Volume 26 No. 3, 1976

the telecommunication journal of Australia

IN THIS ISSUE

26/3

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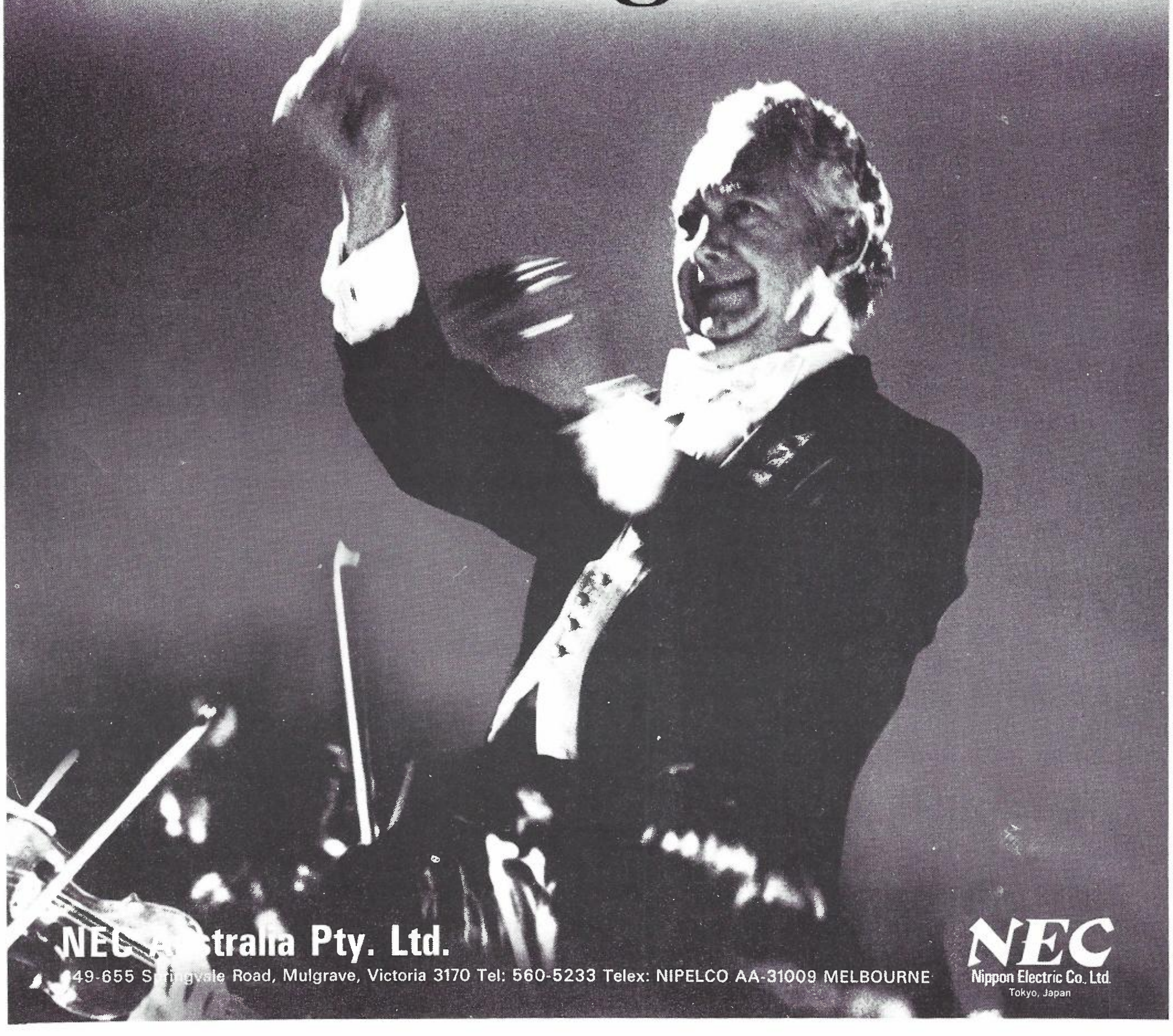

THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

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COVER
SATCOM SATELLITE

The Telecommunication Journal of Australia

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A Model of the National Telephone Switching Network

L. A. TYRRELL and K. A. M. THOMPSON

This article explains why a decision was taken by the APO to build a simulated national telephone switching network at Headquarters; it also describes in some detail the planning of that network and the guidelines that were followed. Some aspects of design are discussed which serves to illustrate how equipment and space were optimised. The role of the network and the precautions that are being taken to preserve its integrity are also outlined.

INTRODUCTION

Telecom Australia and its predecessor, the Australian Post Office, has for many years maintained at Headquarters, small models of particular switching systems to assist in the development and testing of new facilities in the telephone switching network. In due course, a number of such models including the various generations of Step equipment, B and C type RAX's, ARF and ARK equipment, were installed in the Telephone Switching Equipment Branch's Laboratory (now the Switching Design Branch Laboratory). Although these switching models were useful for many purposes, it was usually not possible to test new or modified equipment before its introduction into the field. Protection against design deficiencies lay in the penalty clauses inserted in contracts for equipment of new design and the desire of manufacturers to maintain their reputation as efficient and reliable designers.

The Australian telephone network has become increasingly an amalgam of the products of many manufacturers and no single manufacturer has the capability of system testing new or modified equipment in all of the major switching configurations that now exist in the Australian network. In addition, Telecom Australia designs much of the ancillary equipment needed to support the major switching systems as well as designing the modifications required to update step-by-step switching systems which were installed prior to the introduction of crossbar into the network. All such designs need to be tested under conditions that simulate as closely as possible the conditions that exist in the network.

The circumstances outlined above demonstrate the need which was identified early in the 1970's for a complete restructuring of the switching laboratory to eliminate the severe limitations of the facilities then available.

An additional and important factor in favor of the establishment of an improved switching laboratory was the purchase of a powerful model of the 10C trunk system in conjunction with the Pitt 10C contract to assist in the development of system software. A proposal to establish a model of the national telephone network to enable Telecom Australia to test its own designs and supplement the testing performed by its contractors was approved by the then Director-General Mr. Eber Lane, early in 1973. At the time, this decision was taken, the switching laboratory was located at 10 Lonsdale Street, Melbourne. Space and the special requirements of the 10C model had precluded the use of those premises. The improved switching laboratory was therefore installed in new premises, the Argus Building in Elizabeth Street, Melbourne. Staff from the Victorian Construction Branch commenced work on the installation early in 1973 and the new laboratory was operational in September of the same year.

PLANNING THE MODEL NETWORK

The types of testing which were envisaged when the model was being planned are:

- Test of new switching systems and sub-systems; e.g. ARE 11.
- Test of new items of switching equipment; e.g. new line relay sets.
- Test of interworking between switching systems; e.g. Interception which requires interworking between crossbar terminal equipment and 10C manual assistance.

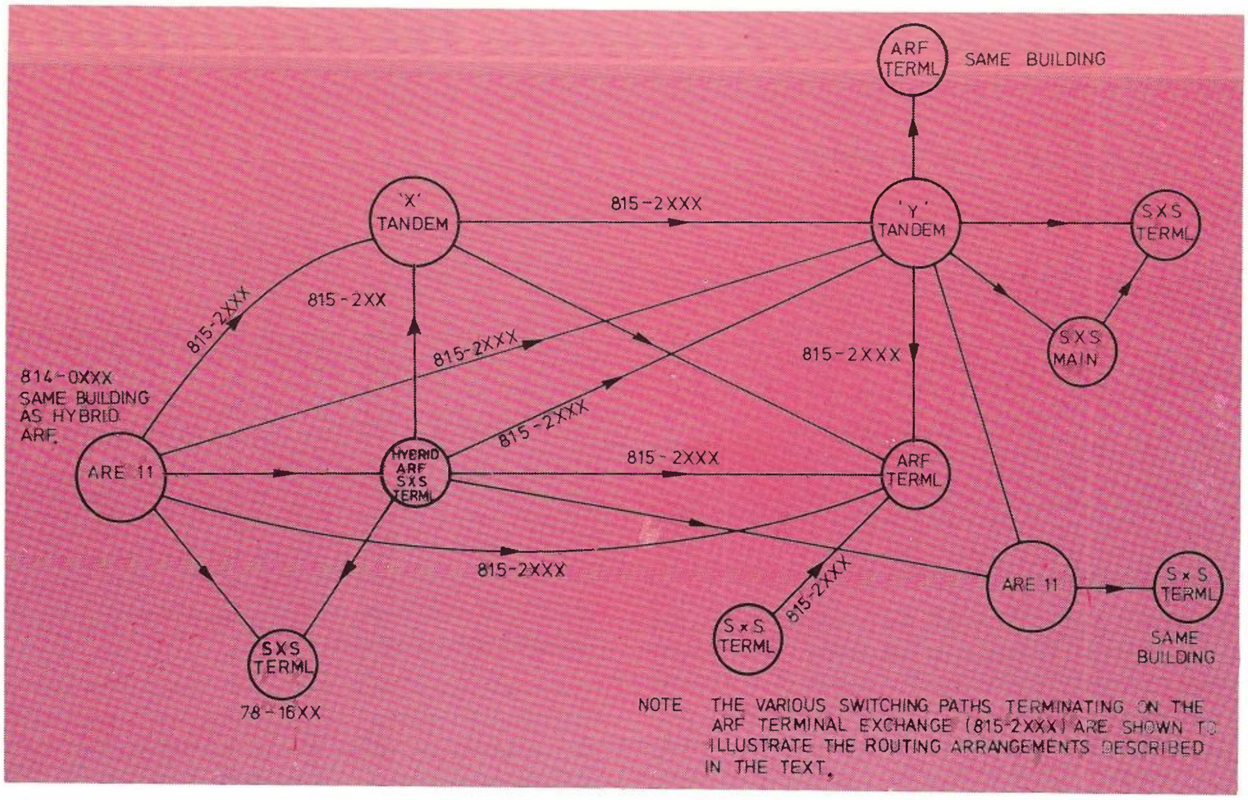

Fig. 1

- Test of modifications of items of switching equipment.
- Study of obscure fault conditions.
- Feasibility studies.

The main users of the laboratory were consulted to determine the principles to be observed in trunking the model network. The system designers required a network which was a true replica of the national switching network incorporating the standard switching hierarchy of terminal exchanges, originating and terminating tandem exchanges, minor switching centres, secondary and main switching centres. Although it was acknowledged that all trunking configurations could not be realised in combination with all signalling sequences, all the significant switching and signalling paths were to be incorporated.

In order to build and house the model at a reasonable cost, it was planned to use some items of equipment in a variety of modes. For example, a single ARM switching stage was to serve as four ARM exchanges through re-entrant trunking arrangements. The efficient operation of the network demanded that the various switching paths be established simply by dialling appropriate codes. Temporary patches and number changes were not to be permitted in order to maintain reliability of the equipment at a high level and minimise the time the model would be unavailable for testing on account of ad hoc trunking re-arrangements.

Various trunking arrangements were examined in the light of the considerations described. It became clear that the use of unallotted national codes would enable the model network to operate within and be connected to the national network so that by dialling the full national code calls could be terminated in any part of the national network. By dialling the codes appropriated for the network's own closed numbering area, calls could be terminated within the model network. The means were therefore to hand to simulate a model national network which also had access into the public telephone network.

DETAILED DESIGN OF THE MODEL NETWORK

The simulated national telephone switching network was designed in three discrete stages.

- Typical metropolitan network
- Provincial network
- Four wire trunk network.

In addition, the normal ancillary equipment was also installed.

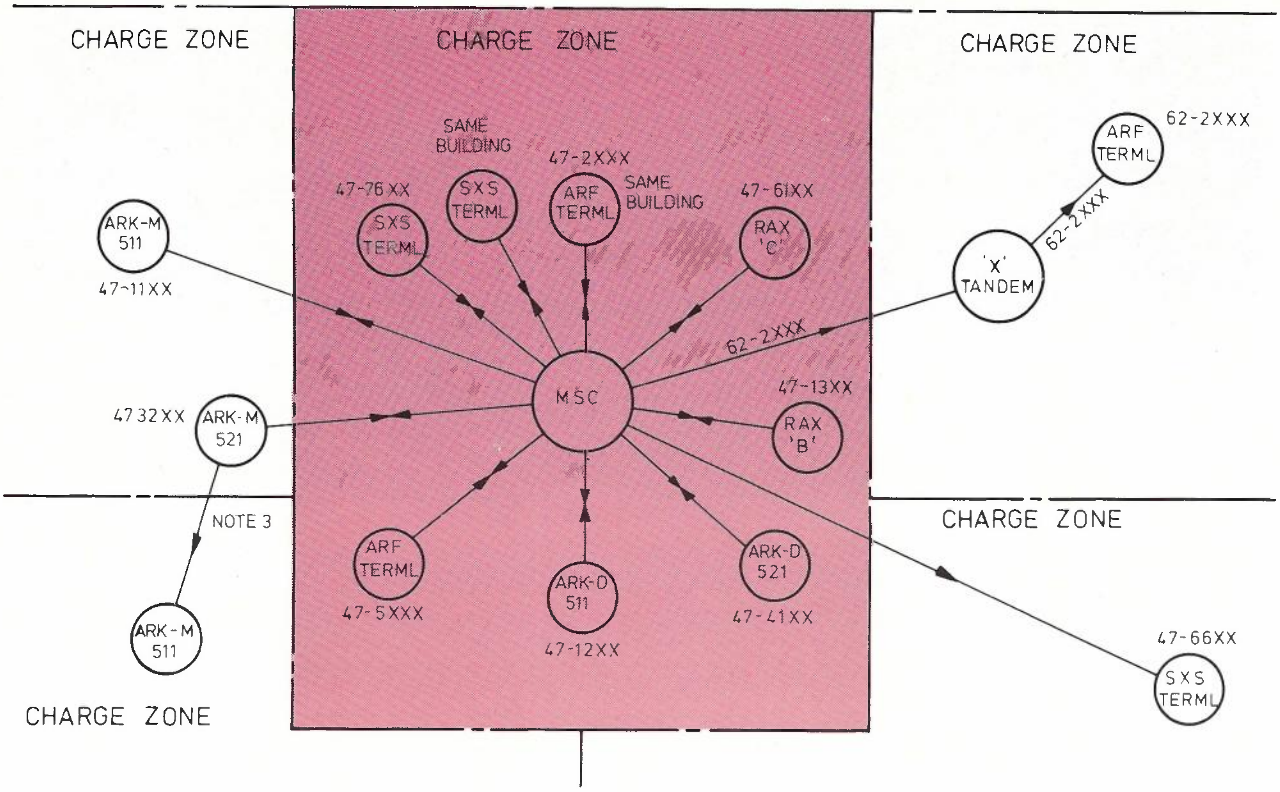

Fig. 2

The metropolitan network was designed incorporating ARF, Step and Hybrid terminal exchanges, ARF originating and terminating tandems, as well as SXS Main Exchanges. Subsequently the metropolitan network was extended to include ARE 11. (See Fig. 1.)

The exchange systems within the metropolitan network were interconnected with the standard exchange line relay sets. The routing and numbering scheme was organised so that calls could be generated to exercise the alternate routing function of the common control equipment as well as exercising the facilities provided by the interfacing relay sets without having to patch circuits within the network.

In Fig. 1 it can be seen that a call may be generated from a terminal exchange to any other terminal exchange via the direct route by dialling the appropriate code — arrows indicate direction of traffic flow. If however the direct route is manually blocked, the alternate routing function of the common control equipment associated with the originating terminal exchange will redirect the call to the first alternate route.

Other alternate routes can be selected by the same process. Provision has also been made to select any switching path within the network by dialling a unique code which will cause the path to be selected independent of the alternate routing arrangements.

The provincial network was designed around a Register E LP/H4 Minor Switching Centre (MSC). The selector stage at the MSC is a 2/160/700 group selector. (See Fig. 2.) Terminal exchanges comprising ARK 511D, ARK 511M, ARK 521D, ARK 521M, ARF 102, SXS, B and C type RAX's were connected to the MSC using standard line relay sets. The numbering scheme for the provincial network was organised to exercise most of the facilities provided by an MSC including the relevant charging facilities.

The trunk switching network comprises standard ARM 201 and 10C trunk four wire switching equipment. The trunk exchanges have been set up in accordance with the standard hierarchical structure that exists in the Australian network. Examination of Fig. 3 will illustrate that both main and secondary exchanges have been installed and these exchanges have the standard hierarchical switching relationships with the metropolitan and provincial networks. Calls can be generated to and from all lower order exchanges through the four wire net-

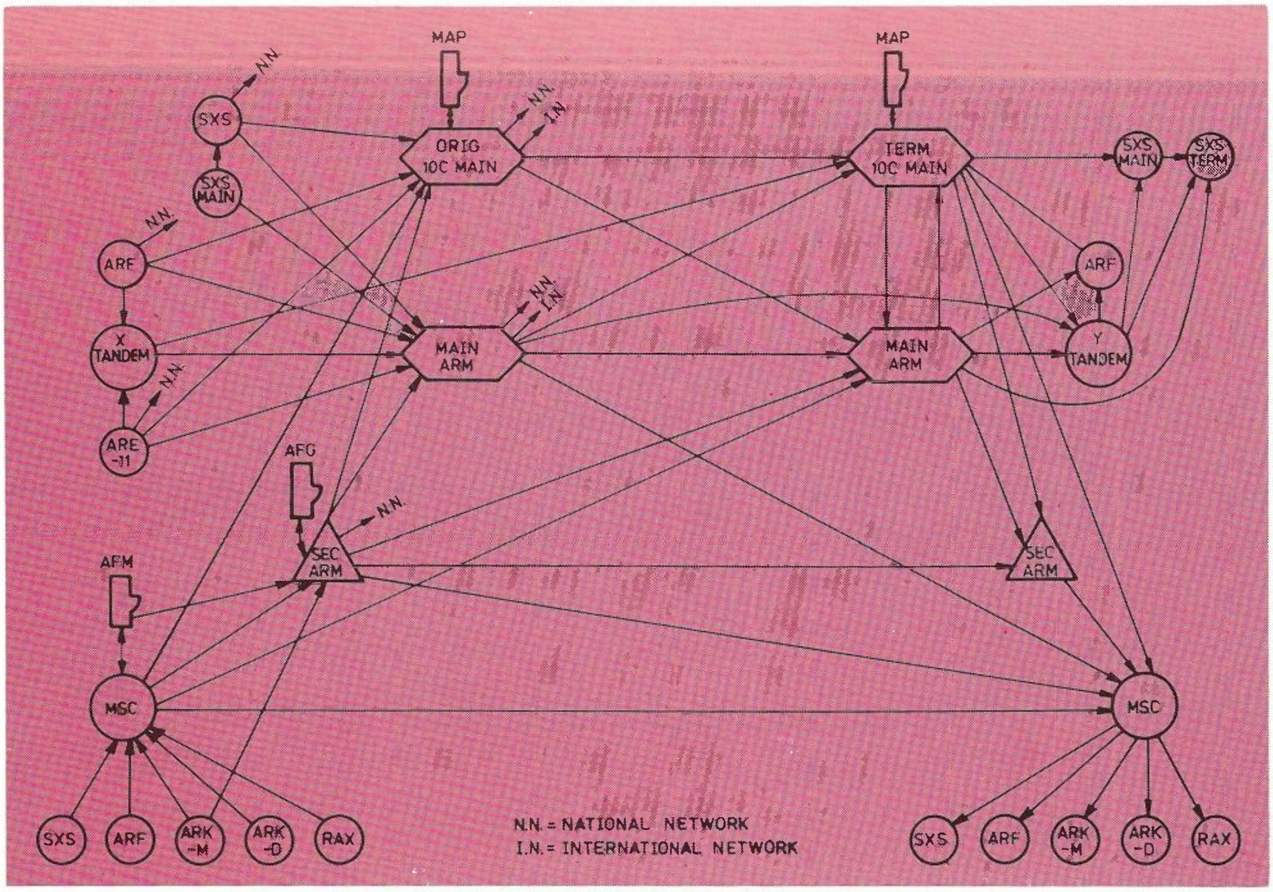

Fig. 3

work. Access can be obtained from the terminal exchanges via the four wire network to the international gateway by dialling the ISD code. Access can also be obtained to the national network using standard routing patterns by dialling the national code.

Three types of manual assistance systems were included in the model network — AFM, AFG and 10C. The Telecom Australia designed AFM system was parented off the MSC, whilst the AFG was parented off the secondary ARM. In the case of 10C a full range of manual positions have been installed — Operator, Monitor, Interception, and Superviser positions. The compete operational software for these positions is loaded into the 10C common control equipment to enable the operation of the positions to be fully simulated.

The main items of ancillary equipment which have been installed in the model network are:

- Automatic Disturbance Recording (ADR).
- Traffic Data Equipment (TDE).
- Service Assessment (Local and STD).
- Centralograph.
- Traffic Route Tester (TRT).
- Automatic Exchange testers (AET).
- Tariff Tester.
- Register Tester (RKR).
- Subscribers Automatic Line Tester (SALT).
- Test Desk.

The list is not exhaustive but illustrates the policy that was followed whereby all the standard operational and maintenance equipment has been installed. In this way new circuit developments in the ancillary equipment can be tested upon the appropriate switching systems and vice versa.

The model network has its own unique numbering scheme within the national numbering plan and accesses the national network using the standard access codes. Provision was made to access the national network at various levels within the switching hierarchy — terminal to terminal, tandem to tandem and so forth. To protect subscribers in the national network, no calls from the national network can be terminated onto the model.

OPERATING THE MODEL NETWORK

Extensions to the network are carefully planned by a planning secretariat composed of representatives from the major users of the model to ensure that the development of the model is orderly and its efficiency is preserved. All of the equipment is to the latest issue and is progressively updated as work specifications are received. Work specifications are performed in the model in advance of their issue to the field.

The network is continuously being tested and monitored for correct switching performance. The TRT is run daily with a variety of programs to ensure that the equipment is functioning correctly. AET's (Automatic Exchange Testers) are almost continuously generating test traffic. Supervisory staff within the laboratory are given particular areas of responsibility and are expected to maintain surveillance over the circuit integrity and switching performance of the equipment under their control.

As the network is continually changing, strict rules have to be applied to preserve correct records of cabling, jumpering, strapping details, rack appropriations, and so forth. Experience has demonstrated the need to guard against the possibility of network degeneration through the lack of adequate and effective recording and policing procedures.

CONCLUSION

The model as planned is working now. The first substantial expression of Telecom Australia's capacity to test new designs being offered for introduction into the Australian telephone network was the system test of L. M. Ericsson's ARE 11 equipment. Currently, the modifications to crossbar equipment required for Calling Line Identification and Interception are being tested prior to introduction in the field. On a more modest scale, the model network is continuously used to test new designs and work specifications. Various specialist areas also make use of the model to check interworking of their equipment with the associated switching equipment.

The authors wish to acknowledge the work of the many technical staff, draftsmen and engineers, who contributed to the design and construction of the model.

LEO TYRRELL joined the Department as a Clerk in 1956. After advancement to Cadet Engineer and later qualifying as an Engineer he worked in the Victorian Administration on Trunk Service, Regional Works and Exchange Installation. In 1969 he was appointed to the Telephone Switching Equipment Branch Headquarters, where he was concerned with the design and testing of switching equipment. He is now in the Telephone Switching Construction Branch, co-ordinating the introduction of new switching systems into the telephone network.

K. A. McN. THOMPSON is a Principal Technical Officer Section Manager, Laboratory Services Section, Switching Design Branch, Engineering Development Division, Headquarters. He first joined the APO as a Linemen-in-Training in 1940. After qualifying as a Lineman he transferred to Internal Plant as a Technicians Assistant and subsequently qualified as a Technician in 1948 and as a Senior Technician in 1954. After several years on Metropolitan Services, Sydney, he transferred to the Technician Training School, New South Wales, and remained there until 1966 when he was promoted to STO1 (E), Trunk Service, New South Wales. In 1969 he was promoted to STO3 (E), Laboratory Manager, of the then Telephone Switching Equipment Branch Laboratory, Victoria, HQ and has served continuously in Headquarters since that date.

Accident Prevention in Telecom Australia

Editorial note: This article was supplied by the Headquarters Engineering Safety Steering Committee.

Each year between 300-400 members of the Australian workforce lose their lives through accidents connected with their work. Some 270,000 others suffer disabling injuries severe enough to keep them from work, often for long periods and in some cases resulting in permanent disability and premature retirement from the workforce. There are also many minor injuries and 'near misses' which though less serious, nevertheless cause inconvenience and temporary disruption and induce a sense of insecurity among employees.

This loss to the Nation in valuable manpower and skills, damage to equipment, investigation and legal costs, medical and social services payments, has been conservatively estimated at $2,000 M per annum. Suffering and hardship to the unfortunate victims and the distress to their families and work mates cannot be measured in terms of cost.

The Australian Government has expressed its grave concern at this useless waste of the Nation's resources and unnecessary human suffering and has recently called upon all its Departments and Instrumentalities to implement, within their organizations, a Code of General Principles which expresses the Government's requirements for the protection of its employees against injury and ill health occasioned by their occupation, and aims to achieve substantial reductions in the frequency of accidents and the lost time they entail.

The Code — entitled Code of General Principles for Occupational Safety and Health in Australian Government Employment — calls for a uniform approach by all Government Departments and Instrumentalities towards the reduction of work hazards and the prevention of accidents to their staff. It defines the responsibilities of management and supervisors for the promotion of safe working conditions and safe work practices, and emphasises the requirement for co-operation, at all levels, in the development and implementation of accident prevention programmes and for the involvement of all staff in the achievement of safety objectives. It calls for the establishment, in each organization, of adequate safety units and committees to co-ordinate accident prevention measures and to develop and oversight safety programmes and performance.

In Telecom Australia the Code provides sound backing for the new Commission's safety policy which was announced recently (see inset).

TELECOM AUSTRALIA

ACCIDENT PREVENTION POLICY

A Code of General Principles on Occupational Safety and Health has been adopted in Australian Government employment. It is the policy of this Commission that every employee shall be provided with a safe and healthy place in which to work. To this end, every reasonable effort will be made in your interest in the fields of accident prevention, fire protection and health preservation.

In particular terms, this policy is:

1. To place the safety of employees and the public ahead of protection of the Commission's equipment and service.
2. To provide and maintain a safe plant.
3. To ensure that all staff are instructed how to perform their jobs safely.
4. To train supervisors in high and potentially high accident rate areas in the basic principles of accident prevention.
5. To establish safety committees in appropriate areas and to provide for employee consultation on accident prevention measures.
6. To hold all levels of management fully responsible and accountable for accidents in the areas under their control.
7. To ascertain the cause and take corrective action for every accident, whether it has caused injury or not.
8. To regard all industrial accidents as preventable.

The Commission's 61,000 engineering employees are exposed to a variety of working hazards in a varied and often hostile environment. The incidence of accidents is high and in 1975/76 reached an index of approx. 41 Lost Time accident occurrences per million manhours of working time — the accepted indicator of accident performance. As is evident from the trend graph the situation has worsened progressively over the past 5 years and the current accident tally now represents around 70,000 lost man days of working effort per year — indeed a severe drain on the Commission's engineering resources.

The Commission is aiming to achieve a 50% improvement in the next 5 years and a target index for the engineering department of 20 has been set.

But can this be achieved and if so, how? It certainly can, as has been amply demonstrated by a number of major employers who have introduced rigorous programmes of accident prevention substantially in line with the principles which the new code advocates, and who after a few years of

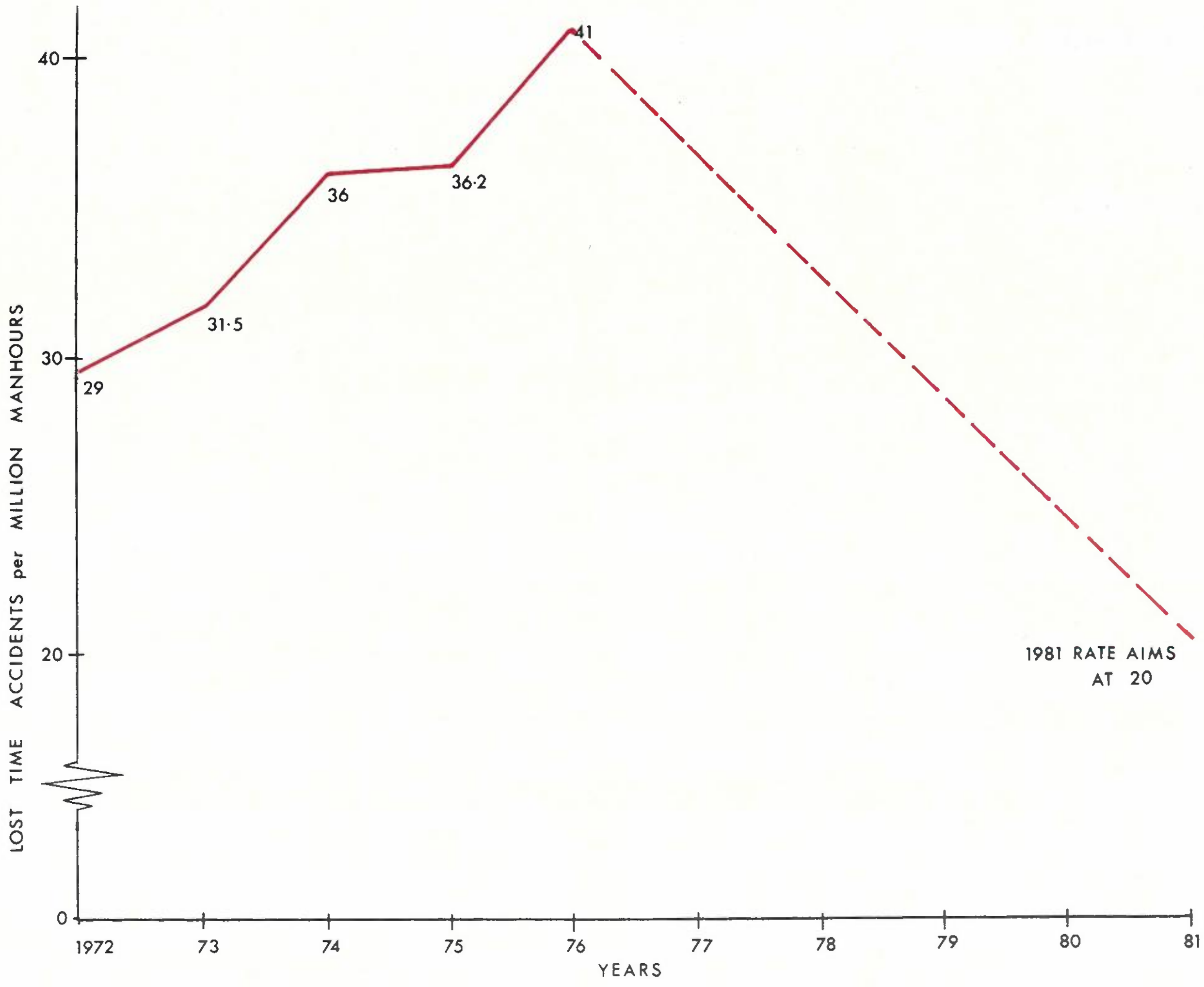

Fig. 1 — Engineering Staff Lost Time Accident Manhours.

intensive effort have succeeded in reducing their even higher accident rates to single figures.

The Commission is planning similar programmes and a strengthened safety organization is a feature of the new staff structure, both in Headquarters and in the States, to implement and oversight their effectiveness.

Training in accident prevention techniques is an essential feature of such programmes and is being arranged for management and supervisory staff throughout the Commission. Most Lines Instructors have attended a course on accident prevention which was enthusiastically received. An Internal Plant course and a Management course have also been devised and these will commence in 1977.

The prompt investigation of all accidents is another essential if recurrences are to be prevented, and recently a revised system of local recording and analysis of accident reports has been introduced to provide line management with the control information necessary for prompt investigation and remedial action.

The Commission is also reviewing the current information system for computerized analysis of accident statistics, with a view to providing more meaningful summaries and in-depth analyses of trends and accident factors, so that the Commission's future accident performance and the success of its accident prevention measures can be more effectively monitored.

Above all, the Commission aims to promote throughout its organization a realization that accidents *don't just happen*. There is always an underlying cause and recurrences can be prevented. Belief in this principle is the key to success in accident prevention and, with the full co-operation of management, supervisors and staff, the Commission is confident that its 5-year target can be achieved and that its objectives for the safety of its employees can be realized.

Common User Data Network — Part 2

B. T. JACKSON

This is the second article in this series on CUDN. The first article which appeared in Vol. 25, No. 2 described the facilities offered and the hardware used in the system.

This article describes the software programs used to control the hardware and to receive messages from the input lines, store them for security and switch them to the desired output terminal when a free line is available.

The final article will describe how Telecom and the customers supervise the flow of traffic through the network.

INTRODUCTION

The software for a computer consists of instructions to perform a specific operation, e.g. ADD numbers. When a number of instructions are grouped together they are called a program. The software for CUDN has many programs, each of which is designed to do a particular job.

There is one major program called the executive which controls the operation of all other programs. The executive can respond to events as they occur because it is able to interrupt or suspend a working program in order to receive input data or control signals from any terminals.

A feature of the CUDN software is its modular design where all major programs work independently of each other and communicate by passing information from one program to the next. Some of the major programs are shown in Fig. 1 which also shows the two functional data paths, message switching and packet switching.

The main function is message switching which uses the store and forward technique to prevent loss of data in the event of a main processor failure and to enable a queueing or stacking of messages for output. The packet switching function provides fast switching methods for customers who maintain an information service for clients which requires fast responses to queries. These messages are not stored.

The description of the CUDN software is preceded by a section describing the line tables used as reference points for reception, queueing and transmission of messages.

LINE TABLES

The CUDN system uses a series of permanent line tables in core which provide static information such as line identification, line speed, code type, customer number and message format. These tables also have fields allocated for dynamic information used during the input or output of a message. The static information is retained on disc to enable the recreation of these tables in core in the event of a main processor failure and subsequent recovery procedures.

The standard line table arrangement is shown in Fig. 2 and applies to all types of terminals except the CUDN and CCU links. The lines connecting the tables are linkages maintained for identification purposes. The link control tables shown in Fig. 3 have no such linkages. The channel tables are only concerned with data blocks received or transmitted on the physical circuits whereas the link tables look after the reception or transmission of messages within priority groupings. The link routes each have a route table and its associated queue tables for queueing of messages for output via a link.

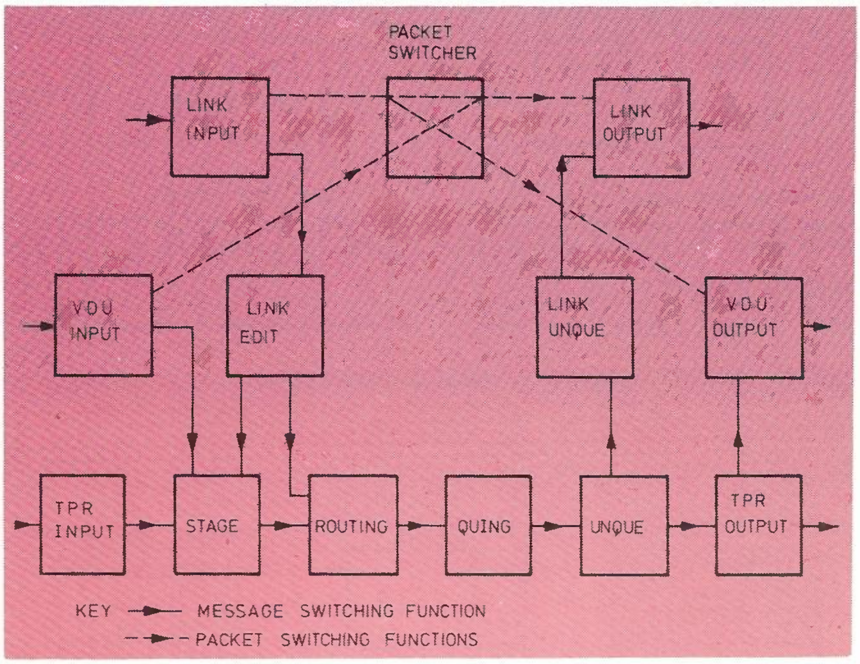

Fig. 1 — Main Software Modules.

TELEPRINTER INPUT

The Telemux hardware provides a 20 milli-second interrupt to the main processor together with a bit matrix of line state changes for the Teleprinter Input routine. Those lines which are marked active are then sampled at a rate determined by their line speed and the results of the sample stored in a character assembly word associated with each line.

When a complete character is assembled in any of these words, it has its line identification number added to the character and these are stored in a general input buffer. The arrangement of characters in the buffer is mixed because of the cyclic means used to sample the bit matrix, thus it would be unusual for two characters from the one line to be adjacent in the buffer.

When any characters are stored in the general input buffer, a call is made to the Stage routine to process the characters.

STAGE

The basic function of the Stage routine is to take characters from the general input buffer one at a time and to link the characters with others received from the same input line so that a message is formed. The line number attached to the character is used to find the associated input line table. The

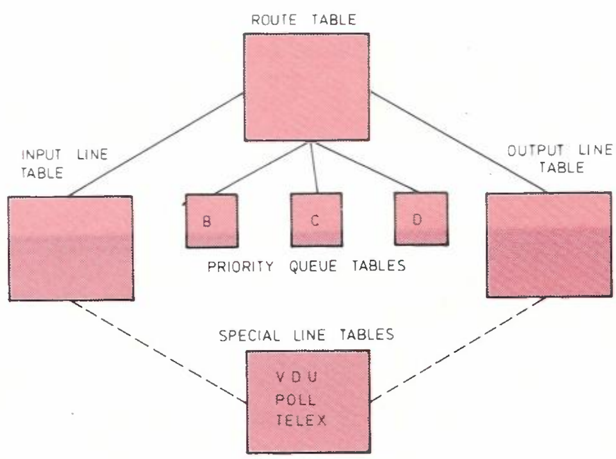

Fig. 2 — Permanent Line Tables.

static information held in the line table determines the action to be taken with the character.

e.g. Special character combination checks, code conversion from No. 2 to No. 5 alphabet, format checking and message header.

If the character passes all the checks, it is

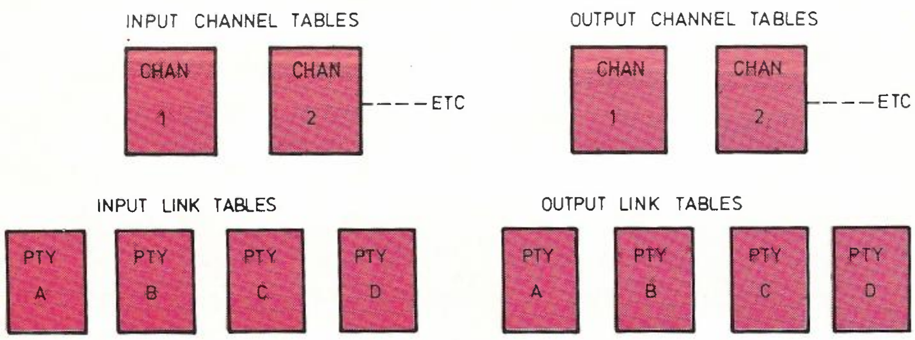

Fig. 3 — Link Control Tables.

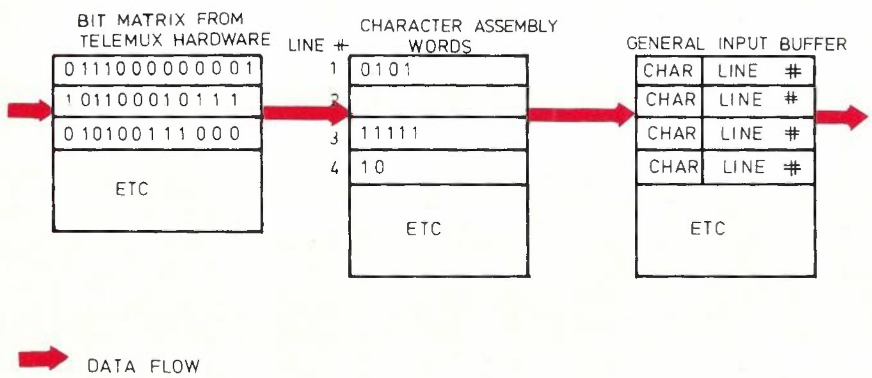

Fig. 4 — Teleprinter Input Processing.

stored in a temporary buffer attached to the line table, however, if the character fails any of the checks, then the message will be intercepted and an alarm sent to the customers control terminal.

When the temporary buffers attached to the input line table are filled, the characters are written to mass storage (disc) for security and also to optimise the usage of temporary buffers. After the end of message characters are detected, a special disc record is written to link up all previous records of the message on disc for use at output time.

A copy of the address characters in the message header together with information about the message which is required for forming a history record is then chained to the Routing routine to determine the destination of the address.

The processing of the VDU message by the Stage routine is basically the same as that described for a teleprinted message, except that the characters are taken direct from the temporary line buffers instead of the general input buffer. The message format would also differ from other teleprinter lines.

The Link Edit interface with Stage is used for all priority B, C and D messages received via a link route. When the message is input via a CCU link, the full header will be checked against the specified format table, whereas with a message from a CUDN link, only the address characters are extracted so that local routing can be performed.

ROUTING

There are two forms of addressing used for the message switching function. The standard CUDN form consists of a four alpha group RSSS, where R represents the CUDN centre or region and the SSS identifies the station within that region. The IATA form contains seven alpha characters RRRSSCC, where RRR represents the destination city or region, SS the station identifier and CC the customer destinator.

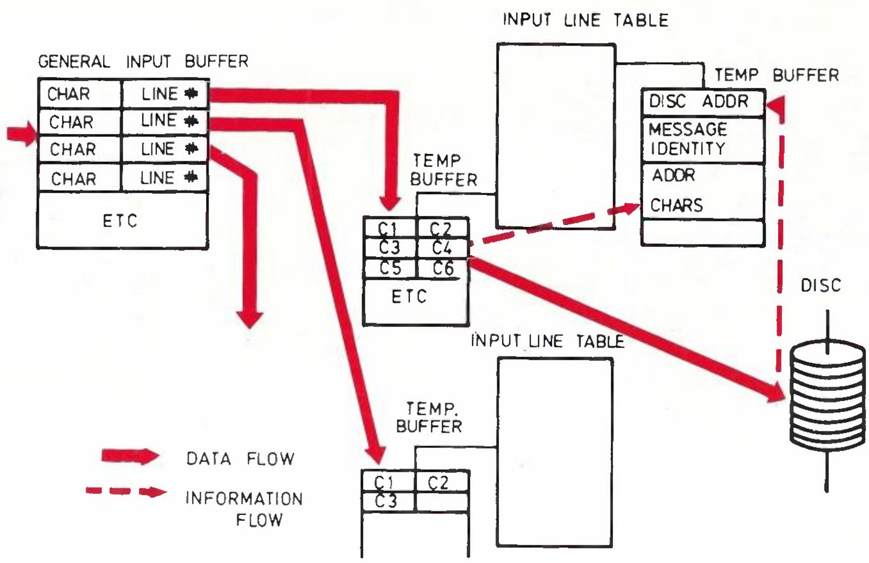

Fig. 5 — Stage Processing.

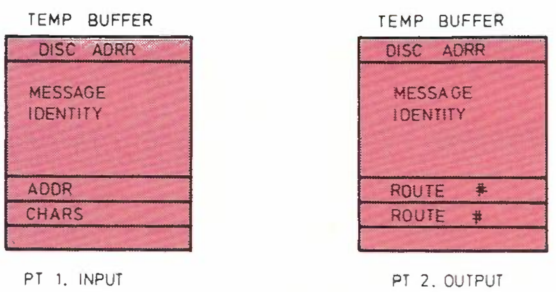

Fig. 6 — Routing Processing.

When the temporary buffer containing the address(es) in a message are chained to the Routing routine for processing (Fig. 6 Pt. 1) the region Code is first examined to determine if the addressee is local or connected to another CUDN centre. If the region shows non local, the station identifiers are ignored and the message is marked for output on the CUDN link to its exit centre.

For messages to the local region, the station identifiers are compared with the customers list of valid addresses which are stored on disc. As each terminal belongs to a particular CUDN customer, only that customers list is checked to prevent inter customer traffic. If the address is not found, the message is intercepted and delivered to the customers control terminal.

When the address is matched with one in the list, the route number allocated to the address is then stored with the message identifiers in the temporary buffer (Fig. 6 Pt 2) to be passed to the Queueing routine.

QUEUEING

When the Queueing routine is called, it firstly creates a history to acknowledge the receipt of the message by CUDN. The type of data recorded in this history is the input line identifier and sequence number, the customer number, the message priority, the accounting rate, the location of the special disc record and the output route number. For multiple or group address messages, a separate input history is written for each destination to enable successful delivery to be determined for each addressee.

After the history data has been stored, the special disc record address is placed in a small buffer and connected to the end of the queue specified by the route number and the message priority. Next, a test is made to see if there is an idle output line associated with the route to which the message was queued. If an idle line is found, the Unque routine is called to begin the message output process, however, if none are available, no further action is taken. When the output route is a CUDN or a CCU link route, a call is made to the Link Unque routine to initiate the output of the message.

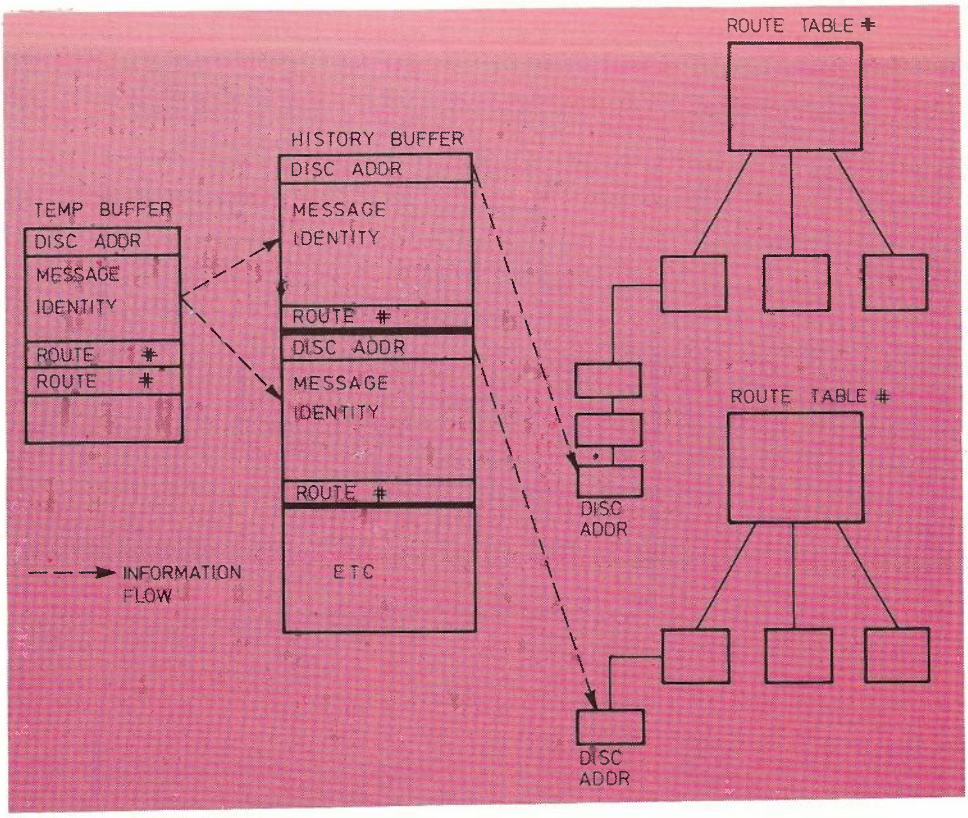

Fig. 7 — Queueing Processing.

UNQUE

When a message is placed on a queue and an idle line is found, Unque is called to commence the output procedures. The message data is obtained from the head of the queue and the disc record address is stored in the output line table (Fig. 8 Pt. 1). The Teleprinter Output routine is then called to read the message from disc and to arrange for the transmission of the message to the terminal.

When transmission has been completed, the Unque routine is called to prepare an output history of the message (Fig. 8 Pt. 2). It contains many of the details recorded in the input history as well as the identity and sequence number of the output line. The presence of an input history together with a matching output history forms a basis for accounting and message retrieval.

Once the output history has been written to disc, tests are performed to see if any more messages have been added to the queues whilst the line was active. The order of search for another message is to examine the priority B queue first and if it is empty, then examine the priority C queue, etc. (see Fig. 2). Thus urgent priority messages will be output with only minimal delays. If all the queues associated with the route are empty, the output line is marked idle.

TELEPRINTER OUTPUT

This routine arranges for the message data to be read off disc, formatted in accordance with the line specifications and physically transmitted to the terminal.

When this routine is called by Unque, the special disc record specified in the output line table is read so that all blocks of the message on disc can be located. For poll and telex lines, reference is made to auxiliary routines in order to perform the poll terminal selection or to establish the telex connection.

Then the first block containing the message header is read from disc and stored in temporary buffers. Editing of the header and code conversion is performed as required. Messages to be output to VDU terminals are now chained to the VDU Output routine.

For low speed teleprinter lines, the characters in the temporary buffers are fed to the output

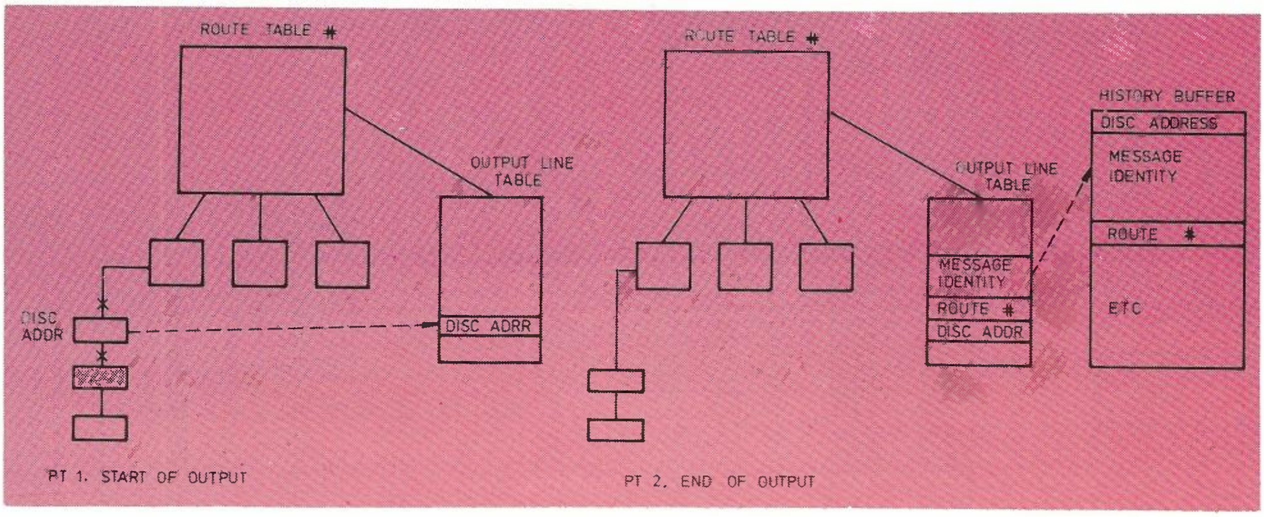

Fig. 8 — Unque Processing.

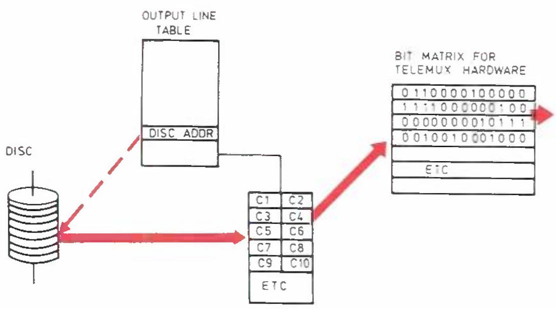

Fig. 9 — Teleprinter Output Processing.

buffer matrix in full or half words depending upon the line speed. When all but the last few characters have been transmitted, the next message block is read off disc. The transmission continues until all the message has been sent to the terminal. Finally, the Unque routine is called to write an output history and to get the next message.

VISUAL DISPLAY UNIT (VDU) PROCEDURES

The VDU is one of the modern terminal devices used for message transmission and reception in CUDN. Because of its high transmission rate (up to 4800 bits/second) many VDUs can be connected to one line. The line protocol developed for the VDU procedures includes polling for input, selective calling for output and a compelled acknowledgment sequence for error detection and retransmission in either direction.

The criteria for controlling poll cycles, message input and output is contained in the VDU line table which is linked to the input and output line tables (See Fig. 2). The data in the VDU line tables includes all terminal identifiers, specified poll clock rates, counter fields, current terminal pointers, status flags showing current activity and small input and output buffers. The poll rate ranges from continuous poll (i.e. less than 200 milliseconds) up to once every 3 seconds.

VDU Input

VDU terminals on a line are polled at the prescribed rate to solicit traffic from those terminals. When an operator presses the transmit button, the VDU waits until the poll is received before commencing the transmission of the message. The message data is preceded by terminal identification characters and the end of the message data is identified by an end of text (ETX) and a block check character (BCC). Temporary line buffers in the CUDN processor capable of holding 240 characters are attached to the physical line when a VDU terminal begins transmitting a message.

If the message is received from a VDU permitted to use the packet switching facility (priority A messages), the total number of characters in the message will not exceed 240, so one pair of buffers is sufficient for the message. When the ETX is detected, the VDU Input routine uses the BCC to perform error checks to ensure the data was not mutilated during transmission.

When the checks show the message data is cor-

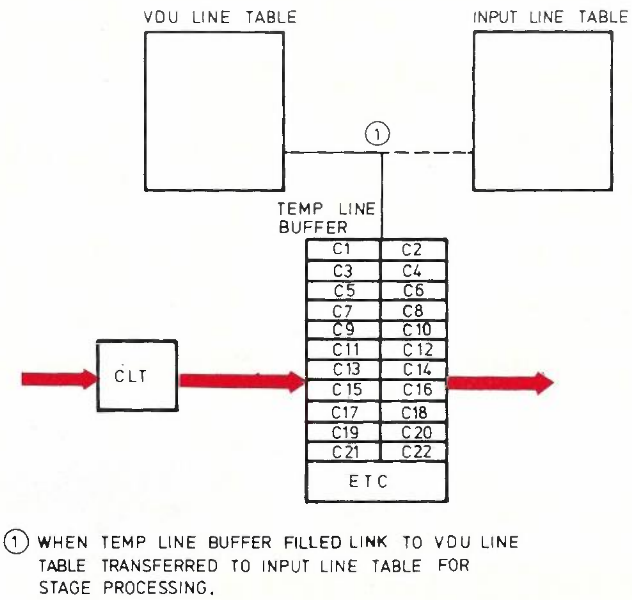

Fig. 10 — VDU Input Processing.

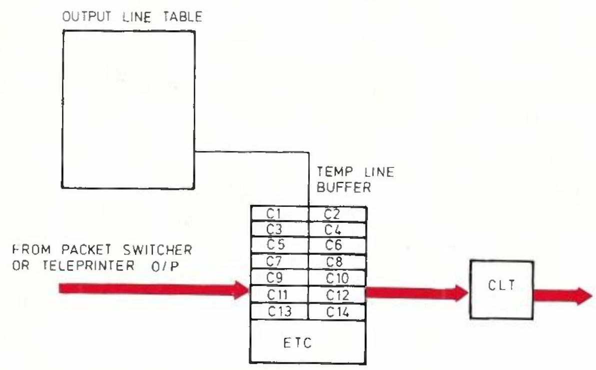

Fig. 11 — VDU Output Processing.

rect, a message header containing the routing information is added to the message which is then passed to the Packet Switcher routine. An acknowledgement of the receipt of the message is added to the next poll. However, if the message data is corrupted in any way, the VDU Input routine arranges for a retransmission request to be forwarded to the VDU terminal to retransmit the message.

For the normal message switching input from a VDU terminal, the signal from the interface hardware that the line buffers have been filled causes the VDU Input routine to connect another pair of empty buffers to the VDU line to receive the next part of the message. Then the buffers full of data are chained to the Stage routine via a special interface for format processing. When the ETX character is received, the error checks are performed and providing they are satisfactory, a message acknowledgement is added to the next poll.

VDU Output

The functions of the VDU Output routine are to initiate polls for input and to arrange the transmission of messages to VDU terminals as they become available. When control is received from the system timer, a check is made of all VDU line tables to see if a poll is required. If one is found, the type of poll is determined and the necessary characters which make up the poll are assembled in the output buffer in the VDU line table. Then the output buffer is connected to the physical line which is activated so that the characters are transmitted.

Messages for output to VDU terminals can come from two sources. The first is a priority A message from the Packet Switcher routine. In this case, the message data is held in temporary line buffers which are chained to the VDU line table. After preparing the header of the message for transmission, the temporary line buffers are connected to the physical line which is then activated. When all the characters in the buffers have been transmitted, the VDU Output routine set a timer in the line table to await the arrival of an acknowledgement from the VDU terminal. If it is not received within the timeout period, the message is retransmitted to the VDU terminal.

The other source of messages is from the standard route queues. The output of these messages is begun by the Teleprinter Output routine which prepares the message header characters and performs the disc reads necessary to get the first block of data into temporary line buffers for transmission. This data is then passed to the VDU Output routine which arranges for the connection of these buffers to the physical line for output. When the message has multiple blocks of data on disc, successive calls are made to the Teleprinter Output routine to perform the disc reads as the data in the buffers are transmitted.

When all the message has been transmitted and an acknowledgement received from the VDU terminal, the Unque routine is called to write an output history and to get the next message for output. If, after four transmission attempts, the VDU terminal fails to send an acknowledgement an alarm is generated to identify the faulty VDU and the message is returned to the customer CCU.

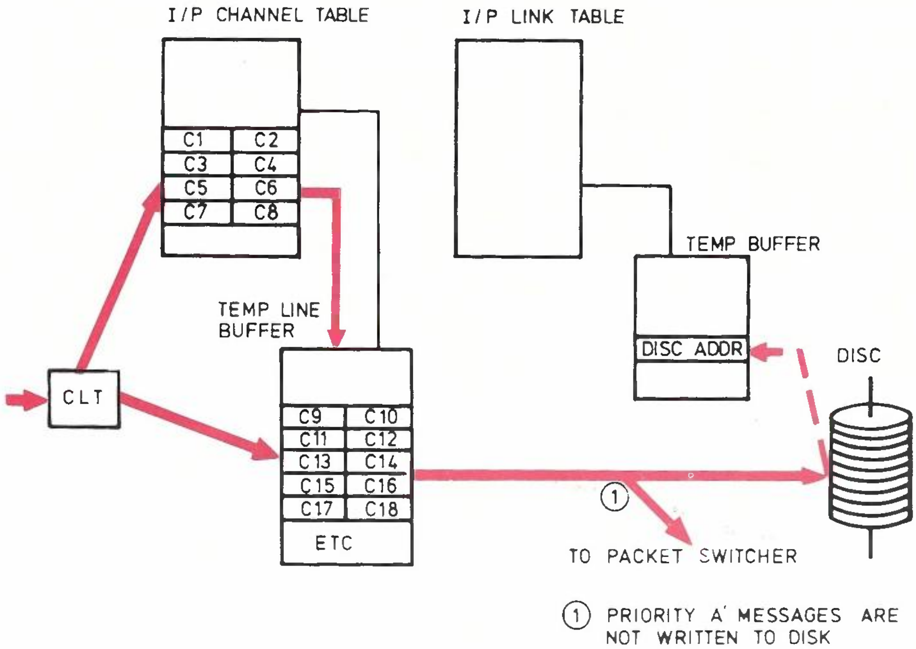

Fig. 12 — Link Input Processing.

LINK CONTROL PROCEDURES

The Link Control procedures designed for CUDN use short control blocks to supervise the data flow on a link channel, e.g., a response block acknowledges the successful receipt of every data block. The use of control blocks enables a retransmission to be automatically initiated if an acknowledgement fails to arrive within the prescribed time period. Other control blocks establish the link, maintain sequence numbers and enable recovery after a line or processor failure. Dummy blocks are transmitted during no traffic periods to maintain line integrity.

Each message is divided into 240 character blocks with message identification characters added for transmission. The procedures allow for transmission according to priority. This means that the transmission of a string of low priority message blocks can be interrupted by interleaving higher priority message blocks. Two small character buffers are provided in each input channel table, one of which is connected to the physical line so that data can be sent from the distant end at any time.

Link Input

When characters are received in the first input channel table buffer, the type of block can be determined. If the characters are part of a control block, it will fit into the channel table buffers, however, if it is the start of a 240 character data block, then it will overflow and a pair of temporary line buffers must be connected to the line so that all the characters can be saved. After all the characters have been stored in the temporary buffers, the buffers are linked to the input link table handling the specified message priority. Error checks are then performed on the data to ensure that no mutilation occurred in the transmission. Blocks with errors are rejected.

If the message is at priority A (packet switched), then the buffers are chained directly to the Packet Switcher routine for delivery to the designated address. For all other message priorities arrangements are made to have the data written to disc for safe storage. When the disc write is completed, the Link Output routine is notified to send a response block to acknowledge the successful receipt of the message block.

When all the blocks associated with a message have been received, a special linkage disc record is written. The disc record number together with message identification details are stored in a buffer and chained to the Link Edit routine for preliminary processing prior to placing the message on the required output queue. A special control block acknowledging the receipt of the complete message is sent to the Output Link Routine for transmission to the sending centre.

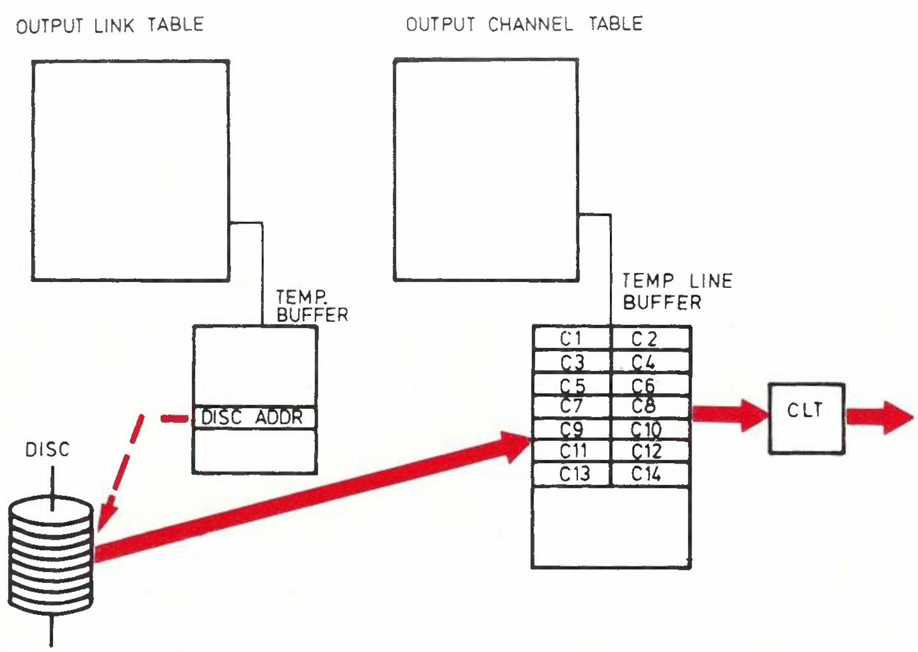

Fig. 13 — Link Output Processing.

Link Output

Each message disc record, placed in an output link table by the Link Unque routine, enables the blocks of the messages to be read off disc. The data is transferred to temporary line buffers which are then chained to an output channel table queue at the appropriate priority level. The selection of an output channel is based upon a weighting factor which distributes the load evenly over all available channels.

The six levels of queue contained in an output channel table provide the fixed priority sequence for transmission. The priority order is retransmissions, control blocks, priority A, priority B, priority C and priority D. As each block is selected for transmission, a sequence number is added to the message identification data and character parity checks are performed to ensure that the data is error free upon transmission. This enables transmission errors to be detected at the receiving centre.

When the parity checks have been completed, the temporary line buffers are connected to the physical line and a control signal sent to the interface hardware equipment to commence the data transmission. When the transmission of a block is completed, the Link Output routine is called to scan the queues in the output channel table associated with the physical line in the fixed priority order so that the highest priority block will be selected for transmission.

Link Edit

This routine is responsible for determining the destination of the message as well as arranging for a full header edit on messages received from a customer CCU. When a message is received from another centre via a CUDN link, the destination exit centre in the buffer is examined. If it is found to be non local, the route number corresponding to the exit centre is placed in the buffer which is then passed directly to Queueing.

If the exit centre is local, the first block of the message is read off disc so that the address characters in the message can be extracted by the Stage routine and passed to Routing. In this case, Routing would only provide route numbers for addresses connected to the local centre.

When the incoming message is received from a customer CCU, the header block is read from disc and passed to the special Stage interface for checks in accordance with the specified format. Address characters are also extracted during the header checks. When the Stage processing has been completed, the buffer is chained to Routing for a full address conversion.

Link Unque

The CUDN and CCU links are designed to carry high concentrations of traffic between CUDN centres and to customer processors. The average disc access time to read message data for output would not be fast enough to fully utilise the capacity of a link if messages were handled one at a time. For this reason, the output link tables (one per priority) have the ability to hold up to 8 messages for transmission. This permits overlapping reads to be performed thus reducing the impact of the disc read times.

The purpose of the Link Unque routine is to obtain messages from the link route queues as they become available and place them in order of arrival in the appropriate output link table. When a message has been transmitted and acknowledgement of its safe arrival has been received, this routine prepares the output history information and passes it to the Unque routine for inclusion in the history file.

PACKET SWITCHER ROUTINE

There are three types of messages presented to the Packet Switcher routine for forwarding to the desired destination. They are interrogations — VDU to CCU traffic, responses — CCU to VDU traffic, and unsolicited responses — also CCU to VDU traffic. The interrogation message is a request from the VDU terminal for some information from the CCU data base. The response message is the reply to the VDU interrogation and the unsolicited response is some routine or control message generated by the CCU for one or more VDU terminals.

The first three characters of the priority A message header are used to determine the switching. The first character represents the type of message, the second identifies the CUDN centre to which the VDU is connected and the third identifies the particular customer. When an interrogation message is received, it must be switched to the customer CCU. If the CCU is connected to the local CUDN centre, the message will be switched direct to the CCU route, but when the CCU is connected to another CUDN centre, the message must be switched via a CUDN link to that centre.

Both types of response messages are destined for a particular VDU terminal. Thus, the second character in the header becomes the main switching character. Response messages which are for VDU terminals connected to the local centre are passed to the VDU Output routine for transmission, whereas, messages for another centre are switched to the CUDN link for the specified centre.

ACKNOWLEDGEMENTS

The author wishes to thank his colleagues who suggested amendments to the original draft in order to present this article in a form suitable for all readers.

CONCLUSION

The software in the CUDN system has been designed to allow the greatest flexibility of customer facilities on common equipment, whilst still maintaining the privacy of each customers network.

Features such as access to the Telex network and the ability to connect various types of modern data terminals to a customer's central computer make this system a leader in message switching technology.

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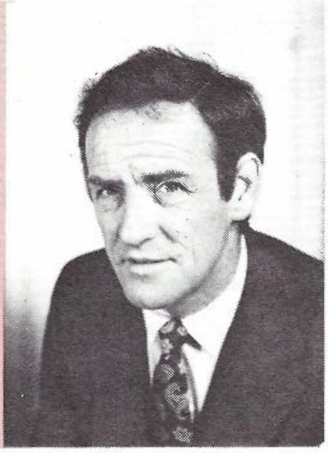
In 1970 he moved to Headquarters as a Senior Technical Officer, Grade 2, when he was selected to join the CUDN project team. He was appointed a Senior Technical Officer, Grade 3 in 1973 and stayed with the project until its completion. He is still associated with CUDN as Controller of software development.



The Melbourne Television Operating Centre

D. L. HUMBERSTONE, B.A. (Hons.) and K. R. LOCK, B.E.

The new Melbourne Television Operating Centre (TOC) was placed into service in Sep. 1976. This article describes the facilities provided in the new installation and outlines the function of the TOC as part of Telecom's video relay network. The future development of the TOC is discussed with particular emphasis on the application of insertion test signals.

INTRODUCTION

Television Operating Centres (TOC) are situated in each State Capital to provide an interface between the Television Authorities and Telecom Australia's video relay network. Melbourne TOC has been in service since 1962; the centre had evolved over a number of years and as a consequence the area available for future expansion was limited. The introduction of colour television in March 1975 required extensive modifications to the existing Telecom video relay network and as part of the colour conversion exercise a new Melbourne TOC was designed and installed.

VICTORIAN VIDEO RELAY NETWORK

As illustrated in Figure 1 the network is divided into three areas of operation:

- The National Television Service, which consists of video relays between Australian Broadcasting Commission studios and the transmitter stations. Telecom Australia is responsible for the provision and operation of the national television service network including the operation of the transmitters and translators.
- Inter and intrastate video relays, which are either permanently leased or provided on an itinerant basis to the Television Authorities. Outside the cities microwave radio systems are used as the transmission medium.
- The Melbourne network, consisting of coaxial cable video systems which connect the Television Authorities to the Telecom video relay network. The TOC is the switching and control centre for Telecom's video operations in Victoria.

The effects of colour television transmissions on Telecom plant and the methods used to improve the performance of the national television transmitters are described in References 1 and 2.

Prior to the introduction of colour television extensive testing of the existing baseband coaxial cable video systems revealed that the equipment could not meet all the technical standards imposed for colour transmission. For all links greater than 3 km in length the existing baseband coaxial video equipment is being progressively replaced over a three year period by DSB amplitude modulated equipment which has automatic regulation and requires no routine maintenance. In the interim modifications have been carried out on remaining baseband systems to minimise linear distortions and noise.

FUNCTIONS OF A TOC

During 1975, over 30,000 video and associated audio switching operations were performed at Melbourne TOC. Switching operations can vary from a complex multistate link-up for a federal election or sporting event to a simple confirmation of circuit connection for permanently leased bearers. Figure 2 gives an indication of the distribution of switching operations over a typical day and week.

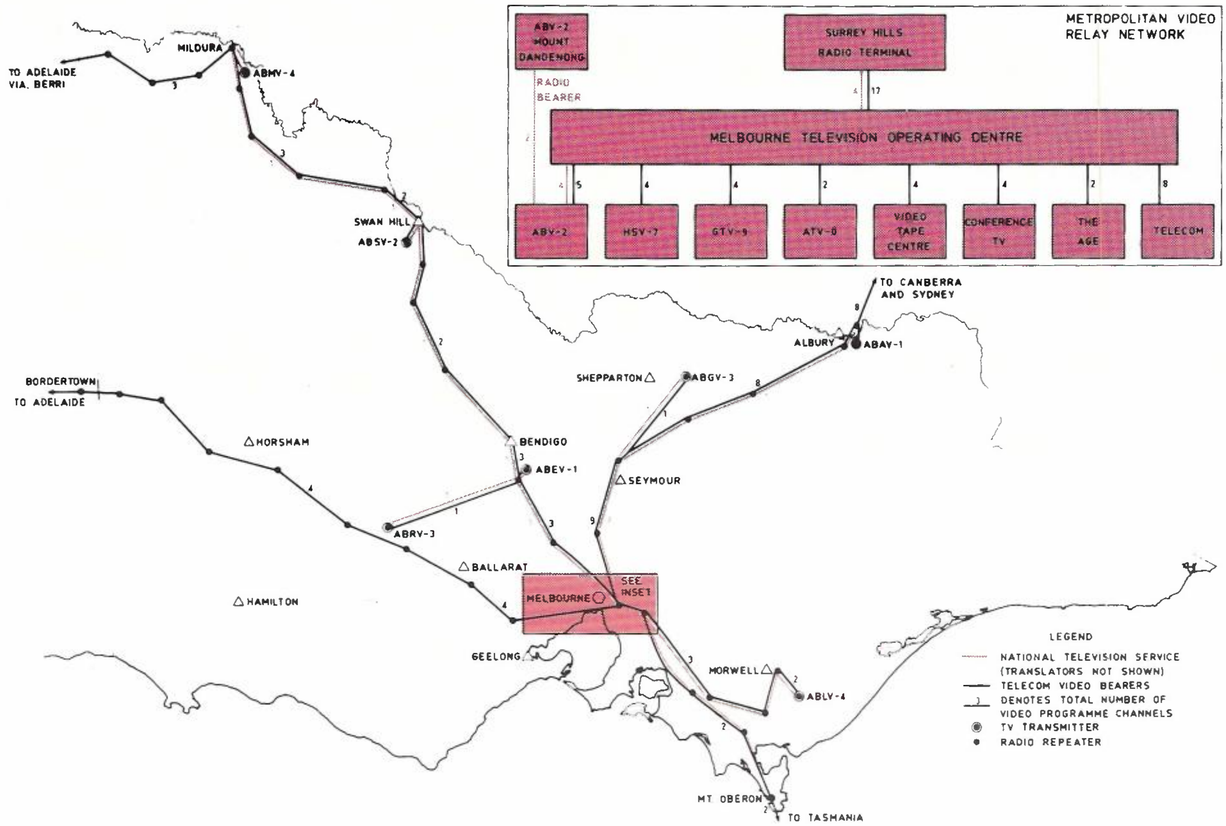


Fig. 1 — Victorian Video Relay Network.

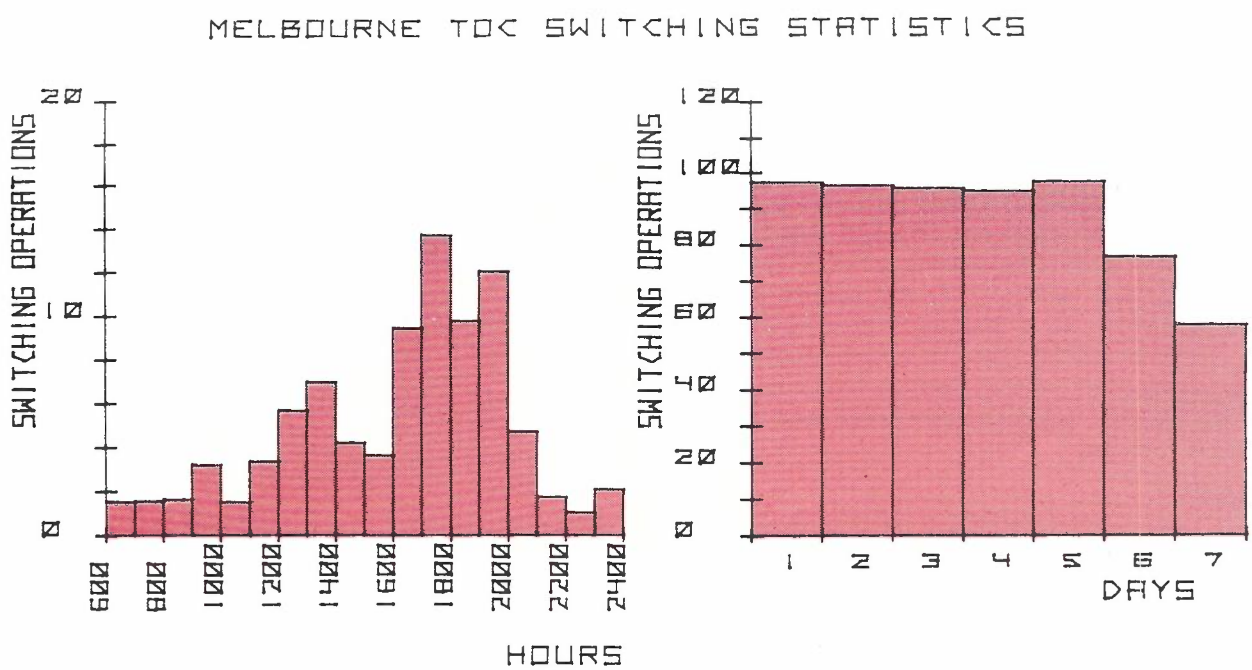


Fig 2 — The Distribution of Switching Operations in Melbourne TOC Averaged over a Six Month Period.

The functions of a TOC may be summarised as follows:

- Control and co-ordination of all switching on the Telecom video relay network.
- Monitoring of video channel status and quality of transmission on the network.
- Overall testing and mop-up equalisation of interstate video channels.
- Routine maintenance and equalisation of metropolitan coaxial cable video systems.
- Fault control centre for processing complaints on performance received from the television authorities.

In Melbourne, the TOC is under the control of the City Operations Section and forms part of the Melbourne Trunk Terminal. The TOC is staffed between 7.00 a.m. and 11 p.m.; after hour switching such as international events is the responsibility of the Trunk Terminal supervisory personnel.

FACILITIES

Design Considerations

The basic requirements for equipment and facilities were defined by the functions of the TOC and by Telecom's technical standards and practices for video installations. In designing a new TOC the operational requirements and the need to incorporate future developments were considered paramount.

The work load in the TOC consists of switching, routine maintenance and fault rectification. Facilities for signal monitoring and external communications were given sufficient flexibility to allow staff to work independently, during peak periods, from either of two identical control positions or adjacent to the relevant equipment. The TOC was provided with audio and video patching fields for bearer switching and testing. In the second stage of development a 40 x 40 audio/video switcher will be installed. Initially manual control and monitoring facilities will be provided, but computer control of the switcher can easily be incorporated at a later date if required.

Layout

The TOC was planned as a 20 year development with space being allocated to accommodate expansion and new types of equipment during the life of the installation. A simplified floor plan of the TOC is shown in Figure 3. The installation consists of two rows of enclosed equipment racks and an operator's console. Dual facilities for signal monitoring as well as master alarm indication and lighting

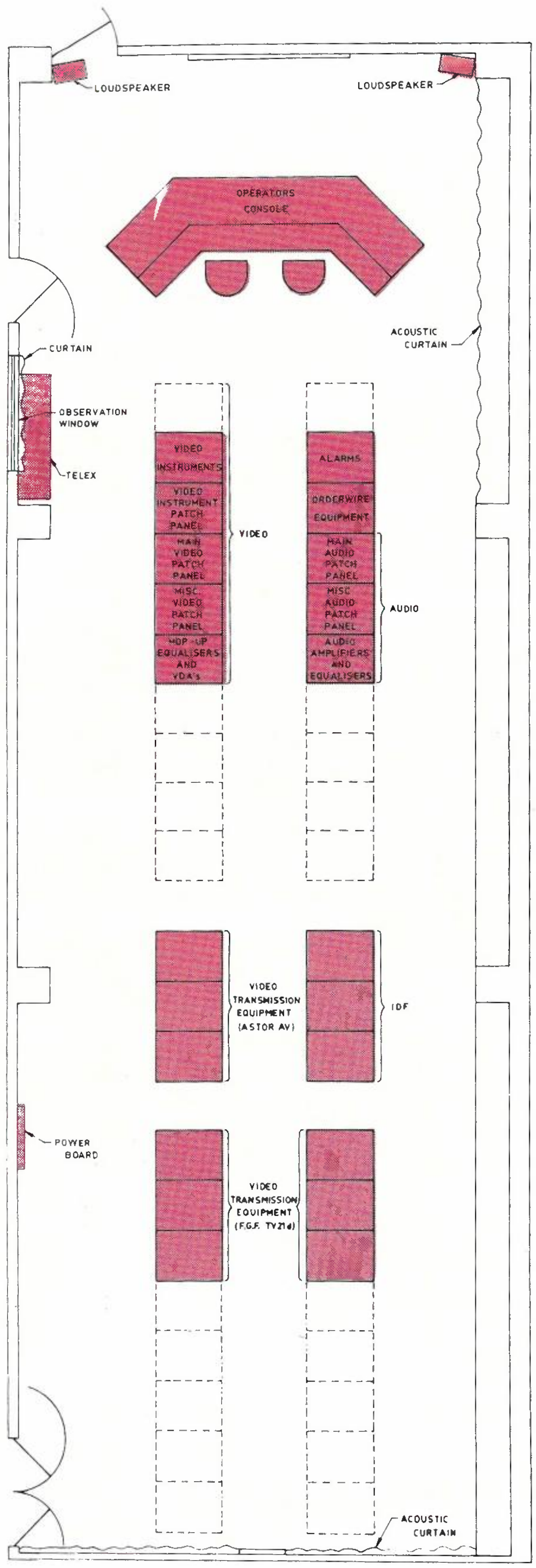


Fig. 3 — Simplified Floor Plan.

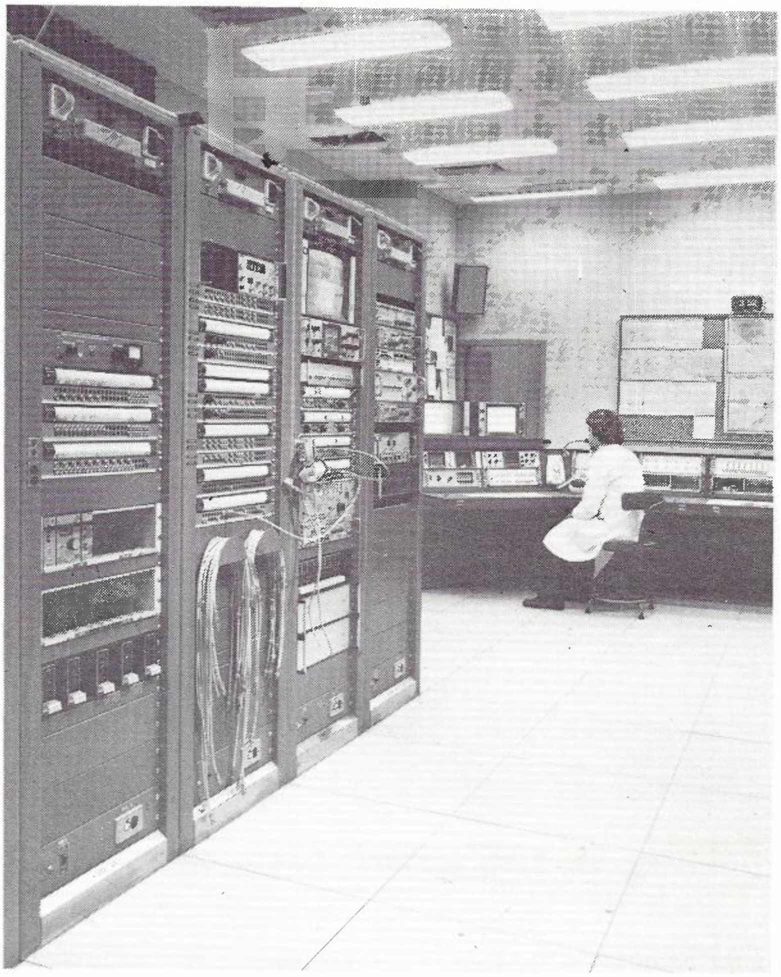


Fig. 4 — Melbourne TOC.

control are located at the operator's console. The front of the equipment racks face towards the centre with the audio/video patching and testing facilities being located close to the console for ease of access by operating personnel.

The following features are incorporated in the installation:

- *Cabling*. A false floor is provided to accommodate all cabling and inter-rack wiring. Both internal and external audio wiring is routed via the IDF. These arrangements facilitate modifications and extensions to the installation with a minimum of disruption to TOC operations.
- *Earthing*. In installations of this type, the earthing arrangements are critical. The TOC utilizes a common bussing system connected to the exchange earth. The mains earth is not used.
- *Lighting and Acoustics*. Optimum viewing and listening conditions are required in TOC's for operating personnel to identify and assess complaints received from the customer. Fluorescent lighting of a specific colour temperature (D6500) is used and illumination controlled at the operator's console. Curtains and carpets have been provided to improve the acoustics of the installation.

Signal Switching and Trunking

Separate patch panels for routing of audio and video are provided; these will remain when the audio/video switcher is installed as an emergency facility and for patching of rarely used circuits not permanently connected to the switcher. The patch panels and associated equipment provide for a capacity of 48 incoming and outgoing video and associated audio circuits. Approximately 60% of this capacity is in service at the present time.

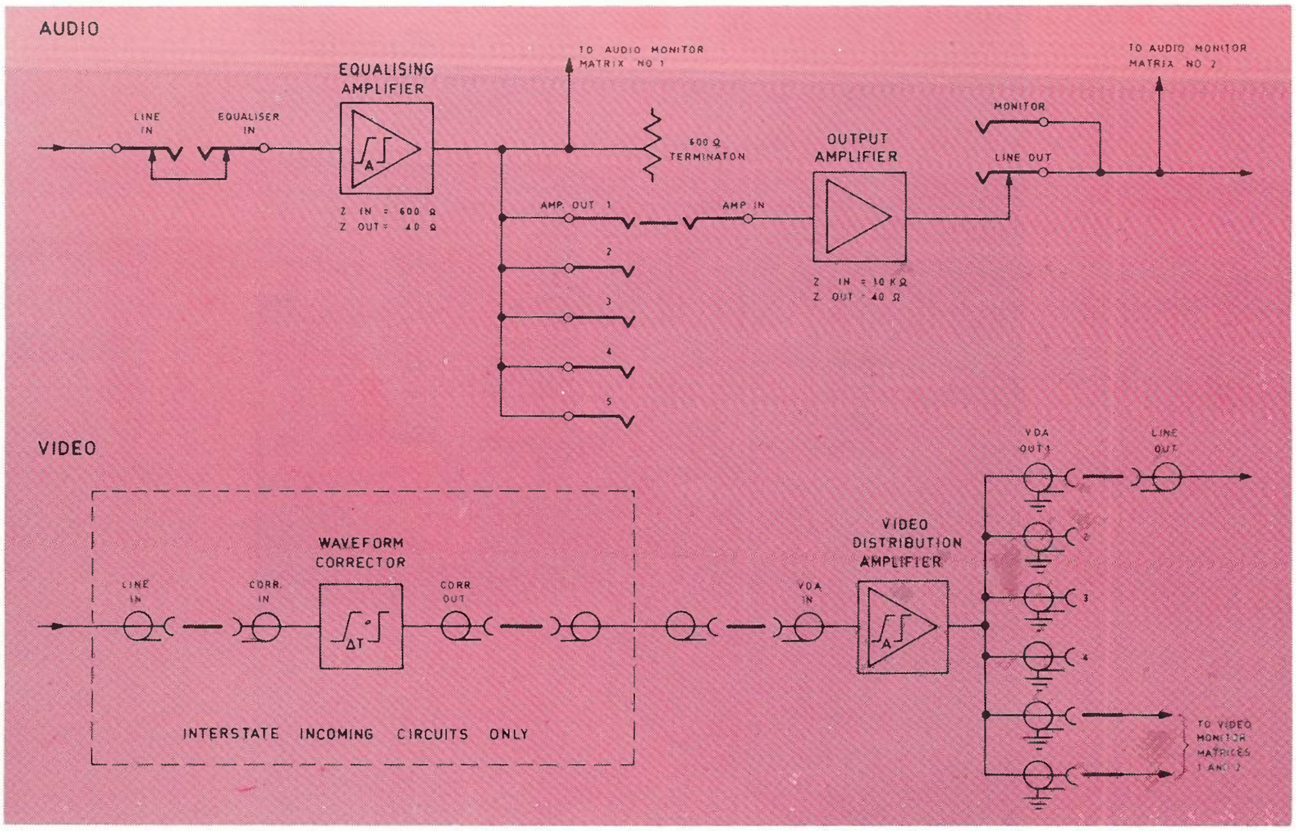


Fig. 5 — Audio and Video Trunking Diagram.

The signal trunking for circuits passing through the TOC is shown in Figure 5.

Video. The outer conductor of the unbalanced coaxial cable is earthed at voltage sources in the circuit. Using this technique the hum rejection facilities in the video equipment are fully utilized. Each incoming video circuit is connected to a video distribution amplifier (VDA) which equalises in-station cabling and provides six outputs for monitoring and patching purposes. VDA's are also used to compensate for the effects of temperature variation on baseband coaxial video systems and for equalisation of coaxial cables up to one kilometre in length.

On incoming interstate video channels, where several transmission systems are connected in tandem video waveform correctors are installed to compensate for accumulative linear distortions.

Audio. Variable active equalising amplifiers are used to equalise all incoming audio channels. The output of each equalising amplifier is terminated in 600 ohms and five patching outlets provided for connection to bridging amplifiers installed on each outgoing channel.

Testing

Video and audio instruments required for performance testing are located in racks adjacent to the main patch panels. Telecom's video test requirements consist of a series of 38 tests, 20 of which are used in routine maintenance procedures. To facilitate convenient setting up of testing configurations and their connection to channels, access to all instruments and maintenance aids is provided on video and audio instrument patch panels.

Audio and video source identification signals are provided to aid the setting up of complex network configurations. The video source identifier provides an alphanumeric display on a television monitor and is used in conjunction with a full field/insertion test signal generator. The audio source identifier consists of a recorded announcement followed by a 1KHz test zone.

Monitoring

The audio monitoring system is designed to monitor both incoming and outgoing circuits in the TOC, whereas the video system provides for incoming signals only. Monitoring operations are controlled at twin positions on the operator's con-

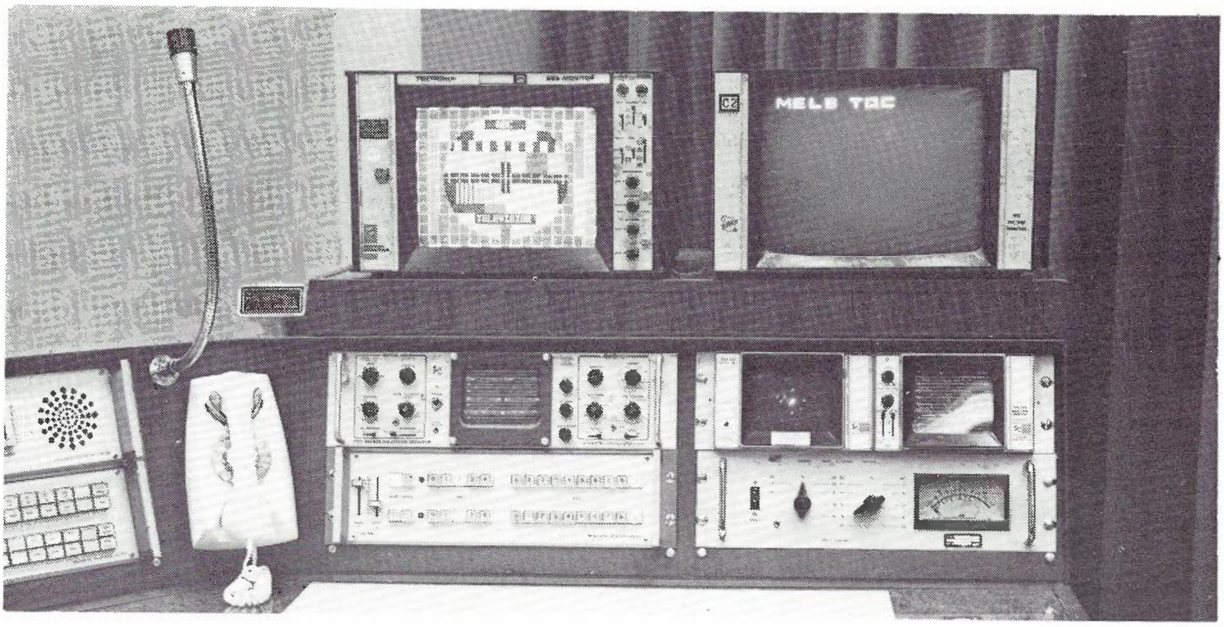


Fig. 6 — Operators Console.

sole and at two equipment racks adjacent to the video and audio patch panels respectively.

Two 30 x 1 video switching matrices and two 50 x 1 audio switching matrices are provided along with associated control and distribution facilities. The video switching matrix inputs are derived from the VDA outputs associated with each incoming bearer. Inputs to the audio matrices are taken from the incoming and outgoing circuits via bridging networks.

The audio and video switching matrices are controlled by interlocking control units situated at each monitoring position. Each control unit consists of a tens and units selector and two seize control keys. Control of a switching matrix is transferred between monitoring positions by engaging the appropriate seize control key.

The output of each video switching matrix is fed via distribution amplifiers to monitoring equipment on each side of the operator's console and at the video rack. This equipment consists of picture monitors, waveform monitors and vector display units. The outputs of the two audio switching matrices are distributed to loudspeakers and VU meters associated with each monitoring position, as well as a headset bus appearing on each alternate equipment rack.

External Communications

The TOC orderwire system was designed to provide the necessary communication facilities for the setting up of video and associated audio connections, fault location and performance testing.

The inputs to the system include orderwires to local television authorities, other TOC's, radio terminals and miscellaneous video outlets in the metro area. In addition to the private lines, multiple connections to the switched telephone network are provided for routine communications, emergency situations and communication to centres where permanent orderwires are not justified.

A block diagram of the orderwire system is shown in Figure 7. The system is equipped with twin control facilities centred at the operator's console. Access to the system is provided at the console and equipment rack positions. Monitoring facilities enable communication via telephones, headset, or microphone/loudspeaker as required.

The system uses standard telephone switching and signalling techniques. Interface units on each incoming line provide the necessary call and pickup facilities. Under control from either of the control positions any line may be switched onto one of two associated orderwire buses. Either of

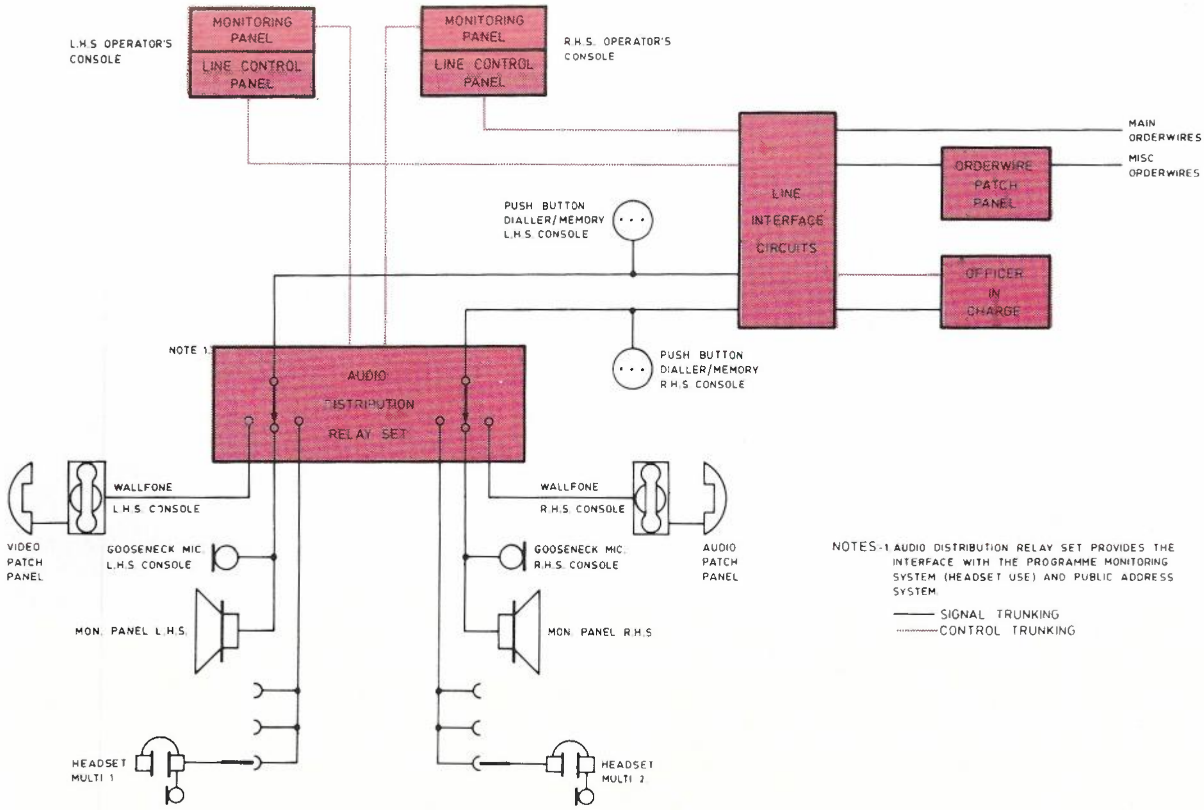


Fig. 7 — External Communication System - Block Block Diagram.

the three modes of communication may then be selected at the monitoring panel.

On the orderwire patch panel facilities are provided for signal mixing, two to four wire conversion and detachment of any line from the main orderwire system for long term usage.

FUTURE DEVELOPMENTS

In this section the techniques that could be used in the future development of Telecom's video relay network are discussed.

The field blanking interval of the video waveform contains a number of vacant lines which are provided to allow time for the field retrace in a television receiver. These vacant lines may be utilized for the transmission of data information and test signals. This technique allows transmission quality to be measured and data to be transmitted continuously since the signals do not interfere with the normal programme transmissions.

Insertion test signal (ITS) analysers, now commercially available, automatically make a complete series of video tests in less than a minute, compared with the several hours required for the existing manual full-field tests. The test results are presented in the form of a digital display and also as data for connection to a computer/printer or transmission to a remote location.

The insertion of ITS at the input to a video channel would enable a complete evaluation of the performance of the channel. The data outputs of ITS Analysers installed along the route would be connected back to the receive station TOC for processing by a computer. In the situation where a gradual deterioration of performance is occurring a 'caution' alarm would enable the fault to be investigated on a non-urgent basis; an urgent alarm would be given for a severe deterioration or failure. By connecting the analyser back to the receive station TOC the fault can be sectionalised and alternative arrangements made whilst the fault is investigated. In the transmitter application ITS Analysers can detect any deterioration in off-air performance and then systematically scan the main and standby equipment in the installation. On detecting the defective equipment the standby facility is automatically switched into service.

Waveform correctors are available which operate on the ITS to automatically correct for most linear distortions which occur in a transmission network.

With ITS being used as the test signal the automatic waveform corrector continuously compensates for both short and long term linear distortions, whereas the existing units used by Telecom are manually operated and require frequent adjustment by a skilled operator.

The data capacity of the field blanking interval is considerable and at the present time is not utilised on the Telecom network. Data on source and destination identification as well as control, switching and perhaps costing information are some of the more obvious Telecom applications of insertion data signals (IDS).

The introduction of insertion test signal measurements and the use of automatic ITS test and waveform correction equipment would greatly improve the supervision and consequently the performance of the video relay network. The degree to which automatic switching is introduced into the network will depend on the future use of television in Australia, the services offered and the associated costs.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the contributions of Mr P. G. Bourne, Engineer Class 3, formerly of Trunk Service, who was responsible for initiating the project and Broadband Installation who, in constructing the TOC, provided the many innovations necessary to the completion of a special purpose installation.

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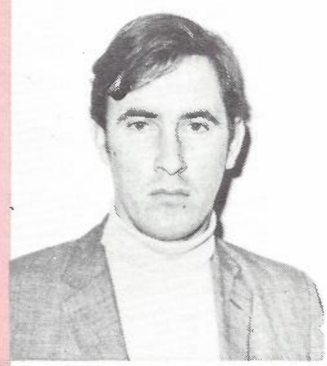
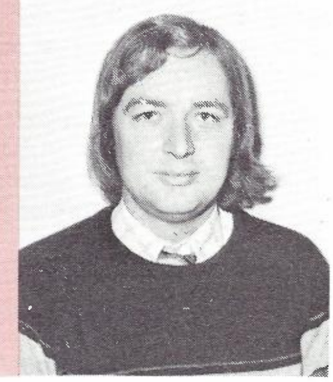
DAVID HUMBERSTONE obtained a degree in Electronic Engineering from the University of Essex, UK. Prior to joining the APO in 1972, he worked as a computer engineer in the UK and as a maintenance technician with The Gambian Post Office, West Africa. He is employed as an Engineer Class 2 in Victorian Trunk Service and during the period 1972-1975, was involved in a wide range of long line transmission projects. Currently he is engaged upon several projects relating to Telecom's video and programme relay networks and is a member of the ITS Working Party.



KEN LOCK obtained a B.E. Electronics from Footscray Institute of Technology in 1973 after having a PMG Cadetship for 3 years. Since being appointed to Trunk Service Victoria he has been involved with various aspects of the TOC project. Other projects have included participation in commissioning of the FM stereo network and a number of exercises involving computer aided design and analysis. He is currently employed in problems regarding installation and maintenance of switching equipment.



Exchange Network Planning; Use of the I.T.T. Computer Program–Part 1

M. J. PRIEST, B.Sc., M. Eng. Sc., M.I.R.E.E. and P. R. HALLAMS, B.E., M.B.A.

A computer program to aid Network Planning of Telephone Exchanges in Urban Areas has been developed by ITT (Spain). The program has been used to analyse the networks of a large provincial city and the Sydney ELSA area. This two part article describes the main features of the program and some aspects of its practical application. Results indicate that the program is a useful aid to short and long term planning.

INTRODUCTION

The Australian population is highly urbanised, and available evidence (refer Table 1) indicates a continuing trend towards increased urbanisation. A significant feature of Australian urban development is its relatively low density.

Population projections by the Planning and Environment Commission (State Planning Authority) of New South Wales indicate that very rapid growth should occur in the outer metropolitan growth centres and the new cities (refer Table 2). Most of these growth centres will require substantial development of virgin land, which has none, or very little, existing telecommunications plant. Since telecommunications services are growing faster than population, average growth rates of 10% and higher should be expected (refer Table 3).

A 10% compound growth rate has a doubling period of about 8 years. The lead time from recognition of a need to cutover of a permanent exchange is currently from 6 to 8 years.

Thus we are planning networks which will double in size within the normal planning period. The efficient development of the network therefore requires earlier recognition and planning of development areas.

The basic objective of network planning is to provide service to subscribers at the least cost to meet prescribed standards. This is achieved by trading off the cost of establishing new exchanges and junction routes, against the savings made in subscribers cable by avoiding long cable loops to serve new areas. For a given area (say a tandem or minor switching area) containing a known distribution of subscribers, there is a configuration of exchanges and cable layout, such that the total network cost is minimal. This occurs when the marginal cost of establishing a new exchange is equal to the marginal saving in cable cost (refer Fig. 1).

This complex task of considering all feasible combinations for a network is almost impossible by manual means. To date this work has been done by the Planning Engineer using theoretical studies (showing optimum exchange area for various subscriber densities), and professional experience to reduce the number of alternatives. Because of the time consuming nature of undertaking detailed economic comparisons manually, it is necessary to reduce the alternative network arrangements examined in detail, to two or three. Whilst experience may lead to the selection of the appropriate alternatives for examination, it is highly desirable, bearing in mind a capital expenditure of over $400M p.a., that a more rigorous approach which is able to examine a bigger range of alternative network arrangements should be used.

Network planners are faced with the situation of rapid growth in a number of "virgin" areas, an annual investment of about $400M, a shortage of experienced engineers, and techniques which are time-consuming, tedious and not terribly accurate. There is apparently a need for more powerful tools for planning exchange network. Such a tool is the ITT Computer Program for exchange area design and exchange placement. This program was developed by the Spanish subsidiary of the company for use in planning telephone networks for South American cities. The present version has evolved as a result of a number of years of the company's experience in planning of networks throughout the world. The program is written in Fortran with some sub-routines in IBM assembler language.

TABLE 1 — POPULATION URBAN AND RURAL AUSTRALIA

Division	Population		% of Total	
Urban	**1966**	**1973**	**1966**	**1971**
Major Urban	6.7M	8.2M	58.26	64.56
Other Urban	2.9M	2.7M	25.21	21.25
Rural	1.9M	1.8M	16.53	14.19
Total	11.5M	12.7M	100.00	100.00

TABLE 2 — PROJECTED POPULATION: SYDNEY REGION (000's)

Sydney Region	Census 1971	Projection 2000	Compound Growth Rate
Central Core	412.2	394	—0.1 %
Inner and Intermediate Suburbs	902.6	994	+0.35 %
Outer Suburbs	1161.5	1837	+1.6 %
Outer Metrop.	289.1	741	+3.3 %
Growth Centres			
Peripheral Areas	34.5	71	+2.5 %
New Cities	136.0	885	+67 %
Total Region	2935.9	4922	+1.8 %

TABLE 3 — ESTIMATED SUBSCRIBERS, SYDNEY METROPOLITAN AREA (000's)

	1974	1980	1994	Compound Growth
Inner Area (15 Km)	800	1125	1924	4.5 %
ELSA Area	70	143	404	9 %

THE COMPUTER PROGRAM

The program applies an algorithm of new exchange placement and network optimisation for a range of specified conditions to a model of the existing network. This model includes forecast subscribers development and the existing exchange network configuration. The input data for the model includes a grid matrix, each square indicating the forecast subscriber demand appropriate to the study date. The location of existing exchanges is nominated and maximum and minimum sizes appropriate to their development specified. Areas of the grid can be zoned according to common characteristics (land cost or traffic) and reserved areas (parks, lakes, etc.) ensure no new exchange is placed in an unrealisable location.

Other input data specifies the cost structures of various plant classes; Subscribers Cable, Junction Cable (both including conduit), Switching Equipment, Buildings, Land and Power Equipment, in their appropriate form. Cable costs are expressed as a function of distance, switching equipment costs as a function of subscribers and junctions.

The effect of natural boundaries, representing obstacles for cable access, can be modelled by allocating routing zones and routing nodes. Cables between routing zones can therefore be forced along given routes by nominating node points; permitting realistic modelling of junction cable network design in the presence of physical constraints.

Based on this network model the algorithm first designs boundaries for minimum cost. (This in itself providing a useful indicator of the need for review of current boundary designs.) One new exchange is then added to the network, at the location selected according to a set of factors designated as influencing exchange placement. The boundaries are then redesigned for minimum cost, and the total network costs associated with the design calculated. The program then steps on to establish additional exchanges until the stopping criteria (maximum number of exchanges) is reached. Details of this procedure have been described in Ref. 1.

The output data for each plan includes a reproduction of the subscriber grid, incorporating assignment of each grid square to a particular exchange. Exchange locations are also shown. A summary of costs gives a breakdown of costs per subscriber in each exchange area for all plant classes, as well as total network costs and subtotals for each investment category.

The minimum cost network design at the study year can then be determined by inspection of the total costs associated with alternative plans.

Other facilities are available, including the assessment of the effect on total network costs of variations in the location of new exchanges. By changing input data, a sensitivity analysis of varying influences can be obtained.

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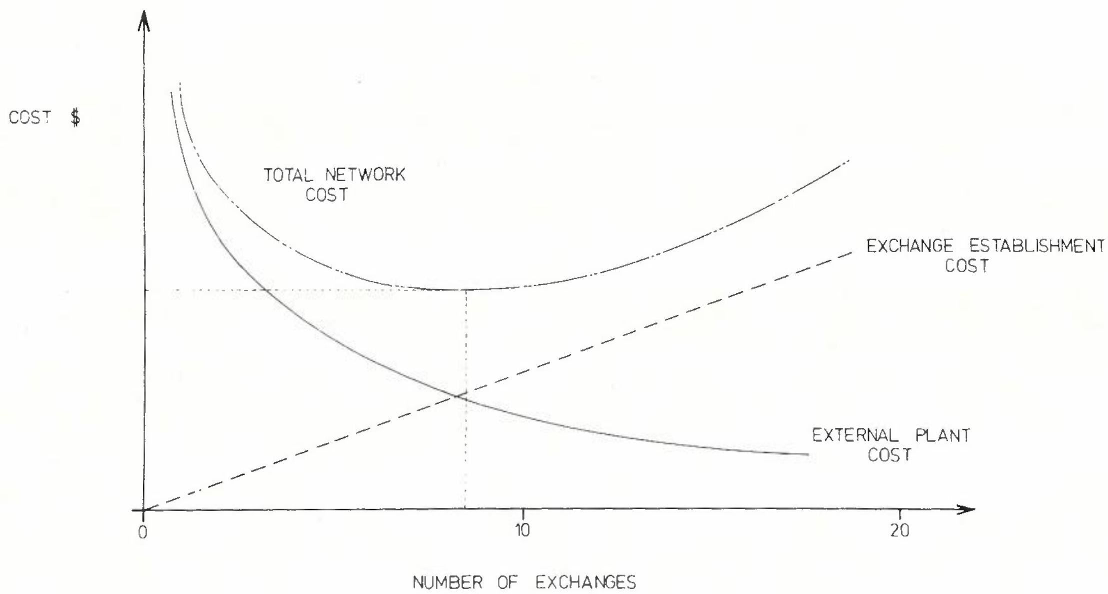
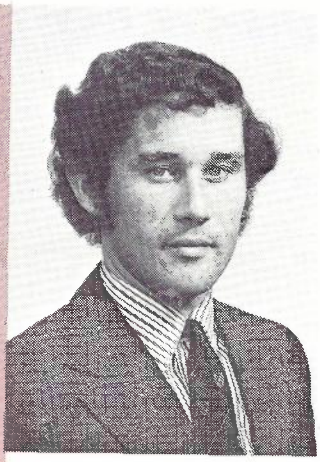


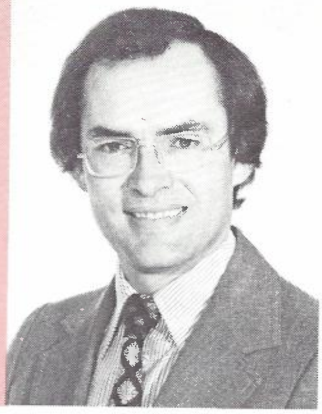
Fig. 1

MICHAEL PRIEST was born in Bristol, U.K., in 1948. He studied at the Lanchester Polytechnic (Coventry) and was awarded an Honours Degree in Electrical/Electronic Engineering in 1969. Subsequently he completed a post-Graduate apprenticeship with G.E.C./A.E.I. (Telecommunications) Ltd., U.K., and was employed by the company as a Telecommunications Systems Commissioning Engineer. In 1970 he joined the Australian Post Office as Engineer Class I in the Sydney Metropolitan Branch. From 1971 - 1975 he was Engineer Class II in Transmission and Lines Planning (Metropolitan), Exchange Networks Subsection.

Following part-time studies at the University of N.S.W. during 1971/72 the Degree of M. Eng. Sc. was completed. Since 1975 he has been employed by the N.S.W. Department of Technical and Further Education in the Division of Electronics and Communications.



P. R. HALLAMS joined the Post Master Generals Department as a Cadet Engineer in 1967. After graduating from the University of New South Wales in 1968, with a B.E. in Electrical Engineering, he worked as an Engineer Class 1 for eighteen months in Trunk Service and Telegraphs Section. He was transferred to Metropolitan Equipment Service Section for six months, before joining Planning Branch as acting Engineer Class 2. In 1970 he gained admittance to the Graduate School of Business Administration at the University of New South Wales, graduating Master of Business Administration in 1972. His experience in Planning Branch has been gained in the Transmission and Lines Planning (Country) Section, and involves bearer provisioning, exchange area design and bearer utilisation.



Important Announcement to Society Members

Telecom Australia has approved a scheme for members of the Telecommunication Society of Australia to have their membership and subscription fees automatically deducted each fortnight from salaries. Before this can be arranged the member or prospective member must complete the special authorisation form held by his or her local agent or State Secretary. We urge you to take advantage of this arrangement and the convenience it offers. Save yourself the worry of whether your fees are paid, and at the same time assist us in the smooth administration of the Society.

Membership rates for 1977 remain the same as for 1976, which means that a member receives the Telecommunication Journal and other advantages of Society membership for 12 cents per fortnight, or alternatively both Telecommunication Journal and Telecommunication Research for 27 cents per fortnight.

We regret that these facilities for deduction from salaries are not available to other than Telecom Australia employees.

Connection of PBX Lines to Exchanges

J. A. G. TAGG, M.I.E. Aust., M.I.R.E.E. Aust.

An important aspect of the telecommunication network is the provisioning of lines between PBX's and the public exchange network. This introductory article describes the methods used in Victoria for the connection of lines to step by step and crossbar exchanges. Night switching, indialling, traffic and equipment utilisation matters are discussed.

INTRODUCTION

A subscriber with more than one exchange line expects that a call made to him will not be engaged unless all his lines are in use. In manual exchanges, lines are grouped on the exchange switchboard so that a telephonist will know those that are engaged and can easily select a free line. In automatic exchanges, the lines may be similarly grouped together to provide the same type of facility.

Where a bothway (B/W) line is needed then it is either connected to a step by step or crossbar subscribers stage. If more than one line is required then there are a number of choices available depending upon the equipment installed and the requirements of subscribers. Generally, modest needs are met by B/W lines whilst subscribers with greater traffic requirements need incoming only (I/C) and outgoing only (O/G) lines. In this article, I/C and O/G will always be with reference to the public exchange equipment e.g., an I/C line is one that originates calls from a Private Branch Exchange to the public exchange. Private Branch Exchanges (PBX's) may be Private Automatic Branch Exchanges (PABX's) or Private Manual Branch Exchanges (PMBX's).

This introductory article discusses the methods of connecting PBX lines to 2000 type step by step and Ericsson ARF crossbar exchanges as practiced at present in Victoria.

CONNECTION TO STEP BY STEP EQUIPMENT

Requirements up to 10 B/W Lines

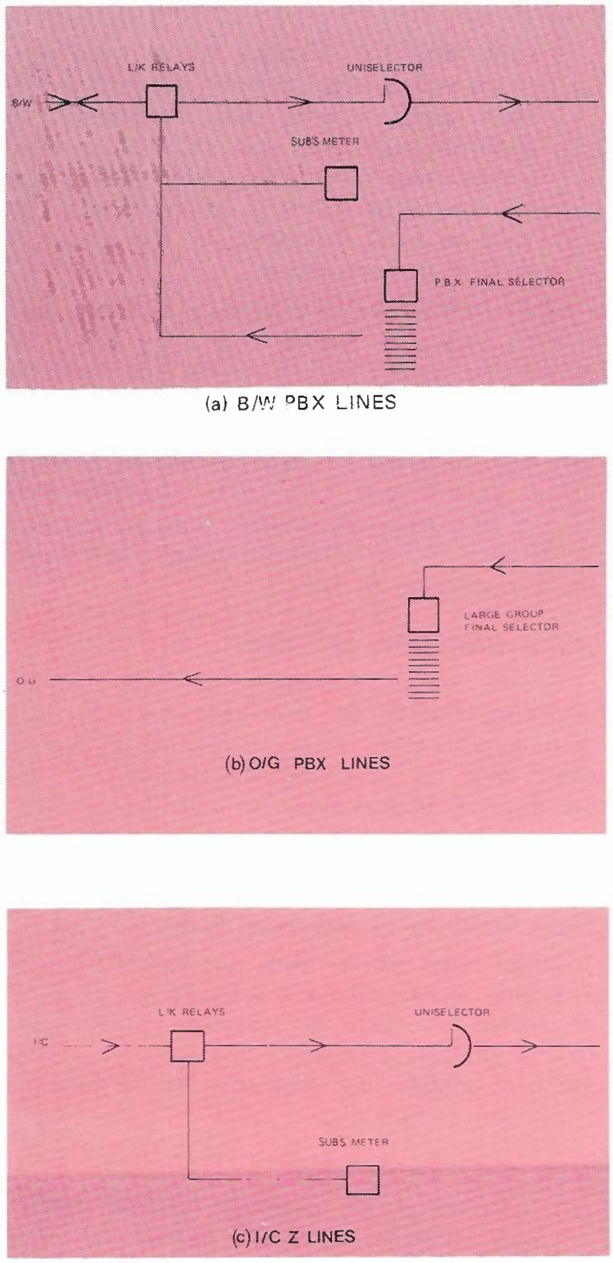
For this requirement, lines are connected to 2/10 type PBX final selectors, the figures referring to the minimum and maximum number of lines possible, grouped in a rotary sequence. A single number is inserted in the directory and when this is dialled the final selector performs an automatic rotary search around the bank contacts to locate the first free line of the group or if none are available then busy tone is returned to the caller.

If a call is made to any other line than the first line in the group, which is the directory number, then automatic search does not take place and the switch functions as a straight line final selector. The lines are also connected to uniselectors to make them B/W as shown in Fig. 1 (a). There are two types of final selectors to cater for a maximum of either 100 or 200 lines.

Requirements for More Than 10 Lines

The 2/10 PBX final selector may be used as follows to provide more than 10 lines:

- Some lines may be allocated numbers outside the rotary group for use as I/C only whilst retaining up to a 10 line rotary sequence solely for O/G calls;
- If more than 10 lines are needed to cater solely for O/G calls then a second rotary group may be provided by using a second directory number with a loss of efficiency compared with a single group. This method would only be used if there were no other alternative available;
- The outlets may be graded within the rotary group by providing individual early choices and commoned late choices. This method is normally not used.



(a) B/W PBX LINES

(b) O/G PBX LINES

(c) I/C Z LINES

Fig. 1—Connection of PBX Lines to Step By Step Equipment.

Outgoing lines may be connected to a group selector level where a ringing relay set repeater is required for each line. If more than 20 lines are needed then they are graded because the selector has an availability of 20. A single directory number is used. The subscribers I/C lines are connected to uniselectors. This method of providing a large number of lines led to the development of the large group (L/G) final selector. This selector has an availability of 10 with 10 levels for up to 10 subscribers and it caters for O/G lines only as shown in Fig. 1 (b). The I/C lines are connected to uniselectors. The digit dialled after the selector has been seized, selects a subscriber's level and the last digit dialled starts a rotary search on the 10 bank contacts. Depending upon the circuit when the last digit is dialled, this search may be as follows:

- Any digit causes a search for the first free outlet;
- Digit one causes a search for the first free outlet but, if any other digit is dialled, then the L/G final selector steps to the specific outlet.

The L/G final selector is used for subscribers who require more than 10 O/G lines. The outlets are graded so that a call will not be connected to a specific outlet. Growth for the subscriber's group is provided by rearrangement of the grading.

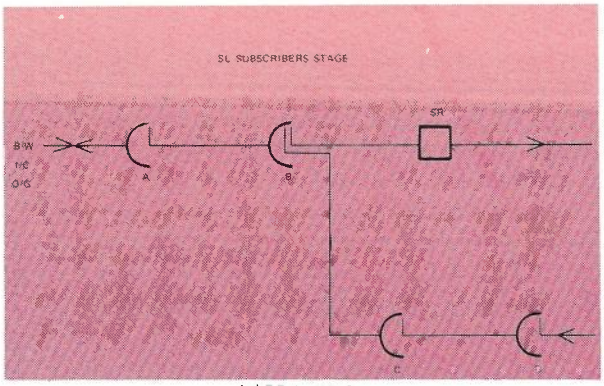
As shown in Fig. 1 (c), at some exchanges special uniselectors and subscriber meters are provided to cater for high calling rate I/C only lines which are not associated with final selectors. These are commonly called Z lines.

CONNECTION TO CROSSBAR EQUIPMENT

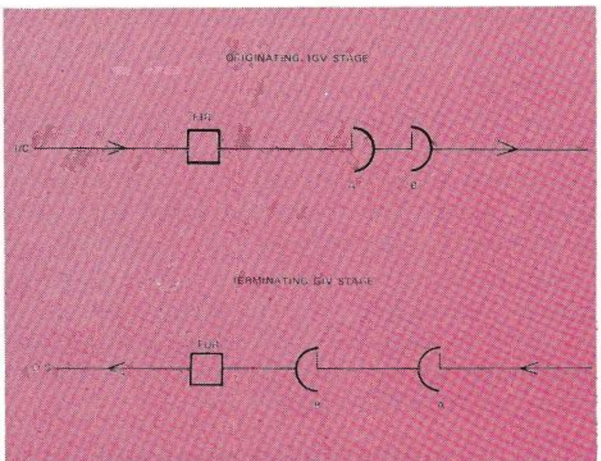
Lines may be connected to a SL subscribers stage or to a GV group selector stage.

SL Subscribers Stage

For this stage, PBX equipment may be installed with each 1000 line group. Each PBX subscriber has a number of B/W auxiliary lines and a line which is the directory number. If this number is dialled then a sequential fixed order search is made over all lines with the actual directory number being the last choice. If an auxiliary number is dialled then it is selected as a straight line. For one PBX number the auxiliary lines can be selected anywhere within the 1000 line group, whilst the directory number usually ends in double digits in order to facilitate connection. Up to 20 auxiliary and one directory number can be provided in one full availability group. If additional lines are required then these are divided into separate groups with a call distributor so that for each call made only one group is tested. If all lines in the tested group are busy then the caller will obtain busy tone. To overcome the loss of efficiency of a line possibly being free in another group, a facility has been provided at some exchanges so that auxiliary lines are commoned to different groups to provide a form of grading.



(a) PBX LINES



(b) ONE WAY PBX LINES

Fig. 2—Connection of PBX Lines to Crossbar Equipment.

Fig. 2 (a) illustrates the SL subscribers stage. In certain circumstances I/C or O/G only lines may be connected to this stage but these lines are usually connected direct to group selector (GV) equipment.

GV Group Selector Equipment

This consists of basic units with 80 inlets and 400 outlets. Units are grouped to provide the required number of inlets and the outlets may be graded into routes of different availability.

The following may be used:

- GV1/80/400. This consists of a basic unit of 80 inlets and 400 outlets with a minimum availability of 10 for any route so that the maximum routes possible are 40;
- GV2/160/400. In this instance two basic units with 160 inlets are used with a minimum availability of five for any route so that the maximum routes possible are 80;
- GV2/160/1300. Because of the need for a switch with a larger number of outlets, a three stage group selector was developed. The GV2/160/400 stage was modified to enable a third stage GVC to be added. This enables the number of outlets to be increased to 700, 1000 or 1300 depending on the amount of GVC equipment added.

Most crossbar exchanges have separate group selector stages to handle originating (1GV) and terminating traffic (GIV). Incoming and O/G PBX lines may be connected as shown in Fig. 2 (b) via the appropriate line relay sets. The GV stages may be connected in different configurations to obtain greater total availability. Outgoing lines off the GIV stage are graded and calls can only be directed to the directory number because of a random selection of lines.

NIGHT SWITCHING FACILITIES

Private Branch Exchanges can have a night switching facility so that calls may be automatically connected to extensions. There are two basic ways of providing the facility — night switching of calls received on individual exchange lines, or night switching of any call made to the directory number.

Night Switching — Individual Exchange Lines

Earlier type PBX's have an Individual Night Switching facility where a selected exchange line is directed to a particular extension. This line may be the directory number, a line within the rotary group or another line depending on the exchange equipment as follows:

2/10 PBX Final Selectors

- Selection of the directory number. This is only suitable in quiet periods of traffic because a second call will switch to another line;
- Selection of another line within the rotary group, so that a call will only be directed to that line. This is the usual method.

L/G Final Selectors

- Selection of the directory number by the provision of a common choice on the first outlet of the grading so that in quiet periods of traffic a call will be directed to that line. This has the disadvantages of making the grading inefficient and a second call will not be connected to this line;
- Use of a common choice of the grading. This can only be provided if the L/G final selector

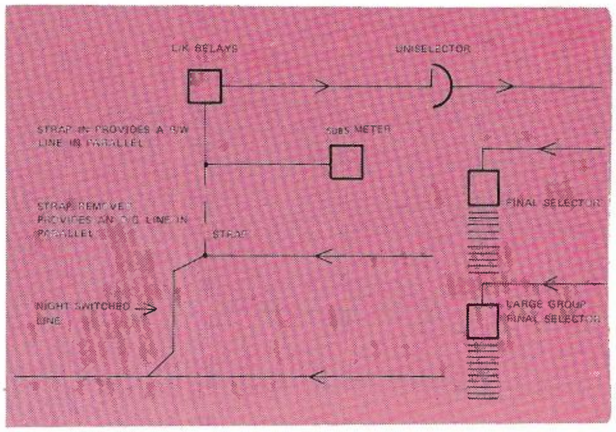


Fig. 3—Night Switching of Step By Step Large Group PBX Lines.

is of the type where the last digit dialled identifies a specific outlet;

- Connection of a subscribers stage line in parallel to a selected O/G line as shown in Fig. 3. This is the usual method.

SL Subscribers Stage

Selection of an auxiliary line so that a call will only be directed to that line. The directory number is not suitable because it is the last choice line.

GV Stages

It is not possible to select a particular line off the terminating (GIV) stage because of a random selection. Instead a subscribers stage line is connected in parallel to a selected I/C line on the originating (1GV) stage as shown in Fig. 4.

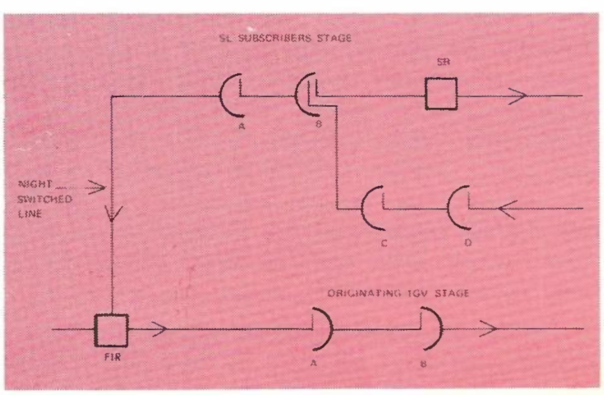


Fig. 4—Night Switching of Crossbar One Way PBX Lines.

Night Switching — Directory Number

In addition to the facilities mentioned above modern PBX's can provide either singly or in combination the following forms of night switching on calls made to the directory number:

- Selected Night Switching. In this instance calls are directed to a particular extension;
- Doctor Night Switching. As for Selected Night Switching but the choice of the extension is made by the telephonist;
- Group Night Switching. Similar to Selected Night Switching except that a group of extensions may be called;
- Remote Alarm Night Switching. Calls are connected to a system of alarms.

This type of night switching has the advantage that the directory number can always be used and no special arrangements are needed at the exchange.

PABX INDIAL LINES

This is a facility whereby calls are dialled direct to PABX extensions without a telephonist's assistance.

The main advantages are:

- Reduced telephonist's time and if a large PABX is installed then less telephonists may be needed;
- A simplification of night switching;
- A shorter holding time for calls on the exchange lines.

Some of the disadvantages include:

- Allotment of large group code ranges to each PABX which usually would be a 1000 line group compared to a telephonist controlled PABX in which instance only 100 or 10 lines of code is used;
- Loss of calls if the extension is unattended or engaged;
- The impracticability of listing all numbers in the directory with the disadvantage that the caller must know the required extension for indialling to be fully effective.

Because it is necessary to send the first few digits of the subscriber's number to the PABX it is not possible to provide this facility with PBX final selectors or the SL subscribers stage. For step by step equipment indial (I/D) lines are provided off group selector levels with relay set repeaters and for crossbar off terminating GIV stages with FUR relay sets. If provided off the GIV stage then signalling may be decadic or multi frequency code subject to Telecom requirements.

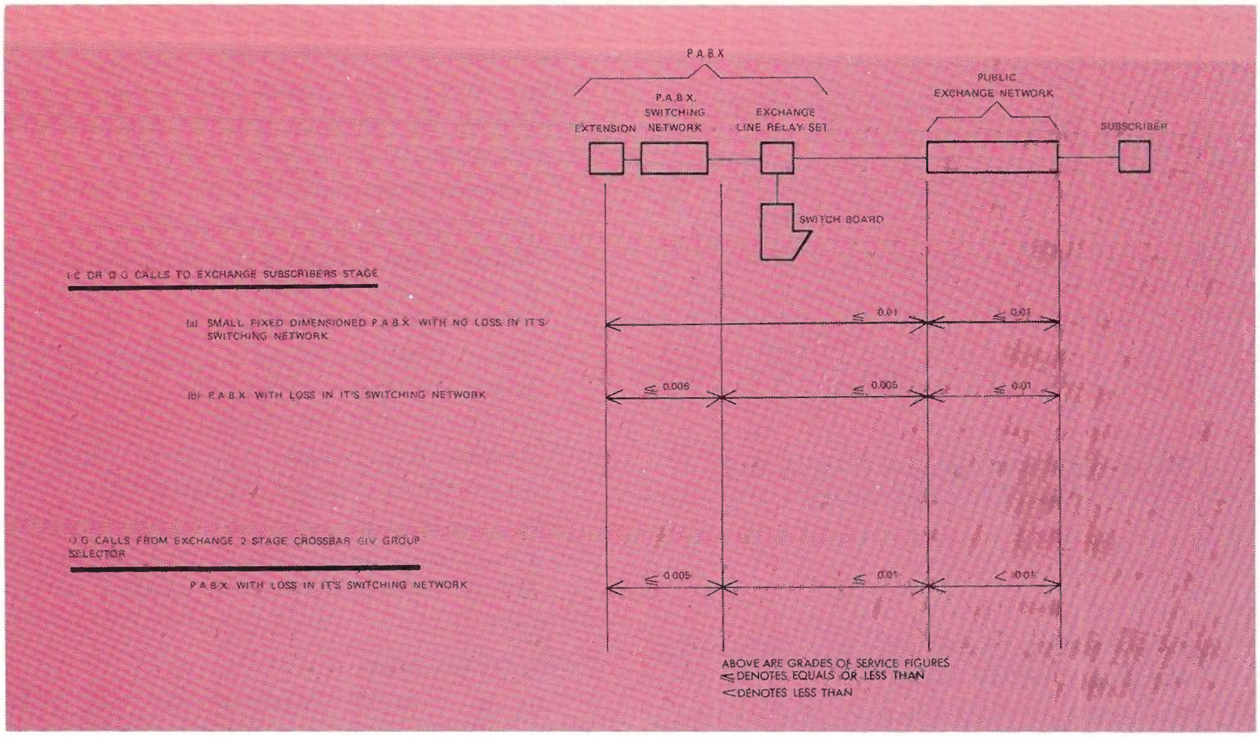


Fig. 5—Dimensioning of PBX Lines.

TRAFFIC

Dimensioning of PBX Exchange Lines

It is not economic to provide sufficient PBX lines to cater for every call in the busy hour. The grade of service required between the public exchange network and a PBX extension is one call lost in one hundred during the busy hour. This may be expressed as a grade of service of 0.01. In addition the grade of service in the exchange local network must not exceed 0.01. There is a concession given in the case of I/D calls where an additional grade of service loss of 0.002 is allowed in cases of losing or misdirecting an indialled call because the equipment is not ready to receive the digits of the number.

The actual grade of service provided for exchange lines will depend upon:

- Trunking availability of the route off the exchange equipment;
- Congestion loss in PBX, if applicable;
- Whether the subscribers or group selector stage is used.

Some common dimensioning examples for PABX's with I/C and O/G lines are illustrated in Fig. 5. In the last example because the subscribers stage is by-passed, the network grade of service will be better than 0.01, hence the grade of service to the PABX can be slightly lower than would otherwise be the case.

Trunking Availability

The trunking availability of the exchange equipment, to which PBX lines are connected, can have an appreciable effect on the traffic handling capacity. For step by step equipment there are not many alternatives available: PBX final selectors with a maximum number of 10 lines provide full availability, group selectors for I/D lines have 20 availability whilst L/G final selectors have 10 availability. For crossbar equipment, B/W lines off the SL stage have full availability up to 21 lines, whilst O/G and I/D lines off GIV stages may have an availability of between 5 and 80.

Table 1 illustrates examples of the traffic carrying capacity for lines on step by step and crossbar equipment at a grade of service of 0.01 assuming typical traffic loading to the input side of the exchange equipment concerned. The traffic figures

TABLE 1: TRAFFIC CARRYING CAPACITY IN ERLANGS AT A GRADE OF SERVICE OF 0·01

NUMBER OF P.B.X. EXCHANGE LINES	IF FULL AVAIL	EXCHANGE EQUIPMENT STEP BY STEP			EXCHANGE EQUIPMENT CROSS BAR		
		P.B.X. FINALS FULL AVAIL	L.G. FINALS 10 AVAIL	GROUP SELECTORS 20 AVAIL	SL SUBSCRIBERS STAGE FULL AVAIL	2 STAGE GIV 10 AVAIL.	2 STAGE GIV 20 AVAIL.
10	4.46	4.46	4.46	4.46	4.46	3.29	4.22
20	12.03		9.90	12.03	12.03	6.0	10.95
40	29.0		20.78	26.10		10.87	23.51

NOTE – AVAIL DENOTES TRUNKING AVAILABILITY OF EXCHANGE EQUIPMENT

have been derived from Traffic Engineering tables used in Victoria. The effect of availability on the traffic carrying capacity can be shown in the following example.

Twenty O/G lines can carry 9.9 erlangs if connected to L/G final selectors of 10 availability, 10.95 erlangs if connected to a GIV stage of 20 availability or 12.03 erlangs if connected to a SL stage of full availability. It may appear that the GIV stage should provide a full availability condition but because of the trunking of links within the stage itself, the full availability condition does not apply.

For O/G lines connected to a GIV stage generally 20 availability is preferred for each subscriber which is a reasonable compromise between the traffic carrying efficiency and the utilisation of the limited total availability of the stage but if more than about 40 lines are needed then larger availability could be considered. Generally for crossbar equipment the SL stage caters for all B/W requirements and the 1GV and GIV stages are respectively used for I/C and O/G lines.

UTILISATION OF EQUIPMENT

In order to fully utilise the exchange equipment it is necessary to consider subscriber's development in the exchange area. The ideal would be to fully allot the subscribers stage ensuring that it carried the maximum originating and terminating traffic permitted and to provide sufficient group selectors, L/G final selectors or GV stages to cater for high calling rate and I/D requirements.

Consider a Metropolitan City crossbar exchange. If all originating traffic was switched through the SL stage a high originating traffic rate could limit the number of lines connected to the stage. Therefore I/C lines connected to 1GV inlets would be provided to carry originating traffic for high calling rate lines. The connection of lower calling rate lines, mainly B/W, to the SL stage would enable higher occupancy to be achieved within the originating traffic limit. Similar methods are used to optimise the utilisation of equipment in the case of terminating traffic.

Lines need to be carefully allotted to achieve the best loading on the available equipment and frequent checks are needed to ensure that future extensions will be correctly provided in order to cater for the expected growth.

FUTURE DEVELOPMENT

The Ericsson register processor exchange ARE11 is now in service at Elsternwick exchange. This provides the following PBX facilities:

- Simple jumpering where one solderless jumper is used for each line;
- A choice of numbers within a 10,000 line

group;

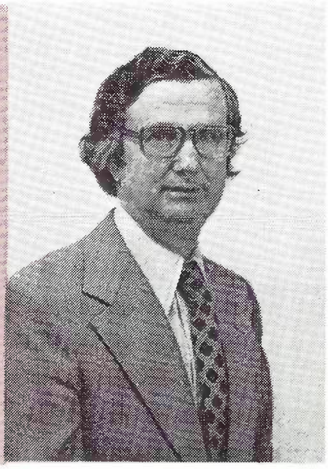
- Up to 126 numbers for each PBX group.

At the time of preparing this article schedules are being considered for the provision of a Stored Program Control local exchange for urban application. This would provide software for the control, routing and numbering of PBX lines.

CONCLUSIONS

Rentals are partly based on the number of exchange lines provided and do not take into account additional exchange equipment that may be required for night switching or the traffic handling capacity of lines. It is considered by the author that these aspects should be examined.

J. A. G. TAGG as an engineer joined the APO in 1957, after working for Marconi Wireless Telegraph Co. Ltd., in the United Kingdom. From 1957 to 1961 he was engaged on the installation of internal equipment in Victorian country areas and for the next 2 years he assisted in the planning of exchanges in Melbourne. Since then he has worked in various Melbourne Metropolitan Operations Sections. At present he is Engineer Class 3, City Operations.



Technical News Item

ARE-11 INTRODUCTION INTO THE AUSTRALIAN NETWORK

In the national telecommunication network there is a continuing demand for new and improved facilities and with this in mind, Telecom Australia has been evaluating the L.M. Ericsson ARE-11 exchange switching system for use in new exchanges and for updating existing ARF 102 exchanges. This system uses the same crossbar switching stages as the current standard 102 exchange equipment but employs stored programme control techniques (in lieu of wired logic) to perform the common control functions of the exchange. In the ARE-11 system, the common control equipment is known as ANA 301. When installed in an ARF exchange, the exchange type becomes ARE-11.

An ARE-11 model exchange has been installed in the Switching Design Laboratories in Melbourne and two trial exchanges are being installed, one at Elsternwick, Victoria and the other at Salisbury, South Australia. The model exchange has been used for evaluation and training purposes since March 1975. Elsternwick, a new exchange installation replacing obsolete equipment was cutover on the 20 June 1976. The Salisbury installation is an upgrading of the existing exchange by replacement of the existing common equipment with the ANA 301 sub system and will be cutover in September 1976.

In March 1976 the ARE-11 exchange system was accepted as an alternative to the ARF 102 standard switching equipment for use in urban network applications in the Australian network. The ARE-11 exchange system provides all the existing and new facilities currently proposed for introduction in the network. ARE-11 will therefore be used where economic, for new exchanges and in upgrading existing exchanges to provide new facilities, such as automatic message accounting for international calls, voice frequency push button telephones and automatic diversion when required to an interception service centre. The ARE-11 system also offers the potential to provide other facilities when required more economically than the current electromechanical systems and in addition will provide significant operational and maintenance benefits.

An order has recently been placed with L.M. Ericsson for ARE-11 material to be delivered early in 1977/78 to enable 13 existing ARF exchanges distributed amongst all States to be upgraded to ARE-11.

Memory Controlled Crossbar Queue

T. KALDOR, B.E., B.Sc., A.S.T.C. (Radio).

The queueing system described provided an inexpensive, "perfect" queue of modular construction, using standard crossbar components. It provides "first in — first out" service (whether callers abandoned their places or not) and utilises up to 20 serving devices for 40 incoming lines in a queue with a capacity of 59 places. All of these limits can be varied. The system was installed on one BCH rack in 1970 for the Sydney Metropolitan Area Changed Number Enquiry Service and has been proven to be dependable in operation.

INTRODUCTION

Several queues have been installed in the Sydney Metropolitan Telephone Network for manual assistance centres utilising the best technology available at the time of their design.

Maintaining of the expected level of performance of these queues became an increasingly difficult task. It was never an economically attractive proposition to improve the facilities provided by an already installed system; consequently, when replacement parts became difficult to obtain, all of the inducements needed for a new design were present.

In the early sixties the need for a new approach to the problem of queueing telephone calls was recognised and the N.S.W. Metropolitan Branch proceeded to establish the feasibility of a new, dependable, "perfect" queue system. By December 1963 a suggested scheme was referred to the Supervising Engineer, Metropolitan Equipment Service and the project was given to the then Equipment Service No. 5 Division, for evaluation and development.

While this work was in progress, it was resolved that the new system would be employed for the "2049" enquiry service.

SYSTEM DESIGN

The following parameters were established for the system design:

- All equipment used would need to be familiar to APO Technicians;
- No solid state components were to be used;
- System design to be based on the use of a crossbar switch;
- All relay sets to be modular;
- The system was to be readily adaptable to any kind of service, anywhere in the telephone network.

The system evolved is called a "Memory Controlled Crossbar Queue". It comprises Incoming Line Relay sets, Crossbar Relay sets, one Common Control Relay set, one Monitors' and Operators' Relay set, Console Positions for Monitors, Operators and a Supervisor and finally one Optional Wall Display of Lights.

SYSTEM ORGANISATION

Each vertical of the crossbar switch is dedicated to a line through its Incoming Line Relay set. The horizontals of the crossbar switch are commoned through all switches, providing access for 20 operators to all incoming lines.

Unique serial numbers are generated in the Common Control Relay set for queueing and, later, connecting the calls in strict order of arrival. The Common Control Relay set is used a third time in handling a call, if it is to be transferred to a Monitor.

No provision is necessary for a central memory to retain information about the location of the coded calls in the queue, Incoming Line Relay set memories are used to mark the wanted relay set when its code is called.

If an equipment malfunction cannot be immediately rectified, provision is made for the suspension of queueing. In this case, no calls are lost from the queue and incoming calls are served at random. This mode of service is brought about by

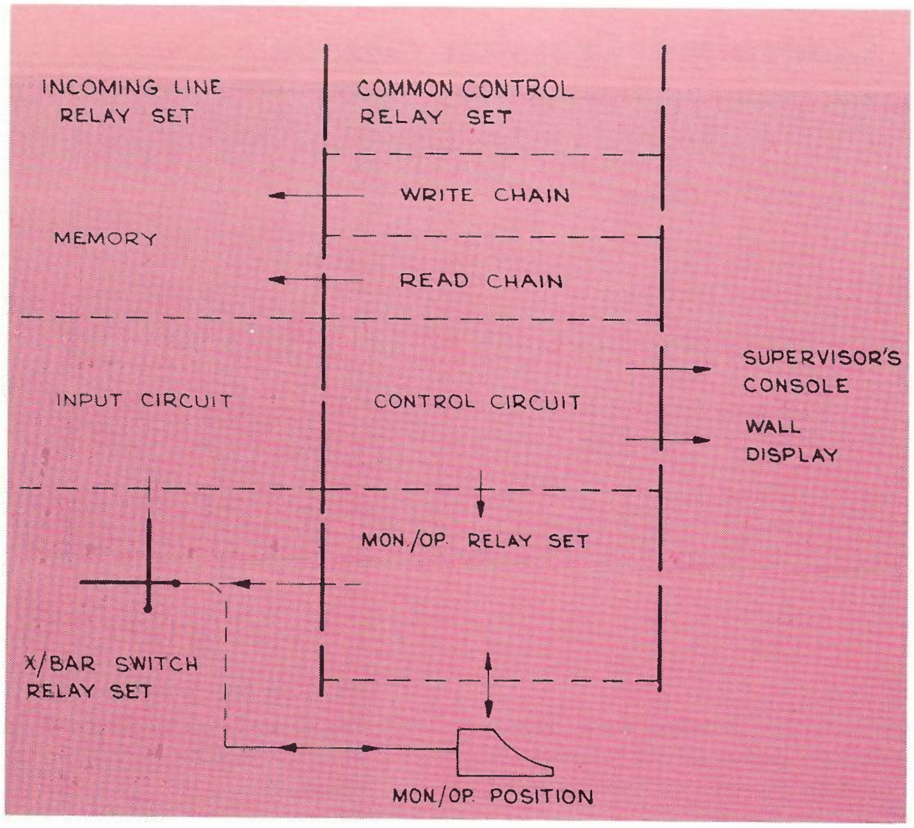


Fig. 1 — System Block Diagram.

the operation of the Queue Fail Key, located on the equipment rack. If Operators are on duty in sufficient numbers, the callers would not be aware of the prevailing fault condition.

BRIEF DESCRIPTION OF OPERATION

A call arriving to the queue is terminated in an Incoming Line Relay set, a serial number is allotted to it by the Write Chain in the Common Control Relay set and is stored in its own memory of miniature relays "SA", "SB", . . . "SF". The Write Chain then steps up on. During the waiting period of queueing, Ring Tone is fed to the caller; this tone can, however, be easily replaced by a recorded announcement and/or background music.

When the Operators have worked down the queue, this call is located and connected by Common Control Relay set to any free Operator. The number retained in the Incoming Line Relay set memory is changed to the "answered" code.

If the caller is satisfied with the information given, the call will be terminated on calling Party Release, this in turn will mark the Incoming Line Relay set as free and available for the next call.

The Monitors' and Operators' Relay set will mark simultaneously the Operator's position as idle and if there are waiting calls, one will be switched to it, without any action on the Operator's part.

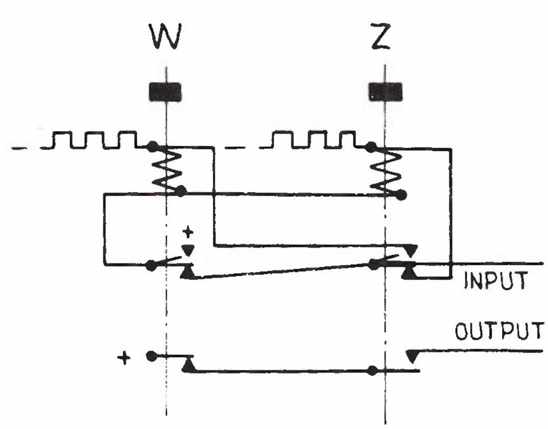


Fig. 2 — "A" Stage of the Write Chain.

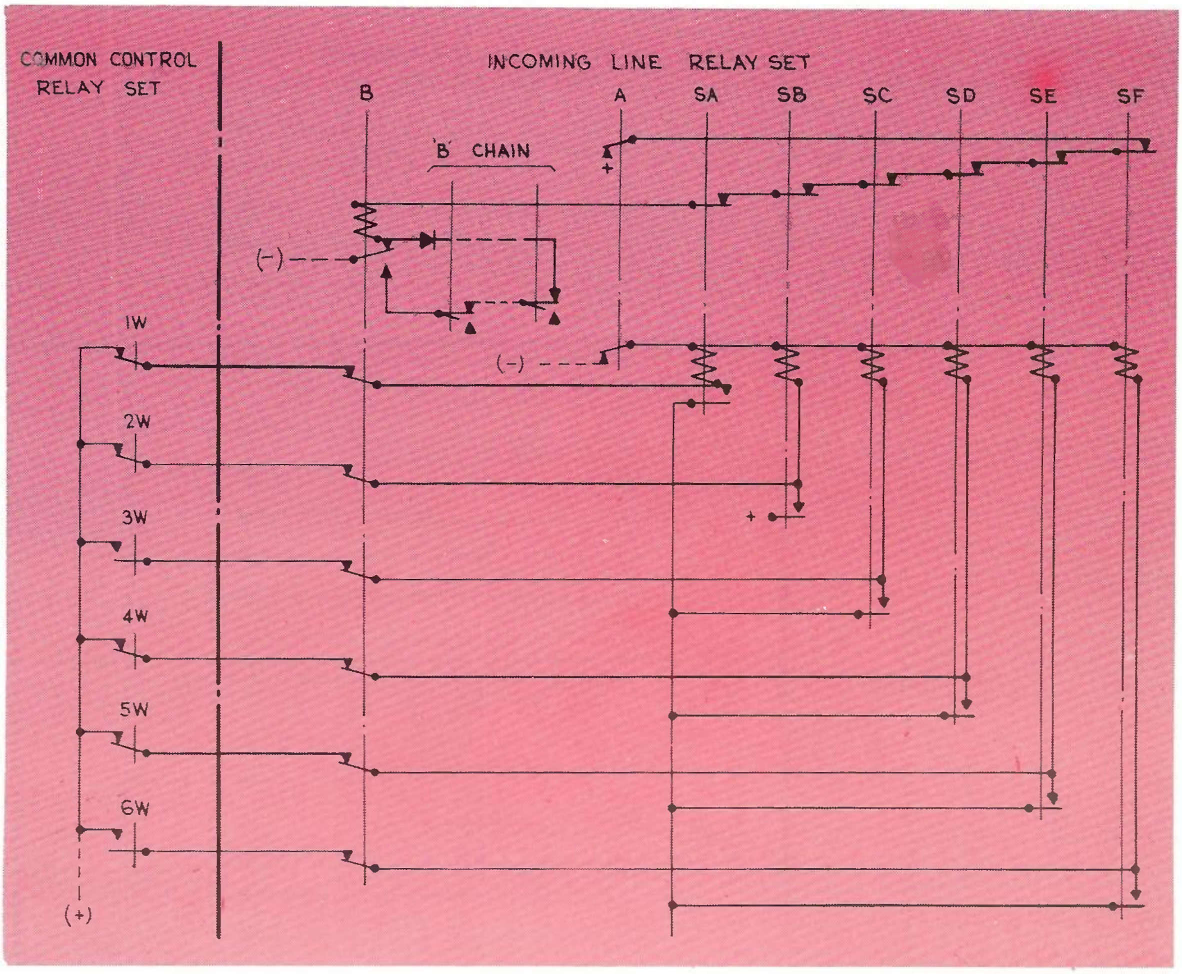


Fig. 3 — Code "27" offered to the Incoming Line Relay Set Memory.

If the caller does not hang up, the Operator can terminate the call by the use of the Release Key, thus preventing the queue being disabled by malicious calls.

If the call is a difficult one, the Operator can hold it while the Monitor is consulted, or the call can be transferred to the Monitor. This last option involves changing the memorised code in the Incoming Line Relay set memory to that of "transfer". When that is done, the Operator is free to take the next call while the transferred caller waits again. Once the Monitor is ready to accept the transfer, the Incoming Line Relay set with this special code in its memory is connected to the Monitor's position by the Common Control Relay set.

Only one transfer at a time is provided for; this obviates the necessity for a separate queue of transferred calls. Warning lights advise all Operators of the availability of the Monitor for consultation and/or transfer.

DESIGN FEATURES

(i) Common Control Relay set Write and Read Chains use two relays in each of the six binary stages.

The arrival of an input earth pulse operates "W" but not "Z" relay, as the "Z" coil is shunted by its own K contact. The cessation of the input pulse removes the shunting earth, and "Z" can now operate. Both relays lock in parallel on the "W" contact.

The next input pulse shunts the "W" coil, "W" releases and disconnects "Z". During the release time of "Z" an output pulse is sent to operate the next stage.

When code "63" is reached, the chain is reset to code "4".

(ii) Encoding the memory of the Incoming Line Relay set is achieved by the use of a dedicated relay "B".

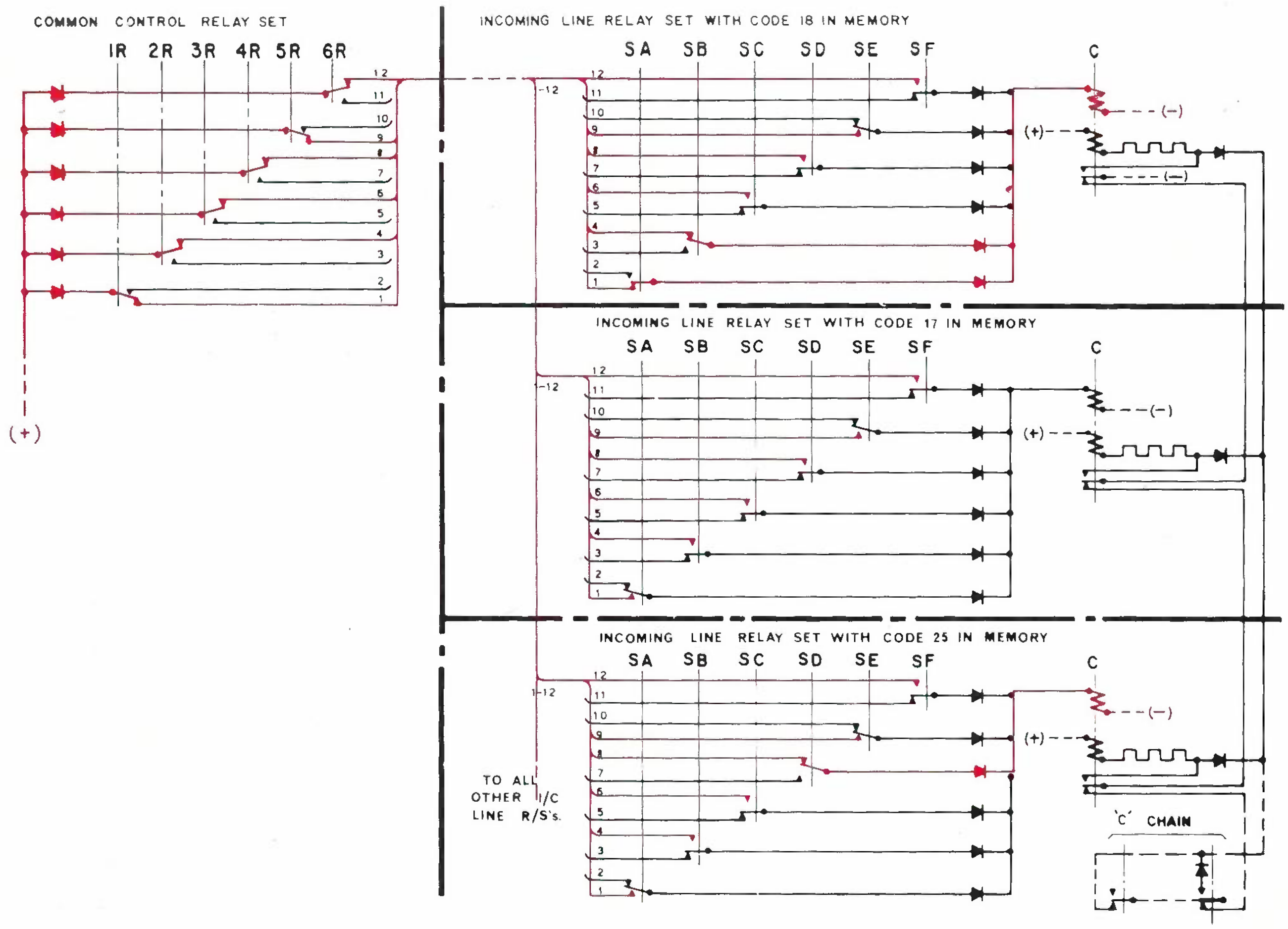


Fig. 4 — Common Control Relay Set Calls the Incoming Line Relay Set with Code "17" in its Memory.

When the arrival of a call operates "A" relay, it busy-marks the Incoming Line Relay set and operates the "B" relay. "B" relay contacts extend the memory leads to the Write Chain contacts in the Common Control Relay set and the "SA", "SB", . . . "SF" relays — corresponding to the binary code number offered by the Write Chain — operate and lock. Operation of any one of the "SA", . . . "SF" relays opens the holding path of "B" relay, which then releases.

The resolution of arrival priority of calls depends on the operate time of "SA", . . . "SF" relays and the release time of "B" relay. This is not a significantly long period; calls arriving during this time are differentiated by the priority of their "B" relays in the "B" chain. This chain ensures that only one "B" relay can operate at any time; it also favours early "B" relays.

(iii) Preparation for switching the next call is started when the previous call is served, whether there are free Operators or not. This is achieved by the use of a dedicated relay "C". This relay has two windings, one for operation, the other to inhibit operation.

This inhibit winding can be energised through contacts of memory relays "SA", "SB", . . . "SF" by contacts of the Common Control Relay set Read Chain. The chain is stepped up one when the previous call is switched through. The code of the next call appears now on the twelve wires extended to all Incoming Line Relay sets "SA", . . . "SF" contacts. Since the wanted code can be stored in one relay set memory only, in all other relay sets the code retained will be different from the one now offered by at least one binary number. Consequently, the earth extended will energise the inhibit

Fig. 5 — Operators' Room, Showing Operators' and Monitors' Positions.

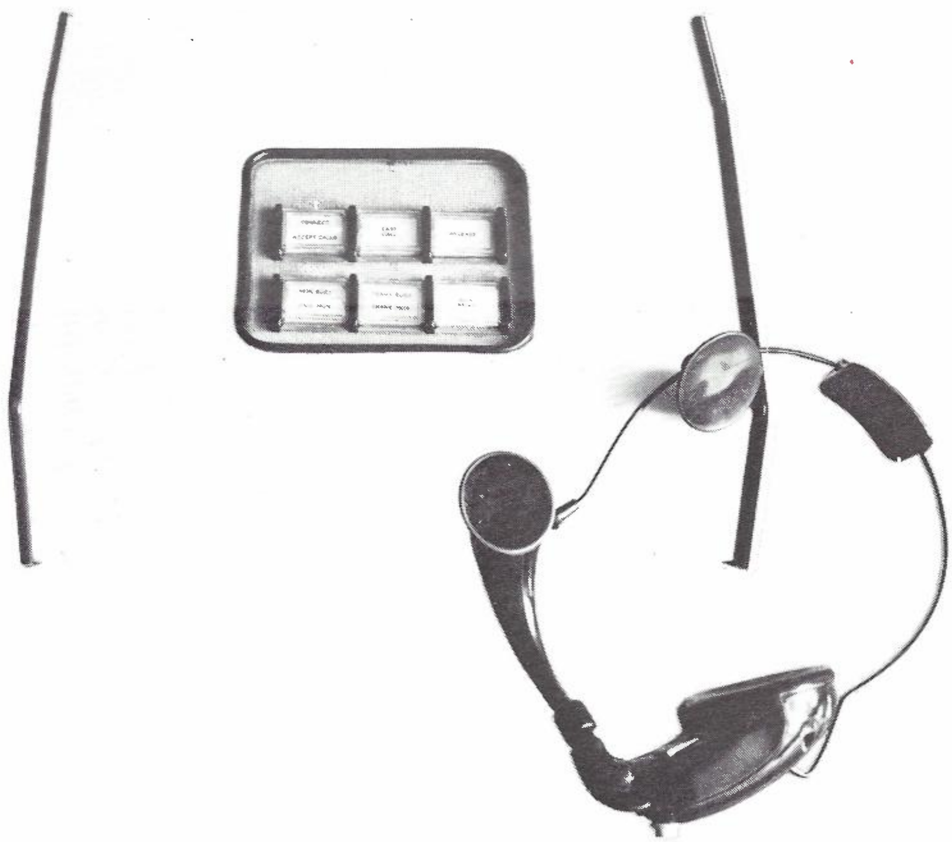


Fig. 6 — Operators' Position.

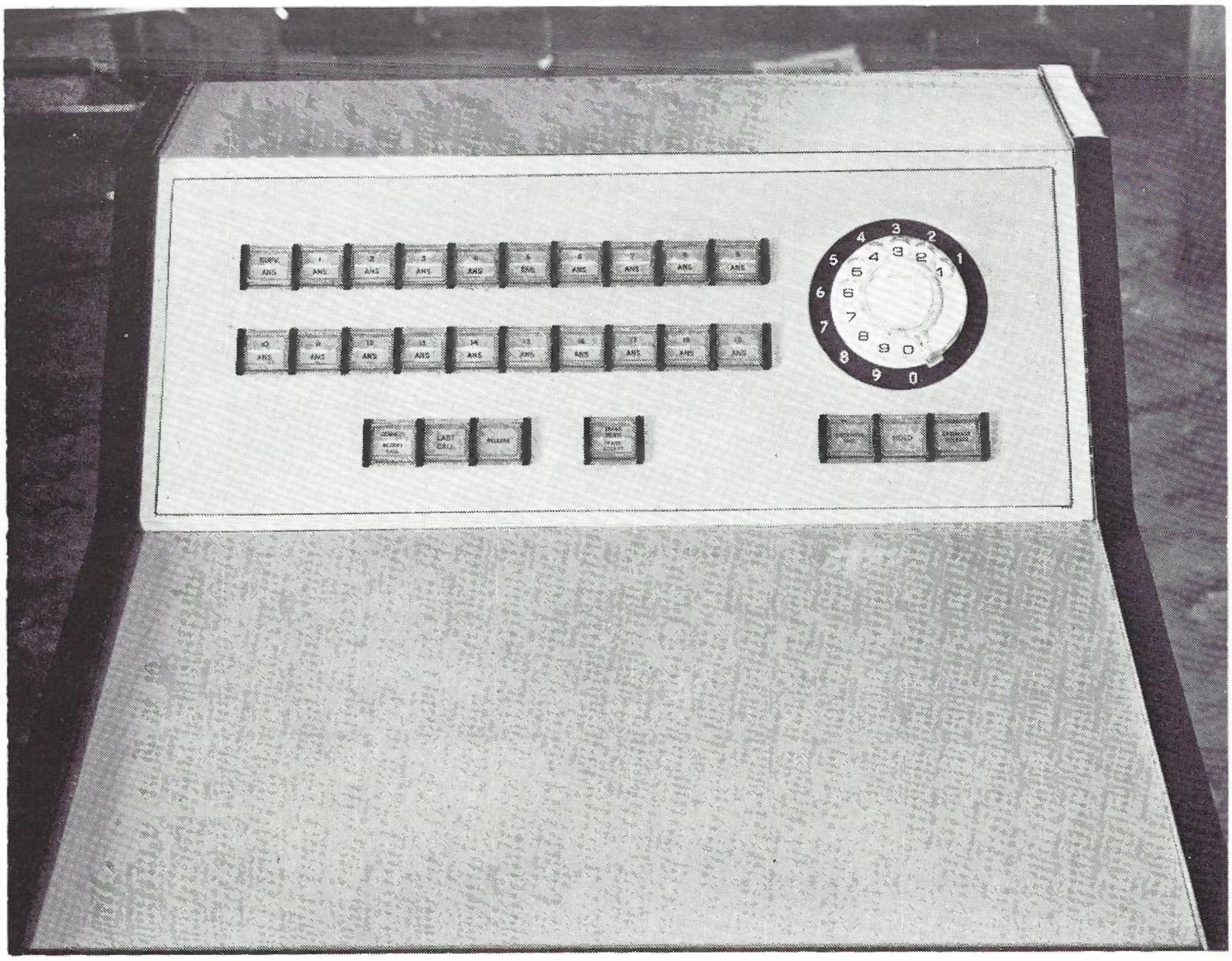


Fig. 7 — Monitors' Position.

winding through at least one path in all these relay sets and only in one, the relay set with the wanted code, will a complete non-coincidence keep the "C" relay uninhibited. This is clearly demonstrated in Fig. 4. This "C" relay will now operate and mark the Incoming Line Relay set as the one to be connected to the next free Operator.

(iv) Two Monitors' Positions were necessary at the present installation, each to cater for (and accept transfers from) 10 Operators. Both Monitors can work as Operators, that is, can receive calls from the queue, if they wish to do so.

(v) The analogue equivalent of "call waiting time" is measured in every Incoming Line Relay set and is translated for display at the Supervisor's Position as an "Urgent" light. If this light shines, more Operators are needed, as the waiting time of the last switched call was longer than the predetermined period.

(vi) If a caller hangs up before being answered, the Incoming Line Relay set will have all its relays released, so the code in its memory is erased. (Such an idle Relay set would be taken by a new call.) But when the turn of the original call arrives, there is no operated "C" relay to mark an Incoming Line Relay set for connection.

Provision is made for such a case in the Common Control Relay set to step the Read Chain to find the next waiting call. If 10 such steps are to be taken before one waiting call is found (it is very unlikely to have such a condition which is equivalent to 10 callers to hang up in a row) the Supervisor is alerted.

FACILITIES

(i) All Operators' Positions have keys for the functions of:

- Accept call,
- Last call,

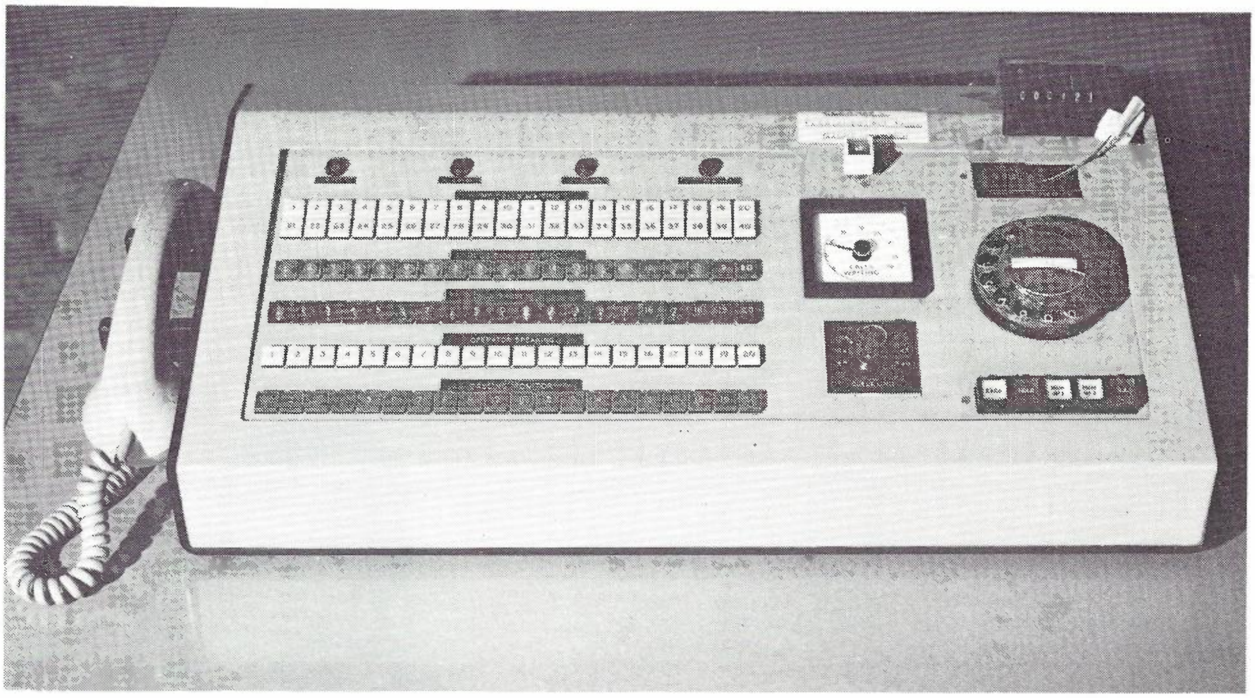


Fig. 8 — Supervisor's Position.

- Call Monitor,
- Transfer call,
- Release call.

There are lights to indicate the execution of these keyed commands and to signal "connect", "Monitor busy", "Transfer busy".

(ii) All Monitors' Positions have similar facilities and indicating lights to signal a call from the Operators, with keys to call them.

(iii) The Supervisor's position has lamps to indicate when any Operator's position is:

- Occupied,
- Ready to accept calls,
- Engaged on a call,
- Calling Monitor.

In addition, there is a lamp for each Incoming Line Relay set to indicate when it is occupied by a call.

There are several lamps to show when non-standard conditions prevail.

(iv) A queue-limiting feature is provided to busy out free inlets (at the discretion of the Supervisor) if the number of Operators available is inadequate for the demand.

FURTHER DEVELOPMENT

There is no inherent limitation in the system. Incoming lines can be added in modules of 10, with the addition of one crossbar switch per module. The length of the queue can be doubled by adding one miniature relay to each Incoming Line Relay set and two relays to both Read and Write Chains in the Common Control Relay set, with some additional rack wiring. If the number of the Operators is to be increased, a new Operators' Extension Relay set would be necessary.

It is now recognised that some of the main considerations leading to the preliminary decisions are no longer valid. Solid state devices are, by now, very reliable and are increasingly familiar to Telecom Technicians.

A solid state version of the queue equipment (still based on the crossbar switch) has been designed by N.S.W. Construction Branch, Telecom Australia.

CONCLUSION

A versatile, reliable and inexpensive queueing system has been realised and its performance in the Sydney changed number information service has proved to be satisfactory to the users (Officers of the Telecommunications Division, now Customer Services Department) and the maintenance T.T.O.s.

ACKNOWLEDGMENTS

Many thanks are due to Mr. F. J. White, Senior Engineer, for backing and encouragement, to Mr. J. G. Harris, for guidance and selfless application, and to Mr. R. H. Errey, for stimulating discussions and timely warnings.

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TOM KALDOR migrated from Hungary in 1957; worked in Australia for AWA and the University of NSW before joining the PMG's Department. Since then he has been engaged in Equipment Service, presently as Engineer Class 2 at the Sydney City Operations Section. He is qualified as B.Sc., B.E., also A.S.T.C. (Radio).

New Headquarters Editors

Geoff Woolfall and Russell Clark have retired from their position of Headquarters Editor for the Journal. Geoff has been the editor for the Planning Division for some years and Mr. Lindsay Cunningham will replace him. Russell was the editor for External Plant and Mr. Michael Rheinberger will take his place.

The Council of Control records its appreciation to Geoff and Russell for the contributions to the Society's work in recent years. The Council also appreciates the willingness of Lindsay and Michael to take over these tasks.

Department of Transport Computer Based Message Switching Systems

W. T. MALONEY, B.Sc. (Hons.) Elec. Eng.

The Air Transport Group of the Department of Transport has installed three computer controlled "store and forward" message switching systems at Sydney, Melbourne and Brisbane. The systems are of an advanced type, providing many special features the more important of which are described.

INTRODUCTION

The Department operates an extensive message switching network, and presently some ten million messages are delivered each year through the Australian Aeronautical Fixed Telecommunications Network (AFTN). Primarily the system is used for operational purposes such as:

- Flight movement and control messages (flight plans, departures advice, etc.)
- Notams (Notice to Airmen)
- Meterological messages (terminal forecasts, route forecasts, etc.)

The rate of traffic growth in the AFTN is such that to achieve the required message transit times automation of the major centres was essential during the early 1970's with an extension of automation to all centres later in the decade. World wide tenders were called for systems for the Sydney, Melbourne and Brisbane airports. The contract was let with Ferranti (UK). The Sydney system was commissioned in March 1973, Melbourne in 1974 and Brisbane just recently.

DEPARTMENTAL NETWORK

The Aeronautical Fixed Telecommunication Network in Australia was originally based on manual tape relay centres at the larger centres, with private wire circuits and teleprinters providing service to smaller stations. Telex is also employed. Much of the equipment has been leased from Telecom Australia. A diagram of the present network is shown in Fig. 1.

The network is now in the process of modernisation to meet the accelerating demands of the jet-age. In this, as in other areas of civil aviation, a continual upgrading of ground facilities is necessary to satisfy the needs of a modern airways system. The modernisation plan is aimed at the complete automation of the network over a period of several years, and the Ferranti systems represent a significant achievement to this end.

BRIEF SYSTEM DESCRIPTION

Automatic switching relies on strict adherence to a standard format, which in this case is the International Civil Aviation Organisation (ICAO) message format for aeronautical telecommunications. The Department has been using this format for many years with the manual relay centres. Many aspects of the format are familiar to those who receive teleprinter messages, eg: ZCZC (start of message), NNNN (end of message) and such things as channel identification and message number, along with one or more six letter addresses.

The computers used in this system are the Ferranti 'Argus 500'. Each message switching system is fully duplicated for high reliability. An additional off line system is installed at Sydney to provide a repair base for faulty modules, and for the development of new hardware and software for both operational and diagnostic purposes.

The three centres, containing seven computers, represent the first large scale application of computers in a real time environment by this Department.

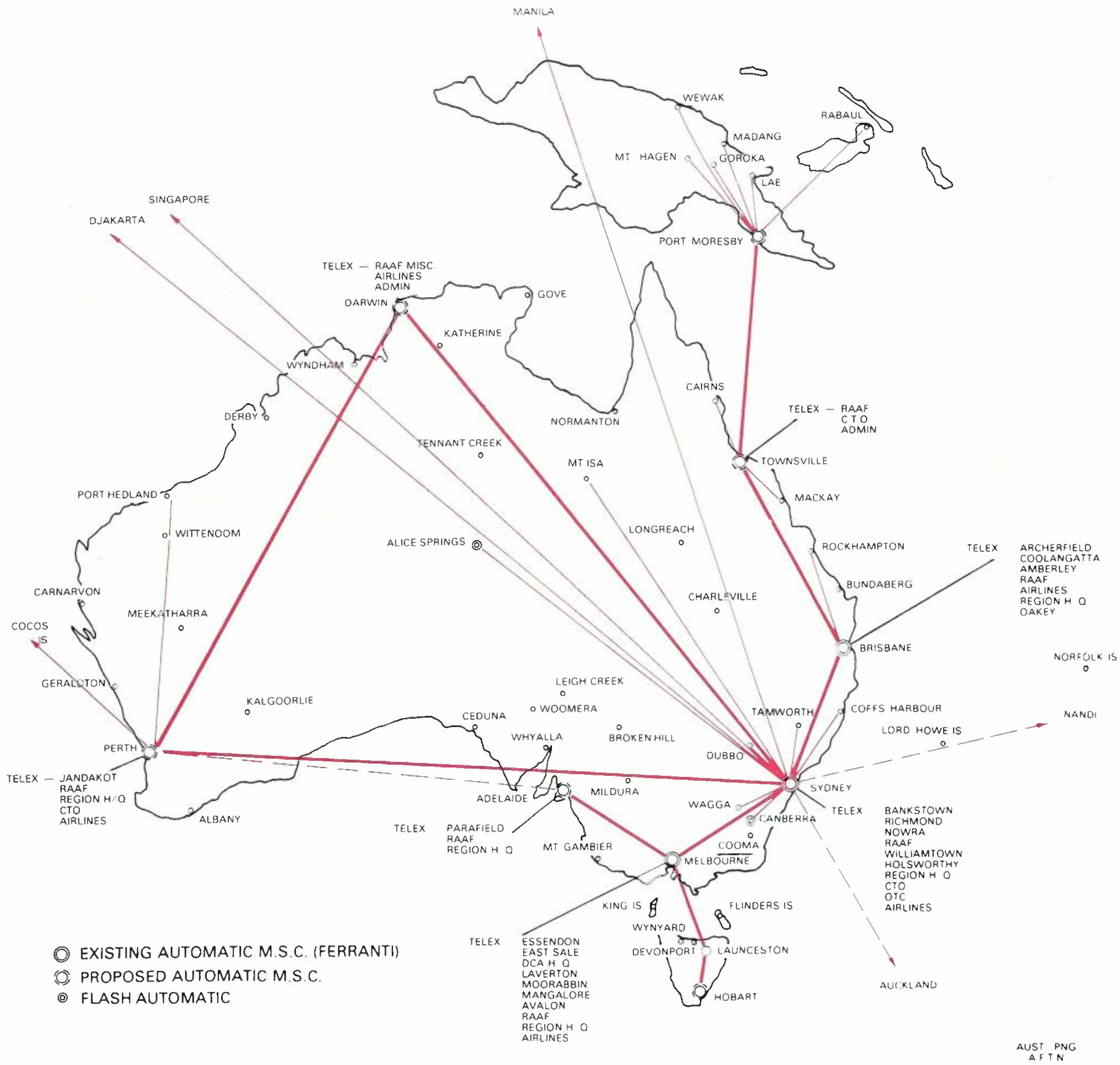


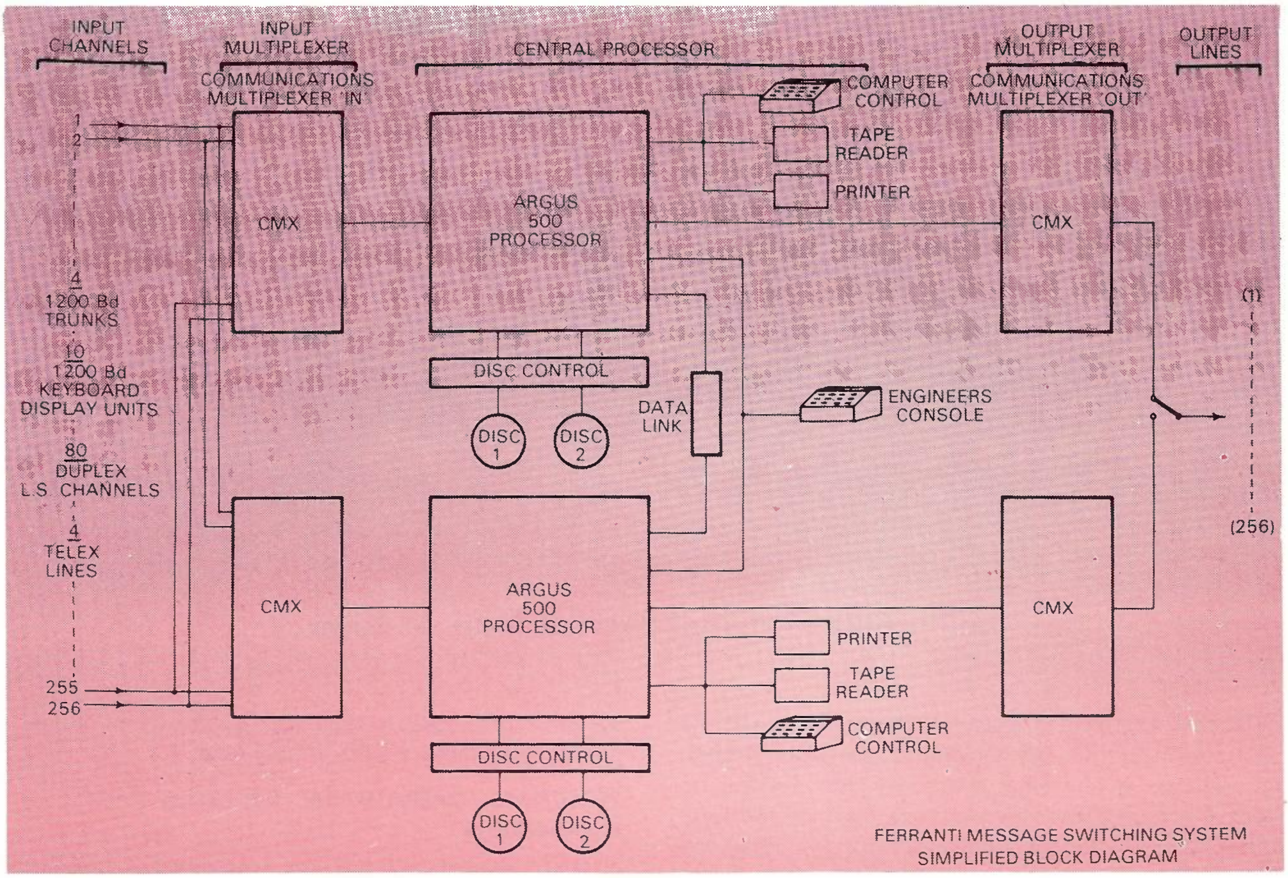
Fig. 1 — Australian AFTN Network.

The system hardware uses TTL, DTL and MOS integrated circuit logic; multilayer printed circuit boards are used throughout.

A block diagram of the main parts of the system is shown at Fig. 2. It will be seen that interface between the data lines and the central processor is by means of a Communications Multiplexer. Fixed head discs are used as the backing store and a number of input/output devices are provided for control and monitoring of the system. To ensure the highest reliability the complete electronic system is duplicated, either half being capable of carrying the full traffic load; also, on each half of the system the mechanically rotating discs are duplicated to provide similar reliability to that of the electronics. (In effect there is a copy of every message on each of four discs.)

Should a fault develop in the 'on line' system, this is detected automatically and a system change-over takes place. Monitoring and message status update is continuously inter-changed between the on-line and stand-by suites by means of the 330 Kbit fast data link.

Keyboard Display Units (KDUs), Ferranti Type TDM 2020, are used at several input positions and



System Features:

- System fully duplicated — automatic changeover.
- 12000 messages/hour traffic capacity.
- 256 line channel capacity.
- Keyboard Display Unit Message entry.
- Pre-format Facility.
- Automatic Generation Service Messages.
- Duplicated Disc Backing Store.
- Disc Storage Capacity 2 Million Characters.
- Multilayer Printed circuit Cards and Integrated Circuit Technology.

Fig. 2 — Block Diagram.

also for supervisory functions. The KDU's interface the multiplexer at medium speed (1200 baud), as distinct from the telegraph lines, which are low speed (75 baud). Medium speed links are used between automatic centres.

TECHNICAL SUPERVISION

Each computer system is controlled from a separate console on which is situated the computer monitor panel, teleprinter and high speed tape reader. (Programs are entered by paper tape). A third console houses the engineer's panel which concentrates alarms and controls for all sub systems. Also located at this position is a Keyboard Display Unit and a teleprinter for entering commands and receiving print-outs from the system. A particularly useful facility available at the supervisory KDU is the ability to display and alter, in 32 word blocks any area of core or disc, thus speeding the entry of software patches and the investigation of software eccentricities. (This facility is under lock and key to prevent accidental software damage). Fig. 3 shows the Sydney switching system and the three control consoles.

COMMUNICATIONS MULTIPLEXER

Messages enter the system via the multiplexer, which assembles message characters in a data buffer. Up to 256 duplex lines of various types including Telex may be connected to the multiplexer. The multiplexer then transfers the data to the computer store by a method known as "Direct Store Access" which minimizes processor loading.

The word length in the Argus 500 is 24 bits, and three characters are packed to a word. The system uses 32K words of store. (The addressable limit is 64K). As blocks of core (32 words) are

Fig. 3 — Automatic Message Switching Centre — Sydney.

filled they are transferred from the core store to the disc backing store again using Direct Store Access. As well as assembling characters for transfer to store the multiplexer also detects Start of Message and End of Message indicators on all types of lines, vertical block parity or polynomial parity as required, and the "Ack Nack and Enq." control blocks, although in this system the latter function is done in software.

MESSAGE HANDLING

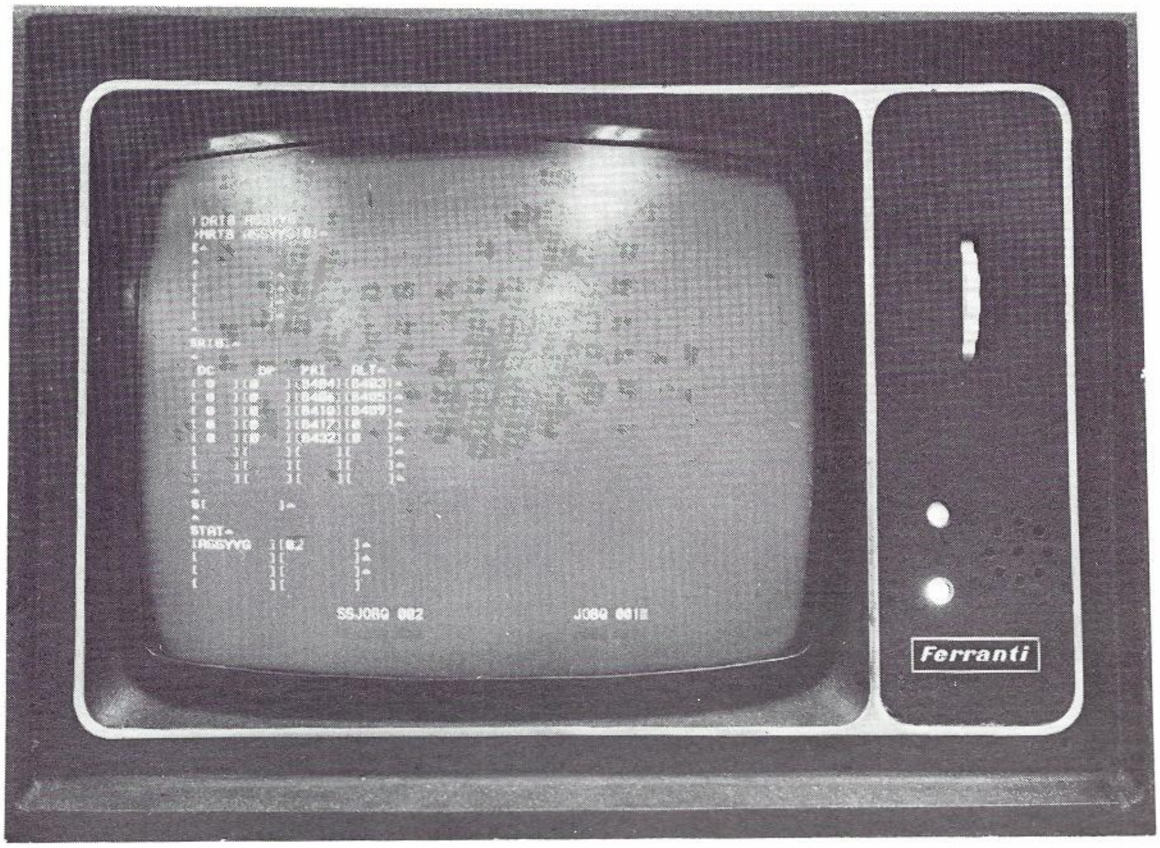
On receipt of the 'End of Message' indicator the complete message is then processed under software control. As outgoing lines become available the reverse process occurs, messages being read from disc into core and then transmitted via the multiplexer. Thus expensive core store is only used for transitory storage of messages as they arrive and leave. Copies of all messages are retained on disc for retrieval purposes. When the disc is full earlier data is overwritten, commencing with the oldest recorded message. Messages yet to be sent are protected against being over written by being repositioned on disc.

The International Civil Aviation Organisation requires that a minimum of one hour of immediately retrievable traffic be held, and that for extended message tracing beyond one hour a journal of input channel identity and message number be kept at each relay station so that the originator can be located and a repeat mesage obtained. The journal data is recorded on a fast teleprinter at the operational supervisors position. The present system traffic load is such that six hours of immediately recallable traffic is available.

TERMINALS, OPERATIONAL FACILITIES AND SUPERVISION

Many special facilities are provided by the computer message switching systems. Messages may be input from either standard teleprinters or alternatively from Keyboard Display Units, which present the message on a TV type screen. The display units may also be used for entering Supervisory commands from both the Technical Supervisory position, referred to earlier, and from the operational supervisory position. Typical of an Operational Command would be a change in the routing table for a particular address. The computer switches messages to their correct destinations by comparing the address on the message with the routing list for that address held in store. This routing list gives the computer the channels on which the message is to be routed. The computer identifies channels as numbers. All channels to the same destination have a common route group number (e.g. Sydney to Melbourne is B426), whereas each duplex channel in the group has its own number (e.g. Sydney to Melbourne channel C is C028).

An example of the routing table for the address ASSYYG is shown at Fig. 4 along with the translation. The Supervisor may add or delete the routes (B numbers) on which that message is transmitted by changing the entries displayed on the KDU.



Entries in the table have the following meaning:

E — Four exception addresses, such as (ASSYYGAA), whose routing is defined in a separate table.

SR — Field indicates whether messages should be routed to the supervisor.

DC or DP — Divert and copy or divert certain priorities (four levels exist in the system) from the primary channel group (PRI) to the secondary channel group (ALT). In this case messages with the ASSYYG address will be switched to five outgoing circuits, and by table entries in the DC or DP field may be diverted to three circuits.

S — Substitute address — a means of outputting the message with a different address to that existing in the original message.

STAT — An entry to enable messages with the specified addresses to be logged on up to 10 counters.

The last line on the display indicates the state of high and low priority job queues requiring attention by the supervisor.

Fig. 4 — KDU Screen Displaying Routing Table.

In addition to the message switching function, provision is made for the automation of input as far as possible. This has been done by permitting the use of group addresses on any input channel, and the use of pre-formatted messages on selected inputs. The group addresses follow the practice recommended by ICAO of an address in the form ASZZ followed by any two letters of the alphabet. This allows for the 676 discrete codes, and each code can represent up to sixteen standard ICAO addresses. The computer at Sydney will delete any ASZZ address detected, replace it with the list of addresses stored, and make up additional copies of the message if the number of addresses exceeds the maximum number allowed for one message. The lists of stored addresses may be changed by an operator by simple data entry from a control position.

Aircraft movement messages for regular flights contain a large number of elements which do not change. For a given flight, the address and origin sections, together with reporting points and other fixed data can be stored by the computer. When an operator is preparing a flight plan message, he can enter a simple command which will cause the computer to display the message on a keyboard display unit fitted with a standard keyboard. The displayed message is in correct ICAO format with blank data fields in which the operator enters the variable elements of the message, such as time

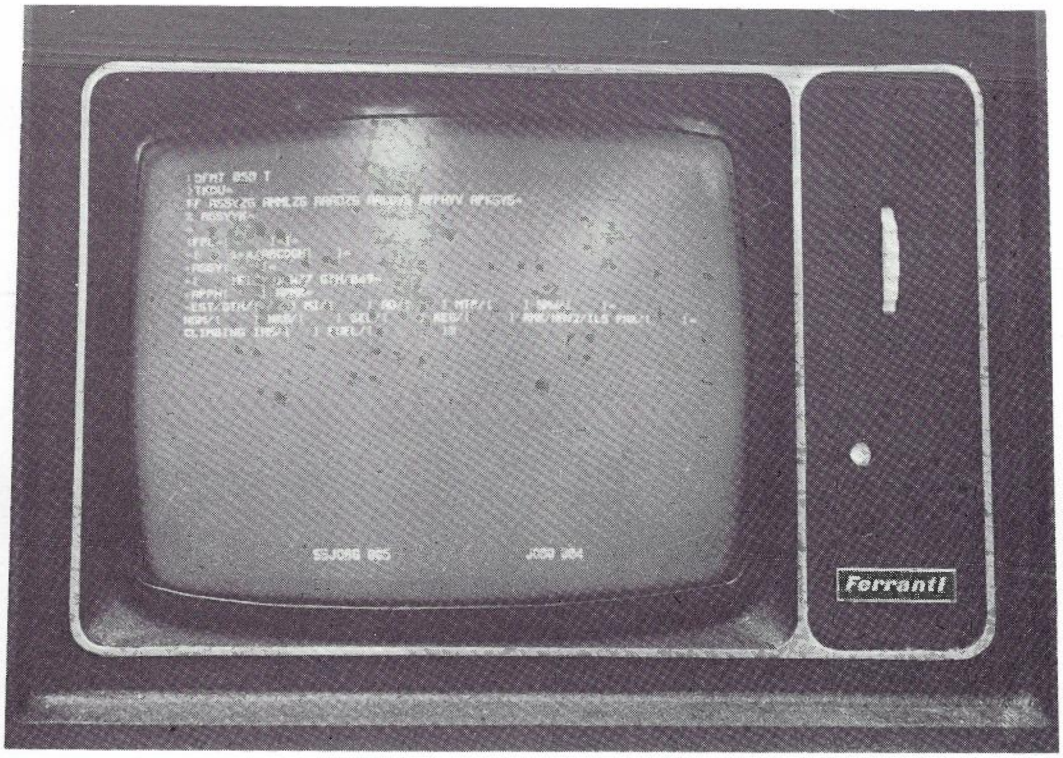


Fig. 5 — KDU Screen Displaying Pre-format Message.

intervals and flight levels. The pre formatted messages stored by the computer may be modified easily from a control position. The facility can also be used for NOTAM and MET messages. An example of a preformat called out from the computer is shown at Fig. 5.

A number of different communication codes may be used with the systems, and this provides the necessary flexibility for data link operation with Air Traffic Control computers and other systems in the future.

In addition to operational and administrative traffic for air traffic control the message switching systems have been designed to handle bulk ADP data traffic. The Department of Transport, like most major departments, has its own data processing system centred on a large scale data processing computer located at Melbourne.

In addition to normal business and accounting facilities, the ADP system provides a wide range of services both within the Department and to the aviation industry. Typical of such services are the updating of flight crew licence records, the distribution of operational documents, and the sorting and collation of aviation safety data. To enable these services to be expanded data collection inputs are provided on the mesage switching system for the transfer of bulk data to and from the ADP computer in Melbourne. This facility is provided in such a way that the data traffic is of lower priority than the operational traffic, hence it does not result in operational message delays but merely uses excess capacity in the system.

INSTALLATION AND ACCEPTANCE TESTING

During the installation and testing phase a team of twelve of the contractors personnel were stationed in Sydney, for the purpose of correcting observed system deficiencies during test, and assisting in the introduction of the new systems. At all times close liaison was maintained between Departmental staff and company personnel, and this contributed in no small measure to the success of the project.

Prior to commencement of system testing, a set of agreed Acceptance Tests was prepared, covering some eighty specific test sequences each sequence exercising many different aspects of the facility. The formal acceptance tests occupied four large volumes, from which some gauge of the test program may be made.

During acceptance testing the necessarily extensive monitoring of input and output channels was

Fig. 6 — Machine Test Facilities at Sydney.

provided by one hundred and thirty teleprinters hired from Telecom Australia. A photograph of the test room in Sydney is shown in Fig. 6.

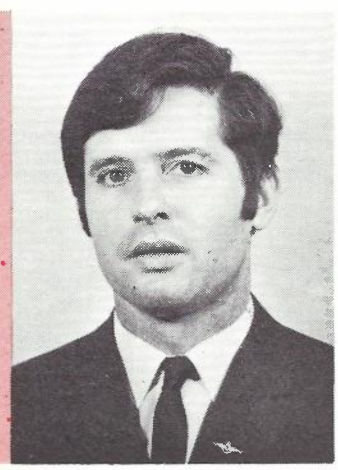
CONCLUSION

Although the main object in introducing the automatic systems was to meet aviation message transit time requirements, substantial savings in operating costs have also resulted. In the case of Sydney a staff of nearly 100 were employed in operating and maintaining the old manual torn tape system. The automatic system is now run by less than 30 technical and operational staff. In effect the installed cost of this system has been more than recovered during its three years of operation by the savings in staff.

With the automation of the three major nodal points in the network with systems that can handle traffic efficiently and rapidly, the strain on the remainder of the Australian network has been considerably eased. Further systems are planned to achieve the goal of a fully automated message switching network nationwide.

W. T. MALONEY was educated at Melbourne University, where he completed the B.Sc. (Hons.) degree in the Department of Electrical Engineering in 1960. He joined the then Department of Civil Aviation in 1961 as an Airways Engineer, initially in the VHF Communication and then the HF Communication section; more recently he has been working on the development of message switching systems.

In 1970 Mr Maloney led a team of four specialists on site at the Wythenshawe factory of Ferranti Ltd., and in 1973 was promoted to Principal Engineer in charge of message switching systems and Project Manager for the implementation of the Ferranti systems.



New Generation Communication Satellites for U.S.A.

Editorial Note: This short article was prepared by the Satellite Section in the Research Department, Headquarters, and is published with the kind permission of R.C.A. Princeton, N.J., U.S.A.

The first of a new generation of geostationary satellites, providing 24 independent communication channels, is now in service over the U.S.A., following two successful launches, in December, 1975 and March this year. The satellite communication system is owned and operated by RCA Americom. It is designed to provide coverage for all 50 states.

Each of the satellites' transponders (or communications channels) can carry one colour TV transmission or 600 two-way voice circuits or 64 Megabits/second of data. Transmissions up to the satellites are in the 6 GHz communications band, and the down-links are at 4 GHz.

Each spacecraft has been designed to allow continuous operation of all of its 24 transponders at specified power, even during eclipse periods (when it is in the earth's shadow), for a minimum life of eight years in space. It is a three-axis

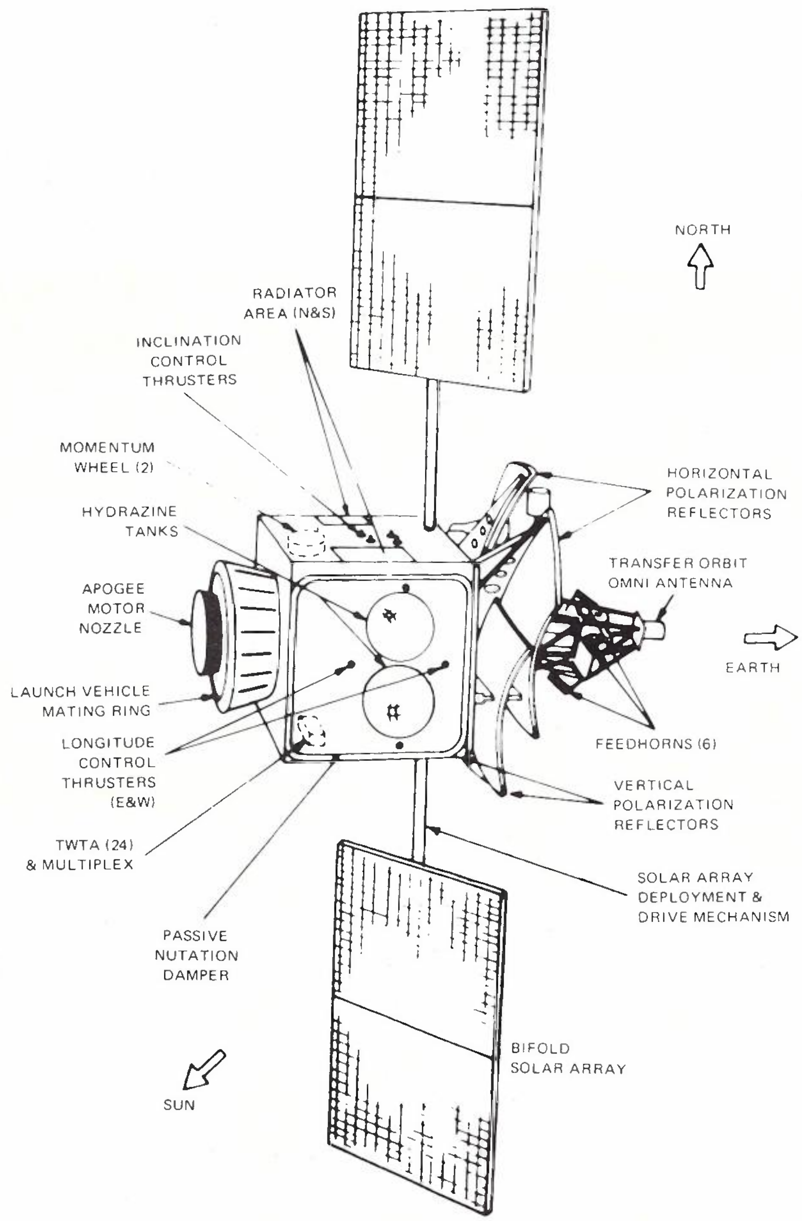


Fig. 1 — New Generation Communications Satellite.

stabilized design which offers advantages over the earlier spin-stabilized type of communications satellite. Satellites derive their operating electrical power from solar cells which charge batteries. Three-axis stabilization of the satellite allows large panels of solar cells to be continuously directed towards the sun while communication antennas point to the chosen parts of the earth. In the spin-stabilized design, the antennas must be "de-spun", while only some of the solar cells, which are mounted on the spinning body of the satellite can be illuminated by the sun at any time.

The 4 GHz and 6 GHz communication bands, used for both terrestrial microwave systems and satellites, each have 500 MHz of available bandwidth. Each RCA satellite channel is allocated 40 MHz, of which 34 MHz is usable and the remainder provides guard bands, etc. Thus, in order to provide 24 channels on each satellite, a combination of polarization diversity and frequency interleaving is used. Spacial antennas were developed for the satellite, so that 12 channels use vertical polarization and the others horizontal.

The main body of the spacecraft is approximately 1.6 x 1.2 x 1. 2 metres and weight is about 450 kg in orbit. Its layout is illustrated in Fig. 1. The arrangement of major components on board the RCA Americom synchronous communications satellite is shown in drawing. Note the overlapping parabolic reflectors made of Kevlar honeycomb on earth-facing side (right), which are cross-polarized to provide adjacent channel isolation for communications transponders. The solar arrays have an area of about 6.6 square metres total, and provide about 770 watts of power initially, declining to a minimum of 550 watts after eight years.

All of the spacecraft elements, including antennas, are launched in normal operating position. The solar arrays are extended in orbit, using a spring mechanism. The antenna system consists of dual overlapping reflector segments fed by a total of six feedhorns. These reflector segments are composed of a series of parallel conductors. As such they reflect only signals of one polarization and appear transparent to the oppositely polarized signals. Antennas are optimized for the 4 GHz down-links and provide sufficient gain at 6 GHz for the less-critical up-paths.

In normal operation, the satellites will handle various combinations of TV, point-to-point and switched telephony, and other telegraph and data services.

Technical News Item

THE AUSTDATA STUDY

The Planning Division at Headquarters is undertaking a study entitled AUSTDATA to provide information which will permit Telecom Australia to meet the future needs for data communications. It is being carried out under contract by W. D. Scott, Management Consultants, jointly with Logica (UK).

The first stage of the Study covers data communication requirements to 1985. It is based on historic information and customer expectations obtained from personal and mail interviews. Economic trends are predicted for 32 industry sectors and 64 geographic areas and the impact of new technology is evaluated. All of this is included in a forecasting technique, from which can be derived the expected number and distribution of data, telex and facsimile terminals, the signalling rates, and the traffic streams between regions. The potential demand for new kinds of services is also identifiable.

The second stage of the study uses techniques appropriate to long term forecasting to the year 2000. Emphasis is placed on establishing the characteristics of activities giving rise to the need for data communications, taking account of several possible social, economic and political environments.

The Maintenance of Carrier Supplies for Broadband Telecommunication Systems

G. V. CONROY, B.Sc., B.E., M.Eng. Sc.

The maintenance objectives with respect to the frequency stability of the telecommunications network are discussed. The paper also examines the use of a new two-tone demodulator in achieving these objectives.

INTRODUCTION

The carrier frequencies required for the broadband frequency division multiplex (FDM) carrier systems used by Telecom Australia are generated from high stability crystal controlled oscillators. These oscillators are subject to long term aging which causes frequency errors (asynchronism) to become significant in the network. It is necessary, therefore, to regularly recalibrate these oscillators to ensure that these errors are kept within acceptable limits.

EFFECT OF FREQUENCY ASYNCHRONISM

Frequency errors of 10 hertz and greater have been produced in channels as a result of the above-mentioned master oscillators drifting off frequency. Errors of this magnitude while having little discernible effect on voice communications can contribute significantly to errors in data transmission. Some of the systems which are affected by frequency asynchronism are indicated below.

Frequency Modulated Voice Frequency Telegraph Systems

To send over these systems the mean or "carrier" frequency for the channel is generally decreased by 30Hz for a mark and increased by 30 Hz for a space. In the receiver the marking and spacing frequencies are applied to two tuned circuits. The output of a tuned circuit varies with the applied frequency. Any change in the marking and spacing frequencies from the standard, therefore, results in a change in the amplitude of the mark and space currents. Frequency errors produce mark and space elements of unequal amplitude causing bias distortion.

The majority of FM type telegraph systems in use in Australia send a pilot signal of 300 Hz to enable compensation to be made at the receive end for any frequency asynchronism in the bearer. The older systems derive a dc signal from the pilot proportional to the difference between the frequency of the incoming pilot and local resonant circuits tuned to 310 Hz and 290 Hz. This dc voltage is used to drive a uniselector which switches various circuit elements into the discriminator (FM detector) circuit. The discriminator voltage — frequency characteristic curve adjusts so that the mark and space frequencies produce elements of equal amplitude and hence no bias distortion. For out-of-synchronism $\pm$ 10Hz telegraph bias distortion should not exceed 2% when tested with a signal ratio of 2:2 at a telegraph speed of 50 bauds (Ref. 1). The distortion increases rapidly if the asynchronism exceeds 10Hz as no further compensation is possible.

The newer type FM VFT systems use a frequency compensation network which employs an additional modulator and demodulator to eliminate the effects of frequency asynchronism on the line. The incoming pilot frequency 300 + EHz (E being the frequency asynchronism) is picked off and modulated with a locally generated 4320Hz.

$$\text{i.e. } f_1 = 4320 - 300 - E$$
$$= 4020 - E$$

At the same time a locally produced pilot of 300Hz is subjected to the same modulation process in a similar circuit.

$$\text{i.e. } f_2 = 4320 - 300 = 4020$$

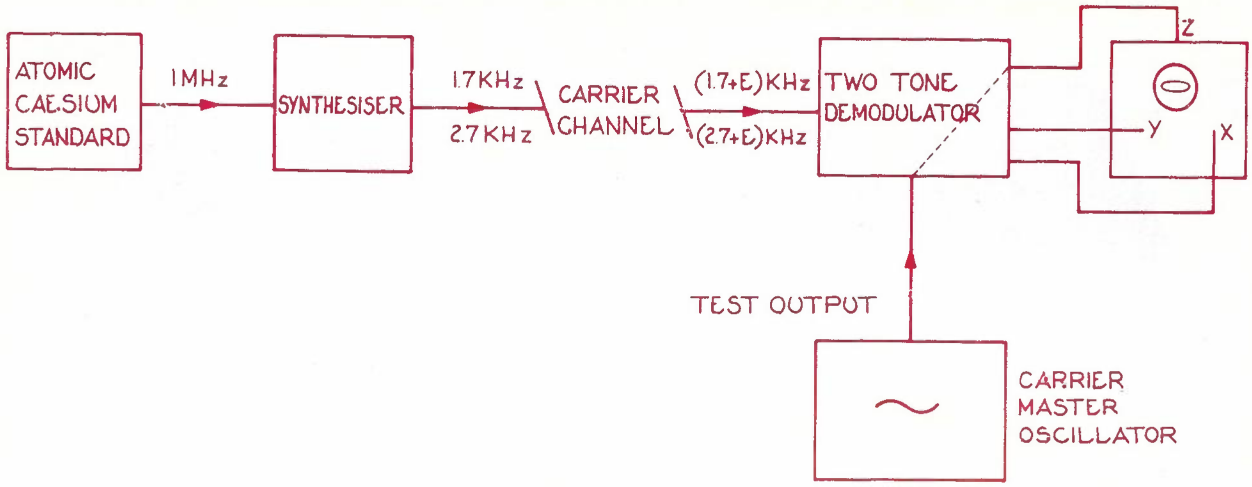


Fig. 1 — Transmission of Two-Tones.

The transmitted VF telegraph signal $f_T + E$ say, is modulated first by f_1 and then by f_2 to eliminate the frequency error. The receive frequency f_r applied to the receive detector is:

$$\begin{aligned} f_r &= f_T + E + f_1 - f_2 \\ &= f_T + E + 4020 - E - 4020 \\ &= f_T \end{aligned}$$

This type of FM VFT system would tolerate a frequency asynchronism limited only by the pass-band of the various filters associated with the modulators in the frequency compensation network.

Low/Medium Speed Data Transmission

Low (200 bauds) and medium (600/1200 bauds) speed data transmission generally use Frequency shift keying modulation schemes similar to the telegraph system described above. Frequency asynchronism therefore contributes to errors in a similar way to Telegraph Transmission.

The low speed modems are built on the assumption that the line conditions meet CCITT recommendations (Ref. 2 — Recommendation V21). This recommendation assumes a maximum drift of ±6Hz for the line. The receivers are then designed to accept signals displayed by up to 12Hz from the nominal channel frequencies.

CCITT Recommendation V23 for 600/1200 baud transmissions again assumes ±6Hz drift for the line but recommends tolerances on the mark and space frequencies at the receiving modem of ±6Hz. Some 600/1200 baud modems employ synchronous transmission where the receive clock derives a timing signal from the incoming data in the form of a 1200Hz or 600Hz square wave. This would eliminate the effect of all but very large frequency asynchronisms.

High Speed Data Transmission

Modems transmitting data at 2400 and 4800 bits/sec generally use phase modulation schemes. One of the outstanding limits of phase modulation is its low tolerance to frequency errors in the network which largely destroy the sense of absolute phase. Synchronous transmission and differential coding, however, normally remove the data errors caused by frequency error.

The exact process by which the frequency error interferes with the demodulation depends on the particular demodulation technique chosen by the manufacturer. One technique generates a reference carrier against which the received phase samples are compared and then differentially decoded. The amount of frequency error tolerable in the link depends on the tracking ability of the reference carrier (normally at least 7 Hz with small phase errors).

CCITT recommendation V26 relating to 2400 bits per second phase modulated transmission states:

"noting that the carrier frequency tolerance at the transmitter is ±1Hz and assuming a maximum frequency drift of ±6Hz in the connection between modems, then the receiver must be able to accept errors of at least ±7Hz in the received frequencies".

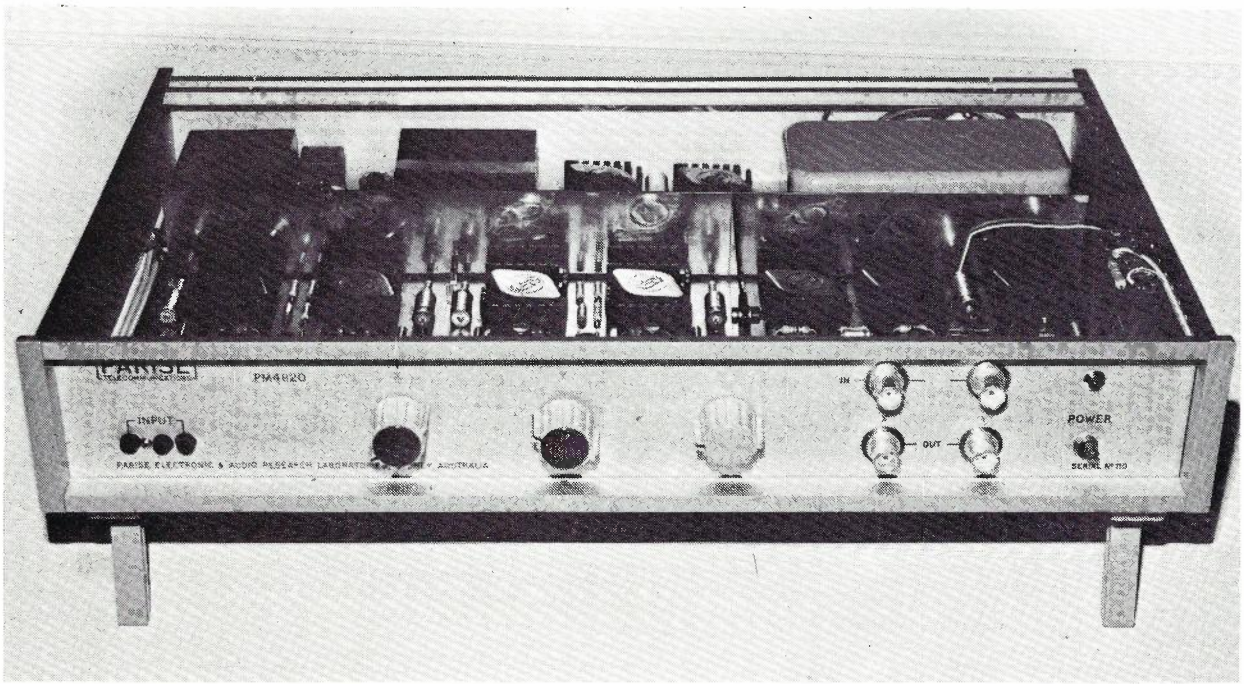


Fig. 2 — Two-Tone Demodulator.

CARRIER SUPPLY FREQUENCY ACCURACIES

As indicated above, various CCITT recommendations exist for maximum frequency asynchronism over channels. The most stringent is the requirement of less than 2Hz (Recommendation G225) for international circuits which may use voice frequency telegraph. To attain this objective CCITT recommends that for a 12MHz system Group and Supergroup carrier frequencies have an accuracy of ± 1 part in 10^7 and Mastergroup and Supermastergroup carrier frequencies of ± 5 parts in 10^8.

These are the accuracies to which the master oscillators which generate these carriers are maintained to in the Telecom Australia network (Ref. 3).

It is not possible to use the normal commercially available counters to adjust these master oscillators. The reason is that the counter time base oscillator on which the accuracy of the counter depends is often less accurate than the oscillator to be calibrated. The method described below allows the master oscillators of 12MHz systems to be adjusted to an accuracy of 1 part in 10^8. Experience with the current commercially available master oscillators shows that these oscillators are subject to a long term drift of up to 2 parts in 10^8 per month. The maintenance programmes must be arranged so that at no time could a master oscillator be off frequency by as much as 5 parts in 10^8.

TWO-TONE METHOD OF OSCILLATOR FREQUENCY CALIBRATION

This method compares the frequency of the local master oscillator with a primary standard frequency clock in the Telecom Research Laboratories in Melbourne. The primary standard used is an Atomic Caesium beam standard which has an accuracy of better than 1 part in 10^{11} compared with international standards such as the United States Naval Observatory master clock (Ref. 4).

The system which allows remote carrier oscillators to be compared with the standard is shown in Fig. 1. The atomic standard produces a 1MHz output which is fed to a synthesiser which in turn produces two tones at 1700Hz and 2700Hz. The two tones are fed oved a carrier channel to a two-tone demodulator (Figs. 2 & 3). Each tone will suffer the same frequency error and the accuracy of the 1KHz difference frequency will be preserved.

The demodulator produces two outputs separated in phase by 90°. One output is fed to the X input of a Cathode Ray Oscilloscope (CRO) and the other to the Y to produce a lissajous type figure. The test output from the master oscillator is fed to the Z input of the CRO via an amplifier in the demodulator. This Z amplifier raises the level sufficiently to produce a series of dashes on the screen (Fig. 4).

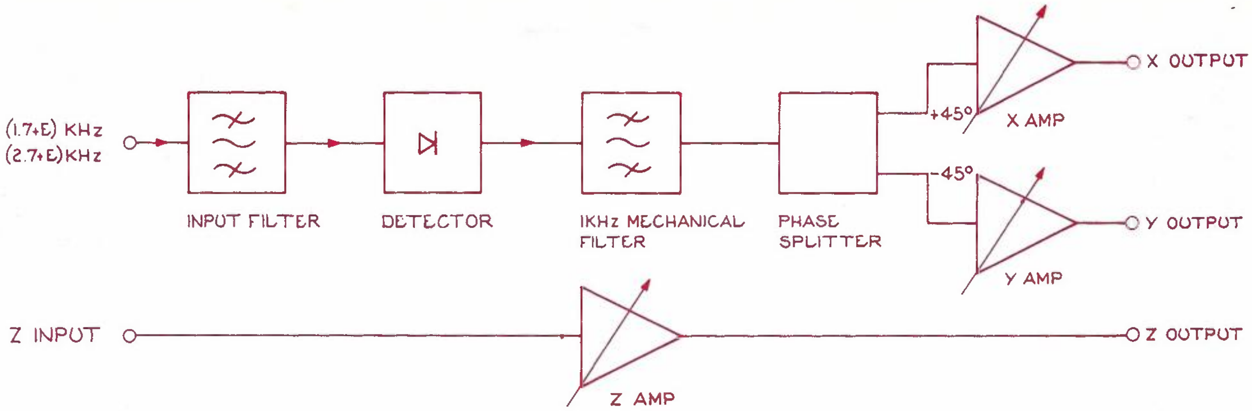


Fig. 3 — Two-Tone Demodulator Circuitry.

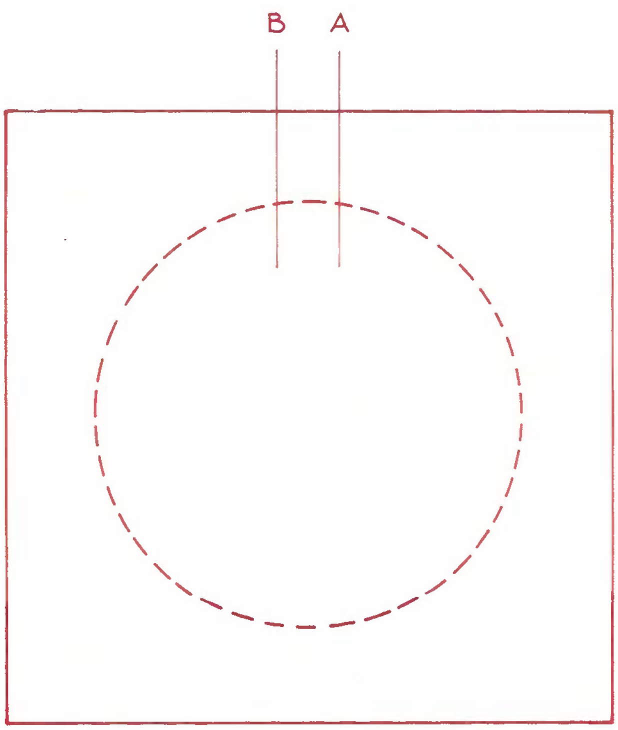


Fig. 4 — Intensity Modulated Lissajous Figure.

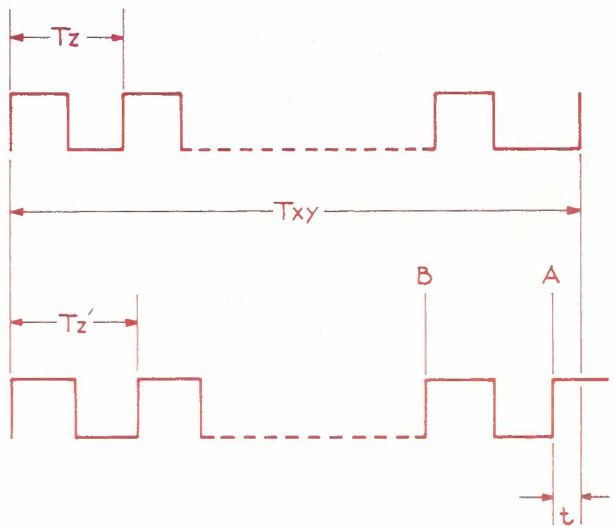


Fig. 6 — Linear Representation of Fig. 4.

The number of dashes produced on the screen equals the ratio between the frequency under test and 1KHz. For a 124KHz test signal 124 dashes are produced. The pattern will rotate at a speed and direction proportional to the error in the test signal.

The frequency error in hertz is equal to the inverse of the time in seconds that it takes one edge of a dash to replace the same edge of the next dash (B to replace A in Fig. 6). 124KHz master oscillators are calibrated to an accuracy of 1000 seconds or 1 part in 10^8.

If f_{xy} = frequency applied to X-Y inputs

$$= \frac{1}{T_{xy}} \qquad \text{(1 KHz normally)}$$

f_z = frequency applied to Z input

$$= \frac{1}{T_z} \qquad \text{(say 124KHz)}$$

$$= nf_{xy} \; \ldots\ldots \; (1)$$

n is an integer (say 124)

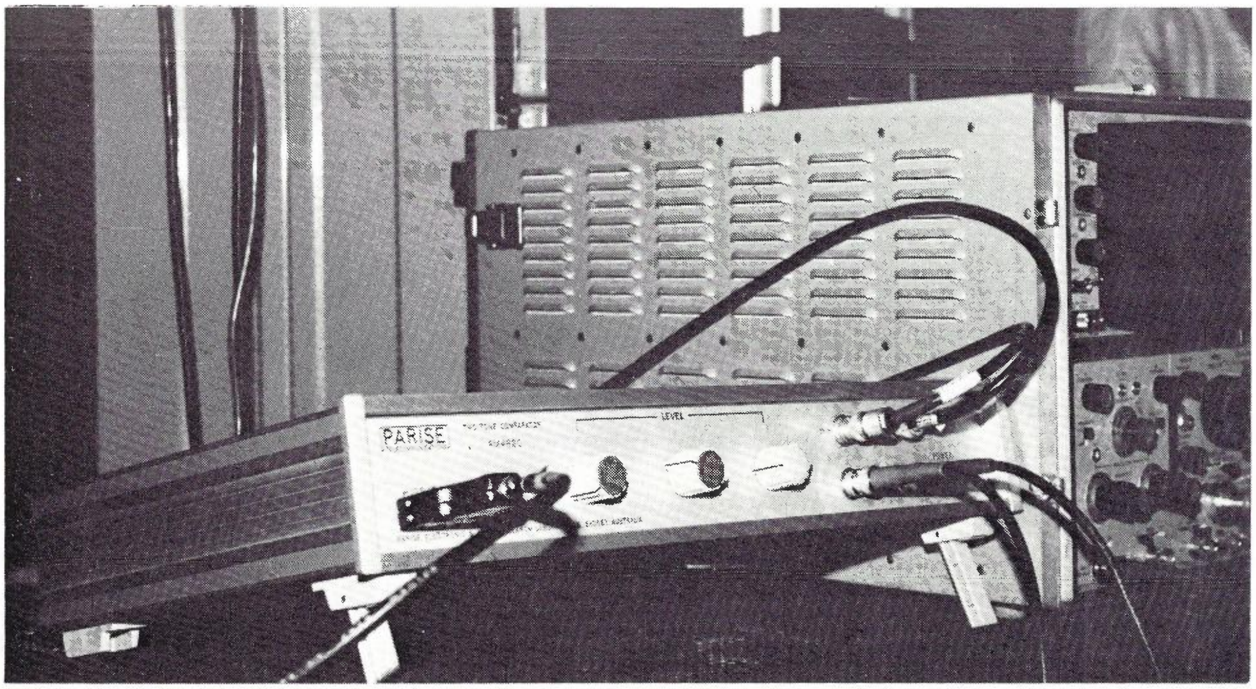


Fig. 5 — Two-Tone Demodulator in Use.

and assuming the period of f_z is changed to T'_z which is not an exact multiple of T_{xy}.

Then $T'_z = \frac{1}{f_z + f_e}$ ..... (2)

where f_e is the frequency error of the oscillator to be calibrated. Number of revolutions of f_{xy} for edge B to replace edge A in Fig. 6.

$$= \frac{T'_z}{t} \quad ..... (3)$$

where t is the minimum difference between the period of f_{xy} and an integer times the period of f'_z.

i.e. $t = T_{xy} - nT'_z$ ..... (4)

Therefore the time taken for edge B to replace edge A on screen (T say)

= No. of revolutions (3) X period of each revolution.

$$= \frac{T'_z}{t} \times T_{xy}$$

$$= \frac{T'_z \times T_{xy}}{T_{xy} - nT'_z} \quad \text{from (4)}$$

$$= \frac{T'_z}{nT_z - nT'_z} \times nT_z \quad \text{from (1)}$$

$$= \frac{1/(f_z + f_e)}{n/f_z - n/(f_z + f_e)} \times \frac{n}{f_z} \quad \text{from (2)}$$

$$= \frac{1}{f_e} \quad \text{(independent of } f_{xy} \text{ and } f_z\text{)}$$

$$f_x = \frac{1}{T} \quad ..... (5)$$

Therefore the frequency error in hertz is equal to the inverse of the time in seconds that it takes one edge of a dash to replace the same edge of the next dash as required.

TWO-TONE DEMODULATOR

Units such as the one shown in Fig. 2 are manufactured in NSW to a design based on a prototype built in the Telecom Research Laboratories. The design includes a number of features as a result of experience by the NSW Trunk Service Section with the prototype unit.

These features include additional filtering to reject spurious channel signals and high gain X, Y and Z amplifiers. These amplifiers enable the unit to be used with the many different carrier supplies and Cathode Ray Oscilloscopes used by the Commission. It is intended that these units will become part of the maintenance test equipment in the major broadband carrier stations.

CONCLUSIONS

An examination of the effect of frequency asynchronism in the broadband telecommunications network has shown that provided the frequency accuracy of carriers is kept within CCITT limits the effect is not significant. These carriers can be kept within the required limits by regular checks using two-tone demodulator units.

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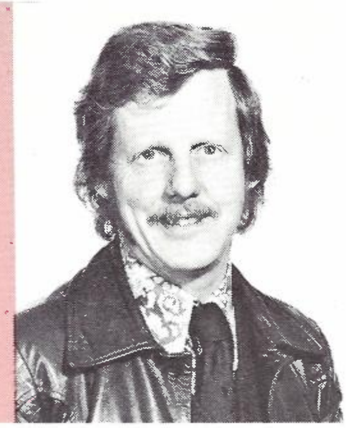
G. V. CONROY graduated in Science and Engineering at Sydney University in 1965 and 1967 respectively. He completed a Master of Engineering Science degree at the University of NSW in 1971. Prior to joining the PMG in 1973 he spent six years in private industry in Australia and in the UK in the field of communications equipment design.

Since joining the PMG he has been working in the NSW Trunk Service Section on the development of new maintenance practised and performance measuring techniques.



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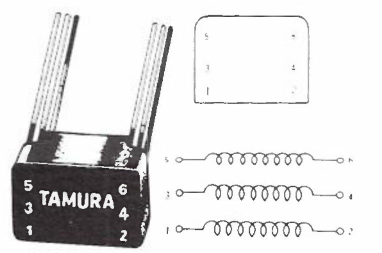

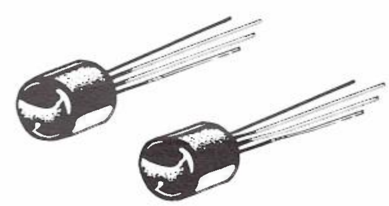

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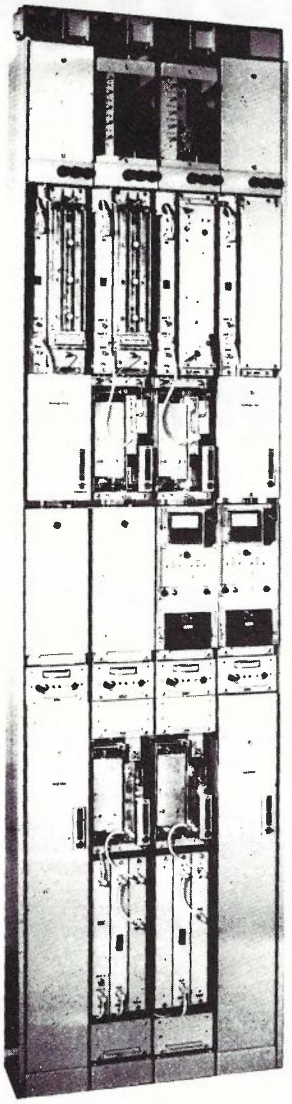

Four 6.8 GHz equipment racks.
Left to right:
1 watt, 960 channel rack, covers on
1 watt, „ „ „ „ off
10 watt, 1800 „ „ „ off
10 watt, „ „ „ „ on

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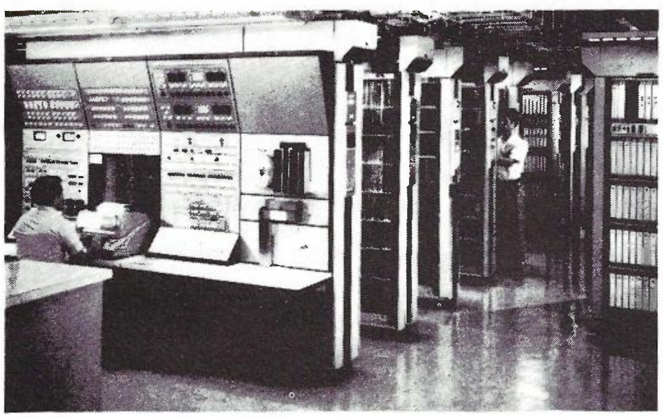

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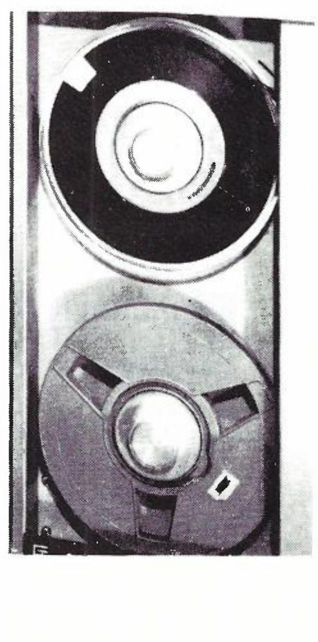

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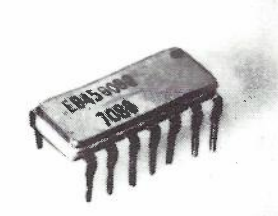

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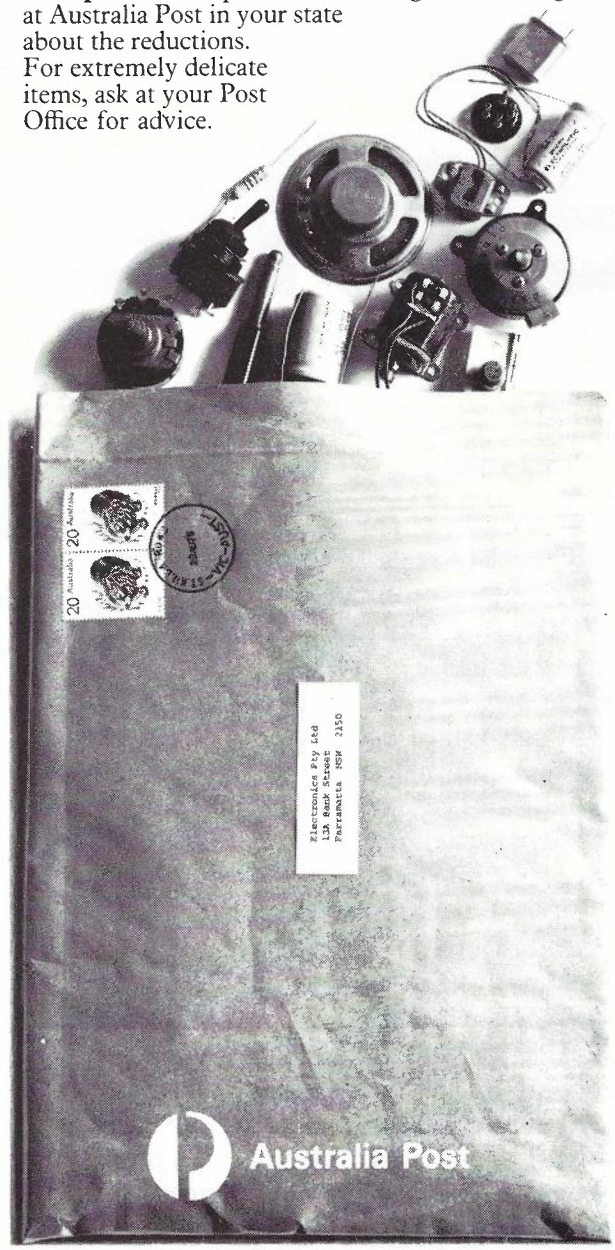

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The Telecommunications Journal of Australia

ABSTRACTS: Vol. 26, No. 3.

CONROY, G. V.: 'The Maintenance of Carrier Supplies for Broadband Telecommunication Systems'; Telecomm. Journal of Aust., Vol. 26, No. 3, page 236.

The maintenance objectives with respect to the frequency stability of the telecommunications network are discussed. The paper also examines the use of a new two-tone demodulator in achieving these objectives.

HUMBERSTONE, D. L. and LOCKE, K. R.: 'The Melbourne Television Operating Centre'; Telecomm. Journal of Aust., Vol. 26, No. 3, page 200.

The new Melbourne Television Operating Centre (TOC) was placed into service in Sep. 1976. This article describes the facilities provided in the new installation and outlnes the function of the TOC as part of Telecom's video relay network. The future development of the TOC is discussed with particular emphasis on the application of insertion test signals.

JACKSON, B. T.: 'Common User Data Network — Part 2'; Telecomm. Journal of Aust., Vol. 26, No. 3, page 190.

This is the second article in this series on CUDN. The first article which appeared in Vol. 25, No. 2 described the facilities offered and the hardware used in the system.

This article describes the software programs used to control the hardware and to receive messages from the input lines, store them for security and switch them to the desired output terminal when a free line is available. The final article will describe how Telecom and the customers supervise the flow of traffic through the network.

KALDOR, T.: 'Memory Controlled Crossbar Queue'; Telecomm. Journal of Aust., Vol. 26, No. 3, page 219.

The queueing system described provided an inexpensive, "perfect" queue of modular construction, using standard crossbar components. It provides "first in — first out" service (whether callers abandoned their places or not) and utilises up to 20 serving devices for 40 incoming lines in a queue with a capacity of 59 places. All of these limits can be varied. The system was installed on one BCH rack in 1970 for the Sydney Metropolitan Area Changed Number Enquiry Service and has been proven to be dependable in operation.

MALONEY, W. T.: 'Department of Transport Computer Based Message Switching Systems'; Telecomm. Journal of Aust., Vol. 26, No. 3, page 227.

The Air Transport Group of the Department of Transport has installed three computer controlled "store and forward" message switching systems at Sydney, Melbourne and Brisbane. The systems are of an advanced type, providing many special features the more important of which are described.

PRIEST, M. J. and HALLAMS, R.: 'Exchange Network Planning; Use of the I.T.T. Computer Program — Part 1'; Telecomm. Journal of Aust., Vol. 26, No. 3, page 208.

A computer program to aid Network Planning of Telephone Exchanges in Urban Areas has been developed by ITT (Spain). The program has been used to analyse the networks of a large provincial city and the Sydney ELSA area. This two part article describes the main features of the program and some aspects of its practical application. Results indicate that the programme is a useful aid to short and long term planning.

TAGG, J. A. G.: 'Connection of PBX Lines to Exchanges'; Telecomm. Journal of Aust., Vol. 26, No. 3, page 212.

An important aspect of the telecommunication network is the provisioning of lines between PBX's and the public exchange network. This introductory article describes the methods used in Victoria for the connection of lines to step by step and crossbar exchanges. Night switching, indialling, traffic and equipment utilisation matters are discussed.

TYRRELL, L. A. and THOMPSON, K. A. McN.: 'A Model of the National Telephone Switching Network'; Telecomm. Journal of Aust., Vol. 26, No. 3, page 183.

This article explains why a decision was taken by the APO to build a simulated national telephone switching network at Headquarters; it also describes in some detail the planning of that network and the guidelines that were followed. Some aspects of design are discussed which serves to illustrate how equipment and space were optimised. The role of the network and the precautions that are being taken to preserve its integrity are also outlined.

THE TELECOMMUNICATION JOURNAL

OF AUSTRALIA

VOL. 26, No. 3, 1976

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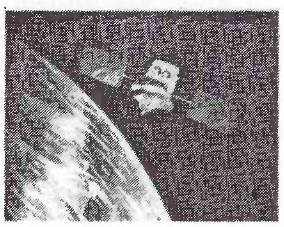

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