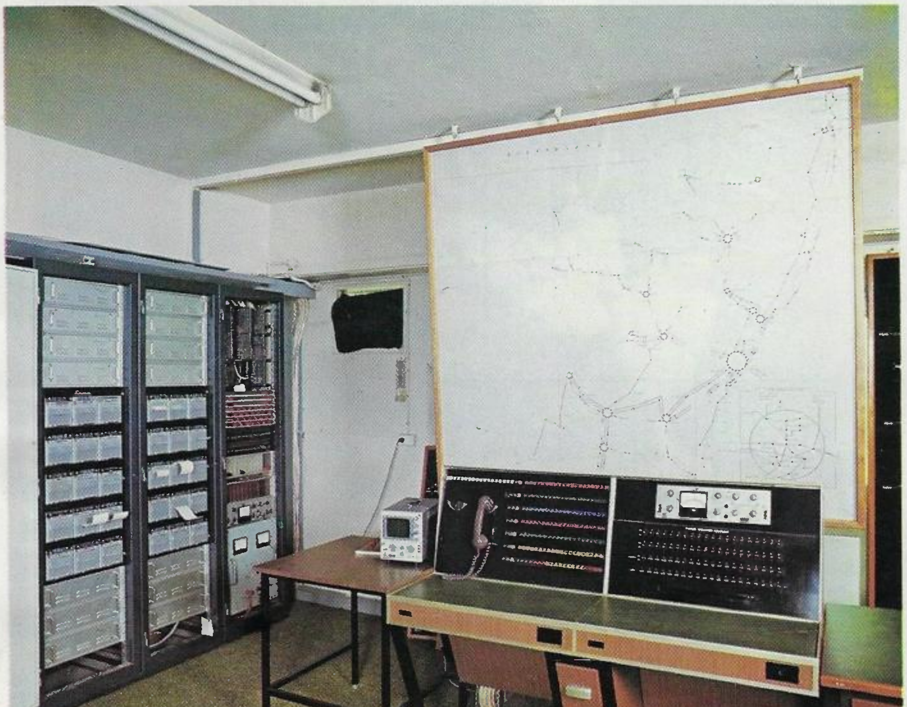
Volume 27 No. 3, 1977

the telecommunication journal of Australia



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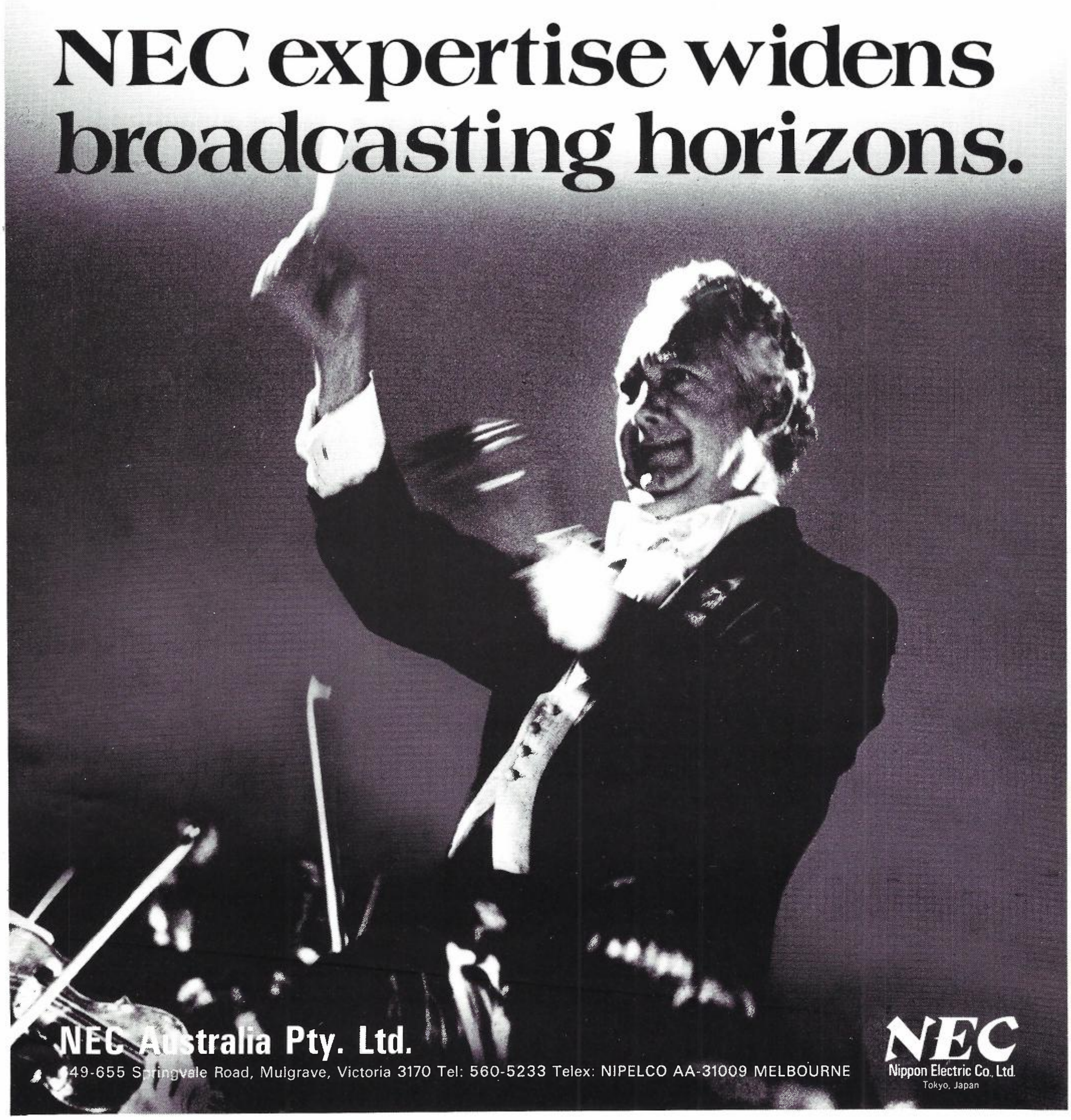

THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

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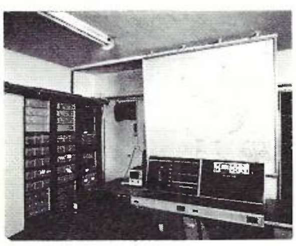

COVER

SERVICE RESTORATION AND TRAFFIC CONTROL CENTRE

The Telecommunication Journal of Australia

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Service Restoration and Traffic Control, Its Concept and Its Centre

J.P. SALTER, Grad. I.E. Aust.

Most large telephone administrations have been obliged to develop special operational practices and techniques to coordinate temporary restoration of service when major plant breakdowns or serious traffic overloads occur. Telecom has established a Service Restoration and Traffic Control Centre in each capital city and at Telecom Headquarters for this purpose. This article outlines the background to the development of the SRTC concept and the establishment of the Sydney SRTC centre which was the first and is the largest such centre in Australia.

INTRODUCTION

Towards the end of the late 1960s it became obvious that the methods for advice to management and for service restoration of telecommunication plant failure or overload, and the co-ordination for the removal of telecommunication facilities for planned engineering work were in need of review. The methods to be reviewed were those which evolved during the 1960s, for the engineering operational management of the Sydney-Canberra-Melbourne coaxial cable and paralleling micro-wave radio facilities. The methods then used were beginning to prove unsuitable when applied to the developing coaxial cable, and micro-wave radio network, and with the establishment of the ARM trunk switching exchanges and more than one capital city long line equipment terminal. (**Fig. 1** indicates the extent of the present national network.)

To this end a Headquarter's Working Party was set up and its report of October 1970 stated the Service Restoration and Traffic Control (SRTC) policy, and principles to be followed in the establishment and operation of Service Restoration and Traffic Control Centres (SRTCC). Most of the Working Party report has since been published in an information bulletin (Ref. 1). This Working Party not only considered those aspects of plant and telecommunication facilities for planned engineering work, but also the broader aspects of traffic control, service restoration, reporting of network status change to management, when necessary, and failure of major communication facilities.

Service Restoration and Traffic Control (SRTC) centre functions are applicable to the entire Commissions telecommunications network and refer to those operational techniques which insure the optimum use of the immediately available transmission media for handling of "network traffic" when there are major plant failures or an extreme traffic overload in the switched telephone network. The term "network traffic" is taken in its broadest context, and refers to telephone traffic, data traffic, television programmes, and all other types of communication services provided by the Commission's telecommunications network.

The purpose here is to outline briefly the establishment of the Sydney Service Restoration and Traffic Control Centre (SRTCC), facilities required to achieve the SRTC functions, the evaluation of these facilities to date, and some of the experience gained in the operation of the Centre.

ESTABLISHMENT OF THE SRTCC

In the past the capital city Trunk Test Rooms provided the means of reporting plant failure to engineering management, while the manual telephone exchange operators reported such failures to their management. The Trunk Test Rooms also exercised control and co-ordination over maintenance outage requirements, for repair and restoration of services, dealing mainly with the existing open wire trunk line and telegraph network. When the broadband (co-axial cable, radio micro-wave links, trunk switching exchanges, etc.) network was established and as it grew the control functions were devolved from the Test Room to more appropriate areas. A similar devolvement of functions, from the Test Room, was required in the reporting of plant failure to management and for the control of withdrawal of facilities for engineering work.

In June 1969, a "Trunk Network Control Centre" began operating with a staff of two in Sydney. However since the creation of this initial centre, SRTCCs have been established in all the main state capital cities with a National co-ordinating centre in Telecom Headquarter's offices in Melbourne. The aim of this centre was to perform where appropriate those existing "Test Room" type functions, together with a much expanded role. After the October, 1971, report of the SRTC Working Party, where Service Restoration and Traffic Control philosophy were expanded, and bearer status monitoring equipment became operational, the centre began to fulfil one of its intended functions,i.e., reporting network status change to management and co-ordination of service restoration, a role more aptly described by its new name the "Service Restoration and Traffic Control Centre". In all discussions related to the SRTCC the autonomy of the established exchange, radio and long line equipment control station role was protected. The SRTCC does not usurp the control station role, that is the SRTCC is not involved in the maintenance repair activity of facilities, but provides the restoration contingency plans and procedures, and status reporting to management. This evolved function, of the control station, required a new role relationship with the SRTCC, and the establishment of free flow of

Fig. 1 — Australian Inter-Capital Broadband Bearer Network.

fault, and network status type information. The need to separate the SRTCC function from that of a maintenance control station was fully recognised when the site for the SRTCC was chosen. The existing Trunk Test Room or main city long line equipment carrier terminal was not appropriate. Further it is required that the SRTCC and the Network Performance and Analysis Centre (NPAC) be adjacent to each other or co-sited.

Initially the SRTCC Staff were occupied mainly with reporting of network status changes to the management and in gathering and maintaining accurate records of the network in regard to group, supergroup, supermaster group, NEX services, etc., records of which are necessary to maintain essential services during heavier outages or withdrawal.

In the early part of 1971, a review was made of the operation of the Sydney SRTCC and from this study it was considered that the centre should be divided into two functional groups, in order to meet the intended or planned role of the SRTCC. These groups were called:

- Operations
- Restoration Planning

The groups each consisted of four Technical Officers having a leader who would report to a higher grade Technical Officer under direct engineer control.

The Technical Officer in charge of the centre is responsible for:

- the operations of the Centre
- implementation of policies necessary for the proper operation of the Service Restoration and Traffic Control principles
- the proper functioning of the two groups (i) Operations (ii) Restoration Planning
- the publication and distribution of the SRTCC report
- the preparation of reports and descriptions as required by management on faults and failures in the trunk transmission and switching networks.

The Operational Group Functions

The Operations Group is responsible for the day to day working of the Centre. These functions as outlined below assume the existence of comprehensive restoration procedures and plans to cater for the majority of service interruptions which can be implemented by simple direction from this group:

- Reporting of network status to management, including progress reports on restoration
- Coordination and direction of activities at control stations and by any other staff in the event of a major interruption to service not covered by pre-arranged plans, i.e., some unforeseen set of circumstances which put the normal performance of the network in jeopardy.
- Coordination and arranging for the final authorisation of the temporary release of circuits and facilities for planned engineering work.
- Undertake liaison between Telecom and major special private line users such as NASA, Overseas Telecommunications Commission, Australian Broadcasting Commission, etc. when faults or outages occur.
- Issue of "Breakport" messages. "Breakport" is the telegraphic address of special advice to Headquarter management giving details of major plant failures and loss of service. It includes broadcasting stations as well as other telecommunications network failures. The "Breakport" is sent in a prescribed time from the first indication of a problem.
- Receive and record information on plant failures from control stations, and produce the network status performance statistics, including information on 'scheduled' and 'unscheduled' outages.
- Act as a coordination point for the temporary provision of special TV and other facilities to cover events of national importance. This includes establishment of priorities and restoration procedures should failures occur with the special arrangements.
- Maintain the bearer surveillance status equipment, and order wire facilities (See **Fig. 2**).

The Restoration Planning Group

This group carries out the following long term planning activities:

- Continuous review of the facilities and procedures for the temporary restoration of service in the event of major plant breakdown or overload. This includes all aspects of private lines, broadcast and TV services, OTC and NASA circuits etc. to ensure that priorities for restoration are properly and efficiently allocated.
- Plan for the provision of group, supergroup, and supermaster group patching facilities in all long line equipment stations.
- Establish and maintain accurate records of the trunk network and eventually of the city and large provincial networks. Initial efforts in 1969 to establish a computer based record system for the SRTCC was terminated in view of the Trunk Record System development

known as the Link Route Detail (LRD) system. The SRTC centre records are at present gathered, recorded and maintained manually.

- Plan and arrange for the provision of bearer surveillance status equipment.
- Plan and arrange for the provision of network traffic flow indicating equipment and exchange performance equipment as may be specifically required for the SRTC functions.
- Plan and update the State communications network configuration fault indication map.
- Review the telecommunication network for its ability to handle breakdowns and overloads.

INITIAL FACILITIES PROVIDED

The following is a list of the initial facilities provided in the Sydney SRTC Centres. Mention is made later in this article of the need to develop further facilities to enable the Centre to operate more effectively.

- Bearer surveillance status monitoring equipment
- Orderwire between the SRTCC and the control station

Fig. 2 — Bearer Surveillance Status Equipment at long line equipment control stations. The facilities have been built into the telephone. The status monitoring facility is disconnected whilst the telephone is in use as an order wire to the SRTC centre.

- Orderwire and communication facilities between State SRTCC, and these and the headquarter SRTCC
- Telephone traffic flow measuring equipment (Route Occupancy equipment)
- Means of determining exchange overload (Exchange Performance Index Measurement)
- Telex machines
- State Communication Network Configuration Faults indication map
- Self answering telephone service
- A proper record system for the circuit allocation of the telecommunication network and storage of up to date maintenance etc.
- Full accurate and up to date contingency plans for restoration of the network, under fault or traffic overload conditions.
- Means to enable ready patching of groups, supergroups, supermastergroups, etc.

The development and practical experience to date with these items is outlined below.

SERVICE RESTORATION

Initial operating procedures for the SRTCC required that long line equipment stations and telephone switching exchanges report to the SRTCC those changes which are causing a change of status, or could cause a change of status, in the entire telecommunications network. This verbal type of reporting was not entirely satisfactory and the status monitoring system was developed.

To overcome this immediate problem a telephone channel on each major co-axial cable and microwave radio system was connected into the SRTCC. The channels were "looped back" at the distant end. An 820 Hz VF tone was then sent out and returned via the "loop back" to the SRTCC. This received tone was fed into an 820 Hz detector which gave an audible alarm and allowed the appropriate control station to be connected via the switched network for details. (The 820 Hz tone detector was readily available; is was part of a dual tone detector (820/400 Hz) developed earlier for equipment used for automation traffic route testing). While this arrangement overcame the immediate problem and provided a basic means of network bearer surveillance, it was not really satisfactory as the recording of details of time, date, length of outage was manually recorded, and was not available when the Centre was unstaffed.

Because of the urgent need to overcome this problem and allow the SRTCC to function with its intended role, a decision was made, to obtain and fit equipment developed some years earlier for a project to upgrade the performance of VF telegraph systems. This equipment was known as the "Missed Transition Detector". It was readily available as the design and production planning work had already been done. The equipment included a SODECO printer to record the date and time of interruption, and of restoration of a VF tone. It gave satisfactory results and also enabled the performance of the bearer to be monitored for short term breaks (about 10 ms). Any bearer deterioration detected is dealt with on a real time basis.

While these developments were being carried out to enable the SRTCC to determine network and bearer status the CCITT were working towards a recommendation for the measurement of short term interruptions to telephone circuits. This recommendation is for the measurement of a 2KHz tone (either on a channel or derived from a systems pilot) for interruptions in the following categories:

- 0.3 ms to 3.0 ms
- 3.0 ms to 30 ms
- 30 ms to 300 ms
- 300 ms to 5 seconds
- 5 second to 1 minute } Telecom Australia requirement
- Greater than 1 minute } Telecom Australia requirement

This requirement together with Telecom Australia service objectives (Ref. 2) caused an engineering review in 1973 of those facilities needed for the SRTCC and other related network performance activities, and led to the development in NSW of an integrated, computer based, Network Performance Measuring System (NPMS) for the automatic collection of data. The exchange equipment for this system is now commercially available. It is beyond the scope of this article to describe this NPMS, but those appropriate to the SRTCC will be mentioned. Of these items (called peripheral equipment) there are four (4) so far developed for the SRTCC activities. These are:

(i) Bearer Status with orderwire facilities
(ii) Route Occupancy
(iii) Exchange Performance
(iv) Pilot Monitoring

Of these only the *Bearer Status* equipment is related to the service interruption automatic reporting function. This equipment consists of terminal equipment located in the SRTCC, which sends out VF telegraphic frequency spaced tones, on a 4 wire channel. These individual tones are looped back via a distant unit provided in each control station (see **Fig. 2**). The normal 4 wire VF channel is connected in tandem (or series) throughout the network and 24 tones make up one system. When a failure occurs in the network, one or a number of VF tones are not received at the SRTCC, and this is indicated on the Network Configuration Fault Indication Map by lighting up one or a number of light emitting diodes (LED). By operating a key, provided on a console (see cover picture) in the SRTCC, the status system is converted into an order wire to the control station nearest the indicated fault site. The lights and alarm are delayed by 25 seconds, while SRTCC outage information is stored in the computer.

Pilot monitoring has been included here since it evolved from the earlier equipment. Pilot Monitoring equipment to the CCITT requirements is now working on the Gas Pipe Line System. The output from this Pilot Monitoring equipment is made available to the Network and Plant performance groups, and is no longer needed by the SRTCC which now has the Bearer Status outputs.

Service Restoration can be performed or achieved in a number of ways, the two most common being:

(i) Patching groups, supergroups (SG), supermastergroups (SMG)
(ii) Changing exchange common equipment traffic routing patterns.

Because of the recommendations of the Headquarters Working Party, work associated with (ii) has been limited to route occupancy measurements, etc. while most of the effort has been directed towards (i). At this stage this involves the use of supergroups, etc., with low priority services to restore priority supergroups having high priority services.

When investigations were carried out into the feasibility of patching group, SG, or SMG's it became immediately obvious that the method for radio and long line equipment design, of equipment configuration, layout, etc., did not lend itself to ready access at the points needed for "restoration patching". Because of these limitations it was decided that "manual patching" was all that could be done immediately, and even this would not be easily achieved. The cost of equipment modification, and the study needed to enable the development of network models and for automatic computer controlling restoration of services was beyond the immediate available resources.

To this end, the manufacturers of "U link" coaxial type links were approached, and developed a suitable "U link" arrangement that could be readily fitted to group and SG distribution frames (see **Fig. 3**). The work of providing this facility is progressing. A similar study needs to be undertaken for SMG patching facilities. For example when a number of carrier terminal locations has been established in a capital city the various group, SG, SMG distribution frames in these exchanges and between the exchanges must be joined together with "patching circuits" (shown as test trunks in **Fig. 3**), which will need to be equalised, amplified and switching (control of co-axial relays) provided. There is a need for overprovision of plant to be used for restoration activity, such as initial full provision of supergroup equipment, or 12MHz "tail" equipment between the carrier terminal and the radio terminal in the City and Country ends where radio and co-axial cable systems came together. This will enable the protection bearer of a radio system to be used for limited restoration of services in co-axial cables.

TRAFFIC CONTROL

As mentioned above work on the traffic control function to date has been limited to measuring route occupancy and the ability of the switching equipment to carry the offered traffic. A comprehensive traffic control system is envisaged in which traffic flow on key routes is monitored and facilities are provided for temporary blocking or redirection of traffic to make for better use on available plant in the event of major failures or traffic overloads.

Traffic control facilities are available in the new stored programme control 10C trunk exchange installed in Sydney, and some other capital cities. There is a need to develop computer network simulation models which will facilitate the development of the best traffic control strategies. As yet there has been little detailed study undertaken of this complex traffic control function's application to the Australian network.

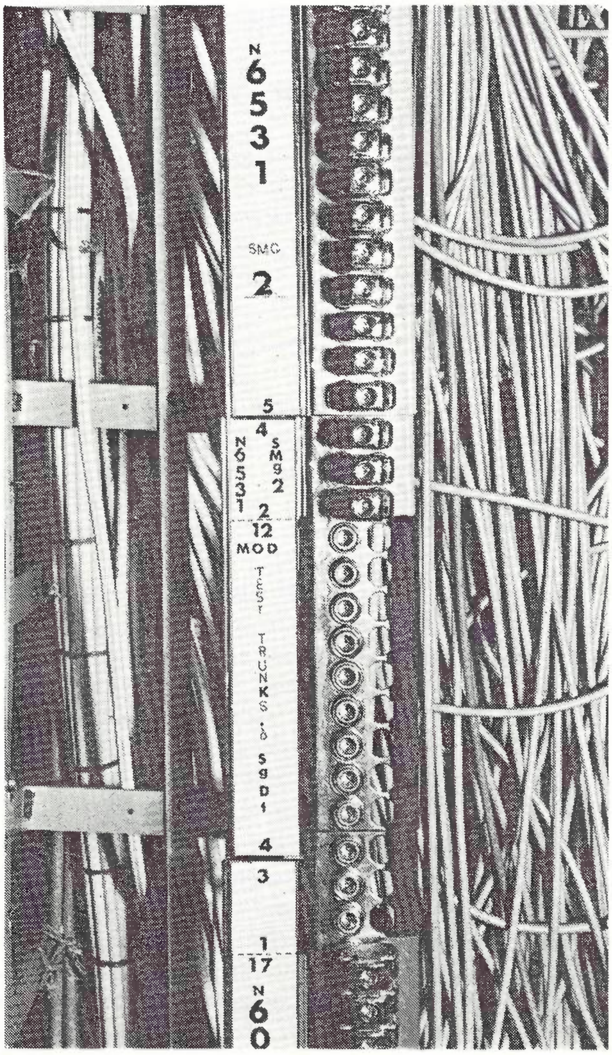

Fig. 3 — A Standard Type Distribution Frame Modified to Provide Supermastergroup Patching.

It is considered that when circuit or facility re-arrangements are made to meet a network failure, the effects of these re-arrangements on the performance of the network must be known. As an initial step towards this, and as a means to determine plant and network congestion, two types of peripheral devices for the Network Performance Measuring System have been developed as stated above; these are the Route Occupancy peripheral, and the Exchange Performance peripheral.

Briefly, the Route Occupancy peripheral allows for the measurement of the percentage of circuits in use to the total number of circuits available on a route. The information is stored, and "polled" by a centralised computer on a programmed basis to allow continuous monitoring of the Route Occupancy peripheral output on a real time basis. As the information at all centres where the peripheral is installed is stored, a history of the total network traffic should be available at any past point in time. The Exchange Performance peripheral on the other hand has been developed to measure the crossbar exchange switching plant performance, or rather its ability to handle the offered traffic. This is achieved by collecting electrically (automatically) the statistical and permanent meter information for a given exchange. This total information is combined together to give what has been called an "exchange index number". It is expected that once the "exchange index number" has been developed for a given ability of an exchange to handle traffic, any change in this index will indicate a plant or network problem.

At the time of writing field trials had commenced of the prototypes of these two peripherals, the Route Occupancy, and the Exchange Performance peripheral.

EVALUATION OF THE SRTC FACILITIES

The facilities provided to date in the SRTCC, do little more than allow the surveillance of the status of the broadband transmission network, on which service restoration can be based. This equipment does provide an orderwire system between the SRTCC and the control stations as well as giving data on the performance of the broadband transmission network. Very little has been achieved in establishing the basic contingency plans for restoration of lost communication facilities in event of failure in the network, nor has much progress been made in developing a capacity to indicate the percentage loss of public traffic and special services under failure conditions. The provision of group and supergroup patching facilities by modification of the appropriate distribution frames (see **Fig. 3**) has enabled a more acceptable means for restoration patching. However in most cases this is done on an as required basis and little forward restoration contingency planning has been effective.

There is a need to develop systems and procedures for information processing, for the development of network models, for the measurement of real time network traffic, of changes in status of exchange switching equipment and transmission equipment on a real line basis so that appropriate protection strategies can be implemented. These facilities will enable the SRTCC to better fulfill its intended role of service restoration and traffic control.

EXPERIENCE GAINED IN OPERATION OF THE CENTRE

The SRTC centre has achieved its initial primary objective of providing a co-ordination point for the removal of telecommunication facilities for planned engineering work, for the co-ordination of the restoration of limited facilities and urgent or priority services in the event of "unscheduled" (plant failure) outages and for the co-ordination of unscheduled outage information to management.

In at least one instance, during a critical stage of a NASA manned flight, the bearer surveillance equipment indicated that a plant failure could be about to happen. The SRTCC arranged for the patching of the NASA circuits under controlled conditions, maintaining uninterrupted service. This was completed and the predicted plant failure did take place without causing any undue stress.

Although beyond the scope of this present article much transmission network and plant performance information has been made available from the equipment in the SRTCC, and this information has been used to correct maintenance methods and practices as well as special maintenance investigation.

CONCLUSION

The topic of service restoration and traffic control is very broad and many aspects could not be included above, however an attempt has been made here to introduce the subject, its facilities and its control centre. As a telecommunication network evolves, develops and grows there will be a greater need for the SRTCC and future years will see the centre develop more of its intended role.

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1. N.P. & O. Information Bulletin No. 2, "Service Restoration and Traffic Control Centres", issued by Telecom Headquarters, 1973.
2. Engineering Instruction, Long Line Equipment, General PO 497 "Service Objectives for Broadband Systems".

J.P. Salter is appointed to the position of Supervising Engineer, Trunk Service Section, Engineering Department, New South Wales. See page 246 of T.J.A. Volume 23, No. 3.

Design Principles of a New Telephone Apparatus Measuring System — Part 1.

R. W. KETT, M.I.R.E.E., Fell. R.M.T.C. Comm. Eng.

An examination is made of the problems involved in measuring the characteristics of telephone apparatus for transmission quality assurance purposes.

Techniques which have been used in the past, both in Australia and overseas, are discussed.

INTRODUCTION

The Customer Apparatus Section of the Research Laboratories has been engaged in the design of a new series of equipment to replace the Telephone Efficiency Testers Type R3 (TET R3). About eighty of these instruments are used in Australia for the quality assurance of new and reconditioned telephone apparatus. The new design is to be known as Telephone Apparatus Measuring System — Series 4 (TAMS-4).

As this development is approaching the field trial stage, it is an appropriate time to record something of the history of telephone measurements and the principles which have guided the design of TAMS-4.

The testing of telephone components has always been beset with peculiar difficulties. We are attempting to make numerical measurements of the ability of economically produced components to accurately transmit thoughts between human beings. So difficult a task does not lend itself to rapid production line testing. We must confine ourselves to measuring those parameters which we have found to have a major effect on performance or reliability and which are within the scope of our technology.

A SHORT HISTORY

The Early Days

In the early 1880s, when telephones began to be used on a commercial scale, engineers possessed only relatively crude electrical instruments and measurement of ac speech voltages was almost impossible. It was therefore necessary to employ test procedures which involved communication between two persons. To set standards, telephone engineers would select from an initial production batch of transmitters, receivers, induction coils and bells, a number of samples which appeared to have typical performance and which could be obtained from current manufacturing processes. These would be suitably labelled and were henceforth called "sealed samples." The manufacturer's future deliveries were required to be no worse than these reference standard samples in all respects, including dimensions and finish.

Transmitters and receivers were acceptance tested by setting up two telephones, using the "sealed samples" and conversing through them, possibly via a line represented by a resistor. The delivered transmitters or receivers could then be substituted and their performance compared. This principle of testing by substitution is widely used in telephone quality assurance.

It is worth reflecting on the merits and demerits of this primitive acceptance testing procedure, as it illustrates many of the problems we are still required to solve. It is also important to bear in mind that telephone transmitters and receivers had then, and still have, resonant peaks in their frequency responses, a limited transmission bandwidth and very likely, some distortion in their output. Furthermore the carbon transmitter has an unstable performance. These factors lead to measurable interactions with different observers and different instruments. A telephone component should be considered unsatisfactory if any of these factors become much worse than usual, as well as when it has unduly low sensitivity.

The simple subjective test is open to the following criticisms:

- It requires the two people performing the test to have repeatable speaking volume and to make repeatable listening judgments. They must also handle the telephone in a repeatable manner.
- Two different people, with different speech characteristics and hearing losses, may react differently with the resonances in the components and produce different results.
- It is difficult to detect a drift in the performance of the sealed samples, especially when the individuals of a nominally identical group all move in the same direction. If however, some appear to have grown worse than the remainder it cannot be ascertained whether this is really so, or whether the others have improved.
- It subjects the standard components to undesirable wear and tear.

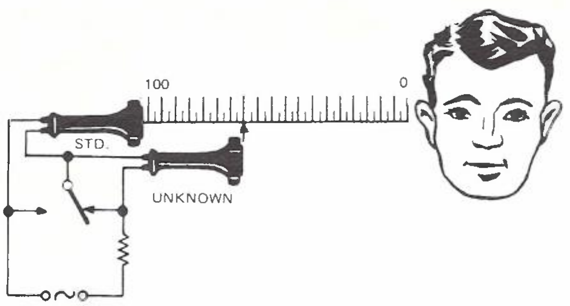

Fig. 1 — An Early Method of Comparing Receivers.

- In its simplest form it does not yield numerical data. Only broad categories of good, fair and bad are possible and arguments regarding marginal performance cannot be settled objectively.
- It is slow.
- It requires more than one testing officer.

On the other hand it has certain merits:

- Faults such as excessive distortion, frying noise, instability and poor frequency response will probably be detected.
- The realism of the testing technique cannot readily be questioned; i.e. real people are making realistic use of the components. It can be demonstrated by the purchaser and the manufacturer to each other.
- The resources of two human brains are available to make decisions.

The desire of these early workers in telephony to obtain quantitative data led to some most ingenious techniques. Van Deventer (Ref. 1) in 1910 described a number of methods for measuring the efficiency of receivers. An electrically maintained tuning fork was used as a source to excite the receiver and it was moved away from the ear of the observer until the sound just became inaudible. The distance from the ear was measured and called the "vanishing point". A more reliable method used a standard receiver at say 100 inches, another receiver, excited from the same source was moved until the two gave equal loudness and the distance was recorded. (See Fig. 1).

It was also clearly recognised by early writers that "clarity of transmission" rather than loudness was an essential criterion for transmitters and receivers. Simple word articulation tests were

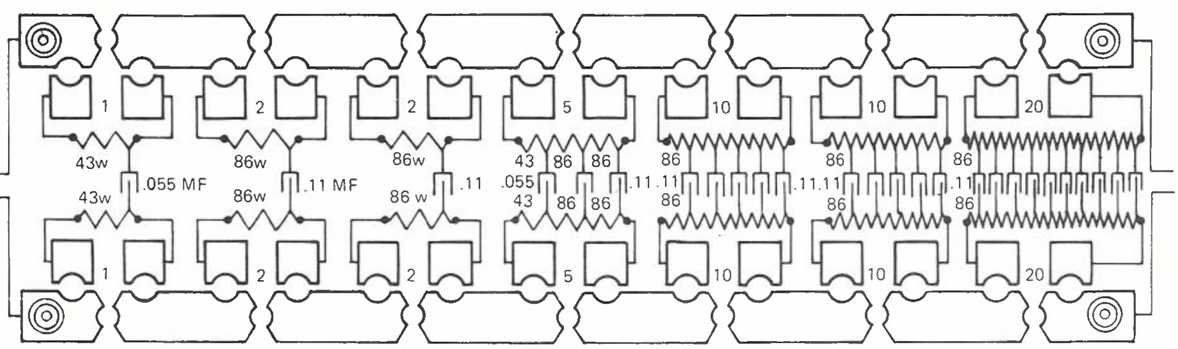

Fig. 2 — Artificial Line: 50 miles of Standard Cable.

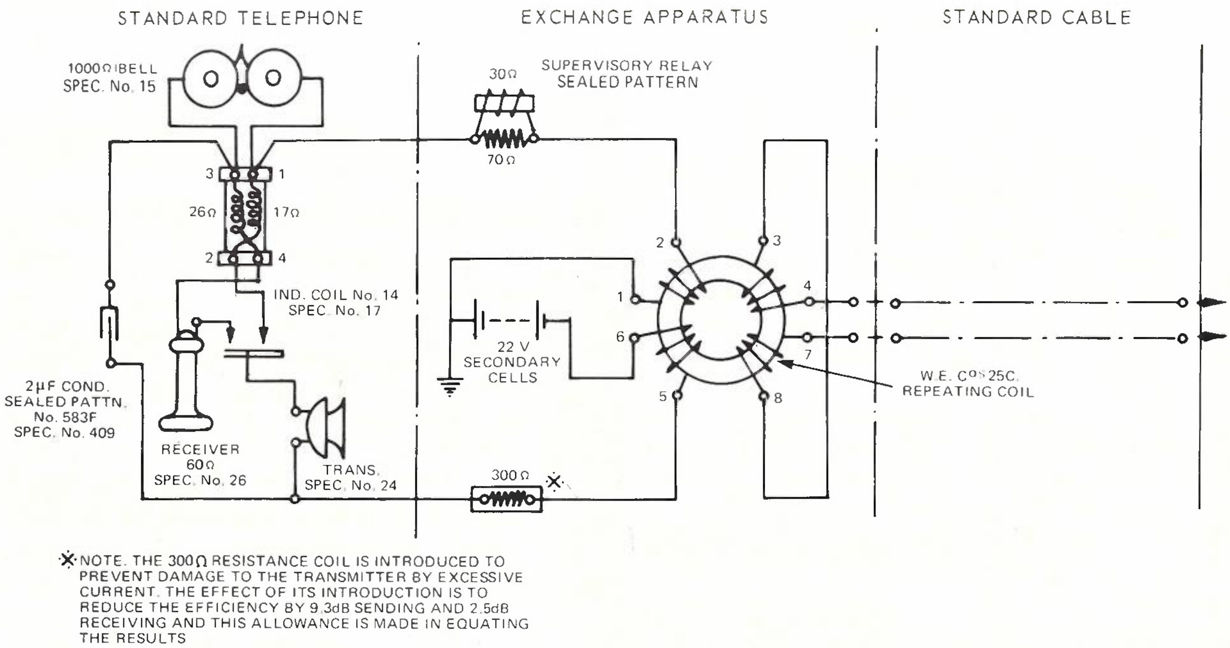

Fig. 3 — AT & T Co. Standard Transmission Circuit.

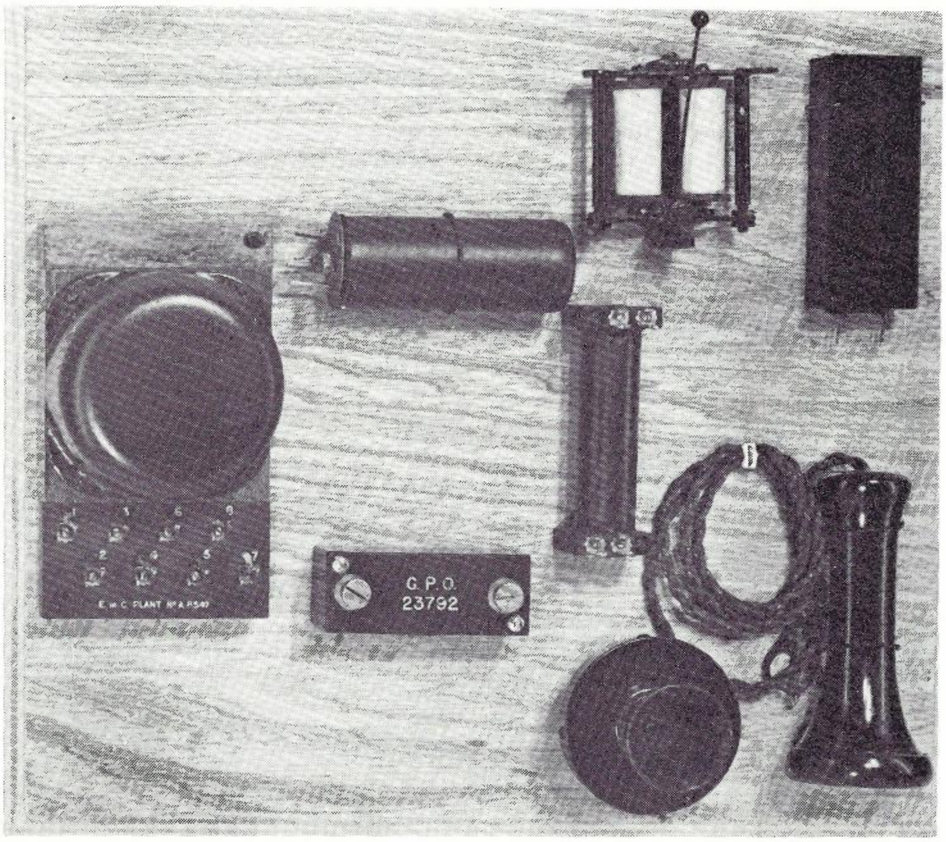

Fig. 4 — Sealed Samples Supplied by BPO.

used for subjective assessment. Although it is recorded that the output of transmitters had been measured in the laboratory with sensitive thermo-galvanometers, no production line objective measurements of volume appear to have been attempted. However, measurements of transmitter speaking resistance were relatively easily made and were relied upon to control carbon granule quality and the degree of filling of the transmitter.

The Evolution of Standards

Engineers needed a standard unit by which they could measure the "audibility" of telephone connections. The American Telephone and Telegraph Co. (AT & T Co.) introduced the concept of a mile of standard cable (msc). This was based on the constants of the 20 lb. cable of those days, namely 88 ohm and 0.055 microfarad per loop mile. Laboratory models of this cable were built, switchable in one mile units from 0 to 50 miles. (See Fig. 2 and Ref. 2). (Note: Slightly different constants are given by different texts.)

For planning and testing purposes it was also necessary to define the standard telephone instrument, limiting local line and the feeding bridge. The complete circuit used by AT & T Co. is shown in Fig. 3. The telephone was a candlestick type with solid back transmitter and bell receiver. Using speaking and listening tests, telephone components could be compared with sealed samples of similar type, by substitution in the standard circuit. Comparisons were made in terms of the difference in msc required to give equal loudness when the test sample was substituted for the sealed sample.

This form of standard was adopted by Great Britain in 1904 (Ref. 3). Initially 46 msc was set as an absolute maximum permissible loss for any connection, but this was found to be excessive and had been reduced to 35 msc by 1915. Further reductions occurred in later years.

In 1920 the British Post Office (BPO) established a group of twenty Primary Reference Standard transmitters and receivers with their associated telephone components. These formed their primary standard for the next 27 years.

In 1925 the Australian Post Office (APO) purchased seven similar sets of calibrated sealed samples from the BPO for use as the Australian primary standards in the Research Laboratories and each of the States. (See Fig. 4). Voice-ear techniques were to be used for acceptance testing deliveries of telephone in each State. The APO was highly dependent upon the BPO for specifications and standards at this time and purchased the bulk of its equipment from British companies.

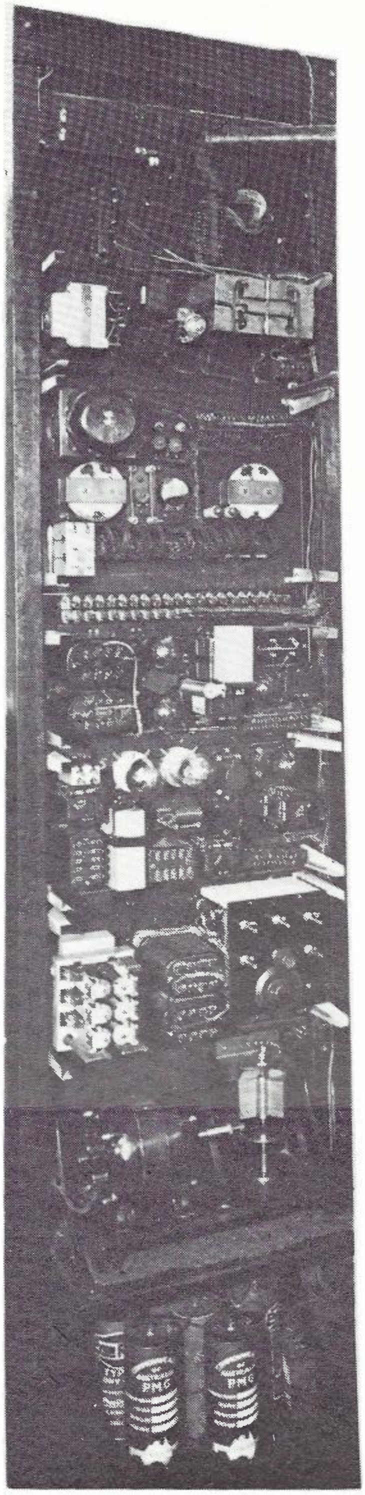

Fig. 5 — First Experimental APO TET — Rear View.

The advent of improved microphones and receivers, together with valve amplifiers, enabled the next major step to be taken in the early 1920s.

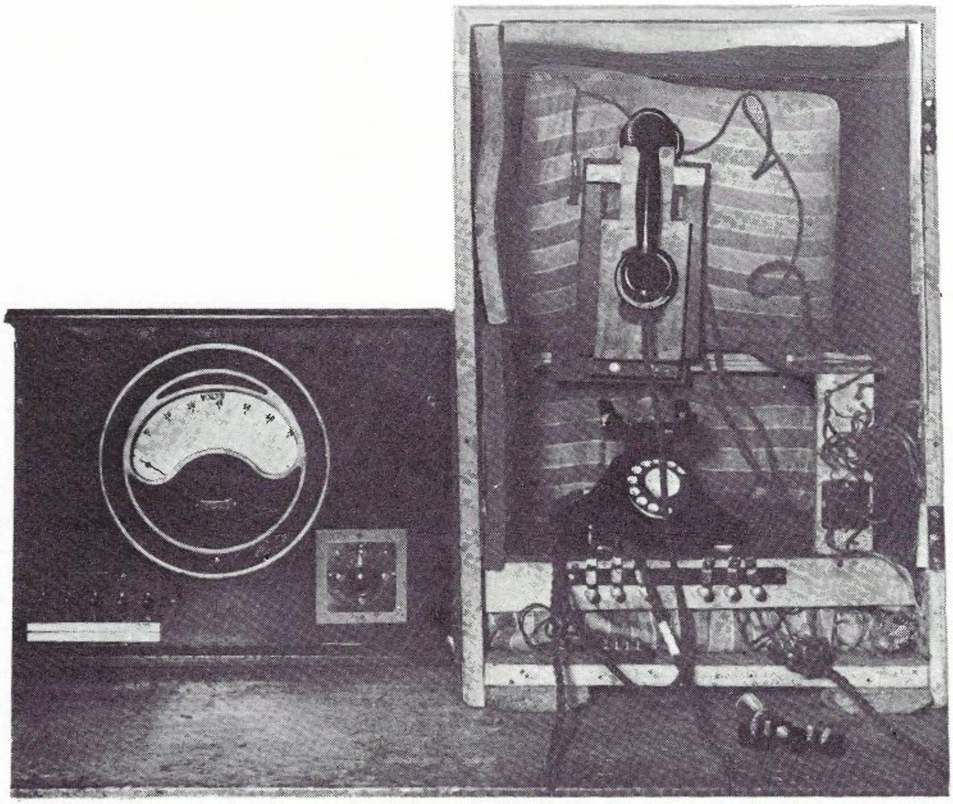

Fig. 6 — First Experimental APO TET — Meter and Acoustic Cabinet.

The AT & T Co. developed a Master Reference System, against which telephone connections could be rated. It consisted of a capacitor microphone, an amplifier, a 600 ohm attenuator and a moving-coil receiver. The attenuator could be varied until equal loudness was obtained with the reference system and the telephone connection under test. The "Reference Equivalent" rating was given in terms of the attenuator setting in decibels. The microphone and receiver were standardised from primary acoustical standards. A replica of this system was installed in Paris in 1928, becoming the European Telephone Transmission Standard (SFERT); another replica was installed in the BPO Research Station. The modern development of this standard has been described in this journal by E. J. Koop (Ref. 5).

Instrumental Testing Begins

As early as 1915 British engineers had suggested that a rhythmically swept tone could be used to simulate speech and by 1929 technology had advanced sufficiently for the BPO to produce the first objective telephone test instrument. The instrument was described in October 1929 (Ref. 6) under the title "Mechanical Testing of Transmitter and Receiver Efficiencies". The article produced an immediate reaction in the APO and enquiries were sent to the BPO for details. As the BPO were too heavily committed to manufacture a tester for the APO, the Research Laboratories were given the task of designing a similar instrument. In 1935 an experimental version (See Figs. 5 and 6) was sent to Sydney to test the first delivery of the new handset telephones type 162.

At about the same time Amalgamated Wireless of Australasia imported a BPO Telephone Instrument Tester from Siemens Bros. of Woolwich. (See Figs. 7 and 8). This instrument has been preserved and is now in the Telecom Australia Research Laboratories Museum.

The usefulness of these instruments was speedily recognised and a standard design, Telephone Efficiency Tester Type R1A (TET R1A) entered service in 1939. (See Fig. 9 and Ref. 7).

The TETs R1A were transfer instruments. Each was standardised daily by means of a group of six working standard handsets, deriving their calibrations ultimately from BPO Primary Standards. The TETs incorporated the BPO standard of Local Line transmission embodied in the sealed samples mentioned above. In fact several of these sets were actually built into the first batch of TETs. Measurements could be made of transmitter and receiver efficiency, and transmitter resistance. Transmitter frying could be detected by a listening test.

There was necessarily a considerable heirarchy of standards between the BPO Primary Standard and the Australian travelling Working Standard Handsets and a long sea voyage was involved. The situation in the 1940s is believed to have been as follows:

- BPO Primary Reference Standard Telephones
- BPO Inspection Branch Working Standards
- APO Laboratory Reference Standards
- APO Laboratory Working Standards
- APO Travelling Working Standards
- Standardised TET.

The BPO may have used additional steps unknown to us.

It was learned in 1947 (Ref. 4) that the BPO had maintained their 20 Primary Reference Standard telephones independently of SFERT and without reference to their own replica of SFERT. An irreconcilable difference of several dB between these two Master Reference Systems, supposedly defined in terms of fundamental physical standards, no doubt lay behind this decision. Instead they had relied on the principle of "zero average change", i.e. the assumption that individuals in their group of standards were equally likely to rise or fall in sensitivity with time and that the group mean would have

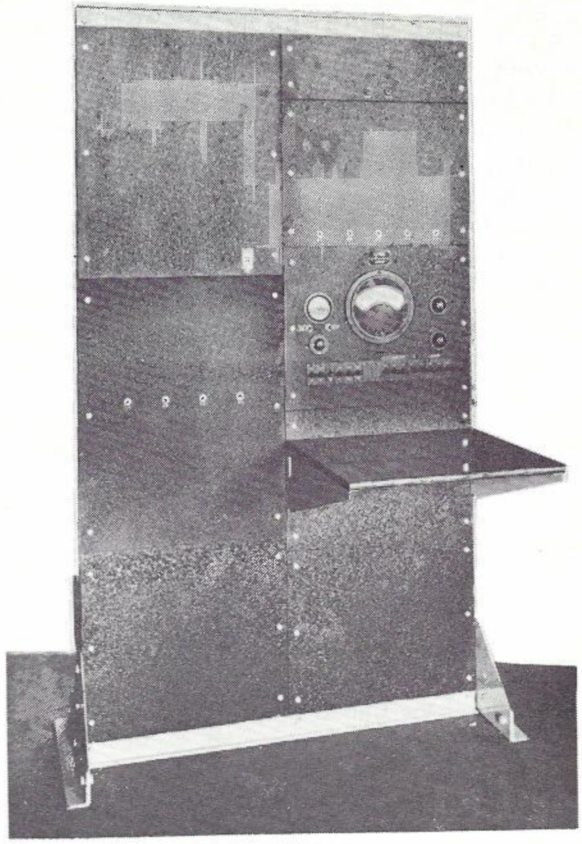

Fig. 7 — Siemens Bros Telephone Instrument — Tester — Front View.

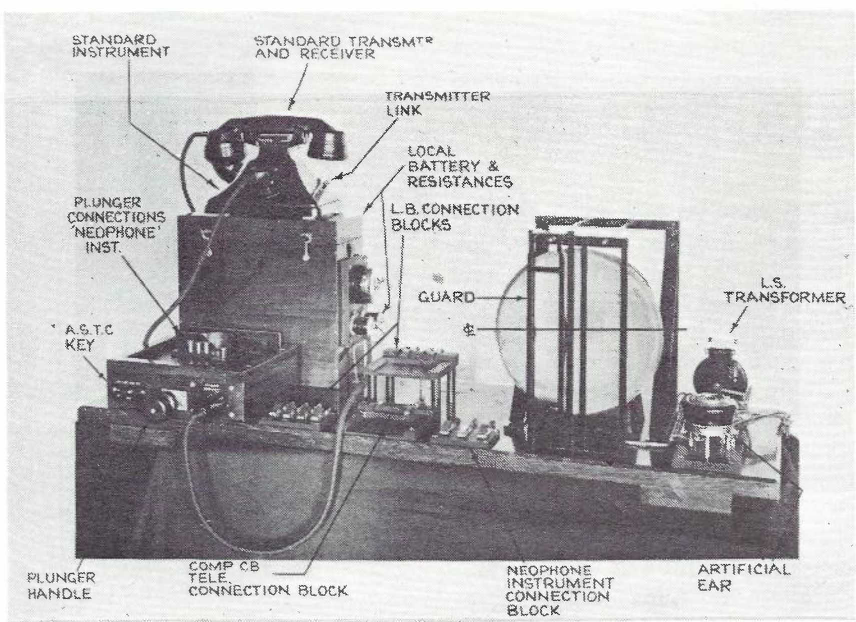

Fig. 8 — Siemens Bros Telephone Instrument Tester — Bench Equipment.

long term constancy. This was felt to be justified by the fact that the mean efficiency of manufacturers' samples, made to meet the BPO Standard, had not altered significantly between 1932 and 1940.

A study of our own, made on similar standards has shown that this assumption is incorrect. In SLT (See Fig. 10) which was also used by the BPO, the dc shunting effect of the antisidetone transformer reacts with the normal rise in resistance of the transmitter with time, to give a continuous loss of transmitting efficiency. The BPO rated individual transmitters in dB relative to the group mean. At subsequent calibrations, they replaced any primary standard transmitter which had departed more than ±1.3 dB from its previous calibration. In other words, those which had declined least and were significantly more efficient than the group mean were likely to be discarded and the mean efficiency, in absolute terms, was steadily falling. It can be seen that the transmitter standard must have declined significantly over a period of thirty years.

World War II caused a disruption of our BPO calibrations and when new standards were purchased from the United Kingdom in 1946 a significant discrepancy was discovered. Further complications had arisen because the BPO had radically altered their testing equipment.

Although this now appears a rather shaky basis for the APO standard, it did have considerable advantages initially, namely:

- It was faster than voice-ear methods and larger samples could therefore be measured.
- Simple numerical data could be obtained, which was reasonably reproducible in both Australia and the United Kingdom.
- The use of working standards with characteristics similar to the telephones to be tested, permitted the use of TETs with relatively crude artificial voices and ears and poor long-term stability.

The TET R3

The R3 series of TETs were introduced in 1962 at the same time as production of the telephone type 801 commenced. (See Fig. 11 and Ref. 8). A few years previously, the BPO had issued specifications for the No. 13 transmitter and No. 4T receiver, which for the first time specified their performance in absolute terms. There were no such references as "equal to the Department's Standards". It was now possible to set up specified electrical and acoustical environments in any laboratory and measure transmitters and receivers to the BPO standard. The R3 system was standardised in this manner and was at last on a firm and independent footing. APO specifications for transmitters and receivers were also issued, based on this new standard. Independence from BPO specifications was justified by the size of our requirements and the existence of local manufacture. Problems had often arisen through changes having been made in BPO specifications, unknown to the APO, being reflected in deliveries from the United Kingdom.

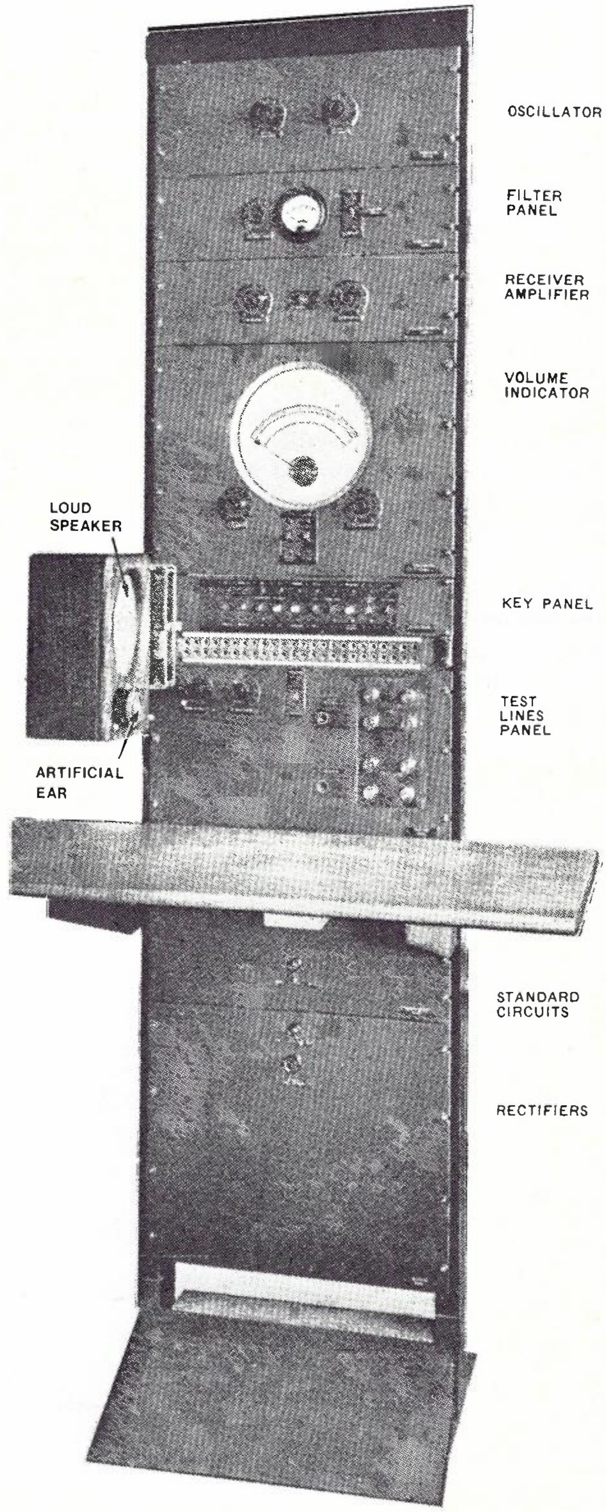

Fig. 9 — Telephone Efficiency Tester Type R1A.

It is of prime importance that any two TETs should give similar results, within reasonable limits. The standardisation of the TETs R1A by means of working standard handsets having very similar characteristics to the product to be tested, compensated to some extent for the differences in response of the artificial voices and ears and in the oscillator spectra of different TETs.

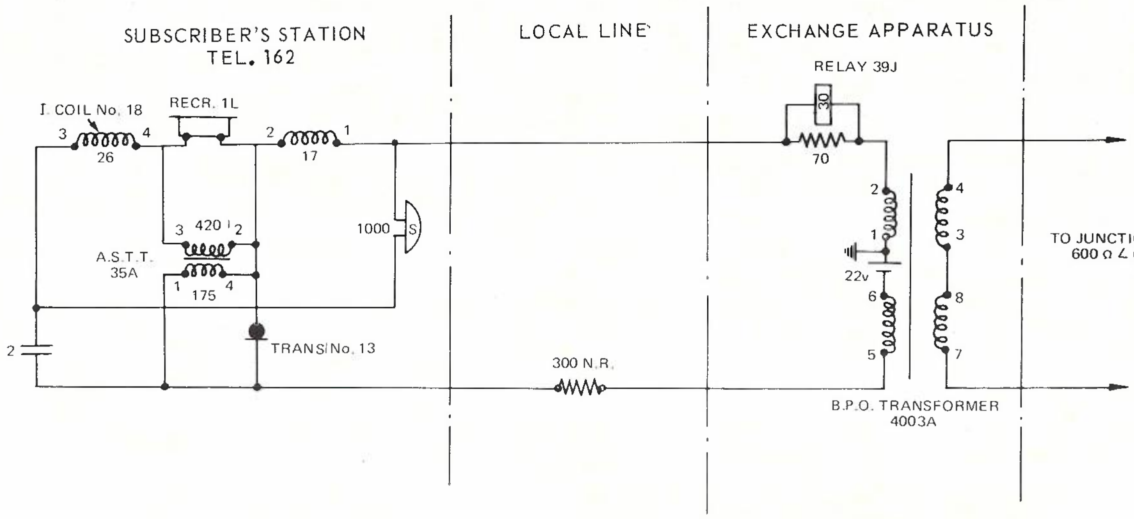

FIG. 10 — APO Standard of Local Line Transmission (SLT).

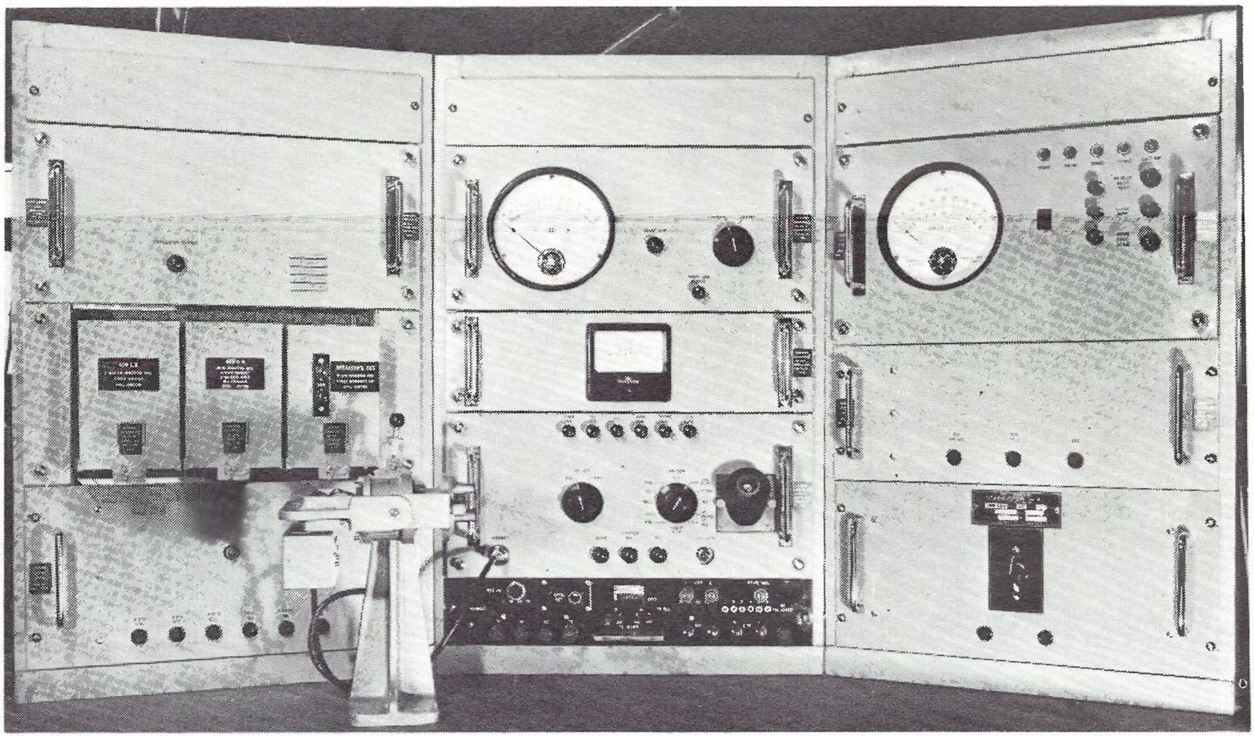

Fig. 11 — Telephone Efficiency Tester Type R3.

The discontinuance of travelling working standards with the introduction of R3 TETs sharpened up the problem of obtaining consistent results between TETs. Telephone components interact strongly with their testing environment. Fig. 12 illustrates the responses of two artificial voices which have been equalised to within ±2.5 dB over the working range. They have also been adjusted to give equal output by exciting them with TET tone (swept 300 - 3000 - 300 Hz at a 25 Hz rate) and measuring their output with a small capacitor microphone with uniform frequency response.

The No. 13 carbon transmitter has a resonance in the region of 1500 Hz which is assisted by the slight rise in response of one voice and reduced by the dip in the other. In this way, small but significant differences in readings may occur, even though the TETs have been adjusted within technically achievable limits. It is interesting to reflect that the worse the frequency response of the product, the more uniform must be the frequency response of the measuring equipment, if consistent results are to be obtained at differing testing stations.

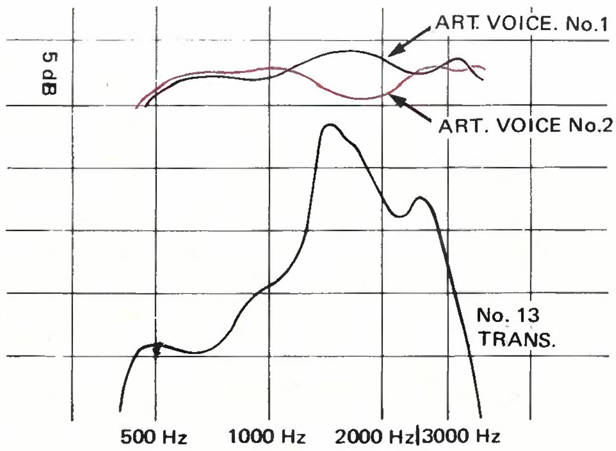

Fig. 12 — Interaction of Transmitter and Artificial Voice.

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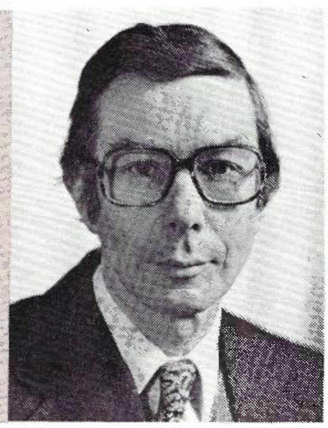

Style 72A—New Generation Carrier Multiplex and Line Transmission Equipment—Part 1

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In 1968, the then APO first issued a specification for a unified construction practice with standardised electrical interfaces for locally produced line transmission equipment. After a series of consultations with local manufacturers, a "Design Guide for Long Line Equipment" was finalised. This article describes the Style 72A generation of carrier multiplex and line transmission equipment which has been designed and manufactured by Siemens Industries Limited in accordance with the "Design Guide" and to its basic requirements. The resulting family of equipment includes the entire range of carrier multiplex equipment from channel modems to 15 Supergroup (SG) assembly modems and its associated equipment and line equipment including 12-channel pair cable and coaxial line systems.

INTRODUCTION

The opening of the first Broadband System between Melbourne and Bendigo, Victoria, in 1959 was a milestone in the history of Australian telecommunications. From that time the long haul and large capacity communication routes started to multiply in quick succession. With this expansion grew the requirement for trunk channels and thus the demand for multiplexing equipment, which provided the basis for expansion of local activities in the long line equipment field.

Siemens Industries Limited commenced the manufacture of carrier telephone equipment in Melbourne in 1962 and soon afterwards participated with Telecom Australia (then the Australian Post Office) and other Companies in the first standardisation discussions concerning long line equipment. The result was the Type 66 high density channel modem equipment (Ref. 1) with features such as standardised rack dimensions, a capacity of 120 VF channels per rack and a central test access field. The next standardisation of long line equipment introduced by Telecom Australia, in 1968, has been defined by the "Design Guide for Long Line Equipment" (Ref. 2). This standardisation concept, called Type 72, has been taken much further than the previous concept with the smallest exchangeable unit now being a panel instead of the previous Type 66 rack.

Whilst the Type 66 equipment was realised by all manufacturers with more or less the same conventional techniques, new technologies and components were available for the new Type 72 standardisation, such as integrated circuits, thick film circuits and, in particular, the electromechanical filter (Refs. 3, 4). With these components it became possible not only to improve technical characteristics, but at the same time to increase reliability, to reduce size and power consumption and, most importantly, to allow the automation of the manufacturing process to a very high degree. A new premodulation scheme (12 x 1), where all channel modem plug-ins are identical, increased the production quantities by a factor of 3.

Siemens Industries Limited had access to these new developments and, after negotiations with and acceptance by Telecom Australia, decided to incorporate some of these new technologies in their new generation of equipment. First supplies of the new channel modems from the Richmond plant commenced in 1974.

Successively higher order multiplexing and line transmission equipment were also developed along the standardisation concepts of the "Design Guide". Today a complete and compatible family of Style 72A equipment is available.

This article describes the Style 72A family and the techniques used. It is in two parts; Part 1 covers mechanical construction principles, channel modems, Z12 cable carrier equipment and through filters, whilst Part 2 deals with group modems, supergroup modems, fundamental carrier supply equipment, 15 supergroup (SG) assembly modems, carrier program equipment and coaxial line transmission equipment.

MECHANICAL CONSTRUCTION AND COMPONENTS

Two methods of installing the equipment into Telecom Type 72 racks are employed; subrack and panel mounting.

Subracks provide the mounting facilities for the self-contained insets, which hold the equipment slide-in units. The subrack contains all the inter-inset wiring, as well as the station and inter-subrack wiring terminals. In the panel the units slide into a horizontal frame which provides the interconnections between the units and the terminals for the station and inter-panel wiring.

Subrack mounting

Up to four insets can be installed side by side into one subrack. The subrack height varies with the length of the equipment installed and is of 5 rack units height (220 mm) for channel modem and Z12 equipment, of 12.5 units height (550 mm) for 15 kHz carrier programme and coaxial line equipment, and 15.0 units height (660 mm) for 15 SG assembly modem equipment (Fig. 1).

The space provided on the left hand side of the subrack is used for mounting an alarm unit, patching facilities, etc., if required.

The termination points for the power supply

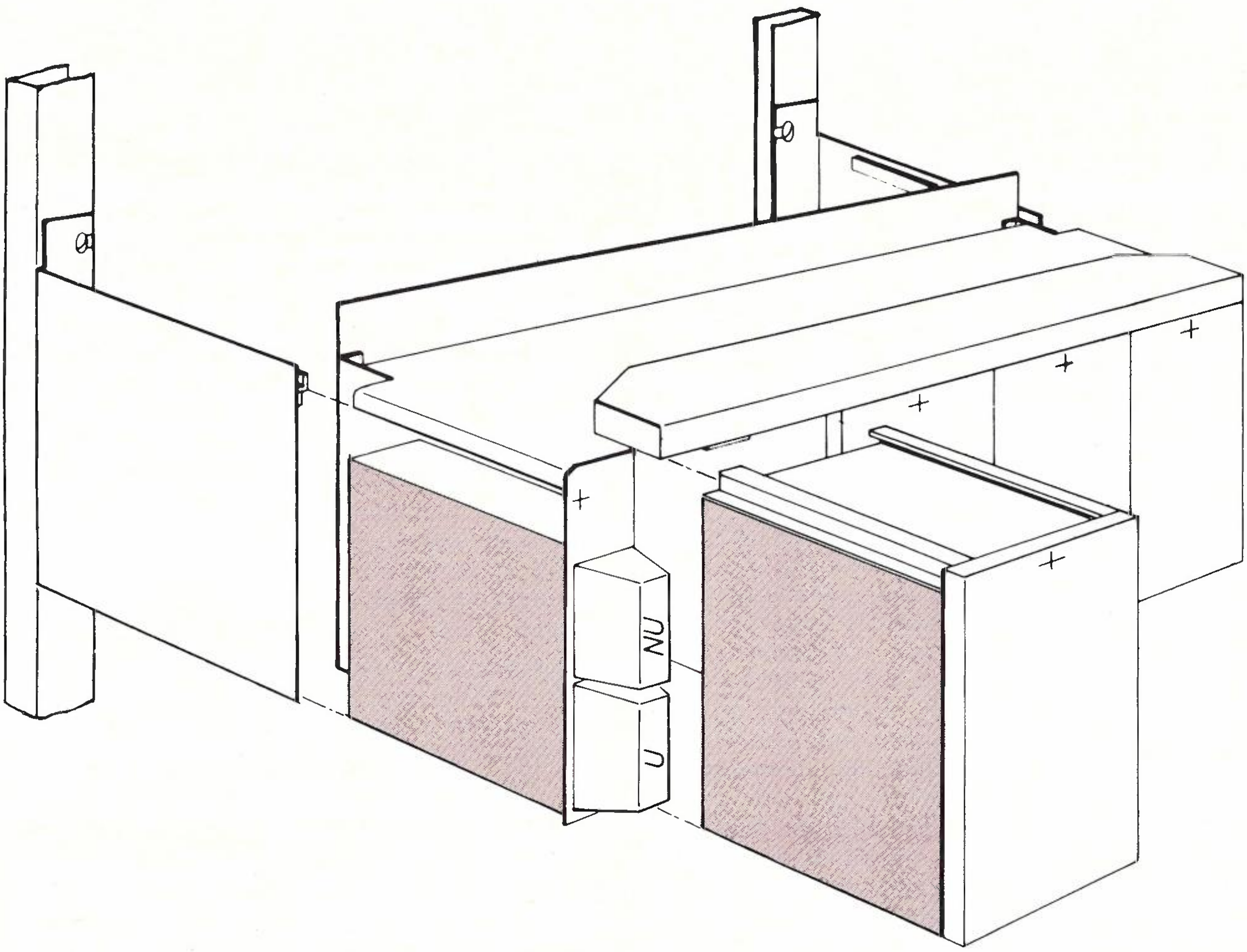

Fig. 1 — Style 72A Subrack for Equipment Insets.

and alarms are situated behind the panel above the insets and are accessible after removal of the front cover. Patching and monitoring facilities may also be located here, as in the case of the channel modem subrack.

The right hand side is reserved for the ring-wiring connectors, providing the power, carrier and alarm connections to adjacent subracks. Either two parallel-wired self-aligning connectors are located there, requiring an additional connecting cable to an adjacent subrack, or this cable already forms part of the subrack, providing a "flying-lead" connection to the adjacent subrack.

All station cables enter the subrack from the left hand cable duct, whilst all inter-subrack wiring is carried out via the right hand side of the subrack. The station cables are terminated on to cable connectors, by wire wrapping or by soldering processes; dc connections are made with screw terminals. All station cable connectors are accessible from the front and may be removed for easier installation.

Each inset is plugged into the subrack with the aid of guide rails and secured at the top by means of an Allen screw. The insets are of an open-box construction providing the slide-in unit guides and the wiring between the individual units. Either free wiring or printed circuit board wiring is used.

The mechanical and electrical components are mounted on printed circuit boards, forming a slide-in unit for one or more electrical functions. Every unit carries an insulated metal cover on the solder side, which acts as a shield to the next unit. In the higher frequency type of equipment shielded units are used.

Panel mounting

Similar design principles, as described for the subrack mounted equipment, are employed.

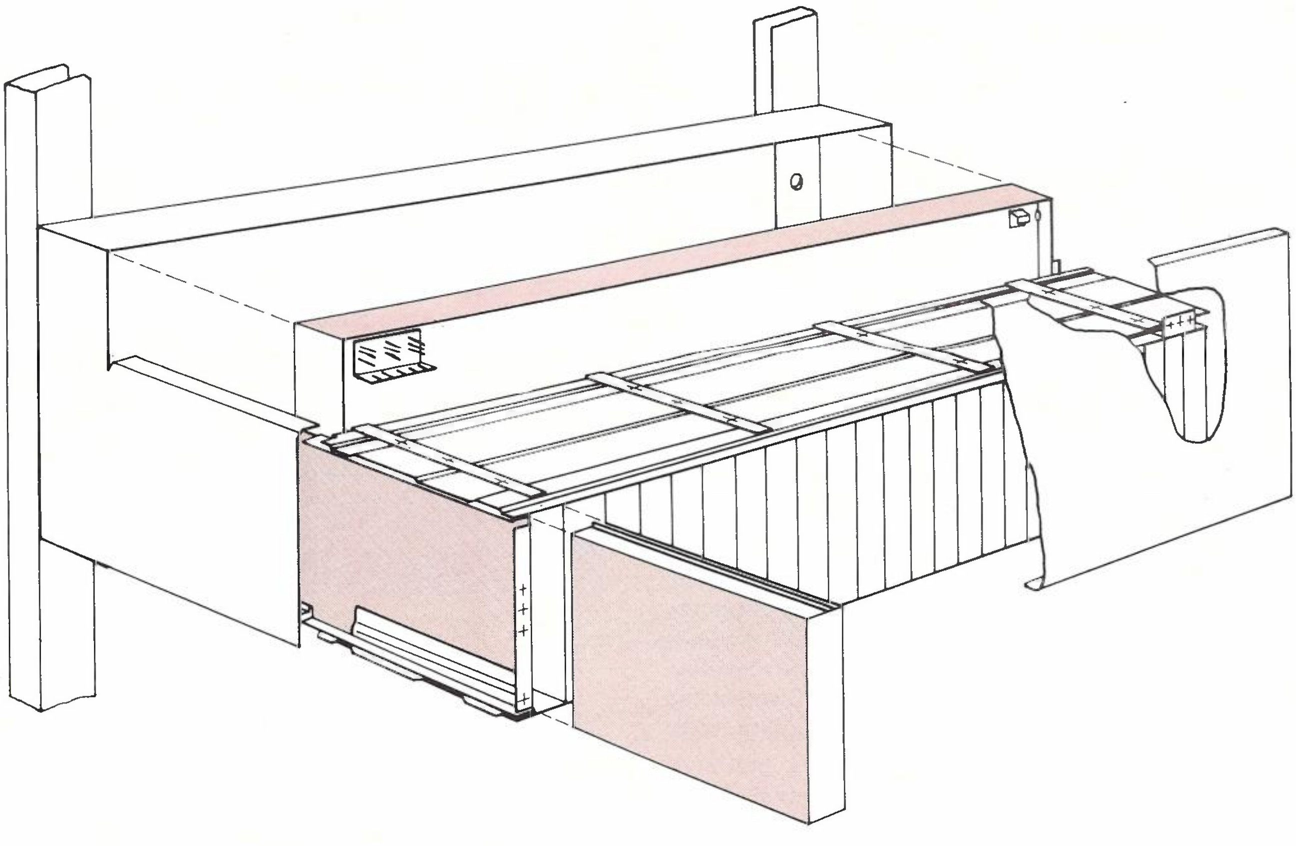

Fig. 2 — Panel for Slide-In Units.

The panels provide, like the insets, the guides for sliding in the units, and their inter-wiring. In addition, they carry the station cable and ring-wiring connectors. The station cables are terminated directly to the panels from the front by means of connectors or wire-wrap terminals. Screw terminals are provided for the power supply connections.

The station cables enter the panels from the left hand rack cable duct, whilst the ring-wiring cables are located in the right hand cable duct. The panels, which slide on guide rails, can be easily removed for installation and maintenance. Free wiring or printed circuit boards are used to interconnect the units, which are of the same construction as those described above. Fig. 2 shows the panel construction.

CHANNEL MODEMS WITH ELECTROMECHANICAL FILTERS

The first building block of the FDM system is the channel modulation equipment, better known as the channel modem.

Due to ever increasing costs, a new channel modem has been developed offering the user a sub-system of small size, high reliability, high transmission quality, low power and low operating and maintenance costs. The use of a relatively new technical innovation played the major role in this development—the use of electromechanical filters.

Electromechanical Filters

The telephone channels have to be modulated and assembled in a group of 12, side by side in a frequency band 60 - 108 kHz. In order to separate the channels from one another, filters of high selectivity are required.

Previous versions of Siemens channel modems used a modulation scheme which is commonly called 3x4 or pre-group modulation. This scheme offered an excellent solution for the channel filters and used ferrite coils and capacitors. In view of the spiralling cost of labour used in the manufacture of coils it was decided to pursue the development of a new filter for channel modems which would be coilless. The result of this development is the electromechanical filter. Fig. 3 shows the mechanical filter with and without coupling coils.

The desired stopband attenuation is produced by twelve resonators acting as flexural mode vibrators which are coupled via a longitudinally vibrating wire that acts upon them at the resonant frequency. Thin wafers of a specially developed piezoceramic material are soldered to the first and last resonators for the electromechanical conversion of energy. The coils of the final circuit act as both impedance transformers and modulation transformers.

Modulation Plan

The modulation scheme adopted for the new generation of channel modems is called the pre-modulation plan. Fig. 4 shows this plan. Although double translation is employed, suitable selection of the carrier frequency in the pre-modulation stage allows the modulation filters for the second translation to be eliminated and replaced by a common filter for all 12 channels in the basic group section. By pre-modulating each channel to the same pre-modulation frequency band, one obtains the advantage that all twelve channel modems are identical, which means a reduction in the number of types of filters to be manufactured. This favourable arrangement is made possible by using the mechanical filter with its high Q value lying between that of LC filters and crystal filters.

Frequency Allocation

As shown in Fig. 4, each 0.3 to 3.4 kHz voice channel, 12 of which are required for the assembly of a basic group, is first translated with the aid of a 48 kHz pre-modulation carrier to the frequency range 48.3 to 51.4 kHz.

The twelve channel carriers required for the second modulation stage in the assembly of the basic group, 60 to 108 kHz, are spaced at 4 kHz intervals between 112 and 156 kHz.

The signalling frequency is coupled in and out, by means of another set of mechanical filters at 51.825 kHz. The injected group pilot can be 84.08 kHz or alternatively 104.08 kHz.

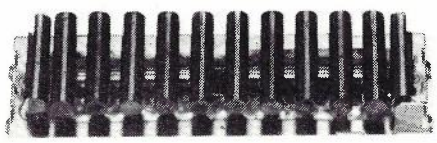

Fig. 3 — Electromechanical Filter with Cover Removed.

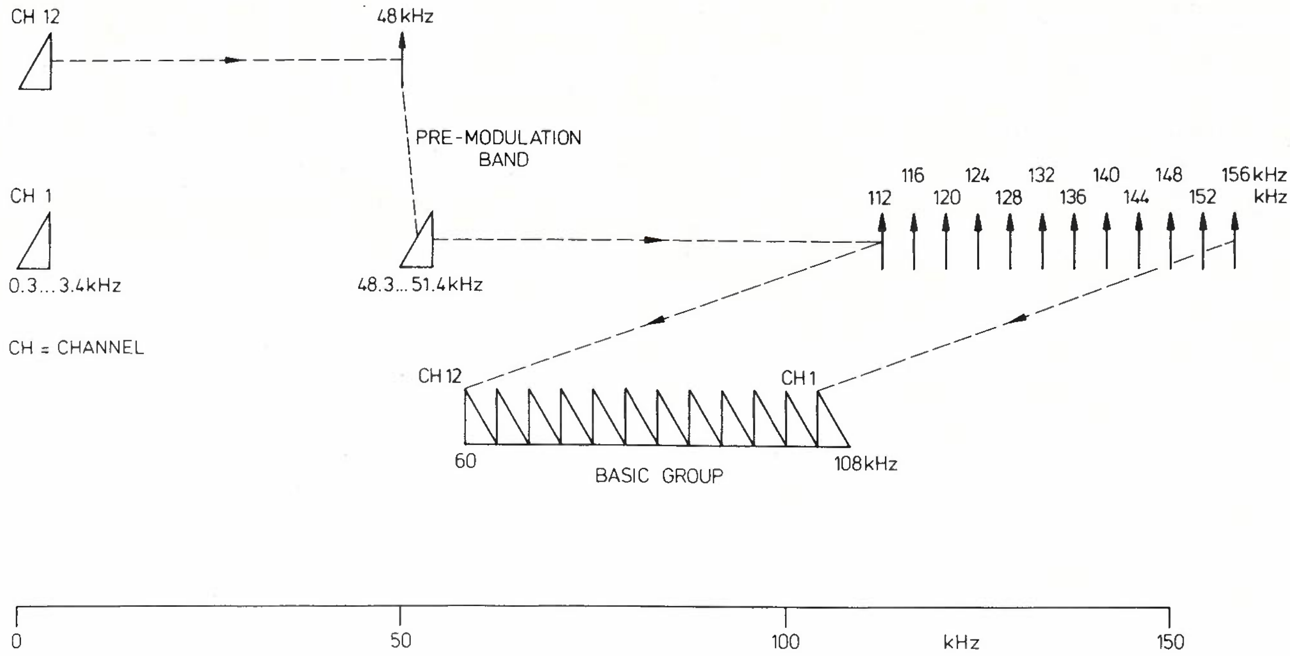

Fig. 4 — Frequency Modulation Plan for Channel Modem.

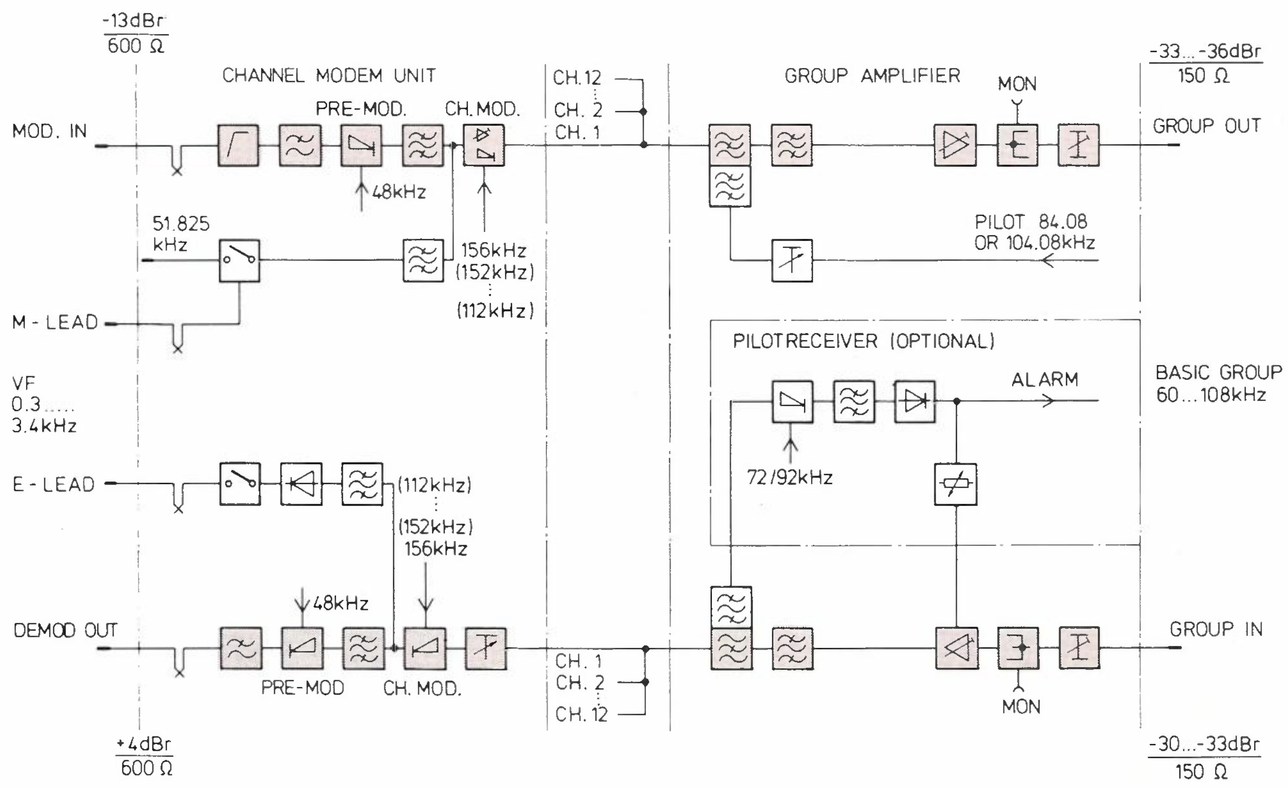

Fig. 5 — Schematic Diagram of Channel Modem Equipment.

Sub-System Assembly

The sub-system is mechanically and electrically established by using the following building blocks:

- channel modem inset
- carrier supply inset
- power supply inset
- alarm unit
- subracks (1st and 2nd-in).

Channel Modem Inset

The heart of the sub-system is the channel modem and the inset houses the plug-in units. These are:

- channel modem unit
- group amplifier
- pilot receiver (optional).

Fig. 5 shows a schematic diagram. Fig. 6 shows a channel modem inset.

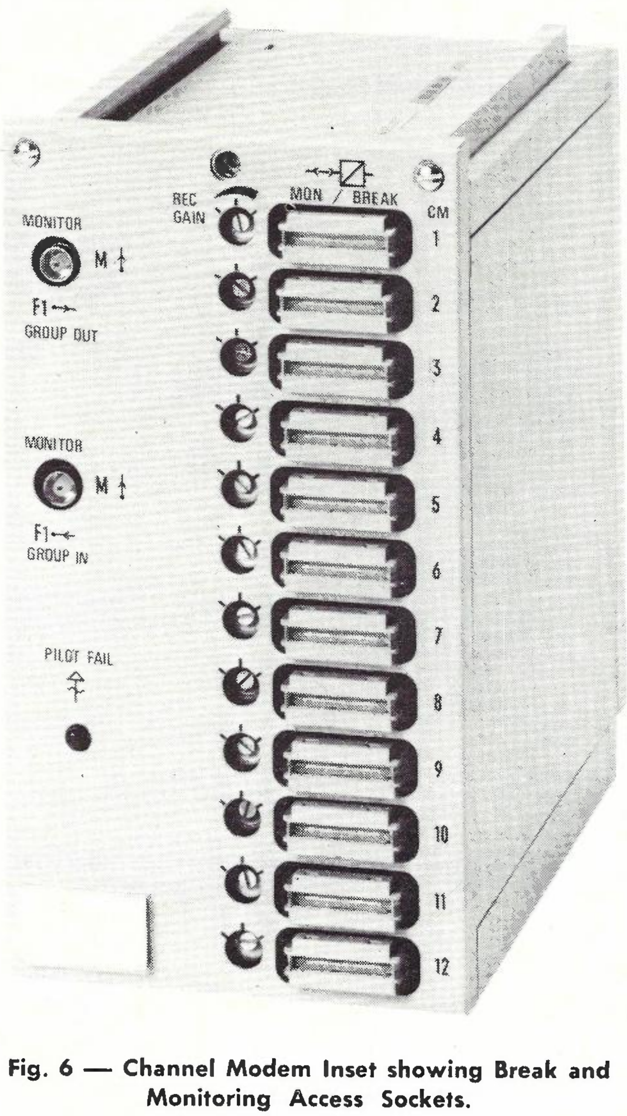

Fig. 6 — Channel Modem Inset showing Break and Monitoring Access Sockets.

Channel Modem Unit

Twelve identical channel modem units are housed in the inset, and, as the block diagram shows, each unit contains a pre-modulator and a channel modulator in both the transmit and the receive paths. Fig. 7 shows a channel modem unit.

The 48 kHz pre-modulator on the transmit side is a passive solid-state single balanced modulator of simple design and low carrier leak. The electro-mechanical channel filter follows the pre-modulator. Thick film circuits mount the transistor modulators and resistors. The outband signalling frequency is then coupled in and out of the pre-modulation band and bypasses the channel filter.

The channel modulator, which is fed by one of the carriers between 156 kHz (channel 1) and 112 kHz (channel 12), is an active single-balanced modulator. The twelve channels are combined into a group of simple parallel connection of all twelve outputs.

On the receive side active double-balanced modulators mounted on thick film circuit boards are used. Each channel modulator processes the entire frequency band of the group. The pre-modulation band 48 to 52 kHz is selected by an electromechanical channel filter similar to that used in the transmit direction. The modulator following it produces a nominal VF output level of +4 dBr. This saves a special channel amplifier at this point. The output level can be varied from the nominal by a trimmer capacitor.

The signalling section on the channel modem unit processes either signals for low-level signalling or for the international signalling system R2. A solid-state switch is the output interface.

On the front of each channel modem unit is mounted a test access socket. This socket allows for break access and for monitoring access of the channel and its signalling leads.

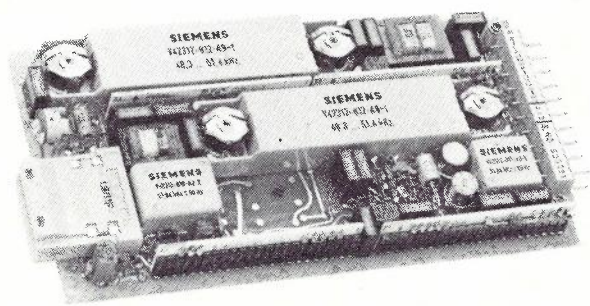

Fig. 7 — Channel Modem Unit.

Group Amplifier

The group filters and amplifiers of the transmit and receive directions are combined on a common printed circuit board. The 84.08 or 104.08 kHz group pilot, required for pilot supervision and automatic level regulation, is injected in the transmit side and extracted on the receive side via separating filters. The receive gain can be regulated automatically with this pilot by an optional pilot receiver.

Pilot Receiver

The pilot 84.08 kHz or 104.08 kHz is picked off and modulated with either 72 kHz or 92 kHz respectively to a frequency of 12.08 kHz enabling the use of a simple two-resonator mechanical filter. The monitoring circuitry which amplifies and rectifies the incoming signal contains an automatic gain regulation output and an alarm facility.

Carrier Supply Inset

The carrier supply can be fed either by an external generator or operated independently using an inbuilt master oscillator. After frequency division the actual drive frequency of 16 kHz is obtained. Although all carriers are multiples of 4 kHz, the harmonic generator is driven by 16 kHz. It has two outputs—one containing even multiples of 8 kHz, the other containing the odd multiples of 8 kHz. Seven carriers can be directly filtered out of the harmonic spectra. The second harmonic of the other six carriers appear at the outputs of the harmonic generator and can be derived by 2:1 frequency division before filtering and amplifying.

The pilot and signalling frequencies as well as the auxiliary carrier for a pilot receiver are derived from the carriers. By the addition of another slide-in card, frequencies of 60 and 114 kHz can be generated for use with Z12 pair cable systems.

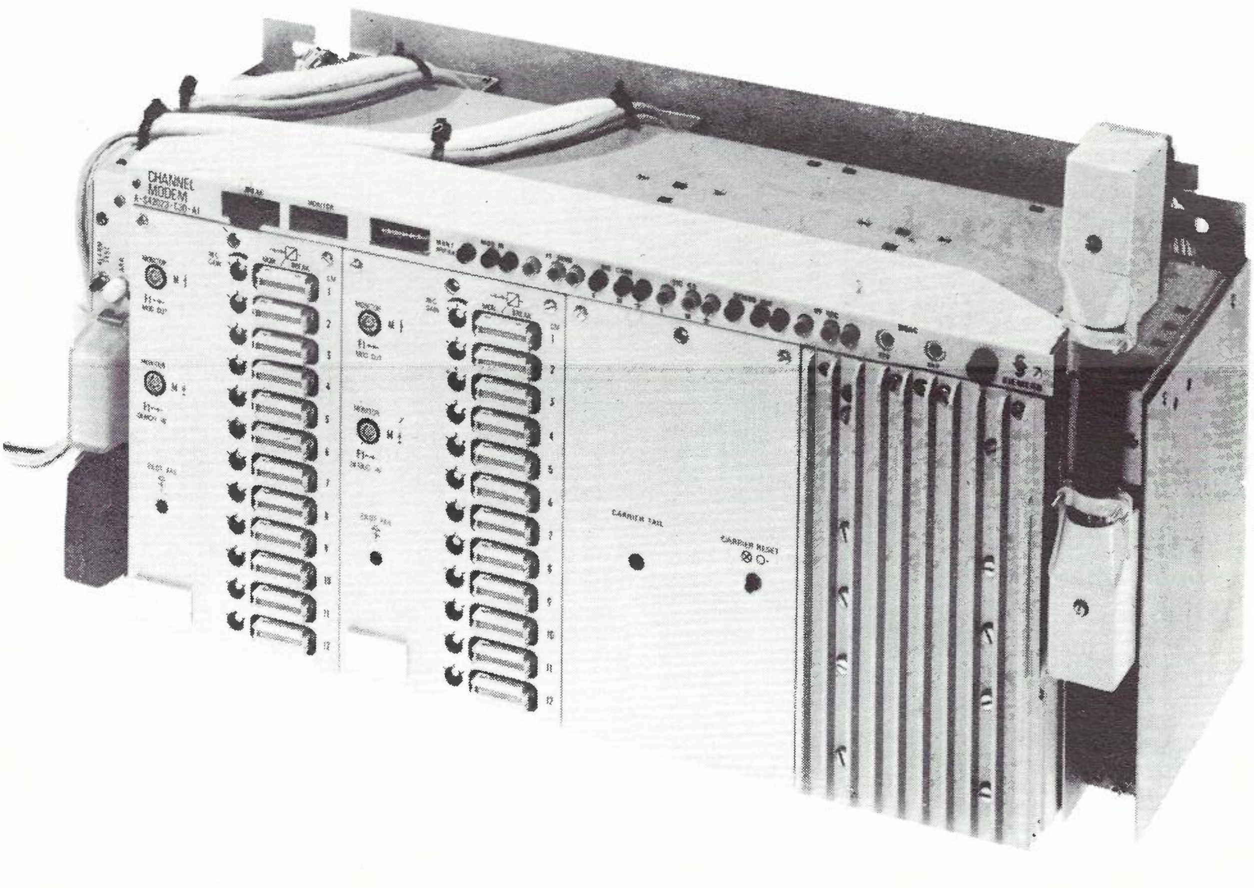

Fig. 8 — First-In Channel Modem Subrack with Interconnecting Carrier and Power Link.

Where a standby carrier supply is used, it automatically takes over when the normal carrier supply fails.

Power Supply Inset

One power supply is sufficient to feed 20 group ends (240 channels) and associated carrier supplies. Two power supplies can be operated in parallel, i.e. in operation/standby mode. Normally one unit feeds 10 group ends or 120 channels. Both units are powered and share the load via redundancy diodes.

The power consumption for 120 channels is about 45 VA. The unit is a switching type converter operating outside the audible range.

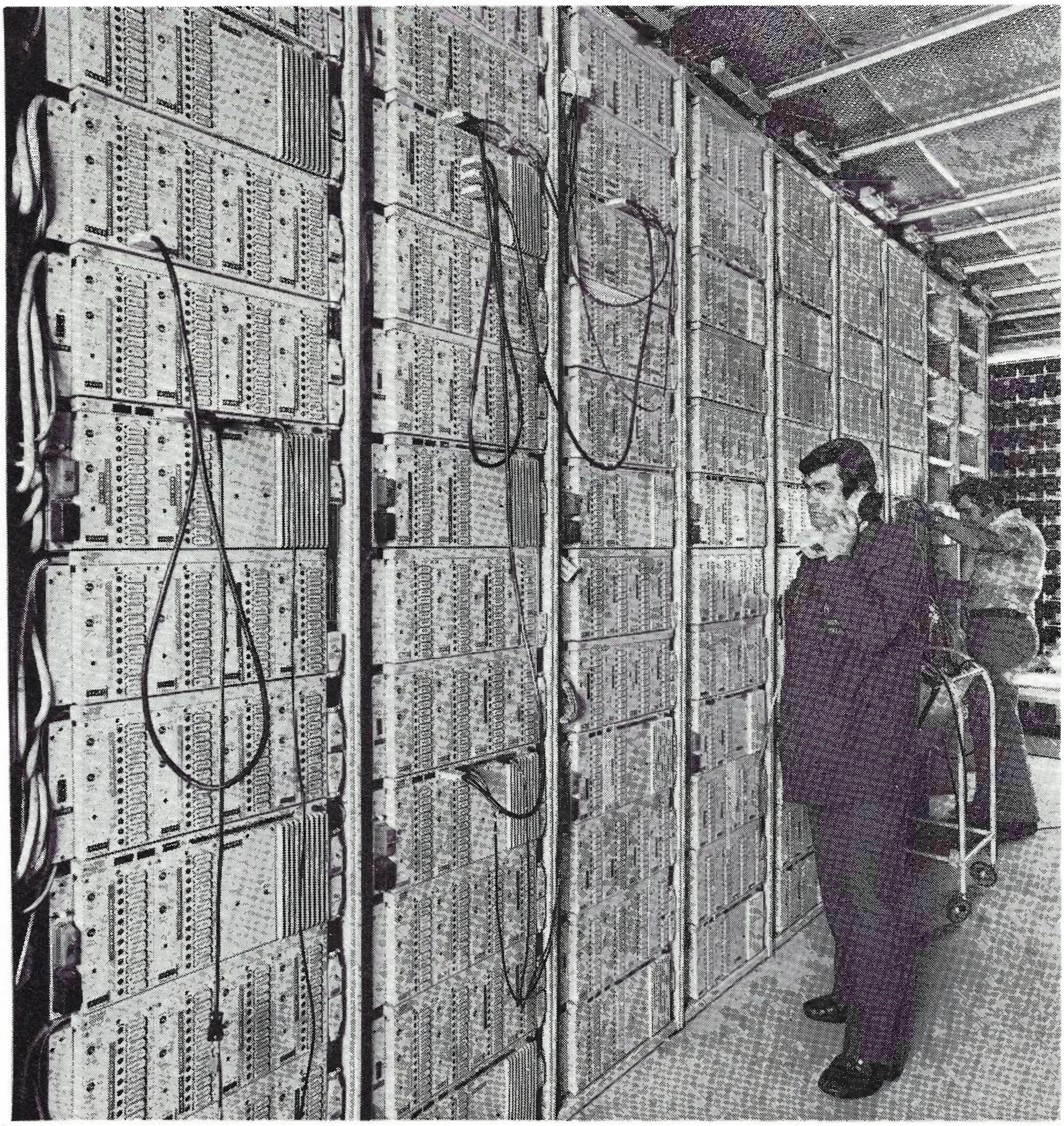

Fig. 9 — Telecom Type 72 Racks each Equipped with Channel Modems for 480 Channels.

Alarm Unit

The alarm unit centrally indicates all alarms originating within a system of up to 240 channels.

Subracks

Two types of subracks are used for the channel modem equipment. The so-called first-in subrack contains up to two channel modem insets, a carrier supply inset, a power supply inset and the alarm unit. The second-in subrack accommodates up to four channel modem insets. The necessary power and carrier supplies are fed from the first-in subrack to the second-in subrack via link cables which plug into connectors on the right-hand side of the subracks.

Four second-in subracks and two first-in subracks can be interconnected, thus giving normal/standby carrier and power facilities for up to 240 channels. Two such blocks, i.e. 480 channels, can be accommodated in one Type 72 rack.

A socket adaption facility is built into the top panel of the first-in subrack. This facilitates easy connection to test equipment for line-up and monitoring. A measuring cord is used to connect the channel modem VF test point socket to the adaption panel.

For added flexibility, a Z12 terminal inset for high level operation can be fitted to the subracks in lieu of a channel modem inset.

Fig. 8 shows a first-in subrack equipped with two channel modem insets, a carrier supply inset and a power supply inset.

Fig. 9 shows Telecom Type 72 racks fully equipped with channel modems for 480 channels.

CARRIER SYSTEM Z12

General

Z12 carrier systems have been used in the Australian Network since the mid-fifties (Ref. 5). The latest equipment as described below has, however, several new features.

The carrier system Z12 has been designed for two-wire operation with 12 channels via unloaded balanced cable pairs and for four-wire operation with 12 or 24 channels via unloaded balanced cable pairs or radio relay systems. It is used either in the high or low gain configuration on unloaded cable pairs or on single quad cables. To cover longer routes, either locally powered or remotely dc power fed repeaters can be used.

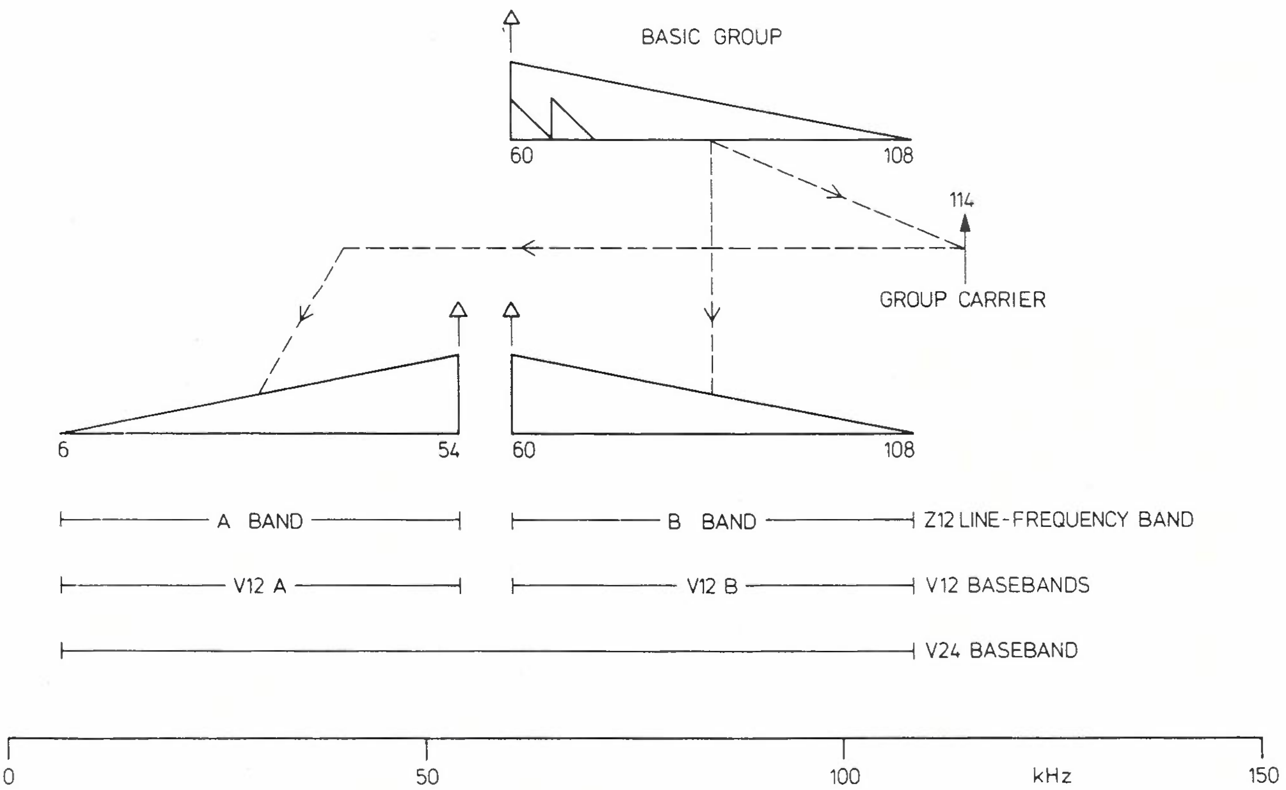

Fig. 10 — Frequency Modulation Plan for Z12 System.

Frequency Allocation Plans

Fig. 10 shows the frequency plans for the Z12 line band, and the V12 and V24 basebands when used together with radio links.

In the case of the Z12 system, the 6 to 108 kHz line frequency band is divided into the A-band, 6 to 54 kHz, and the B-band, 60 to 108 kHz. According to the grouped frequency method, the A-band is transmitted from A to B (A-station) and the B-band from B to A (B-station). Translation therefore takes place either only on the transmitting path or only on the receiving path. The Z12 system consists of the following building blocks:

- The Z12 Subrack making up a terminal or intermediate locally fed repeater, and
- The Dependent Repeater.

In the Z12 subrack up to three Z12 insets and the supplies inset can be mounted. The Z12 insets can also be plugged into the channel modem subracks, which have the necessary wiring included, in lieu of one channel modem inset. Fig. 11 shows a Z12 subrack and dependent repeater.

Terminal Equipment

The Z12 inset forms the link between a basic group and the line frequency band or baseband.

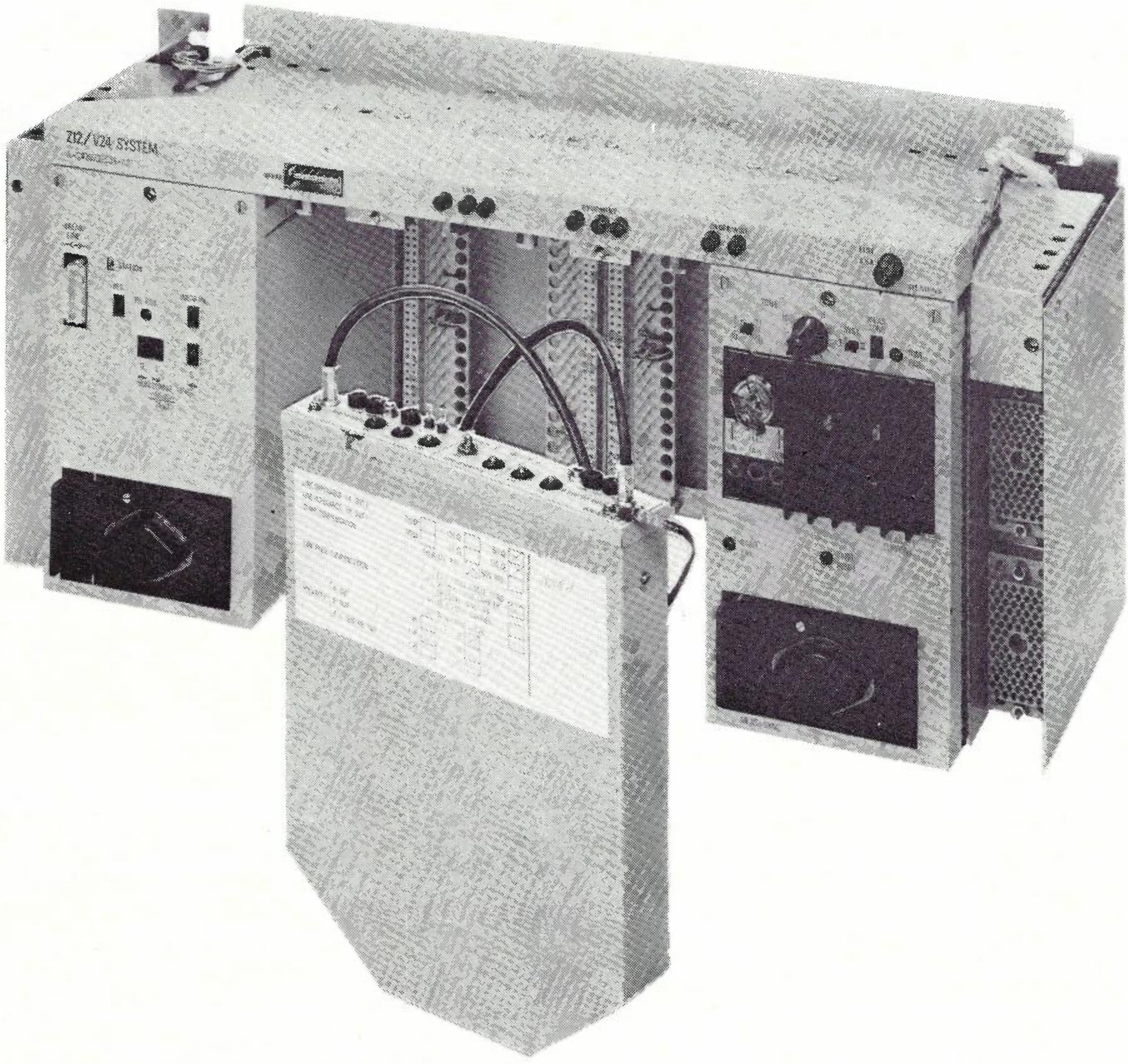

Fig. 11 — Z12 Subrack Equipped with Terminal Inset and Supplies Inset and a Dependent Repeater.

The schematic diagram of a terminal is shown in Fig. 12.

The same type of inset is used for either an A- or a B-station in two-wire operation. The station type is determined by the position of the modulator (accommodated in the transmit amplifier). The modulator is situated in the transmit path in an A-station and in the receive path in a B-station. The station mode is selected by interchanging the transmit amplifier and the receive band equalizer plug-in cards. The line level can be set to the high transmission level of +5 dBr or to the low transmission level of —10 dBr in the transmit amplifier. The signal is then transmitted to the line via the directional filter, the line matching transformer and the high voltage protection devices.

The main equalizer for the receive band compensates for the attenuation/frequency response of unloaded balanced paper or plastic insulated cables with 0.63 mm, 0.9 mm or 1.27 mm conductor diameter or single quad cables (1.27 mm) with high level transmission. The maximum section cable loss can be 72 dB at 108 kHz if no repeater station is used. For routes with one or two repeater stations this loss should be no more than 65 dB, and if there are more than 3 sections no more than 60 dB. Using 0.9 mm or 1.27 mm cables, the maximum section length is then approx. 18 or 30 km respectively.

A cable loss of up to 57 dB can be compensated for in the low level transmission mode, but only 27.5 dB is normally used, corresponding to the gain of the dependent repeaters.

An equalizer is provided for the band 6 to 30 kHz and in addition up to three optional mop-up equalizers can be used with one terminal. They allow correction of residual equalization errors anywhere in the transmission band due to cable mismatch, irregularities in the cable frequency response, etc.

For level supervision and automatic level regulation of the line frequency band, a 60 kHz line pilot can be used. An optional pilot receiver via an AGC amplifier automatically corrects the changes in cable loss.

In the case of power fed routes, faulty repeaters can be detected from the terminal station by a fault locating device. Every repeater transmits its

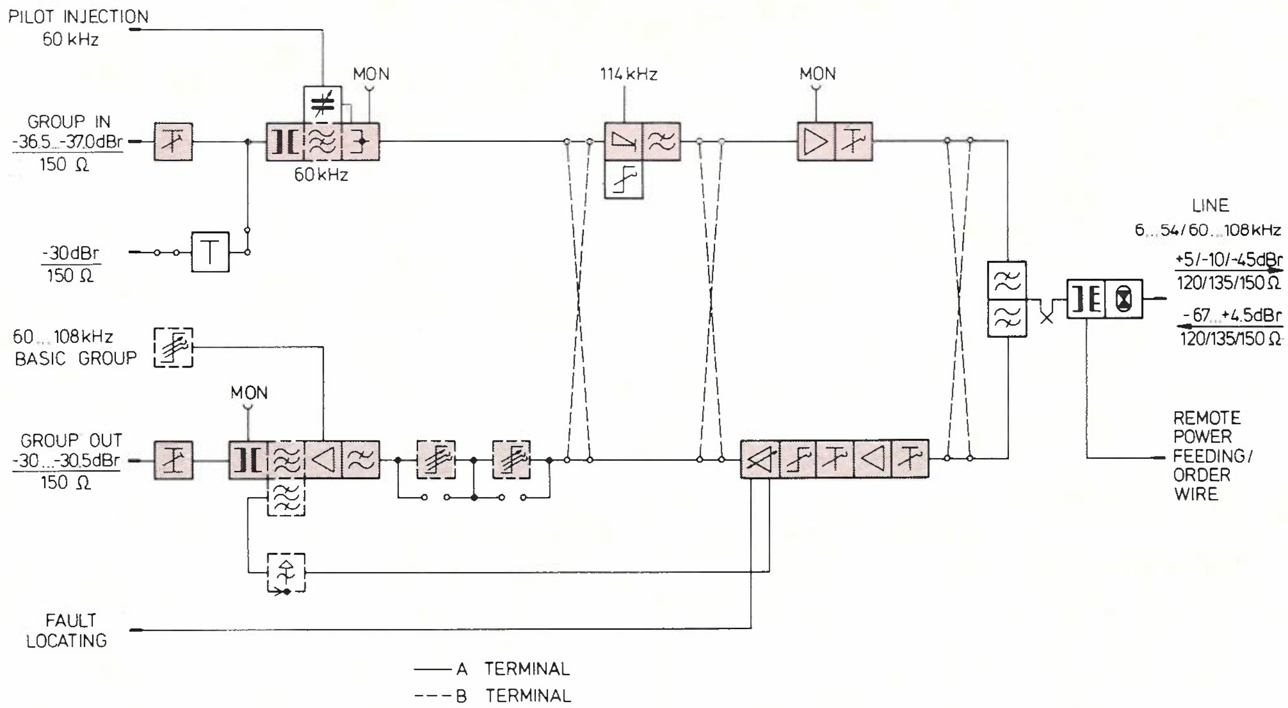

Fig. 12 — Schematic Diagram of a Z12 Terminal.

own individual identification tone at a frequency above the normal transmission band. The fault locating unit in the supplies inset detects faults or even slow level changes.

The supplies inset contains also the power feed and carrier supplies for up to three Z12 insets and the remotely fed repeaters.

In the four-wire operation mode two Z12 insets are interconnected to form two separate transmission bands of 6 to 108 kHz in the transmit and receive directions.

Repeater Equipment

To bridge longer routes, either locally powered repeaters or remotely dc power-fed repeaters are used.

In case of the locally powered repeater equipment two Z12 insets are interconnected at the group inputs and outputs via a 7 dB pad. Frequency frogging is possible.

For long haul applications, the low-level terminal can be used together with low gain power-fed underground repeaters without frogging (Fig. 13). The repeater is designed for a maximum line loss of up to 27.5 dB at 108 kHz for one repeater section, or 25.5 dB at 108 kHz for several repeater sections.

The maximum repeater section length for a 1.27 mm cable is approx. 12 km. Up to 15 repeaters can be power-fed from one terminal section, so that feeding points can be spaced at a maximum of approx. (15 + 15 + 1) x 12 km = 372 km.

The line transformer at the input of the repeater provides line isolation and connection to the

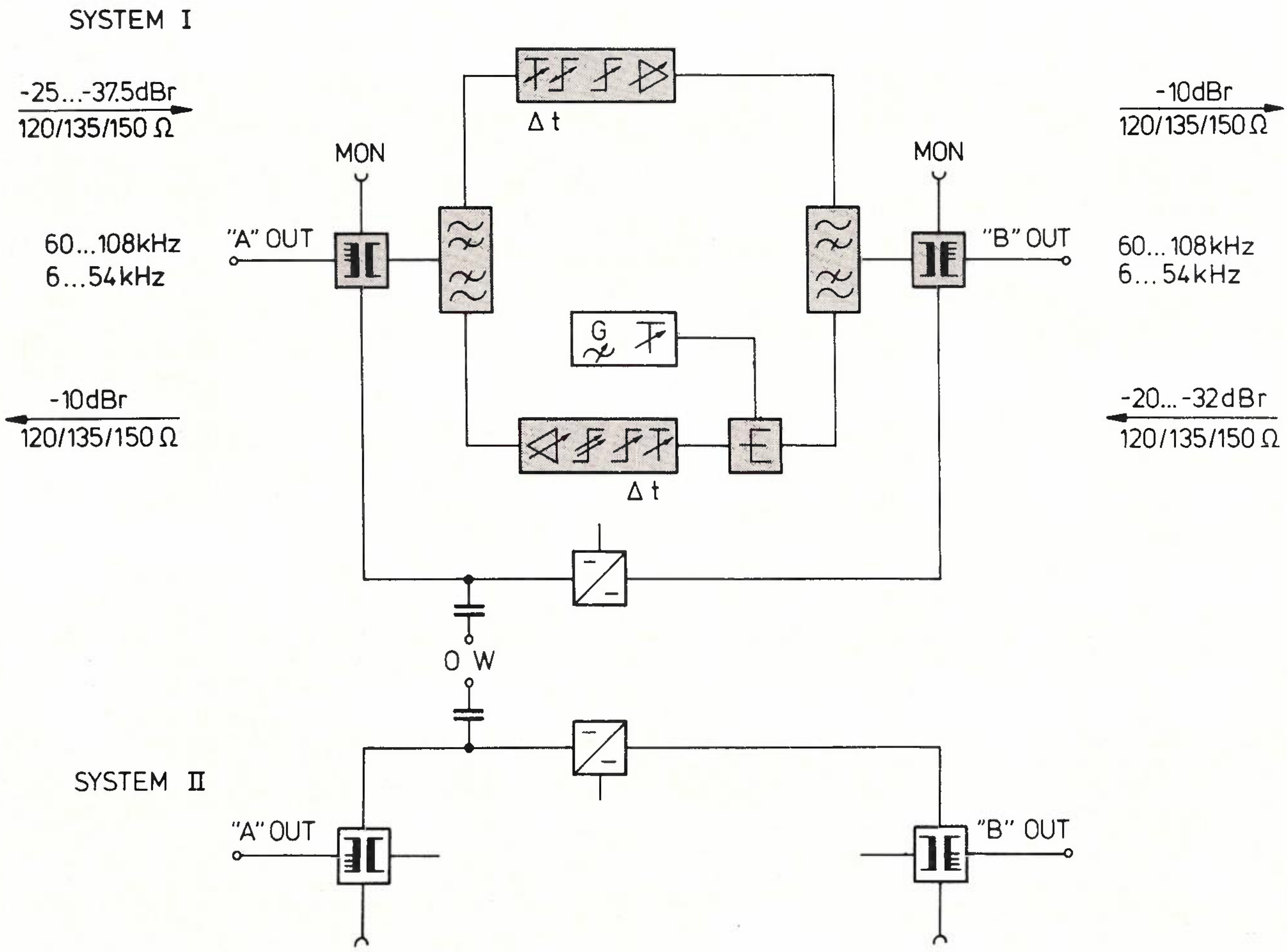

Fig. 13 — Schematic Diagram of Z12 Dependent Repeater.

monitoring point, as well as decoupling for the constant current power feeding and the order wire equipment. Separate amplifiers and equalizers are used for each direction of transmission to simplify alignment in the field.

The frequency of the tone generator can be set so that each repeater in the power feed section has an individual fault locating tone. The tone is passed through both transmission directions of the repeater concerned to allow supervision of all active parts of the repeater.

If required, frequency dependent and/or independent thermal regulation facilities can be strapped in to equalize variations in the cable attenuation due to temperature changes.

The repeater is protected against voltage transients due to lightning and induced currents. It is covered by a splash proof case which normally is stacked upright in a repeater housing similar to Telecom drawing CL 1121.

THROUGH FILTERS

In long range communications networks, with line frequency bands composed on a frequency division multiplex basis, through connection is arranged by splitting up the bands into standardised frequency blocks: supermastergroup, mastergroup, supergroup or group etc.

Through-connection is understood to be that of a standardised basic frequency block extended from one system to another. After modulation, a frequency block is surrounded by remnants of adjacent blocks and after subsequent modulation these remnants are filtered out. In through connection, however, the block is introduced into entirely different surroundings where, if they were to remain, the remnants would give rise to crosstalk in the adjacent groups, etc. The through filters described below eliminate these remnants.

Each filter is accommodated in an individual slide-in unit, and two filter slide-in units are required for the through connection of a basic group or supergroup, one each in the transmitting and receiving directions. The filters are of the passive type and require no power for their operation.

Two steep sided group filters together with two simplified group filters can be installed in the group filter panel or, alternatively, four simplified filters. In the through supergroup filter panel two through supergroup filters can be fitted. Both the steep sided group filter and the supergroup filter are hermetically sealed which gives a high degree of immunity to climatic influences.

Fig. 14 shows a through group filter panel equipped with one steep and one simplified filter.

Through Group Filters

For the through connection of basic groups of 12 channels (60-108 kHz), filters with a steep-sided or sharp cut-off characteristic or simplified or low-slope cut-off filters can be used.

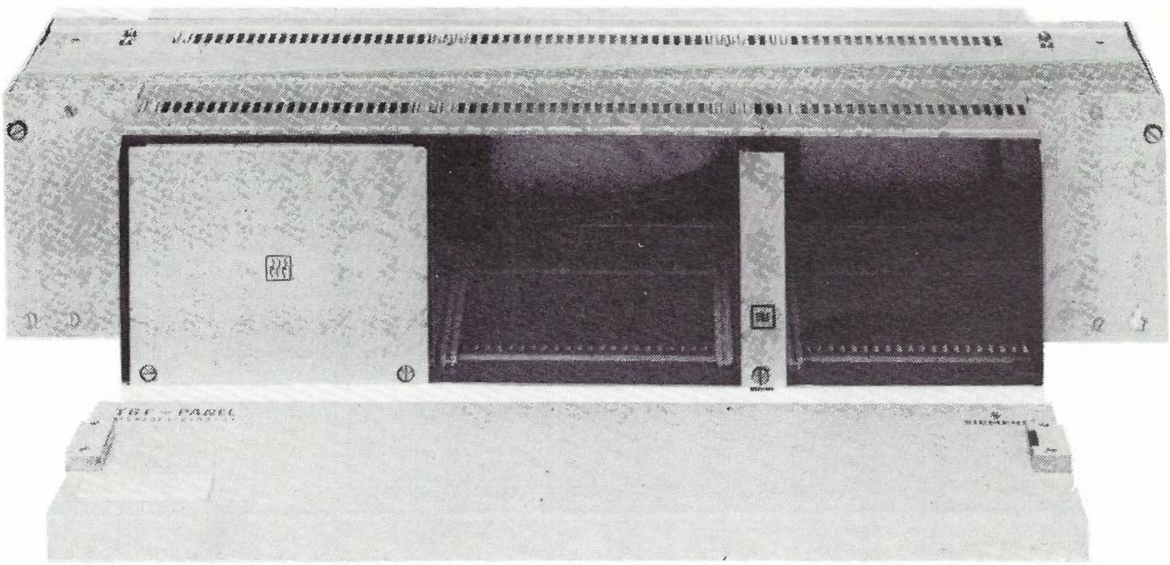

Fig. 14 — Through Group Filter Panel equipped with a Sharp Cut-Off and a Simplified Filter.

Sharp Cut-Off Type

Sharp cut-off filters are used primarily for a through conection of a basic group between two wideband systems and are required due to the narrow 0.9 kHz gap between the five groups within the basic supergroup.

The filter consists of a passive crystal band-pass filter with extremely steep cut-off and wide relative bandwidth. High-grade crystals ensure the stability of the cut-off edges, and ferrite coils of high Q ensure the attenuation values demanded in the more remote parts of the stop bands. Equalizing networks minimise the peak-to-valley ratio of the insertion loss in the pass band.

The pass band of the sharp cut-off filter begins at 60.12 kHz so that the signalling frequency of 3,825 kHz associated with the edge of channel 12 can also be transmitted in the frequency position 60.175 kHz. The basic attenuation demanded within the range of the transmitted speech bands (60.6 to 107.7 kHz) is 6.1 dB. See Fig. 15.

The group delay curve of this filter is symmetrical over the pass band which is ideal for the transmission of stereo carrier program systems.

Simplified Through Group Filter

Simplified or low-slope through group filters are suitable for the connection of basic groups from a wide-band system to a lower order line system such as a 12 or 24-channel cable system as the A-band and B-band are separated by 6 kHz.

In comparison to the type of filter providing steep cut-off by the use of crystals, an inductor-type passive band-pass filter suffices for the simple filters. As in the case of steep filters, the pass band extends from 60.12 to 107.7 kHz and the basic attenuation is 6.1 dB. An equalizer keeps the frequency response within ±0.4 dB in the range of 60.6 to 107.7 kHz.

The lower stop band terminates at 54 kHz, the upper one begins at 120 kHz; in both stop bands the filter produces an attenuation of at least 70 dB.

Through Supergroup Filters

Each filter necessary for the through supergroup connection of 312-552 kHz is contained in a separate slide-in unit (one filter for each direction of transmission).

The through supergroup filter is made up of three sections:

- The *Bandpass Filter* is a filter designed with high quality capacitors and inductors only.
- An *Equalizer* which precedes the bandpass filter is adjusted to offset the frequency response of the attenuation in the passband to within ±0.5 dB of both the 411.92 kHz and 547.92 kHz pilots.

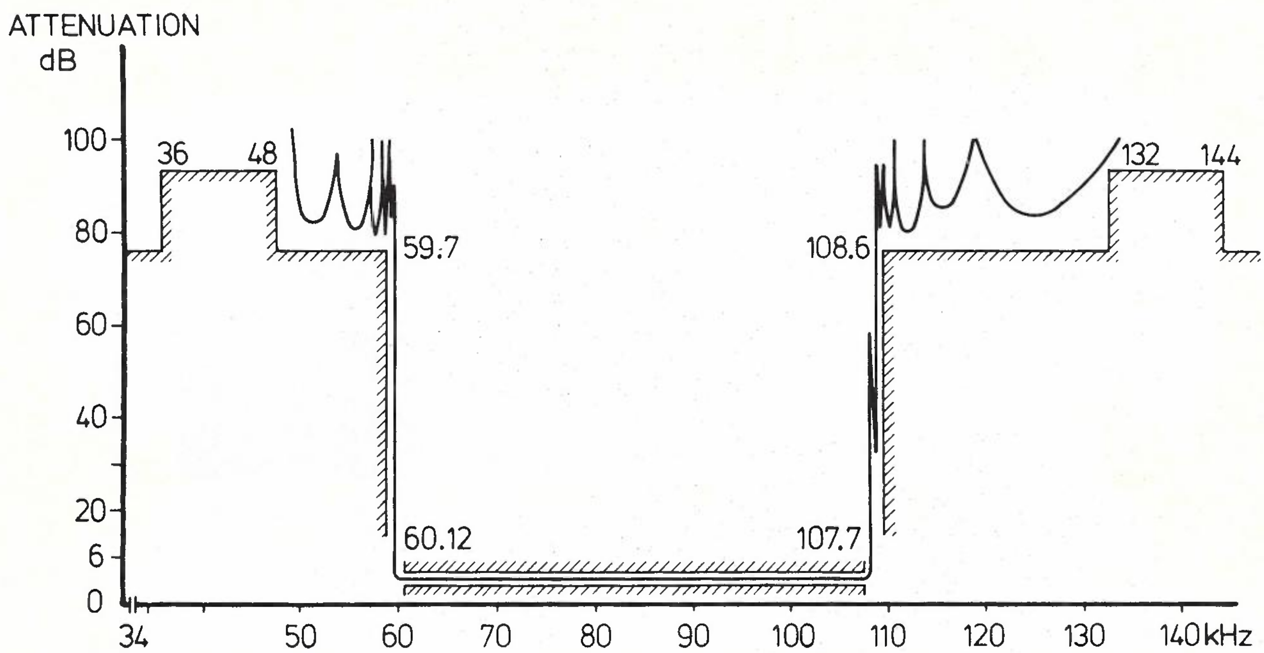

Fig. 15 — Frequency Response of Sharp Cut-Off Filter.

- As an optional item the *Interchannel Pilot Stop Filter* consists of a three-crystal band-stop filter which suppresses the frequencies of 308 and 556 kHz, each of which is separated from the basic supergroup by 4 kHz. These frequencies are translated interchannel pilots of 808 and 1552 kHz, which must be suppressed prior to re-injecting a pilot into another system.

The unit is a passive device requiring no power.

Fig. 16 shows a through supergroup filter outside its sealed case.

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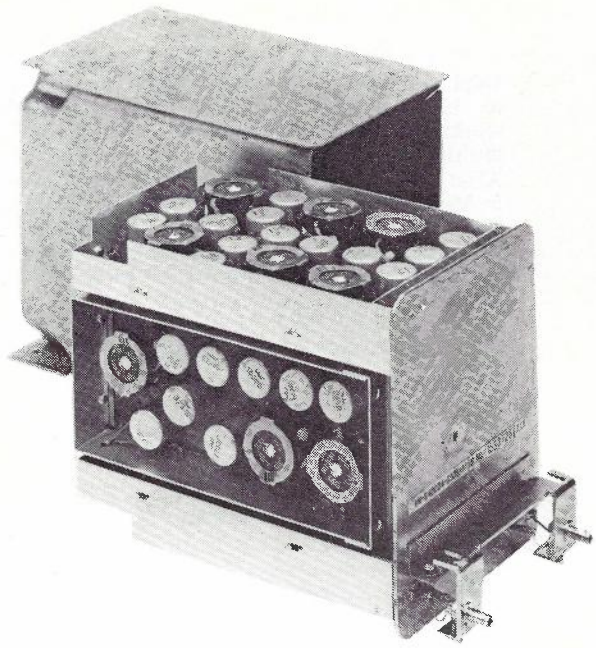

Fig. 16 — Through Supergroup Filter with Sealed Case Removed.

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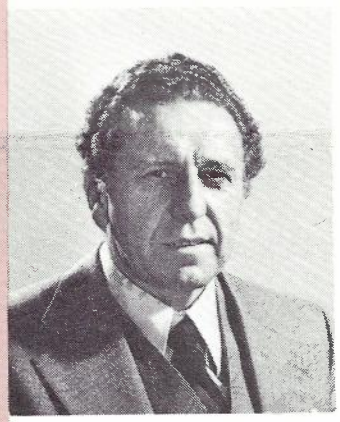
Starting as a P.M.G. Technician in Training in 1947, he spent most of his early career in the Victorian Country Installation area, except for two years as an Instructor in the Training School. In 1960 he graduated from R.M.I.T. with an Associate Diploma in Communication Engineering, and returned to appointments with Country Installation as Engineer Class 1 and later Class 2. During this period he was involved in the early years of coaxial system installation.

In 1967 he joined L. M. Ericsson Pty. Ltd., transferring to Siemens Industries Ltd., in 1972, from which time he has occupied his present position.



T. KLINK joined the Long Range Communications Dept. of Siemens Halske AG in Munich after graduation in 1953 at the Technical University, Stuttgart. He worked in the Design Dept. for Carrier Telephone Multiplex eqt. and in 1958 transferred to Australia. After a short period with National Instrument Company in Melbourne, at the time agent of Siemens Halske AG, Mr Klink started with the newly formed Communications Division of the local Siemens organisation, today known as Siemens Industries Limited. He became Manager of this Division in 1967.

Since early 1977 Mr Klink joined Siemens Head Office in Munich again, where he is Sectional Manager, Export.

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Towards Maritime Communications By Satellite

G. BERZINS, Grad. I.E. Aust.

Since the early part of this century, communication with ships at sea has been by means of medium frequency radio, and since the early thirties by high frequency radio. Now the development of maritime communications satellites promises to bring fundamental changes to communication with ships, changes which will almost be as radical as was the initial introduction of radio to ships.

Satellites for maritime communication will differ in a number of aspects from the now common point-to-point communications satellites, giving a new range of engineering problems to be solved. Compared to the present radio systems which are essentially manual, the new systems will be highly automated and in the years to come, should lead to fully automatic dialling between subscriber and ship for telephone and telex, and to a distress and safety service of very high reliability.

As the advantages of maritime satellite communications are realised, an increasing number of vessels will be equipped with terminals. Nevertheless, for reasons of cost and shipboard space, satellite communications will tend to be limited to the larger ships, and smaller vessels and boats will still continue to rely on radio for communication. Consequently, for the foreseeable future, conventional radio services will have to be provided.

EDITORIAL NOTE: This paper was originally published in the Electrical Engineering Transactions of the Institution of Engineers, Australia. The Institution's kind permission to reprint it is gratefully acknowledged. The author has made some minor amendments to update the paper for this reprint.

INTRODUCTION

Once a boat or ship ventured to sea, communication with land, or with another ship, was only possible visually, by flags or lamps, and it was only with the discovery of radio that communication beyond the horizon became possible. Apparently, the first vessel fitted with radio was the American liner *St. Paul* which in 1899, bound for Southampton, received a message from the Marconi station on the Isle of Wight whilst still 105km distant.

In succeeding years many other vessels were equipped with radio and it became an integral part of maritime life. Radio was provided mainly for passing commercial or social messages and it required a number of disasters, including the sinking of the *Titanic* in 1912, to highlight the value of radio to the safety of life at sea.

THE COASTAL RADIO SERVICE IN AUSTRALIA

History

The Coastal Radio Service is Australia's oldest currently operated radio service. Beginning from experiments in ship-shore radio communication at the turn of the century, the first regular coastal radio service commenced from a private station in Sydney in 1910. Two years later, the service was taken over by a new Government station, and since that time has been operated by various authorities —PMG (1912-1916), RAN (1916-1920), PMG (1920-1922), AWA Ltd. (1922-1946) and OTC(A) (1946-present).

The original radio system was established mainly for maritime safety and defence, and was designed to provide, as far as possible, continuous radiotelegraphy coverage around the coast on 500 kHz.

The Present Service

Over the years the spark transmitters and crystal detectors have given way to valve equipment and finally to semi-conductor equipment. In addition, new techniques have been introduced, e.g. single sideband transmission. The services provided have also been expanded by the introduction of radiotelephone services, high frequency radiotelegraph services, the free radio-medical service, the small ships radiotelephone, the spoken telegram service on 2MHz, 4MHz and 6MHz and recently a ships' position reporting service.

The present safety services still mirror the original functions and comprise such services as transmission of weather bulletins and navigation warnings as

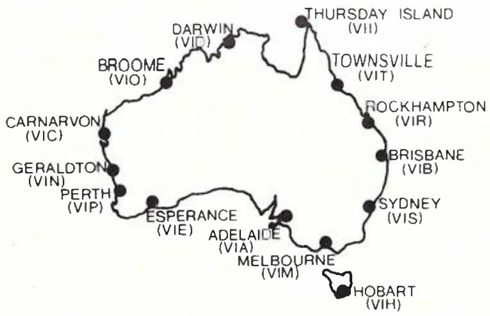

Fig 1 — OTC(A) Coastal Radio Stations.

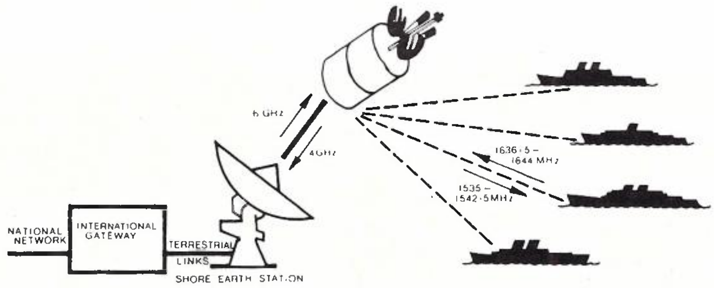

Fig. 2 — Maritime Communications Satellite System — General Arrangement.

well as maintenance of distress watches and search communications. Distress watches are maintained on the two principal international distress frequencies, 500 kHz (morse radiotelegraphy) and 2.182 MHz (radiotelephony). In addition, due to the short propagation range of frequencies around 2 MHz in daylight and their unsuitability for Australia's vast coastline, two other distress frequencies, 4.136 MHz and 6.204 MHz* have been adopted internationally for this part of the world, as a result of Australian initiatives.

The present OTC(A) coast stations are shown in Fig. 1. In addition to these principal stations, there exist a large number of other stations around the Australian coast licensed for particular functions and operated by port authorities, fishing co-operatives, commercial companies, yacht clubs, volunteer coastal patrols and others.

Improvements to the coastal radio service in Australia have continued. In 1975, radio teleprinter operation commenced from Sydney allowing machine transmission of telegrams to suitably equipped ships and the establishment of a radio telex service. In addition, a public VHF radiotelephony service was established for the waters around Sydney, and in future, this service will be expanded to other centres.

Current Problems with Radio Services

The present methods of communicating with ships go back to the beginning of this century, and despite the improvements made in the intervening years, these methods have some serious problems and some fundamental limitations which cannot be overcome.

*These frequencies will be replaced by 4.125 MHz and 6.2155 MHz respectively after 1st January, 1978.

The frequencies most commonly employed, 500 kHz and 2 MHz, are essentially short range, and are now severely congested, particularly in busy shipping routes around Europe. The high frequencies are affected by ionospheric disturbances, and sometimes by interference from other coast stations or from certain broadcasting stations.

The service is manually operated and hence is not only expensive to operate but is becoming increasingly incompatible with the automated national and international communications networks.

This service has rarely been profitable, but many Administrations are now finding that due to the escalating labour costs, this labour intensive service is now resulting in even bigger losses than in the past.

MARITIME SATELLITE COMMUNICATIONS

With the ever-increasing use of satellites for various purposes (meteorology, scientific observation, navigation, military reconnaissance and communication) attention has in recent years turned to communication with ships by satellite. Experiments have been conducted using INTELSAT and NASA ATS satellites, and the world's first satellite system designed specifically for maritime communications, the COMSAT General "MARISAT" system, was launched in 1976, ushering in the era of maritime satellite communications.

Engineering Problems

Whilst the engineering concepts and equipment for point-to-point satellite communications in the 6 and 4 GHz bands have become well established, the advent of maritime communications satellites has brought a new range of engineering problems to challenge engineers.

The principal elements of a maritime communications satellite system are shown in Fig. 2. Trans-

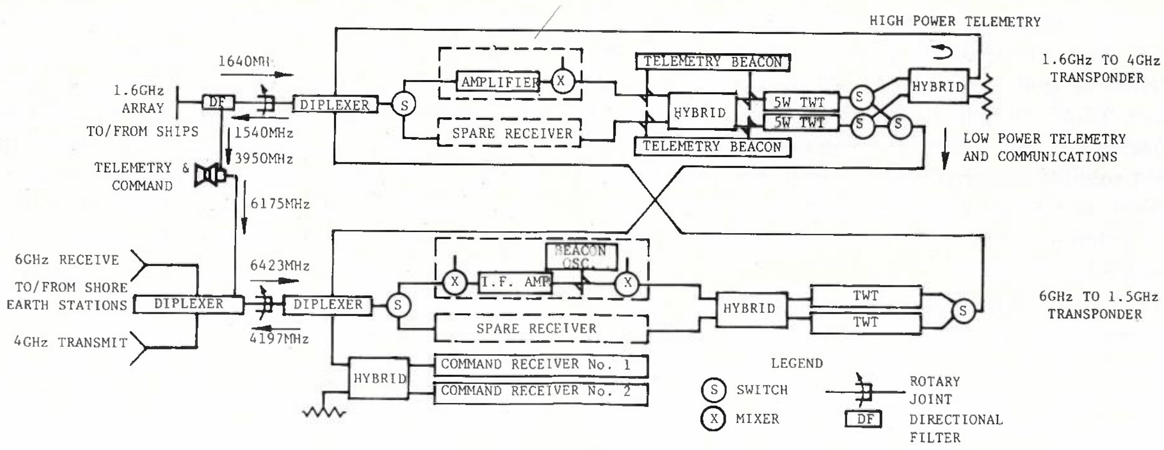

Fig. 3 — Communications Sub-System Block Diagram of MARISAT Satellite (excluding naval UHF Section).

mission between ships and satellite will be at frequencies around 1.6 GHz, but transmission between satellite and land earth stations will use point-to-point communications satellite frequencies, either 4 and 6 GHz or 11 and 14 GHz. The satellite is a repeater translating the 1.6 GHz signal received from the ship and re-transmitting at 4 GHz (or 11 GHz) toward land, and conversely translating the 6 GHz (or 14 GHz) land station transmission to 1.6 GHz and re-radiating toward the ship.

Compared to point-to-point communications satellites, new engineering problems in maritime communication satellites arise from the following principal differences:

- space and cost limitations which prevent the use of large antennas on board a ship
- ship's motion, due to both its travel and the effects of rough seas
- the harsh marine environment
- the new frequencies around 1.6 GHz allocated for transmission between ships and satellites by the WRAC (ST)** in 1971 (transmission between satellite and shore stations will still use the point-to-point communications satellite bands of 4/6 GHz or 11/14 GHz)
- the differing traffic pattern, wherein the traffic generated by each ship would be small but the number of ships connected to the system would be large, ultimately numbering thousands.

Due to the first factor, which dictates the use of parabolic antennas not exceeding 1-1½ metre diameter, or other types of antennas with similar gain, e.g. helical antennas, the antenna gain is quite low, of the order of 20-25 dB, compared with about 60 dB at 4 GHz for a 'standard' 30m antenna used in INTELSAT point-to-point services. Furthermore, for a simple ship terminal, it would not be economical to employ extremely low noise receivers such as cyrogenically cooled parametric amplifiers as in INTELSAT stations, but instead transistor or uncooled parametric amplifiers will be employed. Consequently, the sensitivity (G/T)* expected for ships terminals is about $-4dBK^{-1}$ to $-10dBK^{-1}$, compared to 40.7 dBK^{-1} for INTELSAT stations.

The maximum weight, size and primary DC power of a satellite are limited by the launch vehicle used to place the satellite into orbit. These factors in turn govern the satellite communications sub-system design by limiting the number of transponders and the maximum RF power of each transponder. The signal-to-noise ratio of a telephone channel derived from an earth station is essentially determined by the carrier-to-noise density ratio (C/N_0.) available at the demodulator input. Current system designs are based on the use of an efficient modulation method, e.g. delta modulation or narrowband FM with companding, requiring a C/N_0 value of about 50 $dBHz^{-1}$, to obtain the specified telephone channel quality.

At present, most maritime satellite system designs assume the use of a Thor-Delta type launch vehicle. Given the weight and space constraints for this type of launch vehicle, the expected ship terminal

**WARC (ST) World Administrative Radio Conference (Space Telecommunications).

sensitivity indicated above, and the desired C/N_0 ratio, then the total RF power available from the satellite is only sufficient to allow a maximum of about 20-40 circuits to be established. This circuit capacity can be broadly compared with point-to-point satellite systems which, using the same launch vehicle, but employing large and much more sensitive antenna systems, achieve capacities of many thousands of circuits.

The need for maximum satellite RF power, coupled with the need to transmit say 20-40 individual RF carrier, results in conflicting satellite transponder requirements for the shore-to-ship direction. For maximum power the satellite transponder should be operated in a saturated condition, i.e. non-linear condition which gives rise to intermodulation products in multi-carrier transmission. Consequently considerable effort is being directed to satellite transponder designs, particularly the trade-offs between wideband transponders which minimise DC power and weight but create intermodulation problems, compared to narrowband transponders with opposite effects.

As an example, Fig. 3 gives a block schematic diagram of the communications sub-system for the MARISAT satellite, which uses wideband TWT transponders with a carrier frequency allocation chosen to minimise intermodulation effects.

The Ship's Antenna

The crucial item in the ship terminal is the antenna which must meet a number of stringent requirements. It must be physically small, resistant to the marine environment, mechanically reliable, and easy to maintain. In operation the antenna must point continuously to the satelilte, despite the fact that the ship may be pitching or rolling in rough seas. Fortunately, for the antenna sizes under consideration, the 3 dB beamwidth is about 25° so that extremely accurate control is not necessary. The MARISAT terminals use a stable platform and the ship's compass as references to compensate for roll, pitch and yaw. In addition, the antenna is pointed in azimuth and elevation by automatic tracking of the satellite transmission.

OPERATIONAL CONSIDERATIONS

The basic services provided by maritime satellite systems will be telephone, telex and telegram services, as well as high speed data transmission, for instance to transmit engine room indications to shore, and facsimile transmission particularly for weather maps. Ultimately both telephone and telex should become fully automatic services, with calls dialled by a subscriber on land routed automatically to a ship, irrespective of its location in the oceans, and vice-versa. For telex this objective might even be achieved from the outset, but for telephone it will take years to achieve as the problems of interconnecting with existing terrestrial networks are very complex. The satellite system must be made to interwork with existing international signalling systems to match into the present world numbering system, to obtain correct charging information and to operate as efficiently as possible.

Although the principal aim of the maritime satellite systems will be to improve public communications with ships, these systems will also provide a safety-of-life service superior to the present service, being independent of propagation difficulties or of the ship's position at the time of distress. The system should function similarly to the public telephone system which is normally used for social or commercial needs but anyone in danger can use it to call the police or ambulance. In the maritime environment, however, it is also proposed that safety calls would get priority in the satellite system.

In addition, maritime satellites will probably be used for navigation, and experimental navigation systems have been tested by various authorities. However, ship-owners have not been anxious to develop the navigation capability, as the existing terrestrial navigation systems are reasonably accurate and generally available and there already exists a US Navy navigational satellite system, TRANSIT, which is available for commercial shipping.

ORGANISATIONAL ASPECTS

Maritime satellite systems have been established or are being developed under the auspices of three organisations

- COMSAT General
- European Space Agency (ESA)
- INMARSAT

COMSAT General

In mid-1976 a US consortium, with COMSAT General as majority shareholder, and RCA GLOBCOM, Western Union International and ITT WORLDCOM, as minority shareholders established the world's first communications satellite system dedicated to maritime communications. The initial system consisted of an Atlantic and Pacific satellite each served by a US earth station but a third satellite to cover the Indian Ocean was launched in October 1976. The MARISAT system provides communications for both the US Navy and for the commercial shipping industry.

During the first two or three years of operation,

*G/T ratio of antenna gain to receive system noise temperature.

the US Navy will absorb most of the satellite capacity, leaving a commercial capacity of six telephone and 44 telegraph channels. Later the commercial capacity will be expanded as Navy use decreases by switching the satellite power to the commercial transponders.

The commercial services which are provided comprise telephony, telex, data (1200 and 2400 band) and facsimile.

A number of companies now offer ship terminals for operation with the MARISAT System, at a price of about $US50,000 each. As at May 1977, 50 ships and oil exploration platforms were equipped with MARISAT terminals.

Australian subscribers can make telex and telephone calls to ships equipped with MARISAT terminals in a similar manner to making normal overseas calls. The circuits are established via the appropriate US earth station.

European Space Agency

The European Space Agency (ESA), which resulted from the amalgamation of the European Space Research Organisation (ESRO) and the European Launcher Development Organisation (ELDO), is developing a maritime communications satellite (MAROTS) as one of its three main projects, with the UK as the principal country investing in the project.

The MAROTS system was originally intended as an experimental pre-operational system with one satellite located above the Indian Ocean Region. However, discussions are now taking place aimed at establishing a MARISAT 2 system which would be a joint venture by the US MARISAT Consortium and European telecommunications administrations. This system would come into operation when the present MARISAT system reached the end of its design life in 1981 and would employ MAROTS satellites.

If the joint venture does not eventuate, then European administrations are likely to use the MAROTS satellite to establish a separate operational maritime satellite system covering the Indian Ocean and part of the Atlantic Ocean.

Irrespective of the organisational arrangement which finally evolves, the first MAROTS satellite is due to be launched in late 1978 and it will operate to an earth station which is being constructed in Madeley, UK.

The MAROTS satellite will use a high efficiency shaped beam antenna coupled with a 1.6 GHz power amplifier. The first two spacecraft will use 14/11 GHz bands for satellite/shore communications but later spacecraft will employ 6/4 GHz bands.

INMARSAT

The Intergovernmental Consultative Organisation (IMCO) a United Nations specialised agency for coordination of shipping matters, established a Panel of Experts in 1972 to study the institutional, technical, operational and economic aspects of an international maritime satellite system. The Panel held six meetings and in 1974 prepared a report to governments containing a feasibility study for such a satellite system.

Undoubtedly the most difficult question which the Panel had to consider was under what kind of institutional arrangements would the system operate? Various possibilities were discussed, including the use of an existing organisation e.g. INTELSAT, the establishment of a consortium and the establishment of a completely new international organisation.

The report of the Panel of Experts was the basic document considered by a Conference of Governments in London in April/May, 1975, with representatives from nations possessing large fleets, as well as other nations like Australia, which are largely dependent on ships for their commerce. The Conference agreed in principle that a maritime satellite system was desirable and that an intergovernmental organisation, named INMARSAT, should be established for this purpose. However, due to lack of agreement on a number of fundamental issues at the initial conference, it was necessary to hold two further sessions of the Conference in January 1976 and September 1976 before a Convention for INMARSAT was finally agreed and opened for signature by Governments.

The Convention envisages a three-tier governmental organisation (Assembly, Council, Directorate) with an initial capital of $US 200 million, and with a defined initial investment share for each country based on its expected traffic through the system. Countries with the largest investment shares are USA (17%), UK (11%), USSR (12%) and Norway (9.5%) whilst Australia ranks 15th with a share of 2%.

The INMARSAT Convention will come into force when countries representing 95% of initial investment have signed the Convention, which may take up to three years. However, in order to progress the work in advance of the organisation coming into being, a Preparatory Committee has been established which will consider such questions as what kind of system should be established? How should it be established, by INMARSAT itself or by some other body under sub-contract to INMARSAT? Who should operate the system and finally, what are the standards and procedures to which the system should be operated? It will take time to resolve these questions and to make the necessary arrangements, and it will therefore be some years before INMARSAT is actually providing a service. Irrespective of arrangements finally adopted, it is generally expected that INMARSAT will eventually provide the only commercial maritime satellite system and that the MARISAT and MAROTS systems (or the proposed joint venture) would ultimately be phased out or taken over by INMARSAT.

Australian representatives have actively participated in the discussions and OTC(A) has been designated by the Government as the Australian Signatory to INMARSAT.

FUTURE DEVELOPMENT OF MARITIME COMMUNICATIONS SERVICES

The ships initially operating with maritime satellite systems will all be vessels which have been retrofitted with terminals. It will take time for ship-owners to become convinced that the benefits of this new form of communications justify the capital outlay for the ship terminals. Furthermore, other related issues will need to be resolved by shipping interests such as the industrial aspects. As a result the initial growth in the number of ships equipped for satellite communications may not be high. However, the satellite terminal will represent a small portion of the total cost of building a new ship, and consequently most of the ships launched in the future are likely to have terminals. This, together with a growing awareness among ship-owners of the benefits of satellite communications, is expected to lead to an increasing number of vessels accessing the satellites.

Nevertheless, smaller vessels and boats will continue to rely on conventional radio for communication and for the foreseeable future Administrations will have to continue to operate MF/HF radio services in addition to the new satellite services, although the demand for radio will probably decline as traffic transfers to satellite.

CONCLUSION

Satellites for maritime communications will differ in a number of aspects from the now common point-to-point communications satellites, thus giving a new range of engineering problems to be solved. Compared to the present radio arrangements which are essentially manual, the satellite systems will be highly automated and will provide rapid, reliable and high quality public communication services, as well as a distress and safety service of high reliability.

Nevertheless, many smaller vessels and boats will continue to rely on conventional radio and consequently maritime radio services will have to continue to be provided in the foreseeable future.

ACKNOWLEDGMENT

This paper is published with the kind permission of the General Manager, Overseas Telecommunications Commission (Australia).

GUNTIS BERZINS has been with the Overseas Telecommunications Commission (Australia) since 1960, occupying various positions in the Operations and Planning Branches. He is currently a Supervising Engineer, responsible for planning the development of Australia's international submarine cable systems, communications satellite links, and maritime radio facilities. He has represented Australia in meetings of INTELSAT Technical and Planning Advisory Committees and has been part of the Australian delegation to the I.M.C.O. Panel of Experts meetings and to the subsequent Intergovernmental Conference in 1975 considering the establishment of an International Maritime Satellite Organisation (INMARSAT).

Metrology in Material Inspection

P. J. WEIR, B. Tech, B.Eng., Grad. I. E. Aust.

Metrology in material inspection provides a calibration service for inspection gauges and, in Telecom Australia, fulfils a dimensional measuring role for the acceptance testing of the more complex materials.

This article briefly discusses the need for calibrated gauges which can be traced to national standards, some types of metrology laboratory equipment and the skills necessary for a metrologist.

Possible future development of gauge calibration within Telecom Australia is considered and some costs and benefits of the existing system are presented.

INTRODUCTION

The science of precision measurement is now commonly referred to as metrology and this is of particular importance to producers and consumers of manufactured engineering products.

The need for precision measurement was increasingly felt by the pioneers of the industrial revolution and the science of precision measurement dates from about the middle of the 19th century. This followed earlier attempts of defining and maintaining standards, particularly of length and mass.

The modern practice of interchangeable manufacture has highlighted the importance of metrology and this trend has been very evident during the past 40 years. This science, a branch of applied science, is described as 'engineering dimensional metrology'; engineering because the very high degree of precision needed is fundamental to manufacturing technologies, and dimensional because it is concerned primarily with length and angle measurements. Dimensional metrology in the broader sense also covers surveying, navigation and astronomy.

METROLOGY IN TELECOM AUSTRALIA

Telecom Australia is a large consumer of manufactured engineering products and it is essential that the acquisition of equipment and materials is controlled by specifications which aim at achieving physical compatibility with existing network plant. If this compatibility were not ensured the outcome would result in a lower quality of service for the telecommunication subscribers and an inevitable increase in tariffs.

To provide this assurance of compatibility, the Material Inspection and Quality Assurance group within each State maintains a metrology section. The complexity of activities of these sections reflects the variety and manufacturing complexity of the local contractors within the States.

Material inspection ensures quality and the gauges used in checking dimensions must necessarily be consistent with one another. This consistency is essential if contractors are to accept the Commissions inspections, and it is achieved by comparison of gauges with a higher level standard.

CALIBRATION AND TRACEABILITY

The charter of the National Measurements Laboratory, which is a part of the Commonwealth Scientific and Industrial Research Organisation, includes the maintenance of the Australian standards. Fundamental standards are the metre, second, kilogram, kelvin and candella; all other units are derived from these.

Telecom Australia requires its contractors to maintain a gauging system which is traceable through calibration to the national standards. In turn, gauges which are used by Commission inspectors to check material must also be traceable to the same standard to eliminate arbitrary acceptance or rejection of material.

Through continual use, any gauge system will deteriorate in accuracy with a consequent increase in the uncertainty of its measurements. To maintain this uncertainty within prescribed limits, it is necessary to compare the system with one of a higher order in the standards hierarchy. This technique is known as calibration.

It is one of the prime functions of the metrology section to provide a calibration programme for gauges used by inspecting officers.

CALIBRATION AND MEASURING ENVIRONMENT

The measurement accuracy and repeatability needed and the material used in the gauges require that calibration and measurements be carried out in a controlled environment.

In Australia, the temperature requirement is 20°C ± 1°C. It is necessary to avoid thermal gradients since this can produce changes in the dimensions of a gauge or the product being measured. This could cause shifts outside the specified tolerances and produce unstable, non-repeatable results.

Physical vibration due to vehicular and air traffic and activities within the building containing the metrology laboratory must be excluded. To achieve this, it is desirable to locate the metrology area on the lowest floor of the building which should have a concrete floor about 300mm thick and isolated from the walls and footings of the building. Where precision measurements of angle and length are carried out on a surface plate, it is often necessary to provide further isolation. This is given by locating the surface plate on a concrete block of greater thickness than the floor and positioned on sand.

In addition, air treatment should exclude 90% of 10 micron (0.01mm) dust from the external air and any industrial aerosols. Relative humidity must be maintained within the range 45% - 55%.

The above conditions may be considered as the preferred standard. Within Telecom Australia, however, the nature of the buildings used and the length of time the various metrology groups have been established militate against achieving this ideal environment. But knowledge of the limitations of the particular environment means more care must be taken in measurement to achieve the required accuracies. Effectively, this involves a trade-off between capital and operating costs.

LABORATORY EQUIPMENT

A metrology laboratory contains a group of dimensional measuring instruments of varying type and accuracy. Several of these are discussed below.

Surface Plates

The surface plate or table provides a convenient datum line for many types of measurements because the surface of the plate is flat within known limits. Measurements which require multiple contact points in the one plane can be made on a surface plate.

Surface plates may range in size from about 300 by 300 mm up to several metres in size. The size of the plate depends on the size of the work to be dealt with.

Granite or cast iron may be used to make the plate, but whatever material is used it must be rigid and strong enough to support its own weight and the weight of the work placed upon it without producing appreciable distortion.

The use of granite is a fairly recent development (circa 1945) and it was expected that surface plates made of granite would be more stable than cast iron. According to some authorities (Ref. 1) there are unexpected day to day dimensional changes in granite and it now appears that the two types of material will be used side by side for many years to come.

Slip Gauges (Fig. 1)

These gauges provide standards of length. They are made of high grade cast steel and are hardened throughout. The range of sizes enable dimensions to be built up to the nearest 0.005 mm, 0.001 mm or 0.0001 mm according to the grade of the set chosen.

To obtain a particular dimension which is not provided for by single slip gauge, a combination of slip gauges is made by 'wringing' appropriate gauges together.

'Wringing' is the phenomenon of placing two highly polished metal surfaces (lapped) together in a sliding motion. Clean surfaces (in a mechanical, not chemical sense) fill adhere strongly when carefully slid together, but a small amount of grease or moisture must be present for successful 'wringing'.

The explanation of wringing is complex and not altogether satisfactory. Investigation has shown that the forces of adhesion are greater than can be accounted for by atmospheric pressure alone and that this force can be maintained in a vacuum. It is now generally accepted that molecular adhesion occurs between the liquid film and the metal surfaces.

Care must be taken in the handling and cleaning of slip gauges. They are usually handled with soft leather gloves in a leather padded gauge tray. When stored, a thin film of vaseline is wiped over them.

Comparators (Fig. 2)

Dimensional comparators are the principal instruments used in linear measurements.

The general principle of use is to indicate a difference in size between a known standard (slip gauge) and the article to be measured. (e.g. feeler gauge). This difference is generally indicated on a calibrated dial.

A number of different principles are used.

These include:

- Mechanical;
- Mechanical-optical;
- Pneumatic;
- Electrical;
- Fluid displacement.

Electrical comparators generally use the Wheatstone Bridge principle with the instrument being nulled for the standard. Variations from the standard may be read directly from the calibrated scale. In an instrument such as that illustrated, upper and lower tolerances may be set and when these are exceeded a light glows to indicate this, thus allowing faster operation where a large number of similar measurements must be made.

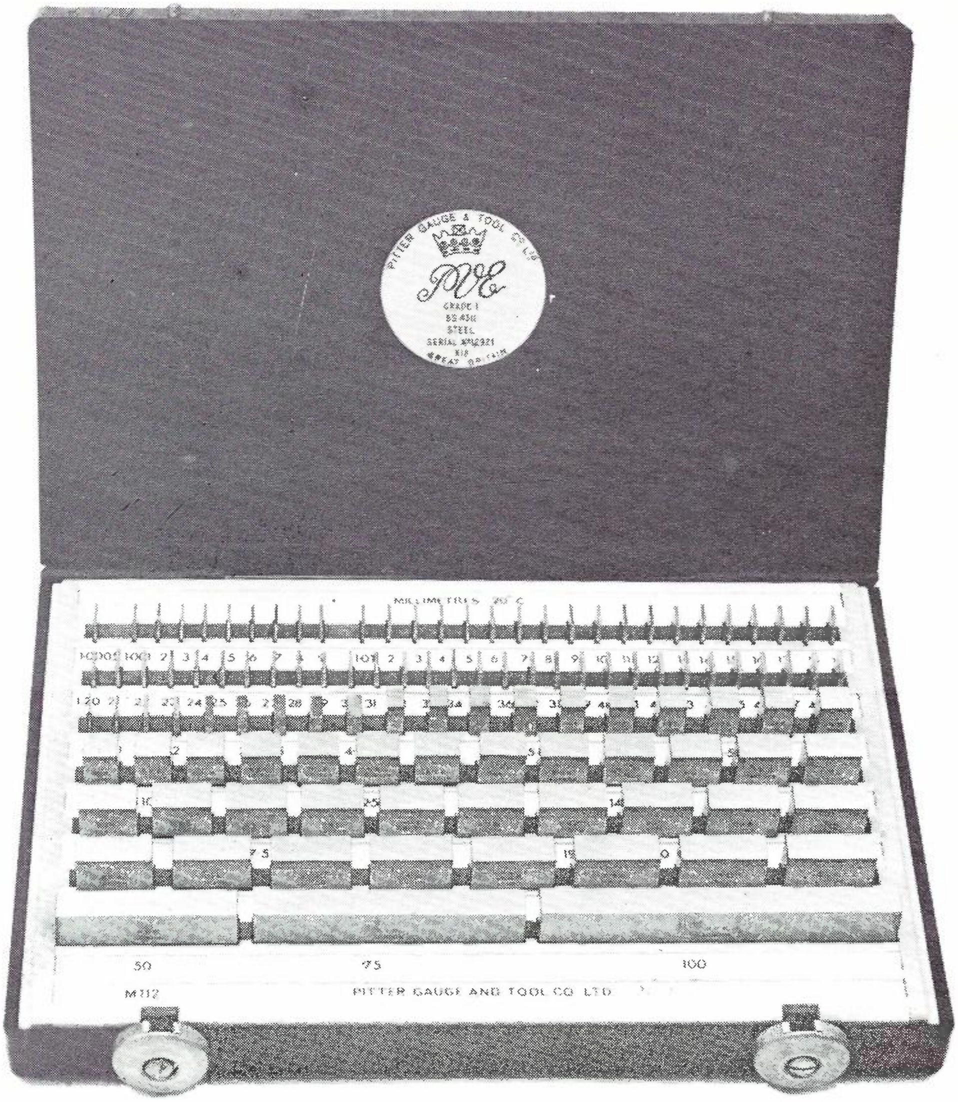

Fig. 1 — A Metric Slip Gauge Set.

Toolmaker's Microscopes

This instrument is similar to a normal microscope except that the work plate may be moved through the 'X' and 'Y' axes using calibrated micrometers. Cross-lines are engraved in the eyepiece thus allowing dimensional measurements to be made.

In more complex and larger toolmaker's microscopes it is possible to measure angles between faces and edges accurately.

Optical Projectors

These are versatile instruments which have become almost a necessity in a well equipped toolroom or metrology laboratory. There are a number of types and sizes depending on the physical characteristics of the work to be measured. All optical projectors are alike in that they display a magnified image of the work piece on an appropriate viewing screen as an aid to the more precise determination of dimension and form. Like a toolmaker's microscope, a two dimensional projection is possible.

The work piece is held on a staging table and illuminated by a suitable light source. An image of the illuminated work piece is passed through an optical system, corrected for the normal optical errors such as aberration and curvature, and projected onto a suitable screen. (e.g. ground glass).

The staging table is capable of being moved in both the 'X' and 'Y' planes by means of calibrated micrometers and measurement is made by reference to a cross-line on the centre of the projector screen.

Optical projectors may be used for single piece

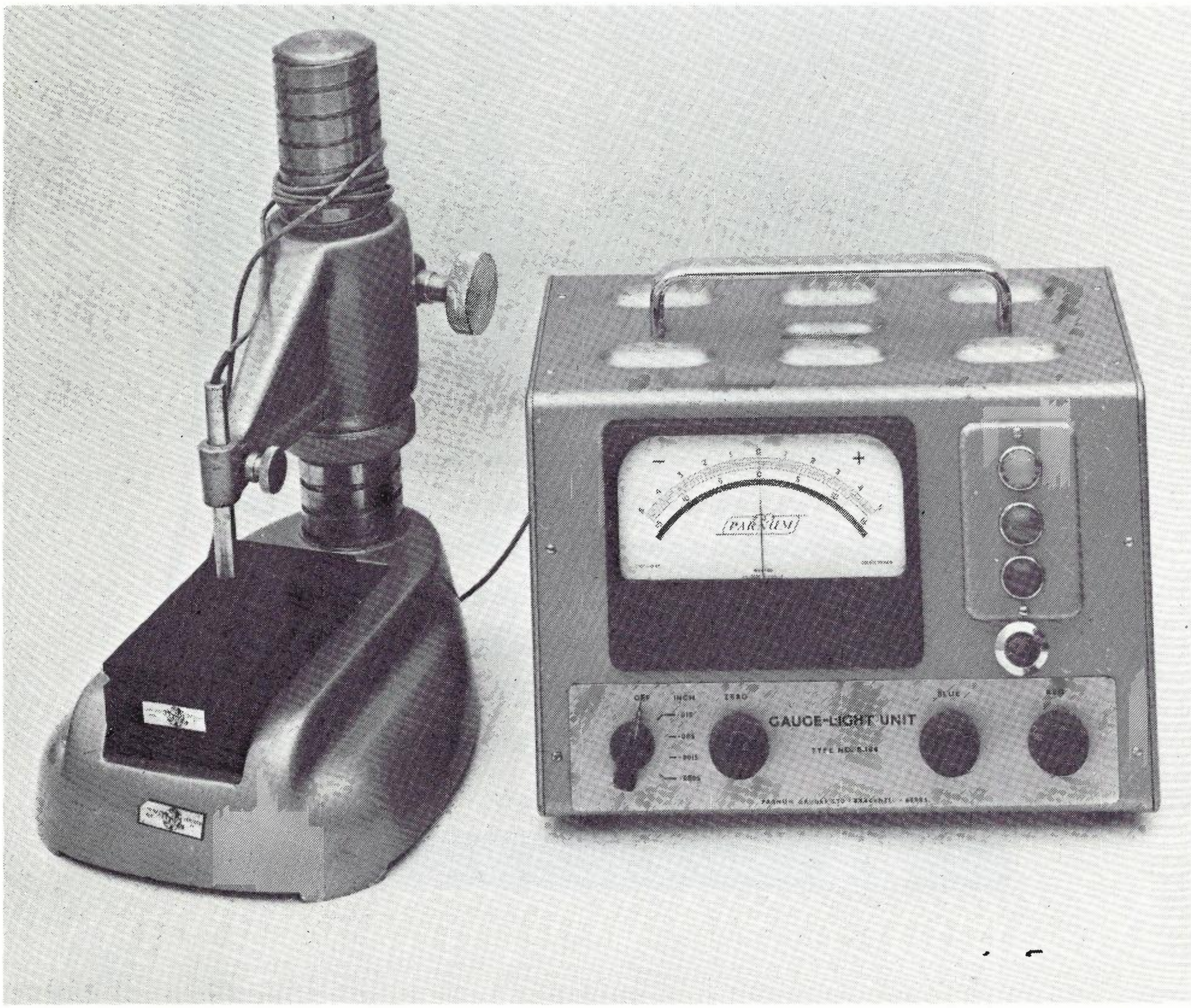

Fig. 2 — Electrical Comparator.

inspections where a prototype or once only job is being produced, and for comparison measurements.

Comparison measurement compares the image projected onto the screen with an accurately drawn enlarged layout placed directly on the screen. Typically in Telecom Australia, this type of measurement is used to check the dimensions of switch wipers produced by contractors.

Other Equipment

A complete group of hand measuring tools such as outside and inside micrometers, vernier calipers, micrometer and vernier depth gauges and steel scales is essential for the less precise measurements in the metrology laboratory. Telecom Australia's metrology laboratories are also provided with:

- Tensile Testers;
- Environmental Cabinets;
- Hardness Testers;
- Magnetic Particle Crack Detectors.

These are not strictly metrological instruments.

IMPACT OF METRICATION

Because Telecom Australia has purchased equipment from European suppliers for a number of years, the impact of metrication has not been significant although, some adjustment by staff has been necessary for the change from CGS to SI units. Metric slip gauges, micrometers and gram balances have been in use during this time, and crossbar equipment has always been manufactured to metric dimensions.

At the same time, it is still necessary to purchase equipment manufactured to Imperial units to service existing equipment. (e.g. feeler gauges for step by step switch equipment).

The main effect of national metrication is the operation of two sets of standards (SI and Imperial). Hence, the calibration of these standards by outside authorities, at a time when the demand for one set (Imperial) is diminishing in industry, remains a fairly constant demand.

METROLOGY SKILLS

Most people when making measurements assume that the reading from the measuring instrument is absolute. They do not generally question the degree of accuracy or uncertainty of the instrument, the errors which may be encountered in their measuring technique and the environment in which the measurement may be made.

Certainly, some instruments provide 'built in' calibration systems. This is particularly so with electrical instruments and gauges such as micrometers and vernier calipers where the 'zero' setting may be checked and reset. However, does the operator know that the internal reference is accurate and has not drifted or that the anvils of the micrometer are flat and parallel?

A metrologist cannot accept these types of inaccuracies and must know the limits of instruments used. Measurements must be related to known degrees of uncertainty using proven methods which produce repeatable results. This is essential so that others making the same measurements or using the same equipment produce the same results. In addition, the metrologist must be aware and be able to calculate the cumulative effect of a series of uncertainties in measurements so that the total uncertainty of a dimension is known.

Metrologists in Telecom Australia's inspection laboratories are not generally trained specifically for metrology. They are usually tradesmen or technical officers who have shown an aptitude for the demanding work of measuring to close tolerances.

FUTURE DEVELOPMENTS

Metrology will continue to play a valuable part in the acceptance testing of material purchased by the Commission by providing gauge calibration and the measurement of more dimensionally complex material forms.

It is possible that in time some higher level standards will be held, perhaps by the Research Directorate with verification of the standards held by the State metrology sections then being carried out within the Commission. This appears desirable as a number of external, registered authorities which have calibration capabilities are becoming overloaded with demand for their facilities.

Many other sections of Telecom Australia use various types of gauges for dimensional measurement and there may be a need for calibration of these instruments in the future. With the expertise available it will be possible to assess such a calibration system if it is considered necessary and to provide an initial service.

COSTS AND BENEFITS

It is not proposed to perform a rigorous cost benefit study since many of the costs are historic and some could not now be readily identified. However, it is possible to itemise the more obvious costs and benefits.

Costs:

- Capital cost of laboratory equipment;
- Capital cost of accommodation;
- Capital cost of laboratory environment;
- Cost of training, both formal and on-the-job;
- On-going cost of labour charges and maintenance.

Benefits:

- Confidence in the dimensional compatibility of newly purchased and existing plant. This confidence allows the orderly development of a telecommunication network without unacceptable outcomes such as, crossbar racks with heights different from those already installed or conduit dimensionally incompatible with that already installed;
- Avoidance of unnecessary delays to capital and operations programmes if gauges were not regularly calibrated to a traceable standard and a contractor called into question the gauges used in measurement and rejection of offered material.

CONCLUSIONS

Calibration of gauges is essential for confident and repeatable dimensional measurements. Telecom Australia provides calibration of gauges used in the quality assurance areas of the Commission; elsewhere, calibration of gauges is not generally required.

Particular skills are required by metrologists and these have traditionally come as much from experience as formal training. However, a thorough appreciation of fundamentals is necessary and some formal study of measuring techniques desirable.

The costs of providing a calibration and measuring service are readily identifiable while benefits are less tangible and fall into two main areas:

- Ensuring continuing compatibility of the expanding telecommunications system, and,
- the intrinsic value of suppliers to Telecom being aware of the need to submit to material acceptance testing.

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P. J. WEIR joined the former PMG Department in 1955 as a Technician-in-Training. He was appointed as an Engineer Class 1 in 1972 after graduating from the University of Adelaide.

For the past two years he has been attached to the Materials Section as the Materials Inspection Engineer, involved in the inspection of material manufactured for Commonwealth and State contracts, the implementation of an effective Defective Material Report System, the establishment of a State Calibration Centre and the National Telephone Efficiency Tester Calibration Centre. Most recently, he has been part of a working party examining the need for and the needs of a new building for the Material Inspection group in South Australia.

Planning for the Future Data Communications Market

P.H. GAMBLE, B. Sc. (Tech.), P.J. HIGGINS, B.E. (Elec.) B.A. (Econ.) M.B.A. and C.J. NELSON

To assist in planning for the future demand in data communications a major study was initiated by the Australian Telecommunications Commission (Telecom Australia). The study, known as AUSTDATA, developed a set of forecasts and an ongoing forecasting methodology to cover data, telex, private telegraph and facsimile services. The study was structured in two integrated stages, Stage 1 detailing forecasts to 1985 and Stage 2 the long term developments to the year 2000.

BACKGROUND

Previous data communications forecasting in Telecom Australia focused on short term requirements. The data communications market has expanded and diversified very rapidly since 1968 and with such a limited history the assistance of external consultants was sought to forecast the future of data communications in Australia. In developing the specifications for the study, Telecom Australia built on the experience of a similar study (ERUODATA) performed for CEPT (European Conference of Posts and Telecommunications Administrations) in 1973. The AUSTDATA study was extended to include telex and facsimile services and the development of an ongoing data base.

While the study sought detailed forecasts, it had broader objectives. An ongoing methodology was required that would continue to assist Telecom Australia in the development of planning and marketing strategies to meet the needs of data communications during the 1980s. The study was to be conducted for different timescales defined as follows:

Stage 1 of the study: 1975/1985 with extrapolation to 1990

Stage 2 of the study: 1990/2000.

The contract was awarded to W. D. Scott & Co. Pty. Ltd., Management Consultants, who performed the study jointly with Logica (UK) and the Industrial Management Centre (Prof. J. Bright—Harvard University).

PROJECT DESCRIPTION

Stage 1 of the study comprised four phases as set out below. Field work, technology and applications research and economic studies were analysed, and in association with historical data from Telecom records jointly contributed to the development of models and forecasts.

Field Work. Approximately 1000 major business customers, computer houses and suppliers of data transmission equipment were surveyed by face to face interviews, telephone interviews and postal questionnaires. This sample frame, comprising the majority of datel and facsimile customers and approximately 6% of telex customers, enabled the construction of a database for subsequent use in the forecasting and modelling aspects of the study.

Technology and applications research: A research program was conducted to identify technological developments likely to impact computer and communications equipment by 1985. An analysis of existing user applications was made, while separate research provided insight into emerging applications and new applications likely to emerge in the next decade.

Economic study: Forecasts of the overall Australian and State economies were developed, using industrial sector breakdowns published in the official National Accounts statistics. The study has provided historical data and forecasts of economic activity in each of 64 geographic zones in Australia and 32 industry sectors within each zone. The economic analysis was based on employment data by industry and zone derived from census results and local government statistics.

Traffic and equipment forecasts: Annual forecasts of communications traffic and equipment were developed for the period to 1985, the forecasting methodology being based on a combination of four techniques:

- intentions, in which individuals or organisations surveyed indicate their intentions concerning likely use of terminals and volume of traffic in the future
- econometric, whereby the relationship between demand for communications and various economic indicators is investigated
- trend, in which the historical values are projected into the future by a statistical curve fitting procedure
- judgement, of suitably qualified persons in the area concerned.

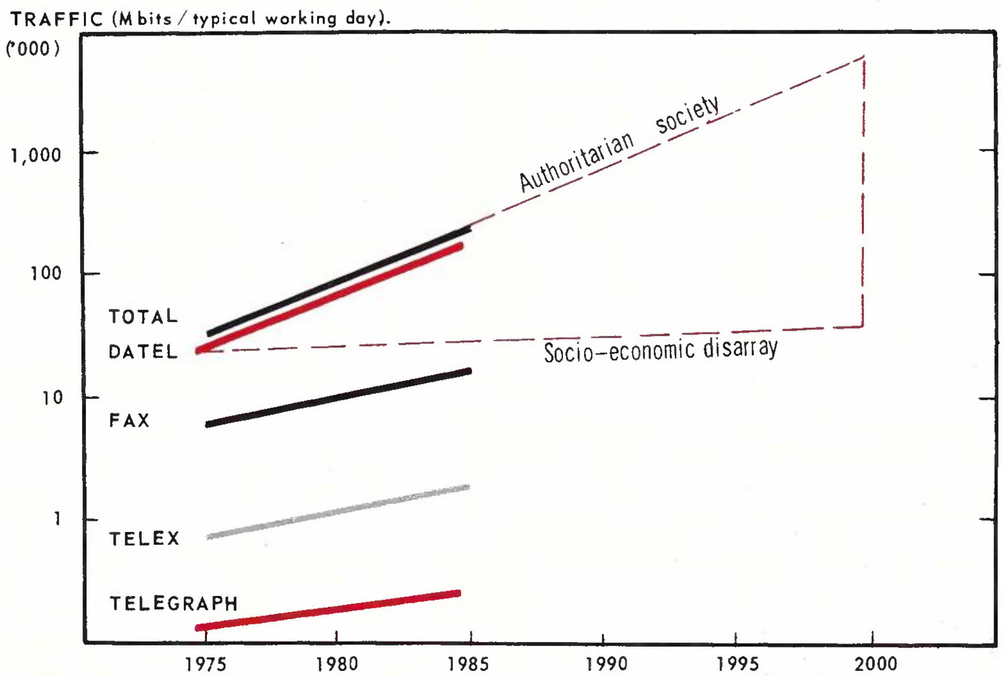
Stage 2 (1990-2000) was performed in parallel with Stage 1 (1975-1985) using techniques appropriate to long term forecasting. A number of social-economic-political scenarios were developed to describe a range of possible futures. These were examined in conjunction with a set of technology prospects using cross-impact analysis techniques. This approach permits the identification of key factors appropriate to each scenario and the development of suitable strategies. Figure 1 indicates the range of growth applicable within the extremes of possible socio-economic circumstance.

OUTPUT FROM THE STUDY

A detailed report has been prepared and presented to Telecom Australia giving the findings and conclusions of the consultant. The output from Stage 1 includes:

- predicted trends in performance and cost of computers, peripherals and software including likely developments in system architecture
- forecasts of the expected number and geographical distribution of data, telex, facsimile and telegraph terminals and the signalling rates and traffic streams between different regions
- forecasting methodology, models and software to generate and modify the forecasts, using the data base and customer files. The forecasting methodology will permit new forecasts to be made in the light of additional information, including new customer data, different rates of technological development and alternative tariff structures.
- potential and emerging applications identified for data and private telegraph.

The Stage 2 emphasis was directed towards establishing the nature and future characteristics of activities and consequent need for data com-



Data communications traffic is expected to grow strongly except in conditions of socio-economic disarray.

Fig. 1 — Data Communication Traffic.

munications, taking into account possible, social, economic and political environments of the future. These findings will be an input to the National Telecommunications Planning group's preparation of a technical framework which will contribute towards the development of long term policies, objectives and strategic plans.

SUMMARY OF MAJOR RESULTS

Summaries of annual forecasts of customer demand in the data communications market for the ten years to 1985 are set out in the following paragraphs, and depicted in the histograms of Figure 2.

Telex: Demand for the telex service is expected to grow at an average 11% per annum, compared to 23% over the past ten years, leading to about 42,000 services connected by 1985. Major growth in demand is likely to occur in the agriculture, retail, health and education industry sectors—the significant emerging application being purchasing (enquiries/tenders and confirmation of orders).

Telegraph: The private telegraph service is well established and a slow growth of around 6% per annum is predicted. Major growth is likely to occur in the wholesale and finance industries. A significant emerging application is the use of private message switching systems linking customer organisations within different cities.

Data and Computers: An average growth rate of 32% per annum has been predicted for the next ten years resulting in a 16 fold increase to about 100,000 modems (or equivalent) by 1985. Emerging applications that will affect demand up to 1980 include financial and point of sale terminals, library automation, computer resource sharing, police command and control, pollution monitoring and a legal information retrieval system.

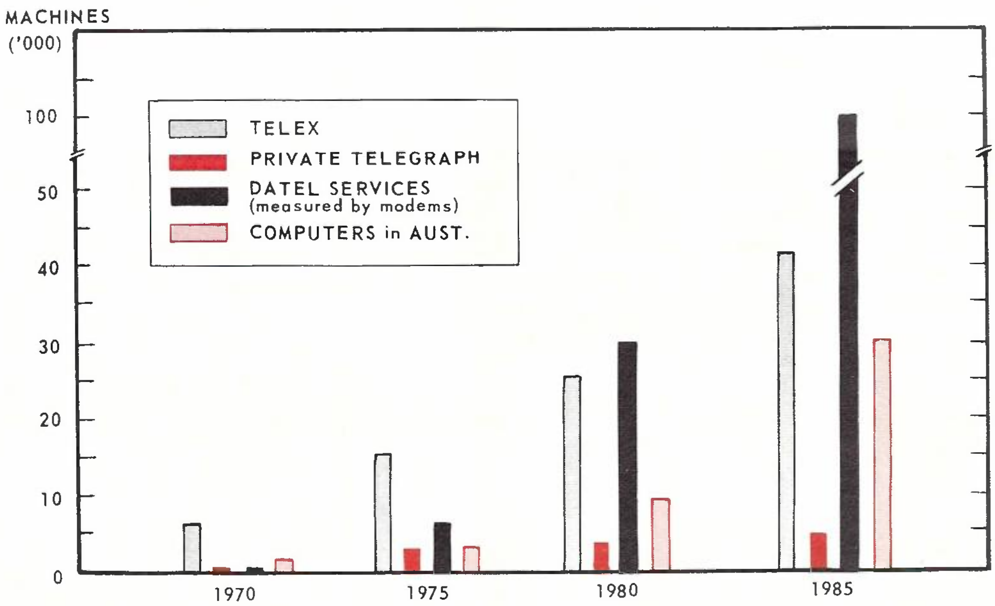
A very large number of potential applications are expected to impact on the demand for datel services in Australia in the period 1980 to 1985, including:

- real estate system
- national freight system
- "small business" service bureau
- farming information system.

Growth rates of around 25% in the number of computers for the next ten years have been forecast, while the percentage of computers with communications capability requiring data lines over this period is projected to rise from 20% to 30%.

Almost all the relevant computer applications will be characterised by two developments:

- a merging of current computer tasks into large and unified systems
- an increasing tendency for many different applications to be implemented at the same site.



Modem demand will lead equipment growth.

Fig. 2 — Equipment Forecasts to 1980.

Facsimile: Widespread acceptance and commercial use of facsimile is dependent on the technological breakthrough that will allow an A4 page to be transmitted in about half a minute at an economic cost. In the absence of this development, growth is expected to be relatively slow at about 15% per annum, leading to about 3000 terminals operating on voice grade lines by 1985.

IMPLICATIONS OF THE AUSTDATA STUDY

In 1975/76, Telecom Australia employed approximately 87,000 staff and invested about $900m in capital development. With an organisation of such magnitude, particular attention must be directed to the planning of telecommunications networks, new products and services and effective allocation of capital and staff resources.

The AUSTDATA study has provided Telecom Australia with an invaluable appreciation of the present data communications market together with a comprehensive set of forecasts and a continuing methodology to assist in identifying future demand. Benefits will accrue particularly in the future from the application of methodology which will support existing forecasting techniques towards the development of marketing and network planning strategies. The study also provides the Commission with other opportunities, namely:

- improved forecasting to better match internal resources to customer requirements. The sixteen fold growth in datel services will place very considerable pressures on Telecom resources. Existing and new customers will benefit from the early recognition of the situation which will allow implementation of new systems and procedures to effectively meet this very large growth in demand for connection of new services and efficient maintenance of existing services.
- anticipation of the requirements for new products and services. The ongoing study will provide a continuing review of future technology and applications and will enable Telecom Australia to anticipate customer demands for new types of services
- review of policy issues affecting the data communications market. The determination of major policy issues can be performed more effectively when information is available to assist in identifying the need for and impact of changes in data communications policies.

The different phases of the AUSTDATA study will be reviewed at regular intervals:

- Australian Government and National Systems every year
- Data Processing Service Bureau every 2½ years
- General Market Survey every 5 years

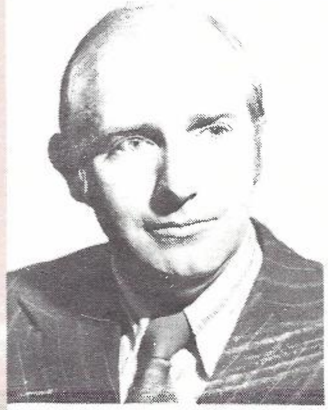
The review will also monitor and investigate developments in the market, including social, political and technological factors. This is part of a larger programme of Market and Field Research studies being developed by Telecom Australia within a broader philosophy of "open planning" to develop closer communication with our customers and a better understanding of their existing and future wants and needs. The Commission already interacts closely with a number of user groups and these ties are to be strengthened and widened by the formation of additional user groups.

CONCLUSION

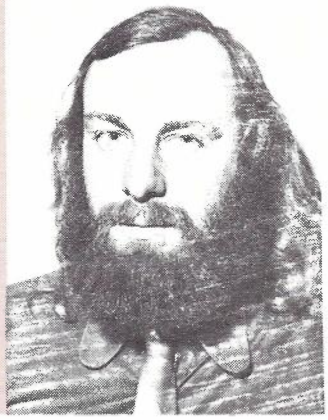
The AUSTDATA market research study has provided Telecom Australia with a large amount of information about its data, telex, telegraph and facsimile customers and the use they make of these services. The forecasts of technological developments and demand for services will permit more effective planning in such areas as network dimensioning, equipment provisioning and the connection and operation of data communications services. A greater knowledge of the market and a recognition of new application areas will enable Telecom Australia to efficiently and effectively meet the continuing demands for new and improved services and facilities. Towards this objective, the Commission will continue to encourage communication with its customers and will, in turn, seek their earliest advice of future proposals to ensure that appropriate plans and strategies can be developed to satisfy these needs and to optimise the use of all resources in the interests of national achievement.

PETER GAMBLE joined the Postmaster Generals Department in 1966 as an exempt Technicians Assistant, while completing a part-time Engineering degree at the University of New South Wales. During this time he was responsible for the commissioning and maintenance of a new generation of electronic traffic recording equipment.
After gaining a degree in 1968, he specialised in the development of a computer based automatic traffic recorder processing system, then in 1970 moved into the data and telex planning area of Switching and Facilities to assist in the preparation of the State Telex and Data Plan. Two years later he moved to Headquarters to continue telex and data planning in a wider context.
Mr Gamble took over as Project Manager of the AUSTDATA Study in late 1975, after having been actively involved in the study since its commencement. Following the presentation of the AUSTDATA report to management, he returned to the position of Class 4 Engineer, Networks Data and Telegraph Planning, where he is currently updating and using some of the results of the study.
He is a member of the Institution of Radio and Electronics Engineers and the Australian Computer Society, and a Councillor on his local Council.

P.J. HIGGINS, joined the Postmaster Generals Department in 1959 as a Cadet Engineer. After completing his Degree of Bachelor of Engineering (Electrical) at the University of Melbourne in 1962, he joined the Victorian Metropolitan Services Section and subsequently worked in Industrial Engineering and Fundamental Planning at Headquarters. In December 1974, he first became associated with the Marketing Division, Customer Services Department, Telecom Australia Headquarters and has since worked in Product Planning, Marketing Planning and is currently Manager, Market Studies Branch, which is responsible for the Forecasting, Statistics and Market Research sections. Mr Higgins was Chairman of the AUSTDATA Steering Committee during the performance of the study.



CHARLIE J. NELSON joined the APO in 1968 and worked in several areas of the Engineering Division, Victoria, until 1973. In 1973, he transferred to the Telecommunications Division and worked in an area responsible for telegraph and data forecasts. In 1975 he transferred to the Marketing Division, Customer Services Department, Telecom Australia Headquarters where he was responsible for telegraph and data forecasts and was the Customer Services representative on several working parties associated with the AUSTDATA study.
Charlie is well advanced in studies at Melbourne university towards a B. Sc. degree and is now Assistant Manager, Call Forecasting.



Australian Telecommunications Commission, Service & Business Outlook for 1977/78: Some Highlights

Objectives

As derived from the Telecommunications Act 1975, Telecom Australia is responsible for the provision, maintenance and operation within Australia of telecommunications services to best meet the social, industrial and commercial needs of Australian people.

It is required to make its services available throughout Australia so far as is reasonably practicable.

Revenue must cover current expenses each year and provide not less than half of capital requirements.

Services are to be kept up-to-date and operated efficiently and economically with charges as low as practicable.

Against this background, Telecom has set four basic objectives for the present financial year:

- To maintain a high standard of service to all its customers.
- To provide capacity within the telecommunications network to accommodate nearly 270m additional telephone calls from existing and new customers.
- To provide resources to satisfy the expected 405,000 applications for new telephone services and meet the continuing high growth demand for other services.
- To take advantage of new technologies which can both reduce the cost and extend the range of services which Telecom can provide to its customers.

Demand

The Commission expects that the demand for telecommunications services will continue to grow strongly. Notwithstanding demand pressures, an important Commission target is to reduce further connection times for telephone, telex and data services and to raise the level of service to the customer.

The estimated demand for new services includes a new high for telephone services of 405,000. This represents an increase of 7.6% over demand in 1976/77 and will represent the highest ever demand for new services in Australia.

Staff

Full-time staff of the Commission at 1 July 1977, was 87,358 which is 1,332 below the staff level on 1 July 1975 when the Commission was formed. The average full-time staff level is expected to increase slightly from 87,519 in 1976/77 to 87,652 in 1977/78.

Inputs

The growth in direct maintenance and operating costs, measured at constant prices, will be contained within 1%, while expenditure on fixed assets will fall by about 3%, measured at constant prices.

Outputs

Overall, output is planned to grow at 8% in order to meet forecast demands. Growth rates for the major components are:

Telephone Services	6.2 per cent
Local Telephone Traffic	6.0 per cent
Trunk Traffic	11.0 per cent
Telex Network	13.4 per cent
Datel Services	41.0 per cent

Productivity

The Commission plans to achieve substantial productivity improvements during the year. Output will increase by 8%, while direct expenditure and staff will be contained to little or no growth. When the capital inputs used to produce the Commission's output are also taken into consideration, a total business productivity gain of 5% is expected.

Network Development

The telephone network is expected to grow by the net addition of about 800 new telephone services on average every working day. There will be growth also to handle additional telex and datel customers and a general increase in traffic.

This overall growth is reflected in over 110 major projects either in progress or to commence during the year. These cover the installation of equipment in large exchanges and PABX's, coaxial cable and micro-wave radio trunk systems and large junction cables linking suburban exchanges. They range in investment from $500,000 to $20 m.

Buildings

Additionally, there will be over 200 building projects each costing over $250,000 either in progress or to be started. The planned expenditure includes an amount of $68.5 m at 1 July 1977 price levels, to be expended by the Department of Construction for Telecom.

Materials

Purchases of telecommunications material for the network development will amount to approximately $300 m during 1977/78.

Public Telegram Service

The programme which is being carried out by the Commission to reduce costs and operating losses involves the use of Visual Display Units to introduce further efficiencies into the service. An initial evaluation of the use of these units at the Adelaide Phonogram Centre has shown advantages over the conventional method used to handle phonograms.

An extended trial in all mainland States is planned using more suitable VDU's and a greater degree of automation, both in the message preparation and the telephone call acceptance (paper-work will be completely eliminated). The extended trial, using eight VDUs per phonogram centre, is planned for commencement in February 1978.

High Capacity Radio Paging Service

Demand has been strong for the Telefinder (radio paging) service now installed in Sydney, Melbourne, Canberra and Brisbane. It will be extended to Adelaide, Perth and Hobart by the end of 1977. A national plan for future expansion of this service to provincial areas has now been completed. By 1981, it is anticipated that the radio paging terminals in New South Wales and Victoria will be fully expanded, and a new high capacity radio paging service will be required to handle future growth. Engineering design of the system is now in hand and competitive tenders will be sought on a world-wide basis in the first half of 1978 for an in-service date of mid-1981.

Push Button Telephones

Telecom Australia has commenced provision of Touchfone 10 telephones in South Australia and will extend the availability of the instrument to other States during the financial year.

Touchfone 12 (VF signalling) instruments will be available as telephone exchanges are equipped to operate on VF signalling and major penetration will occur in 1978/79.

Action is in hand to extend push button signalling into equipment other than the standard table instrument.

Telephone Switching Equipment—ARE II

The Commission's second ARE II exchange at Salisbury, South Australia was put into operation in February 1977. The new system is more cost effective than crossbar and can provide additional customer facilities. Further ARE II equipment will be installed in 1977/78.

Public Coin Telephone Replacement Programme

The Public Coin Telephone Replacement Programme commenced in 1976/77 and is now proceeding smoothly. It will involve an expenditure of $8 m this financial year. An improved version of the current Coin Telephone No. 3 will be introduced in 1978 which will provide even more reliability by greater protection against vandalism and fraudulent operation. The Public Telephone Monitor will be introduced early in 1978 to provide early warning when a public telephone is out of order.

Electronic Local Exchanges

Since July 1975, Telecom has investigated in depth, tender offers for stored program controlled (SPC) local telephone switching equipment as an alternative standard to the existing crossbar system. An SPC system will offer substantial operating benefits to Telecom and also improved facilities at lower costs. When all costs are taken into account, adoption of SPC equipment offers potential savings in excess of $100 m at current prices over a 10 year installation programme, compared with the continued use of crossbar alone. An announcement concerning system selection is expected to be made shortly.

NOTE: This selection has now been made and reference to the announcement appears on page 243 of this issue of the Journal.

Optical Fibre

A contract has been awarded to AWA Research Laboratories to develop a process for the production of optical fibre of up to two kilometres in length suitable for telecommunications transmission. The Telecom Research Laboratories will soon start to test optical fibres for operating qualities.

Solar Energy

Research has proven that the use of solar powered telecommunications equipment is practical for providing economical radio relay systems to service communities in remote areas of Australia.

The first solar energy powered system in Australia will be installed between Alice Springs and Tennant Creek and is expected to be operational in 1979. It will be the first large capacity multiple solar cell power installation of its type in the world.

Rural Services

There is a continuing concern about the needs of people in rural areas for communication services. One method of providing service to some of these customers is by Radiotelephone Group Systems which provide private automatic service to isolated groups, using a small number of VHF radio frequencies.

Contracts were placed in 1976 for rural radiotelephone equipment using the concentrator principle to conserve radio frequency assignments. The first of nine systems averaging about 12 subscribers per system will be installed in Queensland late this year. The equipment is of modern design, provides normal telephone facilities and has been field proven.

By 30 June 1977, the number of manual services had been reduced to 112,000 in a network of 3.9 m. The 1977/78 Works Programme includes provision to further reduce this figure to close to 100,000, representing only 7½% of country services compared to over 10% two years ago.

It is planned to have only 10,500 non-continuous services by 30 June 1978, out of over 1.3 m country services. Within the funds made available, an additional $3 m to $4 m is again being allocated to enable more new connections and part-privately erected (PPE) conversions to be made in country areas in 1977/78.

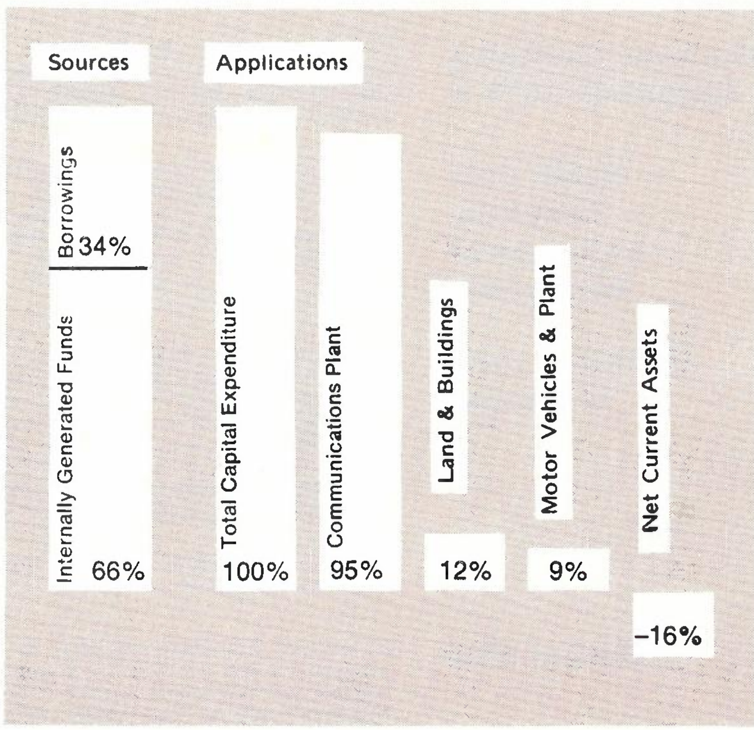
The contribution towards the cost of rural lines beyond the 12 km radius from the exchange will be maintained at $160 per half km — a price fixed in 1973.

Funds

The limit of borrowings in 1977/78 has been set by the Government at $275 m with $65 m being provided in the Commonwealth Budget and $210 m to be raised on the public loan market. In addition, short-term money up to approximately $80 m is to be utilised.

These external funds, together with internally generated funds, will be used to finance planned investment in fixed assets of $926 m.

The relativities of the various sources and applications of funds in 1977/78 are illustrated below.



Borrowings

The Commission has received approval to borrow $210 m on the semi-government loan market in 1977/78. The net increase in telecom stock represents the issue of inscribed stock less planned repurchases by the Commission.

Trading Activities

The Commission buys and sells Telecom inscribed stock in the secondary market for these securities in order to assist the development of a strong secondary market and to manage its overall debt redemption pattern.

The raising of funds on the loan market by the Commission in 1976/77 and again in 1977/78 reflects Government decisions to reduce the Commission's borrowings through the Budget. These have been reduced from $392 m in 1975/76 to $215 m in 1976/77 and to $65 m in 1977/78.

Earnings: For 1977/78, earnings are forecast to grow by about 8%, excluding the effect of tariff adjustments. The effect of the adjustments in 1977/78 will yield approximately $12 m in the year. The underlying growth rate of 8% anticipates an improvement in Telecom business compared with 1976/77.

Current Expenditure: It is planned to hold day-to-day expenditures involved in maintenance, operating, general and administrative activities to a growth of less than 1% in real terms in 1978. This objective emphasises the determination to continue to achieve economies in this area of expenditure while at the same time meeting the forecast growth in business of 8%.

In Brief

NEW GENERATION OF LOCAL TELEPHONE SWITCHING EQUIPMENT

The AXE system offered by L. M. Ericsson Australia has been selected as the stored programme control (SPC) local telephone exchange system to be introduced into the Australian network in the 1980's. The Swedish designed system has been selected after comprehensive investigations. Some 20,000 manhours of work by senior technical, computer, and finance staff have been involved since tenders closed 2 years ago.

The new system has capitalised on recent advances in computer and electronics technologies. It will be cheaper to buy, to install and to maintain than if Telecom continued with the present crossbar system. It will be an important factor in containing cost increases and thus prices to the user in the years ahead. Savings over the first 10 year period are estimated to be in excess of $100M at current prices.

In addition, the new equipment will enable a range of additional facilities to be introduced progressively.

The present crossbar local exchange system is also of Swedish design and is manufactured in Australia by L. M. Ericsson, and under licence by STC and Plessey. The first of the new exchanges will be installed in 1980 but it will be 5 to 6 years before the SPC exchanges are being installed in quantity. During this period crossbar equipment will be purchased to meet needs which are expected to be above those of recent years. Orders for crossbar will decline from 1982/83 onwards as SPC orders grow.

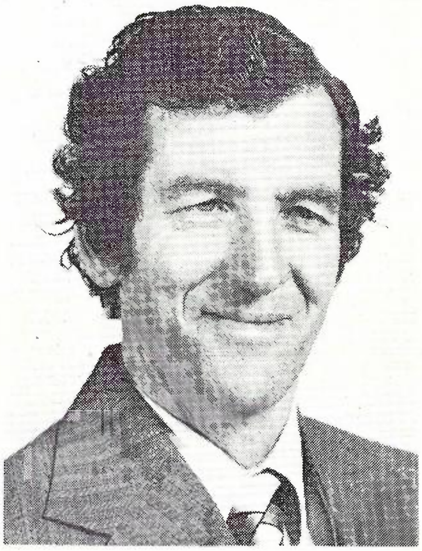
The contract with L. M. Ericsson will require a high proportion of Australian manufacture reaching at least 80% as the volume of orders increases. The contract will provide also for manufacture under licence.

The introduction of the SPC equipment and its adaptation to work with the Australian network will be a substantial engineering undertaking for both Telecom and the Company.

In adopting an SPC local exchange system, Australia is in line with the general trend around the world. An SPC trunk system supplied by STC was introduced into the Australian network in 1974, and this equipment will continue to be the main trunk switching exchange system for many years.

Changes in Board of Editors

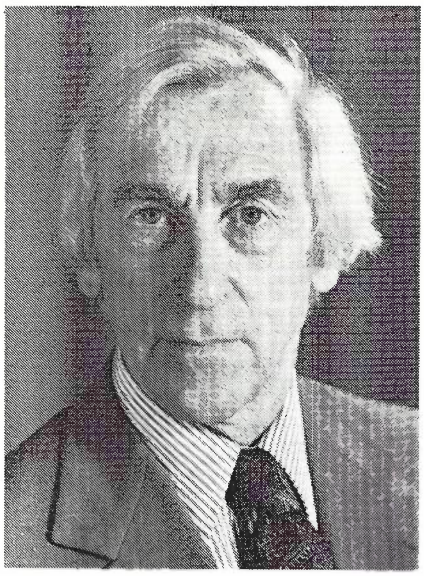
The Council of Control of the Telecommunications Society has accepted with regret the resignation of Mr. George Moot, MIE Aust as Editor-in-Chief of this Journal. George took over this considerable responsibility from Mr. V. White in 1971 at a time of strong membership enthusiasm for change in the already high standard of Journal material and presentation. George responded to this enthusiasm and has progressively introduced a number of changes, including the use of colour, which have been widely appreciated. The Council expresses its gratitude for a good job well done.



G. Moot

The new Editor-in-Chief is Mr. Lindsay M. Mitton, MIE Aust. Lindsay joined the Postmaster-General's Department in South Australia as a Technician in 1947 and qualified as Engineer in 1957. He came to Headquarters in 1970 and has recently been promoted to Supervising Engineer, Workforce Structures, in the Network Performance and Operations Branch. Lindsay was, for 5 years, Secretary of the Telecommunications Society's SA Division and joined the Board of Editors earlier this year as Editor for NP&O Branch, replacing Mr John B. Collins who resigned from this position after many years of service.

It is pleasing to note that George Moot will not be leaving the Board but will take over from Lindsay as Editor for NP&O Branch.



L. M. Mitton

Mr. Russell Clark of Lines Construction has taken over as Indexing Editor from Mr. Jack Pollard who is now retired. Many thanks to Jack for his work over the years in ensuring that all articles were indexed and to Russell, a former Editor at Headquarters, for undertaking this task.

New General Secretary

The Council of Control has appointed Mr. M. R. Sewell, Grad. I.E. Aust, ARMIT, to the position of General Secretary of the Society following the resignation of Mr. N. G. Ross. Mervyn joined the then Department in 1963 as a Technician-in-Training and completed his Diploma of Communication Engineering (RMIT) in 1967. He joined Subscribers Equipment, Telegraphs and Power at Headquarters in 1968. He is presently employed in the Development Division, Transmission Network Design Branch. The Society is confident that Mervyn will continue the tradition of friendly and efficient service established by his predecessors, Noel Ross and Ron Kitchenn, in this important post.

M.R. Sewell

Appreciation

The Council of Control of the Telecommunication Society of Australia has regretfully accepted the resignation of the General Secretary, Mr Noel Ross. Noel was appointed to this position in April 1972 and with patient administration carried the Society's affairs through such significant events as changes of printer for each of the 2 Journals, change of advertising agency, introduction of improved financial arrangements and a business policy, the Centenary of the Society, the vesting of the 2 Commissions and the consequent definition of the role of the Society in relation to the new Telecommunications Commission, and the introduction of deductions from pay of employee members' subscriptions.

Noel arranged the preparation and printing of the Consolidated Index of the TJA Volumes 1-20. He was also responsible for the printing of the special issues of the Colour Television Booklet and the monograph – Automatic Telephony in the Australian Post Office.

We are much indebted to Noel Ross for his excellent work.

N.G. Ross

Hybrid Transformers – Part 1

A.H. FREEMAN, M.I.E. Aust.

This is the first of two articles designed to inform the reader of the properties of hybrid transformers and present simple methods of designing or analysing circuits in which they are used. This article deals in some detail with a specific two transformer circuit widely used in terminating sets and gives equivalent circuits from which it is relatively easy to estimate or calculate the performance with any terminating impedances.

INTRODUCTION

There are three ways of understanding some or all of the properties of hybrids:

- The purely descriptive approach with arrows to indicate directions of current flow and voltages.
- Direct analysis of particular circuits using Kirchoff's rules.
- Developing general rules which are true for all hybrids.

The first is limited to providing some understanding of the way the circuit works but is of little value as a design tool. The second rapidly gets lost in a maze of simultaneous equations, while the third involves some mental acrobatics and techniques which will be unfamiliar to most readers. The intention in this article is to try to get the best mixture of all three approaches, and to do this it is divided into five sections, which are covered in the two parts of the article:

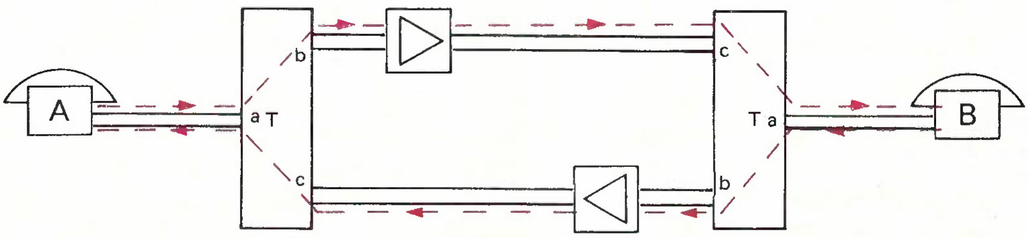
- A descriptive section introducing the main concepts, and showing how a hybrid works.
- A detailed analysis of a particular hybrid circuit, both in the balanced and the unbalanced state.
- Description of a method which allows approximate analysis of circuits using hybrids with a minimum of mathematics.
- A discussion of the practical points of using hybrids.
- An appendix giving proofs of the general rules.

The main application for hybrids arises because subscribers lines and short distance junctions are 2 wire circuits, with speech travelling in both directions over the same pair of wires, while long distance trunks and junctions are 4 wire circuits with separate, amplified paths for each direction of transmission. Hybrids are needed to connect these different types of transmission circuits. A similar requirement assists in a telephone to isolate the transmitter and receiver circuits.

The requirements of a 2 wire and 4 wire interface can be illustrated by reference to Figure 1 which shows a typical switched connection between two telephones A and B involving 2 wire circuits at each end and a 4 wire circuit in the middle. An interface, known as a 2W/4W terminating set is needed at each 2 wire to 4 wire junction, and in the illustration they are represented as boxes, with no internal details. The paths taken by speech currents from A to B and from B to A are shown on the diagram. Each terminating set has three pairs of terminals, designated as shown "2 wire line", "4 wire send" and "4 wire receive".

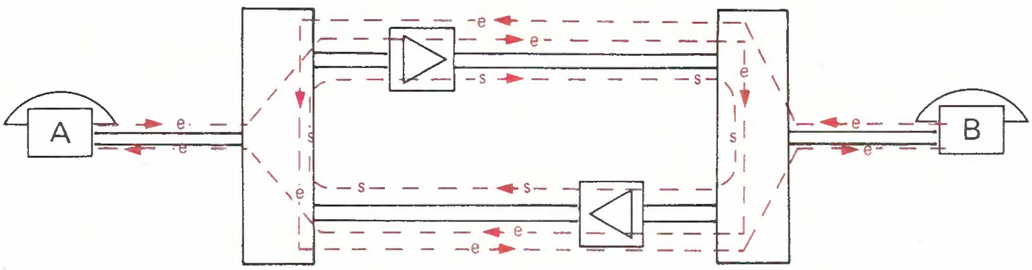
Obviously to meet the requirements of the circuit, speech power must be transmitted from 4 wire receive to 2 wire line, and from 2 wire line to 4 wire send. At the same time transmission of power from 4 wire receive to 4 wire send must be kept as low as possible to prevent two undesirable effects: echo and singing. These effects are shown in Figure 2.

This shows that if there is transmission from the 4W receive to the 4 wire send terminals at the lefthand terminating set, then speech trans-



T is a 2W/4W terminating set with external connections to
a 2 wire line
b 4 wire send line
c 4 wire receive line
path followed by speech

Fig. 1 — Speech Paths in 2W/4W/2W Connection.



e - Echo paths
s - Singing path

Fig. 2 — Echo and Singing Paths.

mitted from telephone B will return over the 4 wire path in the A to B direction and will be heard as an echo at telephone B. Likewise, the 4 wire terminating set at the righthand end can cause echo at telephone A. Finally, if there is some transmission across both terminating sets a feedback loop is set up as shown, which is capable of oscillating if there is a nett gain around the loop. Oscillations, of course, make the circuit unusable, while if the circuit is close to oscillation the quality of speech is adversely affected.

DESCRIPTIVE ANALYSIS

Figure 3 shows the circuit of one type of 2W/4W terminating set. It consists of two transformers, a resistor and a capacitor. The transformers are connected to form a "Two transformer hybrid", while the remaining components are called a "balance network", and are chosen to closely match the impedance of the 2 wire line. If the impedances are identical, and the hybrid transformers are perfect, there will be no transmission from the 4 wire receive terminals to the 4 wire send terminals. Any variation from this causes some transmission between these terminals, and the attenuation between them is called the "trans hybrid loss".

In order to use hybrids effectively in circuit design it is necessary to understand both the properties of the hybrid itself and the techniques and limitations of the design of balance networks. This article is concerned mainly with the first topic.

It will be noted that the hybrid has four pairs of terminals for connection to external circuits designated "4 wire send", "4 wire receive", "2 wire line" and "balance network". In network theory such points of access to external circuits are often called "ports" and this name will be used in this text. The hybrid is, therefore, a particular type of four port network, characterised by the ability to provide power transfer between two combinations of ports and not for a third combination. A characteristic of hybrids is that the ports divide naturally into two sets of two. One set is the pair designated in Figure 3 as 4 wire send and 4 wire receive, while the other set is the two designated 2 wire line and balance network. It is sometimes convenient to refer to the relationship between two ports as being "adjacent" or "opposite", referring to their position in the diagram of Fig. 3.

Arrows in Figure 3 show the directions of current flow generated by a signal applied to the 4 wire line terminals in all parts of the circuit except the 4 wire send circuit consisting of one winding of T2 and the input impedance of the send amplifier. It can be seen that the currents in the other two windings of T2 are in opposition and their magnetising effects will tend to cancel. If the impedances of the 2 wire line and the balance network are identical, the currents in the two windings of T2 will be identical and cancel completely, so that no voltage or current will be induced in the 4 wire send path.

MATHEMATICAL PROOF

A more rigorous proof and one that is applicable to more difficult cases is obtained by examining the circuit of Figure 4. In this circuit the 4 wire send port is short circuited. If in this condition no current flows through the short circuit, then no current will flow if the short circuit is replaced by any other impedance. Also, if no current flows the value of that impedance has no effect on the currents and voltages elsewhere in the circuit.

Now, because of the short circuit across one winding of T2, the voltage across each of the windings of T2 is zero and the following voltages and currents are present:—

Voltage across $Z_L = V_L = \sqrt{0\text{-}5}$ V

Current through $Z_L = I_L = \sqrt{0.5}$ V/Z

Voltage across $Z_N = V_N = \sqrt{0.5}$ V

Current through $Z_N = I_N = \sqrt{0.5}$ V/Z $= I_L$

The nett ampere turns in a transformer must equal zero, therefore for T1 $I_S - \sqrt{0.5}\,I_L + \sqrt{0.5}\,I_N = O$

but $I_L = I_N$

$\therefore\ I_S = O$

Also for T2 $I_R - \sqrt{0.5}\ I_L - \sqrt{0.5}\ I_N = O$

From which $I_R = V/Z$.

Now if, in this circuit, no current flows in the short circuit across the 4 wire send terminals, there will still be no current if the short circuit is replaced by the input circuit of the send amplifier. There is thus no transmission between the receive and send terminals, which is the condition desired.

If Z_L and Z_N are not equal, currents I_L and I_N are also unequal and some current will flow in the short circuit across the 4 wire send terminals. If the short circuit is replaced by the input of a send amplifier, some power will be fed to it. It is not particularly easy to calculate the currents or voltages in this case.

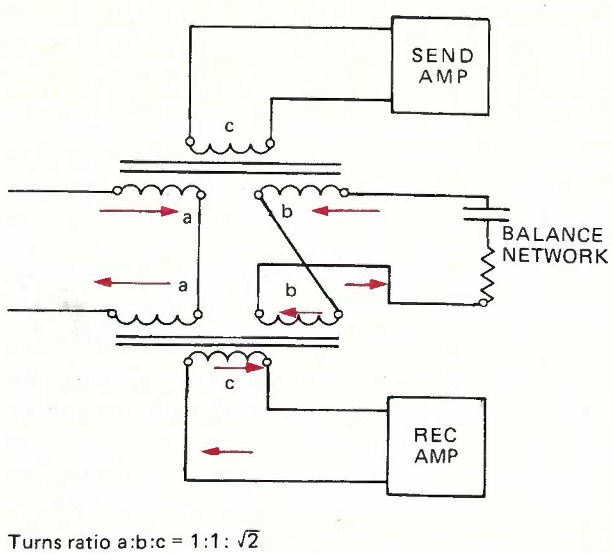


Fig. 3 — Hybrid and Balance Network.

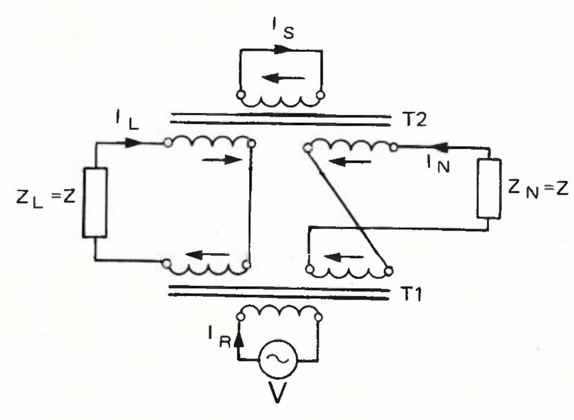


Fig. 4 — Equivalent Circuit for Input Impedance.

PROPERTIES COMMON TO ALL HYBRIDS

This is only one of thousands of circuits using one or two transformers which can be used as hybrids, and nearly a dozen of these have been used at one time or another. Each of these circuits can be examined in much the same way to establish that it has a balance condition, but each circuit requires a slightly different proof, and some of these proofs are rather involved.

However, using more powerful methods of analysis, which do not require specific knowledge of the circuit, it can be proved that any such circuit is a member of the same family, and that they will all have identical properties. An outline of such proof is given in the appendix to this article.

Accepting this statement as true, we will continue to examine the properties of the circuit in Figure 3, recognising that they are applicable, with some reservations to be outlined later, to any other connection of transformers which gives the desired hybrid action.

Input Impedances

In proving the balance condition it was shown that $I_R = V/Z$ so that the input impedance of port 1 in this balanced condition is equal to Z. This impedance is independent of the terminating condition on port 3, since there is no current or voltage in that port.

Because of the inherent symmetry, it is clear that there can be no transmission from port 3 to port 1, and that the input impedance of port 3 is also equal to Z.

Second Balance Condition

It is a property of all hybrids that a balance condition is possible between either pair of opposite ports. More specifically, if ports 1 and 3 of Figure 3 are terminated in impedances equal to the measured input impedances given above, there is no transmission between the other ports (2 and 4) and the input impedances of those ports are equal to the impedances needed to give a balance condition.

This is illustrated in Figure 5, which is seen to be similar to Figure 4, except that the generators and terminations have been interchanged. Also, where in Figure 4 the port opposite the generator was shorted, in Figure 5 the corresponding port is left open. Using very similar methods, it can be shown that the open circuit voltage of port 4 is zero and that no power would be fed to any termination on that port.

Permutations

In fact, so far as external connections are concerned, any of the four ports can be used as (say) the 2 wire line port, with the two adjacent ports used as 4 wire send and 4 wire receive, and the opposite port used for the balance network.

This gives a total of eight permutations, all of which are absolutely identical in transmission performance, apart from any minor details relating to imperfections in the transformers. This characteristic is true for all hybrid circuits and is useful to know. It means, amongst other things, that only one balance condition need be demonstrated, and the other three must also be true.

EFFECT OF TERMINATIONS

Equivalent Circuits

In practical applications the devices connected to the ports of a hybrid differ from those for which it is designed, and it is of considerable importance to know the actual losses between various ports and the input impedances. The necessary calculations can be difficult and tedious but an understanding of the factors involved and an estimate of the values can be obtained by using "equivalent circuits". These equivalent circuits are 2 port or 1 port circuits which give identical results to the 4 port hybrid and its terminations in respect of measurements confined to one or two ports. The equivalent circuits shown here are simplified to the extent of assuming the transformers to be perfect.

Equivalent Circuit for Input Impedance

An equivalent circuit for the input impedance of port 1 is given in Figure 6B. The meaning of the equivalence is that any ac measurement of the impedance of the circuit of Figure 6B would give identical results to measurements of the input impedance of port 1 of the hybrid shown in Figure 6A.

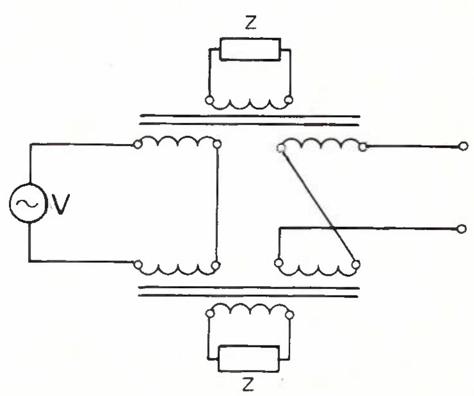


Fig. 5 — Second Balance Condition.

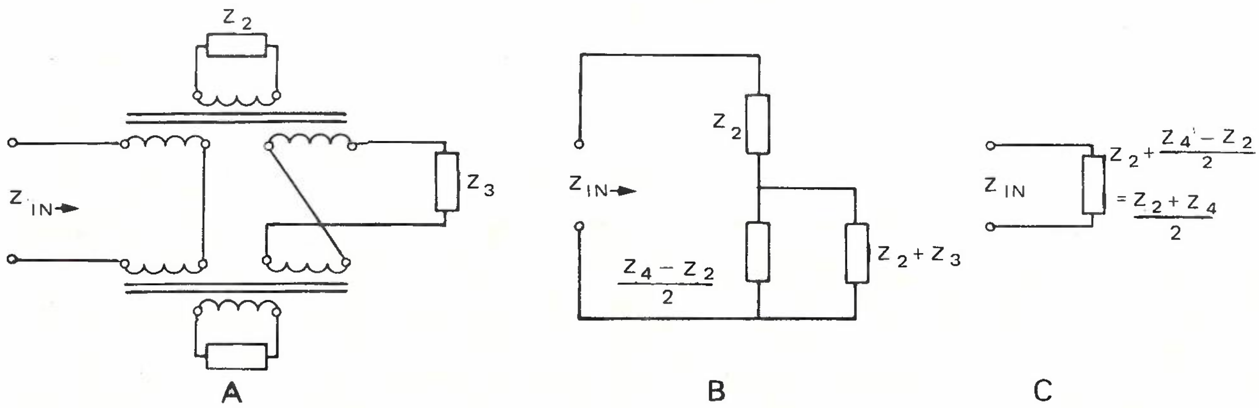


Fig. 6 — Equivalent Circuit for Input Impedance.

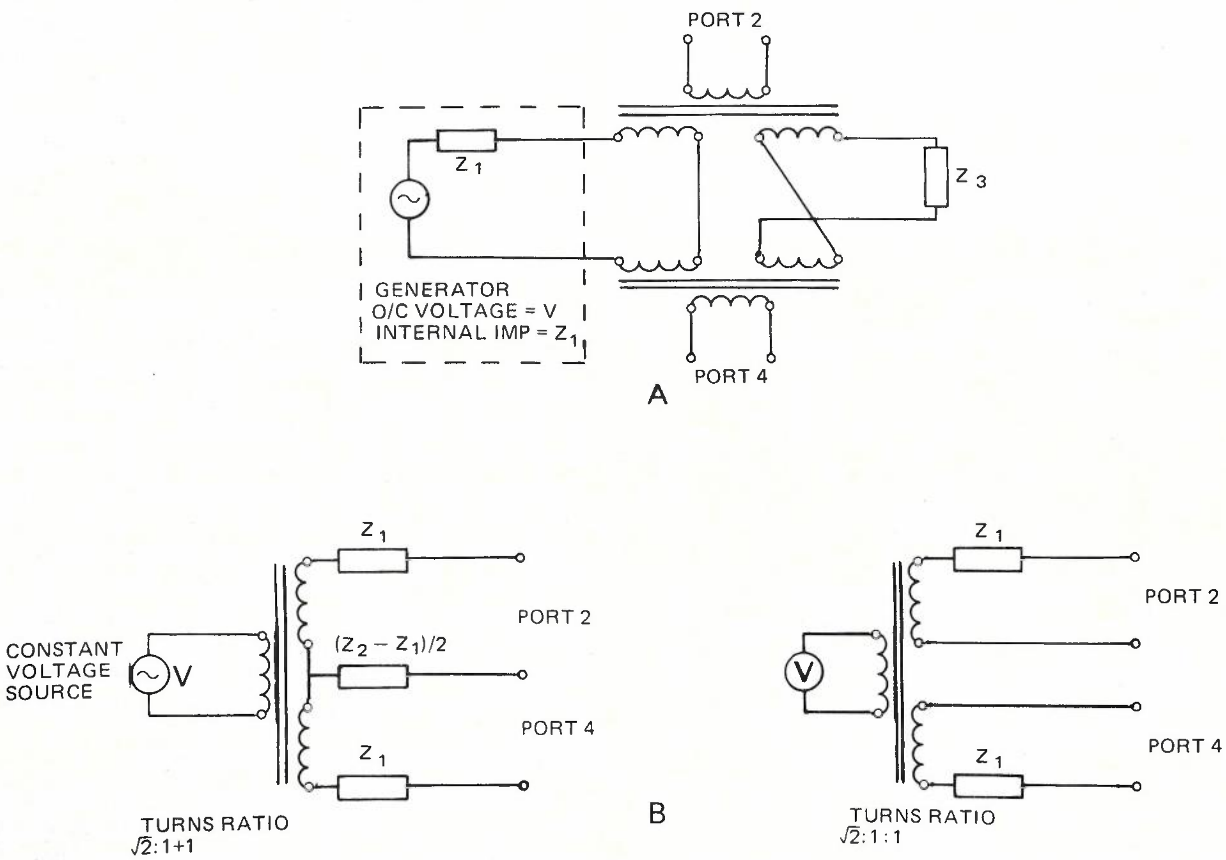


Fig. 7 — Equivalent Circuit for Loss to Adjacent Ports.

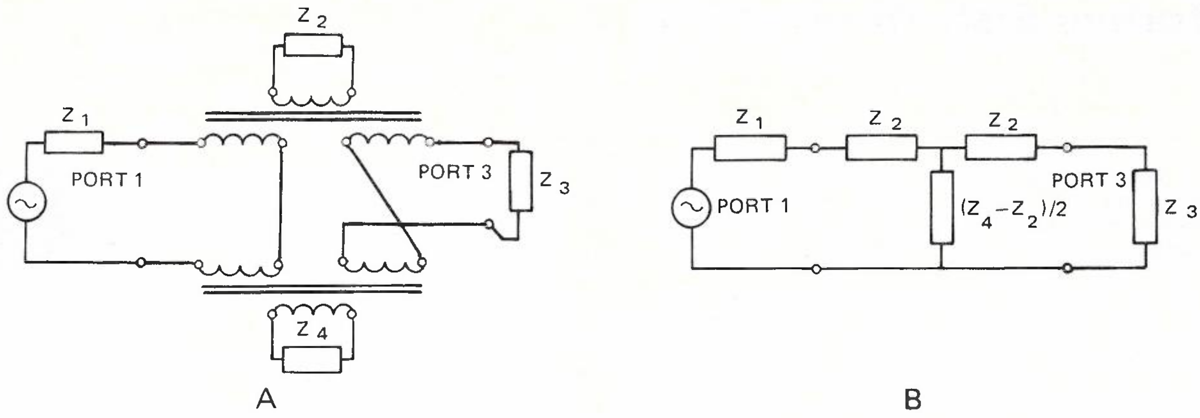


Fig. 8 — Equivalent Circuit for Trans-Hybrid Loss.

In most applications, Z_2 and Z_4 are approximately equal, in which case the equivalent circuit can be approximated by the simpler circuit of Figure 6C, so that $Z_{1X} = (Z_2 + Z_4)/2$. If the ratio of the two impedances lies between 0.5 and 2, this approximation will seldom be in error by more than 3%.

The same equivalent circuit applies from any port, with the appropriate impedances.

Equivalent Circuit for Loss to Adjacent Port

Figure 7A shows the actual circuit and 7B shows an equivalent circuit in which port number 3 is deleted. This can be used to calculate the transmission loss to adjacent ports. However, this circuit does not lend to easy calculations, except for the special case where $Z_1 = Z_3$. In this case the impedance $(Z_1 - Z_3)/2$ reduces to a short circuit giving Figure 7C, which is merely a transformer with two independent secondaries. In practice this loss is fairly close to 3 dB (plus transformer losses) in any real situation where the hybrid is used in a terminating set.

Equivalent Circuit for Trans Hybrid Loss

Figures 8A and 8B show the actual and an equivalent circuit suitable for estimating trans hybrid loss. There are two cases where relatively simple expressions for this loss are obtained:

- If $Z_4 = Z_2$ the shunt arm of the T network has zero impedance and there is no coupling between the two ports. This of course is the balance condition.
- If $Z_1 = Z_2 = Z_3$ but Z_4 is different, then the attenuation between ports 1 and 3 is given by

$$\text{Loss} = 6 - 20 \log_{10} |(Z_2 - Z_4)/(Z_2 + Z_4)|.$$

The second term is the well-known expression for return loss.

For the general case when all the impedances are unequal, the trans hybrid loss is a very complicated function of the four impedances. It is possible to derive a formula from the above equivalent circuit, but it is not of much value. A recent article (Ref. 1) examines the case where $Z_1 = Z_3$ while Z_2 and Z_4 can take any value. This shows that it is usually satisfactory to take the value given above for this case and the errors involved are usually less than 1 dB.

CONCLUSION

The operation of a particular hybrid circuit in the balanced condition has been explained. Equivalent circuits have been described which allow its performance in other situations to be estimated. A subsequent part will show how the same methods can be applied to any transformer hybrid circuit and illustrate the range of applications of these circuits. It will also include an appendix giving proofs of some of the statements made in the two articles.

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1. Kitchenn, R. G. "Trans-hybrid Loss: An Approximation and Its Error". Telecommunication Journal of Australia, Vol. 27, No. 1, 1977.

A.H. FREEMAN is Supervising Engineer, Switching and Facilities, Country Section, Planning and Programming Branch, N.S.W. See Vol. 18, No. 3.

Former State Director Dies

A former State Director of Post and Telegraphs in Queensland, Mr Claude Faragher died suddenly in Brisbane on April 3, 1977 at the age of 84. He held the Director's position from 1950 until his retirement in 1957.

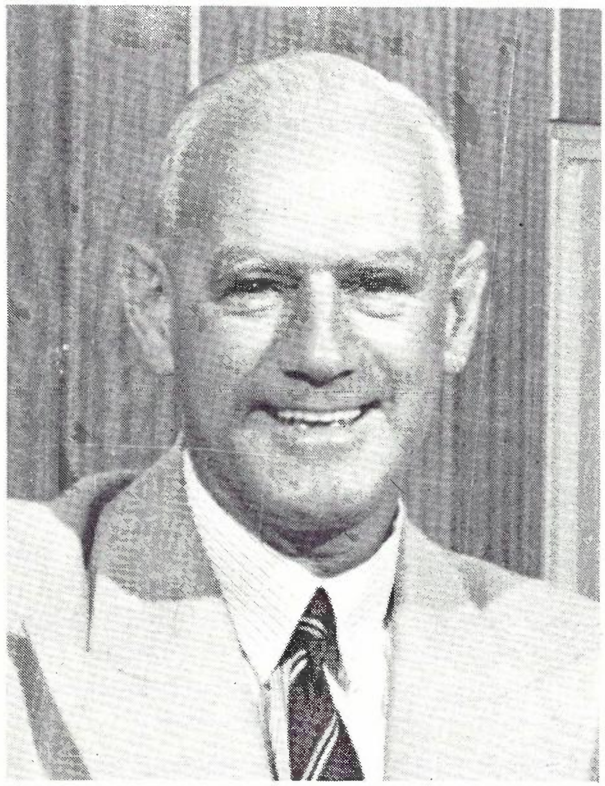
Mr. Faragher was awarded the O.B.E. in the Queen's New Year Honours in 1958 for his outstanding contribution to the development of Communications in Queensland. He served as Chairman of a number of advisory committees established to attack problems affecting the provision and quality of telecommunication services. During the three years the committees were in operation, 1947-50, about 28,000 new telephone subscribers were connected in Queensland. This was a remarkable achievement, considering that in 1950 there were only 105,000 subscribers connected to the Queensland network.

Born in Melbourne in 1892, Mr. Faragher joined the Postmaster-General's Department in 1913 as a Junior Mechanic and rose through the ranks as Mechanic and Engineer in Central Office, Melbourne, to become Director of Queensland.

Mr. Faragher did much to promote and sponsor the formation of the Telecommunication Society of Queensland in 1949 and became that organisation's only life member. He was accorded a similar honour when the Queensland Society became a division of the Telecommunication Society of Australia.

In 1952 when the Post Office Historical Society was formed, Mr. Faragher became its first Patron and during his term as Director gave it his whole-hearted support and encouragement. A room in the Postal and Telecommunications Museum in Brisbane's General Post Office was recently named after him. For a number of years Mr. Faragher directed technical staff recruitment and training and was Chairman of the Classes Committee of the Queensland Postal Institute. He was Secretary and a committeeman of the Professional Officers' Association for a brief period as well.

Mr. Faragher was a former Brisbane Development Commission Chairman, an External Member of the Board of the Faculty of Engineering at the Queensland University from 1950-1960, and a Director of Brisbane Television Limited from the commencement of television in Queensland in 1959 until 1973.



Claude Faragher, O.B.E., M.I.E. Aust.

Mr. Faragher always maintained an active interest in the Telecommunication Society's affairs and was a regular attender at lecture meetings, indeed he was last in attendance at a meeting only a fortnight before his death.

Remote Control Open-Circuit Detector

A. J. VIRDUN, B.E., B.Sc.

This article describes the operation of an open-circuit detector which is installed in an exchange and operated remotely from the Fault Despatch Centre (FDC) or Subscriber District Centre (SDC). It was developed to be used by FDC or SDC staff to determine reliably whether an open-circuit fault is in the exchange or not, because indications derived from the usual method of observing "fleeting" discharge currents on the test desk meter have been found to be unreliable if the open-circuit is near the exchange; the reason for this is that the capacitance of the long junctions involved between FDC and exchange is added to the line under test.

The open-circuit detector design is currently being examined by the Equipment Design co-ordination Section, New South Wales. At present, it is not an official standard design of Telecom Australia.

INTRODUCTION

A problem in testing open-circuit subscribers lines on distant exchanges from a central test point, such as a Fault Despatch Centre (FDC) or Subscriber District Centre (SDC) is to decide whether the fault is in the exchange or outside but close to the exchange.

If the open-circuit is well outside the exchange, there is no difficulty in making this decision by the normal FDC test desk method of observing fleeting discharge currents on a meter; a lineman can be despatched to attend the fault without reference to the exchange. But if the open-circuit happens to be near the exchange, the FDC-exchange junction cable pair capacitance masks that of the tested line, making it almost impossible for the FDC operator, using the test desk method, to decide whether the open-circuit is in the exchange or not. To resolve these doubtful cases, an open-circuit test has to be carried out on the test desk at the exchange; this extra test delays the despatch of a faultman and also takes up the time of a technician, both in testing and advising the FDC of the result.

This remotely controlled open-circuit detector was developed at Sutherland Operations in New South Wales to enable test desk operators at Fault Despatch Centres or Subscriber District Centres to determine with certainty whether an open-circuit fault on a subscribers line is in the exchange or outside. The use of the open-circuit detector reduces the demands upon technical manhours both at the FDC and the exchange by removing the need for the extra test.

METHOD OF OPERATION

The more decisive indications given by this open-circuit detector are possible because it measures the capacitance of the tested line independently of the junction test pair.

The best possible accuracy of measurement, the open-circuit detector is installed in the exchange as close as possible to the subscribers line test relay set FIR-P or test distributor.

The detector can be adjusted within certain limits to allow for the capacitance in the length of exchange wiring from the FIR-P or test distributor to the MDF. If the measured capacitance exceeds by a certain amount that of the exchange wiring, a relay in the detector operates, causing busy tone to be sent to the FDC operator. This indicates that the open-circuit is outside the exchange and the fault should be given to a lineman for clearance. If the measured capacitance is near that of the exchange wiring, the detecting relay does not operate and dial tone is returned. The staff responsible for Main Distributing Frame (MDF) work in the remote exchange are then advised that the open-circuit is in that exchange and the fault is cleared by them.

Most open-circuits in exchanges occur on the Main Distributing Frame with faults such as loose links and broken jumper wires. Other causes include lines temporarily disconnected and jumpers connected to wrong pairs. Due to the variations in exchange wiring lengths between the open-circuit detector and the FIR-P or test distributor, depending on the particular thousands group con-

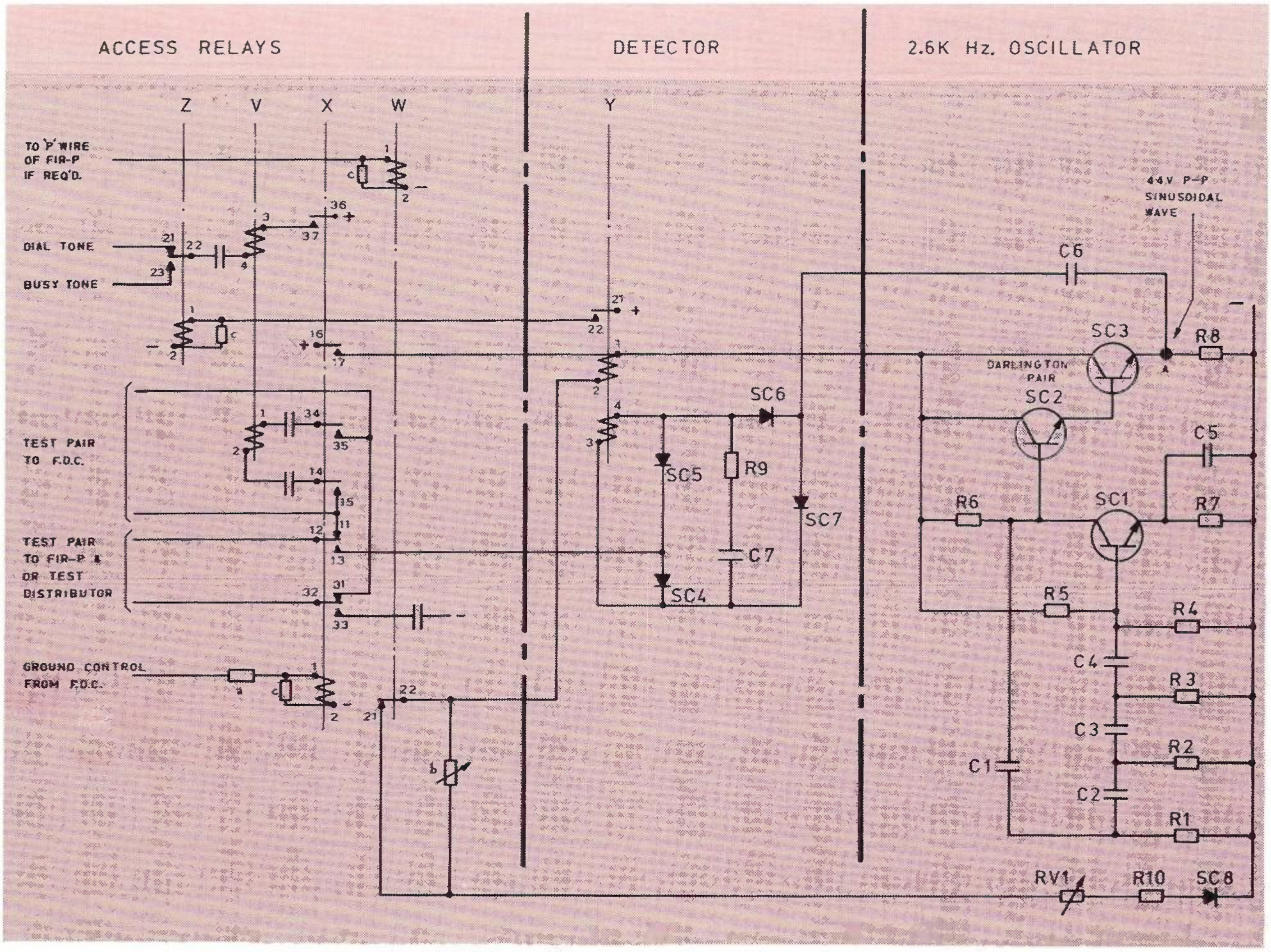


Fig. 1 — Circuit Diagram.

cerned, and due to the tolerance allowed when the detector is set-up to achieve definite operation of the detecting relay, an open-circuit between MDF and the first pillar may be indicated as inside the exchange. However, the chance of this is remote as very few open-circuits occur between MDF and the nearest pillar.

In the initial design, the detector is activated remotely by an earth applied from the FDC via an order wire, but a proposed improvement will be to use an Extended Test facilities Interface relay set installed at the Exchange from which an earth will be extended to operate the detector after the FDC operator has dialled its access number.

GENERAL CIRCUIT DESCRIPTION

When the 'X' relay is operated in the open-circuit detector, after a resistive earth is applied to tag 1 of the 'X' coil, the test pair is broken so that the open-circuit line can be tested with the junction test pair removed (see Fig 1). At this time also a path is connected to carry dial or busy tone to the FDC depending on whether the 'Z' relay operates or not. The oscillator also begins to operate, as soon as earth is applied to it via the operated 'X' contacts 16/17 and its output (44 V P-P sinusoidal wave) is applied to the line being tested via the detector circuit.

The amounts of direct currents flowing through the 'Y' coils 1-2 and 3-4 determine whether the 'Y' relay detector operates or not. The current in the 'Y' coil 1-2 can be varied by adjusting the variable resistor RV1 or 'b' and the current in the 'Y' coil 3-4 is a full-wave-rectified ac smoothed by capacitor C7. This latter current increases as the length of open-circuit line increases (see Fig 2). Thus the 'Y' relay can be set not to operate for open-circuits terminated on the MDF and to operate for those a certain distance beyond this point. Therefore, since the 'Y' relay operated causes 'Z' relay to operate, it can be seen that dial tone will be sent to the FDC via the junction test pair for open-circuit lines at the MDF and busy tone for other conditions.

CIRCUIT DETAILS (See Fig. 1)

'X' Relay

This relay is operated via earth (from FDC or extended test facilities relay set), current limiting resistor 'a', coil 1-2 and negative battery. The functions of the various operated 'X' contacts are as follows:

- Test pair from the FDC is connected to 'V' coil 1-2 via two dc blocking capacitors and operated 'X' contacts 14/15 and 34/35. The test pair is connected in this mode to carry dial or busy tone to the FDC operator.
- Operated 'X' contacts 12/13 and 32/33 break the test pair and connect the pair going to MDF in series with 2.6 kHz oscillator output, dc blocking capacitor C6, full wave rectifier bridge with smoothing capacitor C7 and current limiting resistor R9, 'Y' coil 3-4 and capacitor at X33 to negative battery. This latter capacitor is used to prevent the fuse being blown if the open-circuit detector happens to be operated when an earth fault on the tested pair is connected to 'X' contact 32.
- Earth is connected via operated 'X' contacts 16/17 to the printed circuit board switching on the oscillator.
- 'X' contacts 36/37 operated place an earth on 'V' coil tag 3, resulting in dial or busy tone flowing in 'V' coil 3-4.

It should be noted that the tested pair is not connected between the detecting circuit and the output of the oscillator because any faults on the line could cause transistors (SC2 and 3) to be damaged. Connected as it is now, any line faults will be buffered by the detecting circuit and the transistors will not be affected.

'V' Relay

The coils on this relay, which has no contacts, are used to form a transformer with coil 3-4 being the primary winding and coil 1-2 the secondary winding. Furthermore, the armature on this relay is bent over so that no air gap is present to

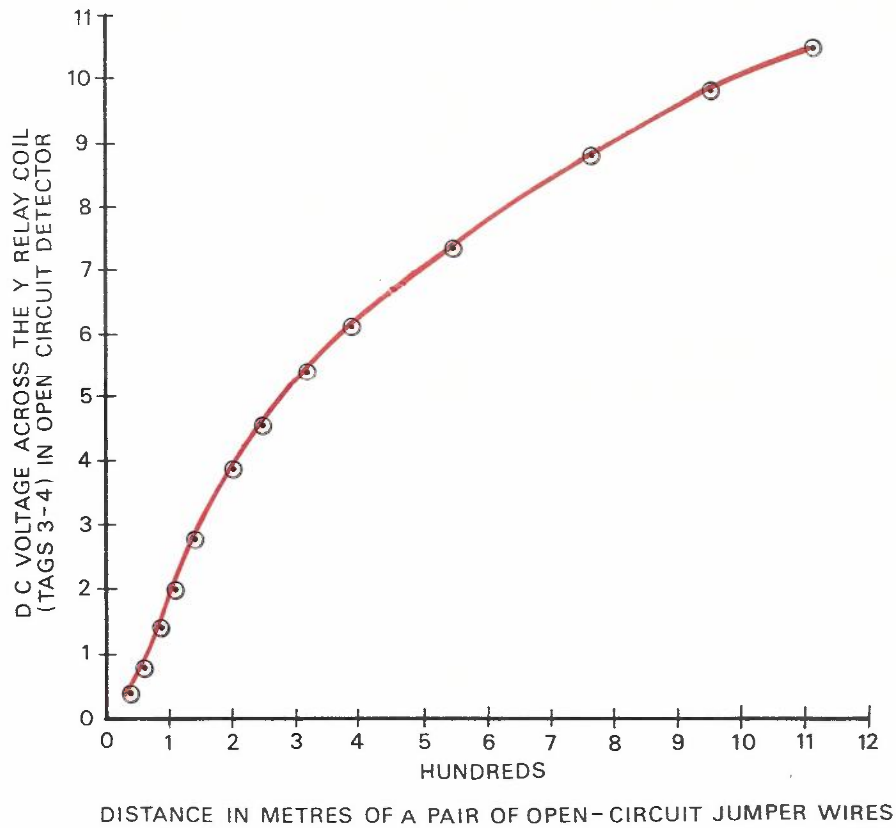


Fig. 2 — Voltage/Open-Circuit Resistance.

improve its operation as a transformer. This relay is used as a transformer to provide good impedance matching between the test pair to the FDC and the output of the tone generator.

'Y' Relay

This relay has the important function of detecting whether the line under test is open-circuit at the MDF or beyond. There are two types of 'Y' relay that can be used. Originally it was a RAF type and it worked satisfactorily even with the residual magnetism and mechanical problems associated with such a relay. However, the other type of 'Y' relay currently being used is a dry reed relay and its performance is better with none of the disadvantages of the former relay. Nevertheless, either relay can be used in the detector circuit without any further circuit modifications required although the reed relay is preferred. If the RAF relay is used, its accuracy can be improved (if necessary) by increasing the tension of spring 21. In most cases, this spring tension should be adjusted to about twelve grams.

'Z' Relay

When the 'Y' relay operates, 'Z' relay operates via earth, operated Y21/22 contacts, 'Z' coil 1-2 and negative battery. Dial tone is sent to the FDC via 'Z' contacts 21/22 normal and busy tone via operated 'Z' contacts 22/23. If the 'Y' relay (RAF type) is used to do this function, no tone would be sent to the FDC when it is partially operated and this is unsatisfactory. Further, the 'Y' reed relay cannot be used as it only has one set of make contacts and so it has not the necessary facilities.

'W' Relay

Variable resistor 'b' and relay 'W' are only used when an exchange contains both step-by-step and crossbar equipment and the same open-circuit detector is used to test either type of line. Thus, if a crossbar number is dialled from the FDC, relay 'W' is wired to operate, removing the short-circuit across 'b' which is then placed effectively in series with variable resistor RV1 for this particular open-circuit test. However, if a step-by-step number is dialled, relay 'W' does not operate resulting in only RV1 being placed in the circuit for this test. It should be noted that relay 'W' is operated, if required, via an earth from FIR-P relay set, 'W' coil 1-2 and negative battery.

When the open-circuit detector is being set up in the above case, a step-by-step number is used first with RV1 being adjusted and a crossbar number is used next with 'b' being adjusted. This order is necessary as less resistance is required for step-by-step lines because of the different characteristics.

Another condition obviously required before the open-circuit detector can be used in the above manner is that the two coded groups of numbers involved are accessible from the FDC via the same set of junctions. Thus, in some circumstances, one detector is all that is necessary to test more than one code of numbers but, in other circumstances, more detectors may be required depending on the trunking and switching methods used.

2.6 kHz PHASE SHIFT OSCILLATOR

Fig. 1 shows the circuit of this sinusoidal oscillator which operates at a frequency theoretically equal to approximately 1/(10Ri Ci) Hz where i = 1,2,3 or 4.

This oscillator is designed to operate at a frequency of about 2.6 kHz to give the optimum current change in the detector circuit for an open-circuit line at the MDF and just outside the exchange.

Transistors SC2 and SC3 (Darlington Pair) and resistor R8 are used to provide a low impedance current source to the detector circuit and open-circuit test pair. The amplitude of this output at emitter of the transistor SC3 is approximately 22V peak.

VOLTAGE SUPPLY

The open-circuit detector is designed to be operated from a dc regulated power supply of about 50V. A regulated power supply is required as the accuracy of the detector is affected by voltage variations although small variations can be tolerated. If the open-circuit detectors are operated from exchange battery supplies, the problem of drifting voltages is minimal.

CONSTRUCTION

Constructional details of the open-circuit detector are according to drawings ND.40914 (Issue 2), NDA.40914 (Issue 2), ND.40919 (Issue 1) and NDA.40919 (Issue 1).

The trimming potentiometers RV1 (on printed circuit board) and 'b' are placed so that they are easily accessible as shown in Figs. 3 and 4.

SETTING-UP

The following setting-up procedure is typical:

- Choose in the exchange the group of lines which gives the furthest electrical distance between FIR-P or Test Distributor and MDF.

- Choose from this group of lines an open-circuit line which terminates on the MDF.
- Ask FDC operator to dial up this open-circuit line.
- Connect about 120 metres of a pair of open-circuit jumper wires to the above line (see section on accuracy of open-circuit detector).
- Adjust variable resistor VR1 or 'b' until 'Z' relay just operates when the 'X' relay is operated manually.
- Ask the FDC to operate the open-circuit detector. When this is carried out check that busy tone is being heard.
- Ask FDC to release detector.
- Remove pair of jumper wires from MDF.
- Operate 'X' relay again manually and 'Z' relay should not operate.
- Ask FDC to operate detector again and check that dial tone is being heard.
- Ask FDC operator to release detector and test pair.

ACCURACY

Although in the previous section on setting-up procedure approximately 120 metres of a pair of open-circuit jumper wires are connected to the MDF to simulate a fault just outside the exchange, the open-circuit detector is much more accurate than this in practice. The reason is that there is more capacitance between open-circuit pair and to earth in a cable than in the same length of a pair of open-circuit jumper wires.

The open-circuit detector correctly indicates whether an open-circuit is at the MDF or the nearest pillar even when this is only 17 metres from the Exchange. (See Table 1).

COSTS AND BENEFITS

The present cost to manufacture this open-circuit detector is about $100 and its installation and setting up procedure requires about eight manhours. Since these detectors have been installed in all exchanges in the Sutherlands Operations Section they have been operating reliably. Faults have been cleared more quickly and incorrect disconnections at exchanges have been detected and rectified with a minimum of delay. The units have also been used to good advantage when testing into exchanges when unattended.

It is estimated that at least 40 manhours are saved annually for each open-circuit detector used at Sutherland Operations. At this rate of saving

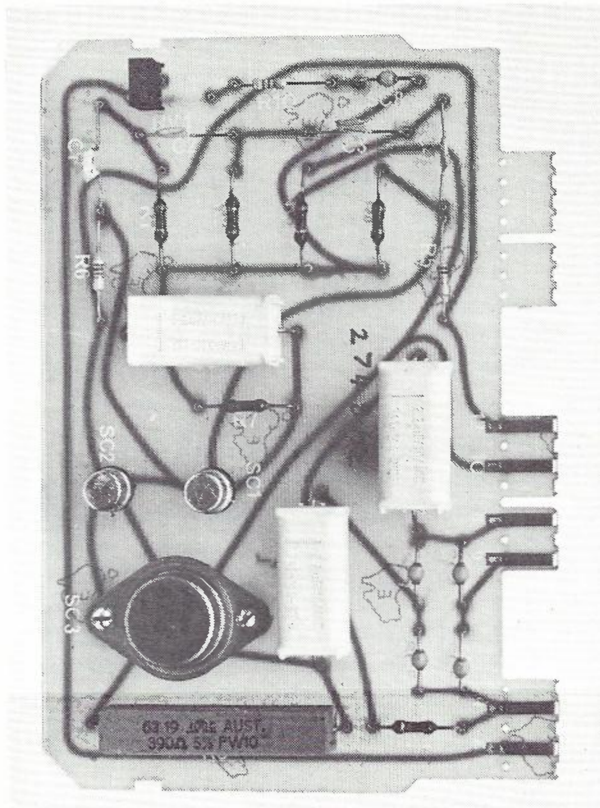


Fig. 4 — Printed Circuit Board in Relay Set.

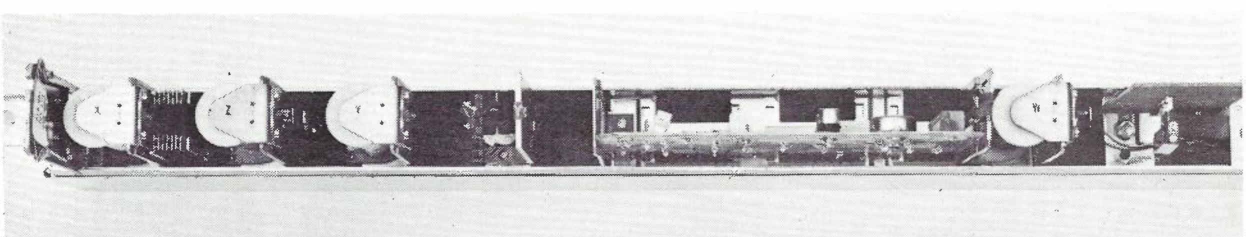


Fig. 3 — Relay Set.

TABLE 1 — ACCURACY OF OPEN-CIRCUIT DETECTOR

Exchange	Approximate Distance between MDF and Nearest Pillar to Exchange (Metres)	DA Number	Remarks
COMO	45	30	In all these cases detector correctly indicated whether open-circuit was at MDF or pillar. Main pairs used were not multipled.
CRONULLA	96	68	
ENGADINE	98	4	
KURNELL	17	2	
MIRANDA	53	74	
RAMSGATE	52	47	

the provision and installation costs will be recovered after the detector has been used for about nine months.

CONCLUSION

The open-circuit detector described in this article was developed at Sutherland Operations to enable FDC test desk operators to determine accurately whether an open-circuit fault is in the exchange or beyond. Twelve (12) such open-circuit detectors have been in use in this Section since September 1973, and all have been operating reliably. They are proving to be of great help to test desk operators at the FDC.

Equipment Design Co-ordination Group (NSW) are currently examining the above detector and future development will depend on this investigation.

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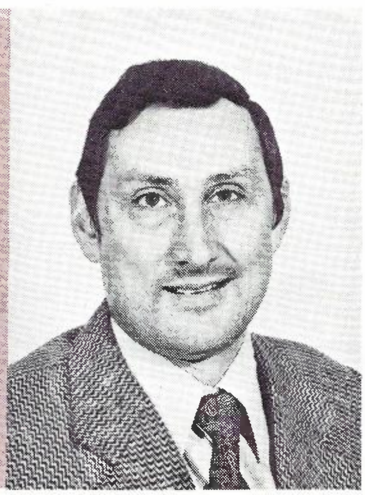
2. Malvino, A. P.: 'Transistor Circuit Approximations'; 1968.
3. 'Maintenance Parts for Automatic Exchanges'; Network Performance, Sydney, 1970.

A. J. VIRDUN graduated from University of Sydney in 1965 with Degrees of Bachelor of Science and Bachelor of Engineering (Electrical). He spent two years at Standard Telephones and Cables, Moorebank, in Radio Communications Section. In 1967, he joined Postmaster-General's Department as an Engineer Class 1. He is now an Engineer Class 2 at Metropolitan Operations Branch, Metropolitan Operations No. 6 Section, Sutherland, New South Wales, and has been involved with exchange maintenance since 1971.



Provision of Telecommunications Facilities to the Sugarloaf Dam

W.J. LAHEY, B. Eng. (Hons.)

To provide telecommunications facilities for contractors working on the dam's construction involved a cable route which would be covered by 35 metres of water. This required a specialized cable to be designed and manufactured together with the use of recently developed jointing equipment. This paper describes the problems encountered and the solutions needed to provide service.

INTRODUCTION

The Sugarloaf holding dam is presently being constructed over a five year period in an area south west of Christmas Hills, 33 km north east of Melbourne. The total cost is currently estimated at $118M.

Apart from the Sugarloaf Creek that will run into the holding dam, there is very little local catchment. The dam will be filled by pumping water up from the Yarra River at Yerin Gorge, through a pipe 1.3 km long. The maximum head of water in the dam will be 35 m. A purification plant will treat the water as it is fed into the metropolitan area.

A small coffer dam has been built across the Sugarloaf Creek to enable construction of the initial stages of the main dam wall to proceed clear of the rising water.

During the busiest period of construction it is estimated that there will be eight major contractors and several subcontractors, employing a total of approximately 250 people. It is anticipated that there will be a high calling rate to Melbourne generated by these contractors plus a large amount of traffic between the Melbourne and Metropolitan Board of Works (MMBW) head office and site office.

Figure 1 shows the general layout of the site with the site office located at point A. The site itself straddles the boundary between the Yarra Glen and Panton Hill exchange areas, the former being a terminal off Croydon and the latter off Hurstbridge Minor Switching Centre.

A new Penteconta PABX is to be provided at the site office by the MMBW, together with about 150 extensions.

After a number of meetings between the MMBW and Metropolitan Operations Branch Victoria, the telecommunications facilities decided upon required 41 cable pairs for:

- 12 lines with indialling.
- 5 exclusive lines with both way working.
- 5 tie lines.
- 2 telegraph lines.
- 12 lines outgoing.

ROUTE SELECTION

The nearest cable to the site office is a 28/0.90 PIQL buried cable north of the dam site (see Figure 1). This cable links Yarra Glen and Panton Hill exchanges. It was decided to utilize this cable to allow the traffic to be distributed to both Yarra Glen and Panton Hill. Both are small rural ARK-D exchanges and it was thought that if all outgoing traffic from the PABX was routed through only one exchange severe congestion would result.

Thus a route was required for a cable to intercept the existing 28/0.90 PIQL buried cable and to be safe from any future disturbance.

This ruled out any route approaching the proposed site office from the west because of the extensive construction planned in the south-west portion of the project area.

Since small rural ARK-D exchanges are not designed to provide for an indialling facility, it was necessary to provide it from the Hurstbridge exchange via the junction cable. This ruled out any route approaching the site office from the east as the route distance from Hurstbridge would be beyond transmission limits. A maximum loss of 7.5 dB between instrument and exchange is allowed and for a crossbar exchange a maximum line resistance of 1500 ohms.

A route had to be taken to site office from the north across the bed of the proposed dam. A great deal of topsoil on the bed of the dam is to be removed requiring a large number of temporary tracks to be built. Because of this the route had to be determined jointly with the MMBW to avoid damaging the cable.

However, because the proposed route crossed the back fill of the small upper dam, which would obstruct the moleplough when full, provision had to be made for a longer alternative route east of the water line.

To keep joints clear of water a single length of 900 metres of cable for the favoured route was required, with the alternative requiring 1200 metres.

DESIGN OF THE CABLE

To meet transmission requirements, a 0.90 mm cable, loaded for VF working, was necessary. This cable had to be flexible enough to be mole-ploughed but have the mechanical strength to

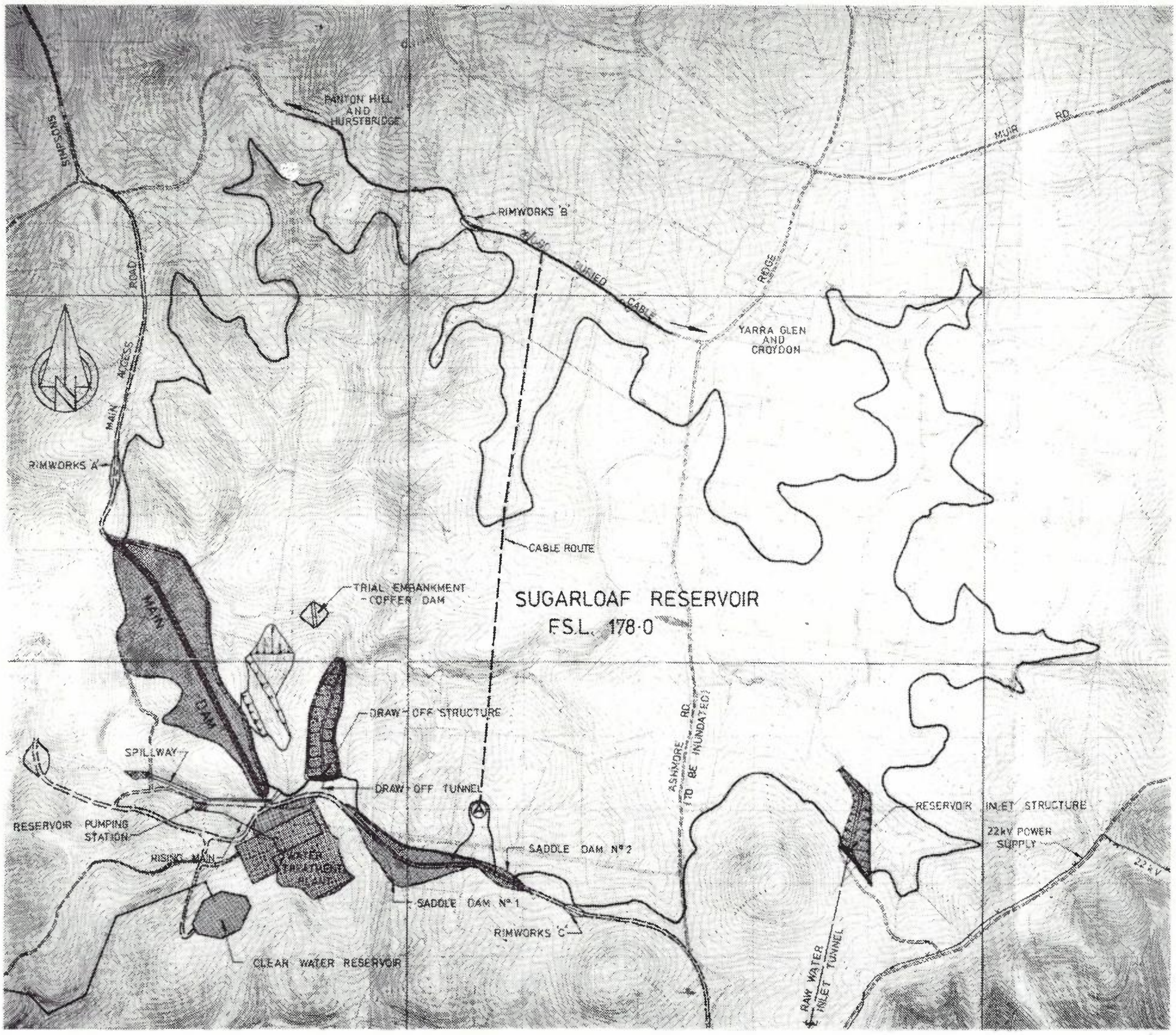


Fig. 1 — Sugarloaf Reservoir Project — General Layout.

Fig. 2 — Moleplough Installing Cable.

withstand the 35 m head of water. These requirements were forwarded to Cable Design Section, Lines Construction Branch, Headquarters, for assistance. In considering which type of cable to install, a number of factors precluded the use of existing types.

Because of the danger of water permeating the sheath, any paper insulated cable had to be rejected since moisture in the cable causes impaired transmission characteristics.

The choice of insulation was between polyethylene (PE) or polyvinylchloride (PVC). PVC insulation was rejected as PVC is not a favoured insulation for such an application.

A number of factors precluded the use of a lead sheathed cable. Not only would such a cable be expensive and a drum of 1200 metres be very heavy but at present the only specification for a lead sheathed, polyethylene insulated cable is for a cable with 0.5 mm diameter conductors.

It was considered that existing polyethylene insulated cables with polyethylene sheathing would not have had the mechanical strength to withstand the 35 m head of water. Also there was a real danger of a polyethylene sheath being pierced during installation.

To provide the necessary mechanical strength a cable with a polyethylene sheath of twice the normal thickness was decided upon and a double thickness nylon jacket to reduce the danger of the sheath being pierced.

Normally a certain number of insulation faults per drum length of cable are tolerated but, because the cable would eventually be inaccessible, a completely fault-free insulation was specified.

Consequently an order was placed with Austral Standard Cables Pty. Ltd. to supply 1200 metres of 50/0.90 PEIUT/PEHJ in accordance with the existing schedule C8064 but with the following exceptions:

- PE (polyethylene) sheath to be 4.6 mm minimum thickness.
- Nylon HJ (Hard Jacket) to be 7.6 mm minimum thickness.
- Core to be found fault-free by spark testing and confirmed by water bath testing.
- The complete cable to be pressure tested at 200 kPa to ensure sheath integrity.

The cable was manufactured in the normal way except that different sized dies in the extrusion

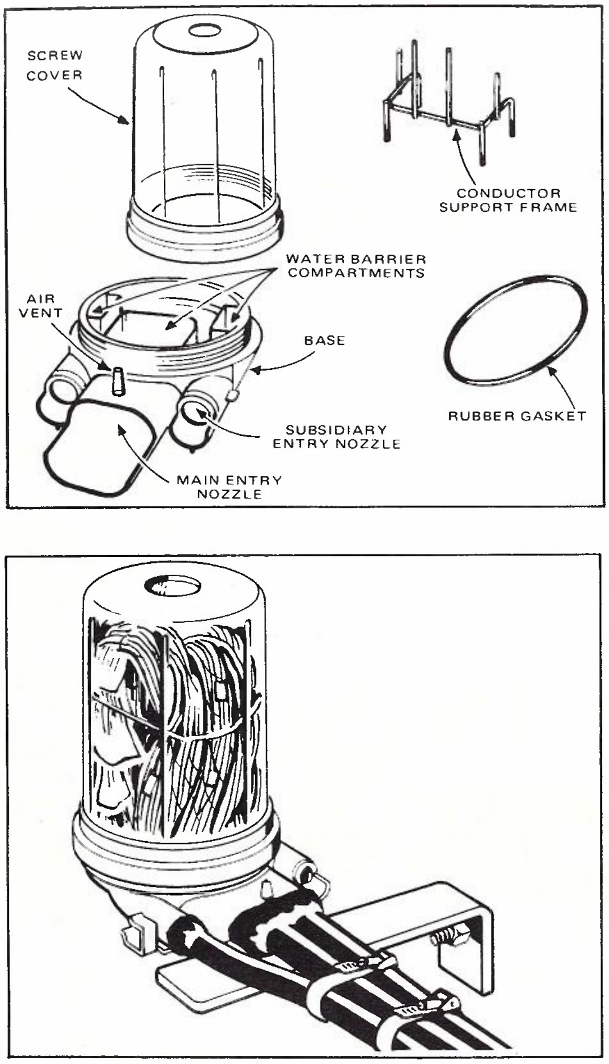


Fig. 3 — Large Screw Type Openable Joint.

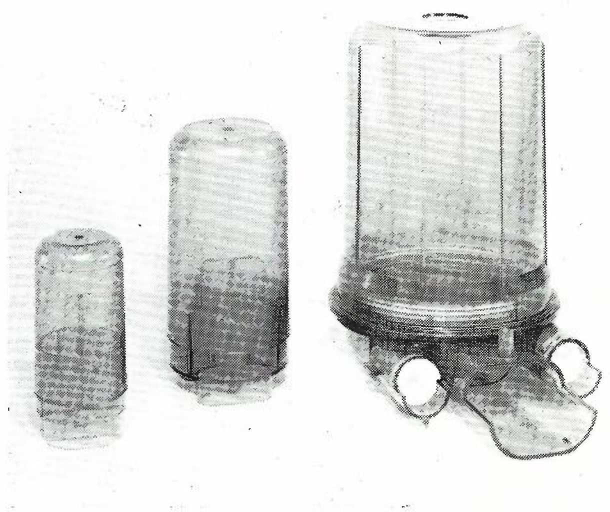


Fig. 4 — Left to Right — Small Openable Joint, Large Openable Joint, Large Screw Type Openable Joint.

process were used to obtain the necessary thickness of sheath and jacket. During spark testing two insulation faults were found. These were repaired by moulding polyethylene over the break in insulation. The cable core was then placed in a water bath for twelve hours followed by insulation resistance testing and confirmed as fault free.

INSTALLING THE CABLE

Fortunately the water in the coffer dam was not deep enough to require the longer, alternative route to be used. The MMBW had cleared a wide track across the main dam bed one week before the moleplough arrived on site. The cable was installed in just over two hours (Figure 2), leaving both ends above the maximum water level.

Due to the conductor gauge and sheath thickness, the normal methods of jointing, using the existing large openable joint or above ground jointing post, were inadequate. The opportunity was taken to use the recently developed Large Screw Type Openable Joint (Figure 3) for its first field installation trial in a work situation.

The Large Screw Type Openable Joint is designed to extend the range of cable sizes which can be jointed in openable type joints. Figure 4 shows a comparison between the small existing and new, Large Screw Type Openable Joint.

Because of the cables stiffness a larger pit than usual was used to house the cable and joint. During the installation of the openable joint a number of weaknesses were found as a result of which some modifications are planned. It was found that:

- The fixing bars that screw into the sides of the pit and support the joint bent when housing the cable. Larger diameter bars are to be specified.
- A larger air vent is necessary to enable all the air to escape during the sealing of the water barriers with epoxy resin.
- The bracket on which the openable joint sits needs to be level in both horizontal axes regardless of the inclination of the pit. Otherwise the epoxy resin will run out and not completely seal the entry nozzle. The Engineering Instructions for the Openable Joints use will include this observation.

CONCLUSION

The MMBW made known their requirements in late July 1976, and the cable was installed just four months later in November. Although a number of separate Departments within Telecom Australia at State and Headquarters were invloved, the quick response was mainly due to decisions being made at the lowest level possible, with excellent co-operation between all parties. Communication between the parties was mainly along informal channels with written correspondence kept to a minimum but still meeting all procedures and adequately recording all essential factors.

Due to the Cable Design Section, Headquarters, becoming involved in the project, a cable well suited to the conditions was installed. It would have been unlikely that the Operations Section, relying on its own resources, could have provisioned a cable equally satisfactory.

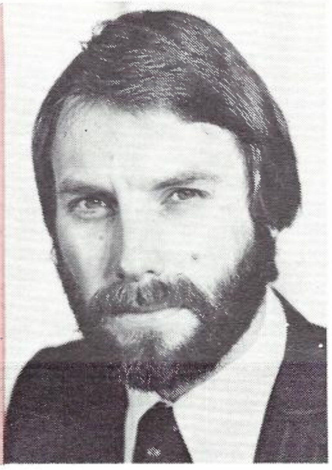
Benefits to both Sections resulted from working together on a specific project. Cable Design Section became more aware of the needs of an Operations Section and the latter gained from the specialised expertise made available. There is scope for Headquarters to become more involved with similar projects in individual Operations Sections.

There is a need to assess the specialised assistance that Headquarters could provide to the Operations Branch and to make it known. Some formal method would then be required to enable Operations Sections to call on this assistance when needed. This method could take the form of a small organisation that assesses the needs of a Section requesting assistance and puts it in contact with the relevant personnel within the Headquarters Administration. Once in contact both parties would decide themselves on the best way to work together.

ACKNOWLEDGEMENTS

The author would like to thank John Groom of Cable Design Section, Lines Construction Branch, Telecom Australia Headquarters for his assistance in preparing this article.

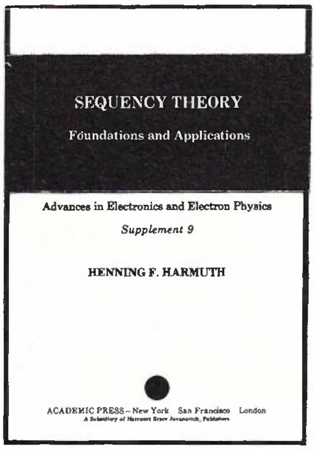
BILL LAHEY graduated from Sheffield University, England in 1972. Before joining the Australian Post Office in 1973, he worked for Standard Telephones and Cables Ltd., England, commissioning T.X.E.2 electronic exchanges. On joining the Australian Post Office he was appointed Engineer Class 1 Wollongong, N.S.W., working on external plant projects. After a period as Acting Engineer Class 2, External Plant Planning, he was transferred to the Metropolitan Operations Branch, Victoria, as an Operations Engineer. He is now Organisation Officer, Establishments Section, Personnel Department, Headquarters.



Book Review

SEQUENCE THEORY: THEORY AND APPLICATIONS

H. F. HARMUTH; Academic Press.



Research into communications applications for Walsh function techniques has continued vigorously since interest was generated, largely by Harmuth, in 1969. This book continues in the deep, exhaustive style of Harmuth's earlier work. In this work (Ref. 1) Harmuth has concentrated on a number of areas of communications research and quantum physics which are well proven applications for sequency techniques. Many other areas of communications and electronics research where Walsh functions are under investigation have not been considered in this work. The emphases here is on filtering and processing of signals for television and underwater acoustic imaging, electromagnetic propagation for radar applications, and mathematical applications in quantum physics.

The first chapter treats the mathematical foundations required for the applications of Walsh functions to signal and waveform processing. A comparison is drawn between Fourier and Walsh-Fourier techniques, followed by a consideration of fast transforms and various dyadic operations commonly used in sequency analysis. The treatment is exhaustive and lucid but requires a high level of mathematical understanding. Diagrams and charts are used very effectively in this part of the work to aid the understanding of some difficult concepts. This introductory, mathematical treatment is handled more lucidly than in Harmuth's first book (Ref. 2).

The remaining chapters specialise in particular applications. Chapters two and three concentrate on communications system applications and chapter four on the applied mathematics of quantum physics. This final chapter is particularly heavy going and is of little interest to telecommunication engineers.

The communication applications are treated with an admirable balance between mathematical theory and practical design. Waveforms and circuit diagrams are used freely throughout as well as occasional photographs of laboratory equipment. All these factors lead to a readable, although conceptually complex account of recent work which is not widely known. The circuit realisations used throughout chapter two are basic indeed, however they are used effectively to bring the reader closer to practicalities. For example, the detailed discussion of generators for time-variable Walsh functions based on recurrence relations is of academic interest only when it is considered that cheaper, more reliable designs may be achieved with a simple counter and semiconductor memory. However, the author obviously has a keen awareness of technology development when discussing the practicability of two- and three-dimensional filters for imaging.

The discussion of general electromagnetic wave effects in chapter three is practically oriented and leads on well to the treatment of practical radiators, receivers and radar applications. The author has been a leader in research into antennae and antenna array design for orthogonal time signals, and over one hundred pages of the book bear this out. Improvements in the resolution of radar arrays may be achieved using sequency techniques; therefore Harmuth's work should be of interest to researchers in this field.

In summary, Sequency Theory is an up-to-date account of proven research techniques in the above fields. Although the field of orthogonal functions in communications is filled with new concepts, sometimes rather complex, the author's treatment is lucid and exhaustive at the same time. The book is likely to be useful to post-graduate researchers in the fields of signal processing and analysis, electromagnetic propagation for radar, acoustics and theoretical physics. The bibliography is extensive and useful to all workers in the Walsh function field. This book is not recommended as a basic introduction to Walsh functions and sequency techniques.

REFERENCES

1. Harmuth, H. F.: 'Sequency Theory—Foundations and Applications'; Academic Press, New York, 1977.
2. Harmuth, H. F.: 'Transmission of Information by Orthogonal Functions', Springer Verlag, New York, 2nd edition, 1972.

Reviewed by P. S. JONES, Research Laboratories, Headquarters, Telecom Australia.

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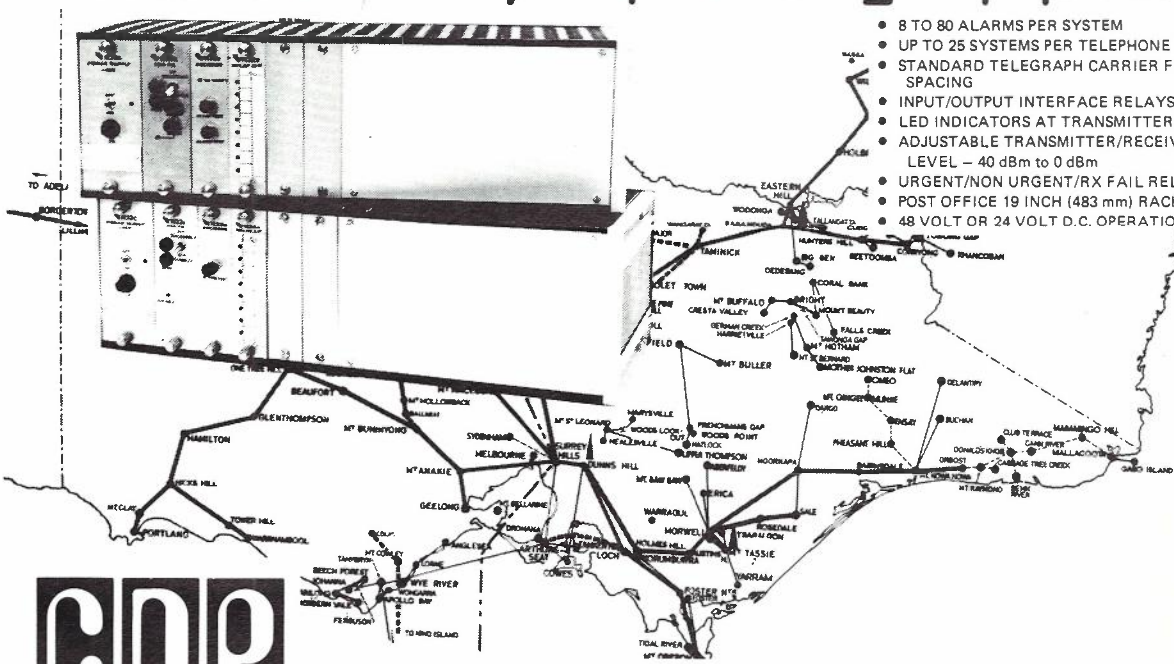
(I.B. refers to the "In Brief" items included in the Journal)

Remote Control/Supervisory Equipment



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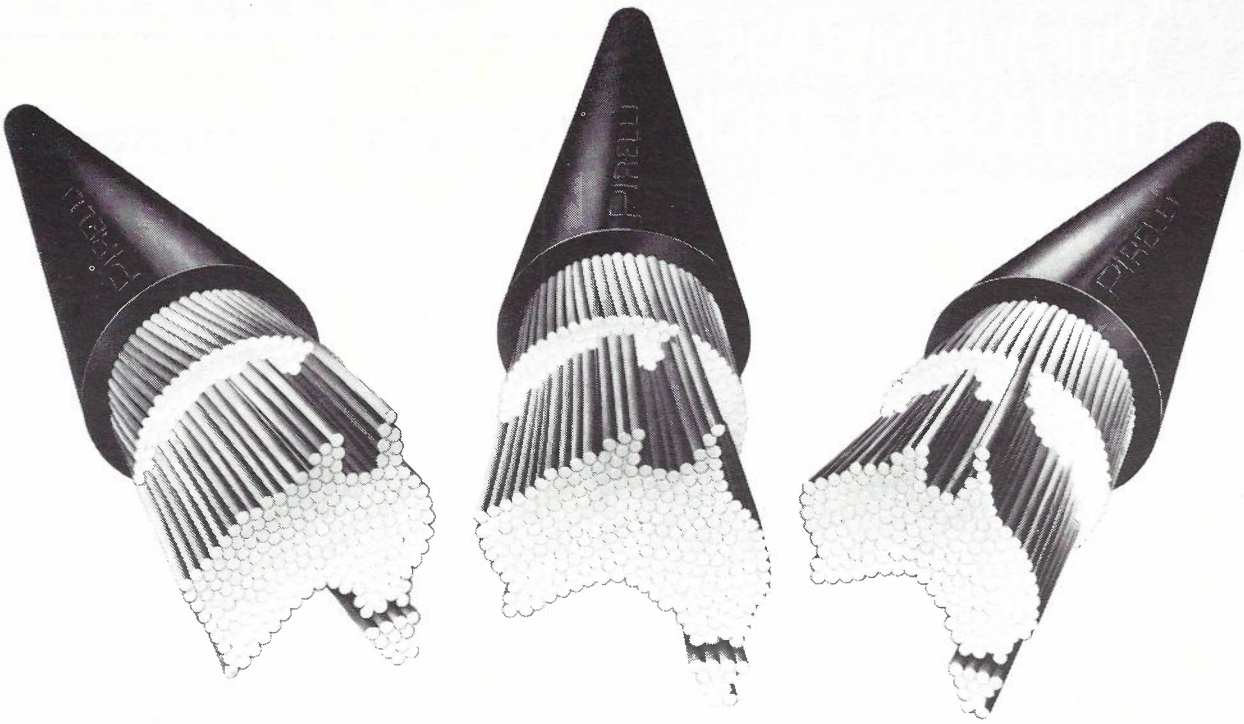

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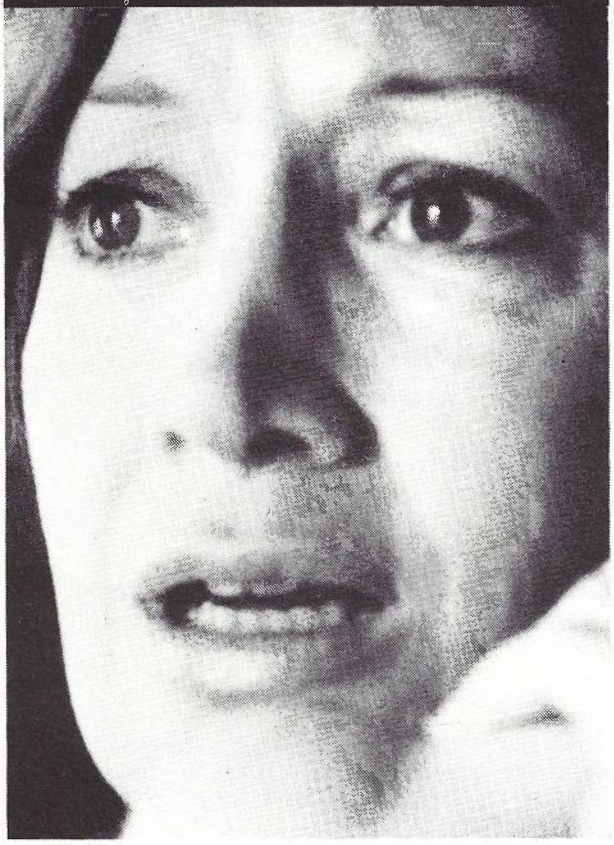

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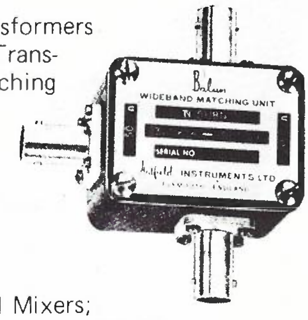

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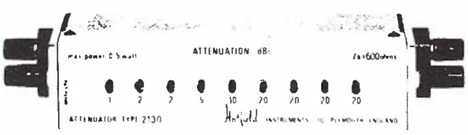

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The Telecommunications Journal of Australia

ABSTRACTS: Vol. 27, No. 3.

BERZINS, G.: 'Towards Maritime Communications by Satellite'; Telecomm. Journal of Aust., Vol. 27, No. 3, 1977, page 223.

Since the early part of this century, communication with ships at sea has been by means of medium frequency radio, and since the early thirties by high frequency radio. Now the development of maritime communications satellites promises to bring fundamental changes to communication with ships, changes which will almost be as radical as was the initial introduction of radio to ships.

Satellites for maritime communication will differ in a number of aspects from the now common point-to-point communications satellites, giving a new range of engineering problems to be solved. Compared to the present radio systems which are essentially manual, the new systems will be highly automated and in the years to come, should lead to fully automatic dialling between subscriber and ship for telephone and telex, and to a distress and safety service of very high reliability.

As the advantages of maritime satellite communications are realised, an increasing number of vessels will be equipped with terminals. Nevertheless, for reasons of cost and shipboard space, satellite communications will tend to be limited to the larger ships, and smaller vessels and boats will still continue to rely on radio for communication. Consequently, for the foreseeable future, conventional radio services will have to be provided.

COLLINSON, J. T., KLINK, T. and LUECKE, H. W.: 'Style 72A — New Generation Carrier Multiplex and Line Transmission Equipment — Part 1'; Telecomm. Journal of Aust., Vol. 27, No. 3, 1977, page 207.

In 1968, the then APO first issued a specification for a unified construction practice with standardised electrical interfaces for locally produced line transmission equipment. After a series of consultations with local manufacturers, a "Design Guide for Long Line Equipment" was finalised. This article describes the Style 72A generation of carrier multiplex and line transmission equipment which has been designed and manufactured by Siemens Industries Limited in accordance with the "Design Guide" and to its basic requirements. The resulting family of equipment includes the entire range of carrier multiplex equipment from channel modems to 15 Supergroup (SG) assembly modems and its associated equipment and the line equipment including 12-channel pair cable and coaxial line systems.

FREEMAN, A. H.: 'Hybrid Transformers'; Telecomm. Journal of Aust., Vol. 27, No. 3, 1977, page 246.

This is the first of two articles designed to inform the reader of the properties of hybrid transformers and present simple methods of designing or analysing circuits in which they are used. This article deals in some detail with a specific two transformer circuit widely used in terminating sets and gives equivalent circuits from which it is relatively easy to estimate or calculate the performance with any terminating impedances.

GAMBLE, P. H., HIGGINS, P. J. and NELSON, C.J.: 'Planning for the Future Data Communications Market'; Telecomm. Journal of Aust., Vol. 27, No. 3, 1977, page 235.

To assist in planning for the future demand in data communications a major study was initiated by the Australian Telecommunications Commission (Telecom Australia). The study, known as AUSTDATA, developed a set of forecasts and an ongoing forecasting methodology to cover data, telex, private telegraph and facsimile services. The study was structured in two integrated stages, State 1 detailing forecasts to 1985 and Stage 2 the long term developments to the year 2000.

KETT, R. W.: 'Design Principles of a New Telephone Apparatus Measuring System — Part 1'; Telecomm. Journal of Aust., Vol. 27, No. 3, 1977, page 198.

An examination is made of the problems involved in measuring the characteristics of telephone apparatus for transmission quality assurance purposes.

Techniques which have been used in the past, both in Australia and overseas, are discussed.

LAHEY, W. J.: 'Provision of Telecommunications Facilities to the Sugarloaf Dam'; Telecomm. Journal of Aust., Vol. 27, No. 3, 1977, page 259.

To provide telecommunications facilities for contractors working on the dam's construction involved a cable route which would be covered by 35 metres of water. This required a specialized cable to be designed and manufactured together with the use of recently developed jointing equipment. This paper describes the problems encountered and the solutions needed to provide service.

SALTER, J. P.: 'Service Restoration and Traffic Control; Its Concept and Its Centre'; Telecomm. Journal of Aust., Vol. 27, No. 3, 1977, page 191.

Most large telephone administrations have been obliged to develop special operational practices and techniques to co-ordinate temporary restoration of service when major plant breakdowns or serious traffic overloads occur. Telecom Australia has established a Service Restoration and Traffic Control Centre in each capital city and at Telecom Headquarters for this purpose. This article outlines the background to the development of the SRTC concept and the establishment of the Sydney SRTC centre which was the first and is the largest such centre in Australia.

VIRDUN, A. J.: 'A Remote Control Open Circuit Detector'; Telecomm. Journal of Aust., Vol. 27, No. 3, 1977, page 253.

This article describes the operation of an open-circuit detector which is installed in an exchange and operated remotely from the Fault Despatch Centre (FDC) or Subscriber District Centre (SDC). It was developed to be used by FDC or SDC staff to determine reliably whether an open-circuit fault is in the exchange or not, because indications derived from the usual method of observing "fleeting" discharge currents on the test desk meter have been found to be unreliable if the open-circuit is near the exchange; the reason for this is that the capacitance of the long junctions involved between FDC and exchange is added to the line under test.

The open-circuit detector design is currently being examined by the Equipment Design Co-ordination Section, New South Wales. At present, it is not an official standard design of Telecom Australia.

WEIR, P. J.: 'Metrology in Materials Inspection'; Telecomm. Journal of Aust., Vol. 27, No. 3, 1977, page 229.

Metrology in material inspection provides a calibration service for inspection gauges and, in Telecom Australia, fulfils a dimensional measuring role for the acceptance testing of the more complex materials.

This article briefly discusses the need for calibrated gauges which can be traced to national standards, some types of metrology laboratory equipment and the skills necessary for a metrologist.

Possible future development of gauge calibration within Telecom Australia is considered and some costs and benefits of the existing system are presented.

THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

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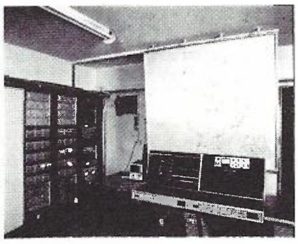

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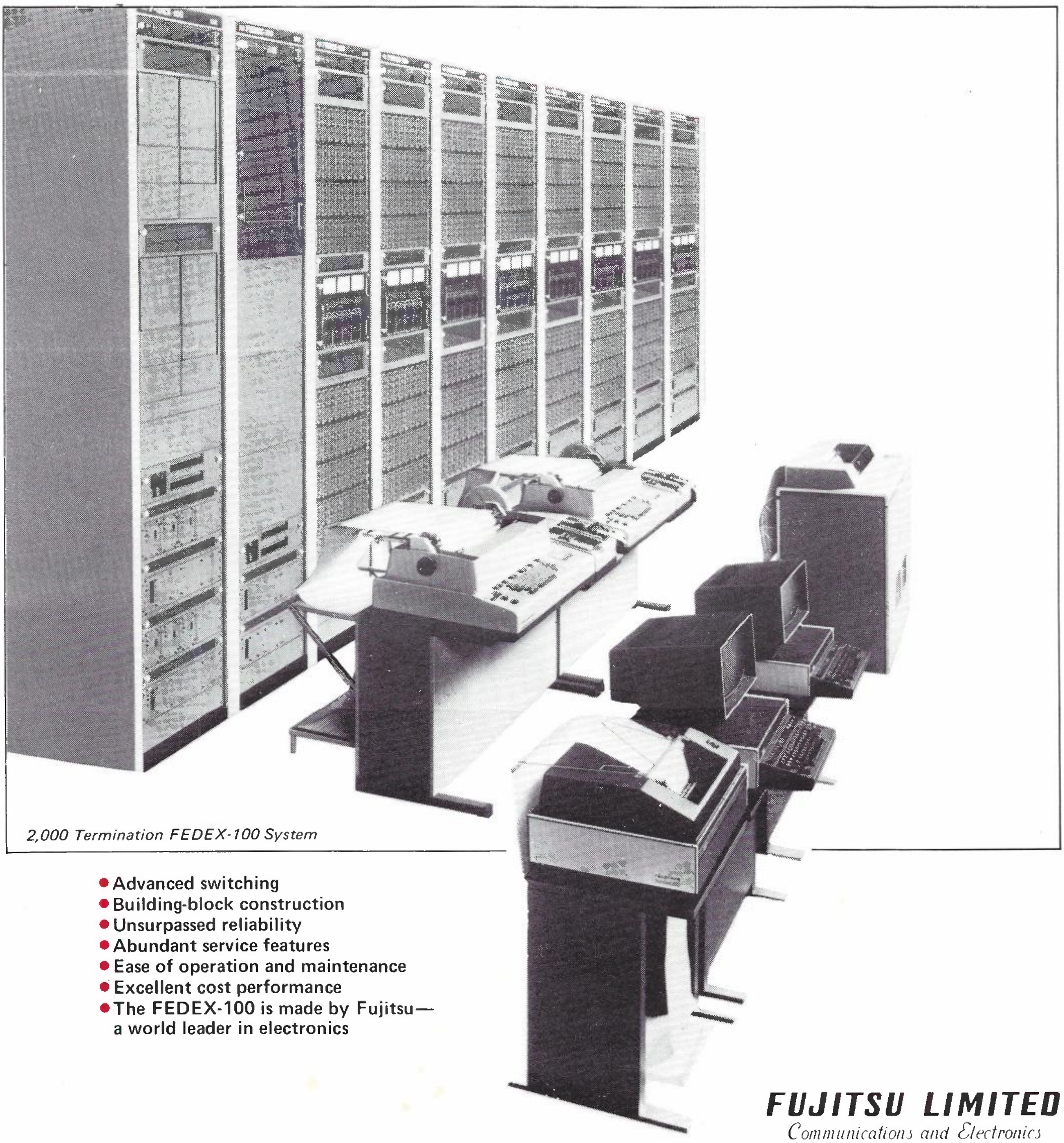

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