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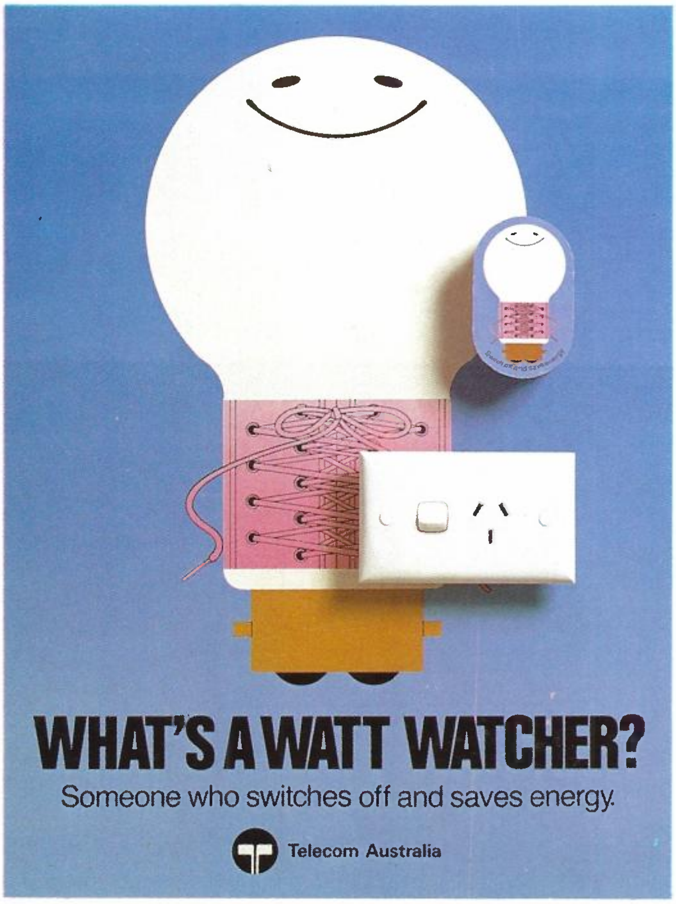
the telecommunication journal of Australia



IN THIS ISSUE

30/3

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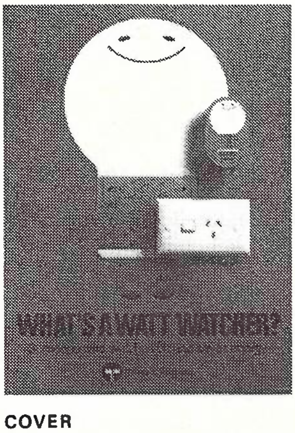

COVER

SYMBOLS OF TELECOM WATTWATCHER CAMPAIGN

The Telecommunication Journal of Australia

The Journal is issued three times a year (February, June and October) by the Telecommunication Society of Australia. The object of the Society is to promote the diffusion of knowledge of the telecommunications, broadcasting and television services of Australia by means of lectures, discussions, publication of the Telecommunication Journal of Australia and Australian Telecommunication Research, and by any other means.

The Journal is not an official journal of the Australian Telecommunications Commission. The Commission and the Board of Editors are not responsible for statements made or opinions expressed by authors.

Residents of Australia may order the journal from the State Secretary of their State of residence; others should apply to the General Secretary. The current subscription rates for both Telecommunication Journal of Australia and Australian Telecommunications Research are shown on the inside back cover of this issue. All rates are post free (by surface mail). Remittances should be in Australian currency and made payable to the Telecommunication Society of Australia.

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OVERSEAS APPLICATIONS

The General Secretary, Telecommunication Society of Australia,
Box 4050, G.P.O., Melbourne, Victoria, Australia, 3001.

Energy Management in Telecom Australia

H. P. GUTHRIE, M.I.E. Aust. and D. A. YOUNG, M.I.E. Aust.

Telecom Australia introduced an Energy Management program in 1978. The objective of the program is to pursue energy conservation through improved energy resource management and by seeking optimum utilization efficiency for all energy consumed. The justification, development and structure of the program are outlined along with the establishment of performance targets and a data base to monitor performance. The initial thrusts of the program are discussed including energy efficient buildings, a re-appraisal of air conditioning requirements, liquid fuel conservation and a Watt Watcher campaign aimed at promoting improved energy housekeeping among all Telecom staff.

The rising cost of energy in all the forms used by Telecom Australia, the drive within the organisation to improve operational cost effectiveness and an increasing community awareness of the need to conserve resources, provide a credible base for a corporate energy management program. Although each of these factors was an important consideration in the formulation of Telecom's Electrical Energy Management Program, the main stimulus was a concern within the Buildings organization in Headquarters that the demand for electrical energy consuming plant was increasing too rapidly in comparison to other network growth indicators. With some 87,000 staff occupying and operating 8,500 buildings, the electrical energy consumed in 1977/78 is estimated at 430,000,000 KWh. The actual cost of this energy was in excess of $18 million and was 17.5% above 1976/77 expenditure. This rate of growth compares in that year with a network growth of 6%, a business growth of 8%, a rise in consumer prices of 10% and a virtually zero Telecom staff growth.

CONSUMPTION CHARACTERISTICS

As seen from **Fig. 1**, expenditure on electrical energy has been steadily increasing at a rate exceeding both network growth, as measured by increases in telephone services in operation, and consumer prices. Part of this cost escalation was due to additional consumption and part to movement in electricity tariffs.

In 1978, an examination of historical commercial tariff growth showed an average annual increase of 4% with power supply authorities forecasting a long-term annual tariff growth rate of 6%. In the past two to three years, the rate of increase in electricity tariffs has exceeded the rate of Consumer Price Index (CPI) growth. Commercial tariff increases, reflecting the effect of inflation, averaged 13% across Australia in 1978/79.

The increase in electrical energy consumption cannot be totally attributed to network growth or to the increasing consumption of new switching systems; see **Fig. 2**. The increasing consumption per exchange line of L. M. Ericsson ARF and ARE equipment, particularly the latter, has been to some extent counterbalanced by the trend in

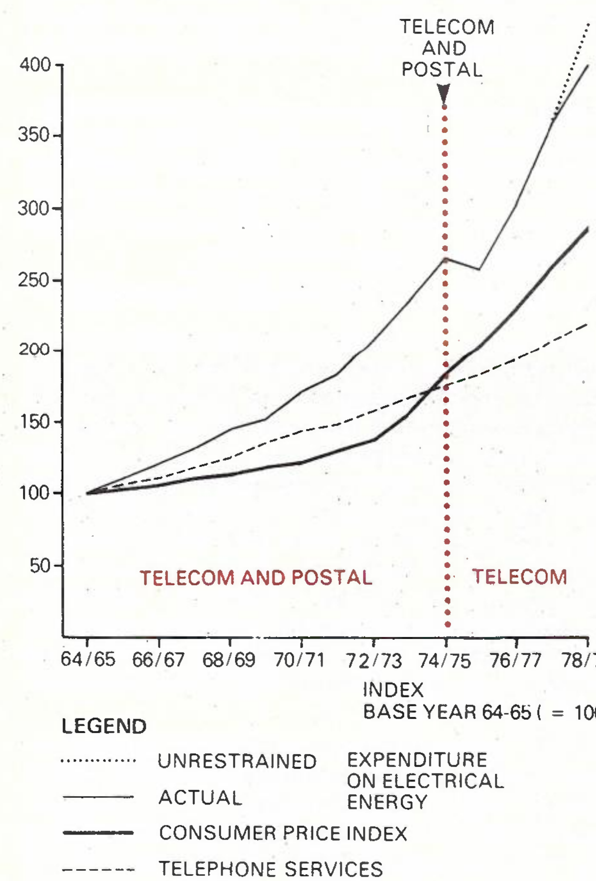


Fig. 1 — Growth — Electrical Energy, Telephone Services and Consumer Price Index.

line transmission equipment in the past 10 years towards solid state technology, and appreciably lower energy consumption per circuit.

Where has the increased consumption occurred? Although the available historical data on the sources of consumption of electrical energy in Telecom have been inadequate to draw firm conclusions, it has been established that the major causes of the rapid increase in consumption since the late 1960s have been the provision of air-conditioning in equipment and staff accommodation buildings, and the electrification of practices within the organisation. This electrification refers to the proliferation of electrically powered equipment ranging from personal heaters and fans through to large computer systems. Overall, the consumption of electrical energy in Telecom is distributed among telecommunication equipment (35%), air treatment (30%), lighting (30%) and other plant and equipment (5%).

The graph of cost of consumption growth in Fig. 1 shows that the increase is not directly related to the increase in the number of buildings operated by Telecom, which has been only 25% since 1965. The rate of increase following on the splitting into the Telecommunications and Postal Commissions and the 'loss' of the Postal buildings supports the proposition that the increases in electrical energy consumption are mainly due to the manner in which Telecom is operating.

It is suggested that the number of locations for Telecom operations is more important than the size of the total operation when attempting to pinpoint the reasons for consumption growth. Small increases at a large number of sites are difficult to recognise at each site, but the aggregation over the total operation is readily discernible.

Whilst accounting information was available which indicated overall trends in consumption, there was little detailed information available suitable for immediately launching corrective action. This lack of historical consumption data was a major challenge as Telecom moved toward controlling energy consumption.

WHY AN ENERGY MANAGEMENT PROGRAM?

Although the 1974 rises in the price of Middle East oil, which set off the so called 'energy crisis', had raised the subject of energy conservation to a degree of public awareness, Australia at that time had not developed a national policy on the conservation of energy resources. Nevertheless, there had been pressure within Telecom for many years to restrain the growth in energy consumption as a means of controlling costs. These calls for austerity requested staff to restrict the use of lighting and appliances, but there had been no indication, considering the paucity of energy consumption records, that these exhortations had any effect. The efficient use of energy became an important criterion in the design and operation of building plant.

In May 1977, the Minister for National Resources requested the National Energy Advisory Committee (NEAC) to submit views on actions necessary for energy conservation in Australia. The Committee presented a Report (Ref. 1) in September 1977 which suggested that all government agencies would be expected to embark on energy management programs. One recommendation of the Report stated: "NEAC recommends that the Commonwealth and State Governments and other public bodies should demonstrate proper energy management in their own establishments, setting examples in energy conservation and providing useful guidelines for other sections of Australian society." The Report suggested that each authority should be held accountable for energy management in much the same way as they are held accountable for financial management.

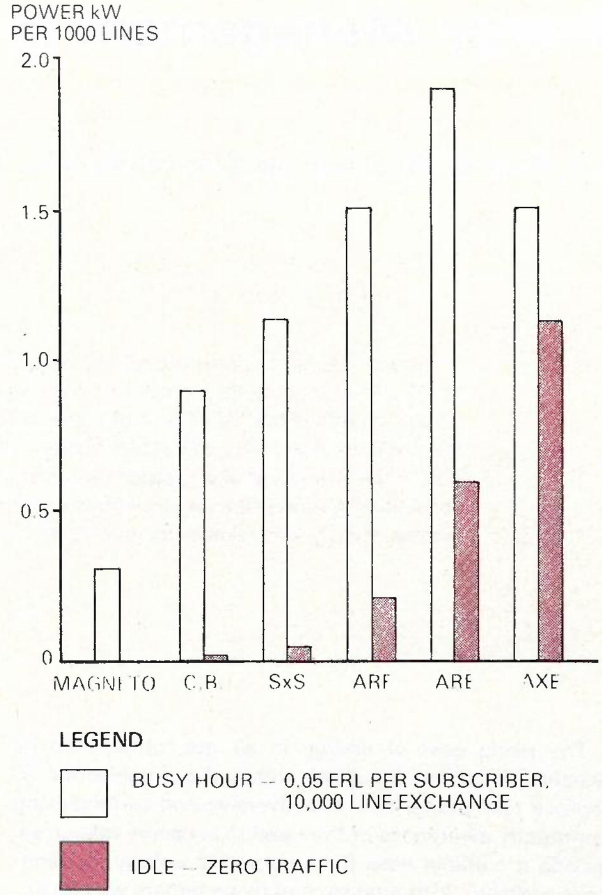


Fig. 2 — Power Requirements for Switching Systems.

At the same time as NEAC were preparing this initial Report, Telecom was seeking to control electrical energy consumption on two counts which supported the NEAC view. Firstly, Telecom, with a considerable number of buildings which are in full public view, should demonstrate its social responsibility toward energy conservation activities by ensuring that these buildings would not be the most brilliantly lit in the country. Secondly, there was the need to contain costs and improve efficiency.

THE PROGRAM

Following a review of Telecom's past expenditure on electrical energy and the establishment of whatever consumption data could be derived from this historical expenditure, forecasts were made and Buildings Subdivision in Headquarters presented a proposal to the Chief General Manager in October 1977. This proposal for a national Electrical Energy Management Program (EMP) was accepted in principle. The proposal was further developed and then approved by the Chief General Manager and the State Managers in February

1978 for introduction as a formal program. The EMP was launched in September 1978.

Liquid fuel for motor vehicles and mechanical aids was determined at that time to be beyond the initial scope of the Program, mainly due to the divergent organisational arrangements for the control of building and automotive plant.

Structure

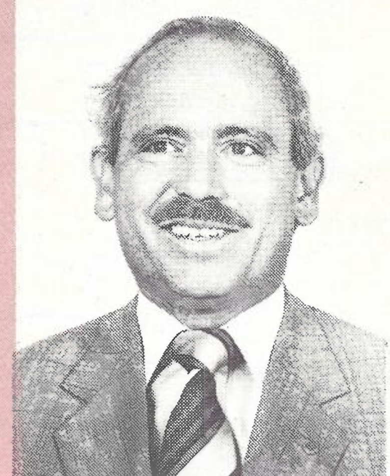
The translation of the need for a program to effectively control the consumption of electrical energy into a practical scheme which would have lasting effect on that consumption posed a problem. Past methods of introducing new systems were considered and rejected. The program had to engender staff acceptance of energy management and within that climate develop technical solutions in step with community concerns. Energy conservation — the saving of energy by careful husbandry — was considered the area in which staff were directly involved. Energy management — the prudent selection and efficient use of energy resources — was considered the concern of the plant and systems designer. Designed to operate in this framework, the EMP represented a radical change from previous internal programs. Its form recognised that the environment in which the Program was to operate had changed. The readily identifiable changes were:

- The old 'orders from the top' management-staff relationships had been greatly diluted by decentralised control.
- Greater autonomy of decision-making at the workface meant that staff had to be convinced of the worth of any change, before it would be accepted and instituted.
- Increased awareness in the community and within Telecom of the effect a change in any one area of activity might have on other areas.
- Competition from the mass media facing any attempt to gain the attention of staff.
- Staff concern for any action which might erode hard-won amenities or improved conditions.
- The increasing complexity of electrical energy consuming plant, so that fewer people now have the opportunity to understand how any total system operates.

In such an environment, the immediate application of engineering practice to provide solutions to increased energy consumption problems without interaction with the staff was likely to fail. There have been instances over the past few years where quite effective engineering solutions have been proposed, and even instituted, which have then failed to gain their expected benefits because the staff were not willing to completely accept their introduction. Failure of communication, lack of joint involvement in the design of the process, fear of change,

HUGH P. GUTHRIE entered Telecom Australia in 1949 and qualified as an Engineer in 1958. He has worked in several areas of Telecom including traffic engineering, exchange equipment installation, automotive plant and network planning. In 1973 he was a foundation member of the National Telecommunications Planning Branch and was co-author of the report 'Telecom 2000'. He joined Buildings, headquarters in 1977 as a staff Engineer where one of his roles is the National Co-ordinator for the Energy Management Program.

DAVID A. YOUNG commenced with Telecom Australia 1960 as a cadet Engineer and graduated in electronic engineering from the University of Adelaide in 1962. As an engineer he was initially engaged for four years on the provisioning and maintenance of the Adelaide metropolitan network and this was followed with 10 years of specifying engineering systems associated with buildings. He also spent a year in Darwin on radio communication projects. In 1978, he was appointed Telecom Australia's first Energy Manager for South Australia and the Northern Territory and is currently occupying that position.



distrust of new technologies are all recognised weaknesses in those processes which have attempted to rely solely on engineering solutions to problems where people are directly involved.

The EMP was designed to avoid these pitfalls by developing a multi-level structure which operated jointly in the social, political, managerial and technical environments. This interaction was necessary to ensure that staff were aware of the Program and its objectives, could identify with those objectives and recognise that conservation in their particular area was a responsible, logical and therefore supportable action. Furthermore, the staff would be encouraged to develop solutions for any problem areas of the Program which they could identify. A flow chart **(Fig. 3)** shows the Program structure and the interaction between related activities. Many of the interactive links have been deleted in the interests of simplicity, since any such depiction can only be a simplified model of a complex and constantly changing system. This flow chart has been instrumental in facilitating the acceptance of the socio-technical program by illustrating the interactions in a comprehensible form.

The emphasis in this program is the continuous exchange of information between those areas where the energy is consumed, and those people who are responsible for that consumption. Reporting to the workface is more important to the Program than reporting 'up the line'. From this model, the Program developed two major streams, one involved in developing an organisation and allied responsibilities to carry out the Program and the

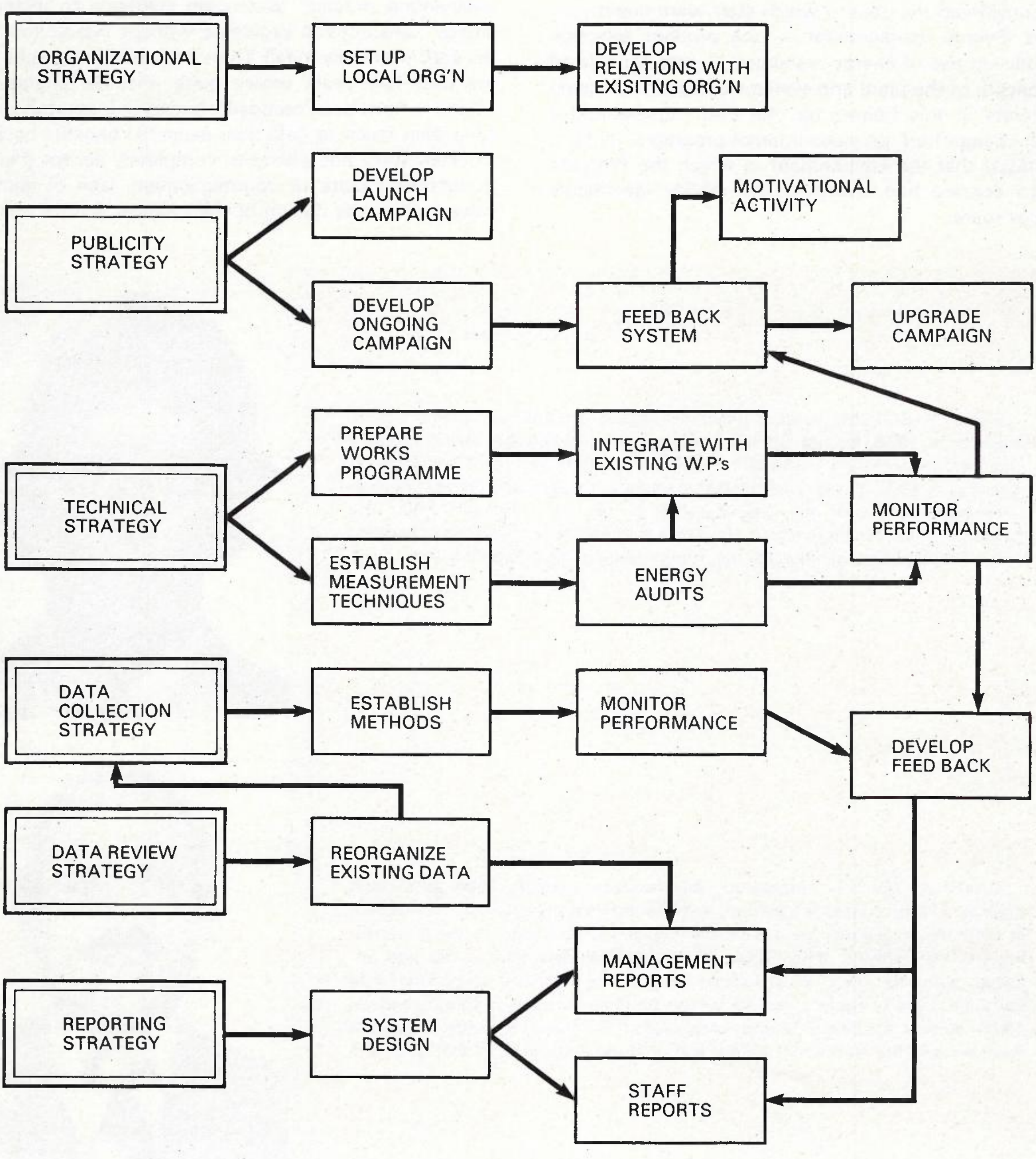


Fig. 3 — Structure of the Program.

other involved in informing, educating and motivating the staff. The first became the establishment of energy Management as an engineering function and the second the Watt Watcher publicity campaign.

Organisation

The EMP is co-ordinated from Headquarters by a Staff Engineer at Class 5 level assisted by a Class 3 Engineer who is also responsible for the energy consumption in Headquarters buildings. Consumption in these buildings is 4% of the national total and has been rising faster — 19% per annum — than that in any State.

Each State has an Energy Manager, a professional engineer in the Buildings Branch. These Energy Managers, each assisted by a Technical Officer, are responsible for the control of electrical energy consumption in their State and run the EMP within broad guidelines established by Headquarters. Although the Energy Manager positions were established in the Buildings Branch structure, the Energy Manager must be conversant with the whole range of Telecom operations to a degree not required previously in that area. As the building oriented component of energy consumption comes under close control, the Energy Managers will need to delve further into the design and operation of the telecommunications network to gain the savings necessary to meet consumption targets.

Targets

When the Program was initially proposed, the long term average growth rate in commercial electricity tariffs was forecast by power authorities as 6% per year. Based on this forecast and a network growth around 5%, the EMP target was a saving of 5% in actual expenditure on electrical energy in each of the first two years relative to expenditure in the previous year. At the end of that two year period, it was expected that a consumption data base, in units of energy consumed, would be available and the ongoing target after the second Program year was zero growth in consumption.

This target was thrown into some disarray by relatively large and unexpected electricity tariff increases in the first year of the Program in 1978/79. These increases averaged 13% across Australia. Tasmania had a tariff increase of 30%; the Northern Territory increase was 50%. Considerable effort has been made to develop a more effective and reliable target after the first year of the Program. The only acceptable ongoing target was one of zero energy growth such that consumption must not exceed the year one figure. This required additional data collection and analysis to provide the 1978/79 base year figure.

At the inception of the Program there was pressure to set a 15% cost saving target, to match the publicly stated performance of other organisations, both in Australia and overseas.

This rather high target was resisted because of the more diverse activities of Telecom compared with steel mills, petro-chemical refineries, industrial complexes and similar large, but usually monolithic organisations. In hindsight, the choice of a conservative target was prudent as the widely diversified operations of Telecom did limit the opportunity to gain a large first year saving.

PRINCIPAL PROGRAM THRUSTS

The design, provision and operation of energy efficient plant and equipment has always been a requirement of all technical areas of Telecom's operations. The specification of the technical actions necessary to upgrade this requirement presents no problems, aside from the magnitude of the task.

The two areas which broke new ground and called for the application of new skills on the part of the Energy Managers, were the development of methods of generating staff interest in energy conservation and the collection of accurate data.

The Watt Watcher Campaign

Conserving energy by reducing wastage is a habit that can only be engendered by constant reminder; the Watt Watcher campaign, as the advertising campaign for the EMP, was designed to develop such a habit. The initial launch of the Program was heralded by the issue of stickers to be attached near light switches and power outlets, and a poster to bring the message home.

The campaign was based on the theme of reducing wastage, without introducing any overtones of sacrifice or loss of amenity. The light globe snugly fitted into a corset, **Fig. 4**, was selected to promote the theme, and has now become widely recognised as the symbol of the Program. At the same time a deliberate, but discreet policy of introducing the Watt Watcher theme into all Telecom publications was set in motion.

The Watt Watcher campaign is designed to be an internal marketing activity rather than a staff information distribution technique such as has been used for the campaigns on industrial safety, industrial noise and so on. The campaign does have target markets within Telecom —

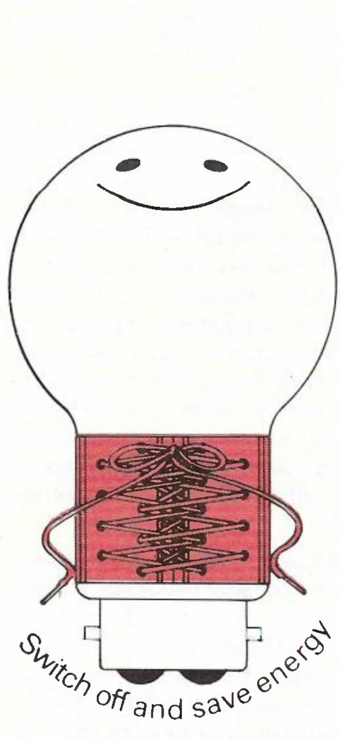


Fig. 4 — WattWatcher Campaign Symbol.

the aim is to interest and educate the people who directly control the consumption.

A survey (Ref. 2) of the impact of the Watt Watcher campaign conducted 9 months after the introduction of the EMP showed that a significant proportion of the staff surveyed had received the message and had in some way reacted.

A further development of the Watt Watcher campaign released in June 1980 uses a professionally written and produced marketing kit comprising a videotape to promote a message in the modern media idiom coupled to a range of posters, publicity material and stickers to repeat constantly the Watt Watcher message — "Switch Off and Save Energy". The videotape introduces a 'disco' theme to catch the attention of the younger sections of the staff.

The campaign is designed to be continuous, repetitive and in step with the technical program. For example, the Watt Watcher message will shortly be directed towards the wearing of cooler clothes in summer at the same time as air-conditioning temperatures will be set a degree or two higher, with consequent savings in energy. Other target audiences within Telecom will each receive special attention.

Database

To be successful, an Electrical Energy Management Program must be supported by adequate information on consumption and effective feedback to the point of control. To this end, the Telecom EMP was designed to provide:

- Adequate data collection and analysis;
- Clearly defined responsibilities and accountabilities;
- Well defined targets;
- Effective reporting procedures.

These objectives, and the capability of monitoring Program performance in relation to targets, are not attainable without detailed information on where and when all electrical energy was consumed.

Before the EMP was introduced, an 'information drought' existed regarding Telecom's consumption of energy. Electricity account anomalies had to be corrected and considerable effort was invested in this area over the first two years of Program operations to assemble, analyse and correct consumption data. In general, central records were already kept in each State on energy expenditure by site, but no consumption records were maintained for any type of fuel or energy for any particular location. An efficient system to collect, record and analyse energy cost and consumption data was needed to allow both management and energy user to measure the effect of the Program. To overcome this deficiency a data base was developed in South Australia and given the name WATTWATCH.

WATTWATCH is a data processing system, matched to Telecom's TACONET computing facility, designed to monitor electrical energy usage and expenditure and to check achievement against usage targets. System input data are extracted from electricity supply authority accounts and include the energy consumed at each site, its cost and the period of usage. Using data which are directly available from electricity accounts avoids the onerous task of collecting this information within Telecom.

The principal output from WATTWATCH is a three monthly report which presents summary cost and consumption information for the current year at State and intermediate levels of management responsibility. Actual and target consumptions are also compared and any variation reported. Additional ad hoc reports are available by processing the site usage data in conjunction with other information held on file for each site. Site cost and consumption data are held for five years. WATTWATCH has proved to be a reliable and precise computer processing system providing vital support to Telecom's Energy Management Program.

WATTWATCH is being introduced in the other States and Headquarters for local data assembly. Some modification of the South Australian system is necessary to cater for detail variation among States in areas such as site identification, methods of accounting and tariff variations. The program offers an eventual nationwide data processing system which may well interface with an accounting information system in the future to allow a single entry of energy account data to cover both financial and EMP requirements.

Telecommunications Equipment

The lifeblood of telecommunications is electrical energy. Fig 2 shows the growth in the power needs for local switching equipment from manual exchanges through to stored program control (SPC). The considerable growth in energy consumption per exchange line for modern solid-state switching equipment is a penalty which must be balanced against the greater facilities and numerous operational advantages offered by processor controlled equipment. The power needs of this new breed of switching equipment are relatively constant being less dependent on the traffic handled than were the earlier electro-mechanical switching systems. The introduction of solid-state electronics has, however, lowered the power and energy consumption of long distance transmission equipment.

Although power consumption has always been a considered parameter in the design of telecommunications equipment, the EMP has helped to raise the priority of lower energy consumption in the mind of the designer relative to other design factors. Energy savings have resulted from the replacement of incandescent bulbs with light emitting diodes and rotating machine ring, tone and power conversion equipment with solid-state units. Depending upon equipment packing density, lower telecommunication power needs may provide a bonus by reducing the capacity of power conversion plant and air conditioning cooling loads. Telecom engineers who design or select telecommunications equipment are encouraged to be conscious of their responsibility to optimise energy efficiency and reduce energy input per erlang of traffic.

Solar energy was first used in Telecom in 1974 to provide the entire energy needs for a remote VHF radio telephone subscriber in outback South Australia. The major operational application of solar photo-voltaic power in Telecom Australia is a chain of 13 microwave repeaters between Alice Springs and Tennant Creek. This system, which was described in an earlier issue of this Journal (Ref.3), employs solar energy as its primary power source for economic reasons rather than to conserve conventional fuels. This form of energy is not likely to provide more than a fraction of a percent of Telecom's electrical energy needs in the next decade.

Building Design

Telecom owns and occupies 6400 buildings ranging from highrise office and telecommunication buildings to small country transportable telephone exchanges. Accommodation is leased in a further 2100 buildings. Almost all of these buildings were designed before the energy crisis was generally perceived.

The engineering systems and plant associated with buildings consume 65% of Telecom's total electrical energy and include air conditioning, ventilation, lighting, vertical transportation, hydraulic services, water heating, canteen facilities, office machines and workshop plant. These systems and the building structure of all new buildings are designed to be energy efficient to keep operational energy requirements to a minimum. Existing buildings are being progressively examined through energy audits to locate areas of inefficient energy use; corrective measures are initiated if such measures can be shown to be cost effective. Accepted standards of accommodation, both for staff and equipment, are maintained with the energy audit principally identifying areas of inefficient usage or the overprovision of facilities.

Energy usage in any building is partly dependent upon factors which cannot be readily controlled, such as the ambient climate, the desired internal visual and thermal environment and the nature and quantity of plant, equipment and staff housed in the building. Important factors which are under the control of the building designers are the building envelope, the building energised engineering systems and the human systems and each of these receive special attention in energy conservation oriented designs. The building envelope includes the walls, windows, doors, roof, ceiling and floor as well as consideration of the shape and orientation of the building. The energised engineering systems are those mentioned above and the human systems include maintenance, cleaning, operational aspects, building management and, of course, the building occupants. Every one of these factors is examined in relation to the others to see how best it can contribute to the efficient use of energy in the finished building.

Fig. 5 shows the administration building for the metropolitan Operations Department District of Adelaide North. This building was completed in 1980 to accommodate 240 office based staff. It incorporates numerous energy saving features: solar screening to east and north facing windows, no west facing windows, double glazing, the exploitation of natural lighting, gas space heating, electric heat-pump cooling, good thermal insulation, variable volume air conditioning and solar water heating. The north-facing solar water heating panels can be seen on the roof. Measured energy input to this building, which is occupied for 50 hours per week, is 490 megajoules per square metre per annum; this is around 20% less than for similar buildings in Adelaide occupied by Telecom.

Air Conditioning

Prior to the introduction of L.M. Ericsson crossbar switching equipment into the network in the early 1960's, air treatment was provided in the larger telephone exchanges using mechanical ventilation, with oil heating where necessary and evaporative cooling in those areas of Australia where cooling of the equipment room was considered necessary. Central evaporative cooling and heating plants were costly to instal and operate and could not provide the degree of control over temperature, humidity, dust and air movement which was required for crossbar equipment. Refrigerated air conditioning was adopted to satisfy these specific requirements with comfort conditions being provided to staffed areas. The consumption of electricity rose considerably with the introduction of refrigerated air conditioning.

In equipment areas, temperature and relative humidity were maintained between 18° and 30° C and 40% to 70% respectively to provide reasonable conditions for maintenance staff, and hence conditions better than those necessary for the equipment alone. Plants operated continuously under automatic control. The need for space heating was reduced by a higher equipment packing density and a higher standing power load for the switching equipment. The heat sources employed were oil furnaces with hot water circulation in the larger exchanges, or electric resistance heaters installed in ducts.

Realization that staff are in attendance for only 45 hours per week and that transmission and switching equipment can tolerate wider environmental limits without detriment to the equipment or its performance has enabled considerable energy savings to be achieved by operating the air conditioning only when staff are in attendance. The climate, telephone traffic profiles and construction of exchange buildings in most areas of Australia have, in fact, permitted the air conditioning to be closed

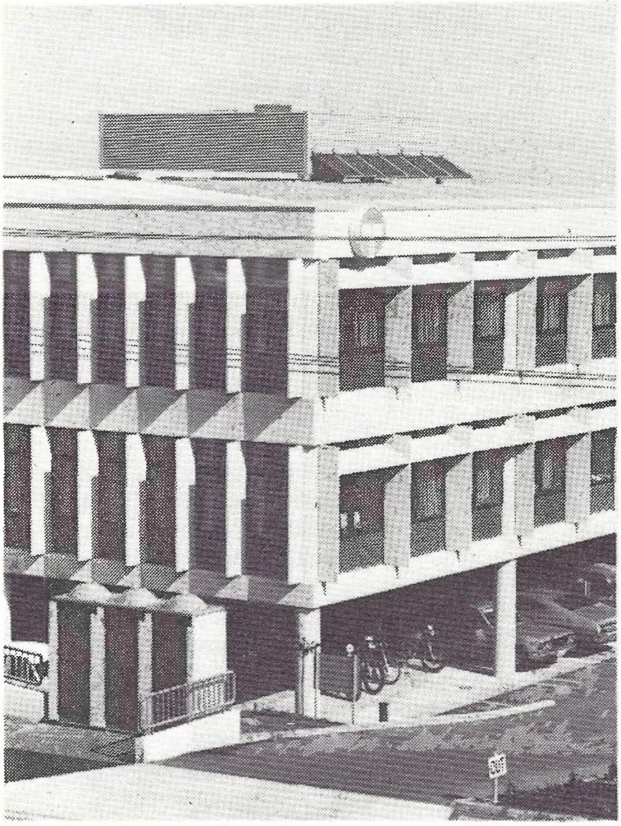


Fig. 5 — Administration Building — Adelaide North District.

down outside the staffed hours of 0800 to 1700 Monday to Friday without the environmental outer limits for the telecommunications equipment being reached. Air conditioning energy savings between 10% and 30% are being achieved with this mode of operation depending upon the size and location of the installation. Automatic starting of the plant 30 minutes to one hour before staff arrive for duty ensures that occupied spaces have been ventilated, odours removed and appropriate conditions established for staff. Metaconta SPC trunk switching equipment, some transmission systems and installations in the warmer regions of the country require special consideration but, as with most air conditioning plants, an examination of operating practices will generally result in economies and energy savings for little or no additional expenditure.

Air conditioning in office and depot accommodation is closed down when not required or when staff are not in attendance.

All aspects of air conditioning needs, design, operation and maintenance are under review. Fresh-air cycles, variable volume systems and computer based monitoring and control of air conditioning and other building services are being introduced as energy saving measures.

One pursuit which has reduced the use of packaged air conditioners has been the redesign of small prefabricated transportable equipment buildings. Recent transportables for use in areas with hot climates have an inner thin-skin metal equipment shelter and an outer insulated sun shade which allows internally generated heat to escape by conduction thus reducing the need for a heatpump unit.

The major difficulty in gaining immediate savings from the introduction of energy-conserving systems has been the number of buildings involved and the limited resources of the Energy Management team in each State. Modifications depend on careful measurement, complex calculations and the application of building design computer programs. The process must be thorough to be successful and this thoroughness precludes immediately significant results.

LIQUID FUEL CONSERVATION

Telecom operates Australia's largest transport fleet of 22,000 motor vehicles which covered 270 million kilometers in 1978/79 and consumed around 50 megalitres of fuel. These vehicles range from small sedans to 50 tonne low load transporters. In addition, and consuming a further 10 megalitres a year, are 4000 construction and materials-handling mechanical aids, 900 small engine driven units including water pumps, chain saws and earth rammers and 2700 engine driven sets for the generation of electrical energy. This automotive plant plays a vital role in the construction, operation and maintenance of the telecommunications network.

Growing community concern about future availability and price of liquid fuel has been recognised by Telecom and positive measures toward improved utilization have been introduced to the provisioning and operation of motor vehicles.

Provision of the lightest and smallest engined vehicles suitable to meet particular operational needs has resulted in a marked increase in the proportion of four cylinder vehicles in general use. At present, of the 16 000 fleet vehicles which are sedans and light commercial vehicles with a capacity of one tonne or less, 11 200 or 70% are already four cylinder. Vehicle purchases in 1980/81 will include 85% in the above category of which 79% are four cylinder. The emphasis on four cylinder vehicles reflects the trend to smaller capacity engines. There is no magic associated with the number of cylinders, since within the bounds of efficient engine design, the swept volume or capacity of the engine has more effect on fuel consumption than the number of cylinders. Simply, larger engines use more fuel than smaller ones.

Fuel efficient diesel engines are used extensively in the major mechanical aids and the heavier long distance road vehicles. When suitable units are available and the cost penalty can be overcome, diesel power will be extended to medium size plant. The use of optional fuel consuming vehicle facilities such as automatic transmissions and air conditioners is restricted to an extremely small number of vehicles, and on the basis of need.

Fuel saving driving techniques have been publicised and staff are encouraged to be conservation conscious and to save fuel when driving both their private vehicles and those of Telecom. The extension of the present Program to formally embrace this aspect of liquid fuel conservation would complement the EMP. Regular servicing schedules are performed to ensure optimum vehicle performance and the economies of more frequent vehicle tuning and the extension of the period between engine oil changes are both under investigation.

An interesting program to monitor and improve motor vehicle fuel economy has been introduced in South Australia. All motor vehicles have been grouped according to both type and area of operation. The average fuel consumption for every vehicle in litres per 100 kilometres is used to determine the mean fuel consumption for each group. Vehicles in each group whose fuel consumption exceed an action limit, defined as the group mean plus two standard deviations, are isolated and individually examined with the aim of improving their fuel economy. This is achieved by improving the vehicles performance or by improving the driving technique of its driver. The mean fuel economy of each group of vehicles is calculated every six months and is progressively improved.

Developments with alternative fuels and vehicle technology are being closely monitored. A trial is being conducted with 100 trucks and utilities operating in the Melbourne area to test the application of liquified petroleum gas as a fuel for Telecom vehicles. No suitable electric vehicles are yet available commercially but 150 out of 330 fork lift trucks and related vehicles are now battery powered.

Oil is no longer the preferred fuel for water and space heating in buildings and is only used where natural gas, electricity, solar energy and waste heat are unsuitable or unavailable.

Telecommunications as a Liquid Fuel Conserver

Telecom has demonstrated its concern for our society's most pressing conservation problem by taking positive steps to reduce the quantity of liquid fuel it consumes. If the cost of liquid fuels in our community continues to rise relative to the cost of telecommunications services, a degree of substitution can be expected between physical transportation and energy efficient telecommunications. This substitution process presents a significant potential saving of liquid fuel and would place added social responsibility on Telecom Australia to improve the management of the energy and fuel it consumes.

The process is worthy of detailed examination. Present telecommunications services can be marketed as alternatives to liquid fuel consumption to a greater extent than at present, and new telecommunication services might be introduced simply because they can replace more energy-dependent services. The social effects of a "Dial, Don't Drive" energy conserving approach to marketing of telecommunication services would be sufficiently widespread to require a thorough examination within Telecom of the telecommunications-transportation substitution.

FINANCIAL ASPECTS

Energy conservation cannot be pursued in isolation. Parallel consideration must be given to related design and operational parameters and the economic, social, industrial and environmental consequences of all proposals aimed at optimizing energy utilization. Usually these interests converge. The degree to which energy conservation can be pursued often requires justification and the analysis of alternatives with the resulting action being one of compromise.

The major factor considered when justifying capital expenditure on energy conservation is the financial viability of the project. Improved maintenance can often improve energy utilization but the engineered solution usually requires the investment of capital. With good design this investment need not be large, especially when incorporated with the initial provision of an asset, but with the retrofit situation extra care is necessary to ensure a cost effective solution. Telecom's Finance Directorate guidelines (Ref. 4) covering the investment of discretionary capital require an internal rate of return exceeding the cost to Telecom of new capital. Discounted cash flow studies should confirm the priority of energy conservation projects in competition for this capital, although it is important to realize that there are additional intangible advantages likely to accrue to Telecom for visible investment in energy conservation. Energy price escalations are making energy conservation and management a wise and sound investment area for Telecom.

Energy costs are taking on an increasing importance in the evaluation of alternative designs for energy-consuming plant. The EMP has adopted the "Worth of a Watt" method developed at Bell Telephone Laboratories (Ref. 5) of comparing the lifetime cost, including energy, of alternative systems. This calculation aggregates all contributing costs into a single capital equivalent cost associated with the continuous consumption of one watt of power. This information makes it easier to select the most cost effective equipment by capitalising the energy costs at present value.

PROGRAM PERFORMANCE

EMP performance in 1978/79, for first year of the program, was measured in terms of expenditure on electrical energy. Actual expenditure was $1.7 million or 8% below the predicted unrestrained expenditure, as indicated in Fig. 1. This unrestrained estimate was based on network growth, actual energy tariff increases for 1978/79 and an extrapolation of trends in previous years. This saving of $1.7 million can be compared with the Program costs over the same period of approximately $300,000.

The second year of the Program saw the introduction of the simpler and more realistic zero energy growth target. At the time of writing national performance figures were not yet available, but in South Australia and Northern Territory actual electrical energy consumption for 1979/80 was 1% below that in the previous year; a better result than zero energy growth. There are indications that this result will be matched in the other States and Headquarters.

The result in the first year can be attributed almost entirely to improved energy housekeeping induced through the Watt Watcher campaign. The 1979/80 performance is a result of the combined effect of the Watt Watcher campaign and the engineered program. In 1980/81, this combination will continue with the engineered program becoming the dominant factor in the result.

Once the available energy savings are made over the next three or four years by modification to air conditioning and lighting, closer attention will have to be paid to the more difficult job of wresting savings from the telecommunications equipment to enable the zero energy growth target to be achieved. Close control of plant operation in the field, purchase of energy efficient equipment, application of pressure on equipment designers and suppliers to reduce energy needs will all serve to make the successful operation of the Energy Management Program in the future a real challenge.

CONCLUSION

Telecom has backed up its concern for the future availability and price of energy in Australia with positive energy conservation actions. The Electrical Energy Management Program and the program to reduce liquid fuel consumption have shown that energy management is not only a wise corporate action but also a cost effective one.

The Telecom EMP is a novel activity for Telecom Australia and covers new ground. This novelty is being exploited to advantage in tackling a serious problem in the operation of Australia's largest business organisation. It must succeed for the good of Telecom and for the good of Australia.

There is still much to be done.

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Call Failure Supervision in a Telecommunications Network

C. R. BRADBURY

Whilst many faults in telephone switching plant can be readily identified by inbuilt self-checking facilities, there remain those more elusive network type faults which result in failure of interexchange signalling.

This article describes a new and efficient means of pinpointing these network type faults in Telecom's networks, which comprise a large proportion of crossbar exchanges and MFC compelled sequence information signalling equipment.

In the 1960's Telecom Australia developed a system for analysing customer trouble reports relating to possible faults in the switching network and from this analysis, localising the exchange and possibly the switching stage where the fault may exist. This development is described in Telecommunication Journal of Australia Volume 13 No. 6 and Volume 15 No. 1. The customer trouble reports analysed are those which point to a switching failure; e.g., repeated no progress call attempts or repeated wrong number call attempts. These reports are plotted on charts depicting the layout of the network; the object being to determine the location of the fault from the patterns developed from a combination of various customer reports. This analysis work is undertaken at the Network Performance and Analysis Centre (NPAC) located in the capital city of each State.

The above analysis system is very effective in pinpointing trouble spots in step-by-step networks because the routing of the call is usually defined by the digits dialled. It is not so effective, however, in a common control crossbar network because of the alternate routing facilities and the random outlet selection features which usually ensure that a customer will not encounter the same fault on successive calls. There are generally less network type trouble reports from customers connected to crossbar exchanges, and effective analysis of any such trouble reports can be nullified by the routing and selection features of the network.

This article describes an alternative and very effective method for detecting network call failures, using information derived from the multi frequency code (MFC) information signalling system. The MFC signalling system used in Telecom crossbar networks is a compelled sequence system in which each forward signal is acknowledged by a backward signal. The forward signals contain the called party information, and failure of the signalling sequence is indicated by failure of a backward signal to be received in response to the transmission of a forward signal. Information about a call failure is collected from a crossbar register in each originating exchange by a Network Call Failure Supervision (NCFS) device. This information is then analysed on a network grid basis at the NPAC using a minicomputer. Trouble spots can thus be pinpointed in a similar way to that used for the analysis of customer trouble reports.

A network performance measuring function (Automatic Service Assessment (ASA)) has also been included to enable selected network performance parameters (switching loss and plant congestion loss) to be measured.

The Network Call Failure System will enable telephone network faults to be efficiently located and thus promises to be a very powerful tool in the maintenance of a telecommunications network.

TELECOM — THE NETWORK AND ITS TRUNKING

The register in the crossbar originating exchange stores the called party (B) number and retransmits it to succeeding switching stages to enable the required switching to take place. Within the register the P relays determine which digit of the called number is to be transmitted to the next switching stage. As each digit is sent, the P relay chain (P) steps forward in readiness to send the next digit. If the call is switched to a tandem exchange, the P chain is reset, by a Restart (R) signal from the tandem, so that retransmission of the complete called number will occur.

The simplified trunking of a typical metropolitan crossbar network is shown in **Fig. 1**.

This network comprises:

- i exchange — originating portion of terminal exchange.
- j exchange — terminating portion of terminal exchange.
- x tandem — originating tandem exchange (which accepts originating traffic from a group of i exchanges and directs this traffic to y tandem exchanges).
- y tandem — terminating tandem exchange (which accepts traffic from other x tandems and particular i exchanges and directs this terminating traffic to a group of j exchanges).

On a call from an i to a j exchange, the call will be offered to the direct route between the i and j if the direct route is provided. If the direct route is not provided or there are no free circuits, then the call is offered to the y tandem serving that particular j exchange. If no circuits are available on the route to the y tandem, then the call is offered to the x tandem (final choice route). If a call fails to be successfully connected to the called party on any of these trunking alternatives (i to j, i to y to j or i to x to y to j) then analysis of the P and R information, together with the called party number and the call origin, will enable the likely area of failure to be determined.

Typical values of P and R for various parts of the network are shown in **Fig 2.** Combinations of P&R will then indicate the probable routing and location of call failure, i.e. P=2 and R=2 indicates that the failure was at the y tandem on an inlet from the x tandem.

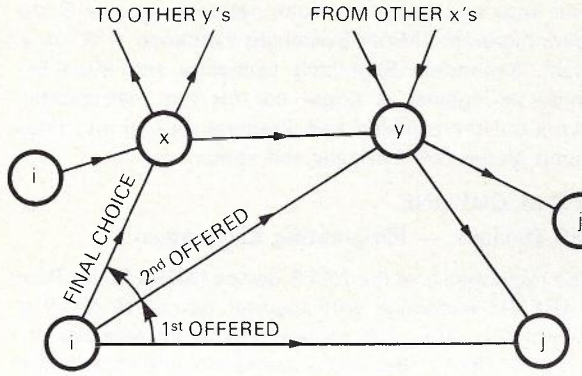


Fig 1 — Simplified Trunking of a Metropolitan Crossbar Network

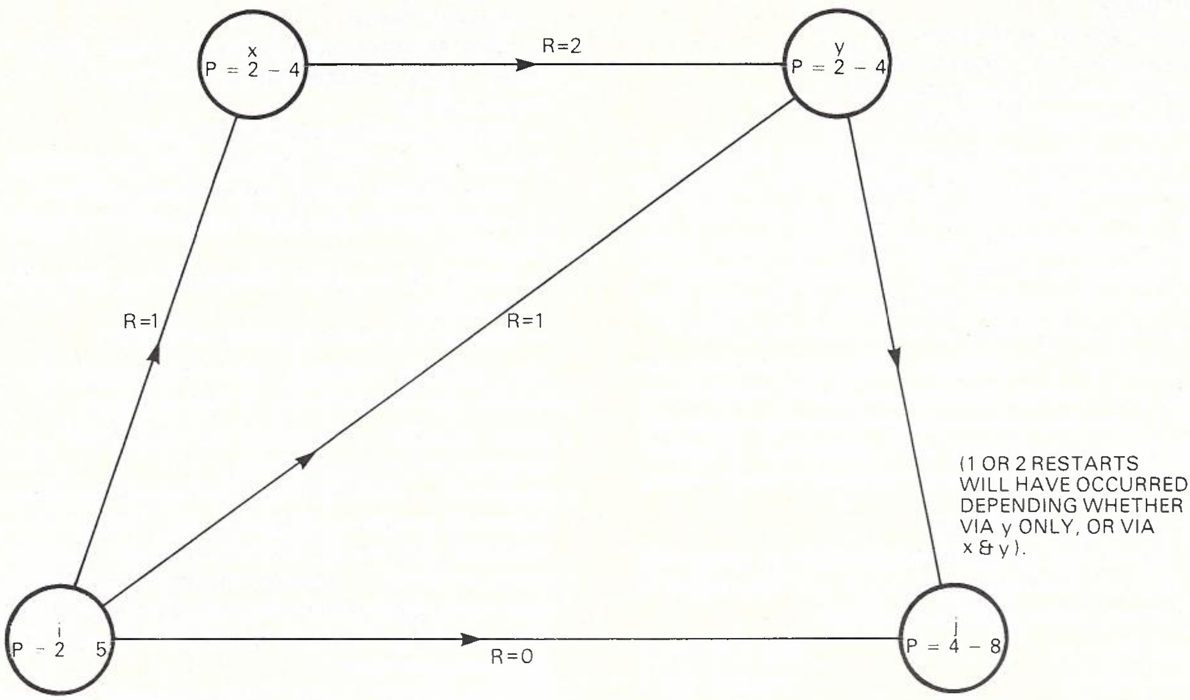


Fig. 2 — Typical P & R Values for a Metropolitan Crossbar Network

ROSS BRADBURY joined the PMG's Department as a Technician in Training in 1958. He was involved in exchange maintenance in Victoria before transferring to Central Office in 1972. After 3 years in the Circuit Design Laboratory/Section he joined Network Performance and Operations Branch, Engineering Department where he was involved with the development and implementation of the NCFS Minicomputer System. He is currently a Clerk 7 with Network Services Branch, Customer Services Department, Headquarters.

The intra and interstate trunk networks have a 3 tier tandem hierarchy (Minor Switching Exchange = 'x' or 'y' tandem, Secondary Switching Exchange and Main Exchange) as against a single tier for the metropolitan network but the trunking and alternate routing principles outlined above, are basically the same.

SYSTEM OUTLINE

NCFS Devices — (Originating Exchanges)

The relationship of the NCFS device (RKR LM or LP) in the ARF102 exchange with register types LM or LP is shown in **Fig. 3(a)**. The register LM or LP receives the called party (B) number and is across the setting up of the call until the 'B' party busy/idle condition is determined. The following network conditions can be detected by the register and the NCFS device during the setting up period:

- MFC failure
- Service tone failure (crossbar)
- Service tone failure (Step by Step)
- Triple connection (Step by Step)
- Network congestion (crossbar)

If a fault condition is detected during the setting up of the call, information about the progress of the call and its routing is extracted from the register by the RKR and transferred to the (ADR) system for transmission to the NCFS minicomputer via the Automatic Disturbance Switching (ADX) system. An example of a typical Message and the information content is shown in **Fig. 4**.

The ADR is an information extraction, buffering, formatting and message transmission system which is also used for extracting other types of information about the performance of individual ARF exchanges. (Telecommunication Journal of Australia Volume 17 No. 1. refers.)

NCFS Message Generation

To ensure that the switching network is adequately covered, NCFS facilities have been or will be provided in the following major switching systems:

ARF 102 (Reg LM)	RKR (LM) Part 2
ARF 102 (Reg LP)	RKR (LP) Part 2
ARM 20 (Reg-EH2Y2)	ARM NPCD
ARM 20 (Reg-H1)	ARM NPCD
ARM 20 (Reg-Y1)	ARM NPCD
ARE 11	NCFS program block
AXE	NEPR & SEQS program blocks

NCFS Minicomputer (Processing and Analysis System)

The NCFS minicomputer which functions as the processing and analysis system for NCFS Messages is sited at the NPAC.

The hardware items are shown in **Fig. 3(b)** and comprise the following:

- Input interfaces — interfaces for 8 50 baud CCITT No. 2 lines and interfacing can be provided for up to 8 1200 bps full duplex asynchronous lines.
- Processor — minicomputer, operating in an on-line real-time mode with a core memory of 64 k bytes.
- System teletype — starting and stopping the system and display of details of system misoperation.
- Visual Display Unit — Display to the Operator details of:
  - — NCFS Messages that have exceeded a preset Action Limit at a particular Network Model point (Pattern Display)
  - — Network Model (parameters defined by Operator)
  - — NCFS Messages currently stored in the system (parameters defined by Operator)

  Also allows Operator to:
  - — update Network Model
  - — change Action Limit and Purge Time values
  - — remove specific NCFS Messages from the system
  - — clear Patterns that have been previously produced by the system
- Line Printer — 200 LPM hard-copy output of:
  - — VDU screen displays
  - — Listing of Network Model
  - — Periodic statistical summaries of system operation.
- Disc System — 10Mb capacity consisting of 2 discs, 5Mb fixed and 5Mb removable for storage of
  - — programs
  - — Network Model
  - — NCFS Messages currently in use in the system
- Paper Tape Reader/Punch — 300/75 C.P.S. read/punch for
  - — initial input of Network Model details
  - — punching of NFCS Messages for transmission to other NPAC's (NCFS Minicomputer systems)
  - — input of system diagnostic programs (as required)
- Cassette
  - — storage of statistical information for later off-line processing
  - — storage of a copy of the Network Model

The software modules, with their associated I/O system(s), are shown in **Fig. 5** and comprise:

- Input Interface — interface the input lines to that required for the minicomputer.
- Input Edit — assemble valid NCFS Messages from the stream of characters (telegraph etc.) arriving on each input line and identify the origin of each message.
- Network Model — contains detailed information about each exchange (orginating, terminating and tandem) in the switching network supervised by that NCFS Minicomputer system.
- Message Plotter — plot NCFS Messages against the points in the Network Model relevant to each Message. If a Pattern is not produced at this stage, the Message is stored for possible later use by the Message Analyser.
- Message File — stores all NCFS Messages that are currently being used in the system. Messages are removed when they are considered to be of no further use.
- Message Analyser — compare in detail, the most recent Message passed to it from the Message Plotter, with all other Messages stored in the system that have firstly the same terminating exchange (j) and secondly the same originating exchange (i) as the 'most recent' Message.
- Automatic Service Assessment — provides a statistical indication of the performances of the network as seen by individual exchanges.
- Reject Processing — records NCFS Messages whose origin or destination cannot be identified by the Minicomputer system, for later analysis to identify malfunctioning NCFS devices or changes in the network which have not been reflected in the Network Model.

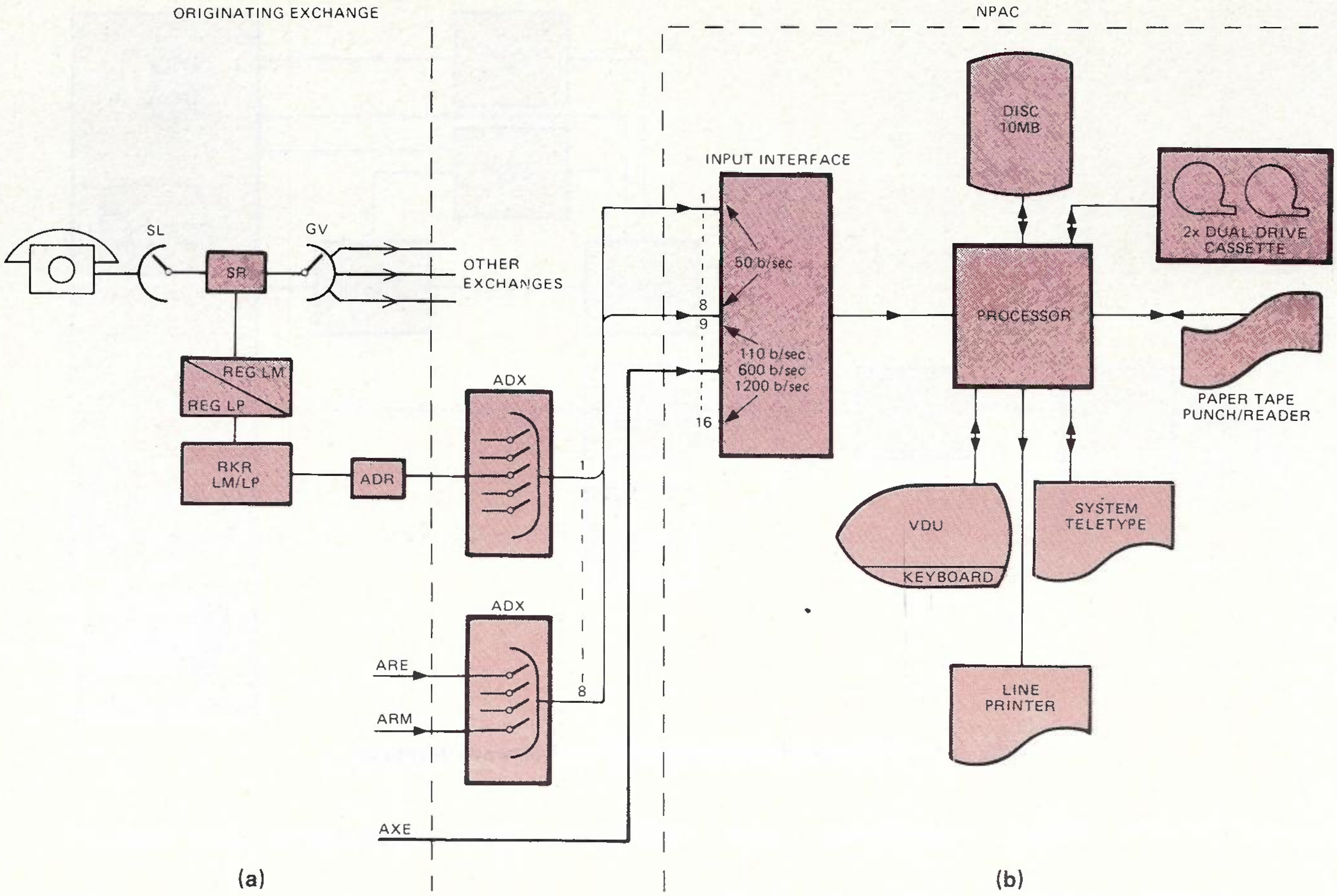
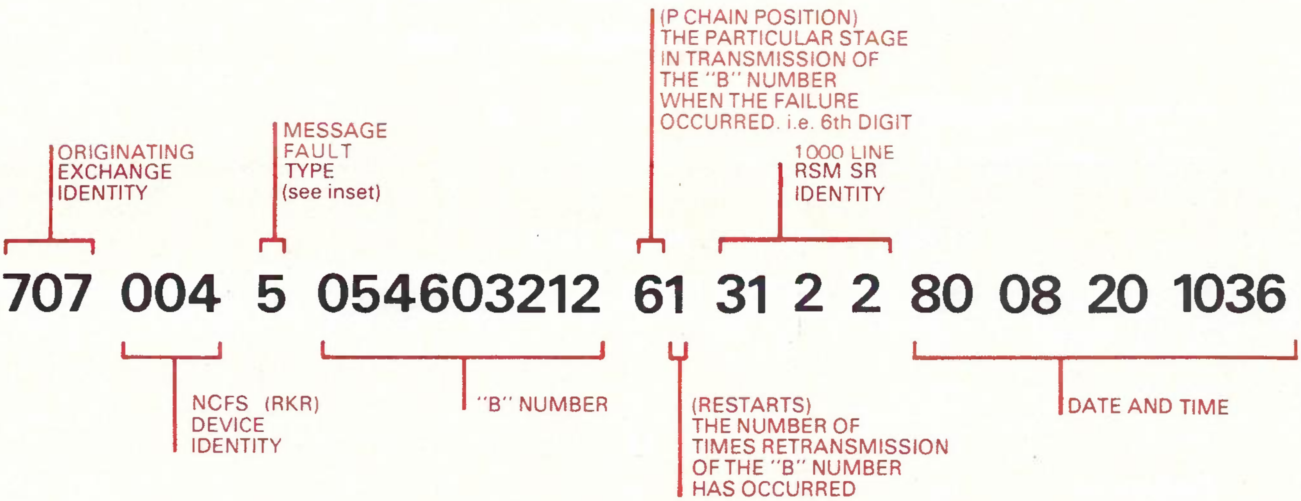


Fig. 3(a) — NCFS Device in a Crossbar Network
Fig. 3(b) — NCFS Processing System — Hardware



LEGEND

5 = MFC FAILURE
6 = MFC SERVICE TONE FAILURE
7 = S x S SERVICE TONE FAILURE
8 = S x S TRIPLE CONNECTION
9 = CONGESTION (B4)
0 = AUTOMATIC SERVICE ASSESSMENT

Fig. 4 — Typical NCFS Message

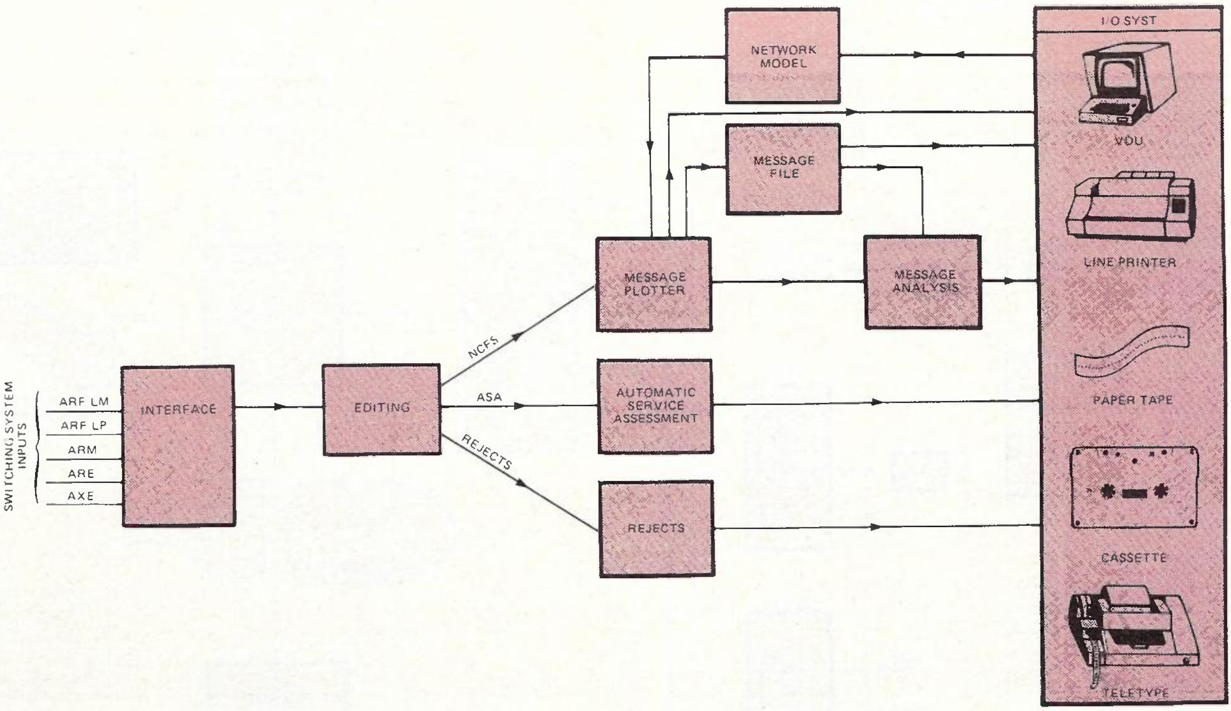


Fig. 5 — NCFS Processing System — Software Modules

```
RKR SYSTEM  OFFSET: 0 MESSAGES: 1510  TODAY: 186  VDUQ: 0 80/08/20 1032 PAGE:1

   DEVICE:S 006 337    EXCHANGE:VAUCLUSE              VAUC

   CNA: 02  PREFIX: 3376     TANDEMS: POTX

   MULT TANDEMS: NO     EQUIPMENT:  X    FORMAT:  3    2GV:   SSI:

   SECTION: MJ  NPAC:     ESTIMATED CALLS PER DAY:    50

                                   SAMPLE SIZE:   200

   ACTION LIMIT CATEGORIES:  23    5    6    8   57

   PURGE TIME CATEGORY:  8

                  ACTION    TALLY    PURGE TIME

   MFC              18        1          3

   MFC NO TONE       3        0          3

   SXS NP           30        1          3

   SXS TC           30        3         14

   CONGESTION       30        1          5

    OVERALL         90        6

   END


>VP
```

Fig. 6 — Network Model Entry — Originating Exchange File

SYSTEM OPERATION

Network Model

The heart of the system is the Network Model which is a 'site dependent' set of parameters.

A Network Model should completely specify the telephone switching network in which it has the prime responsibility and broadly take into account the networks which other NCFS Minicomputer System Network Models cover in detail eg. from Sydney the code 03 (Melbourne) would be treated as a 'large' terminating exchange and NCFS Messages relating to call failures to 03 ..... would be transferred via Telex to the Melbourne NCFS Minicomputer system for detailed analysis against the Melbourne Network Model (as a message originating from a 'large' originating exchange 02).

The Network Model has files relating to:

- originating exchanges (those with NCFS devices)
- terminating exchanges (all number ranges that can be dialled)
- tandem exchanges
- routes (defined as a link between two listed tandem exchanges).

An individual record or entry must be made for each exchange or route in the above categories.

Associated with each individual entry in the Network Model of exchanges and routes, is a Tally File.

The Tally File contains the following information:

- the number of Messages per fault type at that particular Network Model Point.
- Action Limit category which references a file (Action Limits) to obtain values to relate the number of Messages received per fault type to a predetermined value (Action limit) at which action should be taken.
- Purge Category which references a file (Purge Times) to obtain predetermined values to determine whether Message(s), already counted at that point, have reached a particular age in the system and as such do not have relevance to the present situation in the switching network and therefore should be deleted (purged) from the system.

An example of the information entered for an Originating Exchange File entry is given in **Fig. 6.**

Typically, a Network Model will be able to cater for up to:

- 400 NCFS devices
- 1000 Terminating Exchanges
- 200 Tandem Exchanges
- 400 Routes
- 99 Action Limit Categories
- 20 Purge Time Categories
- 500 Multiple Tandem Entries.

After the initial compilation of the Network Model, it will be updated in a 'conversation' mode from the VDU to take account of subsequent changes in the network.

Message Flow

Input Interface

NCFS Messages are received at the Input Interface **(Fig. 7)** where the Message is translated into a form suitable for use within the Minicomputer.

Input Edit

From the Input Interface the Message is passed to the Input Edit program, where the following checks are made:

- that the Message length is greater than 3 characters and less than 80 characters;
- that the origin of the Message can be identified; i.e. the first two fields of an NCFS Message (Identity of exchange and Identity of device, refer Fig. 4) appear in the Originating Exchanges File of the Network Model.

If a Message fails either of the above checks it is transferred to a Rejects File — 'Origin Invalid' for possible later analysis. If the origin can be identified, Messages are classified as 'Valid Call Failures' and are passed via the Input Messages queue to the Message Plotter.

Message Plotter

As each Message is received by the Message Plotter the Terminating Exchanges File of the Network Model is examined to determine if there is an entry corresponding to the 'B' number field (refer Fig. 4) of the Message. If there is no corresponding entry on the Terminating Exchanges file, then the Message is transferred to a Rejects file — 'Origin Known' for later analysis and possible update of the Terminating Exchanges file if the 'B' number is a valid destination.

From tandem information contained in the relevant Originating and Terminating Exchange files, the tandem trunking of a call originating at a particular 'i' exchange and terminating at a particular 'j' exchange, is able to be determined.

In some trunking situations the tandem exchanges cannot be uniquely identified by sole reference to the relevant Originating and Terminating Exchange files. This arises when a terminal exchange has access to or is accessed from two or more tandem exchanges. In these cases reference is made to a Multiple Tandems file which will then allow the particular tandems involved in that call to be uniquely identified.

Within the Minicomputor system, the tandems are given a designation T1 . . . T5, which represents their respective position in the tandem switching hierarchy.

In a country network (refer **Fig. 8**) these will be as follows:

T1 — Minor Switching Exchange (m) T2 — Secondary Switching Exchange (S)	Obtained from the Originating Exchange File
T3 — Main Switching Exchange (m)	One per State obtained from the Tandems file
T4 — Secondary Switching Exchange (S) T5 — Minor Switching Exchange (m)	Obtained from the Terminating Exchange File.

In a metropolitan network these will be:

T1 — 'X' tandem obtained from the Originating Exchange File

T5 — 'Y' tandem obtained from the Terminating Exchange File

Tandem Blanking — Tandems T1 to T5 are broadly analysed to determine which tandems will not represent the ultimate back-bone trunking of this particular call; e.g. if Tandems 1 and 5 are the same it means that both the originating and terminating exchanges have the same Minor Switching Exchange as their parent. In this case

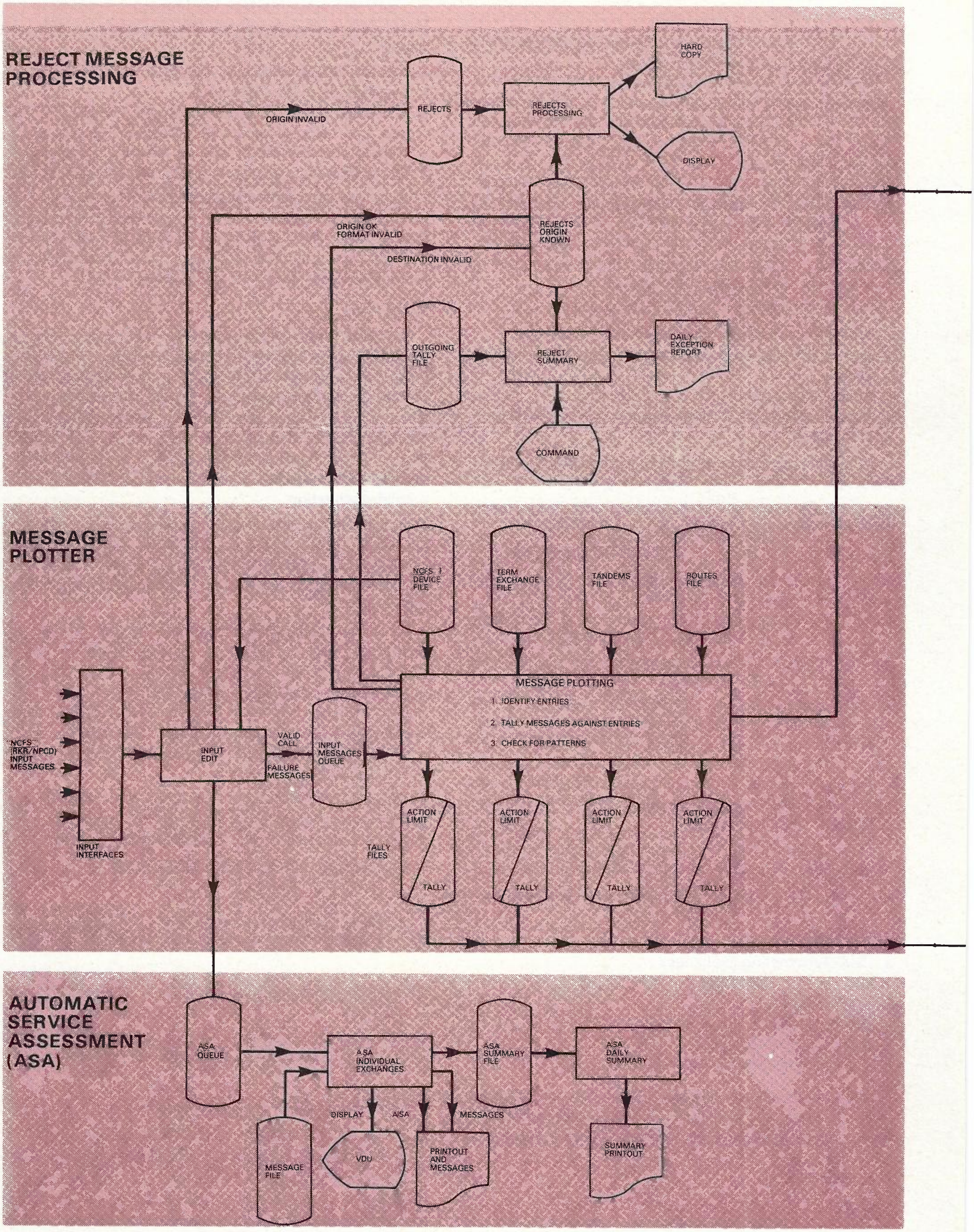
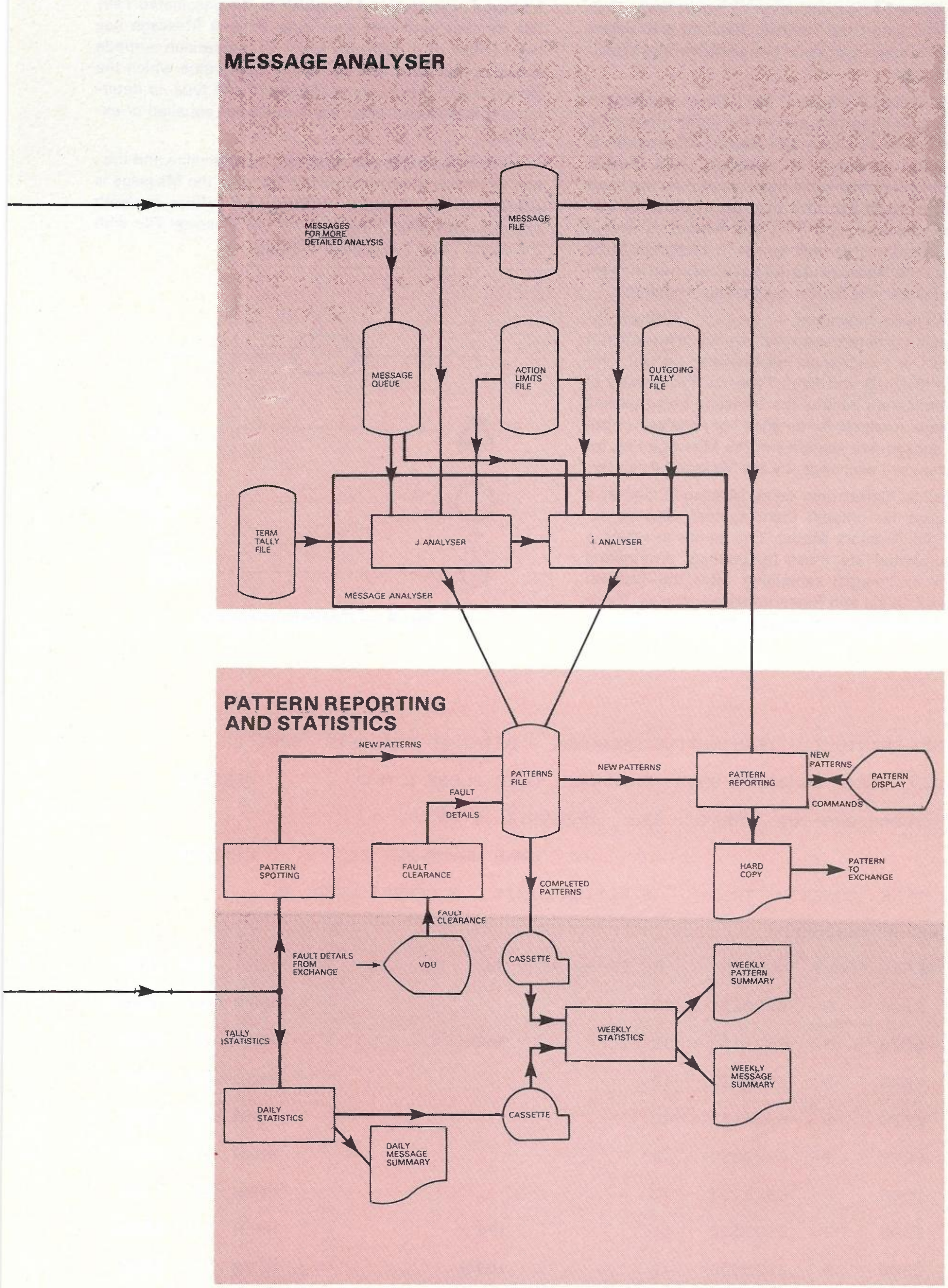


Fig. 7 — General Outline of the NCFS



Processing and Analysis System

Tandems 2-5 will be blanked as the call, in this instance, will not be passed to an exchange of higher order than the Minor. The aim of the Tandem Blanking is to delete those Tandems that a particular call ***could not*** have been switched through.

P Chain & Restart Analysis — the P Chain and Restart analysis forms an important part of the initial processing of a message. The P. Chain and Restart information is used to delete, according to specified rules, further tandems and/or terminal exchanges (i and j) on the basis that the failure ***could not*** have occured at those points.

e.g. a failure message with P=2 and Restart=0 would cause all tandems as well as the 'j' exchange to be deleted as the failure could not have occurred in them i.e., the failure was in the originating exchange.

i and j Analysis Indicators — an i or j Analysis Indicator is set if it is determined that the call failure did not occur at the i or j exchange respectively. e.g. set i Indicator if R=0, P=6 and Fault Type=5. The setting of the i and j Indicators inhibits the Message being passed to the Message Analyser for detailed i or j analysis or being used in subsequent searches of the Message File, for that particular i or j exchange, by the Message Analyser.

The Message Plotter now takes Messages, one at a time, and plots (or credits) them against relevant exchanges in the Network Model. The points at which a Message is plotted are those (originating, terminating and tandem exchanges) remaining after the Tandem Blanking and P Chain and Restart analysis phases. These then are the points at which the call failure may have occurred. At each point in the Network Model at which the Message is plotted, +1 is added to the associated Tally File for that particular fault type. After a Message has been tallied at a particular point, a comparison is made between that Tally and an Action Limit value which the Operator had previously set for that Fault type, to determine if that Action Limit value has been equalled or exceeded.

If the Tally is less than the Action Limit value and the i and j Analysis Indicators are not set, then the Message is passed to the Message Analyser for further in-depth analysis with other Messages on the Message File with the same i and j exchange identity.

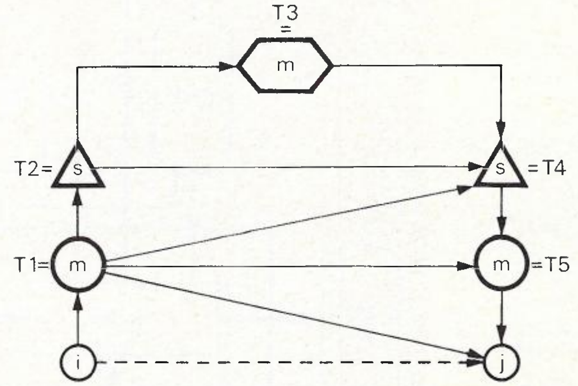


Fig. 8 — Tandem Hierarchy

PATTERN PRINTOUT - TERMINATING EXCHANGE - DETAILED ANALYSIS PAGE 1

SEQUENCE 4104 80/08/08 0930 EXCHANGE: GLEB GLEBE E. M. C. 5697111

FILE: TERM CNA: 02 PREFIX: 692 ANALYSIS: Y TO J

Y : HMKA HAYMARKET T5 2112000

FAULT TYPE: CONGSTN TALLY: 8 ACTION LIMIT: 8 OFFSET USED: 0

DETAILS OF MESSAGES

CNA	PREFIX	FAULT	NUMBER	PRS	SR-AB	RS-L	T1	T2	T3	T4	T5	DAY	TIME
02	2906	9	6920211	42							HMKA	07	1446
02	8076	9	6921133	41			RYDX				HMKA	08	0922
02	8076	9	6921133	42							HMKA	08	0925
02	8076	9	6921133	42							HMKA	08	0927
02	8076	9	6922264	42							HMKA	07	1530
02	2906	9	6923215	42							HMKA	07	1442
02	2906	9	6923520	41			HMKX				HMKA	07	1650
02	2906	9	6923520	41			HMKX				HMKA	07	1651

END

Fig. 9 — Pattern Display — "Message Plotter"

If the Tally equals or exceeds the Action Limit Value, the Messages that represent that Tally are displayed as a Fault Pattern to the Operator at the VDU for detailed technical analysis.

Message Analyser

The function of the Message Analyser is to analyse Messages, one at a time, as they are passed to it from the Message Plotter and to do a detailed comparison with other Messages on the Message File that have the same i and j exchange identities. Messages found on the Message File with the same i and/or j identity as the current Message are further analysed to determine if the following criteria are also the same as the current Message:

j (terminating) exchange
- 200 line group
- 1000 line group
- ϕ first digit dialled
- i exchange
- tandem 5 (y or terminating tandem)

i (originating) exchange
- j exchange
- tandem 5 (y tandem)
- tandem 1 (x tandem)
- ϕ first digit dialled
- other NCFS devices in exchanges

The number of Messages in each criterion are counted or tallied. Each tally is then compared, in turn, to Action Limit values for that particular Message fault type at that point in the network. If a pattern is presented to the operator and is rejected as invalid the comparison of tallies to Action Limit values will continue from where it has previously left off. If a pattern is not accepted during the Message Analyser program, the current message is placed on the Message File for use in other Message Analyser searches.

Pattern and Pattern Display

Patterns can be produced from either the Message Plotter or Message Analyser phases. A Pattern exists when a tally of messages equals or exceeds an Action Limit value set for that fault type at that Network Model point. All the Messages which comprised the tally will be passed to the VDU to enable the Operator to determine, using his detailed technical knowledge of the network, whether an actual fault exists at that point in the network. The operator thus has the option of deciding whether the Pattern as displayed is 'valid' or 'invalid.' Examples of valid patterns produced by the Message Plotter and Message Analyser are shown as **Fig. 9** and **10** respectively.

Valid Pattern — On accepting a Pattern as valid the Message Plotter or Message Analyser will subtract 1 from all the Tally files in the Network Model, which the Messages involved in the pattern were plotted against. These Messages are then marked to be removed from the Message File during the next Message File purging routine. (A message can only be used to form one pattern.)

Invalid Pattern — If a pattern is presented to the Operator and it is rejected as invalid the Plotter/Analyser system will continue, from where it had left off, comparing tallies to Action Limits until a pattern is accepted as valid or the last of the Message Analyser checks are made.

PATTERN PRINTOUT - TERMINATING EXCHANGE - PAGE 1

SEQUENCE 4331 80/08/13 1140 EXCHANGE: DALB DALLEY 278103

FILE: TERM CNA: 02 PREFIX: 2411

FAULT TYPE: CONGSTN TALLY: 10 ACTION LIMIT: 10 OFFSET USED: 0

DETAILS OF MESSAGES

CNA	PREFIX	FAULT	NUMBER	PRS	SR-AB	RS-L	T1	T2	T3	T4	T5	DAY	TIME
02	8076	9	241128	32							HMKA	13	0930
02	3896	9	241143	32							HMKA	12	1537
02	9697	9	2411621	33							HMKA	12	1457
02	4275	9	241167	31	43	51	CHAX				HMKA	13	1141
02	9696	9	2411745	33							HMKA	13	1017
02	2216	9	241176	32			HMKX				HMKA	11	0921
02	8966	9	24120	32							HMKA	12	1527
02	8966	9	24120	32							HMKA	12	1003
02	6356	9	2412251	33							HMKA	11	1615
02	2216	9	241376	32			HMKX				HMKA	13	0932

END

Fig. 10 — Pattern Display — "Message Analyser"

System Statistics

Daily and weekly statistical summaries of NCFS messages received and fault patterns produced are compiled. These enable the operator to oversight the performance of the complete NCFS system and its effectiveness in improving the performance of the telephone network.

Automatic Service Assessment (ASA)

Whilst the main function of NCFS devices is to identify call failures, a performance measuring facility has also been included. On command an NCFS device can be set to count a preset number of call attempts and also count the number of these calls lost due to network faults and plant congestion. Upon reaching the required call sample the ASA facility is reset and the numbers of call attempts, network faults and plant congestion is transmitted as an ASA message to the NCFS minicomputer.

On receipt of an ASA message, the Input Edit program passes it to the ASA program.

At the end of each day an ASA summary is produced for each exchange at which the ASA facility had been finalised. The ASA summary contains a percentage, switching loss (network faults) and plant congestion for the network as seen from that particular exchange. A network figure is also produced by the summation of the call attempts, switching loss and plant congestion figures from all the exchanges.

CONCLUSION

At present NCFS Messages are being produced by over 70 NCFS devices in the Sydney Telephone District. These Messages are being processed by the initial NCFS minicomputer system installed at the Sydney metropolitan NPAC. The initial NCFS minicomputer installation has met all Telecom's expectations and at present plans are under way to provide eight systems which will cover the entire Telecom network.

The initial study of the application and value of NCFS information was undertaken by staff in Adelaide. The feasibility study, production of system specification, and field evaluation of the minicomputer system was undertaken by staff in Sydney. The success of the project is a tribute to the work of these people and the contractor for the minicomputer, Computor Sciences of Australia Pty. Ltd.

THE WINSTON CHURCHILL MEMORIAL TRUST
CHURCHILL FELLOWSHIPS TO UNDERTAKE OVERSEAS STUDY PROJECTS

Objects of the Churchill Trust

THE WINSTON CHURCHILL MEMORIAL TRUST was established in Australia in 1965, the year in which Sir Winston Churchill died. The principal object of the Trust is to perpetuate and honour the memory of Sir Winston Churchill by the award of Memorial Fellowships shown as "Churchill Fellowships".

Function of the Churchill Trust

The aim of the Churchill Trust is to give opportunity, by the provision of financial support, to enable Australians from all walks of life to undertake overseas study, or an investigative project, of a kind that is not fully available in Australia. This opportunity is provided in furtherance of Sir Winston Churchill's maxim that: "With opportunity comes responsibility".

There are no prescribed qualifications, academic or otherwise, for the award of a Churchill Fellowship. Merit is the primary test, whether based on past achievements or demonstrated ability for future achievement in all walks of life. The value of an applicant's work to the community and the extent to which it will be enhanced by the applicant's overseas study project are important criteria taken into account in selecting Churchill Fellows. However, Fellowships will not ordinarily be awarded in cases where the primary purpose of the application is to enable the applicant to obtain higher academic or formal qualifications nor to those in a vocation which offers special opportunity for overseas study.

The Churchill Trust gains its income from its capital fund which now stands at over $6.2m. The original capital of $4.2m was subscribed, or pledged, in 1965 by all sections of the Australian community to enable the Churchill Trust to be established as a perpetual memorial to Sir Winston Churchill.

Scope of Churchill Fellowships

Churchill Fellows are provided with a return economy-class overseas air-ticket and an Overseas Living Allowance to enable them to undertake their approved overseas study project. In special cases they may also be awarded supplementary allowances including Dependants' Allowance. Fifty-one Churchill Fellowships were awarded for 1981 at a total budgeted cost of $450,000.

All Churchill Fellows are presented, at an appropriate ceremony, with a certificate and badge identifying them as such. The certificate bestows upon the recipient the prestige of being a Churchill Fellow and, while a Fellow is overseas, serves to open many doors that would not otherwise be opened to a private individual.

Applications for Churchill Fellowships

The Churchill Trust is now calling for applications from Australians, of 18 years and over, from all walks of life who wish to be considered for Churchill Fellowships tenable in 1982.

Completed application forms and reports from three referees must reach the Churchill Trust by 28 February 1982.

People wishing to be considered for a Churchill Fellowship should send their name and address NOW with the request for a copy of the Churchill Trust's Information Brochure and application forms to:

The Winston Churchill Memorial Trust (M),
PO Box 478,
CANBERRA CITY ACT 2601

or, for residents in South Australia, Western Australia, Tasmania and the Northern Territory, the appropriate address below:

The Winston Churchill Memorial Trust (M),
GPO Box 498, ADELAIDE, South Australia 5001
PO Box 6209, Hay Street East, PERTH, Western Australia 6000
GPO Box 1260N, HOBART, Tasmania 7001.
PO Box 2147, DARWIN, Northern Territory 5794.

Social Needs and the Interaction with Technology: Progressing from Telecom 2000

DOUGLAS M. ROWELL

Telecom Australia has adopted social research and planning techniques which are able to recognise and internalise social needs as they interact with technology. This activity in progressing on from Telecom 2000 has provided new dimensions to telecommunications planning in Australia.

The term 'social needs' may have many connotations from the standpoint of telecommunications planning; the notion that people have a need to relate to one another, to communicate, seems to have greatest relevance to this context.

There was a time, not so long ago, when technology was both the limiting factor and the driving force in telecommunications development. The range of telecommunications services available to society limited the scope for choice. New technologies, new concepts, new economies were necessary. The basic telephone services and some relatively minor variations were available to satisfy the very basic needs.

Now the tables have turned. Technological developments have resulted in a situation where many new types of telecommunications facilities can be produced and choices must be made by the telecommunications planner and society. The driving force has become the social need, e.g.:

- do we require confravision and videophones;
- do we want to work at or near home;
- do we want "follow me" calls, cordless telephones and mobile communications?

It is no longer a case of "if only we could" because the technology to do many things is available and the present limiting factor and important considerations in telecommunications planning and research as seen by Telecom Australia, is the social needs of the Australian people for telecommunications services.

The impact of technology on society is the subject of continuing current debate and one inference is that society is under attack from some diabolical, uncontrollable force called technology. To adopt such a thesis is to take far too simplistic an approach to a complex and highly interactive set of issues and to focus on today without due consideration of history. Various forms of technology have been developed and applied to fulfil the social needs of humanity since time began. The motor car was built to provide mobility, the house was built to provide protection and comfort and the telephone provides communications.

"Society's needs, technology, and the social effects of technology are all interacting parts of a continuous process — a sort of complex chain reaction. There is nothing novel in emphasising the uneasy partnership that exists between technology and society in emphasising the complex and often ambivalent effects of much technological development — some good for society, some bad. Basically, the ambivalence stems from the very nature of the two systems. To strike a sharp distinction — technology can be described as rationally based, scientific, logical. The social system is a human, living system, one in which large measures of irrationality, illogicality and unpredictability are likely to be encountered in its development." (Telecom 2000, p.2).

Notwithstanding this brief expose of the socio-technical system, it is necessary to maintain proper perspective by emphasising that it is society (i.e. the people) who make decisions about technology, not vice versa.

The question still remains, however — how do we plan in such circumstances?

A FUTURES STUDY — TELECOM 2000 AND OUTCOMES

The Study

In the early 1970s there was growing awareness of new possibilities in the application of technological change in providing telecommunications services, e.g., "the wired city", "the global village", "the information based society", "the home office", and this suggested

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See Volume 30, No. 2.

that telecommunications was on the threshold of a new era. To undertake an exploration of the possible directions of long-term development of telecommunications in Australia, the then Australian Post Office set up in 1973 a planning group known as the National Telecommunications Planning Branch (NTP).

The NTP multi-disciplinary team set about this examination with the interactive assistance of users, academics, industry, Telecom people and others by way of seminars, discussion, consultancies and correspondence.

Public Comment and Outcomes

The major product of this planning exercise, **Telecom 2000 — An Exploration of the Long-Term Development of Telecommunications in Australia**, was distributed in 1976 to all sectors of the community. Copies were sent to members of the Federal and State legislatures and judiciary; Federal, State and Local Government Departments and Authorities; educational institutions, industrial, professional, business and social organisations; and many private citizens involved in community and social activity. The public was invited to obtain copies.

There were 210 written responses to the invitation to comment on Telecom 2000 and its recommendations, ranging from formal acknowledgement to comments in depth. Most of the detailed commentaries were of a high calibre, introducing a wide range of complex issues and suggested solutions. An analysis of the responses and the recommendations as accepted by management in 1978 are set out in the publication **Outcomes from the Telecom 2000 Report**.

TELECOM 2000 AND FUTURE TECHNOLOGIES

Telecom 2000 identified the emerging technologies which had the greatest potential for development of telecommunications over the period of 25 years to the year 2000 as those associated with:

- computers
- digital communications
- wideband distribution media
- mobile radio
- satellites

Advances in technology since 1975 — in a short 4-5 years — have exceeded expectations. Technology is available to provide for all manner of services in these categories. Some discussion of the current state of development will remind us of the highly advanced state of development that now exists in telecommunications technologies. It may well be said that society can have the services it wants if it is prepared to "pay" for them. It is a question of value versus cost, where the cost may be both in monetary and social terms. It is on the balance of these issues that society is now required to make a choice.

Computers

The computer industry has been transformed by the nature and the rate of change towards miniaturisation, the development of sophisticated software languages and the increased speed and reliability now achievable. Increasing speeds have overtaken the speed capabilities of input and output devices so that large central computers now serve a large number of timeshared speed-buffered terminals which may be located anywhere. In 1960, man went to the machine; within a decade, the machine was coming to man and since then improved operational ease and reduced cost have enabled these machines to come to more and more people.

Time sharing and sophisticated software have facilitated the interactive use of computers so that their powerful capabilities are now available for use by relatively inexpert operators. Within Telecom alone, there are now many very complex programmes being used by people who know nothing about programming; who feed data in and use the results in exactly the same way that many people use STD in complete ignorance of the telephone network's response to dialling a number.

Computers, being machines with the capacity to carry out complex sets of instructions, are being used to control a very wide range of industrial processes, machines etc. The telephone switching equipment, which, in Australia, facilitates the interconnection of over 4 million telephones, is being converted to processor (computer) controlled equipment — in other words, to computers — in a steady programme in which most of the electromechanical equipment in the Australian network will have been replaced by the year 2000.

Digital Communications

Stemming from technological advances in the utility and application of solid state electronic devices, it is now practical and more efficient to carry out transmission and switching functions on signals in digital rather than analogue form. The basic attraction of digital transmission is that the interference and noise, which inevitably accumulate along the entire length of a transmission system, can be virtually eliminated by regeneration of the signal. Further, gain stability and overload characteristics are determined almost entirely by the coders and decoders, not by intermediate repeaters.

However, the high investment in the existing analogue transmission/space division switching network is a brake on the rapid introduction of digital systems, as these must be interlaced with the existing network as they are introduced. It is clear, however, that there are already economic advantages in the provision of digital group switching stages in the next generation of computer-controlled local exchanges.

It will be readily appreciated that the signals transmitted between computers and their associated terminals, being already in digital form, would most ideally be transmitted via a digital transmission and switching network. Bearing in mind this and the 40% annual growth rate in data traffic occurring and forecast for the future, Telecom decided in June 1977 to establish a pilot digital data network providing about 90 leased lines linking Melbourne, Sydney and Canberra by mid-1981. If successful, the network would be extended to all capital cities other than Darwin by mid-1982.

However, the need for a digital data network has increased since 1977 to the point where Telecom found it necessary in December 1979 to set up the Data Services Sub-Division in Telecom Headquarters to accelerate the establishment of the digital data network, to extend it to all capital cities and to establish a packet switching system to service the new network by the end of 1981.

Wideband Distribution Media

In many parts of the world, TV transmission operates on a wideband cable distribution system (Cable TV) in addition to the conventional propagation through the air (Broadcast TV). These systems carry tens of channels, but are designed for one way transmission.

The development of optical fibre transmission systems, however, offers the possibility of a practical and in the long term, cheaper wideband distribution network. Experimental optical fibre systems, particularly in USA and Canada, have been operating for some years, but it is not expected that they will be economic for voice telecommunications traffic until the mid-1980s.

In mid-1980, a repeaterless 10 fibre, 9.6 kilometre system will be laid on the high density route between Seattle and Everett, Washington. Initially the system will carry 1344 voice channels with ultimate capacity of 3360 voice channels or the equivalent video transmissions.

Similar developments are taking place in Canada. Of particular interest is the Elie, Manitoba, Winnipeg Trial. A remote area 40 x 60 kilometres consisting of 150 homes is being reticulated with optical fibres. A sophisticated package of communications including TV, Telidon, alarm and control systems, will be provided as a technology trial, a user acceptance trial and a new services trial.

Apparently, a significant contract is about to be let for optical fibres for Saskatchewan. This contract will require a greater level of production than before and it is considered that this should bring about large price reductions.

Telecom studies indicate that the earliest optical fibre applications in Australia are likely to be in metropolitan junction networks on high growth routes and later as an alternative to coaxial cable in the trunk network. A trial optical fibre junction cable is being installed in Melbourne shortly, but extensive use of wideband services is not planned in Australia in the immediate future. Developments in other parts of the world are, however, being closely monitored.

Mobile Radio Telephones

The keynote of future telecommunications services must be flexibility in that we must attempt to provide service when and where it is wanted. An important example of this flexibility is the provision by Telecom Australia of sophisticated mobile radio telephone systems in the large metropolitan areas of Sydney and Melbourne by mid-1981. These systems, each having a capacity of 4000 services, will enable calls to be established and maintained automatically between the motor vehicles in which they are installed and all telephones and other vehicles connected to Telecom Australia's network.

For Melbourne, the system design includes the provision of three base stations giving three overlapping radio zones.

Commonly the radio zones are given the name 'cells' and the overall system is known as a 'cellular' system.

Extension of the service to other places will depend on the outcome of experience with the Sydney and Melbourne services in terms of demand and economic viability.

Satellites

The key advantage of satellite communications compared with terrestrial systems is the extreme flexibility which they offer. This flexibility has two features:

- Communications can be established between any two points located in the area covered by the satellite's antenna system; and
- In a network consisting of more than two earth stations, the satellite's capacity can be variably assigned with time to cater for variations in demand for transmission capacity between pairs of earth stations.

Satellites are currently used to provide many forms of communicating services both nationally and internationally.

Present day technology offers the possibility of large platforms in geostationary orbit with available primary power of 1-2 kilowatts. These platforms could accommodate a number of special purpose transponders in addition to or instead of the basic 'standard' transponders, and the diversity of communications functions now available is virtually unlimited. Plans are being made for satellite to satellite links and for on-board switching of digital traffic.

Basic trade-offs in design exist between the facilities the satellite provides, the life of the satellite and the size and basic cost of the earth stations. There is room to move on each of these parameters, but the ultimate trade-off lies in the costs versus the social needs fulfilled by the satellites.

The Information Revolution

With the advent of computer sciences and sophisticated telecommunications developments, advanced industrial based societies now find themselves in the midst of an information revolution and this situation, which was evident during the Telecom 2000 studies, is even more apparent and pertinent to telecommunications planners today.

Technology has provided the fundamental tools for more effective information transmission, storage and retrieval. Society's need for information has fanned this revolution, the need being perceived as an important factor in obtaining personal (or group) comfort, security and/or pleasure, or in establishing and maintaining a competitive edge.

Economists, in developing methods to classify, measure and account for its sectorial significance, have developed the notion of a fourth sector, the information sector, in addition to the three traditional sectors; primary (agriculture, minerals), secondary (manufacturing), tertiary (service industries). This thesis provides a means of dimensioning the effects of such a revolution and its further development may assist the understanding of telecommunications planners.

The increasing importance of information, and more specifically, its transfer using telecommunications, in the Australian economy, was recognised at the time of developing Telecom 2000. At that time it was noted that approximately 30% of the total workforce were involved in the collection, storage and dissemination of information and that in industrialised societies the increasing dependency on information technologies was becoming more apparent. Concentration on telecommunications, which represents only about 2% of the workforce, may be viewing only part of the problem and thereby obscuring the socio-economic significance of decision-making in this rapidly developing field.

Some characteristics of the information revolution are:

- Fundamental — making radical change in lifestyle
- Universal — affects almost everyone
- Irreversible — return to prior ways and customs impossible
- Iconoclastic — destroys old beliefs and creates new ones
- Accelerative — high rate of change

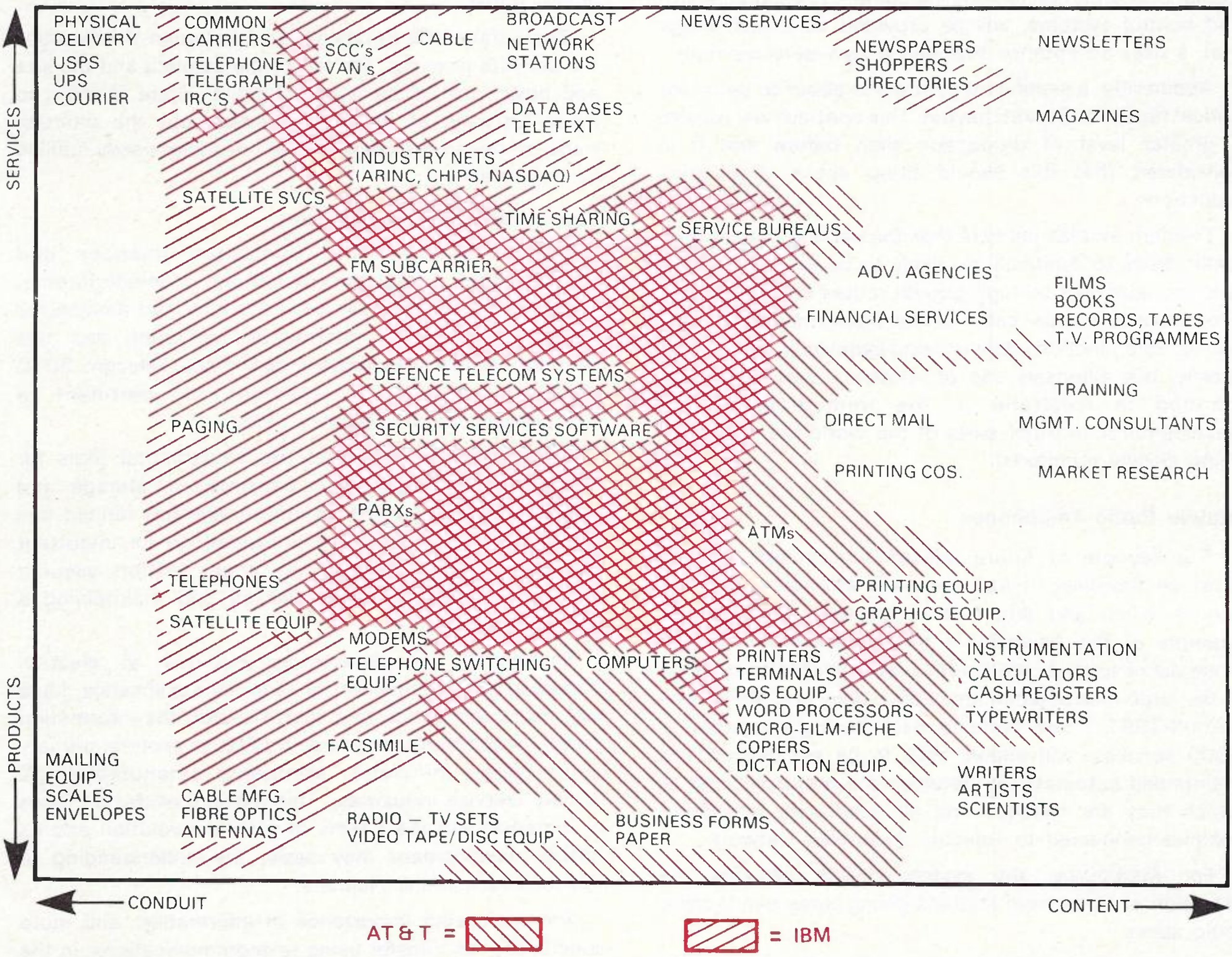
There are few technological impediments to such a revolution and the acceptance or non-acceptance will be a matter of social pressure, adjustments and ultimately, decision-making.

Some of the social factors influenced by the information revolution include:

- everyone can be his own publisher
- universal access to knowledge
- work from home or near home
- decentralisation
- energy conservation (communicating instead of commuting)
- transformation of education
- place and time independent
- tailored to individuals
- pedagogical excellence
- destroys tyranny of place
- creative freedom of choice

It is obvious that these factors have a profound effect on society and the lifestyle of people and therefore people will be the 'change agents', not technology. The additional question raised by the information revolution is its effect on the relative socio-economic position of the "information poor" and the unskilled.

If such a state of change — be it defined as a revolution or not — is to be effectively managed by telecommunications planners and researchers, an improved understanding of the social factors involved and their interaction with the technology is paramount — more information is needed about information.



Reprinted by permission from John F. McLaughlin with Anne E. Birinyi Mapping The Information Business — December 1979 Working Paper W-78-8
Harvard Program on Information Resources Policy Cambridge, Ma, Dec 1979

Fig. 1 — The "Information Business'

MAPPING THE 'INFORMATION BUSINESS'

Some interesting work has been done by John F. McLaughlin of the Centre for Information Policy Research, Harvard University, and documented in a paper on Mapping the Information Business (December, 1979). He considers that the phrase "information industry" suggests a degree of structure, cohesion and integration that is misleading. The map in **Fig. 1** sets out on two axes a number of products and services which could be said to make up the information business. The axes of the map are Services and Products on one axis and Content and Conduit (or distribution system) on the other.

McLaughlin in his paper goes on to illustrate the way such a map can be used to look at the theory and practice of government legislation or the market scope of companies and organisations in the information industry. In particular, he looks at the convergence of telecommunications and computers (known to some as compunications) and outlines current and future maps of the IBM and AT&T markets in USA.

For the purpose of this paper, however, the map demonstrates the extent and a form of relative positioning of the many facets of the information business and illustrates why an information revolution is so pervasive to society.

A NEED TO BE EMPLOYED

One cannot address the question of technology or technological change without considering employment aspects. At the level of the individual, man has a need for employment in order to purchase goods and services associated with food, accommodation, health, safety and security. In addition, employment is used by the individual to achieve recognition, self-esteem, growth and self-actualisation. (Maslow's hierarchy of needs). At the community level, low unemployment is seen to be associated with stronger economic development and lower levels of unemployment benefits and personal taxation.

In pursuit of the need to be employed, with a desire to make life easier and more secure, man has researched, developed and implemented all manner of technologies. The economic structural relationships are complex with one man's product being another man's feedstock and one man's achievement being another man's purchases.

Current debate and popular newspaper influence (e.g. Computer Holocaust) would suggest man's quest for employment in the development of technology will react adversely in causing unemployment. As stated in the study on 'The Implications of Technological Change' by I. Mapperson, published by the Committee for Economic Development of Australia (CEDA), November 1979:

"Technological change has engendered a quite remarkable degree of public debate and discussion in Australia over recent years. In 1978 a strike by members of the Australian Telecommunications Employees Association brought into sharp focus the question of whether technological progress will give rise to substantial unemployment".

The same report quoted from Mr Christopher Jay's article from the Australian Economic Review, March 19, 1979, on 'Technical Innovations':

"Studies of Australian companies have shown that those which have failed to invest in new, high productivity equipment have actually sacked more workers than companies which have protected their competitiveness by modernising their production machinery".

A central thesis of the report is:

"That significant unemployment will not arise because of the implementation of new technologies, but in fact will only occur if such technologies are not implemented".

Man's need for employment may be said to be of a primary (for food) or a secondary (for fulfilment) nature. In fulfilling the social need to be employed, man provides the economic outputs of the primary, secondary, tertiary and quartinary industries. These outputs, in themselves, might be said to provide the sustenance, mobility, comfort and information he needs for his social well-being. The technologies employed in these industries have been developed as a result of man's quest to improve his social well-being.

The argument as to whether advanced technology creates or destroys jobs is indeed complex and will continue. It is clear, however, that new services and products are created by new technology. The telephone was itself new technology only 100 years ago.

Telecom is seeking new services and products such as facsimile, videotex, teletex and with the application of fibre optics, a whole range of new visual services requiring new cable systems to be provided may emerge. If these new services and products are seen by society as fulfilling an affordable need, they will be provided.

SOCIAL ACCEPTABILITY OF PRODUCTS

Just how socially acceptable are the telecommunications technologies now available? Do people want to live in 'wired cities' and work from 'home or near home offices'? Notwithstanding the economics of these possibilities, the technology is available to bring about these changes today. With further technological developments occurring day by day, the economic aspect is becoming more attractive and this, of course, is assisted by rapidly increasing fuel prices. There is evidence to indicate that the technologies which exist today may have far greater capabilities than are required by society at this time. This does not mean that application of existing technologies and further development is not required in some areas. It does mean that the response of society as seen in the marketplace — the demand for services — is shaping the direction of development. Such products as video telephones, confravision and home office facilities have not received the level of acceptance anticipated and this had affected developments in these areas. Questions remain concerning the acceptability of Videotex from the sociological viewpoint.

SOCIAL RESEARCH AND PLANNING IN TELECOM AUSTRALIA

Policy Research

To help answer some of the questions relating to the appropriate direction of technological development in support of products which fulfil social needs, Telecom undertakes policy research work employing interdisciplinary groups and the range of studies includes the internal organisation, interaction with the external environment and general policy concerning the application of technology to the fulfilment of social needs — in particular — those of its customers. Policy research, as a prerequisite for policy review and formulation, is now performed on a much broader base with the involvement of the major functional areas and the use of consultants as necessary. Of particular interest is a Social Research seminar recently conducted and a planned seminar on Public Policy-Making and Telecommunications Planning.

Social Research Seminar

In August, 1979, Telecom Australia organised and funded a seminar; 'Social Research and Telecommunications Planning', with the following objectives:

- to increase the awareness within Telecom of the social impacts of its policies and services as perceived by external experts;
- to keep Telecom in touch with social and economic trends that will affect the type of service that will need to be provided in the future, and the manner in which the services have to be provided;
- to further Telecom's commitment to open planning as a way of developing policy;
- to identify fields of social research work of particular relevance to telecommunications planning.

Seminar Concept and Structure

The concept of the seminar was initiated when the National Telecommunications Planning (NTP) Group, now the Policy Research Branch, set about reappraising its organisational role and began questioning the fundamental nature of the social sciences and the contribution they could be expected to make to telecommunications planning. The outcome of this process was a seminar covering a broad range of topics, and involving social scientists, both academic and practising, and Telecom managers — a total of 60 attended with a ratio of about 2:1 non-Telecom to Telecom being the design objective. Two days were set aside for the seminar with opening and concluding half-day sessions spanning two half-day workshop sessions. In summary, we were particularly keen to progress from **Telecom 2000** and the **Outcomes**, and this seemed like a good way to take that step.

The following six workshop topics were derived from NTP's understanding of definitive areas where some social research seemed to be necessary. A degree of overlap was recognised, but it was considered that this type of generous model would enable flexibility of coverage to be achieved in the seminar:

- Social Trends and Communication Patterns
- Distributional Consequences of the Provision of Specific Services
- Social and Technical Implications
- International Developments as they Affect Australia's Telecommunications Planning
- The Information Economy
- Planning — Theory and Practice

To cover the topics and derive maximum benefit from the resources, which would be necessary to achieve such coverage, an interactive design process was arrived at. We started with the idea of a Delphi process, but decided that we should give the participants more scope to tell us what the topics were really about. In the first instance, the six workshop topics were defined briefly (in about a page) and no attempt was made in this exercise for completeness or to otherwise polish the definitions. To some extent they were designed to be thought provoking. These definitions, for want of a better description, were sent to each invitee as part of the invitation process, and a contribution of not more than two pages was requested on one or all of the topics. Three-quarters of the invitees responded to this request. In all, counting general and specific comments, 100 commentaries were received. These commentaries were then synthesised by Departments within Telecom into opening papers for each topic, and copies of these were distributed before the seminar. These synthesis papers avoided identifying contributors, to avoid putting people at the seminar in fixed positions prior to entering the workshop activities.

Seminar Analysis

The 'increased awareness', 'keep in touch' and 'open planning' implications of the first three objectives of the seminar (listed above) are somewhat less tangible than those of the fourth, but generally all three were felt to be successful. This success may in part be measured by the spirit of mutual goodwill which has been cemented between Telecom planners and the social science 'world' in Australia and the formal and informal contact chains which have resulted.

The six workshop reports contain a fund of interesting and useful ideas, information and proposals, but it is not possible to give full coverage in this paper. These proposals are being considered by Telecom Australia management and definitive action will be taken to obtain maximum benefit from what is considered as a most meaningful planning activity.

To assess the full value it is necessary to read the *Proceedings* and in particular, the workshop reports. Comment on the *Proceedings* of the seminar has been invited as part of its 'open' approach to planning.

Public Policy-Making and Telecommunications Planning Seminar

It is recognised that telecommunications is an integral part of the fabric of society in Australia. The extent and nature of the role telecommunications plays in shaping society and complementing its development is a complex and dynamic question and therefore requires continuous study in order to develop the necessary understanding to enable effective planning of telecommunications in Australia to take place. There are many institutions, government departments and organisations who, in fulfilling their functions, make decisions which affect public policy and, as a consequence, influence the nature of Australian society. It is of value to telecommunications planning to develop an understanding of the interaction between these various bodies and Telecom Australia to facilitate the mutual development of public policy.

A seminar on Public Policy-Making and Telecommunications Planning was held during August, 1980. This seminar took a similar form, both in objectives and format, to the one on Social Research and Telecommunications Planning, in that internal and external participants were invited to discuss issues of mutual interest and concern. 40 policy makers from Federal, State and Local Government Organisations were invited to discuss these topics with about 25 senior Telecom participants.

The four broad topic categories and associated workshop topics considered appropriate for discussion were:

Planning and Policy-Making Processes

Institutional Approaches to Planning and Policy-Making

Community and Environmental Considerations in Planning and Policy-Making

Telecommunications and Economic Development

The Effect of Telecommunications Services on Development

Support of Australian Industry

Technical and Service Developments

Social and Welfare Aspects of Telecommunications

New and Emerging Telecommunications Issues

Telecommunications and Land Use

Spatial Development Issues

Telecommunications and Energy

Open Planning the Corporate Plan

The concept of "open planning" as developed in the **Telecom 2000** study is currently being applied to the revision of Telecom's Corporate Plan. Accordingly, participation was invited from people who otherwise would not have taken part in producing the new Plan. These included users of the Plan in Telecom, both in Headquarters and the State administrations, fourteen Staff Associations and Unions representing almost all of Telecom's staff, organisations representing Telecom's customers and suppliers of equipment, and bodies associated with science, technology and communications. Each participant was invited to say what the Plan should be about, what points should be made and how the Plan should be structured.

Remote Area Needs Study

The multidisciplinary Policy Research group which was involved in the **Telecom 2000** study, has been working closely with a consultant on a study of the needs of the people living in the remote areas of the Northern Territory for telecommunications services. This work has involved a detailed socio-economic study involving a demographic survey, structured interviews, multiple choice demand questionnaires and associated analysis as well as an in-depth anthropological study of Aboriginal needs.

Similar work has been undertaken in the remote areas of other States to enable the work done in the Northern Territory to be readily extended to the national level. This work will be of immense value to the future planning of the application of technology to fulfil identified needs in these areas.

SUMMARY AND CONCLUSIONS

Telecom Australia recognises its responsibility for the balanced development of telecommunications services throughout Australia. In carrying out this task it must take into account the social needs of the people of Australia for telecommunications and manifest these needs in the form of meeting and satisfying demand on its development plans and programmes. At a time of rapid change in society, there is a tendency to focus on the 'means' and not the 'ends'. Technological change occurs (in most cases) because society wants it to occur and the rate at which it changes is a direct function of the acceptability of and demand for services, which fulfil social needs. Technological change forced by technocrats against the will of society will be destined for failure. The work of the telecommunications planner is to adopt social research and planning techniques, which are able to recognise and internalise social needs. **Telecom 2000** and its sequel, **Outcomes,** were socio-technical research and planning activities that provided new dimensions to telecommunications planning in Australia. The more recent seminar on Social Research and Telecommunications Planning further extended this work and with its success comes a host of useful concepts, attitudes and recommendations — a veritable window into understanding social needs. The seminar on Public Policy-Making and Telecommunications Planning will extend even further these ideas and the research and planning networks established should assist in the formulation and implementation of Telecom Australia's future development plans.

Open Planning, the Corporate Plan and the socio-economic study of the needs of the remote areas of Australia for telecommunications services provide a richness of understanding in the planning process that can only come from the people of Australia.

FURTHER READING

Rowell D. M., 'Social needs and Technology — A Partnership for Future Telecommunications Developments in Australia'; Telecom Journal of Australia, Vol 30, No. 2, 1980, pp 92-99.

Statistical Methods in Quality and Reliability Assurance

J. R. TAYLOR, MIE (Aust), CQE, and M. H. ROSSITER, B.Sc. (Hons), (Statistics)

The use of Statistical Methods, central to the Science of Quality and Reliability Engineering from its origin in 1924 with the publication of Dr W. A. Shewhart's early papers, is becoming increasingly recognized as necessary in all Technological work. The application of the Scientific Method requires the use of Statistical Mathematics, which in turn makes possible proper planning, design and testing of the continuing sequences of hypotheses necessary for Technological development and growth.

The definition of the terms used in describing the different categories of work associated with Quality and Reliability Engineering places the work in perspective. The paper describes the application of Statistical Methods in economising the effort required, and in increasing the productivity of each of the functions which must contribute to the Quality and Reliability of the telecommunications system.

Telecom Australia purchases hundreds of millions of dollars worth of telecommunications equipment each year to satisfy the communications needs of the Australian nation. Ordinarily one would think that the high levels of Quality and Reliability required in such high technology equipment would make it necessary to examine in infinite detail all of the many types of equipment and their myriad of component parts. Such an approach would require the Telecom Headquarters Quality Assurance (QA) organisation to be many times its present size, and to have a large army of inspectors performing the measurements and supplying the Headquarters Statisticians and Quality Engineers with data on every feature of every product. If this strategy were used, each piece of equipment would have to be disassembled, giving access to the thousands of component parts, electrical contacts, integrated circuits, optical elements, and each individual piece of wire and metal part. And then, after reassembly, would they be as high in Quality and Reliability as when the manufacturer had made them?

Fortunately such an expensive testing and inspection procedure is made unnecessary by the use of Statistical Inference. What is this mathematical magic, and how is it made valid by the way designs and manufacturing processes produce and assemble such a vast array of high technology equipment? The use of statistical methods, both in the control of the manufacturing processes, and in the inspection of products from these processes, permits an acceptable level of knowledge of the equipment quality and reliability to be inferred from the measurement of a small representative sample.

Most of the assurance of quality and reliability comes from what the Supplier of the telecommunications equipment does, some from the work of Telecom Inspectors and Quality Assurance Statisticians and Engineers. It is the role of the Telecom Headquarters Quality Assurance organisation to provide assurance that the many types of cable, network equipment and subscriber's instruments all have the necessary quality and reliability to provide good service throughout their planned lifetime. The Oxford concise dictionary defines 'assurance' as a formal guarantee. It is through the rigour of statistics and the scientific method that statistical inference is able to provide a high degree of formality in the assurance of Telecom's raw materials, equipment and software.

Quality work performed by Telecom Australia's suppliers, and that carried out by Telecom Staff can be best understood when each is defined. Suppliers do Quality Control work, while Telecom Staff do Quality Assurance work. This is explained as follows;

Quality Control Work: All that work carried out within one organisation and having as its purpose the achievement, measurement and reporting of acceptable levels of Quality and Reliability in the products produced by the organisation. (In the equipment supply situation this work is normally performed by the equipment manufacturer, however the term applies to all types of work performed within the organisation by all kinds of organisations.)

Quality Assurance Work: All that work carried out by one organisation which has as its purpose the achievement of acceptable levels of Quality and Reliability by a second organisation, and the measurement and reporting of the levels of Quality and Reliability being achieved. (In the equipment supply situation this work is normally performed by the Customer when working with a Supplier).

Confidence by the Customer that the equipment being supplied has the required levels of Quality and Reliability is what is sought. Confidence must therefore be transferred from each supplier to each customer in the supply sequence. Confidence in a product's Quality and Reliability may be gained by a Customer in three ways. These are;

- from the Suppliers total control of quality in his production operation, and a statistically valid sample of data from measurements on the products.
- from a 100% measurement by the Supplier of all specified product features, using a measurement system in which the Customer has confidence, and the supply of data from the measurements.
- from a remeasurement of the products at the time they are offered, the measurements being performed by the Customer on a 100% basis, or as most often happens, on a statistically significant sample.

Confidence in the Quality and Reliability of telecommunications equipment is of a statistical nature based on the laws of probability. Over the years the methods of statistical inference have been developed to a high state of refinement, giving Quality Statisticians a powerful tool with which to investigate the high technology products used in telecommunications.

QUALITY AND RELIABILITY

Quality and Reliability, as normally used, are qualitative terms which mean to the Customer that a product having them will do what he wants it to do when first received, and will continue performing as desired over some period of time. There are two kinds of Reliability, that without repair where the product must be thrown away when no longer serviceable, and that with repair where the product may be returned to operating condition for an economic cost each time it has failed, and may be successively repaired for some number of times.

The Quality Assurance Statistician must have these terms expressed definitively so that they may be assessed on a quantitative level in order to provide assurance through the use of statistics. For this purpose we may define them as follows;

Quality: The probability that the feature dimensions of the item of product will fall within their specified sets of limits at the time the product is offered to the Customer by the Supplier.

Reliability (Without Repair): The probability that the feature dimensions of the item of product will fall within their specified sets of limits after enduring the specified environment and/or operating conditions for the specified lifetime.

Reliability (With Repair): The probability that the feature dimensions of the item of product will fall within their specified sets of limits after enduring the specified environment and/or operating conditions for the specified mean time between failures.

The achievement of Reliability in products is a three step procedure. First the designer attempts to conceive of the device or system which will fulfill the intended function. Then he attempts to provide a clear, unambiguous

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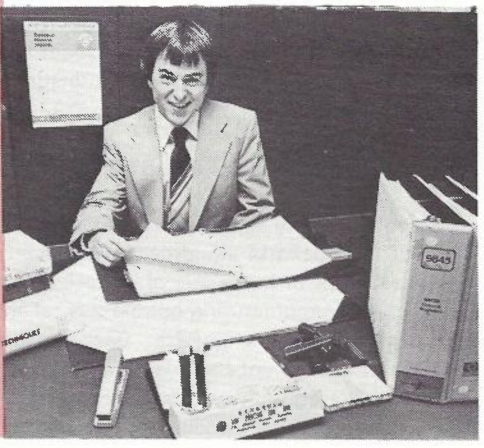
After graduating in Engineering in Australia in 1950 he joined Western Electric as a Design Engineer, then General Electric (1957) as Design Engineer and Laboratory Manager, and TRW Inc. (1965) as Engineering Manager responsible for design, development and production engineering of a range of products.

While in the U.S. he graduated in Business Management. He is an accredited Professional Quality Engineer, a member of the Institution of Engineers (Aust.), a Senior Member of ASQC(US), a Member of AOQC(Aust.), and a Member of IEEE(US).



MARK ROSSITER joined Telecom Australia after graduating in 1977 with an honours degree in mathematical statistics from Monash University. Since graduating Mark has worked as Statistician in the Quality Assurance Area of Telecom Australia Headquarters. He is a Quality Assurance Statistician and consultant in statistics to professional engineering staff in the area. His projects include the design and investigation of statistical sampling schemes and the development of mathematical models in support of the Quality Systems Unit. He has also been involved with the Headquarters Engineer Development Programme as an Instructor in Statistics. Mark is currently pursuing a Master's Degree in Statistics on a part time basis.

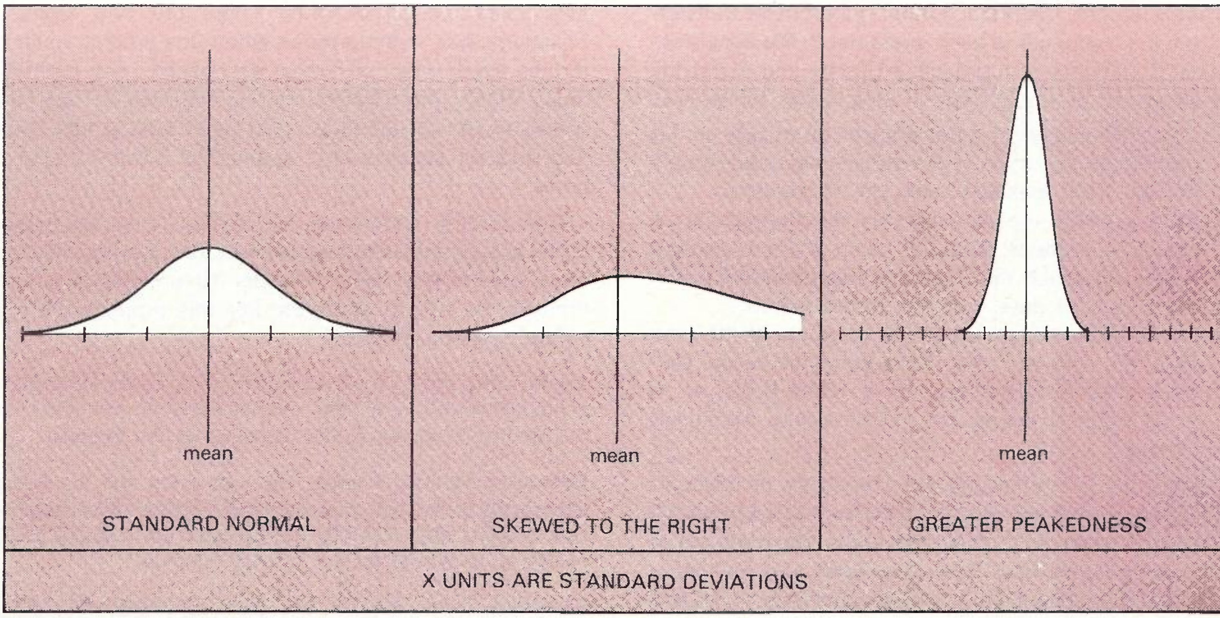


Fig. 1 — Some Probability Density Curve Features

and complete statement of the requirements covering all the characteristics of the device, with appropriate limits, necessary to ensure its functioning in the way desired under the required conditions. The third, and often misunderstood, step in achieving reliability in a product comes when the producer must manufacture the device in strict conformance with the specification requirements.

Each of the above three steps is subject to shortcomings which can contribute to poor reliability in telecommunications equipment. The designer may not select, for any number of reasons, the best physical operating principle, or combination of interacting principles. Seldom is the specification comprehensive in complete and total detail, and the Quality Assurance Inspector will find that the manufacturer may misinterpret or need to augment the incomplete statement of needs. When the design concept and specification are as complete and appropriate as is humanly possible, the manufacturer may still produce an unreliable product by allowing the characteristics to stray beyond their specified limits.

Due to the large number of sources for the designs of equipment used by Telecom Australia its Inspecting Officers must be quite versatile and knowledgeable in their work. The Headquarters Quality Assurance Statisticians must be very exacting in their statistical analyses of the large amounts of data supplied from inspection activities and the field.

THE REQUIREMENT FOR STATISTICS

We may classify all things into SETS, including the many kinds of material and equipment purchased by Telecom. The production of these SETS of materials and equipment in the many manufacturing companies takes place with a high degree of randomness. Each separate kind of material or equipment has many features, each of which is also generated with randomly occurring dimensions. It is this randomness of occurrence of the desired dimensions and functions which permits the application of Statistical Methods to be invoked in measuring, analysing and controlling the Quality and Reliability of telecommunications and all other kinds of products of manufacturing industry.

Any Set of things under consideration may be called a population. The common characteristics of the members of each Set indentify them as belonging to the population and they vary from member to member. This gives a distribution of characteristic values and hence scatter of members within each population. Each distribution has statistical features which are important to the assurance of Quality and Reliability. The most important features of each population are its Mean Value characterised by its centralising tendency, its Variance, the square root of which provides the Standard Deviation, its Skewness or tendency to extend farther in one direction from the Mean than in the other, and its Peakedness. The envelopes of three Populations explaining these features are shown in **Fig. 1**.

The dial telephone produced by Amalgamated Wireless (Australasia) Pty. Ltd. constitutes one such Population of closely controlled production. The Crossbar and Stored Programme Controlled exchange equipment supplied to Telecom by L. M. Ericsson Pty. Ltd. represent two others. As in the great majority of telecommunications equipment purchased for use by Telecom the Scientific Method is a rigorously applied principle. It is of considerable importance that work which is to be analysed by the aid of statistics be performed in accordance with the best possible application of the Scientific Method. Design and Manufacture must be based on and interpreted in accordance with Statistical Methods. It is through the application of such methods that Quality Control is achieved, and from controlled design and production that the economical methods of statistical sampling of products offered to Telecom can be successfully applied.

STATISTICS AND THE SCIENTIFIC METHOD

The Scientific Method may be defined as the application of logic and objectivity to the understanding of phenomena. At each stage in the sequential process of bringing a telecommunications product into being, that which is already known must be examined and hypotheses must be derived therefrom which can be experimentally tested. The formulation of hypotheses is an intuitive process calling for appropriately trained minds to be used when examining data by the Statistical Method. Testing hypotheses also calls for the use of the Statistical Method. In the advancement of knowledge there is a distinct circularity (Reference 1) to the Scientific Method from which progress is achieved. **Fig. 2** shows this.

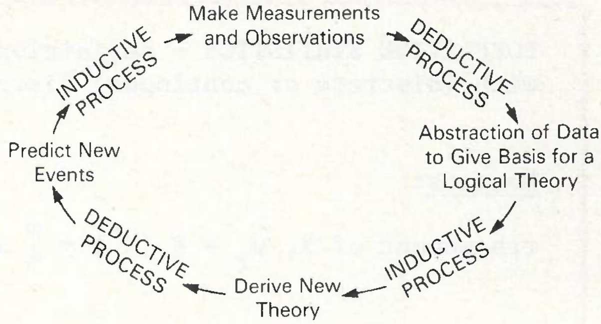


Fig. 2 — The Circularity of the Scientific Method

Statistical Methods are used:

- in the design of experiments,
- in the making of measurements from which observations are taken,
- in the abstraction and presentation of data,
- in comparing the data from the observations with the predictions from the theory.

Experiments and other forms of engineering work, when carried out without the use of statistical methods, will yield empirical results which are only valid in limited situations. Similarly, statistics unaccompanied by scientifically formulated theory, can only provide empirical results to which exceptions will be frequently encountered. Statistical inference, when used with the Scientific Method, provides Telecom Engineers with a powerful tool. Statistics cannot, on its own, yield new scientific theories, except in fields that have a statistically formulated basis. The formulation and statistical testing of hypotheses are the essential elements of the Scientific Method. It is a further essential characteristic of the Scientific Method that hypotheses must be formulated in such a way that verifications, or the lack thereof, may be tested by direct observation, or deductions made from the hypotheses must lead to predictions that can be verified.

BASIC STATISTICAL METHODS

The science of statisics is based on the fundamental concept of a random experiment. This is defined quite generally so that statistics can be applied to every situation where the intuitive notion of randomness is involved. A random experiment is any procedure which leads to an observable outcome which cannot be accurately predicted. Random experiments are important in diverse areas such as psychology, agriculture, biology, and economics, in addition to science and engineering. Most scientific, industrial and engineering experiments can be categorized as random. When a random experiment is repeated a number of times under identical conditions, the theory of statistics provides the mathematical tests needed for analysis of data and prediction.

The use of the term 'experiment' here can be misleading to the non-statistician. It simply means any action such as the generation of a feature in a product being manufactured, or the taking of a sample of units of product for inspection purposes. This is particularly important in the quality control of a manufacturing process, and in the quality assurance of telecommunications equipment. When the quality of a large number of units of product in one population is to be assessed but time and cost factors prevent individual inspection of each unit, statistical inference permits the inspection of a representative sample. The sample is randomly chosen from the defined population. When inspected, the quality of the sample units of product may be used to statistically infer the quality of the entire lot or batch.

Interest in statistical quality control began in the U.S. in the 1920's with the publication of the papers of Dr W. A. Shewhart of Bell Telephone Laboratories. The development of new methods of applying statistics to quality control and quality assurance has proceeded since then. Modern sampling theory is applied in many fields, in fact anywhere there is a population too large or unsuited for other reasons to complete assessment of all members of the population individually. Other examples in the telecommunications industry are market research, traffic measurement, etc. where the techniques give highly accurate results.

Further random 'experiments' which are carried out by Telecom Quality Assurance personnel include accelerated life testing where the results are used to intuitively and statistically infer the actual operating life of the equipment, Quality System audits and product audits of Supplier's Quality Control systems, and the design of experiments for evaluation of components. Statistical analysis also has its part in the performance of physical, electrical and mechanical testing of equipment. It is particularly appropriate for the design of field trials and the analysis of the data they produce.

As was discussed earlier, most scientific investigations, such as quality assurance testing, use experiments with an aim to providing information from which can be drawn valid conclusions about some phenomenon. The terminology of statistics has been developed to fit the framework of this general situation. The phenomenon about which information is desired is termed the 'Target' population. The related phenomenon, about which information is obtainable, is termed the 'Sample' population. Statistical theory and methods are only applicable to the 'Sample' population, and it is of the utmost importance to the inspection process that conclusions drawn about the 'Sample' population may be validly extended to the much larger 'Target' population. In Quality Assurance the 'Target' population is synonymous with the total output from a controlled manufacturing process over many

POPULATION STATISTICS - definitions for a population random variable X with (discrete or continous) distribution F(x).

Moments:

rth moment of X, $\mu_r = E\,(X^r) = \int_{-\infty}^{\infty} x^r \, d\,F(x)$

Mean:

mean or expected value of X, $\mu = \mu_1$, the first moment of X

Central Moments:

rth central moment of X, $m_r = E\left[(X-\mu)^r\right] = \int_{-\infty}^{\infty} (x-\mu)^r \, dF(x)$

Variance:

variance of X, $\sigma^2 = \mathrm{var}(X) = m_2$, the second central moment of X

Standard Deviation:

standard deviation of X, $\sigma = \sqrt{\mathrm{var}\ X}$

Co-efficient of Variation:

co-efficient of variation of X = σ/μ

Co-efficient Of Skewness:

co-efficient of skewness of X = m_3/σ^3

Co-efficient of Kurtosis

co-efficient of kurtosis of X = $(m_4/\sigma^4) - 3$

Median:

a number m such that $P\ (X \leqslant m) \geqslant \frac{1}{2}$ and $P\ (X \geqslant m) \geqslant \frac{1}{2}$ is a median of X.

Table 1a — Population Statistics

SAMPLE STATISTICS - where $X_1, X_2, \ldots, X_n$ is a random sample on a population random variable X.

Sample Mean:

sample mean or average, $\bar{X} = \frac{1}{n} \sum_{i=1}^{n} X_i$

Sample Variance:

sample variance, $S^2 = \frac{1}{n-1} \sum_{i=1}^{n} (X_i - \bar{X})^2 = \frac{1}{n-1} \left(\sum_{i=1}^{n} X_i^2 - n\bar{X}^2 \right)$

Sample Standard Deviation:

sample standard deviation, S, the square root of the sample variance

Sample Co-efficient Of Variation:

sample co-efficient of variation = $S/\bar{X}$

Sample Co-efficient of Skewness:

sample co-efficient of skewness = $\left[\frac{1}{n} \sum_{i=1}^{n} (X_i - \bar{X})^3\right] / \left[\frac{1}{n} \sum_{i=1}^{n} (X_i - \bar{X})^2\right]^{\frac{3}{2}}$

Sample Co-efficient of Kurtosis:

sample co-efficient of kurtosis

$$= \left[\frac{1}{n} \sum_{i=1}^{n} (X_i - \bar{X})^4\right] / \left[\frac{1}{n} \sum_{i=1}^{n} (X_i - \bar{X})^2\right]^2 - 3$$

Order Statistics:

$X_{(1)} \leqslant X_{(2)} \leqslant \ldots \leqslant X_{(n)}$ where $X_{(1)}$ = sample minimum, $X_{(n)}$ = sample maximum, etc.

Sample Range:

sample range = $X_{(n)} - X_{(1)}$

Sample Median:

sample median = $X_{\left(\frac{n+1}{2}\right)}$ if n is odd,

$= \frac{1}{2}\left[X_{\left(\frac{n}{2}\right)} + X_{\left(\frac{n+2}{2}\right)} \right]$ if n is even

Table 1b — Sample Statistics

weeks or months. The 'Sample' population is synonymous with the LOT or BATCH, and the inspection sample chosen is a statistical replica of the 'Sample' population.

After defining the Target' and 'Sample' populations, the next step in applying statistics to such an investigation is the choice of a statistical model. The simplest statistical model describes the sample population by a random variable X, with density f, and distribution F, where f and F may by unknown, or may simply depend on some unknown parameter. The problem then reduces to one of obtaining information, usually by sampling, about the distribution of X. Table — 1a contains definitions of population statistics, important terms used to describe a population random variable X. Table — 1b contains definitions of the sample statisitics used to estimate

DATA, Armature Force (mN)			: 45.47,	38.80,	37.05,	33.91,	37.35,
40.53,	34.33,	41.25,	45.40,	38.25,	40.50,	37,09,	52.74,
39.79,	45.76,	34.75,	33.67,	32.59,	42.73,	38.25,	37.49,
28.97,	42.10,	37.78,	42.52				

NO. OF OBSERVATIONS: 25

MEAN: 39.1668

VARIANCE: 25.5873

STANDARD DEVIATION: 5.0584

CO-EFFICIENT OF VARIATION: 12.9150×10^{-2}

CO-EFFICIENT OF SKEWNESS: 0.4974

CO-EFFICIENT OF KURTOSIS: 0.6233

95% CONFIDENCE INTERVAL ON MEAN: (37.08, 41.26)

MINIMUM: 28.97 MAXIMUM: 52.74

RANGE: 23.77

MID RANGE: 40.855

MEDIAN: 38.25

Table 2 — Normal Data and Basic Statistics

some of these. The random sample $X_l \ldots X_n$ required on X for the calculations in Table — 1b provides another point where the validity of applying statistics needs verification in any practical situation. This requirement can be defined mathematically, but is satisfied in practice if the $X_l \ldots X_n$ are independent, i.e. if the observed value of one has no effect on the observed values of any other, and if each has the same distribution as X.

The data and calculations given in Table-2 result from a basic statistical investigation in a State Inspection Laboratory. The data are a random sample of 25 observations on relay armature force. The relays were selected at random from one day's production by a new manufacturing process. Here the target population is the totality of relays produced by the process, and the sample population is the single day's production. Clearly many factors come into play to determine the time period over which the single day's production will be similar to the target population. However, for that period when the process is stable and in control, the sample population can yield a good estimate of the process capability.

STATISTICAL INFERENCE

Generally speaking, statistical methods can be categorized as descriptive or inferential. Descriptive statistics is concerned with the manipulation and presentation of data, especially by graphical methods. Descriptive statistical methods are usually employed with an aim to summarizing large amounts of data for reporting purposes. However, such methods are also often employed as a preliminary to a more exacting analysis, giving the statistician the 'form' of the data with which he is working. Examples of descriptive methods are the drawing of histograms, scattergrams, and pie charts, and the calculation of averages, percentages and similar summary statistics.

A common descriptive technique used when analyzing continuous univariate data is the histogram plot and the chi-squared goodness of fit test. The appropriate statistical model for armature force in the sample population of one day's relay production, is a normal distribution. Suppose the design specified a mean armature force of 40mN with a standard deviation less than 5 mN. A histogram of the data in Table-2 is constructed in **Fig. 3,** and superimposed to the same scale is the density curve of a normal population. The density curve has a mean of 40 mN and a variance of 25 mN². The chi-squared goodness of fit test of the data to this distribution is described in Table-3.

Often it is desired to check the assumption of normality of experimental data. A ready appraisal of whether the population underlying a given data set is normal or not is given by the normal probability technique. This gives a simple but rough visual test. Writing the data points as $x_l, x_2, , x_n$, the numbers are re-arranged in ascending order to give $x_{(1)}, x_{(2)}, , x_{(n)}$, where $x_{(i)}$ is called the ith order statistic of the sample. The points $(x_{(i)}, i/(n+1))$, after suitable choice of scale on the linear axis,

Class Interval	f_i = No of Observations	e_i = Expected No of Observations	$\frac{(f_i - e_i)^2}{e_i}$
28.5 - 33.5	2	2.1519	0.0107
33.5 - 38.5	11	7.1322	2.0975
38.5 - 43.5	8	9.3987	0.2082
43.5 - 48.5	3	4.9350	0.7587
48.5 - 53.5	1	1.0275	0.0007
		Calculated χ^2_4 =	3.0758

Tabulated χ^2 Value (4 degrees of freedom) = 9.49

Accept hypothesis of N(40, 25) population at 5% level.

Table 3 — Chi-Squared Goodness of Fit Test

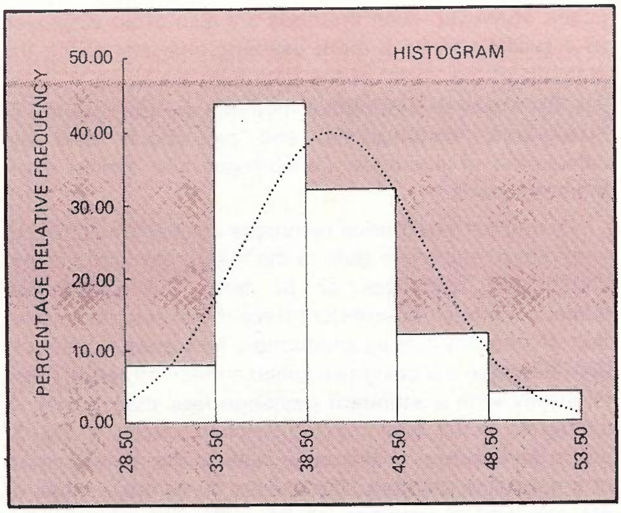


Fig. 3 — Histogram with Superimposed Normal Curve for Chi-Squared Test

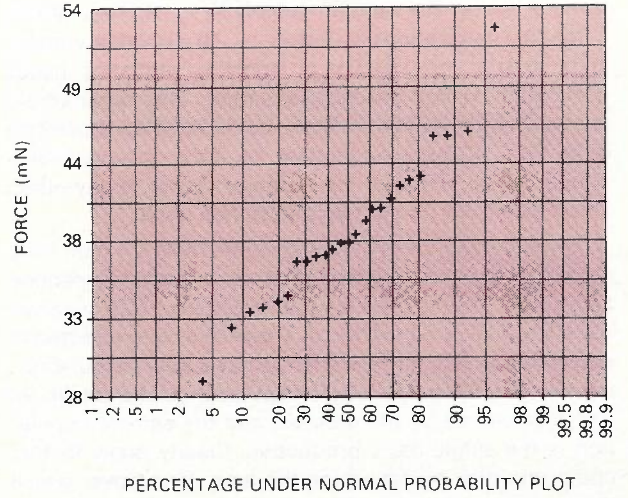


Fig. 4 — Test for Normal Data Distribution using Probability Paper

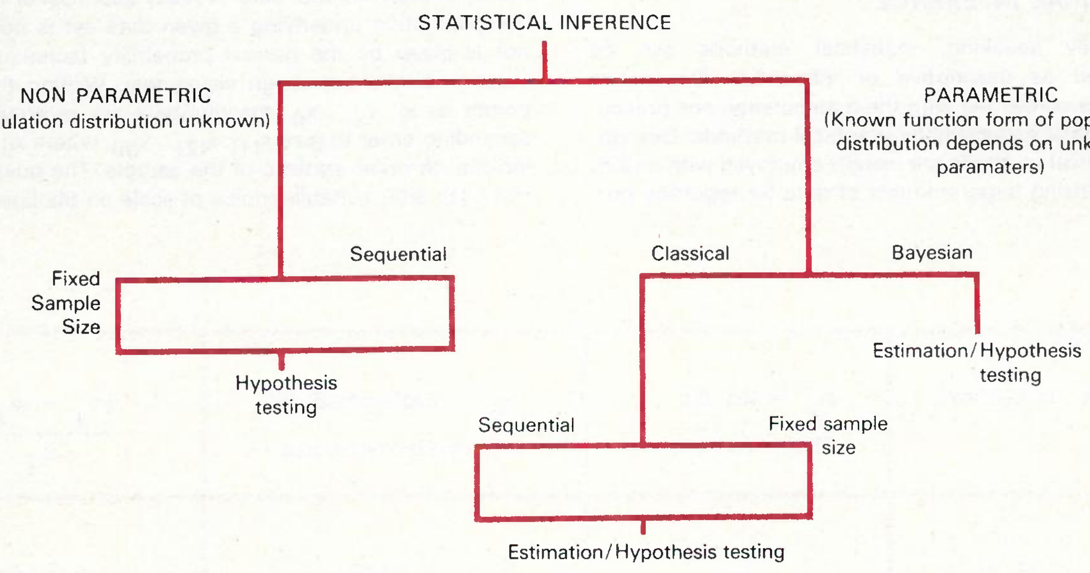


Fig. 5 — Major Branches of Statistical Inference

are then plotted on normal probability paper. This type of graph paper has been constructed so that when a set of data having a normal data distribution is plotted on it the data will appear essentially as a straight line. The population mean is estimated by the 50% point on the graph which, in **Fig. 4**, is approximately 38.7 mN. For a normal random variable the interval $(u-1.645\sigma, u+1.645\sigma)$ has a 90% probability. Hence in Fig. 4, σ can be estimated by (48.6 - 29.9)/(2 x 1.645) which gives 5.7 mN.

The theory of statistical inference is the basis of statistics in that every other branch of statistics depends on it. Inferential statistics is a very large field of research and can be divided into several different branches as shown in **Fig. 5.** Each of these is largely concerned with the calculation of estimates and confidence intervals, as well as the testing of statistical hypotheses. Inferential or Stochastic methods used in the Quality Assurance work draw largely on classical statistics with non-parametric Bayesian and sequential techniques also being employed. (Reference -2).

The use of statistically valid methods at the interface between the Supplier and Customer (in this case Telecom Australia) is considered essential. It is the Quality Level imposed on the output of a factory, and planned into the design and manufacturing phases which partitions the total cost of a product between Design and Manufacturing Costs on the one hand and the Installation, Fault Clearance and Maintenance and Operation through its lifetime on the other. Proper choice and enforcement of the Quality Level can optimize the total project cost to the most suitable level based on the availability of funds. Lower Quality Levels will have the effect of shifting major costs into the maintenance phase, while very tight Quality Levels can raise the total project cost above optimum levels by shifting undue costs into the Design and Manufacture phases of the programme.

QUALITY AND STANDARDS

Telecom Headquarters Quality Assurance staff have actively pursued the goal of establishing adequate standards in each area of quality measurement. Telecom Australia was the first large industrial organisation in Australia to have a complete set of quality specifications defining the quality control systems required of its Suppliers. These standards have been used to provide the foundation for the Approved Firms Scheme in its form as revised since 1972. Under this scheme, as in the earlier one, participating Suppliers are permitted to ship fully conforming product from their total quality control systems directly into Telecom stores without additional inspection by the Customer.

Another important standard is the specification used to assess the validity of Supplier's inspection systems. Attempts to use the U.S. Military Handbook H-109 proved laborious and costly for the reason that the sample sizes called for were incompatible with those from MIL Std. 105-D or Australian Standard AS-1199, both of which use the same sampling tables. Using the Quality Assurance computer at Headquarters, Q.A. Statisticians have completely recalculated the tables and rearranged the material to create a compatible Standard.

Currently the Quality Assurance function at Telecom Headquarters is involved in developing a range of five specifications defining the workmanship quality required for telecommunications grades of modern complex electronic equipment. Particular attention is being paid to the wide range of Suppliers. Wire wrapping methods and materials have been specified, and soft solders and fluxes are next (here a comprehensive standard is under consideration). These standards provide the Telecom Quality Assurance statisticians with a firm foundation for statistical analysis of data collected under closely controlled conditions against well defined and specified levels.

ECONOMIC QUALITY ASSURANCE

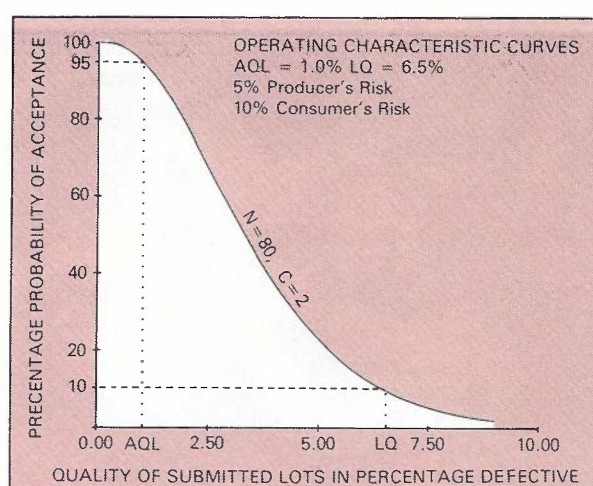
With the wide range of suppliers providing raw materials, equipment and software to Telecom one expects and indeed finds an equally wide range of quality control systems in use to produce these products. The fact that Australia is a developing nation with a small population places greater constraints on quality professionals, forcing them to practice and continually develop more economical methods of assuring the growing range of high technology telecommunications equipment. Each of the six State Telecom organisations provides inspection staff who are trained by the Telecom Headquarters QA function in the science of Inspection. A continuing programme is maintained to ensure that adequate data is supplied to Telecom Headquarters QA Staff by the State Inspectors and the some 480 domestic and 25 overseas Suppliers.

When little or nothing is known about the production background of an isolated batch of material from one of the large number of small Suppliers, more intensive inspection is required to collect the needed data. This calls for the application of Limiting Quality Level sampling, and the consequent larger sample sizes, usually inspected by an itinerant (visiting) Inspector. He uses inspection and testing equipment which has been carefully maintained and calibrated by the State Calibration Laboratory, thus augmenting Supplier test equipment.

In the case of continuous production situations where the producer is not in the Approved Firms Scheme, costs of Quality Assurance can be further reduced by taking smaller sample sizes to infer the quality and reliability of the successively supplied batches of equipment. In electronic assembly plants inspection is in terms of the many attributes of the product. Here Acceptable Quality Levels are used, giving the Supplier the benefit of the doubt by operating at the producers end of the operating characteristic curve (see **Fig. 6**). As quality is proved and continues the Telecom Inspector moves to reduced inspection, further reducing the cost of quality. Telecom Australia buys from two major categories of manufacturer, the electronic assembly industry, and the process industry which manufactures the hundreds of thousands of Pair Kilometres of cable and wire, as well as the large amounts of plastic pipe and cable pits. In this latter type of industry the product characteristics are more appropriately assessed by Variables inspection, with the consequent smaller sample sizes and greater amounts of information obtainable at slightly increased cost per measurement, still yielding an overall reduction in the cost of Quality Assurance.

In the case of those Companies participating in the Approved Firms Scheme it is possible to further reduce the cost of Quality Assurance. Here the closely controlled production operations, supported by statistically valid process control charts and accurate comprehensive final inspection on the part of the Supplier, make it possible to reduce the Quality Assurance cost to two kinds of Audit. One gives assurance that the Quality System is being closely maintained, the other gives that small amount of additional assurance that the outgoing product is continuing to be measured by the Contractor in the appropriate way.

As each Contractor supplying telecommunications equipment to Telecom has to produce objective evidence



AQL — Acceptable Quality Level
LQ — Limiting Quality

Fig. 6 — Operating Characteristic (OC) Curve

of conformance prior to shipment, this information about the quality performance of the supplier is available for purchase under contract as well. For a small additional cost, it is possible to reduce the Telecom inspection effort further, by removing the product audit from those Contractors who operate good quality control programmes, and replace it with the Contractor's Audit data reflecting the levels of quality in the outgoing product. This data is kept secure in the mass memory of the Telecom Headquarters Quality Assurance function's stand alone computer. In this way complete control over the data from the various competing contractors can be maintained, giving concrete assurance that proprietary information from competing contractors will be protected.

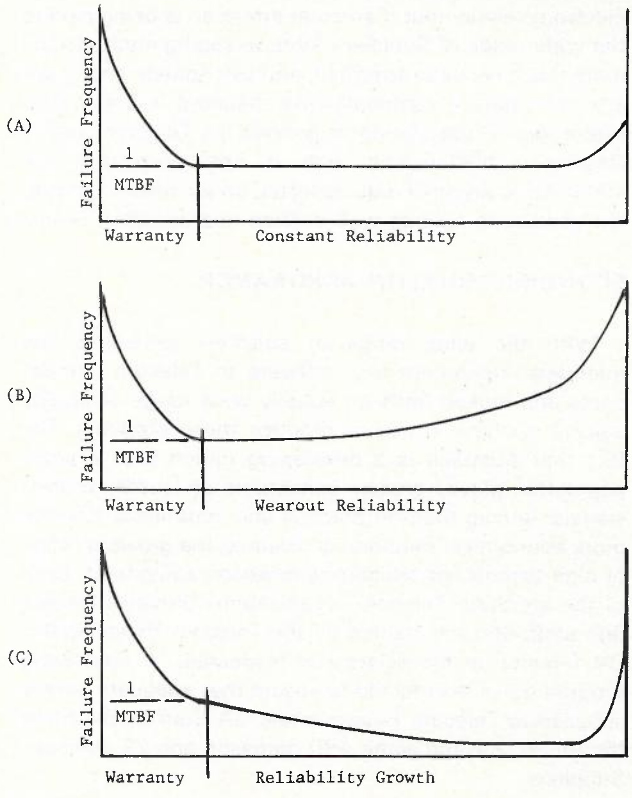
As the amount of data from a target population is steadily reduced in the sampling procedures described above, it becomes increasingly important that the best possible mathematical models are used for its analysis. In Telecom it is the task of the HQ Quality Assurance Staff to ensure that both the statistical validity of the Audit scheme and the accompanying economic considerations consequent in the audit exercise receive appropriate attention in the design of the sampling scheme. We know that all production which is continuing goes through a succession of fluctuations in relation to the level of desired quality. Neither sampling schemes nor 100% inspection of product can produce lots of shipped product with zero defects. For a realistic assessment of shipped quality from a Supplier in a lot-by-lot inspection situation it is necessary for the Telecom Inspector to take account of both rejected lots as well as accepted, and hence good lots. Data from both sources are used by the statistician in estimating the quality of product shipped, as well as the process average of the production operations from which the product came.

THE COMPUTER AID TO STATISTICIANS

At Telecom Headquarters the work of the Quality Assurance statistician has been greatly aided, in both ease and productivity, with the advent of the modern graphics computer. As in many other fields the stand alone minicomputer with mass memory, the many desk top calculators, as well as the terminal availability to Telecom's mainframe computer system, all available to the Telecom statistician working on quality matters at Headquarters, provides the means for better and faster modelling of the many statistical problems which must be solved on a day to day basis.

Using the computer and graphics system, data from Contractors are analysed and plotted on specially prepared graphs, thereby showing the actual quality achieved on the various products against the expected level. Quality Assurance Engineers and Statisticians analyse the data from field feedback as well, both to infer

QA Staff at Graphics Computer



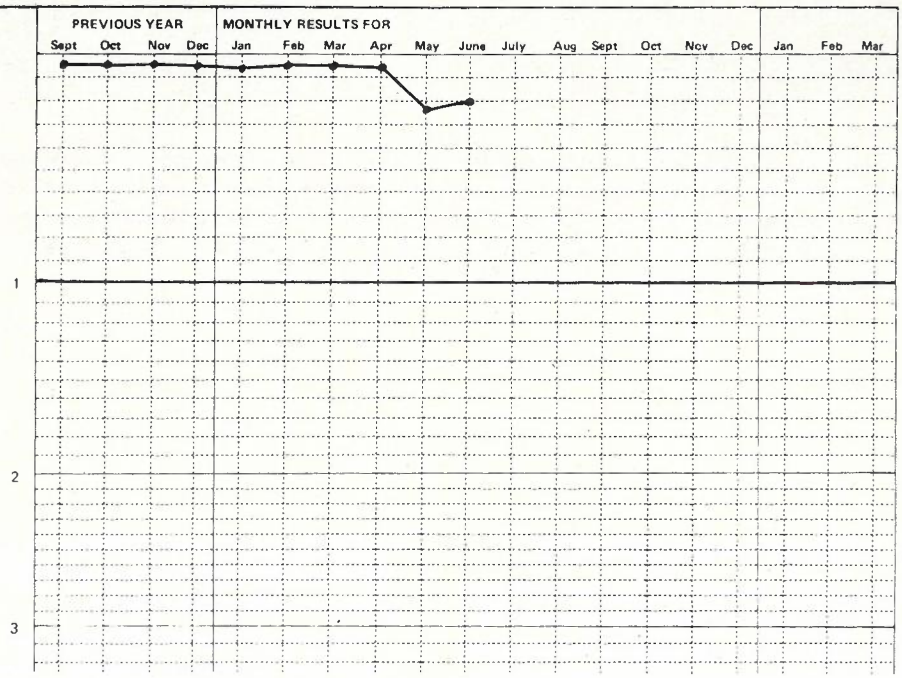
The above failure rate curves show how three different kinds of reliability in telecommunications equipment will vary throughout their lives. Several years ago one of the authors of this article introduced Reliability Growth and reduced Maintenance Cost to Telecom Australia equipment by failed component analysis and improved component reliability in replacement components.

Failure Rate Curves

Telecom Australia

QUALITY REPORT

ISSUED BY: QUALITY SYSTEMS UNIT, HEADQUARTERS	PRODUCT NUMBER: ARE-11
COMPANY: L. M. ERICSSON PTY. LTD.	FACTORY: BROADMEADOWS, VICTORIA
PRODUCT DESCRIPTION: PRINTED BOARD ASSEMBLIES	



The graph shows the average quality achieved for all features of the product for the month. A result of unity, or less, indicates that manufacturing quality standards have been met. Quality levels greater than one usually incur additional cost to Telecom Australia in the form of additional maintenance work in the field.

Contractor Quality Control Reporting

the actual reliability being achieved, as well as solve the quality and reliability problems which arise from time to time. Masses of numbers (typically 3 megabytes annually) from each major contractor must be analysed, for each major category of product supplied to Telecom. These data must be converted into real time information to aid the Inspecting Officers in the factories in their work with Contractors. Similarly they must be displayed in meaningful graphs which convey to management the information needed to gain confidence that the correct decisions and risks are being taken. Without the modern statistical methods at our disposal the high technological levels of products available today could not be economically achieved.

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TASI Systems in OTC's International Network

J. N. HIBBARD, M.E. and P. K. DEE, B.E.

Submarine cables and satellite links are employed in the international network to provide diversity and security of service. To extend the capacity of limited bandwidth submarine cables, Time Assignment Speech Interpolation (TASI) techniques can be used. This paper described how the Overseas Telecommunications Commission (Australia) employs the TASI principle to achieve a fourfold expansion of its telephone circuit capacity in Pacific Ocean submarine cables.

AUSTRALIA'S INTERNATIONAL NETWORK

Australia's international telecommunications network is operated by the Overseas Telecommunications Commission (Australia). Prior to the early sixties, international telecommunications were provided by submarine cables for telegraph and HF radio links for telephone services.

In 1962 a submarine telephone cable, COMPAC, was commissioned between Sydney and Vancouver with a nominal capacity of one supergroup. Australia's international network was supplemented in 1967 by the SEACOM cable routed from Cairns via Madang, Guam, Hong Kong and Kota Kinabula (Malaysia East) to Singapore with a capacity of two supergroups south of Guam and one supergroup north of Guam.

Following the development of communications satellites in the mid-sixties, Australia established earth stations at Carnarvon, Moree and Ceduna between 1968 and 1971. Since that time, much of the growth in international circuits has been via satellite with the regular launching of large satellites to meet the rapidly increasing demand.

In recent times short-haul submarine cables, each of 8 supergroup capacity, have been laid to New Zealand (TASMAN) and Papua-New Guinea (A-PNG).

Whilst HF radio circuits are still used for traffic to a few relatively isolated destinations, Australia's international traffic is now almost totally carried via satellite and submarine cable links.

Fig. 1 shows a map of Australia's major international transmission facilities.

SATELLITE LINKS

The availability of satellite access provides the opportunity for direct connection from any earth station in view of a satellite to any other earth station in view of the same satellite. This permits the ready provision of point-to-point services between many places on the globe; in Australia's case we are able to "see" satellites covering two thirds of the world due to astute negotiation in the 1960's when the locations of international communications satellites were chosen.

However, there are disadvantages with satellite links. These are principally twofold. The first is that a concentration on the use of satellite circuits (rather than cable circuits) means that the international service may be significantly dependent on the availability of a common earth station or satellite. A failure of one of these would have a catastrophic effect on the international telecommunications services. The second disadvantage is the satellite path transmission delay of some 250 milliseconds which results from the path length of 70,000 kms. Whilst a time delay of this length presents little difficulty in conversation, longer delays do impair the ease of conversation. Thus the use of two satellite links in tandem is greatly discouraged in the international network by CCITT, the international telecommunications body which recommends world-wide operating practices. By contrast, the transmission delay via trans-occanic submarine cable is typically of the order of 100 milliseconds.

To ensure the security of the network, alternative routes are provided to most destinations using diverse transmission media and often using transit switching at some intermediate location. Avoidance of excessively long time delays over transit switched routes demands that at least one of the transit links involves only a small delay. For Australia's island continent, this usually requires that the link to the transit point involves a submarine cable.

SUBMARINE CABLES

Because of the need to ensure diversity and satisfactory quality of service in the international network,, there is a continuing demand for submarine cable capacity.

Unfortunately, submarine cables are very expensive, especially those involving long trans-oceanic links. (The cost of submarine cable systems depends on length, whereas the cost of satellite circuits is independent of

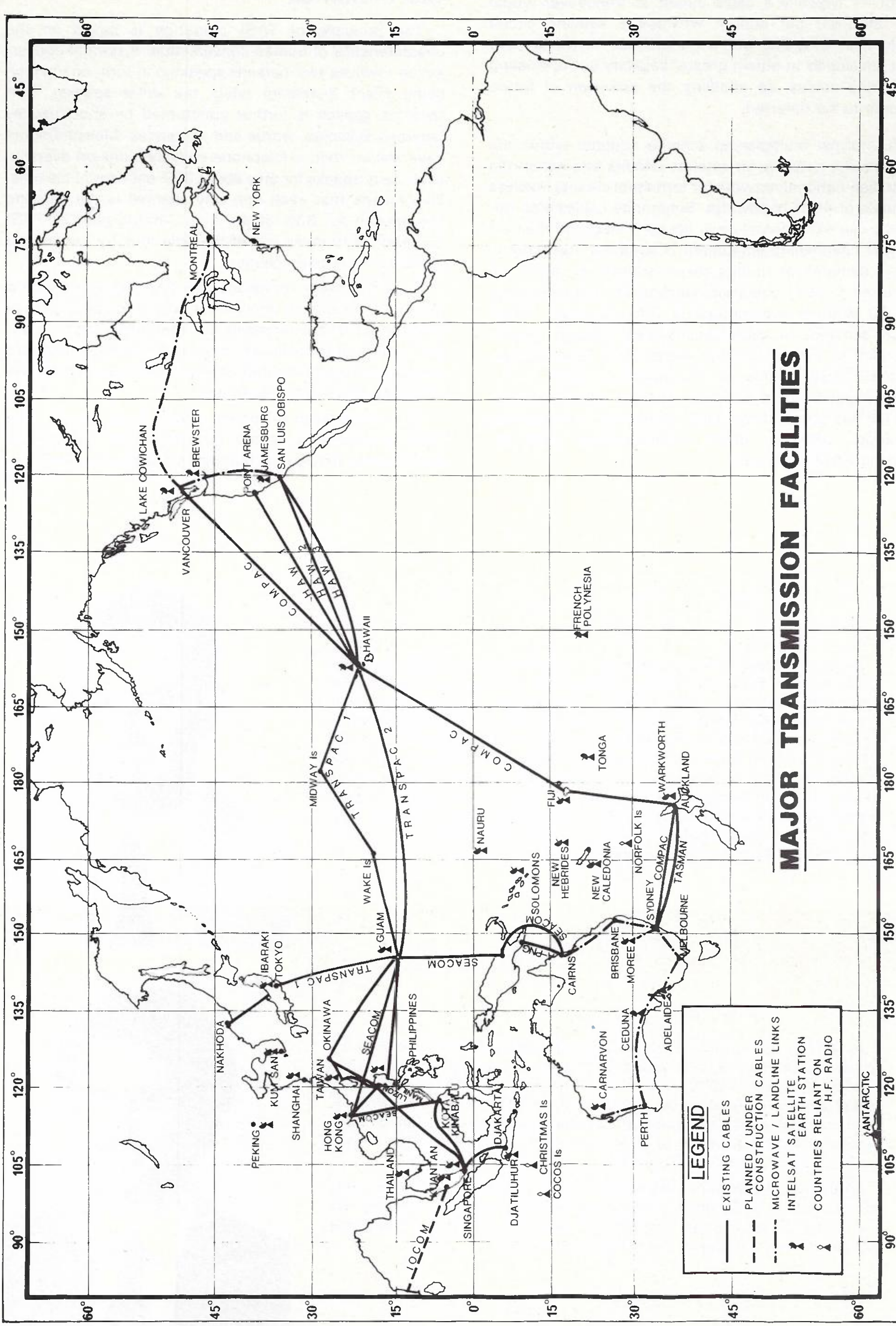

Fig. 1 — Australia's Major International Transmission Facilities.

length — typically a cable circuit to Vancouver would cost $50,000 per annum whereas a satellite circuit would cost $20,000 per annum.) Thus methods have been developed to obtain greater capacity out of existing submarine cables, so enabling the provision of future systems to be deferred.

The normal multiplexing scheme adopted within the international network for satellite circuits and within the Australian national network for terrestrial circuits involves channels of 4kHz bandwidth. Submarine cables also frequently use 4kHz operation in the early stages of their life as 4kHz channelling equipment is relatively inexpensive. As the demand for circuits grows, submarine cables are converted to 3kHz operation, yielding 16 channel groups and 80 channel supergroups (a 33% increase). When further demands for cable circuits arise, capacity may be expanded by means of Time Assignment Speech Interpolation (TASI) techniques. Accordingly, in order to obtain increased circuit capacity from its cable network, OTC (A) has acquired two TASI systems for international operation. Likewise, other administrations have introduced TASI systems.

TASI OPERATION

The principle of TASI operation is based on the characteristics of human conversation. A normal conversation involves two persons speaking in turn, one person being silent (listening) while the other speaks. Each person's speech is further punctuated by short pauses between syllables, words and sentences. Measurements have shown that in telephone conversations on average, each party speaks for only about 37% per cent of his time. This means that each one-way channel is not carrying any speech for 63% of the time. The purpose of TASI operation is to make use of that idle time by assigning a talker to an unused channel.

A TASI system comprises two TASI terminals with a number of telephone circuits connected to each terminal (see **Fig. 2**). These terminals are interconnected by a lesser number of transmission bearers. In addition there are several bearers connected between the terminals for the exchange of control information.

Monitoring each telephone circuit at its input to the TASI terminal is a speech detector. Upon arrival of a speechburst, the speech detector signals the central con-

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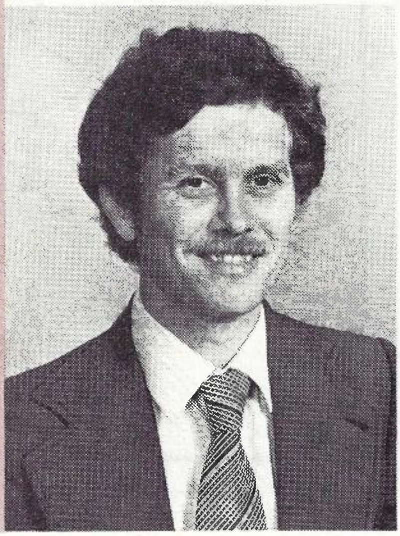
PETER DEE graduated from the University of Western Australia with Honours in Electrical Engineering and joined OTC(A) as an Engineer Grade 1 in the Engineering Branch in 1973, working initially on the installation of satellite earth station equipment. He joined the TASI-B project in 1974, undergoing training in the United States and Canada and participating in the installation of the Sydney-Vancouver TASI-B system until its commissioning in October 1975. He was promoted to Engineer Grade 2 in 1974.

Mr Dee transferred to the Operations Branch in 1976, working in the Cable Services, Quality of Service and Telephone Switching groups. In 1980 he was promoted to Senior Engineer (Network Arrangements) where he is responsible for implementing changes to the international network.



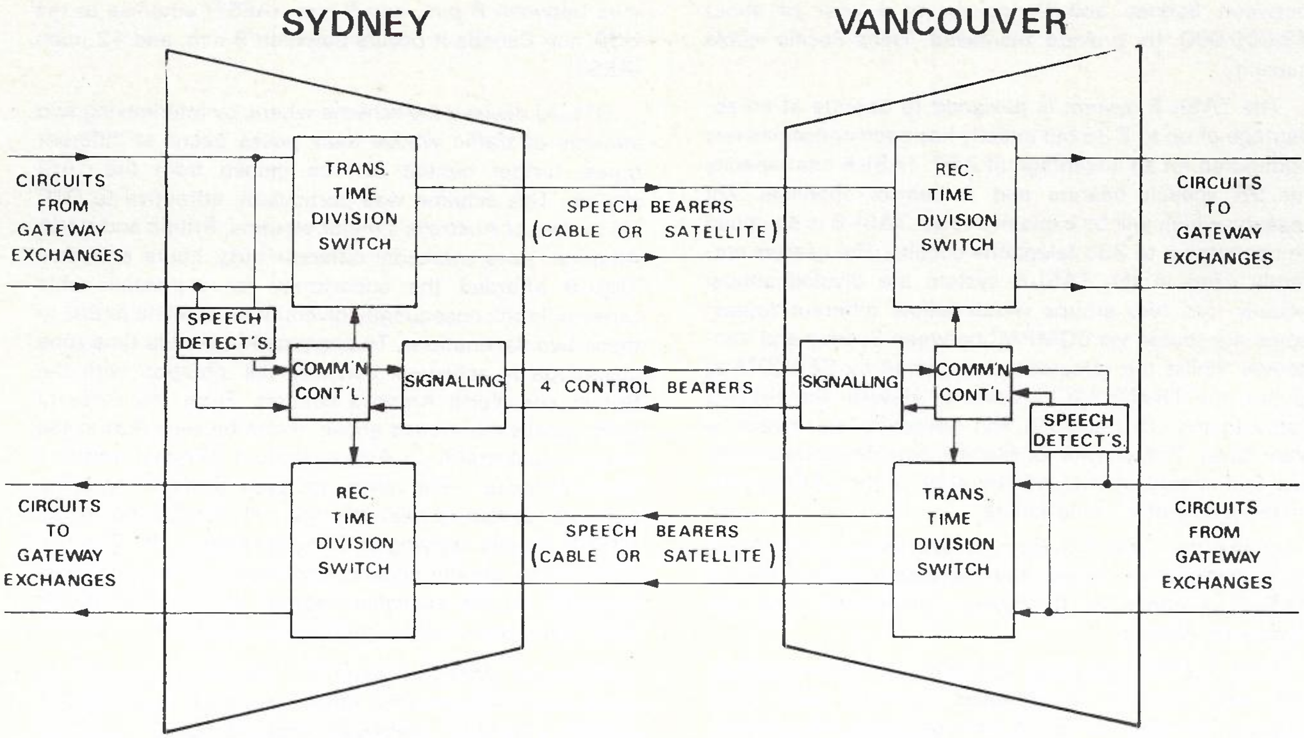


Fig. 2 — Simplified Block Diagram of the TASI-B system

trol unit which assigns to the circuit, from a pool, a particular bearer which happens to be unused at that instant. The control unit then connects the circuit to the bearer and simultaneously forwards information about the connection to the distant terminal, where the reciprocal control unit establishes the connection between the same bearer and the corresponding circuit. The same procedure occurs for speech in the other direction. Because the two directions of speech are treated independently, it is quite likely that consecutive speechbursts from each party in a conversation will be routed via different bearers. A variable delay (hangover) is provided following the cessation of a speechburst, after which the bearer may be assigned to any other circuit on which speech is detected.

By applying the TASI principle to calls with average speech activity of 37% one could theoretically expect a maximum ratio of telephone calls to bearer (called the TASI advantage) of 2.7. However, because of the finite speed of operation of the TASI equipment, the statistical variation of the speech activity of individuals, the time distribution of speech bursts and the need to keep to a negligible amount the clipping of speech caused by the instantaneous unavailability of a bearer, the maximum advantage obtainable from a practical TASI system is about 2.35. With a TASI system in this advantage range, clipping is so short that it is almost impossible for a subscriber to detect that he is speaking over a TASI circuit rather than a directly-connected cable circuit.

The reader might ask why, if additional transmission capacity can be so readily obtained by TASI techniques, are there not more TASI systems in use? Unfortunately, TASI systems have the disadvantage of increasing the power loading of a circuit. The normal power loading of a telephone channel, based on the level and activity of average speech is generally taken to be -15dBm0. The TASI bearer, with an effectively greater speech activity, has an equivalent power loading of around -10dBm0. This additional power, if occurring on a large number of channels on one transmission system, can cause overload conditions to occur. Hence, TASI systems are not usually employed on microwave and satellite links. A submarine cable, on the other hand, is purposely designed to accommodate the additional power loading of TASI systems.

TASI-A

During the early 1960's the Western Electric Corporation of the USA developed the first TASI system, called TASI-A. Australia and Canada jointly purchased one of these systems for about $2,000,000 and installed it in 1967 for use between Sydney and Vancouver over the COMPAC cable.

The TASI-A system is designed around a TASI advantage of about 2.0 and operates on 37 bearers. Employing early discrete germanium transistor technology, TASI-A is physically large, requires substantial maintenance and is very sensitive to temperature variations. For information signalling between the TASI-A terminals, multifrequency tone signalling is used on each channel as well as signalling over a dedicated control channel.

In 1975 a Canadian TASI-A terminal was recovered by OTC(A) and reinstalled at Guam. The Sydney-Guam TASI-A system is now used to provide additional cable circuits to S.E. Asia by augmenting the capacity of the SEACOM cable.

TASI-B

In the early 1970's an updated TASI system, TASI-B, was developed employing discrete silicon transistor technology. Australia, Canada and the USA jointly purchased the TASI-B system in 1975 for installation between Sydney and Vancouver at a cost of about $8,000,000 to provide increased Trans-Pacific cable capacity.

The TASI- B system is designed to operate at an advantage of up to 2.35 but initially has been conservatively configured for an advantage of 2.07. TASI-B has capacity for 96 speech bearers and 4 control channels. For reasons which will be explained later, TASI-B is equipped to connect up to 333 telephone circuits. The bearers currently used in the TASI-B system are divided almost equally into two groups which follow different routes: some are routed via COMPAC between Sydney and Vancouver whilst the remainder are carried by SEACOM to Guam, the TRANSPAC 2 cable to Hawaii, the HAW-3 cable to the US mainland and terrestrial microwave to Vancouver. This division of bearers provides added diversity and enables continued operation of the TASI system in the event of a cable failure.

Unlike the TASI-A system, where control information is exchanged by tones, the necessary information in TASI-B is conveyed by digital transmission over the dedicated control.

With a 2.07 advantage operating on 3kHz channels, the cable capacity is increased over the basic 4kHz capacity by 175%. But still further gains are made by taking advantage of the different time zones of the world.

TIME ZONE ADVANTAGE

Telephone calls are usually established at times mutually convenient to the parties at both ends. In the case of international traffic where the parties can be separated by significant time differences, the period of mutual convenience will differ depending on the geographical location of the parties and is often restricted to a few hours in the day. Hence, at one period of the day there may be heavy traffic to one destination and little to another, whilst in a different period the traffic would be negligible to the first destination but heavy to the other. For example, the majority of Australia-Britain traffic occurs between 6 p.m. and 9 p.m. (AEST) whereas to the USA and Canada it occurs between 9 a.m. and 12 noon (AEST).

OTC(A) devised the scheme where, by interleaving two streams of traffic whose daily peaks occur at different times, further benefit can be gained from the TASI system. This scheme was particularly attractive to OTC (A) as two of Australia's major streams, Britain and North America, have markedly different busy hours and thus TASI-B afforded the opportunity for increased cable capacity (and consequently diversity for satellite paths) to these two destinations. To understand how the time zone advantage is achieved, consider the situation with the Britain and North America streams. From the times of traffic peaks mentioned above, it can be seen that at the time of peak traffic to Britain, there is minimal traffic to North America; while during the peak to North America, traffic to Britain is relatively low. By connecting to the TASI-B circuits carrying both these streams, the effective gain can be greatly enhanced without placing increased demands on the available bearers; the bearers merely carry traffic for a larger proportion of the day.

Plans are afoot to expand the TASI-B system and, by using a less conservative design value for the TASI advantage than 2.07 previously adopted, achieve a circuit to bearer ratio of 4.4 through the use of different time zones. When this occurs, it will mean that the basic 4kHz cable capacity has been increased by 480%. Gains of this magnitude have not been achieved elsewhere in the world. Of course, the real benefit is that cable circuits can continue to be provided long after the nominal cable capacity has been used, thus postponing the time when another very expensive submarine cable is required. **Fig. 3** shows the expanded configuration of the TASI-B system. Of the total 333 circuits connected to OTC's gateway exchanges at Broadway and Paddington (in Sydney), 166 will carry North American traffic via gateway exchanges in Vancouver and Denver whilst 167 circuits will carry Britain and Europe traffic via the

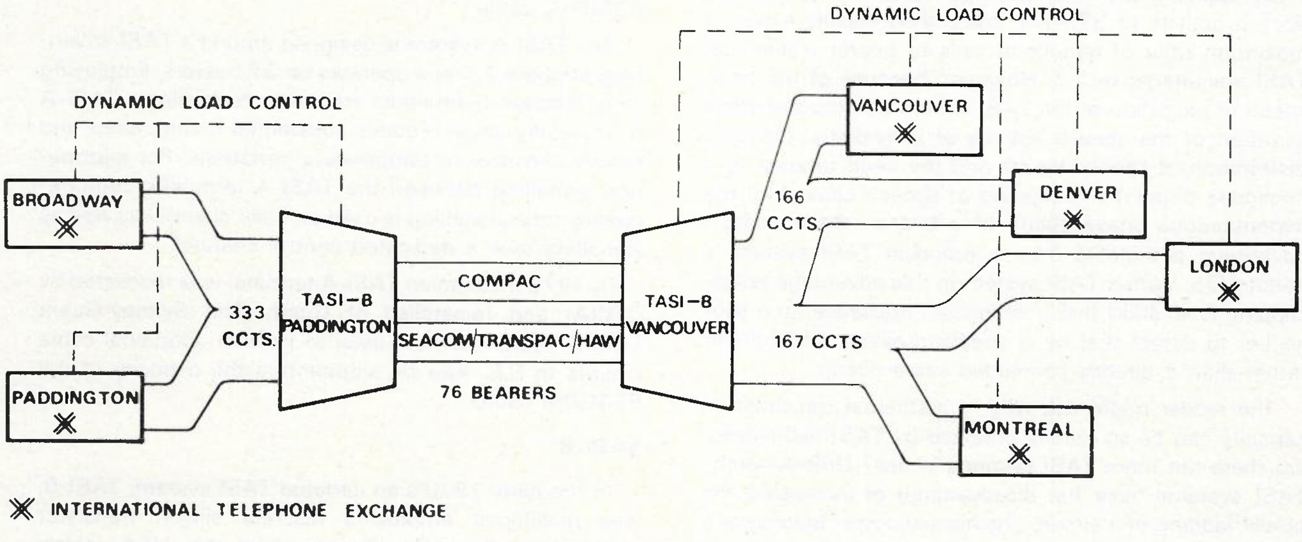


Fig. 3 — TASI-B Expanded Configuration

London gateway exchanges and via transit switching at the Montreal gateway exchange.

SPECIAL FEATURES OF TASI-B

As explained above, the separation between busy hours of the traffic streams carried by TASI-B enables the circuit to bearer ratio to be increased from a nominal figure of 2.35 to a maximum of 4.4.

At any one time, however, TASI-B cannot interleave more than 235 simultaneously occupied trunks onto the 100 connecting channels. Since more than 235 trunks are connected to TASI-B, overloading of the system (which would cause unacceptable levels of speech clipping) is prevented by means of a Dynamic Load Control. Dynamic Load Control constantly monitors the "freezeout" level (the percentage of active trunks which are not connected to a channel) and when freezeout exceeds about 2%, TASI-B instructs each of the connecting exchanges not to place new calls over TASI circuits until freezeout reduces to an acceptable level again. Thus the loading on the system is automatically controlled and freezeout is maintained at 2% or less. Tests have shown that a freezeout level of 2% presents no noticeable degradation in the speech quality heard by subscribers.

The design of the network is such that 2% freezeout rarely occures under normal conditions. However, at periods of heavy demand such as Christmas time, the traffic peaks continue far longer than normal and overlap between North American and Britain traffic occurs. The application of dynamic load control is particularly beneficial at these times and on other occasions when a facility failure may cause a loss of some of the bearers.

Several other features are employed in the TASI-B which are of special interest:

- a channel testing process (channel check) continuously checks the transmission level, noise level and delay on each TASI channel, removing from service automatically any channel that fails the tests. Such a channel continues to be tested and is automatically placed back into service when its transmission quality improves to normal levels.
- the TASI-B system can operate with any mixture of cable and satellite connecting channels. Although normally operated with cable circuits for reasons explained earlier, the ability of TASI-B to operate over satellite is extremely useful for restoration in times of cable system failure.
- in the event of a failure of a TASI-B terminal, selected circuits are through-switched by the TASI-B system directly to the bearers so that these submarine cable circuits can be operated as normal non-TASI circuits.
- low levels of maintenance are necessary since TASI-B is provided with comprehensive alarm systems and self-diagnostic routines.

FUTURE DEVELOPMENTS IN TASI SYSTEMS

The increasing demand for cable capacity, the cost of new larger size cables and the expense of limited production 3kHz channelling equipment (some 3 to 4 times the cost of 4kHz equipment) has turned cable owners to the use of TASI systems as the first means of expanding cable capacity.

Integrated circuits have replaced discrete components and created the potential for digital TASI systems. Currently well advanced in development or on sale are the Western Electric TASI-C system and the French CELTIC system. Both employ analogue inputs with digital transmission between the TASI terminals. TASI-C has a nominal maximum capacity of 240 circuits on 120 bearers, whilst CELTIC has a limit of 120 circuits on 60 bearers. These new systems will be substantially cheaper than earlier systems; the cost of the Western Electric system is expected to be about $1 million (compared with $8 million for TASI-B).

Even more advanced systems are being designed. A fully digital system, TASI-D, will employ digital (PCM) inputs. This will greatly simplify the design of the speech detector and should lead to a further reduction in price. The TASI-D is expected to be in production in the 1980's.

SUMMARY

The dual need to obtain adequate security for Australia's international network and to provide short delay circuits for the routing of transit traffic has meant an increasing demand for cable circuit capacity. The high cost of new submarine cable systems, however, places them at a disadvantage with respect to satellite circuits when considering the options for expanded transmission capacity. Hence the use of TASI systems, which make better use of existing submarine cable capacity, provides an economically attractive means of increasing cable capacity.

The use of TASI on traffic streams with time-coincident busy hours results in a doubling of cable circuit capacity. Used with traffic streams whose busy hours are widely different, such as Australia-Britain and Australia-North America, a TASI system can effectively quadruple existing cable circuit capacity.

OTC(A) currently employs two TASI systems: TASI-A utilises SEACOM bearers between Sydney and Guam; TASI-B utilises COMPAC and SEACOM/TRANS-PAC/HAW bearers between Sydney and Vancouver. Ultimately, the TASI-B system will provide 333 cable circuits to Britain and North America from 76 cable bearers.

Improved designs for systems employing the TASI principle are currently available or on the drawing board. The significant gain in cable circuit capacity and expected low cost of these systems will ensure their continued use in Australia's international network.

Creativity — Who's Got It, and How Do We Use It?

R. G. McCARTHY, B.E.

Some human characteristics such as "habituation" and "association" which are relevant to creativity of the individual are described. The relevance of age and of intelligence to creativity is also examined.

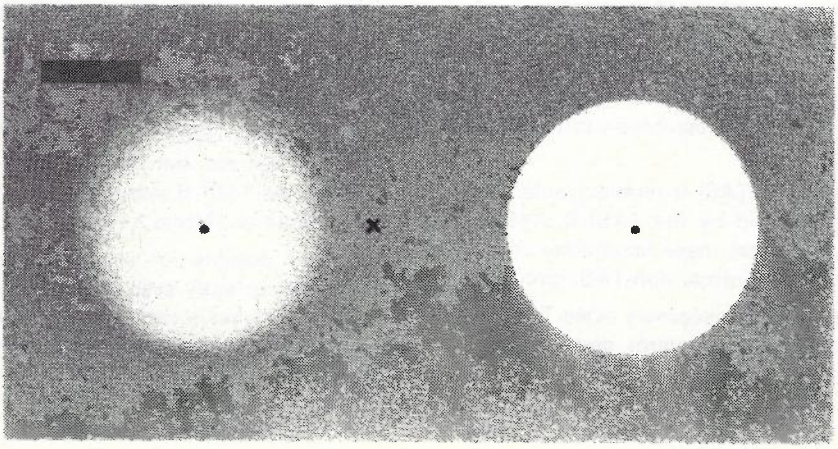
For an environment such as Telecom, a series of recommendations is made which will promote creativity in a practical way to benefit both the individual and the organisation.

HABITUATION

If you are one of a group sitting around a conference table and a wall-mounted fan switches on automatically, you are immediately aware of it. You see it move, you hear it, and most likely you feel the draught of air. After a few moments you become oblivious to the fan and stop paying attention to it. Unless, of course, it then switches off automatically! Then your attention is aroused again, briefly, and possibly only until the blades stop; and the fan again disappears from your awareness. If the automatic cycles continue, eventually, perhaps after a much longer period again, you would not be aware of the fan at all; just as you do not notice the thermostat cycles of your room heater or refrigerator.

This process is called "habituation". Studies on habituation suggest that we make a "model" of the external world within our nervous system, and inputs from our various sensory systems continually test the model, all of this happening at a subconscious level, until a discrepancy or change raises the input to conscious level. We somehow continually revise, or re-program the model. It is believed that this is part of our evolution, to allow us to notice changes important to our survival, but at the same time to protect the central processing system of brain from overload, from the continual bombardment of information from all of the sensory systems. This disappearing circle in **Fig. 1** is a further example of habituation.

The process works also in reverse, known as the "Bowery EL" effect. An elevated railway once ran along Third Avenue in New York City. The line was torn down some time ago with some interesting after-effects. The police received numerous reports of "something strange" occurring late at night and suspected a wave of thefts or burglaries. After lengthy investigation, however, the problem was put down to the fact that people complaining were "hearing" the absence of the familiar noise of a



Look steadily at the left dot; the light circle disappears. You can make it reappear by looking at the X. The right-hand circle will not disappear if you stare at it, although it is as light in the centre as the other circle. The visual system, like other sensory systems, is maximally sensitive to sharp changes.

Fig. 1

former late-night train, whose schedule coincided with the time of the reports.

From the "sensory register" of the brain in which information is held for about a quarter of a second, information is fed to the short-term memory. Here it is held for about two to thirty seconds, just long enough to permit us to carry on conversation and respond to the filtered input in other appropriate ways. A "buffer" process occurs to protect the long-term memory from overload, and only a limited amount of information based on familiarity, interest and attention is fed to the long-term memory. "Rehearsal", or more familiarly repetition, practice and drill, prevent decay and loss in long-term memory so that it remains for days, months, perhaps forever. But it is available only on cue.

Selective Tuning

If you sit in a room containing several people, a number of conversations can be taking place simultaneously, yet your are able to "tune in" at will to any one of these. In the same way, you will "switch off" to conversation or extraneous noises when you wish to concentrate on the television news in a noisy room.

A person walking through the park on a Sunday afternoon will "tune in" to the things he personally is interested in. The amateur yachtsman will admire the model sailing boat, the setting of its sails and its point to the wind. The medical practitioner will see the people, their posture, their ailments. The artist will see not so much the trees, the structures and the fixed objects, as the spaces between them and the patterns and fabric of the total surrounding.

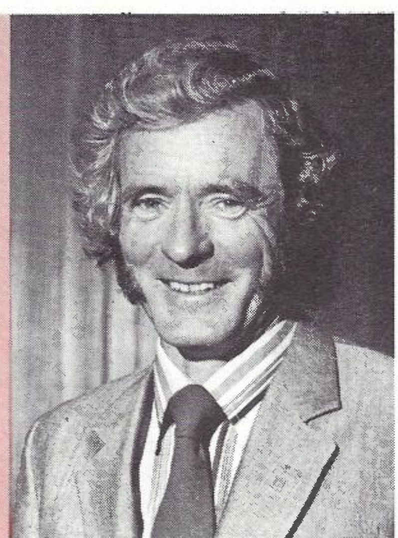
What we see and hear is often a matter of its association with our interest, or with the problem in hand. In the centre of **Fig. 2** we see either a letter or number depending on whether we associate it with a vertical column or a horizontal line.

To be creative in approach to problem solving, a person has to overcome the human characteristics of habituation, selective tuning and association which work together to limit the amount of input to our sensory register in the first place, then focus our attention onto obvious solutions; solutions that are logical, analytical, linear and explicit. Throughout the formative years of our life we train our subconscious "censor" to pass over possible solutions that do not fall into these categories. The academic, the professional engineer, lawyer, or scientist has spent years training his mind to produce these kinds of answers.

CREATIVITY VERSUS AGE

The U.S. Army conducted a study at the U.S. Army Management School, Fort Belvoir, Virginia, in 1964 to try to establish the percentage of highly creative officers in command positions. Industrial psychologists set the test, which began with a population of 45-year-old army majors. To no one's real surprise, the test showed that only 2% were highly creative. Interested to learn at what age

Fig. 2



RON McCARTHY joined the P.M.G.'s Department in 1952 as a cadet engineer and obtained his Bachelor of Engineering Degree with first class honours at the University of N.S.W. in 1956. His early career included periods in Trunk Service, Bearer Utilisation and Country Installation. As an Engineer Class 3 he was project manager for the commissioning of the initial N.S.W. ARM trunk network in 1968. As Engineer Class 4 he was project manager for the Pitt complex in Sydney, including the commissioning of the Pitt 10C trunk exchange in 1976. Since 1976 he has occupied the positions of Staff Engineer, Design and Practices, and Manager, Major Business Customers. At present he occupies the position of Superintending Engineer, Network Service Branch. See Volume 24, No 3, Page 221.

the creativity "petered" out, the school proceeded to test a population of 44-year-olds. Again the tests showed only 2%. Tests continued and indeed became somewhat extended, as it was not until the 7-year-olds were tested that the number of highly creative increased to 10%. With 5-year-olds, the highly creative number jumped to 90%.

The psychologists concluded that the subconscious "file clerk" who runs around furiously looking for items stored in memory that could be relevant to the problem at hand, produces many solutions with only threads of connection for the 5-year-olds. As these often produce disastrous results, ridicule or abuse, the "file clerk" becomes a "censor" conditioned to raise only those items with reasonably strong connections, as the years go by. The highly creative adult is the person who is somehow able to break down these subconscious barriers. This leads us to another interesting discovery of brain function.

THE TWO SIDES OF THE BRAIN

It is a well established fact that the brain is essentially two separate hemispheres, with the left hemisphere controlling sensory and motor functions of limbs and muscles on the right side of the body and likewise the right hemisphere controlling the left side of the body. It is also well established that the hemispheres play markedly different roles in the processing of information.

In 1861 Broca discovered, from post-mortem examinations on paralytics, that the speech function is controlled from an area of the left hemisphere in the outer layer of the brain known as the cerebral cortex, in a position forward of and above the ear. Later, Wernicke discovered that the comprehension of spoken language also occurred in the left hemishphere, in an area of the cerebral cortex backward from the ear. Numerous subsequent experiments have determined that the left hemisphere of the brain can be associated generally with the analytical functions, the logical, sequential, arithmetical, verbal and the explicit. The right hemisphere can be associated with the simultaneous functions, the artistic, the emotional, the visual, the holistic, the implicit and the creative.

These arguments are used to explain why some people can appear to be so bright and so dull at the same time; why the mathematician or scientist may be brilliant at this part of his work and yet completely unable to cope with organisational or political restraints; why the artist may be brilliant at producing a sculpture or model and yet unable to describe his work; why some politicians are unable to produce an efficacious budget.

This is why something can be explained to you and suddenly the "light dawns". You knew all along that this was correct, but you had not recognised the significance of the elements in the proof. Your right hemisphere knew implicitly what your left hemisphere now knows explicitly.

In the highly creative individual, it is believed that many of the "cues" producing the creative input in problem solving come from a well developed right hemisphere.

You may be able to determine which is your better developed hemisphere by a simple test. For example, if you are asked to count the letters in the word "Mississippi", there is a fair chance that your eyes will glance away to the side opposite your better developed hemisphere. If your left hemisphere is better developed, you would glance away to the right. Beware of lefthanded people, however, as it is likely that the functions are reversed.

RELEVANCE OF INTELLIGENCE

Some tests have shown that students with high examination results in a class do worse at creativity tests and excercises than those with low results. These findings tend to agree with the concept of the "file clerk" being programmed to find only the relevant logical, analytical, explicit information for a particular problem.

While the 5-year-old is highly creative, he is not able to solve complex mathematical or analytical problems. His perception may be good, but his inductive reasoning is not yet developed, and his store of relevant information is not yet established.

Similarly, a highly creative bricklayer, one capable of inventing and manufacturing a brick wth similar nailing properties to an Oregon beam, may be quite limited in applying his creative mind to other areas of learning, such as electronics.

Aspects of learning and insight are therefore relevant to the degree of difficulty of the problem, and these qualities are limited to the intelligence of the person concerned. Kohler showed with experiments on apes in 1925 that Sultan, his most intelligent ape, was able to use insight to enable him to reach his food reward, a banana. In a series of experiments Sultan perceived the need to place two boxes, one on the other, to reach a banana tied to the ceiling. He did not perceive the need for a stable structure, however. Sultan also "got the idea" of joining two sticks together (like a fishing rod) to rake in a banana beyond reach from within his cage. Learning through insight depends on the following:

- Intelligence
- Experience
- Organisation
- Trial and error behaviour

If the tools needed for the solution are hidden, the solution through insight becomes impossible. Intelligence, experience and organisation are therefore relevant for establishing creativity in a given environment, and even more important is the scope for trial and error learning.

CREATIVITY — HOW DO WE USE IT?

The following lists the selection of recommendations by the author considered appropriate to Telecom. It is stressed that most of the ideas are not original, but are a collection from the references to the paper. They are described briefly here:

- Tap the Creativity of New Recruits — The new recruit is in many ways like the 5-year-old. He has not been "programmed" to the new work environment, he can look more objectively at it, and often he has a kit-bag of new tools, like Sultan's sticks, to apply insight to solutions.
- Provide Mobility for Specialists and Managers — The reasoning is similar to the above. In this case, the experience from the old environment may be applied to the new. It enables the individual to establish a more diverse background of knowledge and experience and helps to break down the barriers of habituation, selective tuning and association described in this paper.

- Provide Ready Access to Information — This idea occurs frequently in the references and is commonsense. The data should include all aspects, such as financial, industrial, marketing etc., as well as technical.
- Provide Opportunities for "Soft" Data — Face-to-face communication with as many levels and functional groups of an organisation, as well as the individuals in it, is needed to provide access to "right hemisphere" information and attitudes. Just as the Prime Minister or the street-gang leader are the best informed of their respective organisations, the project or group leader needs access to information which is visual, dynamic, emotional, implicit and gestalt, to allow him to make decisions requiring "judgment" and "intuition".
- Provide Educational and Development Opportunities
- Provide Rewards and Credit for Achievement — Both factors are widely written about for encouraging performance and a creative attitude to work. In Telecom the rewards could take the form of published papers, accreditation for completion of projects and achievement, and involvement in seminars and symposia of relevance to the tasks of individuals involved in project work. (See Task-forces).
- Streamline the Staff Suggestion Scheme — This source of creative input is largely neglected and discouraged by the existing impediments, time-lags and methodology. The need for trial and error experimentation is an obvious part of creativity, yet it needs caution in its application. Proponents should be encouraged by quick response and the offer of assistance from the "system" to put forward suggestions in the "ideas" phase rather than to construct a clumsy item or device and test it, often on working equipment, before submitting a formal suggestion. Protection for the proponent and safeguard for the network would result. Progressive awards could be made for suggestions which proved really worthwhile.
- Develop the Industrial Engineering Function — The use of outside consultants provides a source of creativity, because of the objective approach and lack of "programming" or "conditioning" to the problem at hand. The Industrial Engineering groups could be used more frequently in a similar way and it would be an advantage to have a specialist in this area develop creative strategies, such as in synectics.
- Task-force Management Principles — Task-force management principles appear to be ideally suited to an environment such as found in Telecom Engineering. In fact, they exist already in Telecom for hundreds of design and practices projects. The main ingredients of such a scheme are shown below, where the task-force comprises a project team with members working part-time in most cases on this task as a job separate from the normal job, where the "line control" remains intact. Line management at all levels must support the task-force concept for it to be fully effective, otherwise clashes of priority can cause problems for individuals and delays to the projects (or even abandonment of them in the worst case).

TASK FORCES

In an organisation the task-force concept provides a proven creative unit which is rewarding for the people involved. Properly managed and supported, the task-force is a very efficient method of handling design and practices type projects that aim to "change" the nature of the work, or the method of performing it in the normal "performance" area. The main features are stated below.

Five-men Teams, Multi-disciplines

Numerous authorities claim a 5-man team to be the most effective, most creative, and about the size needed to provide adequate representation and later acceptance by the disciplines or functional groups affected. Mixed classification levels as well as mixed skills and backgrounds are important (see "Autonomy of Group and Individuals").

Leadership "Technical" Competence

The most significant factor leading to successful project teams is the selection of a leader considered to be the most "technically" competent.

Multi-tasks for Individuals

All team members must have multi-tasks, separate from the project. It has been established that even some degree of administrative workload tends to increase an individual's innovation. It is probable that this is linked with the "mulling it over" phase of creativity — the same phenomenon that gives rise to solutions under the shower, on the golf course or before or after sleep.

Autonomy of Group and Individuals

Individuals must be allowed to assume responsibility on the team for their respective areas of expertise.

External Scientific and Technological Inputs

The team must research the subject thoroughly to establish their expertise and gain acceptance as specialists in this area.

Task Orientation

The team must be kept aware of the time factors. The "perfect" solution is seldom the best, intermediate goals and trade-offs should be part of the team strategy, and progress towards a set end product must be monitored and oversighted.

Sponsor

The majority of creative works in the industrial arena have had a sponsor, someone high enough in the organisation to provide moral support, policy guidance and preferably some resources at critical stages. Indeed, many would-be designs have withered on the vine because they lacked a sponsor. For this reason, top management has a responsibility to encourage proper assessment of proposed projects in the formative stages to avoid project failures which are not only costly but damaging to morale. Equally damaging is a completed project which is not supported adequately in the implementation phase, and never gains proper field acceptance. Much work has yet to be done in the processes we use to establish and support project teams.

THE BALANCE

In business there exists a paradox with regard to the achievement of innovation. That is, the factors that increase the probability of innovative proposals often are those factors that decrease the probability that the organisation will adopt them. For example, the greater the diversity of an organisation the greater the probability that major innovations will be proposed, but the smaller the proportion of major innovations that will be adopted.

It has been established that the larger organisations, partly because of resource availability, produce more innovations. A great deal of this, however, is in the quest for prestige rather than for organisational effectiveness.

So there is a delicate balance between creativity versus control and restraint, just as there is a delicate balance between the pursuit of new technology versus the optimisation of existing facilities and resources, between improvisation and flair versus standardisation, between productivity improvement versus staff needs and staff association reactions.

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In Brief

IREECON '81—Call for Papers.

Full details of the method of registration of your intention to submit a paper for this convention appear in the advertisement appearing in this issue.

The IREE offices in Melbourne and Sydney would like to hear from prospective authors NOW with notification of intent to submit papers.

"It's important that we hear from authors to give us an idea of the categories of papers we are likely to receive. Our authors play an integral part in the success of IREECON" said Mr Max Williams, Vice President of The Institution and Chairman of IREECON International, Melbourne '81.

Mr Williams, when commenting on recent developments within the electronics industry, said the Federal Government's announcement on cable television for Australia and other news related to the introduction of videotext (a visual display public information service) were promising news for the electronics industry. "We welcome both developments and see the electronics industry receiving a substantial boost from them," Mr Williams added.

He said the electronics industry was pleased to hear that Telecom Australia was looking at the introduction of videotext (a public information service via a modified television set).

Mr Williams welcomed Telecom's current discussions with set manufacturers and other interested parties such as information suppliers.

He said it had been indicated that a videotext service could be in operation within two years and this would be another bonus for electronics in Australia. He was certain that videotext and cable television would feature heavily at IREECON International Convention and Exhibition when it was held at the Victorian Government Pavilion, Royal Agricultural Showgrounds, next August.

"No doubt there will be authors greatly interested in presenting papers on these two subjects . . . and of course the entire range of electronics".

CHANGE OF COUNCIL OF CONTROL CHAIRMANSHIP

Mr R. K. McKinnon, Chief Services Engineer, Telecom Australia, is the new Chairman of the Council of Control of the Telecommunication Society of Australia. Telecom's Chief General Manager appointed him to this position recently in place of Mr P. R. Brett, who stepped down from the office of chairman upon becoming Telecom's State Manager for Victoria.

Under the Society's constitution, its chairman is appointed from Telecom's headquarters staff by the Chief General Manager.

Mr McKinnon's first association with Telecom (then the APO) was as a temporary technician in the Transmission Laboratory in Adelaide in 1944. He later served in the RAN. On discharge in 1946 he undertook a Bachelor of Electrical Engineering Course at the University of Adelaide and on its completion in 1949 returned to the APO as an engineer.

After experience in the transmission, telepower and the telegraph fields in Adelaide, Mr McKinnon was promoted to Headquarters in 1952 where he worked in the data and telegraph field, particularly in the development and automation of the telex system and the development of data services.

He completed a Diploma of Public Administration at the University of Melbourne in 1956.

Later his responsibilities included telecommunication technical and design policy and, on Vesting Day, engineering responsibility for customer networks and equipment. Mr McKinnon became Chief Planning Engineer during the period of development of the plans for digitalisation of the network and participated for Telecom in national consideration of satellite issues. He was promoted to the position of Chief Services Engineer in 1980.

He has contributed to the work of national and international bodies in several different technical fields and published technical articles in various publications. A number of articles on telegraph and data subjects in this Journal over the years bear testimony to Mr McKinnon's long-standing interest in the Telecommunication Society's work.

The Society is indebted to Mr Brett for his oversight and guidance of its affairs from 1975 to 1980, and welcomes Mr McKinnon to the chairmanship.

Radio Propagation Above 10 GHz
Part 1 : An Overview of New Frequency Bands

J. M. BURTON, B.E., B.A. and E. VINNAL, B.E.

The steady trend over the past 20 years of increasing use of the microwave frequency spectrum is forcing radio systems further into the SHF region. New frequency bands above 10 GHz may be exploited sooner than previously thought because of economic as well as technical reasons. The first part of this paper provides an overview of the general characteristics of electromagnetic transmission above 10 GHz. In particular, such factors as attenuation for rain, fog, mist and gases are considered. The provision of junction circuits and other wide bandwidth transmission systems, as well as infra-red and optical systems, are discussed.

As trunk traffic grows in Australia, the frequency bands between 4 and 8 GHz allocated for point-to-point radio systems are filling up. This steady trend over the past 20 years of increasing use of the microwave frequency spectrum is forcing radio relay systems further into the SHF spectrum; particularly in the urban areas. This trend is fully developed in countries from which Telecom buys equipment. Manufacturers in these countries are concentrating their research and development efforts on new systems, which invariably use digital modulation. A number of European telephone administrations do not intend to purchase further analogue radio equipment after 1982. In Japan, a high capacity 20 GHz 400 Mbit/s system has been operational since 1977.

In Australian urban areas, digital radio systems (DRS) may be used to assist in digitising junction networks. Their use assumes greater importance with the recent approval in principle for an integrated digital network (IDN) and the likely early introduction of AXE digital exchanges. DRS will also find application in the next few years for wideband subscriber services requiring bit rates up to 34 Mbit/s. When used for these purposes, the frequency spectrum above 10 GHz is attractive as it avoids the use of bands occupied by analogue or digital trunk systems operating in the same area.

Telecom has recently decided to provide a digital data network (DDN) which will link together the capital cities by 1982. Although this digital traffic will initially be superimposed on the existing analogue trunk radio network, it is expected that a rapid expansion of the DDN will require a separate network to be established after the mid 1980s. In addition, the trend towards digital switching techniques will also favour the consideration of trunk systems using digital radio. For reasons of economy as well as spectrum considerations, these bands above 10 GHz may be exploited sooner than previously thought.

Clearly the Australian demographic distribution is quite different from that in Europe or Japan. Geographical distances between major population centres are greater, population densities are lower in Australia, and the radio climatology* differs vastly over the Australian continent. Compare this to the relatively uniform radio climatology of Japan and Britain. In economic terms, will radio-relay systems in Australia continue to thrive as a recognised alternative and genuinely competitive means of transmission? The 1980s will bring the added competition of a domestic satellite system, and optic fibres which can be used to extend the life of cable ducts. For example, in 1978 a Californian microwave link was replaced with a fibre optic trunk line (Ref. 1). In this instance, 12 TV signals are transmitted over the 8 km trunk to a group of 6000 subscribers.

Telecom is in business to provide telecommunications in an economic manner and hence planners cannot afford to have sentimental attachments to particular methods of transmission. It is therefore timely to re-examine the radio spectrum and to investigate what the emerging role of transmissions above 10 GHz will be. Since nothing comes free, the problems associated with the exploitation of this resource will also be covered. Part 2 of this paper will concentrate on the characteristics of rainfall and the effect it has on microwave radio systems. Methods of predicting the rain attenuation statistics will also be described.

GENERAL VIEW OF THE SPECTRUM ABOVE 10 GHz

Fig. 1 shows the attenuation expected from rain, fog, and various gases whose absorption bands arise due to molecular resonances. Examining the attenuation by

* It is the point-to-point variations in a number of inter-related atmospheric factors such as pressure, temperature, humidity and rainfall which determines the propagation characteristics of the radio transmission path.

gases, the pattern shows a number of peaks due to absorption by water vapour, oxygen and carbon dioxide. These peaks or absorption bands offer high attenuation levels per kilometre. Between these peaks there are a number of "windows" where the absorption is much lower. For example, a window exists in the infra-red region, an area of interest for equipment manufacturers (Ref. 2), centred about a 10 micron wavelength. The windows between absorption bands offer greater transmission distances in comparison though care is required to ensure adequate reliability due to the other propagation effects such as fog, mist, cloud, snow and hail.

Fortunately at frequencies below 50 GHz the attenuation per kilometre from fog is small. In the case of mist, the water droplets are smaller than in fog and the attenuation caused by mist is correspondingly less than that caused by fog. Most radio system sites that will be used above 10 GHz will be below cloud levels. However, where radio terminals are established on high mountains, cloud cover may be experienced. In these cases, cumulus and cumulonimbus cloud water contents are generally less than that of heavy fogs and hence the attenuation will be generally less as well. Snow and hail are an insignificant portion of the precipitation catch over most parts of Australia and the incidence of and resulting attenuation from these causes is insignificant.

Rain attenuation is often the deciding propagation characteristic at frequencies between 10 and about 100 GHz. The dependence of this attenuation upon rainfall rate can be seen from Fig. 1 : for a rainfall rate of 25 mm/h (moderately heavy rain) the attenuation at 10 and 100 GHz is about 0.5 and 10 dB/km respectively. To put these rainfall rates in some sort of perspective, some capital city annual rainfall rates are shown in **Fig. 2.** As expected, the geographical spread is reflected in the rain rate spread. At the 0.01% (about 50 minutes per year) level we can compare rain-rates at Darwin (80 mm/h), Brisbane (55 mm/h) and Melbourne (20 mm/h). Therefore systems intended to meet International Radio Consultative Committee (CCIR) specifications would require larger fade margins or shorter paths in Brisbane or Darwin than in Melbourne.

Telecom is currently concentrating effort in the 10-40 GHz section of the spectrum and experiments are being carried out to enable accurate predictions to be made about reliable path lengths and system availability in different regions of Australia. This entails not only measuring the propagation characteristics of experimental systems operating above 10 GHz, but also requires a careful characterisation of rainfall rate statistics (Refs. 3, 4, 5 and 6).

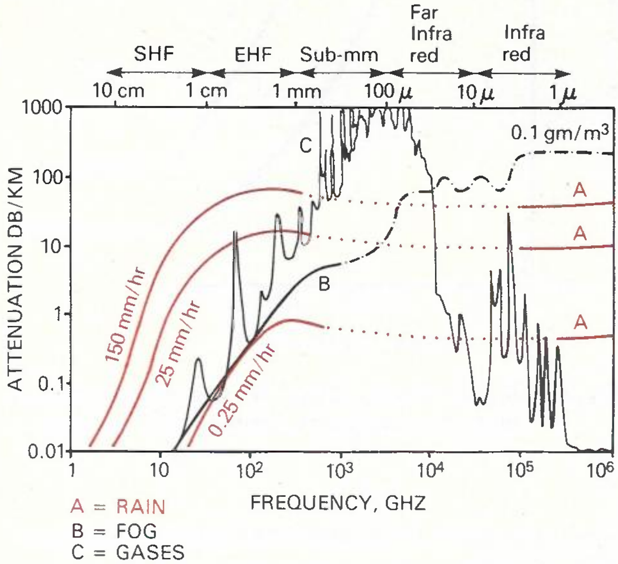
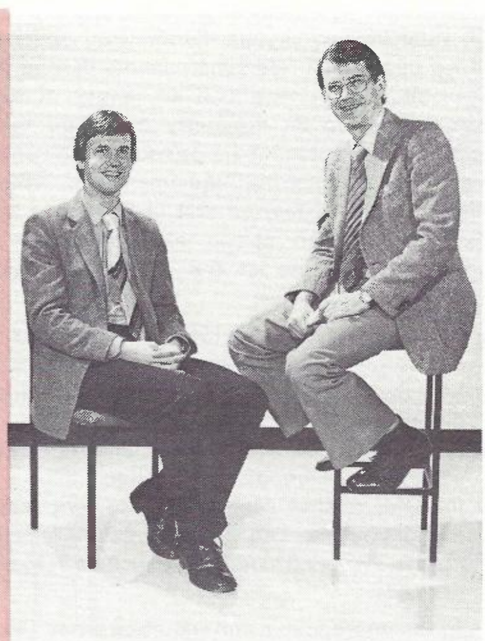


Fig. 1 — Attenuation Due to Atmospheric Constituents

JOHN BURTON is a Principal Engineer with Transmission Planning Branch in Telecom Australia Headquarters. He holds a B.E. (Hons.) degree from the University of NSW and a B.A. degree from the University of New England. He joined the Australian Post Office in the 50's as a Technician-in-Training and worked on broadcasting and subscriber services in Queensland and NSW. In 1974 he commenced with the Telecom Australia Research Laboratories as an Engineer, working on microwave holography and on radio propagation studies. In 1979 he was promoted to Planning Branch and has been working on regional area network studies including the new digital radio concentrator system.

ENN VINNAL graduated in 1972 from Monash University with a B.E. (Hons.) degree and joined the Telecom Australia Research Laboratories. Up till 1979 he worked on investigations into mobile radio and digital radio systems. In 1979 he moved to the Antennas and Propagation Section and is working on radio propagation studies and on antenna measurements.



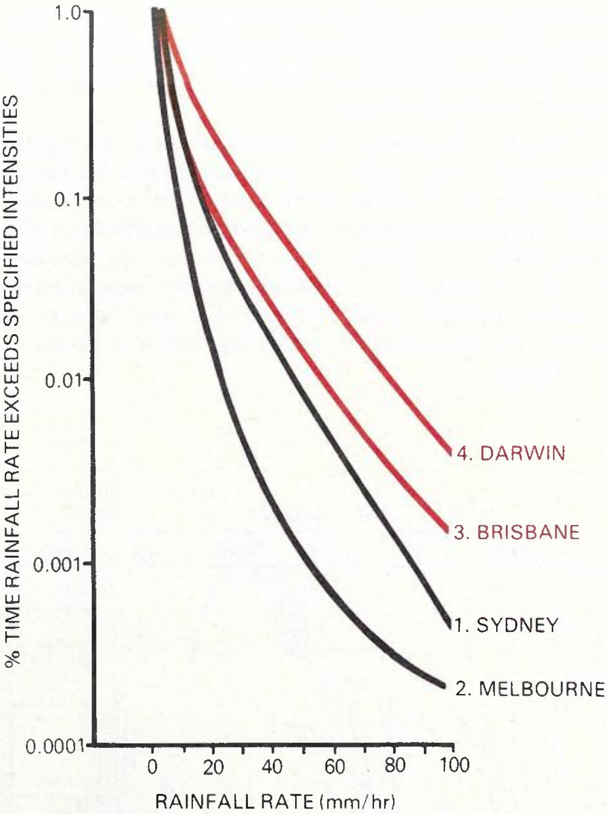


Fig. 2 — Some Capital Cities' Annual Rainfall Rates with an Integration Time of 360 seconds

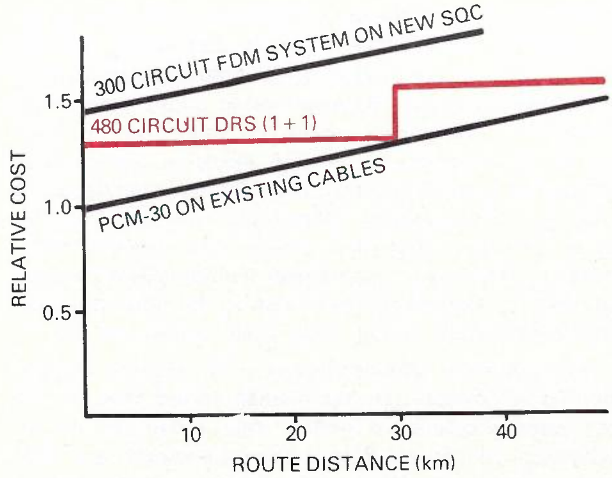


Fig. 3 — Average Cost of Provision of Switched Telephone Circuits in Metropolitan Areas Assuming ARF Exchanges

APPLICATIONS OF RADIO SYSTEMS BETWEEN 10 AND 18 GHz

It seems likely that the 10-18 GHz section of the spectrum will be the area of initial expansion above 10 GHz. A typical application is the provision of junction circuits; equipment is readily available and already widely used overseas. Within inner metropolitan areas, e.g. less than 25 km radius in Melbourne, adequate junction growth can be obtained by converting physical pairs to 30 PCM-derived circuits. Further out where inadequate or no ducts exist additional circuits can be provided by DRS situated at telephone exchanges. Naturally, costs would need to be rigorously examined to define the economic advantage to be gained. But the cost of a DRS, including multiplexing equipment for 480 channels, **Fig. 3**, would appear on first glance to be an attractive proposition when placed alongside cable and duct provisioning. Some of the assumptions about these curves are as follows:

- the single quad carrier (SQC) relative costs include the cable, relay sets, the multiplexers and installation — half the SQC cable was ploughed in and half was placed into existing ducts.
- the PCM-30 relative costs include regenerators, relay sets, multiplexers and installation.
- the DRS relative costs include towers, repeater, relay sets, multiplexers and installation. The DRS operates in the 13 GHz band in locations such as in Melbourne and Adelaide.

In the metropolitan and suburban areas, particular care needs to be taken that the mast and antenna structures are not visually objectionable. Any proposed tower configuration will come under the scrutiny of both the formal planning authorities and various ad-hoc residents' associations. Fortunately, the smaller antennas and lower tower heights used with short-hop SHF systems mean that visually inoffensive and attractive tower structures are possible. An example is illustrated in **Fig. 4**. Where possible antennas should be integrated into suitable buildings.

Fig. 4 — Japanese 18-20 GHz Radio Repeater

Because of rapid unforeseen demographic changes, there may be need to increase junction capacity on a short-term basis in particular areas. The portability and small size of SHF terminals means that radio links can be installed reliably and quickly.

As previously mentioned, environmental restrictions and economic reasons will often preclude the use of high towers in metropolitan areas. It may be feasible to provide temporary junction relief circuits by using reflection and scatter from large buildings to obtain access to low lying areas. SHF systems may be used for other reasons, e.g. to provide access to satellite earth stations or to major city terminals where spectrum space is limited.

In the near future it is difficult to see SHF systems above 11 GHz competing directly with existing configurations to provide trunk radio circuits. In the UK, 11 GHz DRS are being overlaid on existing 4 and 6 GHz analogue routes though this does lead to repeater spacings somewhat longer than the ideal (Ref. 7). This must be compensated for by raising transmitter powers or lowering system availability below CCIR standards. The main repeater spacings will be about 40 km whereas 20-30 km is considered a more suitable distance.

RADIO TRANSMISSION ABOVE 18 GHz

Demand for data services in the Australian national network is predicted to rise as shown in **Fig. 5.** As long as requirements are limited to voice frequencies and medium speed data (less than about 4.8 kbit/s) which can be economically handled by telephone cable pairs, it will not be possible to prove that millimetre radio equipment will be economic. If there is a growing demand for wider bandwidth e.g. to cater for high speed facsimile or higher speed data transmission, there will be increasing need for local links of better quality than ordinary telephone pairs can provide. When their requirements develop, millimetre wave equipment operating in the 18 to 40 GHz bands may be an attractive alternative: large RF spectrum bandwidths are available and the equipment is portable and easily installed. Above 18 GHz however, paths tend to be very short; Japanese 18-20 GHz systems (Ref. 8) have paths about 3 km long which would be suitable within central business districts. The only techniques to ensure that these systems operate during the high rainfall attenuations which occur, is by either shortening the paths or by using route diversity. For example at 36 GHz, a rain rate of 100 mm/h over the path will cause 23 dB/km attenuation. Little is therefore gained by increasing transmitter power by 20 dB. The Japanese high capacity 18-20 GHz system uses the 25 m high repeaters, shown in **Fig. 4,** to provide 5760 voice channels at a 400 Mbit/s bit stream rate. In the U.S.A., the suggestion is that suitable applications for 40 GHz systems are uses between business data processing centres, banks, burglar and fire alarms, remotely controlled and supervised equipment locations, point of retail sales, dispatcher and industrial telemetering, and data gathering sources (Ref. 9).

An interesting alternative to the conventional radio-relay arrangement is the so called "hertzian cable" (Ref. 10). This, if practical, will result in both high information capacity and a larger available margin for rain attenuation. It consists of a series of pairs of focussing and redirecting cylindrical mirrors mounted on suitably high buildings as shown in **Fig. 6.** Operating at 100 GHz the redirectors can be 1 metre square and the interspacing can be at least 100 m. Experiments at 105 GHz using 10 pairs of redirectors over a 0.8 km path show that a clear day attenuation of less than 3 dB from transmitting to receiving waveguide can be achieved. This type of system therefore has very little associated path loss and therefore a considerably larger fading margin (to accommodate rain) than a conventional system. The magnitude of attenuation from a rain-rate of 100 mm/h over the 1 km path will be about 33 dB. In Melbourne and Sydney, this fade depth would occur for approximately 2-3 minutes of the year. In a practical system, spectral components of the beam would be dropped for local use by means of quasi-optical filters.

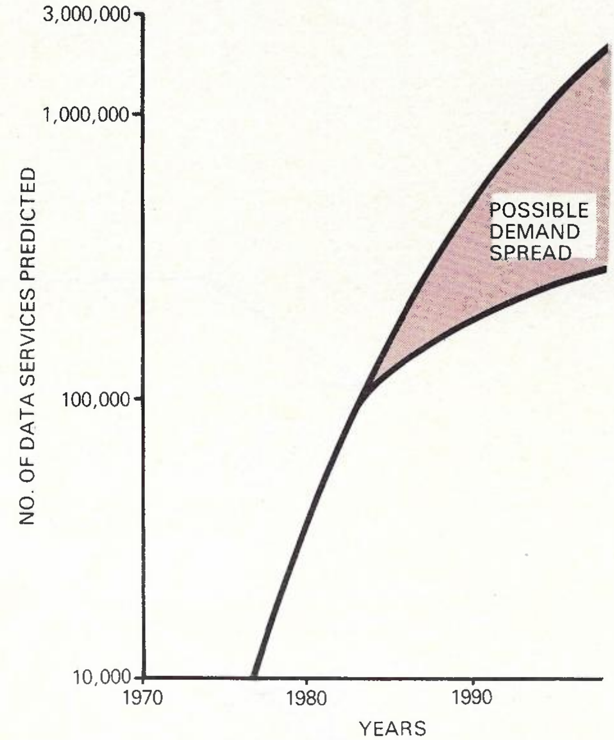


Fig. 5 — Data Modems in the Australian National Network (All Types)

INFRA-RED AND OPTICAL SYSTEMS

Between 500 GHz and about 10 000 GHz absorption from atmospheric gases reaches high levels: over 1 000 dB/km around a broad peak centred on a wavelength of 100 microns, Fig. 1. There are specific applications where this and other absorption peaks may be a suitable operating point e.g. to provide security and good protection against interference and for frequency reuse. It is difficult to foresee the 100 micron band being used to provide terrestrial communications.

However, at 10 microns, the infra-red (IR) band, and again in the visible band, "windows" suitable for operation exist. From Fig. 1, it can be seen that infra-red radiation will penetrate fog better than visible light; a fog where the visibility is about 500 m will cause attenuation of 100 and 300 dB/km to IR and visible light respectively. As an estimate, a light fog (visibility restricted to 1 km) would cause an attenuation of 20

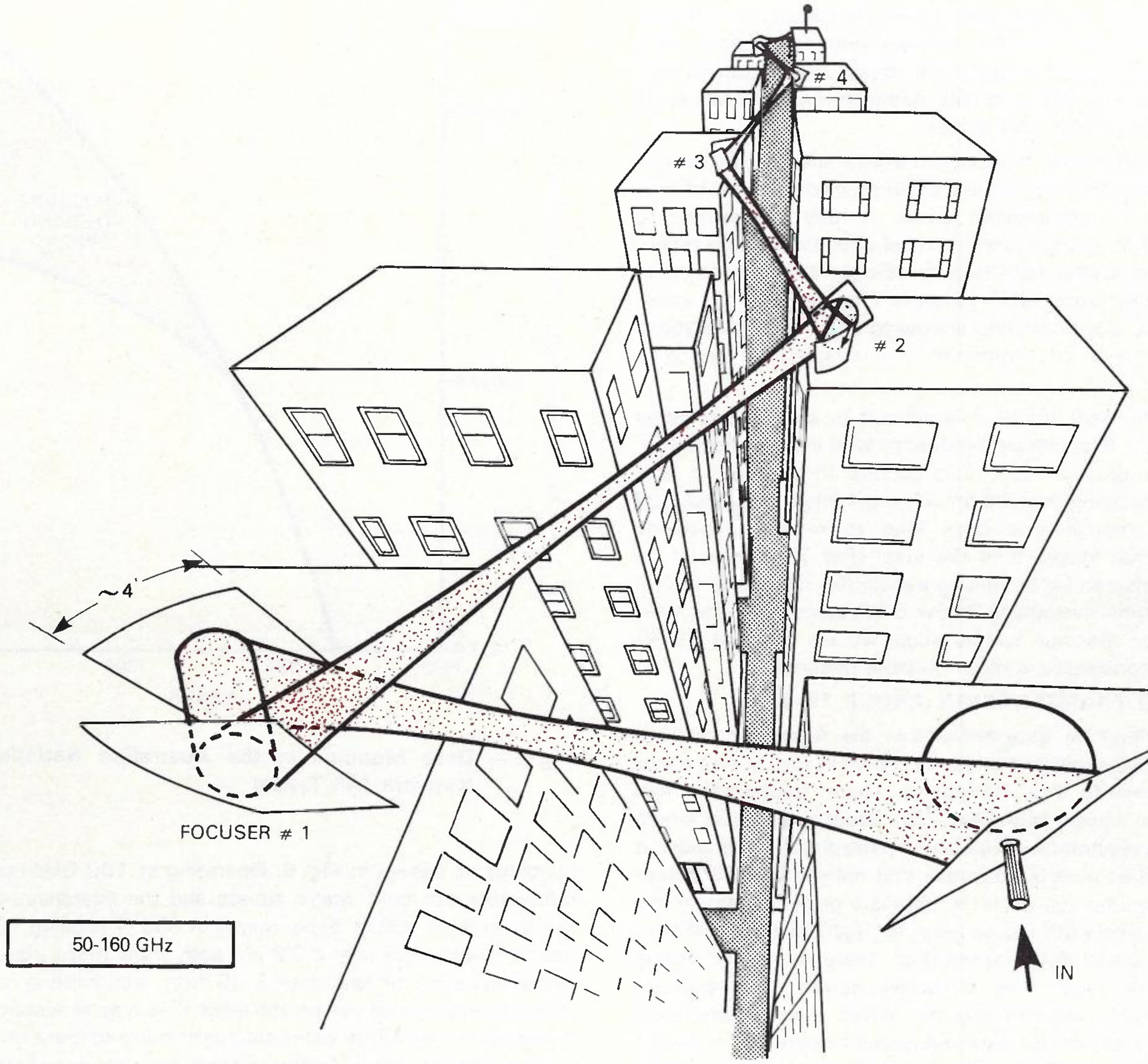


Fig. 6 — "Hertzian Cable" System

dB/km to an IR link. As can be seen, rain results in the same magnitude of attenuation to both IR and visible systems. Both wavelengths suffer attenuations of around 10 dB/km during "moderately heavy" rain of 25 mm/h. Therefore a system with a fade margin of 30 dB could operate over a 1 km path if only the rain attenuation and light fogs are taken into account; heavy fogs "kill" the system. According to Sander (Ref. 11), investigations made by Bell Telephone Co. determined that the maximum repeater spacing of a simple optical link in the U.S.A. is about 90 m to meet a 99.99% reliability of transmission.

Orthodox uses of unguided IR and optical links provide facsimile, conference television, telephony, data transmission and closed circuit television. In Cleveland, U.S.A. (Ref. 11), 35 hospitals are interconnected by means of a CCTV laser colour TV system. Cleveland Police Department uses an optical CCTV link to monitor the university campus. A reported 46% reduction in crime is claimed! For whatever the reasons, U.S. optical system sales rose from $5 million in 1971 to $50 million in 1975.

How would IR or optical systems perform in Melbourne for example? Using Bureau of Meteorology data, IR and optical links would have path lengths restricted to 300 and 100 m respectively for reliable operation. These systems may have uses in restricted circumstances: the transmission of very wide-band high data rate digital communications within the central business district (short path lengths), to provide longer links where high reliability is not required, or to provide emergency circuits for use after natural catastrophies. Regarding the latter case, IR and optical equipments are very light and portable; installation could be carried out by one person. In designing optical systems, the received power density can be increased by reducing the beam divergence; the limit is the stability of the terminal mountings.

The essentially short range characteristic of IR beams can be used to provide a common communications channel: an IR bus. Offices, factories and shops will soon be heavily infested with microprocessors. To connect these all together with wires would be expensive, inflexible and impractical. IR transducers are becoming

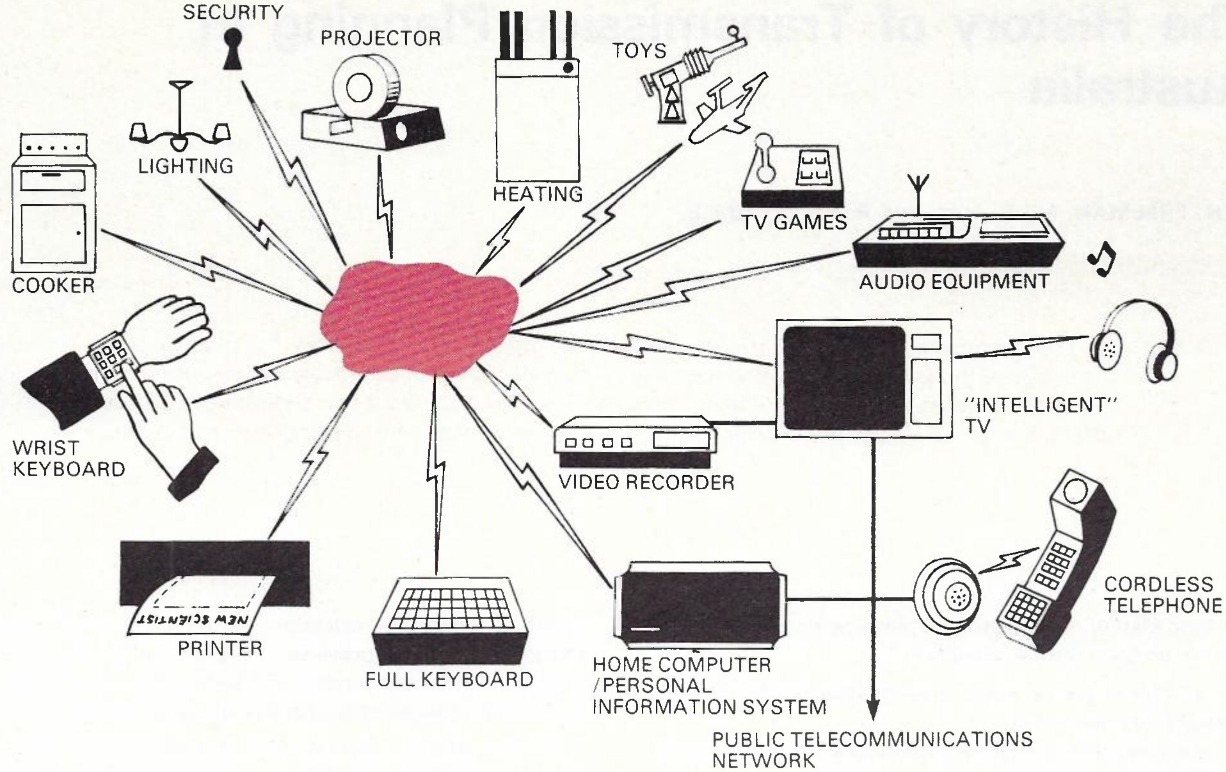


Fig. 7 — Household Infra-red Data Bus

steadily cheaper and could be used to bathe a room or area with modulated IR. The data centre of the future may use IR transmissions to replace signals sent over wires. In the home, **Fig. 7**, an IR bus may one day feed data to a number of appliances including telephones. An infra-red telephone was demonstrated in Europe in 1979. It was claimed that this cordless handset can be used anywhere in a room (Ref. 12). Telecom is at present examining the developments available in the field of cordless telephones, but as yet no decision has been reached about the type of technology that might be authorised to provide such cordless telecommunication facilities.

SUMMARY AND CONCLUSIONS

This has not been an exhaustive examination of the propagation characteristics and transmission techniques above 10 GHz. Rain attenuation on terrestrial radio systems will be examined further in the second part of this paper.

This brief glimpse has shown the general characteristics of electromagnetic transmission above 10 GHz. In particular, the relationship between propagation attenuation and rain, fog and atmospheric gases has been examined. Some aspects of wide bandwidth transmissions including hertzian cables are briefly discussed as are systems in the infra-red and optical regions. Some of these techniques such as the hertzian cable or the infra-red bus are not yet commercially available technologies. Other methods for interconnection of services such as the use of optic fibres, domestic satellite, and point-to-point radio relays operating above 10GHz are possible alternatives to existing bearers. However, the spectrum above 10 GHz may well possess the best means to provide cost effective solutions to many specific services now and in the future.

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The History of Transmission Planning in Australia

A. H. FREEMAN, M.I.E. Aust. and R. KILLEY, B.E.E.

The continued evolution of transmission technology during the century that has passed since the invention of the telephone has been reflected by marked changes in the economical limitations influencing transmission planning. The article traces these changes through four distinct phases and suggests that the present work on digital techniques marks the commencement of another phase in this sequence.

In the history of transmission planning in Australia four distinct phases can be identified:

- A primitive phase when transmission planning was largely unnecessary.
- A pioneering phase when objectives were limited by the absence of amplification.
- A cost-limited phase when transmission objectives were necessarily based on the minimum acceptable transmission quality.
- A customer-oriented phase where cost reductions possible by the use of transistors and integrated circuits are leading to transmission objectives based on customers preferences.

A fifth phase is already in sight, where digital techniques will allow all customers to be given the best possible service without the need for formal transmission planning.

These phases have overlapped and the transition between them has been gradual. The main factors causing the transitions have been changes in network size and structure, and the availability of new types of equipment.

PRIMITIVE PHASE

This began in 1880 with the first telephone exchanges and in some areas it was coming to an end in 1900. This was a period when high costs limited the use of telephones to geographically small isolated networks.

Except for a few short feeds, the most economical line plant was open wire and line losses were so small that they could be and were ignored. Frequently, the line losses were lower than the transmission impairments caused by switching equipment in the exchanges.

Two trends eventually brought this phase to an end. As more telephones were connected the use of longer sections of cable was economically justified until the resulting transmission impairments could no longer be ignored. At about the same time long trunk lines were built for which the conductor size and type had to be selected on the basis of transmission performance. There was a gradual transition to the pioneering phase and as a rough guide it can be considered that the change occurred when the selection of the most economical methods of plant provision resulted in a significant number of interconnections which had a line loss greater than 10dB or when long trunk lines were being planned.

On this criterion, Sydney saw the end of the primitive phase in 1898 when the first trunk line was built to Newcastle. This was also a critical date for the local network, being the last date at which all junctions were open wire, except for the harbour crossing. Ten years later, as much as 25 km of 1mm unloaded cables could be encountered in calls across the junction network.

A similar date seems appropriate for Melbourne while the other capital cities were a few years behind. On the other hand, as late as 1930 nearly all country exchanges were less than 500 lines with no more than 1 km of 0.64mm cable in any subscribers line. Transmission design of subscribers services could, therefore, still be ignored at these exchanges.

PIONEERING PHASE

The main characteristics of the period 1900 to 1925 were the extension of the trunk line network and extensive use of cable in the metropolitan networks. This phase was technologically limited by the absence of any form of amplification. As a result, trunk lines were costly, high costs limited demand, and few trunk lines were built longer than about 400km. Each capital city was the focus of an isolated star network of trunks, and the only interstate line was between Sydney and Melbourne, built in 1907. With a line loss of 16dB it was hardly suitable for extension to country exchanges at either end.

In the local networks the extensive use of cable increased line losses, and as a range of conductor weights became available it became necessary to decide what cable to use to meet transmission requirements. In 1901 the only cable conductor size in use was 1mm, but by 1925 cables were available with 0.64mm, 0.7mm, 0.9mm and 1.27mm. In choosing a conductor size, consideration would have to be given to the losses in existing cables and any future cables envisaged in the network. In practice, however, cables seem to have been chosen without sufficient consideration of the future, and frequently a 0.64mm subscribers cable would be extended piecemeal until it was far beyond the transmission limits, and the same was sometimes the case with junction cables.

The transmission limits adopted for local networks at this time are not known, but they were almost certainly based on B.P.O. practice, which would have allowed a maximum junction loss of 21dB. A drawing of the Sydney junction network in 1931, which is believed to reflect the conditions when this network was largely rebuilt in 1915, confirms this opinion. It appears however that subscribers line transmission limits were not closely observed in this period.

For trunk lines, open wire copper conductors of 2.84mm, 3.48mm, 4.02mm and 4.92mm were used and the choice of conductor was probably an interactive process in which transmission quality and profitability were the major considerations. If the construction was made too costly in order to get better transmission the route might be unprofitable. On the other hand if the transmission quality was degraded too far in order to cut costs the customer might refuse to use it and send telegrams or letters instead. Then again, a line of 50 or 100km might be intended to be the start of a much longer trunk circuit and due allowance had to be made for the future. In any case, with physical line plant trunk line call charges were high and the development was slow.

A useful technique used at that time was multiplexing an existing telegraph circuit to allow it to be used simultaneously also for telephony. This only required high and low pass filters and the arrangement was variously known as a "Condenser Telephone Line," a composite set, or the Van Rhysselburge system. Because existing telegraph wires were usually iron, the loss was fairly high and these circuits could be used only for short distances. However a low-loss copper trunk to a centre some 200 or 300km away could be extended on condenser telephone lines to surrounding towns.

This phase ended with the introduction of amplifiers (1920) and carrier systems (1925). Its main features were an insidious increase in the line losses in local network calls, and the gradual spread of trunk line networks around capital cities and very large country centres. At no time during this phase was it possible to contemplate an Australia-wide trunk network.

COST-LIMITED PHASE

Carrier systems made it possible to plan for a national trunk network and 2-wire amplifiers were a valuable tool in achieving rapid progress at a low cost.

In order to properly plan the introduction of the new technology a group of specialists was set up to form what was to become the Telecom Research Laboratories. One result of this was that transmission, formerly one of the responsibilities of every engineer became a "black art" to be practiced only by those who had been initiated into its mysteries. This was unavoidable in the early years but in the author's opinion it was a tragedy that this isolation was maintained far too rigidly in the following fifty years.

One of the first tasks of the Research Laboratories was the production of the first formal transmission planning rules for Australia. These were issued in 1927 and 1930 and, so far as urban networks are concerned, the present transmission limits are only marginally better. The trunk network limits were a compromise between acceptability and achievability and by 1935 it had been set as a very long term objective that trunk transmission limits should be the same as the urban limits.

Established urban networks did not meet the new transmission standard and, in particular, subscribers' lines on the outskirts of some very large exchange areas were very poor. The networks were improved by sub-dividing the larger exchange areas and loading some junction cables. Up to this time there had been very little loading of cable circuits in Australia but costs were shifting in favour of this practice. These improvements were a long term plan, with new exchanges being programmed to take over growth when an existing exchange building was fully occupied, or when major conduit works would otherwise be needed. Meanwhile, new plant was provided in accordance with the ultimate scheme, and sometimes transmission became worse before it became better.

In the trunk network the long-term plan envisaged a central core of carrier systems linking zone centres, providing low-loss transmission between them, and 2-wire circuits from zone centres via group centres to terminal exchanges. The 2-wire circuits involved were often very long by modern standards.

In 1930 carrier was unlikely to be justified unless there was a requirement for 3 or more circuits between places more than 500 km apart. These conditions were seldom met, and initially the trunk networks were expanded by the use of 2-wire amplifiers. These were operated at what now seem incredible gains, sometimes reducing the loss of a line by 75%.

This opened new possibilities such as effective transmission from Adelaide to Brisbane or Sydney to Townsville and the improved transmission on shorter

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distances stimulated traffic to the point where carrier circuits were justified.

The development of the trunk network over the next 30 years (1930-1960) would require separate treatment on its own, and will not be covered here. There was a steady trend for carrier costs to reduce and the 2-wire portion of the trunk network to become shorter. As it did so transmission limits on these ends could be met with less costly line construction. Thus the transmission gains from carrier were used firstly to upgrade transmission in areas where the limit requirements were not met, secondly to allow transmission limits to be met more economically and never to deliberately improve transmission performance to a level better than the limits.

Over the period, transmission planning methods and detail design rules were modified to allow for the introduction of new telephones, different types of switching and new types of carrier systems with different behaviour in such aspects as noise and attenuation/frequency distortion. However, throughout all these changes there was a continuing emphasis on the limit condition.

CUSTOMER-ORIENTED PHASE

Although, as stated above, the engineering instructions (EIs) and planning methods are limit orientated, carrier development in the 1970s reduced costs to the point where many terminal exchanges were served by carrier and were thus given, at no cost, a transmission performance which was better than the limit. At the same time, the growth of international traffic made it necessary for the Australian trunk network to meet CCITT requirements which, from 1977 onwards, specified mean as well as limiting values for send and receive reference equivalent for a connection to the international exchange.

Transmission EIs are at present under review, and consideration is being given to subscribers' preferences as well as the worst transmission they will tolerate. These EIs are not expected to specify a very great reduction in maximum losses, since at present the cost of upgrading some of the worst lines is still considerable.

DIGITAL PHASE

An exciting change in telephone switching and transmission is in sight with the advent of integrated digital switching and transmission. One of the features of this system is that transmission performance is identical for all calls between subscribers connected to the digital network, as well as for most calls between an analogue subscriber and a digital subscriber. This performance is controlled in the analogue/digital converter which will ultimately be located in the subscriber's telephone.

Consequently, just as in 1880, the situation will be that no specific planning or design will be needed to ensure that transmission standards are met, other than in the design and testing of the telephone instruments. Every call will have identical transmission performance which can be set to the optimum level.

Further Information

The authors have researched the history of Australian transmission performance objectives in some detail. They will be pleased to supply further information to interested enquirers.

Subscription Rate Increases, 1981

The Telecommunication Society of Australia has had to increase its subscription rates and publication prices.

These charges have always been kept to a minumum, thanks to the time and effort voluntarily contributed to the Society's operations by its office bearers and some financial assistance given from time to time by Telecom Australia. This assistance is very gratefully acknowledged.

The subscription rates have, in fact, remained constant for the past two years.

The largest operating expense, by far, is in printing the Society's publications; printing charges have increased substantially in the past year because of labour and material cost rises within that industry.

Hence, with some reluctance, the Society's Council of Control has decided that higher charges are necessary to cover these increased costs.

The new rates, effective from the start of 1981, are shown inside the back cover of this Journal.

The Design and Construction of the Kempsey Railway Bridge Conduit Crossing

A. R. KERR, B.Sc.

Various materials are available to the designer of bridge conduit crossings; the most suitable is PVC pipe.

This article describes the design and construction of such a conduit crossing. It shows the many advantages this material has in the reduction of costs and the simplification of construction.

When the Sydney/Brisbane coaxial cable was installed in 1967 a 207 metre heavy wire armoured section of cable was laid on the footpath of the Kempsey Railway Bridge which crosses the Macleay River. This was necessary because conduits could not be installed on the bridge until supporting brackets were provided by the Department of Railways. An underwater crossing was considered impractical due to the unstable nature of the river bed.

The original design proposed galvanised iron (G.I.) pipes. However, when the design was reviewed in 1975, polyvinylchloride (PVC) conduits were specified allowing a lighter more easily erected structure.

THE BRIDGE

The bridge, as can be seen from **Fig. 1**, consists of two distinct sections:

- The first section is the four span river crossing to which the footpath is attached 7.5 m above the water. The footpath consists of wooden runners supported by two steel (125 mm x 250 mm R.S.J.) bearers which in turn are supported by brackets attached to the bridge spans every 7.62 m.
- The second section is the land section which consists of twelve viaduct spans to which the Department of Railways added support brackets 3.25 m apart. These brackets are approximately 7.6 m above the ground.

THE ORIGINAL DESIGN FOR THE CROSSING

The original design consisted of nine 100 mm GI pipes to be erected on the bridge with three jointing chambers evenly spaced along the run. This was changed because:

- A water main had been placed along the top of the footpath so the planks could no longer be raised to allow the GI pipe to be laid under the footpath.
- Only six conduits could be laid under the footpath as the water main interfered with the proposed design.
- High labour costs would be involved in erecting GI pipes.
- Difficulty was expected in accommodating a 2½° change in direction that takes place between each viaduct span on the land section.
- The erection of pipes weighing 115 kg each presented some hazards.

Why Change to PVC?

The change from GI conduit to thick walled (6 mm) 100 mm diam. PVC pipes was made for the following reasons:

- PVC conduit is light and easy to handle, weighing only 13.6 kg per length.
- It is mechanically capable of supporting the heaviest cables if supported at 2 m intervals.
- It is easily cut to a required length with a handsaw.
- It is sufficiently flexible to permit small changes in direction without preforming.

Like most materials PVC has its disadvantages and these are:

- The coefficient of linear expansion of PVC is approximately 8 times that of steel.
- The strength and rigidity of PVC is much less and therefore it requires support at closer intervals than GI.

THE DESIGN USING PVC

The design for the conduit run across the bridge was treated as two separate problems, the river section and the land section. The following paragraphs outline the design adopted in each section.

The River Section

The Bracket

A bracket had to be designed to support the six conduits under the footpath of the river section of the bridge. This bracket had to be:

- Able to support the heaviest load.
- Cheap and easy to manufacture.
- Easy to erect and able to be positioned to avoid the collars of the PVC pipes or any other obstructions.

The bracket which fulfilled this requirement can be seen in **Fig. 2.** The slots in the bracket allow the fastening clips to be slid into position to clamp the beam to the base of the footpath R.S.J. The clamp, as shown in the diagram, fitted over the six pipes at every fourth bracket.

The clamp was designed to allow longitudinal but not lateral movement of the pipes.

The Pipe Anchor

Across the river section the six pipes were anchored in place at the centre of each of the four spans by 10 mm steel plates welded to the footpath support bracket. The plates had six holes cut into them to allow the 100 mm pipes to pass through but not the pipe collars. **Fig. 3** shows an anchor plate fitted in position under the footpath.

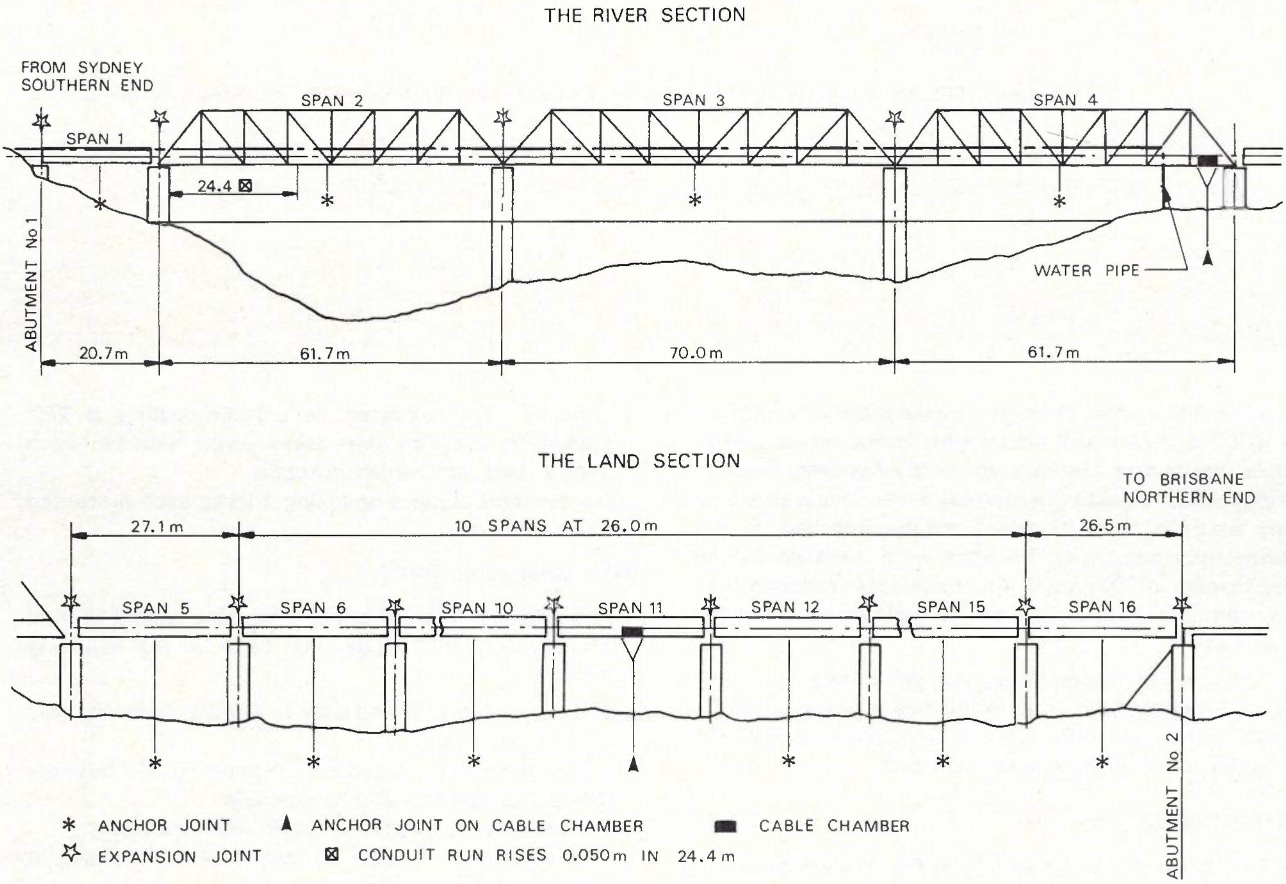

Fig. 1 — The Kempsey Railway Bridge.

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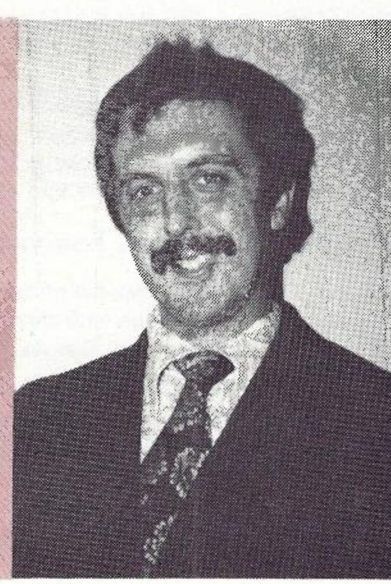
Since emigrating to Australia he has worked in the North Coast Section, NSW, on a variety of engineering construction projects, one of which was this Railway Crossing. In March 1978 he took up the position of External Plant Manager at Cairns, Queensland.



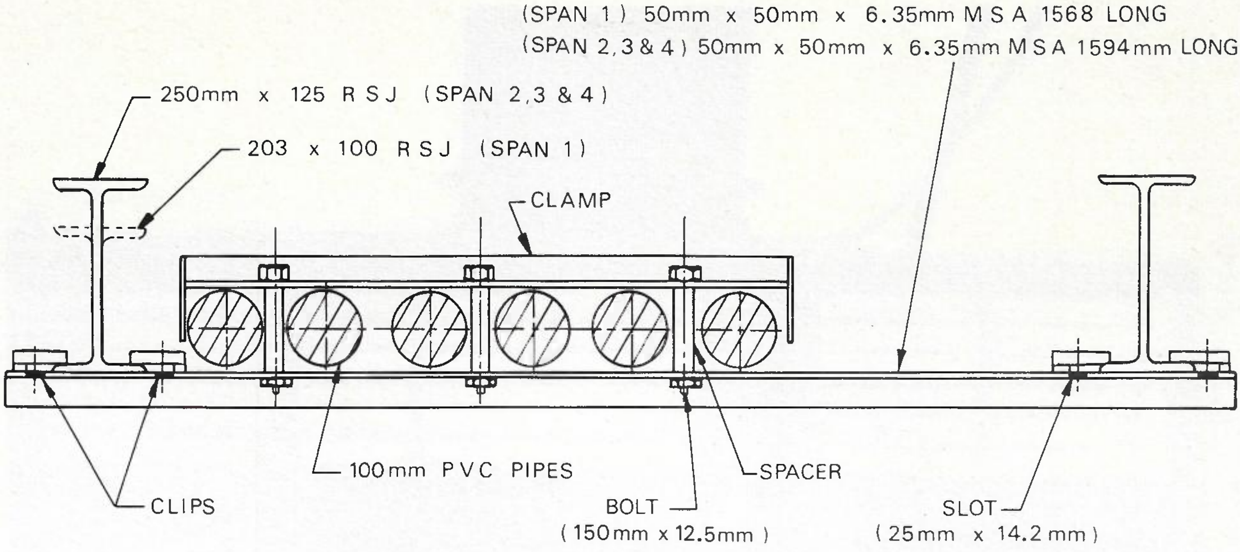


Fig. 2 — The PVC Support Bracket with the Clamp in Position.

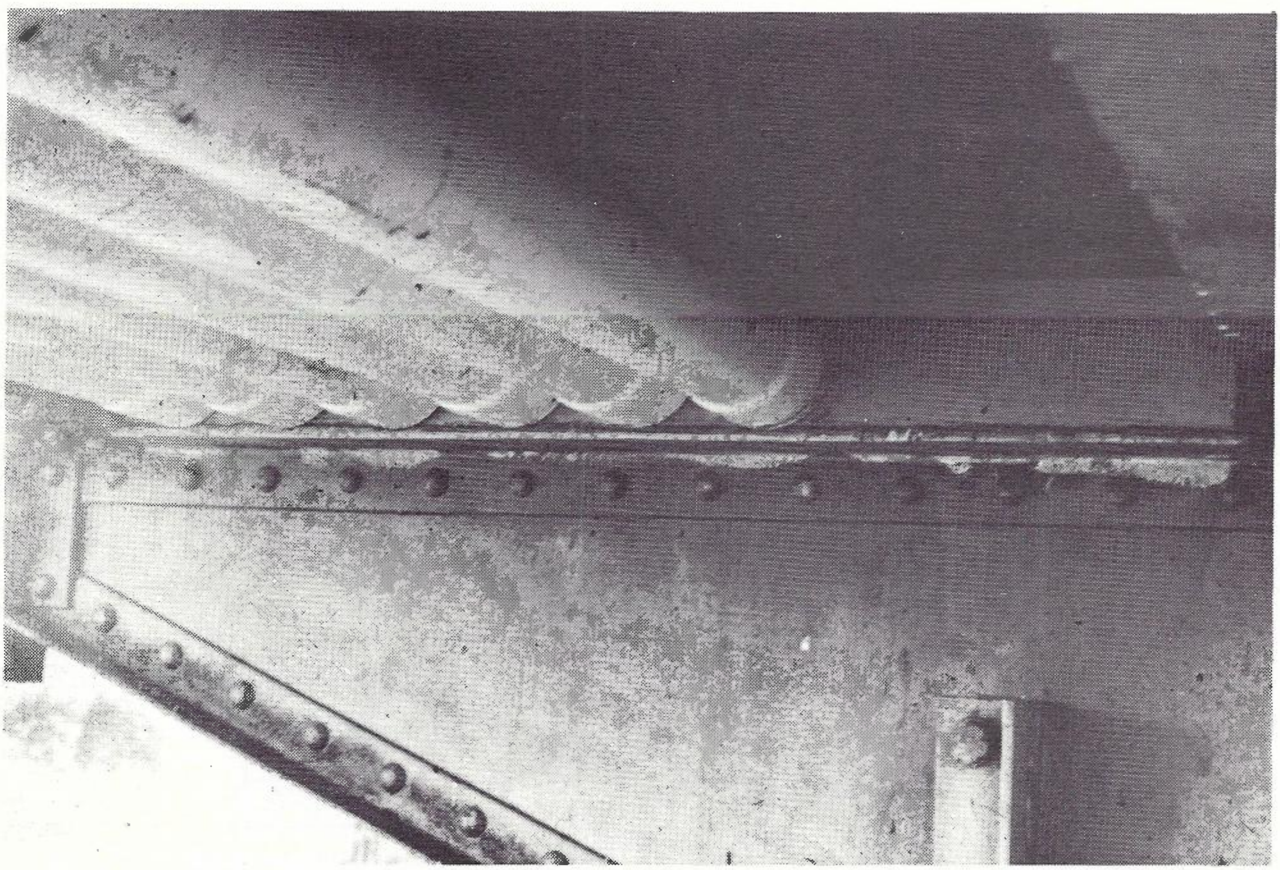


Fig. 3 — The Anchor Plate Welded to Footpath Support Bracket.

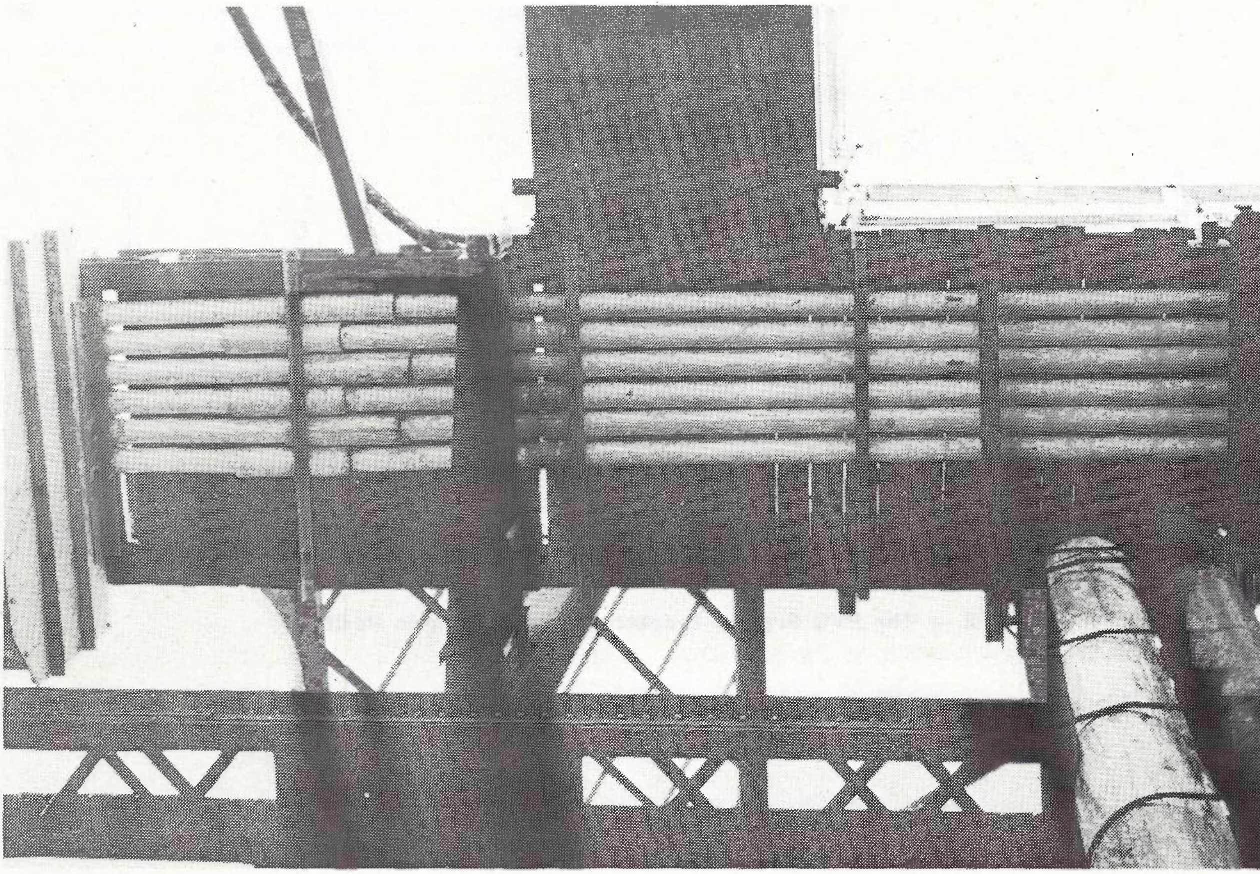


Fig. 4 — The Expansion Joints (Left of Picture).

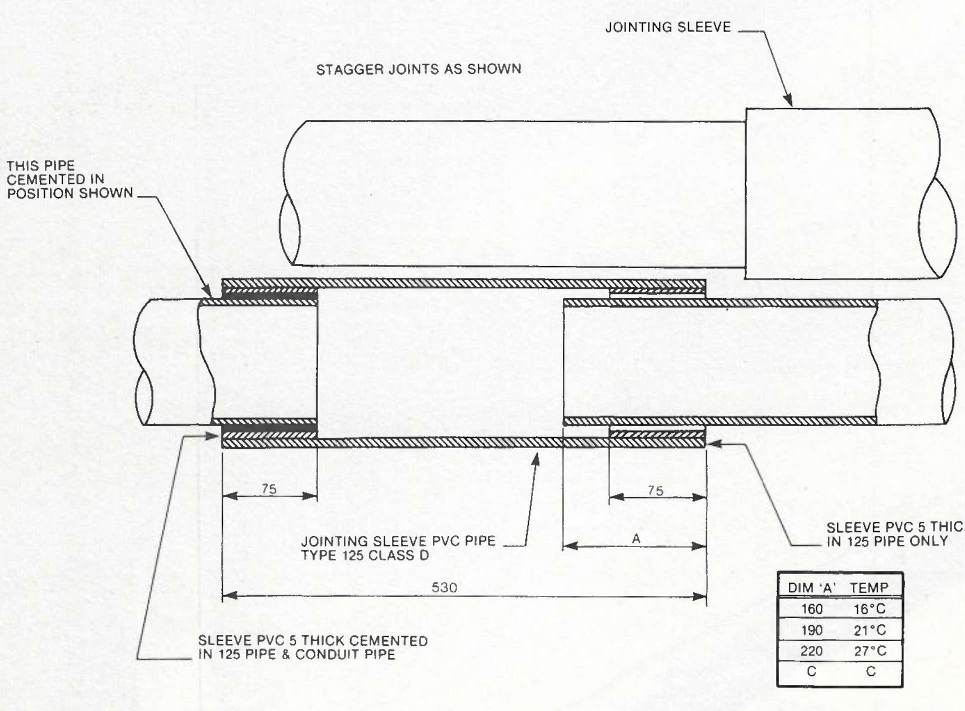


Fig. 5 — Conduit Expansion Joint (Original Working Plan Shown Here for Water Section).

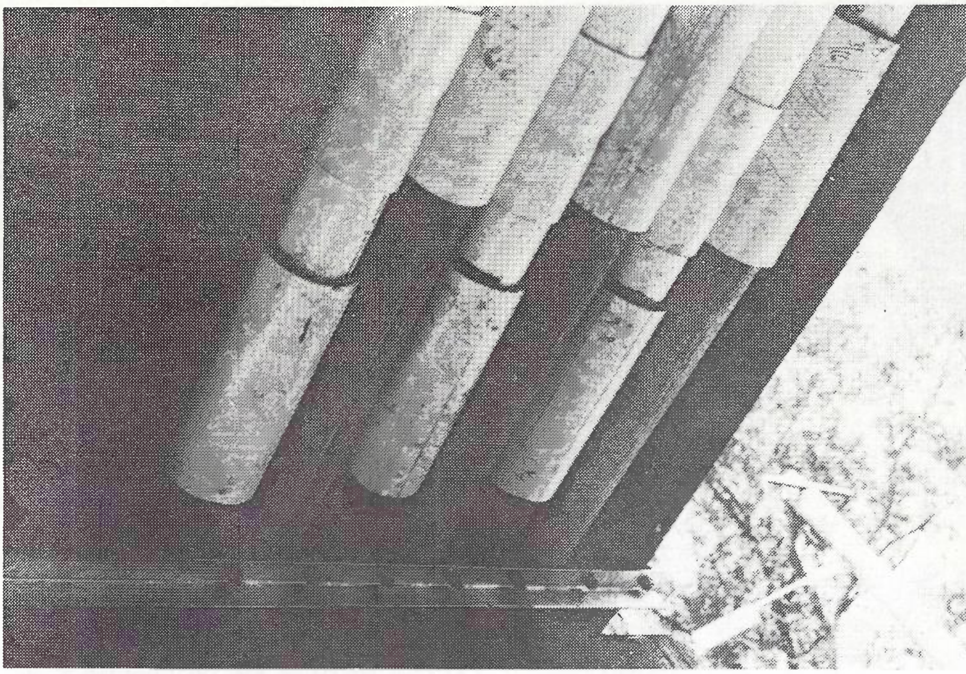


Fig. 6 — The Expansion Joints used as the Interface between the GI and PVC Conduits.

The Expansion Joint

To accommodate an expansion of 25 mm per 5°C in the PVC pipes between the anchor points a special expansion joint had to be constructed. **Fig. 4** shows the expansion joint in use under the footpath and **Fig. 5** shows the make up of the joint.

Specific Design Problems for the River Section

The problems involved were:

- An 18° change in direction of the conduits at the southern end of the bridge on entering the embankment.
- A 50 mm change in conduit levels between span 1 and span 2.

The 18° deviation was overcome by using GI pipes preformed about a 2.5 m radius and supported by a frame set into the embankment. The PVC pipes were joined to the GI pipe with an expansion joint (see **Fig. 6**) and the PVC pipes in the embankment were joined by pushing the collars over the GI pipe and then encapsulating with cement.

The problem of the 50 mm change in conduit levels was easily overcome by using a specially designed set of support brackets which raised the level of the conduits by 50 mm over a distance of 25 m from span 2 to span 1, by effectively increasing the packing under the pipes on each succeeding bracket.

The Land Section

The Trough

As there is no footpath in this section and the PVC pipes could not be self-supporting over a distance of

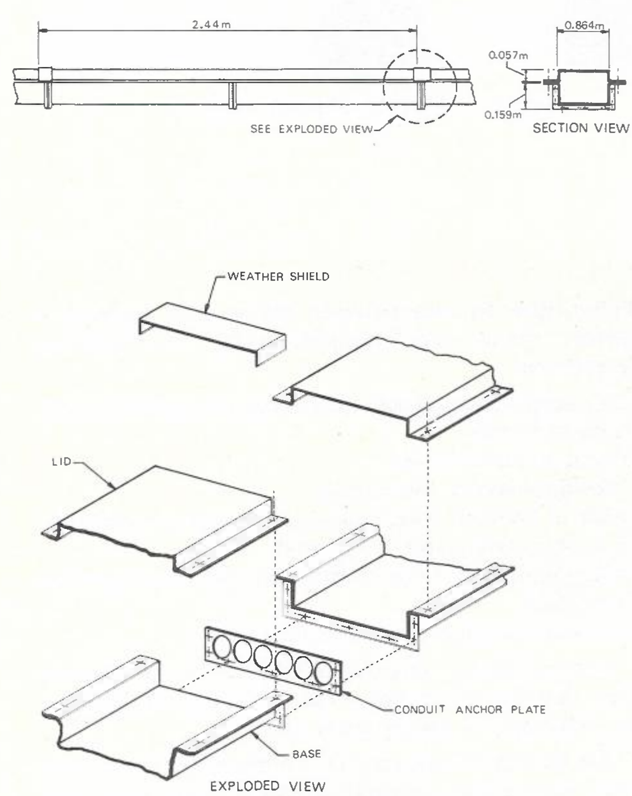


Fig. 7 — The Box Section Beam with the Conduit Anchor Plate.

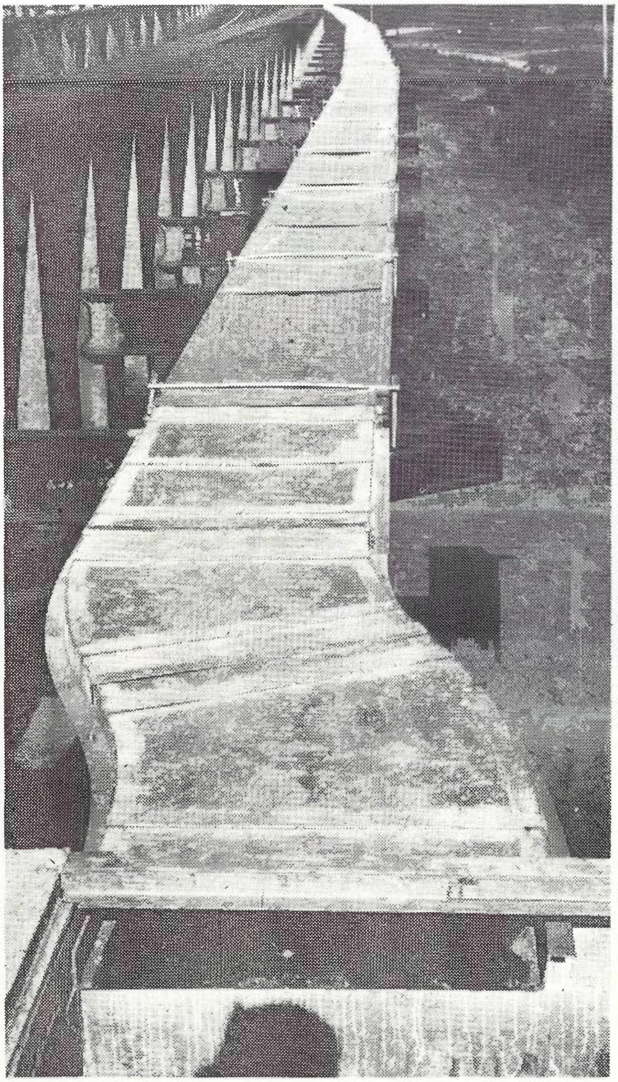


Fig. 8 — The 'S' Shaped Trough.

3.25 m (the distance between the support brackets) a support trough was designed within the following parameters:

- Self-supporting and able to hold the greatest likely load.
- Easy to handle.
- Cheap to manufacture.
- Provide shade for the conduit.
- Able to be foam filled later if future thermal insulation for the coaxial cable is required.
- Allow a footpath to be constructed over the trough at a later date.
- Constructed out of standard steel sheets.

The final design consisted of 2450 mm long, 864 mm wide, box shaped sections, each weighing 82 kg, constructed from 14 gauge sheet steel.

The box itself consisted of a preformed lid and base which were bolted together. Eleven of these boxed sections made up each of the 12 independent 27 m troughs (see **Fig. 7**).

The Bridge/Pipe Expansion

The problem of expansion and contraction of the railway bridge spans was overcome by leaving a 152 mm gap between the 27 m troughs. The expansion of the pipes within the troughs was overcome by using staggered expansion joints each side of the gap. The construction of the joint was the same as that used on the river section (see Fig. 5).

The Conduit Anchors

The conduits were anchored at the centre of each trough with a 6 mm plate which had holes cut into it. The pipes were fitted through and locked in position with the collars, as on the river section. The plate was bolted into position between the central box sections.

Specific Design Problems for the Land Section

One main problem was the misalignment between the trough and the entrance to the cable chamber. The 600 mm misalignment was caused by the cable chamber having to be built beside the buttress of the bridge. This was overcome by altering the raised section of the trough on span 14 and altering the entrance to the chamber. The chamber alteration extended the lids to the front of the chamber making it a fully openable 8 lid chamber.

The conduits were stopped short of the chamber by 3 m and the altered 'S' shaped section of trough could be opened to allow the cable to be hauled over the top and hand-fed into the jointing chamber. (See **Fig. 8**).

THE CONSTRUCTION OF THE CONDUIT RUN

Construction Team Briefing

The team consisted of six men and was briefed before each section of construction both land and river. The briefing consisted of an explanation of all plans and sketches related to the section. This approach ensured that ideas were discussed and a complete understanding of the work was obtained by all involved. All special safety aspects of each section were thoroughly discussed and arrangements made for any special equipment.

Preliminary Work

All materials, tools and mechanical aids were ordered well in advance to ensure that they would be on hand when needed. This allowed any on site alterations or repairs to be carried out without delay.

Work such as manhole alterations and laying of the conduits up to the bridge was carried out prior to the start of construction work on the bridge.

Construction of the River Section

The first part of the bridge construction work carried out was the river section. This relied heavily on three items of equipment:

- A floating platform.
- A power operated scaffolding.
- Scaffolding support beam — "hanging beam".

The Floating Platform

The 4.6 m x 5.3 m floating platform consisted of two cable laying barges joined together and positioned by four anchors to facilitate easy manoeuvring. The platform was used to position the scaffolding below the walkway and to hold it when not in use.

The Power Operated Scaffolding

The scaffolding was similar to that used by window cleaners on large buildings and consisted of a 5500 mm x 500 mm basket with two electric cable climber winches. A 5 Kva generator stationed on the footpath supplied power to the winches. This scaffolding was the key to the erection of the river section of the conduit run.

The Scaffolding Support Beam

The hanging beam was designed to sit on the footpath R.S.J.s (replacing a plank) and was designed with the following in mind:

- Able to support a load of 1000 kg (3 x safety factor).
- To be no wider than 150 mm (average width of a plank).
- To be no thicker than 100 mm where it passes under the footpath water main.
- To allow the wire rope to be positioned accurately.

The resultant design (**Fig. 9**) is basically 6.25 mm mild steel plates welded to two 1400 mm x 63 mm x 38 mm x 12 gauge channel iron and held in place by two rods.

Fitting of the Conduits

Once the conduit anchor plates had been welded into position the work commenced in earnest. The pipes were erected by a six man team working as two groups of three; one group working on the footpath preparing the way for the pipe laying group under the footpath.

The footpath group did such things as removing the planks and replacing them with hanging beams, fitting the scaffolding ropes, rigging the generator, etc.

The group working under the footpath consisted of two men in a basket and one working on the boxed section beam and the old cast iron water main next to the basket.

The co-ordination of the two groups by the team leader made it possible to achieve efficient construction and ensure a minimum amount of delay between scaffolding lifts.

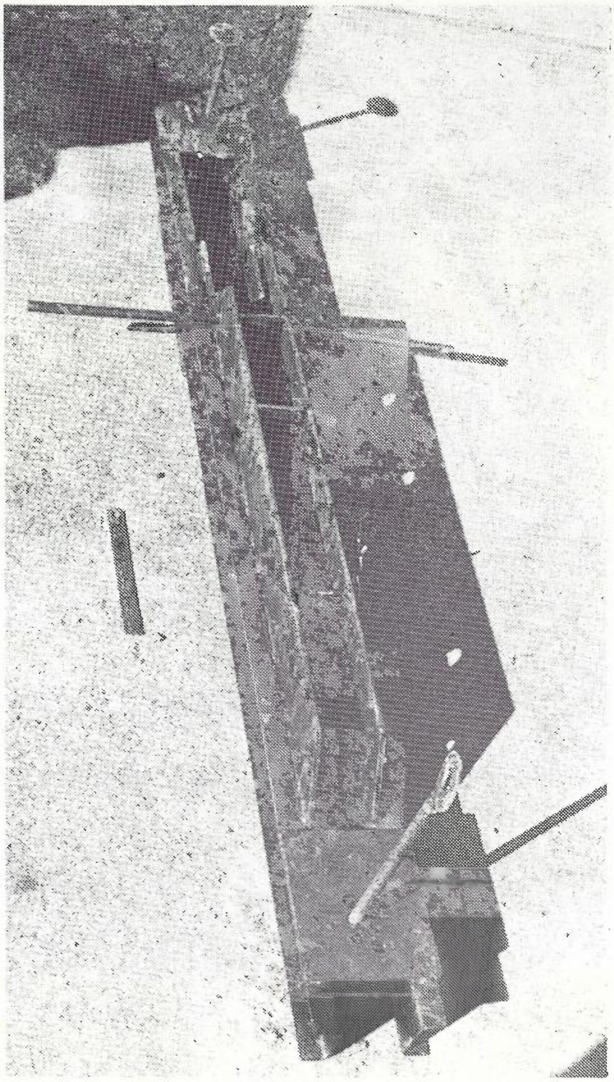


Fig. 9 — The Power Operated Scaffoldings 'Hanging Beam'.

The Land Section Construction

The Preparation and Erection of the Troughing and Pipes

The bases of the trough sections were bolted together in groups of two and three on the ground to reduce the work above. The central section of each group had the anchor plate bolted into position and the pipes fitted each side prior to lifting.

Into the base of each section of troughing 50 mm x 25 mm wooden spacers were epoxied at approximately 1500 mm intervals, to support the pipes and ensure the collars were free of the trough. **Fig. 10** shows the troughing being lifted into position prior to being bolted to the preceding section. The pipes were then installed into the trough and expansion joints were fitted in a similar manner to that used on the river section (see Fig. 5).

Erection of the Cable Chamber

The two cable chambers were the last items to be delivered. One was 3 m in length and weighed 1.1 tonnes and the other was 3.7 m and weighed 1.5 tonnes. They were lifted into position with a special bracket constructed by the manufacturer and a 12 tonne crane. Once in position the special brackets were bolted over the R.S.J.s and onto the chambers. This section of work was completed with the fitting of the lids, pipes and locking bolts.

Fitting of the Trough Lids

As with many jobs, there was an unexpected set-back. In this case it was associated with the trough lids. The method of delivery (strapping them together in bundles) had distorted them and caused the bolt holes to go out of alignment. Special large clamps were needed to fit the lid bolts.

The positioning and tightening of the holding straps completed the work. (**Fig. 11** shows the lid being fitted into position).

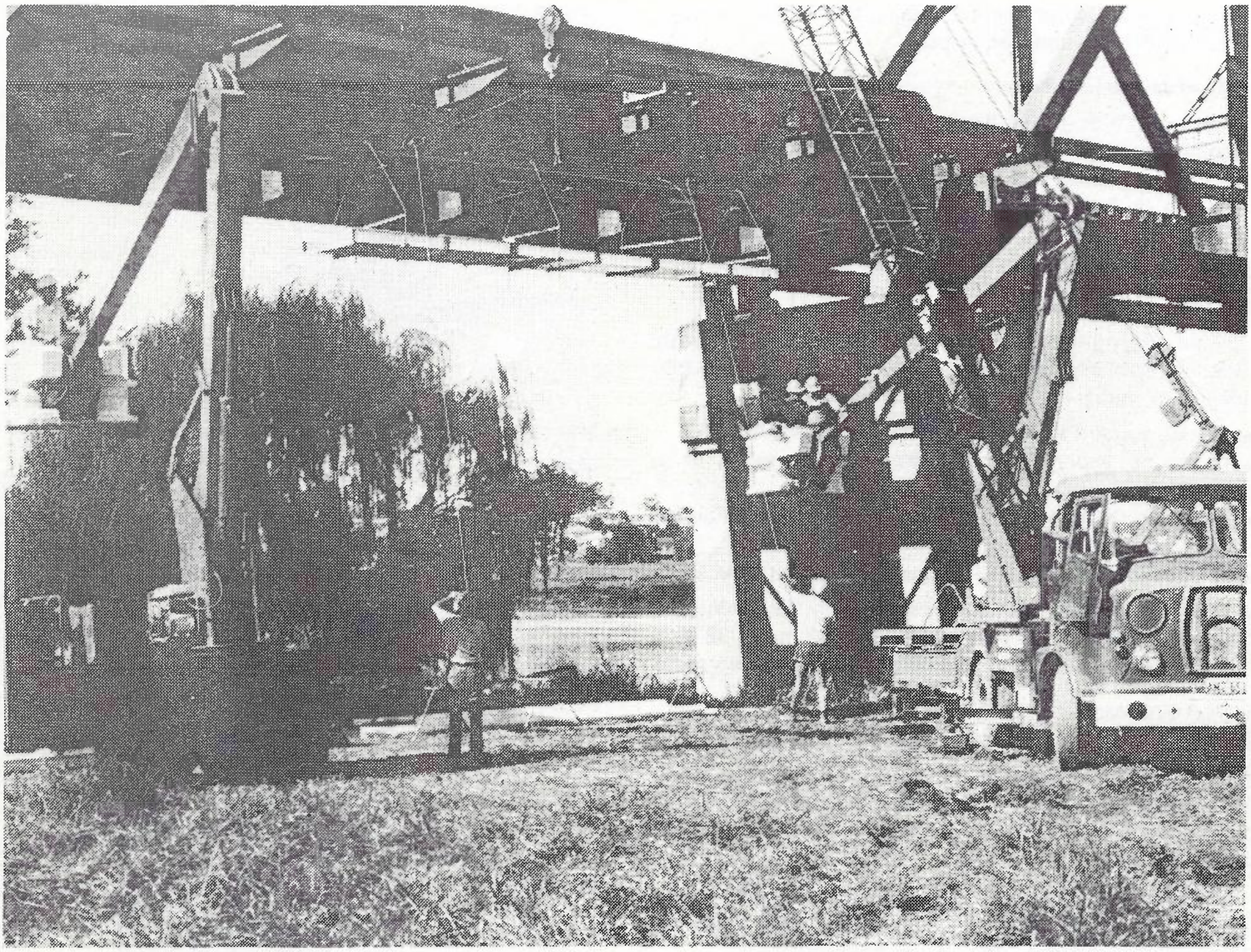


Fig. 10 — The Troughing being Lifted into Position.

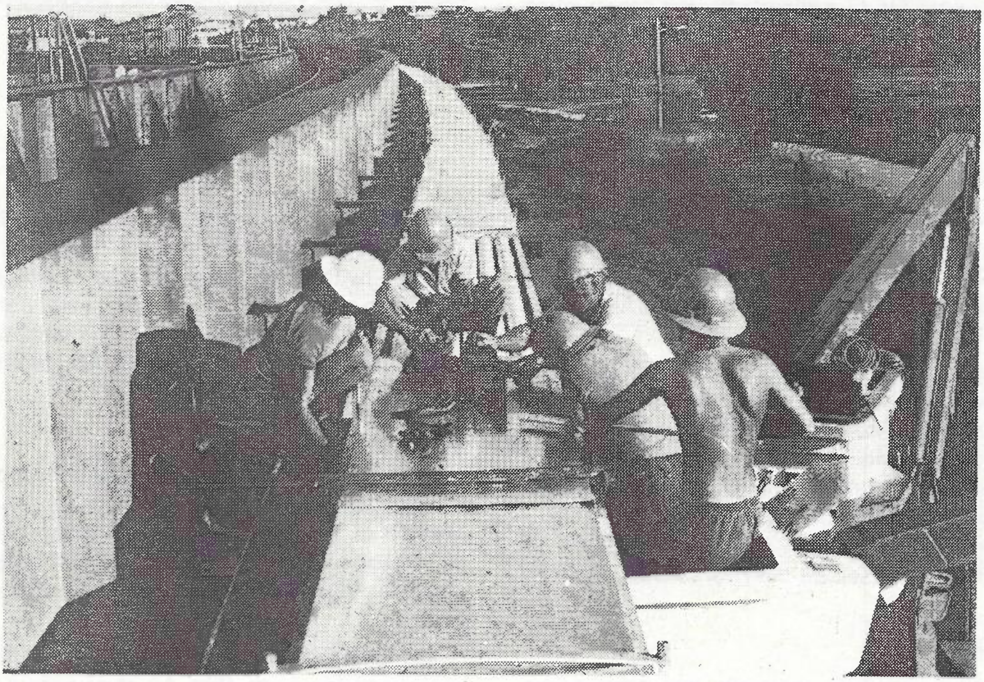


Fig. 11 — The Lids being Bolted into Position.

CONCLUSION

Difficulties associated with the construction were foreseen and taken into consideration during the design stage.

The team members were well briefed before each section of the work and all had their say before construction commenced.

PVC proved to be a very successful material for construction of the conduit run, showing itself to be cheap, light, strong and easily cut to length. It was also considerably easier to install than could be expected with GI. These factors all contributed to the work proceeding smoothly. The job was completed in 37 working days and within its estimated cost.

Book Review

International Conference on Submarine Telecommunications Systems

Published by the Institution of Electrical Engineers London, February 1980

184 pp Overseas Price £14.50

This publication contains the 43 papers presented at the conference; while most of the papers are from the U.K., several originate in France, the U.S.A. and Japan, while the remainder come from as far afield as Jordan, the Philippines and Australia.

The papers in the conference record are arranged in an orderly progression, beginning with surveys of cable network history and development, as well as comparisons with satellite systems. Then come a number of papers on particular cable systems, followed by the "meat" of the conference: cable engineering, reliability and testing, repair equipment, in situ cable damage and protection, and coaxial cable developments. The record is rounded off by several papers discussing the likely optical and digital submarine cable trends.

A clear message coming from the conference is that the advent of the geostationary satellite has not sounded the death knell of the submarine cable. To the contrary, several papers (including the Australian one) make the point that the two systems are complementary, both being needed for diversity and operational reasons. Furthermore, for some applications submarine cables are cheaper. Finally, it seems clear that the next round of submarine cable developments will come with the use of optical fibre systems, with digital signal processing.

Reviewed by George Kennedy, OTC(A).

TELECOMMUNICATION AIDS BOOST AVIATION/MARINE COMMUNICATIONS

A report to Federal Parliament on the Australian transport industry has highlighted significant telecommunications activities in the maritime and air navigation fields.

The report details a battery of aviation and shipping projects which have received close attention from the Government in recent years as well as contracts let to private industry for the development of sophisticated communications equipment.

Projects covered in the report include the commissioning of new air traffic control towers in several States and the installation of the Sydney air traffic control digital radio simulator which is nearing completion. The Melbourne simulator is being relocated in permanent accommodation at Melbourne airport.

The attention to the simulators is aimed at enhancing air safety by switching much of the current on-the-job operational air traffic control (ATC) training to the less critical environment of the simulator.

Prepared by the Federal Department of Transport, the report highlights the department's progressive modernisation of all its radar display systems in conjunction with the local electronics industry. These are being upgraded to provide air traffic controllers with additional information to reduce the maintenance load and repair problems.

Work is also proceeding on the introduction of Alpha Numerics into Australian ATC centres. The report says these will enable air traffic controllers to pinpoint on their radar screens — aircraft identity, actual altitude, assigned altitude and ground speed.

Interim Alpha Numeric systems are being developed to provide aircraft identity and altitude information for installation in the Sydney, Adelaide and Perth ATC centres.

The seven route surveillance radars (RSR) which track aircraft flying over Australian soil are also being substantially upgraded with their conversion to modern solid state equipment. The programmed refurbishment of all route surveillance radar turntables in Australia together with upgrading and conversion of wave-guide rotating joints is continuing as well, as are modifications to convert single and double co-axial wave guide rotating joints to triple co-axial versions for all radar installations.

The departmental report to Parliament places significant emphasis also on the expansion of Australia's network of non-visual navigation aids. These now total 428.

As well, new instrument landing VOR facilities are now installed at a number of regional airports in NSW, WA and the Northern Territory.

A contract has also been placed with Australian industry for the development of a new 100 watt Non Directional Beacon. This is the most common beacon in the network of non-visual navigational aids.

In the maritime field, the Federal Government has approved in principle a five year plan for modernising and upgrading the coastal navigation aids systems. The plan includes modernisation of 114 existing aids, the unmanning of 17 major light stations and the establishment of 44 new visual or radio aids. These moves are expected to result in important contracts to the local electronics industry.

The report revealed that field evaluation of a prototype Australian made remote monitoring equipment is currently in hand. Remote monitoring equipment is planned for 23 unmanned light stations to enable fault reporting to five regional master stations using the Telecom STD network.

The department has also acquired 11 solar powered systems to operate 10 remotely sited, low power wind information units and a radio communications facility. The solar systems are planned for installations at Ayers Rock (NT); Aldinga, Monato South, Two Wells, Goolwa and Moomba (SA); Cardinia (Vic.); Scheyville, Holsworthy and Bringelly (NSW) for wind information recording equipment, and at Woolpunda (SA) a 120 watt system will power a VHF communications unit.

According to the department, increasing costs of liquid fuels required for conventional diesel generating plants has resulted in solar and gas powered supply systems becoming a more economic solution for low power facilities, and investigations are continuing in to the greater use of these types of power generators.

Conversion of the department's existing multi-channel radio bearer system in the 400-470 MHz band to higher frequencies to release the spectrum for mobile purposes is expected to be completed by 1984.

Special inter-face equipment has been designed to enable standard Telecom private lines between adjacent Air Traffic Service (ATS) centres to be used for intercentre communications and reliable ground control of remote very high frequency (VHF) air-ground communications.

Construction continues also on the Omega long range radio-navigation facility at Gippsland in Victoria. This highly sophisticated telecommunications facility will enable ships and aircraft of all nations to determine their position in almost any part of the world at any time, and in any weather.

Omega will have an antenna tower of 427 metres. Currently, there are seven communication stations of this nature in various countries. The Australian centre will complete the network of eight stations giving complete global coverage to marine and air communication needs.

Major suppliers of the high technology equipment used in these fields are the 30-odd member companies of the Australian Telecommunications Development Association, which in recent years, have scored major international successes in the development of navigational aids and transport communication systems.

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OBITUARY

Mr. V.F. Reeves

Many readers will be sad to hear of the death in Melbourne recently of Mr. Victor Francis Reeves at the age of 79. Mr. Reeves retired in 1964 as Assistant Director, Engineering, South Australia, in the then Postmaster-General's Department, a position equivalent to the present Chief State Engineer.

Mr. Reeves joined the Department as an engineer in 1927 after graduating from the University of Melbourne and spending several years as lecturer at the Melbourne Technical College, the forerunner of the present R.M.I.T. His early career was mainly with the Victorian Lines Section where, among other things, he was associated with the installation and maintenance of the Victoria-Tasmania submarine cable. That cable, superseded years ago by radio systems, was "state of the art" in those pioneering days, and it is difficult now to appreciate that there was no telephone connection between Tasmania and the mainland before it was installed. The early issues of this Journal record many real engineering problems which were associated with the cable.

From 1940 to 1957 Mr. Reeves was first with the Headquarters Transmission Section, and then with the Long Line Equipment Section which he headed from 1954 onwards. There he played a major role in establishing sound engineering standards for the open-wire carrier network which carried almost all the longer distance trunk traffic at that time, and in laying the foundations for the present broadband and cable carrier networks. He was active also in setting up an Australian carrier equipment manufacturing industry; before World War 2 all that equipment was imported.

In South Australia, Mr. Reeves will be remembered by his former colleagues for many different reasons. Perhaps his major management contribution was in helping overcome delays in providing new telephone services, which were significantly worse than they are today.

Certainly those people who were associated with Vic. will always remember him as a gentleman in the true sense of the word, always ready to help people and their development, and with a real concern with fostering an interested and happy staff as well as a healthy telecommunications network. Those of more recent generations will be familiar with the Telecommunications Museum in Adelaide which he founded and which will serve as a memorial to his untiring efforts.

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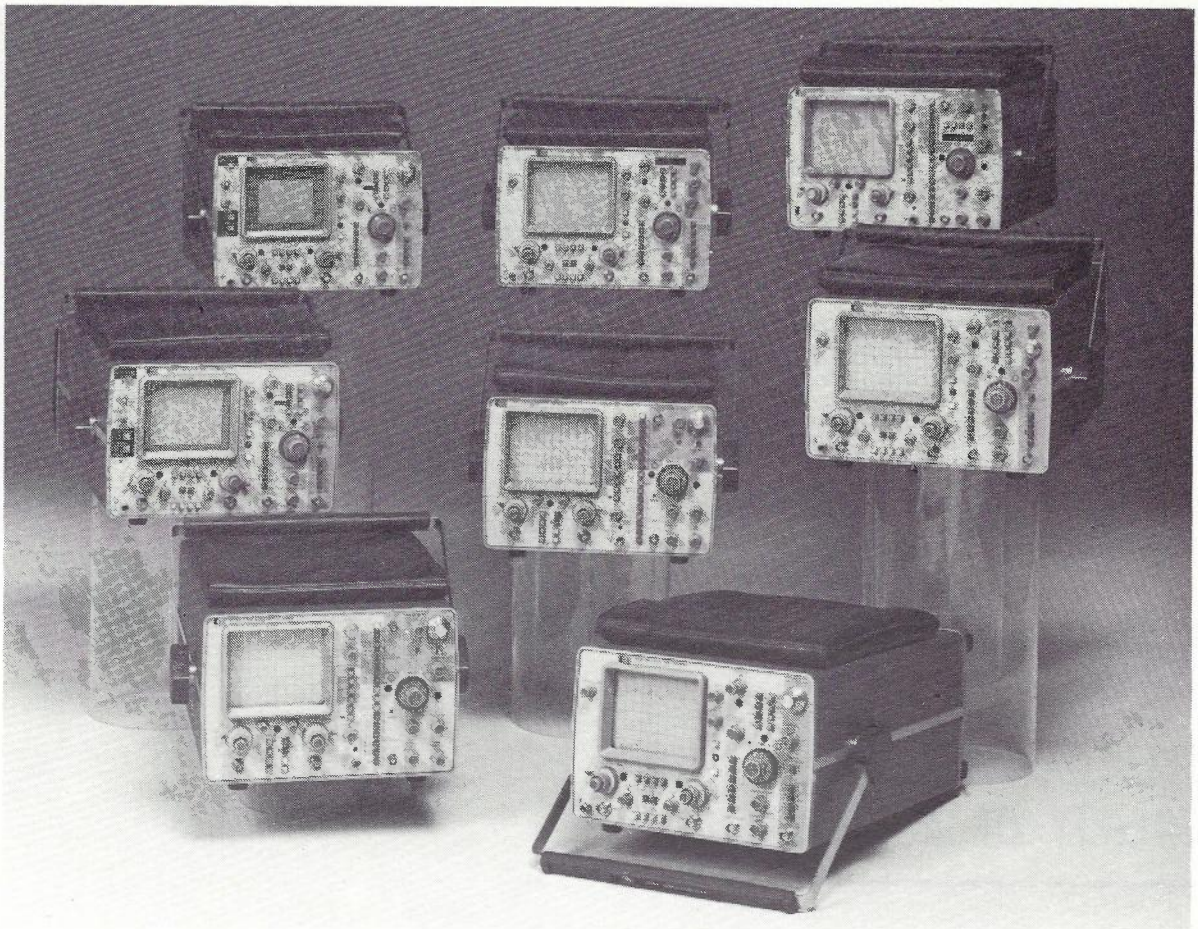
Dr. R. Horton,
IREECON International '81,
The Institution of Radio and Electronics Engineers Australia,
191 Royal Parade,
PARKVILLE. 3052.
Victoria. Australia.



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INTELSAT and TELESPAZIO S.p.A. announce sponsorship of The Fifth International Conference on Digital Satellite Communications

ROME, JANUARY 1979.

The International Telecommunications Satellite Organization (INTELSAT) and Telespazio S.p.A. have announced plans to co-sponsor the Fifth International Conference on Digital Satellite Communications, scheduled to be held in Genoa, Italy, from March 23 to 26, 1981. The Conference will also receive organizational and staff support from Istituto Internazionale delle Comunicazioni (IIC), Associazione Elettrotecnica ed Elettronica Italiana (AEI) and the Region 8 of the Institute of Electrical and Electronics Engineering (IEEE).

INTELSAT is the 102 member-country organization that owns and operates the telecommunications satellites used by countries around the world for international communications, and by a number of countries for domestic communications.

The four previous conferences, held in London (1969), Paris (1972), Kyoto (1975) and Montreal (1978), were all sponsored by INTELSAT and co-sponsored by representatives of many countries. Each of those sessions produced a series of significant reports on the progress being made in the application of digital techniques to satellite communications.

A Steering Committee, chaired by Mr. G. Salvatori of Telespazio S.p.A., and a Technical Program Committee, co-chaired by Mr. N. K. M. Chitre of INTELSAT and Mr. G. Quaglione of Telespazio, have been formed to plan the Fifth Conference in detail. The Steering Committee will be supported by an Administrative Office, divided between the Rome Branch Office and the Genoa Branch Office.

The Conference will address all technological and system aspects of digital communications via satellite. Emphasis will be placed on transmission considerations, integration with terrestrial networks and new service applications.

Requests for additional information concerning the Conference should be addressed to:

Manager of the Rome Branch of the Administrative Office
The Fifth International Conference on Digital Satellite Communications
Telespazio S.p.A., Corso d'Italia, 43
00198 — ROME (Italy)

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The Telecommunications Journal of Australia

ABSTRACTS: Vol. 30, No. 3

BRADBURY, C. R.: 'Call Failure Supervision in a Telecommunications Network'; Telecom. Journal of Aust., Vol. 30, No. 3, 1980, page 168.

Whilst many faults in a telephone swtiching plant can be readily identified by inbuilt self-checking facilities, there remain those more elusive network type faults which result in failure of interexchange signalling.

This article describes a new and efficient means of pinpointing these network type faults in Telecom's networks, which comprise a large proportion of crossbar exchanges and MFC compelled sequence information signalling equipment.

BURTON, J. M. and VINNAL, E.: 'Radio Propagation Above 10 GHz, Part 1: An Overview of New Frequency Bands'; Telecom. Journal of Aust., Vol. 30, No. 3, 1980, page 210.

The steady trend over the past 20 years of increasing use of the microwave frequency spectrum is forcing radio systems further into the SHF region. New frequency bands above 10 GHz may be exploited sooner than previously thought because of economic as well as technical reasons. The first part of this paper provides an overview of the general characteristics of electromagnetic transmission above 10 GHz. In particular, such factors as attenuation for rain, fog, mist and gases are considered. The provision of junction circuits and other wide bandwidth transmission systems, as well as infra-red and optical systems, are discussed.

FREEMAN, A. H. and KILLEY, R.: 'The History of Transmission Planning in Australia'; Telecom. Journal of Aust., Vol. 30, No. 30, 1980 page 216.

The continued evolution of transmission technology during the century that has passed since the invention of the telephone has been reflected by marked changes in the economical limitations influencing transmission planning. The article traces these changes through four distinct phases and suggests that the present work on digital techniques marks the commencement of another phase in this sequence.

GUTHRIE, H. P. and YOUNG, D. A.: 'Energy Management in Telecom Australia; Telecom. Journal of Aust., Vol. 30, No. 3, 1980, page 159.

Telecom Australia introduced an Energy Management Program in 1978. The objective of the program is to pursue energy conservation through improved energy resource management and by seeking optimum utilization efficiency for all energy consumed. The justification, development and structure of the program are outlined along with the establishment of performance targets and a data base to monitor performance. The initial thrusts of the program are discussed including energy efficient buildings, a re-appraisal of air-conditioning requirements, liquid fuel conservation and a Watt Watcher Campaign aimed at promoting improved energy housekeeping among all Telecom staff.

HIBBARD, J. N. and DEE, P. K.: 'TASI Systems in OTC's International Network'; Telecom. Journal of Aust., Vol. 30, No. 3, 1980, page 198.

Submarine cables and satellite links are employed in the international network to provide diversity and security of service. To extend the capacity of limited bandwidth submarine cables, Time Assignment Speech Interpolation (TASI) techniques can be used. This paper described how the Overseas Telecommunications Commission (Australia) employs the TASI principle to achieve a fourfold expansion of its telephone circuit capacity in Pacific Ocean submarine cables.

KERR, A. R.: 'The Design and Construction of the Kempsey Railway Bridge Conduit Crossing'; Telecom. Journal of Aust., Vol. 30, No. 3, 1980, page 219.

Various materials are available to the designer of bridge conduit crossings; the most suitable is PVC pipe. This article describes the design and construction of such a conduit crossing. It shows the many advantages this material has in the reduction of costs and the simplification of construction.

McCARTHY, R. G.: 'Creativity — Who's Got It and How Do We Use It?'; Telecom. Journal of Aust., Vol. 30, No. 3, 1980, page 204.

Some human characteristics such as "habituation" and "association" which are relevant to creativity of the individual are described. The relevance of age and of intelligence to creativity is also examined.

For an environment such as Telecom, a series of recommendations is made which will promote creativity in a practical way to benefit both the individual and the organisation.

ROWELL, D. M.: 'Social Needs and the Interaction with Technology: Progressing from Telecom 2000'; Telecom. Journal of Aust., Vol. 30, No. 3, 1980, page 179.

Telecom Australia has adopted social research and planning techniques which are able to recognise and internalise social needs as they interact with technology. This activity in progressing on from Telecom 2000 has provided new dimensions to telecommunications planning in Australia.

TAYLOR, J. R. and ROSSITER, M. H.: 'Statistical methods in Quality and Reliability Assurance'; Telecom. Journal of Aust., Vol. 30, No. 3, 1980, page 186.

The use of Statistical Methods, central to the science of Quality and Reliability Engineering from its origin in 1924 with the publication of Dr W. A. Shewhart's early papers, is becoming increasingly recognised as necessary in all technological work. The application of the Scientific Method requires the use of Statistical Mathematics, which in turn makes possible proper planning, design and testing of the continuing sequences of hypotheses necessary for technological development and growth.

The definition of the terms used in describing the different categories of work associated with Quality and Reliability Engineering places the work in perspective. The paper describes the application of Statistical Methods in economising the effort required, and in increasing the productivity of each of the functions which must contribute to the Quality and Reliability of the telecommunications system.

THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

Volume 30, No. 3, 1980

ISN 0040-2486

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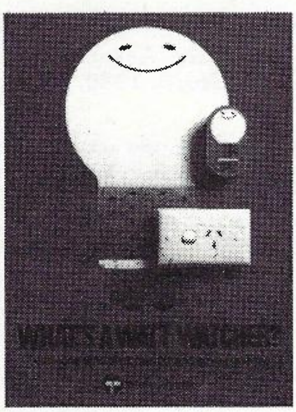

COVER

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The Telecommunication Society of Australia

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