizes, thus eliminating the need for very expensive plating processes.
- There should not be any need for soldering the pins for high reliability applications.
- Repairing of the connections should be easy and inexpensive.

A response to the above set of objectives came from the industry in terms of dirrerent types of compliant pins. Two basic designs, namely, the crescent type and the split-beam type emerged.

In the following, an analysis of each type will be presented along with a relative comparison of the two designs.

CRESCENT-TYPE PIN TECHNOLOGY

As stated earlier, a press-fit pin connection is made by pressing a pin into a PTH. Since an objective is to accommodate a wide range of hole sizes (e.g., 0.036 in. to 0.044 in.) by a single pin, none of the widely available types of compliant pins have that wide elastic range. This wide range in hole sizes is accommodated by allowing a significant plastic yielding of the compliant section of the pin. Since the plastic deformation may significantly change the original shape of the compliant section, the quality of the connection, therefore, can not be judged from the undeformed shape of the compliant section.

Crescent Shape

It is easy to postulate that the crescent shape of the compliant part of the pin was primarily dictated by the hole shape. Since the PTH is a circular one, implicitly one would tend to think that the most suitable object to fit into that hole should resemble a circle. Furthermore, it implies that the pin should contact along the entire circumference of the hole.

Compliant Length

The length of the compliant part of the crescent-type pin is determined by the thickness of the board. The designer intends to provide sufficient length that would make a pressure connection over almost the entire length of the PTH.

Analysis

In the following, it will be shown that a crescent-type pin can neither contact along the entire circumference nor along the entire length of the pin. Instead, the contact is made over relatively small areas along the circumference and the length of the compliant part.

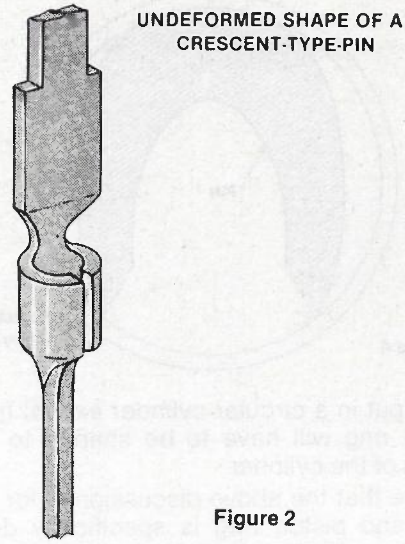


Figure 2

The compliant section of a crescent-type pin is a long C-shape of varying (or constant) thickness. Figures 2 and 3 show schematically these two important features of such a pin. The large length feature of the compliant section is intended to make contact along most of the PTH depth while the C-shape characteristic is supposed to provide a contact area along the entire circumference of the PTH.

As stated earlier, when a crescent-type pin is inserted in a PTH, the compliant section is deformed plastically. The initial hole and pin shapes are different and the pin does not deform uniformly. Therefore, the contact area between the pin and the PTH is not a continuous one. Figure 4 shows a schematic of the C-shape. Much of the pin deformation, in the plane of Figure 4, is localized to the center part of C-shape. Therefore, C-shape acts as a system of two symmetric cantilever beams loaded at their tips.

Alternatively, one can view the case of a crescent-type pin in a PTH analogous to that of a piston ring. Suppose the piston ring of uniform rectangular cross-section is cut in the form of a perfect circle. In order for that ring to fit along the entire circumference of a circular cylinder, it would require that the bending moment should have the same constant value at its free ends. And we know the bending moment vanishes at the tips, the ring would, therefore, not fit the cylinder. See Presscott for details.[2] Similar is the case of an eccentric piston ring. However, it is possible to design a ring of variable thickness that will conform to a circle

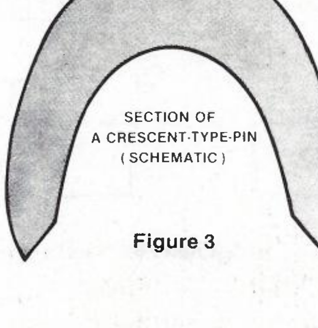


Figure 3

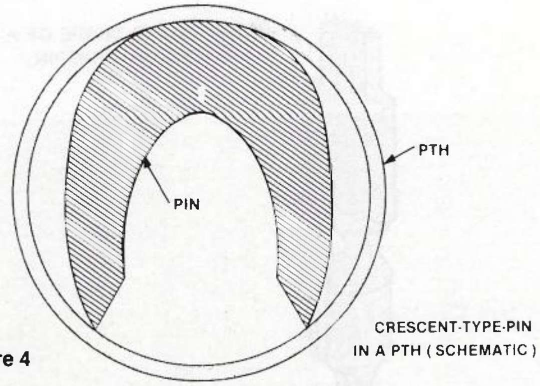


Figure 4

when put in a circular cylinder except that the tips of the ring will have to be shaped to match the radius of the cylinder.

Note that the above discussion is for the elastic case and piston ring is specifically designed to match a cylinder of constant radius. For the case of a compliant pin, one of the objectives is to be able to use the same size pin over a wide range of hole sizes and the mode of deformation is elastic-plastic. Obviously the contact can not be along the entire circumference for the case of a crescent-type compliant pin. Thus, if the design objective was as postulated previously, namely, a crescent shape would be more suitable to go into a circular hole, can not be realized by the C-shape.

The insertion process is shown schematically in Figure 5. As the pin enters the hole, the compliant section is deformed plastically. The total deformation comprises a closing action of the C-shape and a bending action of the compliant length. These two modes of deformation are illustrated schematically in Figure 6. Because of the bending deformation and the force acting at the entry area of the hole, much of the deformed C-section that has entered the hole can not spring back enough to be able to make a pressure connection with the PTH. The contact area under pressure will thus only be confined to the upper region of the compliant part of the pin.

The force necessary to deform the pin will be borne by the entry region of the PTH. Since the contact area is confined to that region only, high stresses will then result in that area. In a study previously reported by Goel and Guancial, some signal layer/PTH barrel interfaces located near the entry area region were found to be ruptured by a commercially available crescent-type of compliant pins.[3]

In summary, the contact area in a press-fit pin connection with a C-shaped pin is localized to the center and tip parts of the C-section. Much of the compliant length is damaged during insertion and the pressure connection is confined to the entry region of the PTH. These conclusions were examined experimentally on a commercially available pin of this kind. Results are shown in Figures 7 and 8. Figure 7 shows that the pressure connection exists over only a small fraction of the total length of the compliant part, while Figure 8 illustrates that the pressure connection is not continuous over the circumference of the pin. Because the entry area

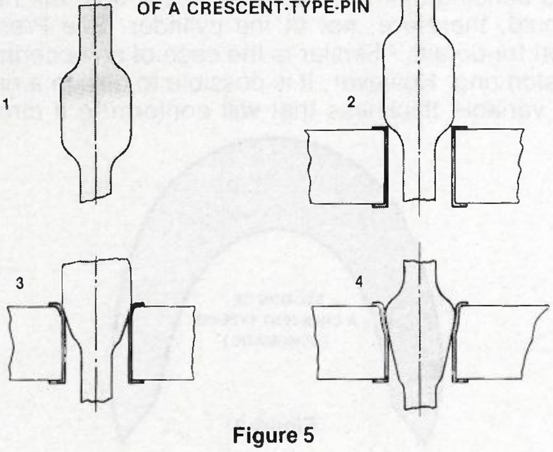


Figure 5

DEFORMATION MODES
OF A CRESCENT-TYPE-PIN

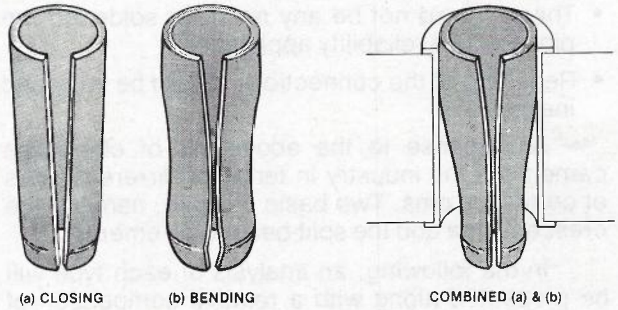


Figure 6

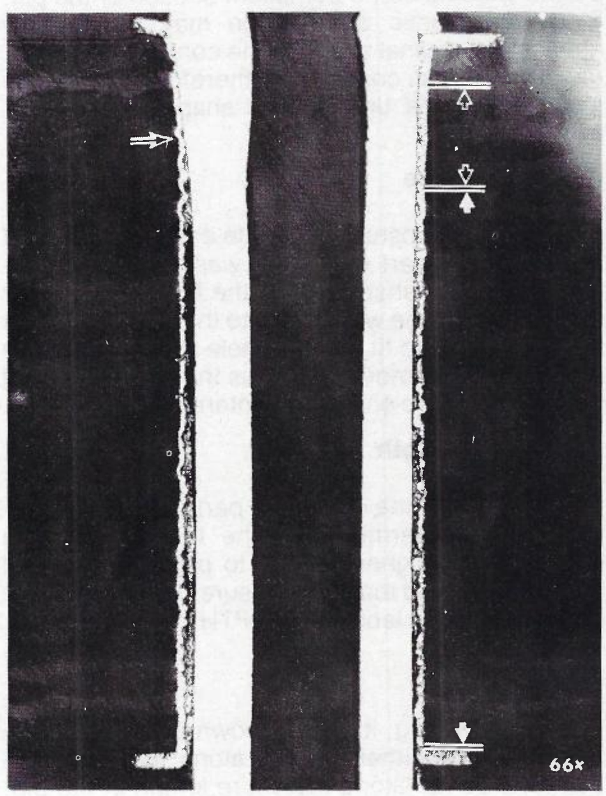
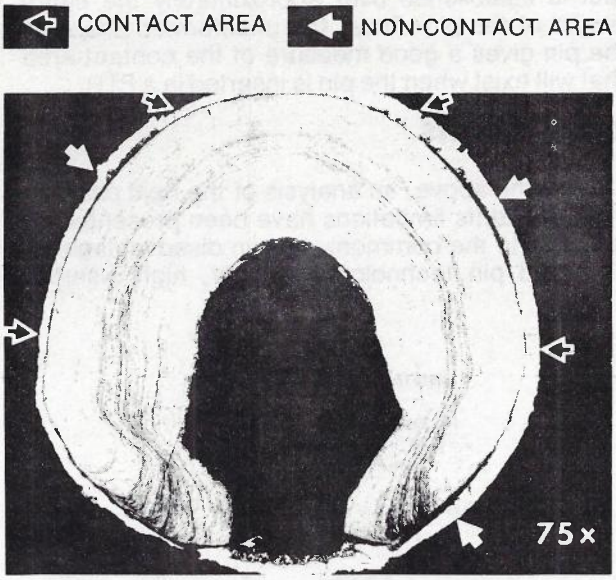
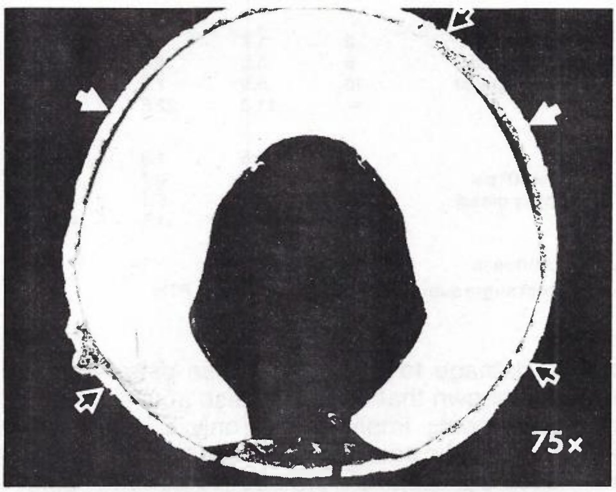


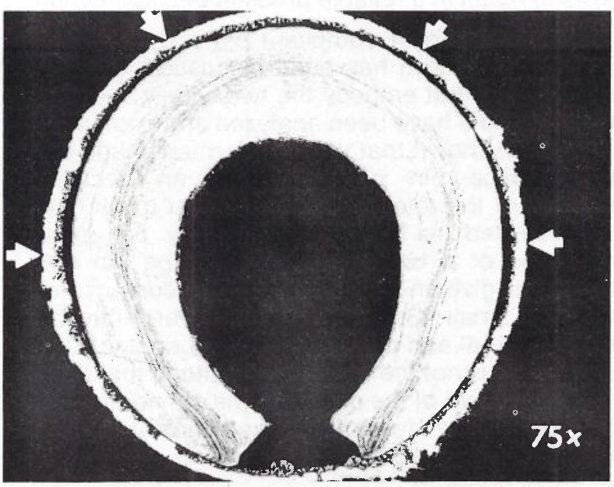
Figure 7



0.005" BELOW BOARD SURFACE



0.015" BELOW BOARD SURFACE



0.060" BELOW BOARD SURFACE

Sections of a Crescent-Type-Pin in a PTH

Figure 8

is the primary area of contact, it becomes high stress region making the board vulnerable to damage. More importantly, the plastic deformations significantly change the original shape of a crescent-type pin such that the final contact area can not be judged from the undeformed shape of the compliant section.

SPLIT-BEAM-TYPE PIN TECHNOLOGY

As the concept of crescent-type pin originated from the shape of the PTH, the concept of split-beam-type pin was developed from the following reasoning.

It was known that solid pins have a high potential of damaging the boards. The question was then asked, "What effect, if any, the number of contact points in a press-fit pin connection would have on the stress levels in a PC board?" Following simple reasoning led to the conclusion that two points of contact would set up lower levels of stresses in a PC board than a connection with more than two points of contact.

Consider two PTHs of each initial diameter D inserted with two different pins such that one would contact at two points while the other would contact at several points as shown in Figure 9. The more than two points of contact hole will expand more uniformly than the two point contact hole. For simplicity of analysis, we can assume the holes to expand to circular and elliptical shapes, respectively. If the two systems are designed to have about the same spring back characteristics, the change in circumference of the hole for the two point system will be about half as much as for the more than two point system. In other words, a more than two point system will tend to set up higher stresses in the barrel of the PTH than the two point system. Based upon this thinking of minimizing the stresses in the PTH, the concept of split-beam-type pin technology was developed.

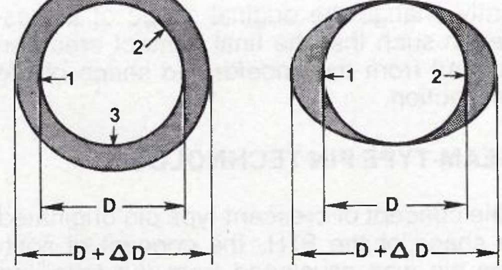
Split-beam technology consists of two beams acting as spring members in the bending mode as shown in Figure 10. The shape and length of these spring members can be designed to approximately match the hole shape and length. This will help to minimize the potential to cause localized damage to the PTH.

The radial force due to the interference between the diagonal dimension of the pin and the diameter of the PTH depends upon the effective interference, pin material, and stiffness properties.

Goel has previously considered the case of an infinite plate with a central hole press-fitted with a pin.[4] The pin was modeled to represent the contact angle, contact length, hole shape, and pin stiffness. Such a model closely resembles the split-beam-type pin. Results of the radial force for different plate materials, pin stiffness, and contact angle are given in Table 1. For details see Reference (4).

The insertion process in shown in Figure 11. The technology can be adopted to confine the plastic deformation only to the transition regions of the compliant part, thereby keeping the compliant

AN ANALYSIS OF 2 vs 3 POINTS OF CONTACT



CONTACT POINTS

	THREE	TWO
$(CIR)_i$	$= \pi D$	$= \pi D$
$(CIR)_f$	$= \pi (D + \Delta D)$	$\simeq \pi \sqrt{[(D^2 + (D + \Delta D)^2]/2}$
CHANGE	$= \pi (D + \Delta D) - \pi D = \pi (\Delta D)$	$= 1/2\, \pi (\Delta D)$

Figure 9

beam and PTH surfaces parallel to one another during the entire insertion process. It enables the contact to be set up over the entire available area. Figures 12 and 13 show the contact length and contact arc length of a commercially available split-beam-type pin. It also helps to distribute the insertion forces acting upon the board over a wider area, thus helping lower the localized stresses in the board.

In summary, split-beam-type pin technology is developed with an objective towards lower stresses in the PC board. Design objectives of radial forces, contact area, etc. can be set as a priority and a product could be developed to meet those objectives based on engineering principles. Plastic deformations are confined to the transition regions of the compliant part of the pin. The pressure contact is established over approximately the entire length of the pin. Thus, the undeformed shape of the pin gives a good measure of the contact area that will exist when the pin is inserted in a PTH.

UNDEFORMED SHAPE OF A SPLIT-BEAM-TYPE-PIN

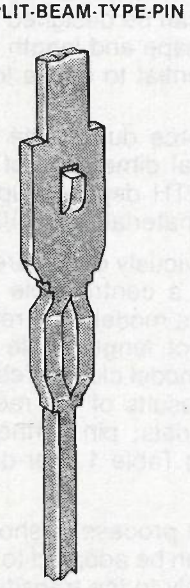


Figure 10

CONCLUSIONS

In the above, an analysis of the rigid pin technology and its limitations have been presented. In addition to the commonly known disadvantages of the rigid pin technology, namely, high insertion forces, damage to the board, loose pins, etc., it has been shown that the board also acts as nearly a rigid element; implying that only a very small amount of elastic energy can be stored in the board and hence a press-fit pin connection can not easily be established. In other words, a rigid pin and a nearly rigid acting board are not suitable components to result in a reliable press-fit pin connection.

Table I

INITIAL RADIAL FORCE (1b)

PC Board Thickness = 0.100 in.
$\nu = 0.25$, k = 2 (Plane Deformation),
Interference = 0.001 in.

Shear Modulus G ↓	$\omega \rightarrow$ / k_1	10°	60°	90°
10 x 10^5 psi (copper)	2 lbs/mil	2.0	2.0	2.4
	5	5.0	5.2	5.7
	10	9.0	23.0	11.0
	∞	56.0	114.0	147.0
2 x 10^5 psi (epoxy glass)	2	1.7	2.0	2.3
	5	3.6	4.4	5.0
	10	5.5	7.5	8.7
	∞	11.0	22.8	31.5
1 x 10^5 psi (epoxy glass)	2	1.6	1.9	2.0
	5	2.6	3.7	4.3
	10	3.7	5.7	6.8
	∞	5.6	11.5	15.7

k_1 = Pin stiffness
ω = Contact angle subtended at the center of the PTH

The need for a compliant pin and the industry's response to it has been discussed. The two technologies that embody the two widely available compliant pins have been analyzed and compared. It has been shown that the undeformed shape of a crescent-type pin can not give an accurate measure of the total contact area that it will have when inserted in a PTH. On the contary, the apparent shape of a two point contact type pin may sometimes give an impression that the contact area would be small. But there may be very little difference in real and apparent areas of contact. It is noted that it is not the undeformed shape that gives a good measure of the quality of the connection but instead it is the deformed shape that should be examined before accepting the use of any kind of pin.

ACKNOWLEDGEMENT

Numerous discussions with Bob Cobaugh are gratefully acknowledged.

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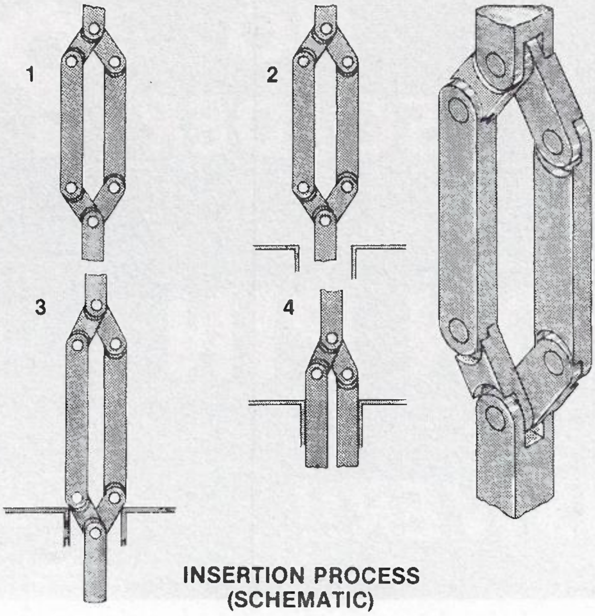

INSERTION PROCESS
(SCHEMATIC)

Figure 11

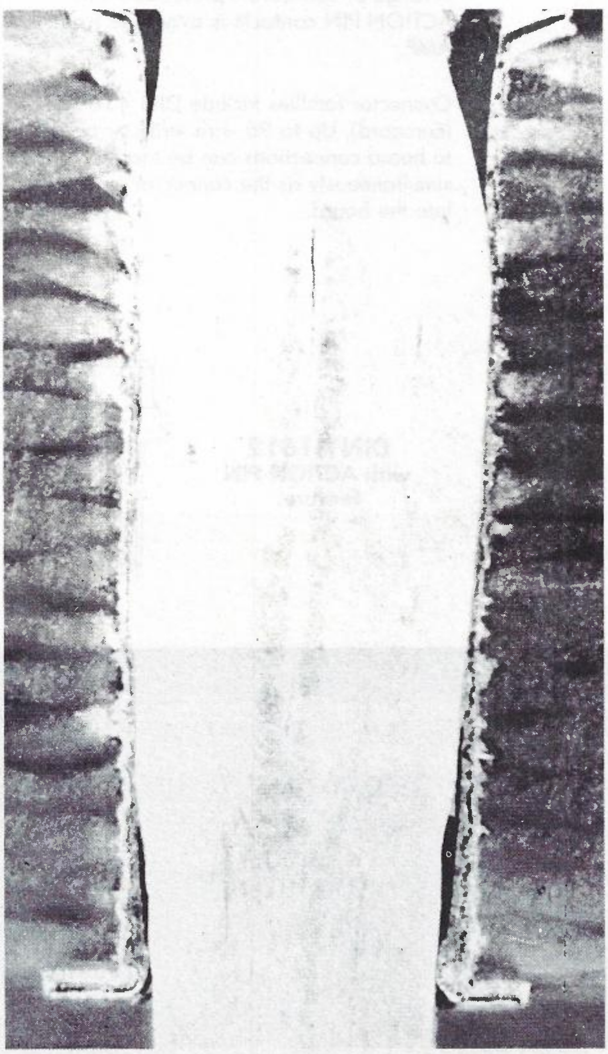

Figure 12

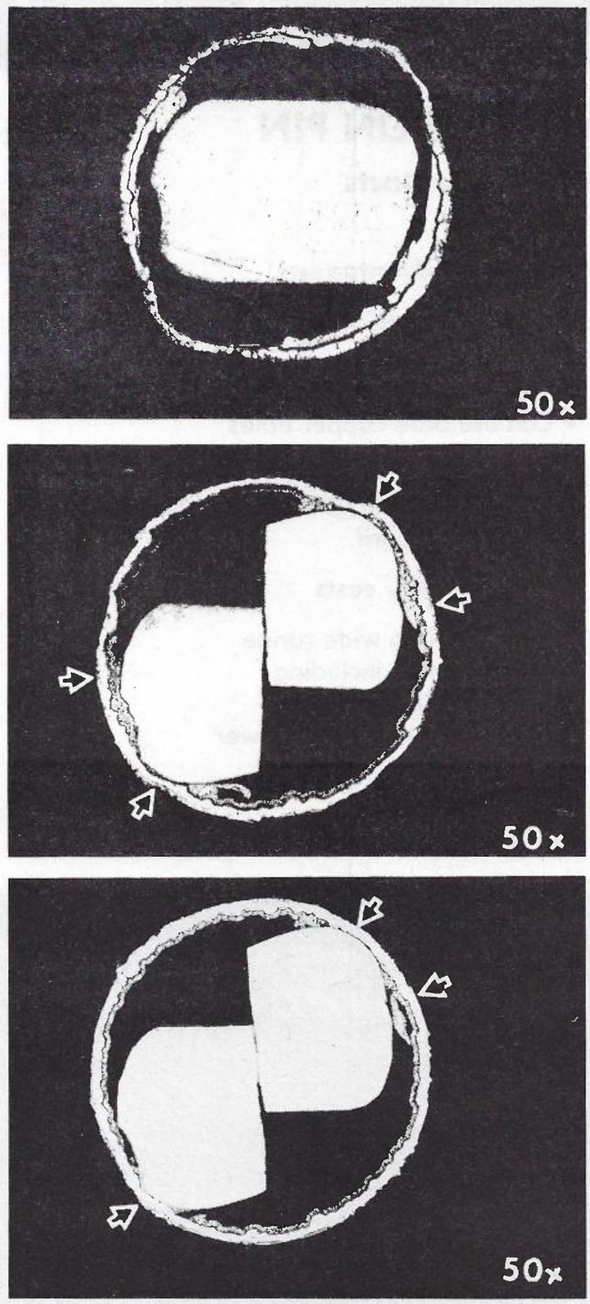

Figure 13


The latest cable conduit installation system
Neat, economical and versatile
This is an extremely economical and neat method of installing electric cables and conduits of various diameters, especially in rows. The system comprises three parts — a clip base, clip top and a track — which make many different applications possible.
For single cables or conduits the clip base is fastened by drilling and anchoring. Cables are laid in place and clamped with the clip top.
Conduits are held firmly in place by pressing them into the base where they are held by reason of the elasticity of the conduit. Another advantage is that all sizes of clips can be joined together in a row without using track.
If the track is used the clip bases are simply snapped in from above. Serrations in the track and on the clip base prevent any sideways movement of the clip in the track. With this system all parts can be removed again with ease.
Clip Base
Clip Top
Track
HILTI
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LIDCOMBE, NSW 2141
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Aussat — The Australian National Satellite System

WHY A SATELLITE SYSTEM

Following the advent of communications satellites in the early 1960s the development of satellite technology and its possible application in the Australian national communications network was closely watched within Australia.

As a large country, with relatively small but scattered population, and with large remote areas contributing much of the nation's mineral and pastoral wealth, Australia is faced with a number of telecommunications challenges that can best be solved by the use of communications satellite technology.

When the Australian satellite system is operational, all parts of Australia will be covered for the first time by a comprehensive and reliable telecommunications system

Such technology is not new. The first such system — the international telecommunications satellite system INTELSAT — has been operational since the mid-1960s, and now carries more than 50 per cent of the world's international telecommunications traffic, including 100 per cent of intercontinental television relays.

National satellite systems have been operating for many years in a number of countries, including Canada, (1973); the United States, (1975); Indonesia, (1976); the USSR (1965) with India's first satellite being launched in 1982, and Japan's in early 1983. More than a dozen other countries operate national satellite systems via capacity leased from INTELSAT. Firm contracts for satellite systems similar to the Australian system have been placed by Mexico, Brazil and Arab nations. Regional satellite systems for Europe have been constructed with the first satellite launched in 1983.

The establishment of a communications satellite system has significant implications for remote area communities, the Australian telecommunications industry, broadcasters, a wide spectrum of public and private sector users and generally the whole Australian business and financial community. Such a system will complement, diversify and add resilience to existing terrestrial communications systems, and in addition provide a capability for services not currently provided.

The Telecom terrestrial system, accepted as being world standard in performance, cannot economically reach all its potential customers, particularly in remote areas. Telecom has announced plans to lease capacity on the national satellite system to fill this gap.

The satellite system will enable the provision of communications and broadcasting services to isolated communities and homesteads which currently have no services, improve the services available to existing underserved communities, and provide an ideal means for the development and expansion of broadcasting services generally.

The capabilities of a satellite system allow the cost-effective distribution of television and radio programs in a manner which is more flexible than a terrestrial telecommunications system. This is demonstrated by experience in North America, where more than 50 per cent of available satellite capacity is used for that purpose.

The use of the satellite system for the national broadcasting service (ABC) and by commercial and public broadcasting operators will contribute to an increase in the choice of television and radio programs for significant sections of the Australian community.

In addition, the satellite system will have the potential to provide more effective aeronautical, maritime and land-based transport communications for the Departments of Aviation and Transport, as well as allowing expanded communications services to mining and exploration organisations, particularly in remote areas of Australia, including the North West Shelf and other off-shore areas.

Special provision has been made to allow the development of similar services within Papua New Guinea by allowing some transponders to be switchable to a beam covering that country. This should provide many benefits to that country given the particularly harsh nature of its terrain.

In summary, the Australian satellite system will improve the overall flexibility, reliability and capacity of the Australian telecommunications system, enabling it to respond to rapidly changing circumstances, and to accommodate special requirements.

HOW AUSTRALIA'S SATELLITE SYSTEM WILL WORK

The Australian satellite communications system is based upon two separate segments:

- A Space Segment which consists of the orbiting satellites and ground control facilities;
- An Earth Segment consisting of communications earth stations which transmit signals to, and receive them from, the satellite.

The Space Segment

Australia's first two satellites are scheduled to be launched from Cape Canaveral on board NASA's Space Shuttle in July and October 1985. Each satellite will be ejected from the Space Shuttle at an altitude some 250 kms above the earth. Special rocket motors will then lift it to its specially chosen orbital position about 36,000 kms directly above the equator and at a longitude just to the east of Australia. At this height, the satellite will move at the same speed and in the same direction as the earth rotates. As each orbit will take 24 hours to complete, the satellites will always remain 'fixed' or 'stationary' when viewed from the ground.

These satellites are based upon a spinning 'drum' design and will be 6.6m tall, 2.2m in diameter, and weigh around 1250kg at launch.

By appropriately designing the satellite's transmitting and receiving antennas, the beam coverage area or 'footprint' can be narrowed and concentrated onto relatively small areas within the satellite's field of view.

The satellite system has been designed so that its coverage area extends over all the six States, the Northern Territory, and surrounding coastal waters.

There is a national beam and four individual 'spot' beams with one each covering Western Australia, the

Northern Territory, plus South Australia, Queensland, and a fourth beam covering New South Wales, Victoria and Tasmania for each satellite.

There is also a 'spot' beam to provide internal communication services for Papua New Guinea.

The typical 'life' of each satellite is expected to be at least seven years. Before end of life another series of satellites will be launched to replace the first series. Each satellite will be capable of receiving radio signals, changing their frequency, and retransmitting the amplified signals back to any point in the coverage area.

The technical performance of the satellites will be monitored by the two control stations, located in Sydney and Perth, known as the Tracking, Telemetry, Command and Monitoring (TTC & M) Stations.

The Earth Segment

In order to use the satellite system, it is necessary to have appropriate ground equipment known as communications earth stations. These earth stations use dish-type antennas of varying diameter and cost, the type chosen depends upon the particular applications which it is intended to implement via that earth station.

Some earth stations are known as 'receive-only' and do just that — receive signals such as radio and television programs directly from the satellite. Other earth stations need to be able to transmit signals as well as receive signals.

The different types of earth stations include:

Major City Earth Stations (MCES)

These are earth stations built in each of the state capital cities, and in Darwin and Canberra. They are single-storey brick buildings with one or two communications dish antennas. Each station also has a radio relay tower and associated facilities.

These stations, owned by AUSSAT Pty. Ltd., contain the earth-based equipment necessary to receive and transmit radio, television, business data and telephone signals from and to the satellite. They also facilitate the transmission of these signals to the users of the satellite system.

Sites selected for Major City Earth Stations have met a number of criteria, including:

- a clear 'view' to the satellite in the North East, unimpared by hills, buildings or other obstructions.
- close to potential users.
- clear of industry that could cause electronic interference to the sensitive equipment housed in these stations.

In Sydney and Perth, the Major City Earth Stations are co-located with the TTC & M Stations described earlier.

Other Earth Stations

Users of the satellite system may, if they wish, own and operate their own earth stations. The type and size of such stations will depend upon the actual application and can vary from relatively large receive/transmit stations for television relay to smaller size stations for voice/data applications such as that required for communications with mining sites and rigs.

The smallest and simplest ground stations will be those installed by people in the remote areas for the reception of television and radio programmes directly from the satellite (the HACBSS service). These stations will consist of a small receiving antenna (1.2 to 1.5 metres in diameter) and capable of easy installation.

Future Launches

It is currently expected that future demand for satellite capacity and other operational requirements will result in a third satellite being launched during 1988. Satellite compatibility is being maintained with the European ARIANE launcher as well as the Space Shuttle to retain maximum flexibility in selecting the launch vehicle for Australia's third satellite. That selection is likely to be made during 1985 and will be based upon pricing and operational factors current at that time.

TECHNICAL SPECIFICATIONS OF THE SATELLITE SYSTEM

Satellites
- Initially 2 satellites in geostationary orbit, 36,000 kms above equator (156°E longitude, 164°E longitude — 160°E reserved for number 3 spacecraft).
- One on-ground spare.
- Mass — initial in-orbit mass of each satellite 655 kgs.
- Size — 2.2m in diameter, 6.6m high.
- Service life — minimum expected to be seven years.

Launch
- First two launches during July and October 1985, on NASA's Space Shuttle.
- The third satellite will be launched about 1988 on either the Space Shuttle or the European Ariane rocket.

Transponder Capacity
- Each satellite will have capacity of 15 transponders — 4 x 30 watts and 11 x 12 watts.
- Spare transponder capacity, both 30 watt and 12 watt, will be available on each satellite in the event of performance degradation or failure of an operational transponder.

Frequency Bands
- 14.0-14.5 GHz frequency band for uplink transmission (ground to satellite).
- 12.25-12.75 GHz frequency band for downlink transmission (satellite to ground).

Coverage Areas
- In uplink direction, each satellite will have two national beams each capable of receiving signals from anywhere within Australia.
- In downlink direction, each will have two national beams and four spot beams covering:
  Western Australia
  Queensland
  South Australia, Northern Territory
  New South Wales, Victoria, Tasmania.
- Small spot beams will also cover Lord Howe and Norfolk Islands.
- In addition, uplink and downlink capacity will be available in a separate Papua New Guinea spot beam.

On-Board Switching Capability
- Considerable capability is provided onboard the satellite to switch transponders to different beams (national or spot) by ground command, providing flexibility to meet customer requirements as they emerge.

Satellite Control
- Two Tracking, Telemetry, Command and Monitoring Stations (TTC & M) will be installed at Sydney and Perth. The Sydney Station will incorporate the Satellite Control and Operations Centre.

Issued by: **AUSSAT Pty. Ltd.**, Box 1512, GPO, Sydney, 2001.

Electronic Hydrometer

F. BODI
Telecom Power Section Headquarters.

Initial design work was prompted by the need to monitor, automatically, battery specific gravity (SG) during charge/discharge testing of stationary lead acid batteries. However, applications can be found wherever this type of battery is to be left unattended for long periods of time. The Australian outback has a profusion of remote unmanned microwave and other telecommunications repeater stations all of which ultimately, depend on the station battery for emergency backup. The reliability of these installations can be improved by providing more effective battery monitoring.

PRINCIPLE OF OPERATION

The hydrometer described in this article operates essentially as an electronic spring balance.

It consists of an acid-proof body which is fully immersed in the battery electrolyte and having negative buoyancy. The body is suspended from a spring which assumes an equilibrium position depending on the apparent weight of the submerged body. As the SG changes, the buoyancy force on the body changes which in turn changes the spring extension. This extension can be made linear to the change in SG. Hence, by converting the spring extension to an electrical signal by means of a displacement transducer, SG is in turn also given an electrical representation.

In its present design, the hydrometer offers a number of attractive advantages over many currently available devices:

- It converts specific gravity of electrolyte into an electrical quantity.
- It automatically provides electrolyte temperature compensation.
- It can be used inside a lead acid cell without removing any electrolyte.
- It can function for long periods unattended.
- Readings are insensitive to small changes in electrolyte level.
- The cost can be kept low with respect to the cost of a cell.
- It can provide a low electrolyte level warning.

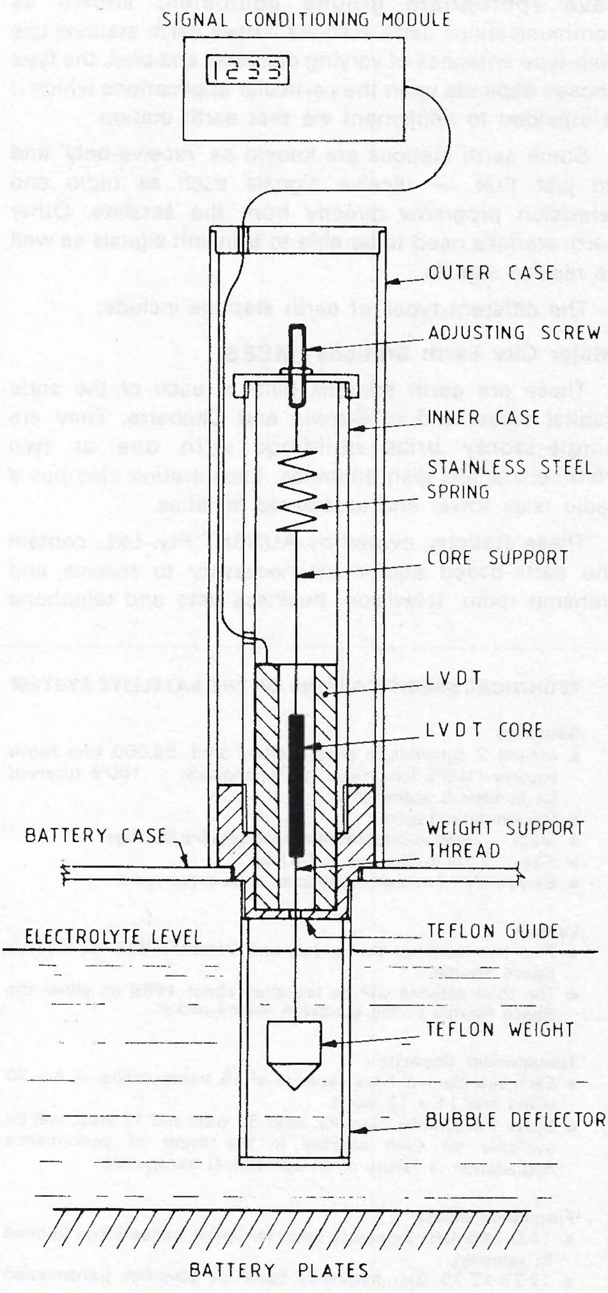
CONSTRUCTION

The displacement transducer used is a commercially available Linear Variable Differential Transformer (LVDT) type. These LVDT's are capable of high linearities with values of .25% being readily obtainable. The electronics necessary to drive the LVDT can also be purchased as a package from commercial sources. The prototype was constructed using a Philips integrated circuit package which is inexpensive yet performs most of the signal conditioning functions.

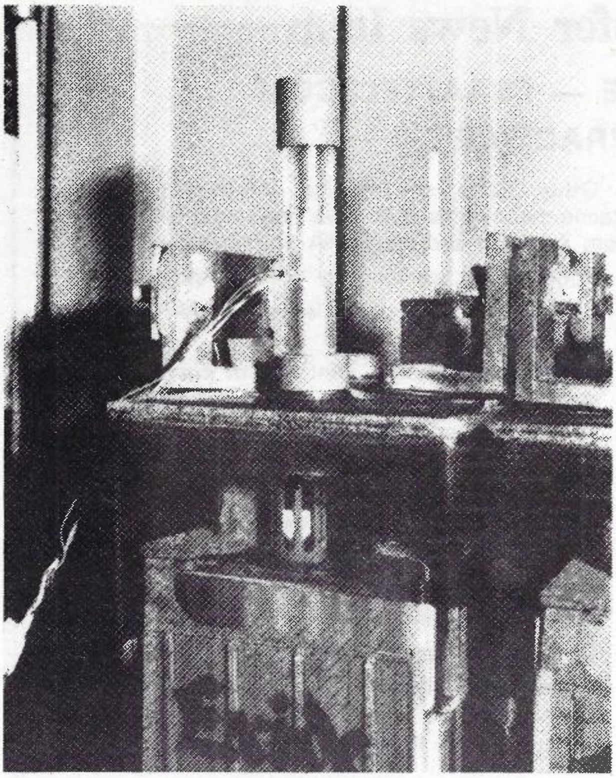
In the construction of the hydrometer, a thermally insulating outer casing was added to protect the inner housing from large temperature gradients which might otherwise develop across the wall and LVDT.

By choosing a suitable weight material (e.g. Teflon), electrolyte temperature compensation can be obtained with no extra complexity. When the electrolyte temperature rises, its specific gravity falls. Experiencing an equivalent temperature rise, the specific gravity of the weight also falls. Although the reduced electrolyte specific gravity acts to make the weight appear heavier, its own specific gravity reduction makes it appear lighter thereby producing a compensating effect.

An inverted frusto-conical shape was chosen for the



Hydrometer Cross Section



Prototype Hydrometer installed in 500 AH Battery

Teflon weight to prevent bubbles clinging to the underside when the weight was first immersed. A deflector was added to ensure that bubbles rising from the battery plates did not attach to the weight.

The Teflon weight, core and core support are suspended from a stainless steel helical extension spring which has initial tension built into the coils. This initial tension was designed to be as high as practicable so that surplus weight could be absorbed without causing excessive spring extension.

As the electrolyte level falls during service and begins to uncover the weight, the effect is to make the weight appear heavier. This in turn is interpreted as a low specific gravity reading by the meter. Without additional hardware it is impossible to tell if this low reading is due to a low electrolyte specific gravity or a low electrolyte level. However, the response from a maintenance point of view is the same. Corrective action must be applied in both cases either by adding more water, charging or even replacing the battery if it is faulty.

SPECIFIC GRAVITY THRESHOLD DETECTOR

A threshold detector does not have the linearity constraints imposed upon it that an instrument has reading over a wide range of specific gravity. For this reason a device that is intended to read accurately at only a single value can be greatly simplified with a consequent reduction in cost and complexity.

One possible approach is to use an inexpensive LVDT which has been designed and constructed without regard to linearity. One such LVDT was constructed using materials costing less than $1 and provided very good performance.

CONCLUSION

A number of successful working models have been constructed and have so far shown that the device should give a practical service life with good performance, and is at the same time economical. This design is owned by Telecom Australia and a provisional patent application has been lodged in Australia.

REFERENCE

Bodi F., "An Electronic Hydrometer". Paper delivered at the 1982 INTELEC Conference.

Information Transfer News Item

EARTH POTENTIAL RISE — ESAA/TELECOM CODE OF PRACTICE

A code of practice for the protection of personnel and equipment caused by high voltage power system faults has been jointly prepared by the Electricity Supply Association of Australia (ESAA) and Telecom Australia. The code was adopted by both bodies in January 1984.

At any high voltage station or earthed structure forming part of a high voltage power system the possibility exists that, due to an insulation failure, an earth fault can occur which results in power frequency current entering the earth through the earthing system. This current raises the potential of the earthing system with respect to a remote earth potential for the duration of the fault. Outside the perimeter of the earthing system the earth potential decreases rapidly with increasing distance from the station or structure. Nevertheless, there may exist an area around the earthing system, known as the "hazard zone," in which the earth potential is of sufficient magnitude to present, in unfavourable circumstances, a hazard to Telecom Australia staff, customers or equipment, because of the presence of remote earth potentials in Telecom's plant and equipment.

The Code is concerned with establishing safe practices to ensure that neither Telecom customers, staff nor equipment can be exposed to a hazard due to earth potential rise.

Other Code of Practice, Arrangements and Recommendations that have been adopted by Telecom Australia and the ESAA are as follows:

- Code of Practice for Stay Wire Crossings;
- Code of Practice for Unbalanced Single Phase High Voltage Power Lines;
- Arrangement for the Joint Use of Poles;
- Code of Practice for Multiple Earthed Neutral High Voltage Power Lines;
- Arrangement for the Common Use of Poles;
- Code of Practice for Overhead Power and Telecommunication In-span Crossings;
- Code of Practice for Earth Return High Voltage Power Lines;
- Arrangement for the Sharing of Trenches;
- Code of Practice for Low Frequency Induction;
- Application Guide for the Low Frequency Induction Code;
- Recommended Practices for Plant Underground.

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The Telecommunication Journal of Australia

ABSTRACTS: Vol. 34, No. 2

THE INTRODUCTION OF TELECOM COMMANDER: E. Blake, Telecom Journal of Aust., Vol. 34, No. 2, 1984, Page 99.

The launch in late 1981 of the first of the current range of Commander small business telephone systems signalled both a revitalisation of an important part of Telecom's product line, and the commencement of a more commercial approach by Telecom to this area of the market place. This article examines the introduction of Commander in terms of its commercial impact.

TELECOM PREMIUM TELEPHONES: A. A. Rendle, Telecom Journal of Aust., Vol. 34, No. 2, 1984, Page 105.

The emergence of LSI technology has enabled the production of relatively cheap telephone instruments with many facilities beyond those offered by the traditional basic telephone. Telecom Australia is offering a selection of these new telephones to customers, but is faced with the problem of maintaining a competitive range in an environment where many new instruments are becoming available.

TECHNICAL ASPECTS OF PREMIUM TELEPHONE INTRODUCTION: W. Trebilco and W. Lew, Telecom Journal of Aust., Vol. 34, No. 2, 1984, Page 109.

When Telecom decided to enter the premium telephone market with telephones of overseas origin, a number of technical problems had to be overcome so that these telephones would comply with Australian specifications and also be compatible with the existing customer installation plans. This article describes how these problems were overcome, and the changes introduced into the standard installation plans to allow parallel working between these new telephones and the 800 series telephones.

LOCAL AREA NETWORKS: P. F. Frueh, Telecom Journal of Aust., Vol. 34, No. 2, 1984, Page 115.

This article describes a relatively new form of telecommunications network, the Local Area Network, which is finding increasing application for office communications. As well as examining the underlying technology and techniques, the article considers standardisation, applications and interworking aspects.

AUTOMATIC TRANSMISSION LOSS CHECKER: A. A. Morkans, Telecom Journal of Aust., Vol. 34, No. 2, 1984, Page 125.

Telecom Australia has recently acquired new transmission testing equipment for telephone circuits. Whilst a comparison with some older equipment is inevitable, the Automatic Transmission Loss Checker provides facilities heretofore unavailable to maintenance staff. This article is a description of the Automatic Transmission Loss Checker and its role in the Australian network.

BARRAGE TESTING FOR 2 MBIT/S PAIR CABLE ROUTES: M. Jinman, Telecom Journal of Aust., Vol. 34, No. 2, 1984, Page 133.

Barrage testing is a method for measuring the effects of crosstalk on digital pair cable systems, by simulating the working conditions. This paper relates the Australian experience in developing barrage test sets for 2 Mbit/s line systems.

EVOLUTION TOWARDS INTEGRATED SERVICES DIGITAL NETWORKS: N. Q. Duc and E. K. Chew, Telecom Journal of Aust., Vol. 34, No. 2, 1984, Page 137.

This paper briefly outlines the evolution of public telecommunications networks towards Integrated Services Digital Networks (ISDNs). Such a network may be regarded as a general-purpose digital network capable of supporting a range of voice and non-voice services through a small set of customer-to-network interfaces. The International Telegraph and Telephone Consultative Committee's (CCITT) current effort in formulating a series of ISDN Recommendations (or standards) is described. Emphasis is placed on ISDN customer access interfaces and protocols.

INTRODUCTION TO THE INTEGRATED SERVICES DIGITAL NETWORK USER PART OF THE CCITT CCSS No. 7: I. P. W. Chin and B. T. Dingle, Telecom Journal of Aust., Vol. 34, No. 2, 1984, Page 145.

This paper gives an overview of the Integrated Services Digital Network User Part (IUP) listing the services currently offered and some of the proposed services describing the basic call control and signalling procedures necessary for the establishment, maintenance, alteration and the termination of call connections in an Integrated Services Digital Network (ISDN) environment. A description of the basic procedures using the CCITT Specification and Description Language (SDL) is also included.

LEOPARD — A COMPUTER BASED SYSTEM FOR PROCESSING TELEPHONE SERVICE DIFFICULTY COMPLAINTS: I. T. Ridge and O. J. Brisbane, Telecom Journal of Aust., Vol. 34, No. 2, 1984, Page 157.

Telecom has developed and largely implemented a major computer based system to support the processing of telephone service difficulty complaints and the repair function. This system, called LEOPARD, not only improves the efficiency of these functions but also ensures that customers are provided with a better standard of repair service. This article describes the functions of the system.

AN ANALYSIS OF PRESS-FIT TECHNOLOGY: R. P. Goel, Telecom Journal of Aust., Vol. 34, No. 2, 1984, Page 169.

Press-Fit Technology is finding more and more applications in the telecommunications industry, particularly in areas where very high pin counts must be inserted into printed circuit boards, but where the disadvantages of the use of solder baths must be avoided. This article provides an analysis of press-fit pin technology.

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The Prize is being awarded every third year in recognition of an outstandingly significant "scientific or technological contribution within telecommunications engineering" during the three-year period preceding the award year. Earlier contributions whose importance becomes established during the three years are also eligible for nomination.

The winner of the Prize is selected by an independent Prize Committee consisting of members appointed by the Royal Swedish Academy of Engineering Sciences, the Board of Directors of the Swedish Telecommunications Administration and representatives of leading Swedish universities of technology.

Candidates may be nominated by members of the Prize Committee and by organizations or individuals active in the telecommunications field.

Nominations are now being accepted for the 1985 award. All nominations must be in writing and should be accompanied by all relevant supporting material. The closing date for nominations is October 1, 1984.

Only the winner's name will be disclosed. Where the Prize contribution results from the work of two or three people, the Prize may be awarded jointly.

Nomination of candidates, or requests for further information including the complete rules governing the award, should be addressed to: *The LM Ericsson Prize Committee, S-126 25 Stockholm, Sweden.*

Prof. Leonard Kleinrock and Dr. Lawrence G. Roberts receiving their prizes from His Majesty, Carl XVI Gustaf, King of Sweden.

Prize amount: 250.000 Swedish Crowns