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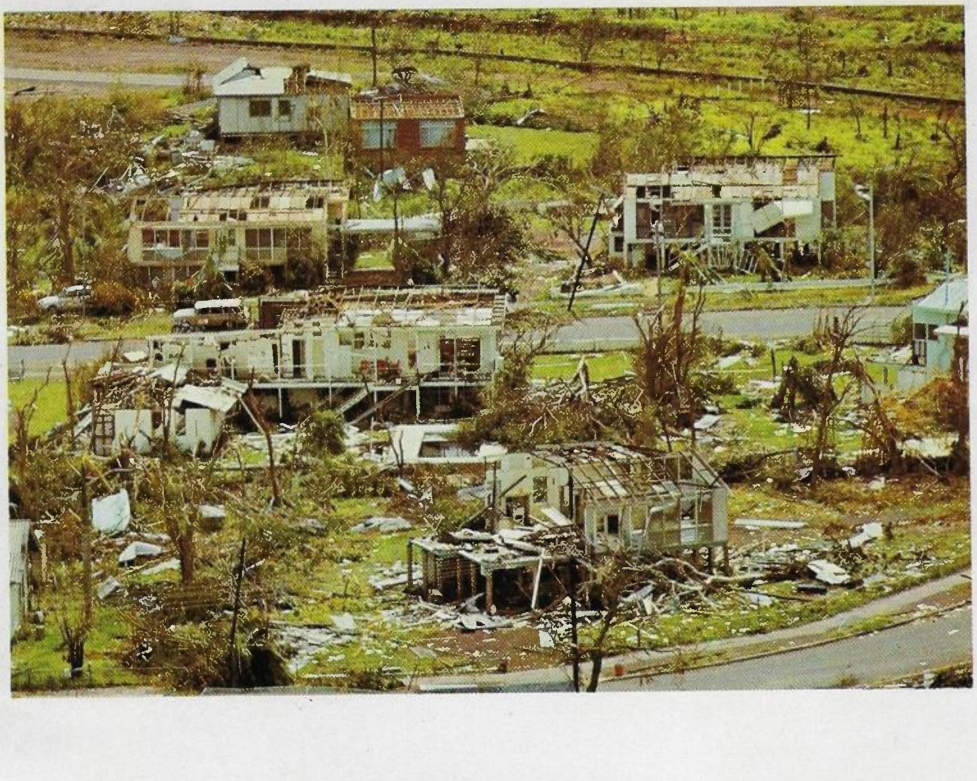

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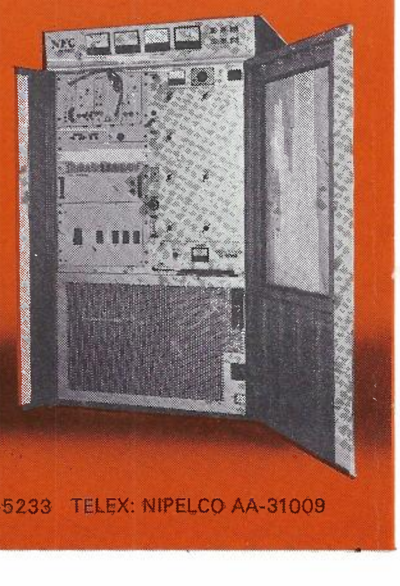

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THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

VOL. 26. No. 1. 1976

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COVER
DEVASTATION BY
CYCLONE TRACY

The Telecommunication Journal of Australia

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

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Darwin Cyclone Tracy – Telecommunications Network Survivability and Security

D. J. OMOND, B.E., F.A.S.M., M.I.E. Aust.

An examination of the underlying reasons for the failures which occurred in the Darwin telecommunications network has enabled a number of principles to be recognised relating to the design of such networks to ensure survivability under conditions imposed by natural disasters. The results of applying the contingency planning approach to the Darwin network are then recorded and some possible questions relating to day-by-day network security are discussed.

INTRODUCTION

The impact of Cyclone Tracy on Darwin on 25th December, 1974 (Ref. 1), imposed what was perhaps the most severe test ever experienced by a telecommunications network in Australia. It is therefore commendable that at least part of the network, namely the microwave radio system, continued to operate throughout this period and maintained contact with the outside world when all the other parts of the network were rendered inoperative to varying degrees.

Prior to the cyclone, Darwin was a thriving city of 45,000 people but separated from the nearest State capital city and from its major support centres by more than 2700 kilometres. Its telecommunications network served 9990 telephone and 221 telex subscribers, two radio broadcasting and two television services as well as supporting numerous other facilities such as data links, PABX installations, radio-telephone services and facsimile for the Armed Services and other Government Departments. A total of 193 trunk circuits, provided by the microwave radio system and a limited number of open-wire carrier systems, linked Darwin to the national network.

When the cyclone had passed, only two order-wire circuits normally used for engineering maintenance purposes, remained in operation and at 8.10 a.m. CST these relayed the first reports of the devastation to Adelaide. At this stage, all other normal communications out of Darwin had failed and further emergency links were established as follows:

9.28 a.m. CST — CW (Morse) link established by HMA Ships 'Assail' and 'Advance' from Darwin Harbour.

10.39 a.m. CST — OTC operators on board MV 'Nyanda' using the ship's communication facilities.

11.00 a.m. CST — Radio link established from 125 Signals Squadron, Darwin.

The manner in which damage and plant failure occurred to the Australian Telecommunications Commission network will be described briefly to give some background to the subsequent discussion leading to principles inherent in network survivability.

DAMAGE SUSTAINED

Table 1 summarises damage incurred while Fig. 1 shows the geographical relationship between the various locations referred to.

At Blake Street, where the building remained intact and the microwave radio equipment and standby power supplies continued to operate, long distance communication was retained but restricted to two sub-baseband order-wires due to the failure of channel-deriving multiplex equipment at Smith Street one kilometre away. In this location, the concentration of a variety of facilities in the main communications building led directly to the loss of a wide range of services when the building suffered major damage allowing the ingress of water.

Not all plant at Smith Street failed due to water entry, however. Rising wind velocities quickly took their toll of aerial power supply mains and with the loss of mains power, the standby power plant was called into operation. This failed to start; although some damage occurred to the power plant building, the diesel alternator itself was undamaged. The reason why it did not and subsequently could not be started was that the doors had been ripped off the power control room located in

TABLE 1 — SUMMARY OF DAMAGE

Location	Equipment	Type/Size	Damage Sustained
SMITH STREET	Telephone Exch. Tandem Exch. Multiplex Carrier Trunk Assistance Local Service Operators Telex PABX Microwave Radio	ARF 3000 SRB 3400 960 Inlets 500 Channels 14 Positions 8 Positions ARB 400 300 Line 300 Channel Link to Cox Pen.	Loss of iron roof over most of building structure allowing ingress of water. Power failure due to loss of commercial supplies and water damage to stand-by plant control circuitry. Widespread water damage to equipment. Physical damage to tower-mounted antenna.
BLAKE STREET	Microwave Radio	1200 Channel	Building remained intact with minimal water entry.
	ABD6	National Television Service	Equipment and standby plant continued operation.
DOUGLAS STREET	8DR	National Radio Service	Building damaged, water entry, transmitter damaged, transmission lines and aerial damaged.
BERRIMAH	Telephone Exch.	ARF 1600	Some water entry due to minor building damage. Batteries discharged due to loss of commercial power.
NIGHTCLIFF	Telephone Exch.	ARF 5000	Extensive damage to roofing and roof-mounted air-conditioning plant allowed ingress of water. Batteries discharged due to loss of commercial power.
CASUARINA	Telephone Exch. Telephone Exch.	ARK 600 SxS 1000	Located in two transportable buildings; one lost its roof, the other was blown off its stumps. Batteries discharged due to loss of commercial power.
HOWARD SPRINGS NOONAMAH	Telephone Exch. Telephone Exch.	ARK 200) ARK 200)	Buildings intact. Batteries discharged due to loss of commercial power.
COX PENINSULA	HF Radio transmitting Radio Australia programmes		Extensive damage to buildings, loss of aerial systems and transmitter damage due to water. Loss of commercial power.
	Tropospheric Scatter Radio System Terminal providing link to Nhulunbuy		System intact and resumed operation when power restored.
	Microwave Radio link to Smith Street		System intact and resumed operation when power restored.

the main building and water had reached the printed circuit boards in the master control cubicle. As a consequence, the batteries were discharged soon after the passing of the cyclone and all equipment was rendered inoperative until emergency generation plants could be set up and put into operation.

With one exception, the outlying exchanges were not equipped with standby power plants and batteries were rapidly discharged there too, due to the combined effects of loss of commercial power and increased current drain resulting from water entry and damage to subscribers' services. Although a considerable part of the external plant reticulation was by underground cable and relatively immune from the direct effects of the cyclone, aerial construction suffered heavily and heavy damage to residences (it is estimated that between 50% and 60% were damaged beyond repair) resulted in high substation plant failures. Above-ground external plant suffered further damage during subsequent clean-up operations when cable, pillars, cable boxes and other above-ground plant became entrapped in debris being bulldozed together for removal.

CONCLUSIONS DRAWN

As a result of the observations made of the effects of Cyclone Tracy, it is possible to enumerate a number of principles related to maximising net-

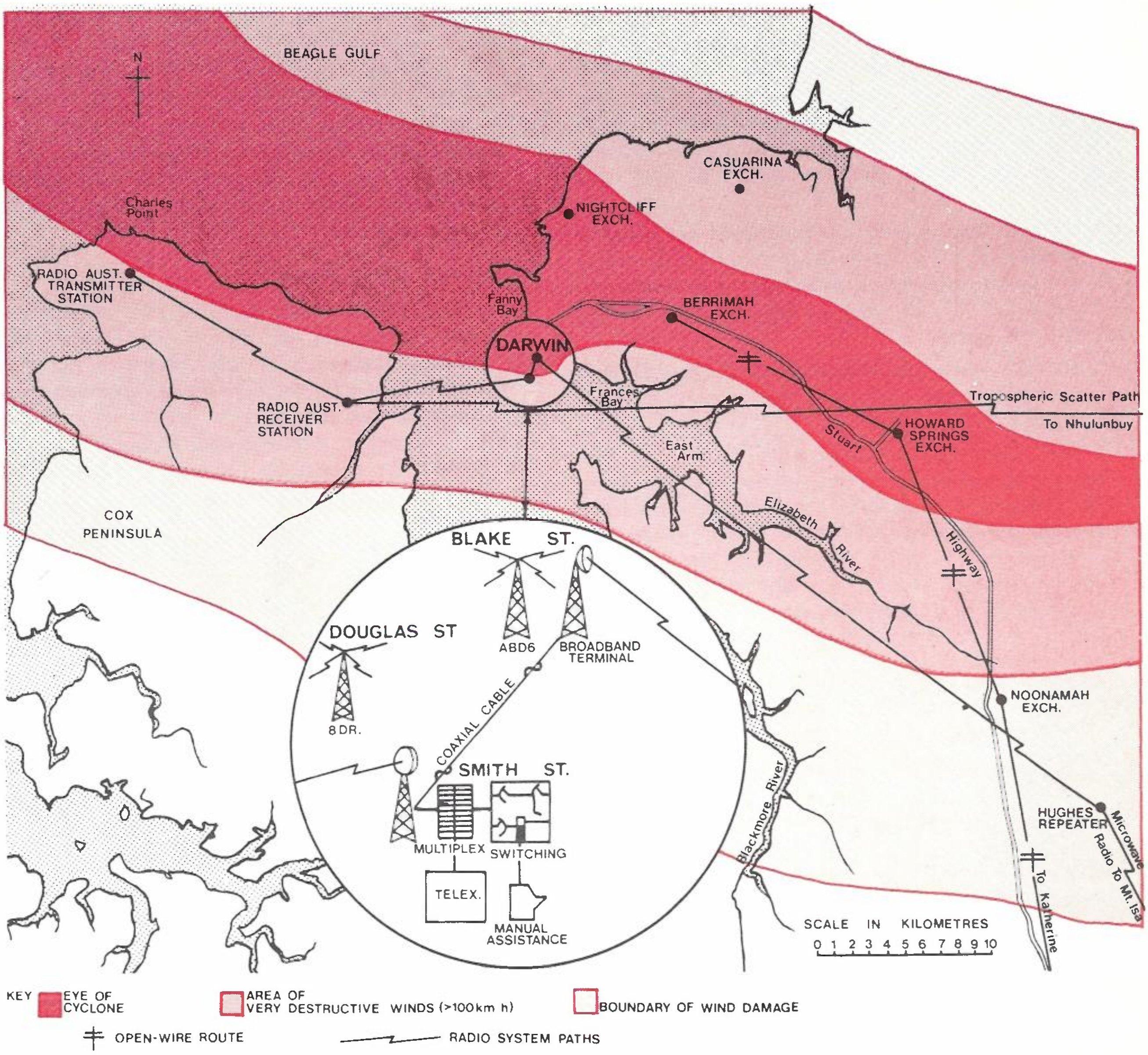

Fig. 1 — The Path of Cyclone Tracy in the Vicinity of Darwin.

work survivability under conditions of extreme stress whether due to natural causes such as cyclones or earthquakes or manmade, such as acts of sabotage, fires and explosions.

It is quite apparent from the foregoing descriptions that the primary element in the majority of internal plant failures was the inadequacy of the building structures to withstand the forces imposed by winds reported as up to 250 kilometres per hour. Roofs blown off, windows smashed by flying debris and doors blown away allowed the ingress of water with a salt content comparable with sea-water rather than rain.

The dependency of communications equipment on the maintenance of a closely controlled environment must therefore be recognised and the first principle is almost self-evident, viz.:

- Building designs must ensure complete plant protection at all times.

Related to this and the need for a controlled building environment, air-conditioning ducts at some locations provided a further means of water entry, while at Smith Street the standby plant capacity was not adequate to carry the air-conditioning as well as the normal equipment loads hence 'drying out' operations could not be assisted by humidity control. The two points of note here are:

- Air-conditioning plant design should not enhance water entry. (For example, it might be necessary to mount condensers externally and totally re-circulate the air inside the building during cyclone alerts);
- Standby power plant capacity should be adequate to maintain the continuing operation of environmental control plant.

The following considerations relate to the functional segregation of equipment between Smith and Blake Streets and the concentration of a large number of facilities at Smith Street. While this arrangement is readily justified in terms of the normal design criteria, namely minimal capital expenditure and maximum operational efficiency, it does lead to weaknesses in overall reliability as was demonstrated in Darwin by:

- The inability of the Blake Street microwave radio to operate independently of Smith Street multiplex equipment;
- The dependence of a wide range of facilities at Smith Street on a single standby power supply;
- The dependence of the standby power supply on control elements which were not safeguarded or duplicated.

It is therefore apparent that in addition to the two criteria referred to above, the design process must also examine the inherent reliability of a given network configuration and determine the improvement in survivability that can be achieved by marginal increases in resource commitments. Implicit in this statement is the contention that significant improvements can be made *at the design stage* with minimal cost increases. The principles arising from this discussion are:

- Physical diversity of plant should be examined as a means of increasing overall reliability commensurate with additional resource commitments;
- Where large quantities or critical plant operation are involved, multiple standby power plants coupled with flexibility in battery supply feeds should be considered;
- Key items of equipment or controls and points of weakness in the network should be identified and either duplicated or provided with by-passing or over-riding facilities. Apart from the power plant master control circuitry referred to above, other examples of items which fall into this category are carrier frequency generators and multi-frequency signalling tone supplies;
- A balance must be achieved between the sophistication possible in network design for reliability and the demands this imposes on operational staff to realise such potential at times of extreme stress.

NETWORK SURVIVABILITY

Use has already been made of this term and it is now appropriate to discuss its significance. Reference 3 defines it as *"the ability of the network to continue to function should elements in it be disrupted due to emergent conditions"*. In the present context in which a natural disaster causes destruction on a catastrophic scale, network survivability is interpreted as the ability to continue to provide some means of telecommunication under all circumstances at all times (cp. later discussion on 'Network Security').

This objective of what is equivalent to 100% reliability can only be met by the use of suitably chosen back-up options in which reliability is traded off against the facilities available, e.g. convenience of access or numbers of circuits. This will ensure that in the initial stages essential communications can be met. Subsequently, greater numbers of circuits and a wider range of facilities will be needed to meet increasing traffic demands but, by this time, reliability is no longer a major consideration.

Requirements for survivability can therefore be graded as follows:

First Stage — Highest Reliability

Required for essential communications under conditions imposed by a major disaster and for communications network control purposes by Commission staff — probably two circuits would be adequate (as was proved in Darwin).

Circuits must be capable of being cross-patched quickly from the widest range of provisioning alternatives to a variety of terminating facilities, e.g. test boards, switchboards, networks, etc. This implies the availability of either a range of suitable signalling relay sets or preferably standardised interface arrangements of the simplest possible form e.g. 2-wire loop signalling is far easier to set up under emergency pressures than 4 or 6-wire circuits.

The Darwin sequence of choices for circuit provision were:

- Microwave radio system plus multiplex channel equipment;
- Open-wire carrier systems (3 or 12 circuit);

- Microwave radio sub-baseband;
- Emergency radio; i.e. HF network or radiotelephone subscriber service.

An important consideration is that all such options must be retained in constant operational use to ensure that they are continually tested. The possibility of faulty operation or of missing interconnecting devices at the critical times is thereby minimised.

Second Stage — Medium Reliability

Required to meet communication needs of control and restoration authorities in the period immediately following the emergency; e.g. Natural Disasters Organisation, police, hospital, welfare services, power supply, communication services etc.

In Darwin, it is estimated that this stage would have involved approximately 100 subscribers' lines and perhaps two trunk groups (24 circuits) to meet external communications needs. This phase was of relatively short duration as trunk circuits in excess of these figures (see Third Stage below) had been restored by the latter part of the day following the cyclone (some telephone services were in fact operational from the afternoon of the 25th December).

Third Stage — Normal Reliability

Circuit provision and facilities to meet public traffic demand and ultimately capable of serving normal requirements.

This stage was quickly reached in Darwin simply because of the heavy loss of subscribers' services in the devastation and the consequent reduced level of traffic demand.

The points to note in connection with network survivability are:

- A high degree of interchangeability of circuits and flexibility of interconnection;
- Emergency circuits and facilities must be an integral part of the normal operational network to ensure their availability in working order when needed.

A further aspect of network survivability is the speed at which it is possible to react in an emergency to meet the commitment to provide communications up to at least the Second Stage referred to above. This requires consideration of possible courses of action and preparations which can be made prior to the occurrence of an emergency and is discussed under contingency planning.

CONTINGENCY PLANNING

The process to be discussed here has nothing to do with the preparation of elaborate plans to cover events which might never occur nor the expenditure of large sums of money on redundant plant. 'Contingency planning' in the present context is essentially a mental exercise reviewing possible events and consequences. While it could involve some commitment of resources, it is more than likely that the benefits it initiates in the short term will be greater than those which could occur in an emergency.

The essential aspect of contingency planning is to extend the normal planning process beyond the cost/benefit, capital limitations and environmental approach to examine the potential operational benefits and penalties in a normal network growth situation as well as when such a network is subject to extreme pressures resulting from unusual, emergency or catastrophic situations. While many would contend that this is not possible, the author would strongly argue that with due application and perhaps a little experience and 'lateral thinking', it can be achieved and the measures being taken in Darwin will be described presently.

Apart from the examination of networks for vulnerable areas which could become points of weakness under stress as has been mentioned earlier, consideration of means of damage appraisal and control under disaster conditions can be an enlightening experience. The following questions might be examined:

- What is the preferred location or locations at which first Stage circuits should terminate? Should a single high reliability control point be nominated or should a number of alternatives be available?
- How can damage appraisal information be quickly obtained noting the possible lack of staff, vehicles, fuel supplies (no power for pumps) and with roads covered with debris? What form of emergency communications should be establised?
- What records are needed, where are they, are they up to date?
- What support facilities would be needed to keep a control centre operating on a 24-hour basis? What support staff would be required? What are minimal staff welfare needs? What space requirements would this entail?
- What type of information would be needed by higher management?
- What advantage would a remote control centre outside the devastated area have? Should this be established on a permanent or temporary basis? What organisational implications arise?

Many of these questions have been discussed since Cyclone Tracy and not all have been resolved. One clear need seen as a result of this type of study is the rapid expansion of the Service Restoration and Traffic Control Centre (SRTCC) role beyond its present responsibilities relating to planned outages and network break-downs. In any large scale emergency, it could provide invaluable support for a State Administration in terms of communications, records and technical advice. Its expansion to embrace these responsibilities as well as becoming a focal point for contingency planning, is being strongly advocated.

CURRENT ACTION IN DARWIN

The following sets out the main lines of action being implemented in Darwin with the objective of completion before December 1975 and the onset of the next 'wet' season and its attendant risk of further cyclone activity.

- A multiplex supergroup (60 circuits) has been installed at Blake Street to provide diversified channel derivation capabilities;
- Modifications to Berrimah exchange will provide a second trunk traffic entry/exit point from Darwin to the national network;
- Cable carrier systems have been provided from Noonamah and Howard Springs to replace the open-wire into Darwin over the last 35 and 24 km respectively through the potential cyclone coastal region;
- Microwave radio system circuits derived separately at Blake Street and Smith Street together with further circuits provided by the cable carrier systems have been allocated to both Berrimah and Smith Street exchanges to provide a maximum degree of circuit diversity;
- Three standby power plants will be installed at Smith Street of which any two will be capable of carrying the combined equipment and air-conditioning loads;
- The present Smith Street standby power plant will then be transferred to Berrimah but as this cannot be completed before the 'wet', a transportable standby will be held at Berrimah;
- Control and restoration authorities possessing multiple exchange lines will have them split between the Smith Street and Berrimah exchanges;
- A completely underground power feed from the electricity generating station to Smith Street has been considered but is not likely to be installed before 1976;
- Building structures will be progressively upgraded to the new Buildings Code (Ref. 4).

NETWORK SECURITY

Network survivability has been defined earlier and relates to its ability to continue providing some form of communication, albeit minimal, at times of maximum stress. Network security on the other hand refers to *the ability to withstand the smaller scale disruptions experienced in day-by-day operations and to continue operating as near as possible to normal capacity.*

Seting aside the redundant plant approach in view of its implicit high cost penalties, two other alternatives can be used:

- *Substitution* — circuits are nominated as either 'priority or 'sacrificial' and when a failure occurs on one path, its priority circuits replace the sacrificial circuits on the back-up path.
- *Diversity* — circuits forming a particular traffic group are split between two paths so that a portion of the total remains in operation should one path fail. An extension of this approach is *link diversity* which is achieved by advancing future bearer provision when relatively small cost penalties are involved.

In applying contingency planning to the routes out of Darwin, it was realised that time would not permit substitution procedures to be organised so the traffic group diversity approach was attempted. It was then realised that past applications of this technique have ignored the differing reliabilities of different systems and paths and in fact, there is no quantitative basis available for comparing, for example, the relative performance capabilities of an open-wire system with a microwave radio system under stress conditions and for allocating circuits accordingly. A benefit of the Darwin contingency planning has therefore been to focus attention on this problem which when resolved, will provide a much more realistic basis for SRTCC circuit re-arrangements.

A second problem which emerged from the process of contingency planning was that of continued access to operators should a failure occur to the normal manual assistance or local service facilities. While STD and local calls present on difficulties in a normal situation, under the stress imposed by an emergency or if removed from normal surroundings and/or directory information, the subscriber immediately seeks the assistance of an operator.

In Darwin, local call and operator access facilities were restored on 25th December while trunk circuits were made available during the latter part of the 26th, well before significant demand from subscribers occurred. In examining their role in an emergency it was realised that the recently installed 4-wire cord type operator positions installed there are dependent not only on normal exchange switching capabilities but also on special registers and multi-frequency code signalling which collectively increase the vulnerability to failure of the operator facilities. If such a failure does occur and it cannot be remedied by repairs to the existing equipment, the problems associated with replacing this facility in a short space of time or making substitute arrangements would prove to be exceedingly complex. The ease and flexibility associated with providing substitute switchboards in earlier magneto or CB networks is no longer available.

The outcome of this study has therefore been to question the suitability of current operator facility designs and the desirability of their location in emergency prone areas or alternatively, to examine potential mechanisms of failure in existing designs and means of improving their reliability and methods of service restoration.

CONCLUSION

Although a formal cost analysis has not been presented here, the actual costs directly attributable to contingency provisions are small after allowance has been made for repairs and replacements as a result of Cyclone Tracy damage and provision for growth. On completion of the measures set out above, the Darwin network will be in a much better position to withstand another cyclone when this occurs. Reference 1 comments on difficulties inherent in prediction processes due to deficiencies in records and in statistical methods associated with cyclone probabilities of occurrence. It does state however, that the figures for Darwin indicate that in a period of 30 years, there are likely to be 15 occasion of a cyclone within 155 km, 11 occasions within 100 km and 4 occasion within 45 km.

Unfortunately, this says very little as to what is likely to occur in the immediate future but in the light of this information, the events in Darwin during the coming and subsequent 'wet' seasons will be watched with interest.

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After two years in the Work Study Sub-Section, Management Services Section, Headquarters, he returned to Adelaide in 1963 where in the Planning Branch, he successively took charge of Sub-Sections responsible for Traffic Engineering, Country Internal Plant Design and 10C Trunk Exchange Design. Since 1972, he has occupied the position of Assistant Superintending Engineer, Network Performance.

Metaconta IOC Operator Toll Exchange for Australia

E. L. DURAND, B. Tech, MIE Aust.

The METACONTA 10C stored program controlled Trunk Exchange system selected by Telecom Australia as the new standard switching system for large STD trunk exchanges in Australia also provides a new, highly automated, manual trunk exchange system featuring modern data base information storage and retrieval systems. This article describes the design features of this manual assistance system and relates the manual call handling to the STD call handling system.

INTRODUCTION

Despite the rapid STD penetration of the long distance telephone traffic in Australia there remains a considerable volume of manually handled calls. These are required to connect destinations not yet available via the STD grid, and to provide special facilities such as pricing, fixed time calls, reverse charging, particular person, and other customer requirements which cannot be given by existing automatic exchanges. Similarly, although the demands on manual operators to handle the rapidly increasing international telephone traffic will be reduced by International Subscriber Dialling introduced in Australia by the Pitt 10C Exchange there will still be a heavy requirement for operator assistance and special facilities in this very important telephone market.

Concurrently with the Australian Telecommunications Commission (ATC) decision to adopt the 10C trunk system a decision was also made to incorporate a fully automated manual assistance system, based on the 10C switching machine, to provide the full range of existing ATC manual call handling facilities for both National and International services. In addition, a new range of customer services was planned which could utilize the unused information signalling capacity of the Australian automatic exchange network, together with the processing power of a stored program control system.

These new facilities, generally grouped under the headings of "Interception" and "Appointment and Reminder", include the following customer services:

- Intercepted and Re-directed calls
- Standard or personal recorded messages
- Nuisance call tracing
- Automatic or manual appointment calls
- Telephone answering service

These new customer services have been provided within the framework of a flexible design so that they may be expanded easily, or new facilities added later, to cater for changing market requirements.

SYSTEM SPECIFICATION

The specification for the 10C Manual Assistance System is the result of very close collaboration between Telecom Australia, and the suppliers, Standard Telephones & Cables of Sydney and Bell Telephone Manufacturing Company of Antwerp in Belgium. The complete repertoire of manual call handling facilities existing in the Australian Network was documented in precise details by ATC in order to provide the basic software specification, while at the same time the Systems designers from STC and BTM produced basic flow charts and suggested changes where necessary in call handling procedures, in order to facilitate the implementation of the new design.

A great deal of effort has been devoted to ensuring that all important features of existing manual assistance systems have been retained, as well as providing a new range of efficient call handling techniques. The best example of this is the call data system which has been made completely automatic with modern data handling methods. The written call docket has been eliminated. Likewise the functional designs of the operator consoles were the result of close co-operation between industrial and production designers of the suppliers and standards engineers and operations experts of ATC. The resulting product combines functional efficiency and pleasing appearance and promises to achieve ready acceptance by its ultimate judges, the telephone operators.

Operator Facilities

A most important new operator facility is the ability to dissociate from the position a call which has been established and is proceeding normally. This dissociation enables the call to be removed entirely from the operator, leaving the connect circuit free to set up subsequent calls, but does not prevent the call from being re-connected to an operator, if required, such as at the end of a prepaid time, or during the supervision of a B party release condition. Traditional speaking, monitoring, splitting and time controls are provided. Other new operating features include:

- A single basic console design for operators, monitors and supervisors enabling a large new range of monitorial features to improve the supervision of the exchange. Monitors may observe, assist or even take over a call from any of their dependent operators without having to leave the Monitor Console.
- Supervisors have a range of performance indicators and exchange traffic, staffing, and queue control facilities, which ensure efficient exchange operation. These exchange supervision controls are exercised from either the Supervisor Console or an on-line teletype terminal.

Call Data Facilities

Call information in the 10C exchange is entered from the Operator Console suitably structured and formatted to enable it to be stored, handled by the exchange processors during call set-up, and later processed by an off-line computer, for accounting and statistical purposes. Formatting of entry information is in part performed automatically by the machine since each item of input is identified by the operator as part of the input operation.

Certain illegal data entries which could affect call switching are refused but this checking is kept to a minimum. The data of a typical call record shown as it would be displayed to an operator is illustrated in Fig. 1.

Operating Instructions

Because of the discipline imposed both by the need to specify call data much more precisely than ever before, and the need to define the exact call handling procedures by the machine for a very large range of call types and variations the ATC faced the task of writing and refining a massive facility specification. The systems analysts at BTM and STC then designed a software package to control the Manual Assistance hardware and interface the10C exchange switching system. The size of this task can be gauged from the fact that the Manual Assistance Specification extends to more than 2,000 pages of documentation and the program itself comprises some 40,000 instructions.

New Customer Services

The new customer services are the Appointment and Reminder Service (ANR) and the Interception Service. The ANR is basically a wake up service which provides for automatic connection of a recorded announcement at a time specified by subscriber. To verify that the call is made correctly two simultaneous calls are generated by the 10C exchange towards the customer. One call must be answered and is connected to a recorded announcement and the other must encounter a busy condition, within certain time limitations, for the service

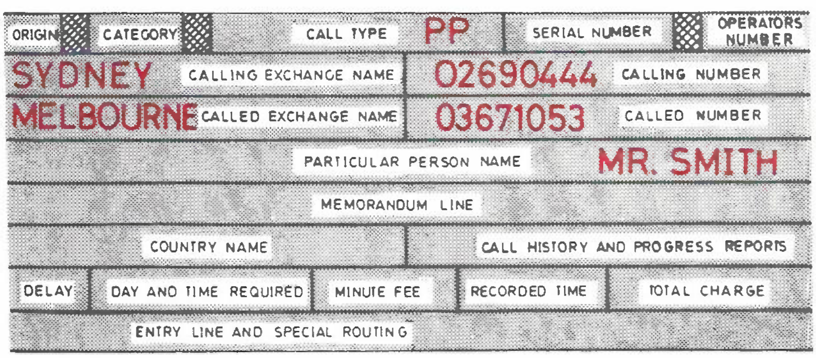

Fig. 1 — Display of Typical Call Record.

to be considered successful. Other options available to the subscriber booking the service are

- Manual or automatic reminder calls.
- Operator assisted wake up calls
- Permanent or casual bookings

The ANR Console provides the operator with facilities to answer subscriber's enquiries, make or cancel bookings, and provide the operator call-out services. The bookings, once made, are stored on a magnetic disc file in order of the time the service is required. At the appropriate time this file is automatically interrogated and the service call, either automatic or manual, is made.

The interception service uses the information signalling of the Australian crossbar exchange network and the switching and processing power of the 10C exchange which, in this context, is known as the Interception Service Centre (ISC). The basic interception service works by having a small memory store at each subscriber exchange. Each subscriber's line is represented by one bit in this terminal store which is interrogated before an incoming call is connected. If the bit is found to be set the call is re-directed to the ISC where the processor will consult a disc file to determine the service required.

The call may then be:

- Connected to the B party with special call hold and trace facilities.
- Routed to an operator.
- Re-directed to another number.
- Tried first on the B party number and if no answer re-directed to another number.
- Directed to a standard, or personalised recorded announcement.

The same consoles as used by the ANR operators are used by the interception operators to answer enquires, make or cancel bookings, by setting or resetting the bit stored in the terminal exchange, and to provide the manual operator callout services. The ANR facilities will be available with the introduction of the 10C manual assistance installations at Pitt, Waymouth and Lonsdale but the complete interception service will only gradually be introduced as the modifications necessary in the terminal exchange signalling and the terminal memory stores are introduced.

Remote Operation

In the 10C Manual Exchange System operator actions on the console do not directly affect any of the call functions but rather cause a data input to the processor where the program itself executes the function to be performed. It has become possible therefore to remove the consoles completely from the processors and the trunk exchange. By providing a suitable data transmission circuit, normally a bothway 40K bit per second data circuit, and one voice channel per position, remote manual exchange units of 24 operators and associated monitors and supervisors can be located at any distance from their switching networks and controlling processors. For consoles located in the same building as the processors the data transmission circuit is not required. Both local and remote consoles are exactly the same and are controlled by the same software program so that, to an operator, there is no discernable difference in working either a local or a remote position.

Call Charging and Accounting

Manual calls handled by the 10C Exchange are timed in the traditional way under the control of the operators TIME key. Timing is started by the operator when a connection is established and may be stopped at any time while the call is associated if difficulties occur. Dissociation of the call is prevented unless timing has been started, and after dissociation timing is under control of A or B party release conditions.

At the end of the call the chargeable time is recorded in the call record. This chargeable time is used, together with charge rate which is entered into the call record at the time of connection, to calculate the basic call charge. Any additional charges such as a PP fee or an STD surcharge are separately listed and then incorporated into the total charge computation. The final call record thus contains a complete history of the call and all the necessary charge information to enable an off line accounting system to bill the customer and to provide a visible record for possible future enquiries.

MANUAL ASSISTANCE HARDWARE

The Switching Network

Fig. 2 shows the various switching networks of the 10C trunk exchange. As has been described before (Ref. 1), STD calls are switched through the exchange from an incoming trunk (ITJ) to an outgoing trunk (OTJ) via the voice network (IVN-OVN) with the temporary association of MFC receivers and senders connected by the signalling networks RSN and SSN during the register phase of the call. This familiar principle of having common signalling equipment associated only during the register phase of the call has now been extended to include the manual operator as well. In the 10C exchange a special Operator Access Network (OAN) is added together with two types of Operator Junctors (OJD and OJR). The operators console now has only 3 connect circuits, which are the equivalent of cord circuits on a conventional switchboard, and

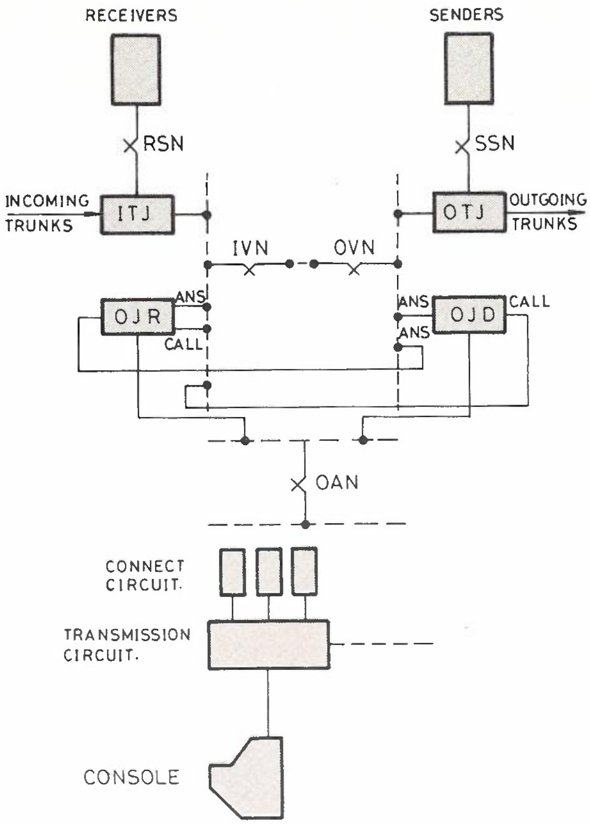

Fig. 2 — Switching Network of a 10C Exchange with Manual Assistance.

these connect circuits are allocated to outlets of the OAN. An incoming call requiring an operator service arrives on an ITJ and is connected via IVN-OVN to the answer (ANS) side of an Operator Junctor Demand (OJD) which supplies ring tone to the caller while the call is placed in a software queue waiting for a free operator. The next free operator will take the call by causing a connection to be made from the OJD via the OAN to one of the 3 connect circuits of that particular console. The operator may now talk with the caller, ascertain the details of the call required, and enter these details into the controlling processor where they are stored in the form of a call record. Switching to the wanted subscriber is initiated by the operator and connection is made from the call side (CALL) of the OJD via the IVN-OVN and an OTJ to the required outgoing circuit.

Once both the calling and called subscribers are connected and timing has commenced the call may be dissociated by the release of the OAN connection thus releasing the console and connect circuit to handle the setting of new calls. If the incoming call cannot be connected immediately, or if the calling subscriber does not require a service on demand but rather a connection at some later time, the call record is stored by the processor, and automatically returned at the appropriate time to another operator, for the call to be re-attempted. At this time a connection to both calling and called subscribers must be made and an Operator Junctor Revertive (OJR) is used. The OJR has inlets to the IVN for both ANS and CALL sides for this purpose, and as well has an inlet on the OVN for the ANS side so that it may also handle demand calls if required.

The Consoles

Modern, low profile, cordless operator consoles have been designed, with variations of a single basic design to account for trunk call handling, Interception, ANR, Operator, Monitor, Supervisor and Service Assessment positions. A suite of 4 operator positions is shown in Fig 3 and a shelf layout of an operator position is represented by Fig. 4. All consoles consist, functionally, of 3 component subsystems:

- Data entry
- Data display
- Transmission

The data entry system comprises a solid state alphanumeric keyboard used to enter call record data into the processor. In addition to the keyboard there are a number of keyshelf keys broadly grouped into 2 classes, Function Keys and Control Keys shown in Fig 4. Function keys define the call record information entered by the keyboard while the control keys, which are analagous to the keys found on a conventional switchboard, provide the speaking, monitoring, splitting, timing, release and similar controls. Once again, as for conventional switchboards, some of these control keys, such as SPEAK and MONITOR are provided for each connect circuit while others only occur once on each console and are associated with an operated speak key.

The data display system encompasses an alphanumeric display which is structured to display the call record to the operator, and the keyshelf lamps to inform the operator of the supervisory conditions on the CALL and ANS sides of the connect circuits, the traffic conditions such as CALL WAITING, and the operated or released status of the various function and control keys. Thus both the data entry and data display systems can be considered as including both the traditional control functions found on conventional switchboards, and a data system which replaces the call information written on paper dockets.

The transmission system is similar to that found on most telephone switchboards. Speaking, monitoring, and overlap working are provided on all connect circuits. In addition a number of order wire circuits and observation buses are provided to facilitate exchange management by monitors and supervisors.

MANUAL ASSISTANCE SOFTWARE

The manual assistance software is closely linked to the software for STD call handling wherever call switching functions are to be performed, but at other points such as console key scanning and lamp driving, is quite separated from STD software package. A system of separate source files for the main program packages, and conditional assembly of these together enable an easy method of preparing a suitable program package for a 10C exchange either with or without the Manual Assistance facilities.

Data Flow

The flow of call record data during a normal MAP call is illustrated in Fig. 5 and is an important part of the manual assistance software system. During the booking of the call data entered at the console is transmitted to the computer, stored in a call record buffer and then transmitted back to the console for display to the operator. When the call is dissociated the call record is transferred to the Calls in Progress File on the magnetic disc. When the call has cleared the call record is returned to the computer memory for the insertion of charging information, after which it is written back onto the disc in the Enquiry File where it remains for a minimum of 15 minutes. After this period the call record is again returned to the memory from where it is written onto the data magnetic tapes for subsequent off-line processing and customer billing. All files on magnetic discs

Fig. 3 — 10C Monitor and Operator Positions.

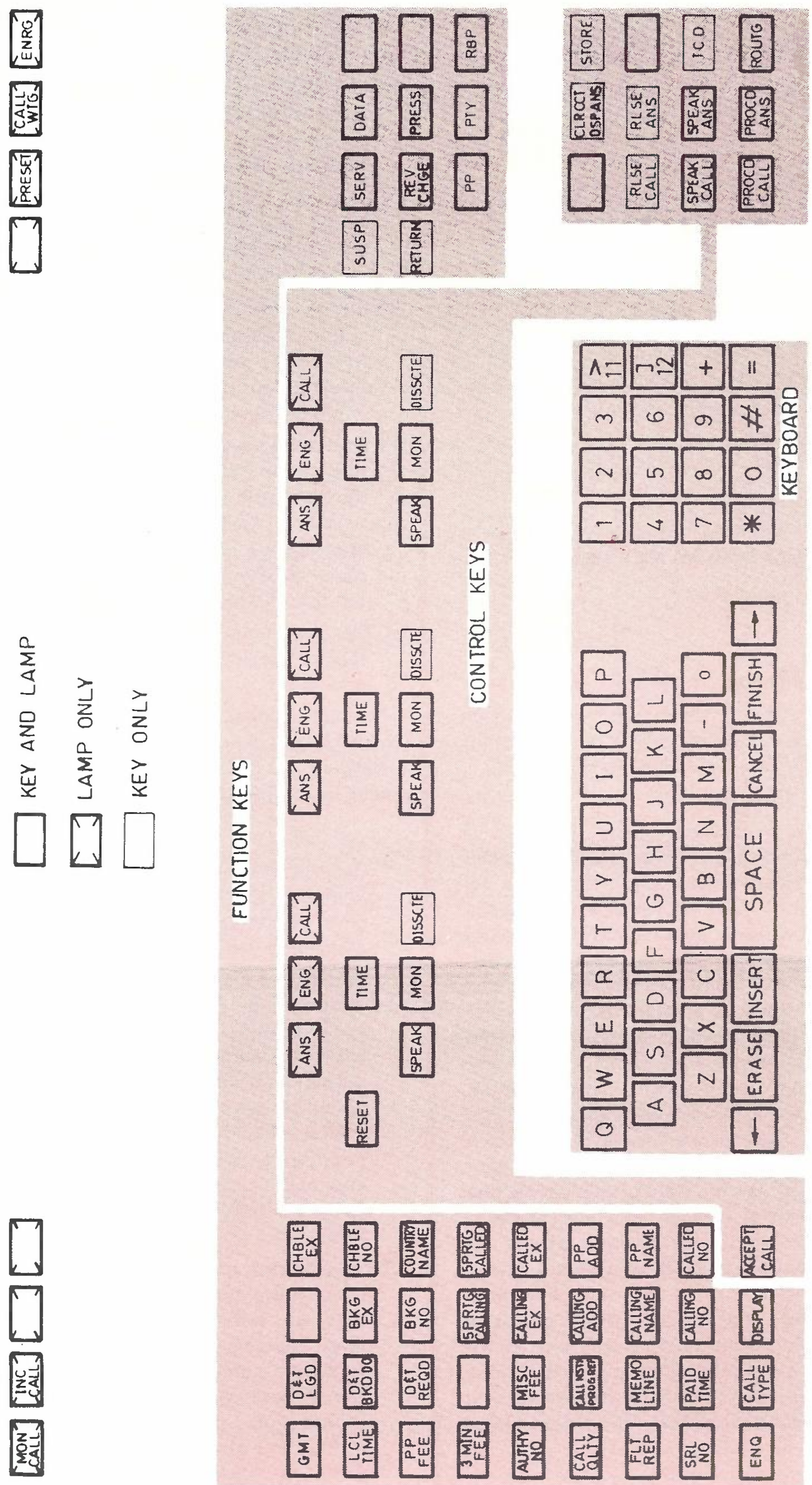

Fig. 4 — Layout of an Operator Console.

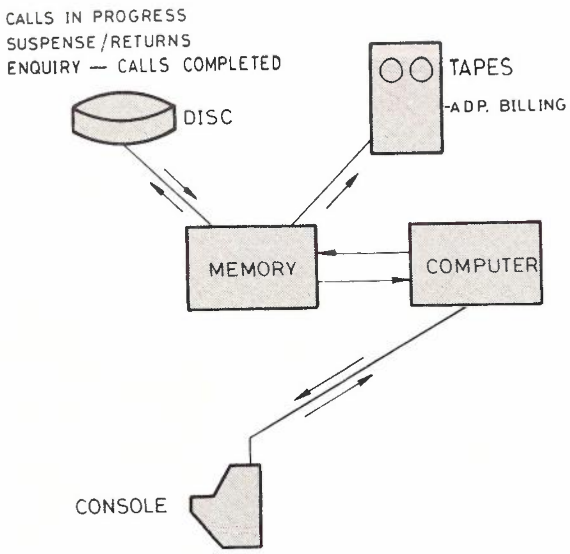

Fig. 5 — Data Flow for Call Records.

and magnetic tapes are duplicated to provide security against loss both within the exchange and in the transport to, and processing by, an off-line processor.

Status Buffers and Hoppers

The organisation of programs for the manual assistance system follows the same principles as the STD exchange software. The complete job to be done at each stage of establishing or handling the call is broken down into small component parts with each part being executed by a specific program which is in turn activated by request bits stored in status buffers and hoppers. A status buffer is a small area in the computer memory dedicated to storing transient information about a particular hardware device such as a junctor or a position. These status buffers also hold details of the linkage of devices in a call. Thus for the simple configuration of an incoming junctor connected to an operator junctor, the incoming junctor status buffer holds the address of the operator junctor, and the operator junctor status buffer holds the address of the incoming junctor. Hoppers provide a software queue of jobs to be performed for a particular hardware device such as the slow driver which performs console switching functions such as splitting a connection or setting the speak or monitor conditions in the transmission circuit. Regularly executed scanning programs detect request bits set in these status buffers or hoppers and initiate the execution of the particular program to perform the required function.

Software Packages

Manual Assistance software is comprised of several independent but interacting packages. The main packages are:

- Console input programs detect and report the operations of keys or the insertion of headset plugs on the manual assistance consoles.
- Lamp driving and display output programs are used to control the data output which results in the lighting of lamps and the display of call record information on the position.
- Queue control programs are used to allocate queue positions to incoming manual assistance calls both new calls from subscribers and represented calls returning from storage on magnetic disc.
- The call processing package contains the bulk of the manual assistance software and includes the analysis and control of all the call handling facilities described in the facility specification. This call processing package interfaces closely with the call handling package for the STD exchange.
- Disc and tape software controls all data transfers between memory and the magnetic discs and tapes.

As well as these predominantly manual assistance packages, there are several important packages existing in the STD exchange which have been extended to incorporate the manual assistance system.

These include:

- On-Line Tests which provide a complete fault finding and reporting system for the maintenance of manual assistance consoles and their associated hardware.
- The take-over package controls the release or retention of MAP calls during system reconfiguration after significant hardware or software faults. This call dependent take-over package decides on the recovery action to be taken by examination of the phase of the call and a set of rules for call recovery actions. In addition a separate system of data recovery and audit programs have been developed to preserve the integrity of the magnetic disc files.
- On-Demand programs have been increased to include the control and updating of large disc files of semi-permanent data, including a large number-name translator which relates exchange names, international country destinations, routing access codes and charging information. On-demand programs are not normally resident in the computer memory. They are written in a relocatable form and

may be loaded and executed from special on-demand memory zones as required.

The manual assistance software package has been designed to use as much as possible the existing software for the STD exchange and follows the same principles of organisation.

Conclusion

The advent of stored program controlled exchanges handling automatic telephone traffic has been rapidly gaining momentum throughout the world over the last few years since the initial introduction of the Bell System No. 1 ESS in 1964. The METACONTA 10C System now being commissioned in Australia provides the advantages already demonstrated for these S.P.C. exchanges to an integrated automatic and manual toll exchange of very large capacity.

ACKNOWLEDGEMENTS

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New Headquarters Editor for Telephone Switching Equipment

The Council of Control is pleased to record its appreciation of the work done by Mr. W. Dedrick in recent years as Headquarters Editor covering the Telephone Exchange Switching Equipment area. Mr. Dedrick recently transferred to the Victorian Administration and we wish him well in his new work.

Mr. Leo Tyrrell succeeds Mr. Dedrick. Mr. Tyrrell is Staff Engineer to the Superintending Engineer, Telephone Switching Construction Branch of the Headquarters Engineering Department.

Colour Conversion or National Television Transmitting Stations

R. P. LEES, B.E.E., and J. D. HODGSON, B.S.C. (ENG.)

Telecom Australia is responsible for the installation and operation of the television transmitting stations providing the National Television Service. This paper describes the approach adopted by the then Post Office in converting these stations for colour, including the performance investigations undertaken and the equipment modifications required to allow the introduction of a colour television service on 1st March, 1975. The paper also describes the configuration of facilities adopted at the converted stations and concludes with a discussion of the problems of converting the Hobart station while maintaining service.

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INTRODUCTION

Monochrome television broadcasting began in the National Television Service in 1956 with the establishment of stations to serve Melbourne and Sydney. Over the period 1959-1967 a further 37 high power transmitters were established by the then Post Office which extended the National Service to the remaining capital city stations and to all except the more remote regional areas. Further extension and improvement in the coverage of the National Service has since been achieved by the installation of low power transmitting and translator stations; at 30th June, 1975, there were 99 such station with a further 26 in the process of construction. This development is shown in Fig. 1. All Australian television services are transmitted in the VHF band.

Telecom Australia is also responsible for the provision and operation of the programme relay facilities which interconnect the transmitting stations with the studios of the Australian Broadcasting Commission where the programmes are produced. With the exception of direct studio-transmitter links established for several capital city stations, the programme relay facilities are provided on the National Broadband Bearer Network. The colour conversion of this network is not discussed in this paper, nor are the colour conversion works required at the studios of the ABC.

In 1969 the recommendation of the Australian Broadcasting Control Board that Australia should adopt the PAL system of colour transmission was accepted by the Government of the day. The previous years of monochrome television had resulted in the development in the industry of considerable expertise and to draw upon this, Industry Working Parties were established involving representatives from television companies, equipment manufacturers and both commercial and national broadcasting organisations. These working parties developed basic system standards for Australia and these were duly embodied in the ABCB publication (Ref. 1) and APO specification (Ref. 2).

COLOUR TELEVISION SIGNALS

Colour television signals have waveform and spectral characteristics which differ from those of monochrome television signals. These differences are such that colour signals impose additional demands upon equipment designed originally for monochrome services. Some of these demands are fundamental to colour signals and must be met before colour services can take place while other demands affect the faithfulness with which the picture is transmitted.

The waveform characteristics of Australian colour and monochrome television signals are shown in Fig. 2, and it can be seen that the proportion of the signal which can be occupied by visible picture information has increased from 100 units to approximately 170 units. As a result, the colour

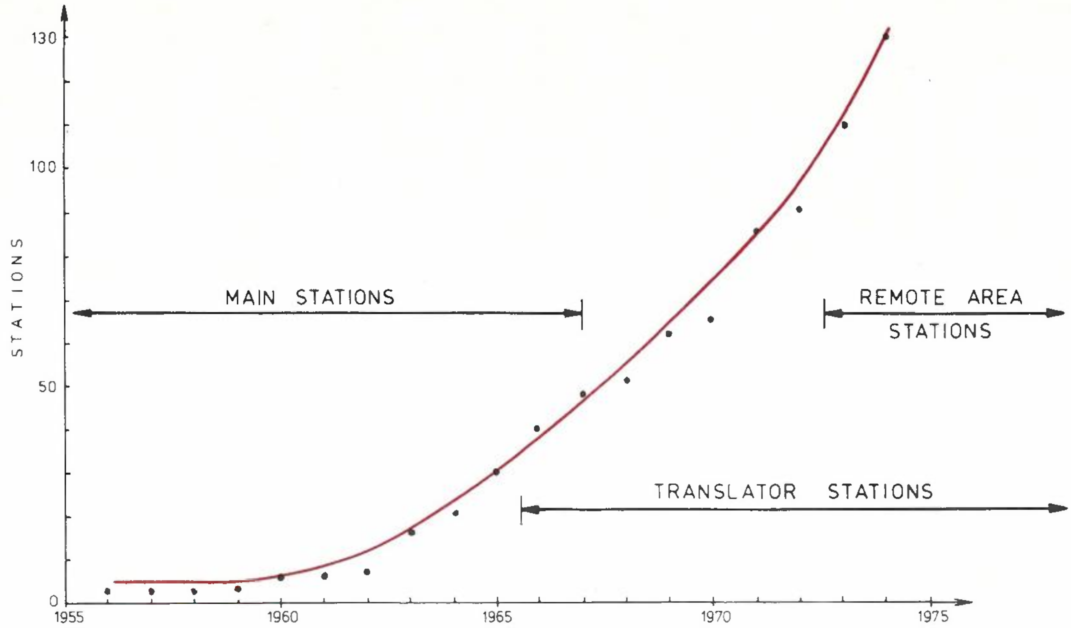

Fig. 1 — National Television Development.

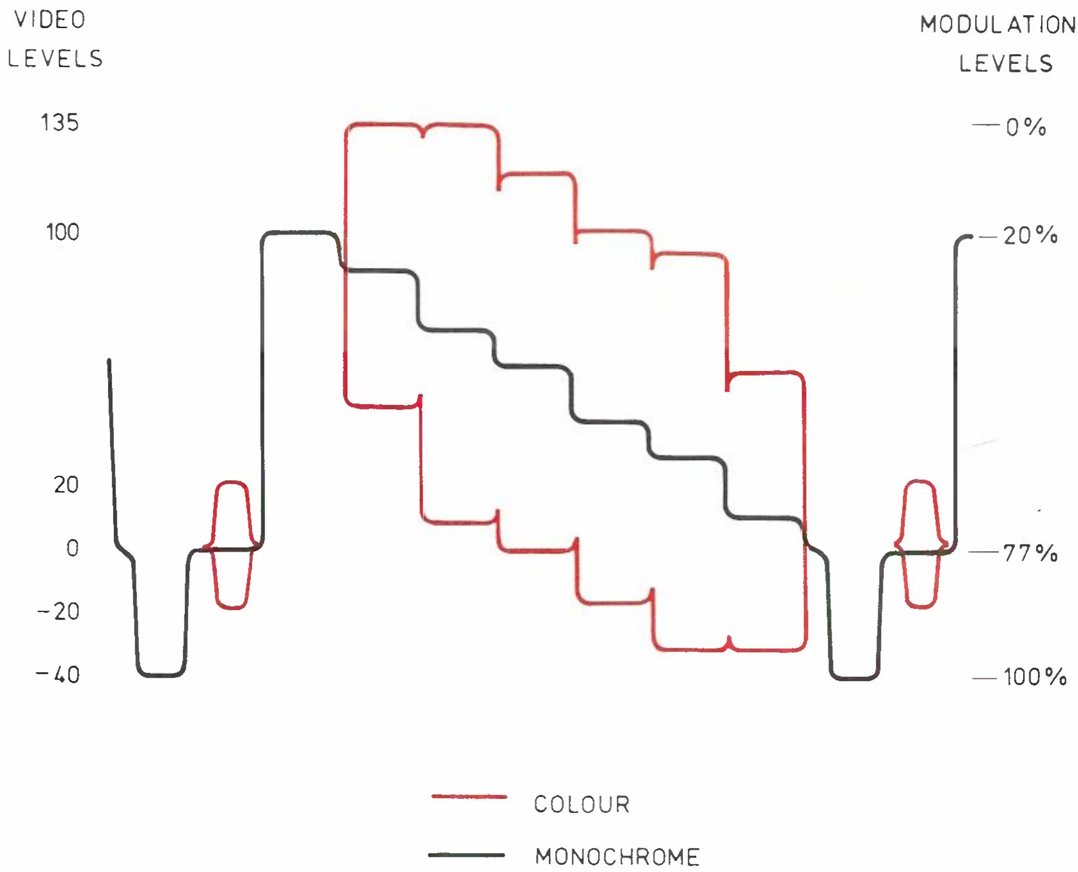

Fig. 2 — Television Line Waveforms.

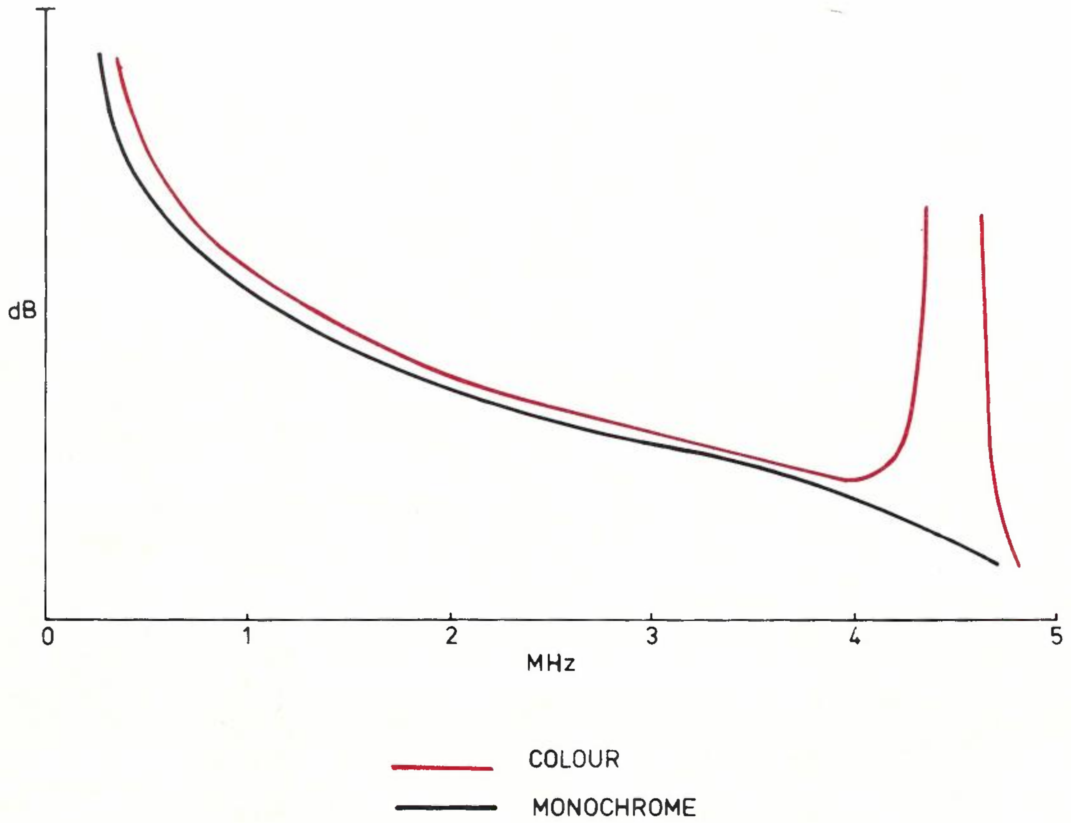

Fig. 3 — Frequency Spectra of Typical Signals.

signal has increased susceptibility to level dependent or non-linear distortions, which affect the accuracy of the picture reproduction.

The excursion of picture information into the portion of the signal occupied only by synchronising information in a monochrome signal affects synchronising signal processing circuits normally used in monochrome equipment. It should be noted that the modulation levels apply to an ideal double sideband signal. In practice this is modified to a vestigial sideband signal in the transmitter prior to transmission, with the result that the amplitude of the high frequency colour or chrominance information is reduced to one half. In addition the synchronising portion of the colour signal includes the "colour burst" which is essential for decoding the colour information in the transmitted signal.

The distribution of spectral energy in colour and monochrome signals is represented in Fig. 3.

The increased level of high frequency energy is due to the inclusion of the colour information, in the form of a colour sub-carrier of approximately 4.43 Mhz on to which the hue or colour itself is phase modulated and the saturation or strength of the colour is amplitude modulated. As a result the colour signal makes increased demands upon the frequency dependent performance characteristics of the transmitting equipment and also increases the frequency range over which level dependent distortions are significant. Deficiencies in these performance characteristics affect the accuracy of picture reproduction. In particular, the different time delays of the frequencies associated with colour information and the picture or luminance information affect the "registration" of the colour with the the picture. The addition of the colour sub-carrier to the vision and sound carriers increases the likelihood of intermodulation and spurious radiation problems.

With the recognition of these characteristic differences between monochrome and colour television signals, the more important basic tests appropriate to explore and quantify the colour performance of monochrome equipment are listed below:

- Differential gain and phase — this test measures the non-linear distortion arising in the chrominance information with level variations in the luminance signal.
- Chrominance non-linearity — This test measures the non-linear distortion arising in the chrominance information with level variations in the chrominance signal.
- Luminance Shift — this test measures the luminance changes arising with level variations in the chrominance signal.
- Luminance-chrominance inequality — this test measures the difference between the gains and the time delays of the luminance and chrominance information, respectively.

A description of these and other tests which can be used to explore the adequacy of monochrome equipment for colour operation is given by Bartlett (Ref. 3). These tests were used in an initial assessment of monochrome equipment in the National Service undertaken in the development of the conversion programme as described in the next Section.

DEVELOPMENT OF CONVERSION PROGRAMME

The basic equipment at National Television transmitting stations falls within five groups:

- Transmitters
- Translators
- Antenna systems
- Studio-transmitter direct links
- Ancilliary Equipment comprising
  - Programme Input Equipment
  - Local/emergency programme source
  - Test and monitoring facilities.

In each of these categories the equipment has been supplied by a wide range of overseas and local manufacturers during the period extending from 1956, when television commenced in Australia, to the present time. The equipment shows the changes in design practice with solid state component availability over the years and different installation reflect developments of station equipment configuration philosophies.

Following the announcement that colour television would be introduced, an assessment was made of the colour transmission performance of this wide range of monochrome transmitting equipment. The assessment was based upon previous experience and knowledge of the equipment and included performance measurements, using the previously discussed tests, on selected representative items. The assessment also included consideration of operating and maintenance aspects of the existing equipment, such as reliability, long term stability of adjustment and current maintenance costs, to determine if any deficiencies developing in these areas would become unacceptable with the increased performance demands of colour operation. Recognition was also given to the desirability of standardising station equipment.

This assessment enabled the development of two interacting programmes; firstly an engineering works programme covering the ordering, installation and funding of replacement items of equipment and secondly, a detailed equipment investigation programme covering the colour evaluation of specific items of existing equipment to enable a decision to be taken between retention, re-design or complete replacement.

The results of this assessment and the subsequent investigations and conversion works that followed are discussed for each group of equipment listed above.

TRANSMITTERS

Table 1 shows the range of high power vision transmitters employed at main 100 kW ERP National Stations and summarises the basic conversion work required. The majority of these transmitters including that at Canberra has been supplied by one Australian manufacturer. This manufacturer was the only supplier able to provide a colour conversion modification kit for their transmitters. Accordingly, the transmitter at Canberra was converted to colour operation by this manufacturer as a model exercise, to enable a full assessment to be made of the colour conversion equipment and the conversion procedures adopted in relation to the cost and final performance achieved. From this work, guidelines were developed for the evaluation and conversion of other transmitters, particularly those provided by this manufacturer.

The transmitters at Melbourne, Sydney and Hobart were supplied by overseas manufacturers who were not in a position to assist with conversion components. These stations were among the first National Stations to commence operation and the transmitters were not capable of conversion to colour operation without extensive and un-economic modifications. They were therefore replaced. Details of the colour evaluation tests conducted on the original Hobart transmitter are discussed later. The other high power transmitters of overseas origin are of more recent design and were assessed as being capable of successful conversion to colour operation, although, in the case of the transmitters at Brisbane, Adelaide and Perth it was necessary to replace major components associated with the band shaping and combining of the vision and sound transmitter outputs.

TABLE 1 — CONVERSION OF HIGH POWER VISION TRANSMITTERS

Group	Country of Manufacture	Station Configuration, Frequencies and Location	Opening Date	Conversion Work
1A	Australia	Parallel 10 kW Ch 3—Canberra	1962	Manufacturer to convert as model exercise
1B	Australia	Parallel 10 kW Ch 2, 3, 4, 16 locations	1963-1967	APO to convert based on: (a) Experience from Canberra (b) Investigation of detailed requirements (c) Modification kit from manufacturer
1C	Australia	Parallel 10 kW Ch 5. 2 locations	1965	APO to convert as for Group 1B pending change of Channel allocation requiring new transmitters
1D	Australia	Parallel 5 kW Ch 6-9. 4 locations	1965-1966	APO to convert as for Group 1B
2A	U.K.	Main 18 kW-4kW standby Ch 2 Melbourne and Sydney	1956	Complete replacement
2B	U.K.	Parallel 10 kW Ch 2 Brisbane Adelaide and Perth	1959-1960	APO to convert based on: (a) Investigation of detailed requirements (b) Replacement of major components (c) Redesign of major circuitry
2C	U.K.	Parallel 10 kW Ch 0, 1 5 locations	1963-1965	APO to convert based on: (a) Investigation of detailed requirements (b) Redesign of major circuitry
2D	U.K.	Parallel 5 kW Ch 6 1 location	1964	APO to convert as for group 2B
3A	Japan	Parallel 10 kW Ch 4, 5 2 locations	1963	APO to convert based on: (a) Investigation of detailed requirements (b) Redesign of major circuitry
3B	Japan	Parallel 6 kW Ch 5A 1 location	1963	APO to convert as for group 3A
4	Holland	Main 22 kW -5 kW standby Ch 2 Hobart	1960	Complete replacement
5	Australia	Parallel 10 kW Ch 7 1 location	1966	APO to convert based on: (a) Investigation of detailed requirements (b) Redesign of major circuitry

The high power sound transmitters were not influential in determining the conversion work required but where the vision transmitters were to be replaced then the associated sound transmitters were also replaced as the two are closely integrated in modern equipment.

The transmitters at low and medium power stations have been installed during the last three years, with few exceptions. The equipment is consequently modern in design and was provided with an awareness that the introduction of colour services was imminent. An assessment of the colour performance of these transmitters showed that satisfactory colour operation could be achieved with minor equipment additions and modifications. These low power stations are not normally staffed and the long term stability of adjustment and performance of the equipment is an important maintenance consideration. In some cases a lack of stability has proved to be a limitation in monochrome operation and with the additional performance demands imposed by colour operation equipment replacement is necessary.

Replacement Transmitters

The replacement transmitters employ low level intermediate frequency modulation techniques in

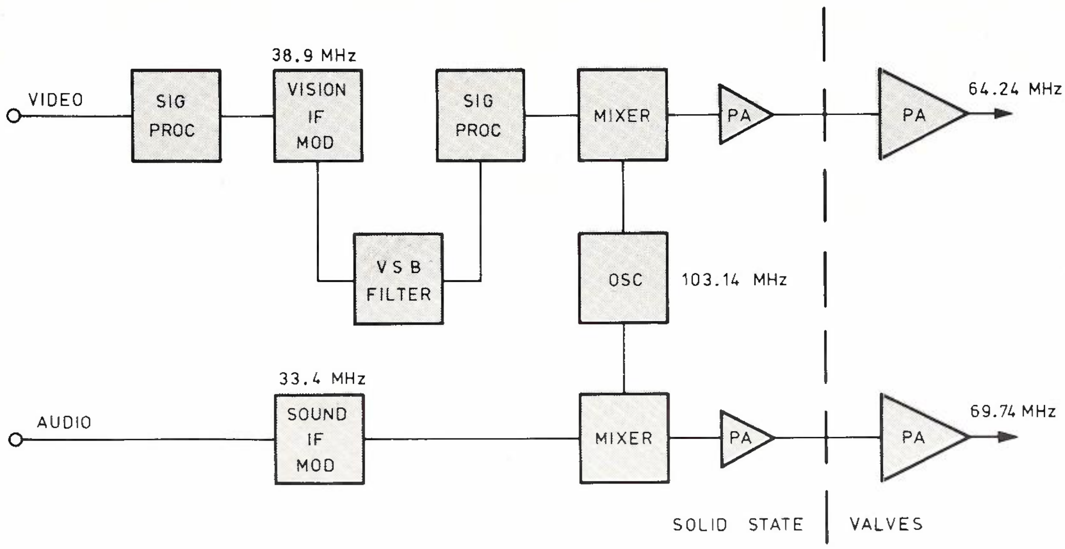

Fig. 4 — Block Diagram of Intermediate Frequency Modulated Transmitter.

accordance with the latest transmitter design philosophy. The principal advantage of IF modulation is that signal processing can be done at low level both before and after modulation. This enables increased use to be made of physically small and highly reliable components and solid state devices, with the result that complex circuitry of improved performance and stability can be designed without sacrificing overall transmitter reliability. A typical modern IF modulated vision transmitter with associated sound transmitter, such as shown in block diagram form in Fig. 4, employs only three electron tubes. Detail of such transmitters is described by Bartlett (Ref. 4) and by Ohshima, Sakai and Higashi (Ref. 5).

The new transmitters are arranged in parallel pairs of both vision and sound transmitters, with all units in operation simultaneously. This configuration avoids interruption to the service in the event of failure of one transmitter and is now standard at all high power National transmitting stations.

Converted Transmitters

From Table 1 it can be seen that the majority of high power transmitters in the National Service were capable of conversion to colour operation, but considerable detailed investigation and redesign of circuitry would be necessary. Although the monochrome transmitters to be converted have been supplied by various manufacturers, it is found that there are common limitations and problems experienced in converting these to colour operation. The components of transmitters in which problems occur and the solutions adopted are as follows:

Modulator

The monochrome modulators used in the medium and high level modulated transmitters in the National Service were unable to satisfactorily handle colour signals without considerable modification. The deficiencies were inter-related and were evident to differing degrees depending upon the transmitter design. They occur in four main areas.

Firstly, the modulators were unable to produce a sufficient output voltage to modulate the transmitter to the lower carrier levels required in colour operation.

Secondly, the requirement in colour operation for modulation by high amplitude high frequency chrominance signals causes modulator output stages and their power supplies to suffer overloading and excessive heat dissipation in their attempts to produce sufficient reactive current to drive the capacitive load presented by the modulated amplifier stage. The modulator in the transmitters supplied by the main Australian manufacturer was a well integrated design for monochrome signals and all the above problems were evident on colour signals. The modification proposals prepared by the manufacturer overcame these by increasing the supply voltage to the final modulator stages and replacing the output stage valves with types of increased dissipation rating, supported by power supplies of higher capacity. The overseas transmitters were found to have a greater margin in their design with the result that a small increase in the gain of an early amplifier stage overcame the modulation depth limitation and only in the case of the Japanese transmitter was it necessary to overcome an output stage overheating problem by means of a replacement valve with increased dissipation rating. Achievement of modulation depths below 5% of the carrier level at the peak of synchronising pulses is dependent on the condition of modulator valves and on careful setting up to prevent grid current caused by any excessive amplifier input voltages from introducing counter-acting black level shifts. The performance defects arising from being unable to modulate below 5% are not frequent or serious enough to justify the more extensive modulator changes that would be required to ensure this could always be achieved, particularly in the case of the overseas transmitters.

The third deficiency in all the monochrome modulators used in the National Service was that the back porch clamping circuits caused interference to the colour synchronising burst which is located on the back porch of the colour signal. The most common method of avoiding this interference, and the method adopted by the main Australian supplier in their modulator modification, is the insertion of a rejection filter at colour sub-carrier frequency to isolate the effects of the clamp circuits at colour frequencies. This method does not entirely eliminate disturbance to the burst information and two alternative methods are bing tested for use on other modulators. The first alternative method is the insertion of a resistor rather than a tuned filter in the clamp line. This removal of reactive elements minimises disturbance to the burst information by only at the expense of clamp efficiency. The second alternative method is the timing of the clamp pulse on the small portion of the back porch not occupied by the burst. In concept this is the superior method as complete independence is obtained between clamp operation and the burst, but complex circuitry is required to ensure that the clamp pulse is correctly positioned, particularly during the field blanking interval, and to ensure continued correct operation of blanking level feedback systems.

The fourth deficiency requiring alteration in monochrome modulators was in the operation of signal processing circuits designed to compensate for non-linearity of the modulation characteristic and limiting circuits designed to prevent excessive signal amplitudes. Synchronising pulse stretching circuits operating on a "stretch and clip" basis interfere with chrominance information extending beyond the black level and they were modified so as to operate only at luminance frequencies. Peak white clipping circuits were similarly modified to avoid interference with chrominance information extending beyond white level. Other linearity correction circuits found in monochrome modulators do not provide adequate correction at chrominance frequencies over the increased range of picture information found in a colour signal, and they make no provision for differential phase correction which is necessary with colour operation. Therefore they were supplemented at the modulator input by a colour correction unit providing a full range of signal processing facilities. There is evidence that in some monochrome modulators the existing correction circuits introduce differential phase errors or are difficult to set up in conjunction with the colour correction unit. If this is confirmed all signal processing circuits will be removed from operation and all correction performed by the colour correction unit.

This process of off-setting errors in one part of the equipment by introducing compensatory errors in another part directly affects the long term stability of the overall equipment performance and has implications for the operation and maintenance of the station. This aspect will be carefully watched as experience is gained with converted stations.

Filterplexer and Other Coaxial Components

All medium and high level modulated monochrome transmitters are equipped with filterplexers to provide vestigal sideband shaping and to combine the output of the vision transmitter with the associated sound transmitter. The outputs of each of the vision/sound transmitters are further combined and connected to the aerial system by various coaxial components such as diplexers and switching frames. The filterplexers supplied with the monochrome transmitters do not offer the same level and stability of performance of parameters such as in-band insertion loss and return loss as do more recently available filterplexers. In addition the design does not reflect such colour requirements as the suppression of the colour sub-carrier image frequency to avoid spurious out-of-band radiation, and adequate cross-insertion loss between the sound and vision input ports which guards against the production of a visible 1.07 Mhz component in the transmitted signal from inter-modulation between the sound and colour sub-carrier. An evaluation program involving measurement of individual filterplexer characteristics was commenced which included measurements on the transmitter-filterplexer combination in those cases where the filterplexer characteristics varied from those obtainable from a replacement unit. The aim was to determine those transmitters where the filterplexer represented the limiting factor in achieving satisfactory stable colour performance. These measurements showed that the in-band insertion loss of the monochrome filterplexers does not vary outside 0.5 dB across the band and does not jeopardise the power-bandwidth performance of the transmitter-filterplexer combination. The out-of-band insertion loss was generally satisfactory but in some cases an additional coaxial notch filter is required to suppress the colour sub-carrier image frequency to better than 60 dB below peak carrier. The filterplexer cross insertion loss was found to be of the order of 30 dB and measurements with both vision and sound transmitters in operation showed that the 1.07 Mhz product is over 60 dB below peak vision power which is satisfactory. The return loss of the existing filterplexers was found to be worse in some part of the band than the 40 dB to be expected in filterplexers of the new design, with deteriorations in some cases of down to 25 dB at the high end of the band. In this situation the overall transmitter-filterplexer frequency response was examined to assess the presence and position of variations caused by changes in the filterplexer input impedance. In some cases these variations improve the overall response by providing a lift at the high end of the band which can compensate for the minor insertion loss deficiencies in the filterplexer. In other cases the variations act the opposite way and degrade the response at the high end of the band or introduce mid-band disturbances. These variations are usually rapid in terms of frequency and cannot be off-set by normal transmitter tuning adjustment without seriously affecting the power-bandwidth performance. When this occurs the only scope for improvement lies in the addition of matching elements between the filterplexer and the transmitter.

If the overall frequency response of the transmitter filterplexer combination could be made satisfactory, notwithstanding the filterplexer return loss, then the existing filterplexer was not replaced, as the influence of the return loss upon other parameters is marginal as argued by Blair (Ref. 6).

It was found that fewer than 10% of the filterplexers in the National Service monochrome transmitters needed to be replaced as an essential part of the colour conversion work. Where this was done the associated coaxial components were also replaced.

TRANSLATORS

The key factor in the performance of translators with colour signals is the linearity of the common amplifiers which handle vision signals including colour sub-carrier and sound signals. The most critical measure of this linearity is the level of the 1.07 MHz intermodulation product for which a level of 50 dB below peak vision carrier level is required.

An evaluation programme was commenced to assess the level of this intermodulation product for each type of translator used in the National Service. Most translators proved satisfactory for colour operations although in some cases it was necessary to improve the performance by a minor adjustment of the amplifier operating conditions.

ANTENNA SYSTEMS

The antenna systems installed in the National Service seek to achieve a reflection coefficient of the antenna input of 1.5% at vision carrier tapering to approximately 3.0% and 5.0% at the lower and upper band limits respectively. This requirement was developed from original work by the BBC and includes a consideration of colour signals. Installed antenna systems meet this requirement with only a few marginal exceptions and it is not expected to replace any antenna systems solely for colour performance reasons. An investigation programme was undertaken to ensure that the antenna systems had not deteriorated in performance since installation.

STUDIO-TRANSMITTER DIRECT LINK

Direct studio-transmitter links using microwave radio systems are installed at the capital city stations in Melbourne, Brisbane, Adelaide, Perth and Hobart. These systems were installed in the period 1956-1960 and the equipment is obsolete in design with unsatisfactory colour performance and presents an excessive maintenance requirement. All links were therefore replaced with modern equipment.

ANCILLIARY EQUIPMENT

The majority of the ancilliary vision equipment at the main National Stations was replaced with modern solid state units designed for colour operation. Equipment replaced includes video distribution and clamping amplifiers, stabilising amplifiers, video switches, waveform and picture monitors, monitoring receivers, synchronising pulse generators and test signal generators. Specialised colour television equipment being supplied includes a test pattern generator and encoder.

COSTS

The costs associated with the colour conversion of the National Television Service transmitter stations are summarised in Table 2.

TABLE 2 — ESTIMATED TRANSMITTING STATION CONVERSION COSTS

Conversion Work	Estimated Final Cost $M
Complete replacement of transmitters and translators	1.2
Modification and partial replacement of transmitters and translators	1.7
Replacement of aerial systems	—
Replacement of studio transmitter direct links	0.3
Replacement of ancilliary equipment	2.5
Total	5.7

STATION EQUIPMENT CONFIGURATION

The increased availability of solid state equipment of high reliability has enabled the configuration of station facilities, particularly in the programme input equipment area, to be progressively simplified over a period of time from that adopted when the major stations were established. A simplified block diagram of the configuration now adopted at a typical converted station is shown in Fig. 5.

PROGRESS AT 1 MARCH, 1975

By 7 October, 1974, progress with conversion work had reached the stage where colour test transmissions were introduced from capital city stations. These test transmissions were subsequently extended to all National television stations and associated translators. These test transmissions which involved test patterns and programme material, proved most effective in enabling available resources to be directed towards the conversion of those aspects of each item of equipment causing the most visible performance deficiencies. By this means it was possible for all National stations to commence regular colour services at a subjectively acceptable level on the official 'C-Day' of 1 March, 1975.

Following this date, the conversion work as planned continued at the majority of regional stations. Completion of this work ensures that the

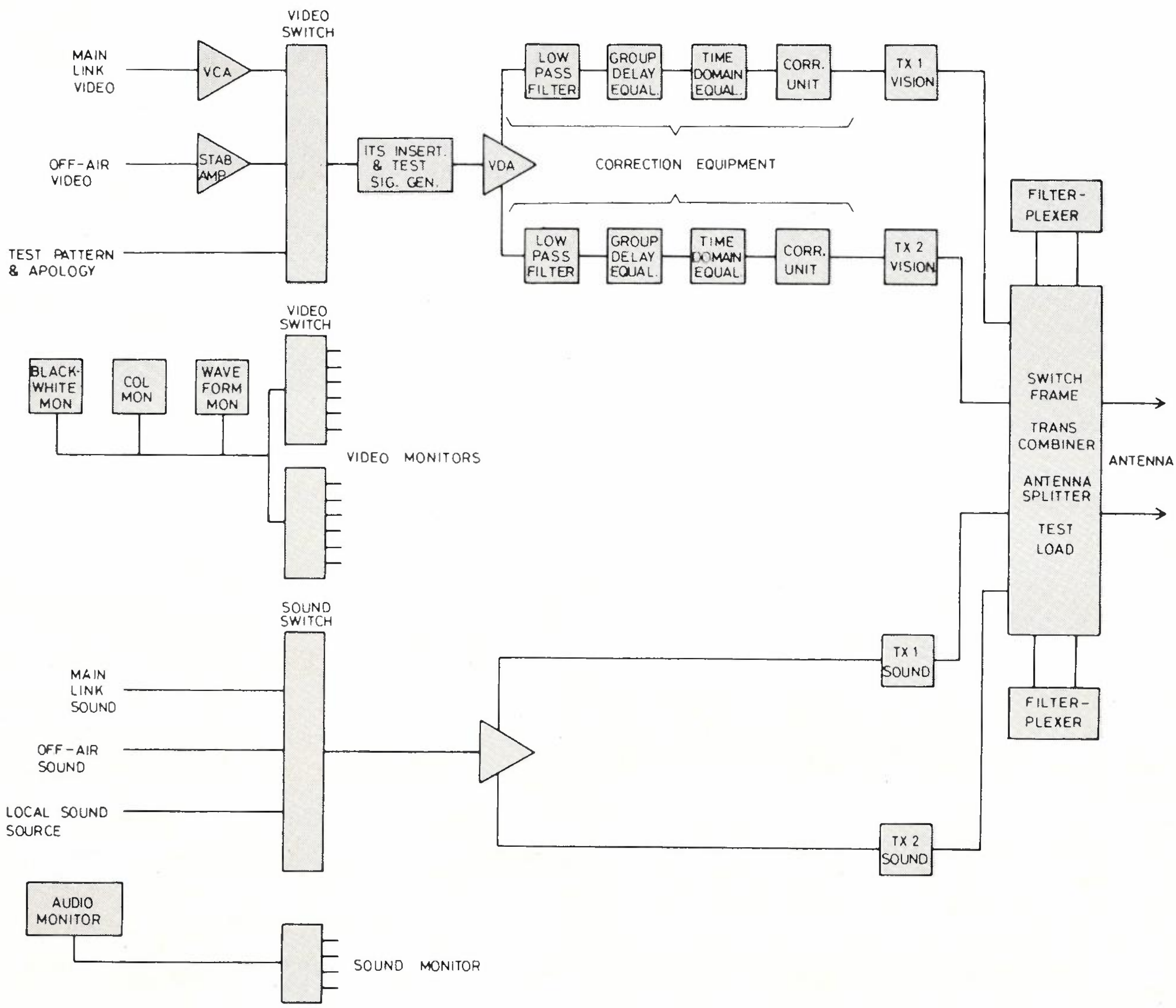

Fig. 5 — Simplified Diagram of Facilities at Typical Converted Station.

stations fully comply with transmission standards and are adequately equipped with the operating testing and monitoring facilities for reliable long term colour operation. Over 75% of stations were fully converted by the end of 1975.

EVALUATION TESTS ON ORIGINAL HOBART TRANSMITTER

The original transmitter at ABT2 Hobart comprised a 5 kW modulated amplifier stage driving a 22 kW linear amplifier stage. In the event of the failure of the 22 kW final stage, the output of the 5 kW modulated stage could be connected to the antenna system directly. This allowed programme to be maintained on low power.

The effect of this arrangement on evaluation work was that testing had to be carried out after close down each night and yet the transmitter had to be ready for operation by the following morning. Also, any work involving existing circuitry was lengthened because any unsuccessful modifications had to be removed before the morning. Overall tests were carried out from the input of the transmitter through all the stages in their normal configuration through the filterplexer into a precision dummy load. It was found that high amplitude high frequency signals suffered serious crushing to less than one half correct amplitude. Work was then undertaken to determine which particular sections of the transmitter were causing the distortion and to see if the performance could be improved. This was done by examining the performance at the output of the 5 kW modulated stage with the stage terminated in a precision load. It was found that serious signal degradations occurred, with the response to high amplitude, high frequency signals being 4 dB down to 5 MHz above vision carrier. This could not be improved by transmitter retuning.

The performance at the output of that stage is shown in Table 3.

TABLE 3 — COLOUR PERFORMANCE OF ORIGINAL HOBART TRANSMITTER

Test	5kW Mod. Stage	22kW Lin. Stage	Overall	Spec.
Chrominance/ Luminance Inequalities				
Gain	—5dB	—4dB	—8dB	—0.8dB
Phase	—100nS	—70nS	—	—30nS
Differential Gain	28%	35%	—	5%
Differential Phase	4°	4°	—	5°
Chrominance Non-Linearity	42%	60%	—	7%

With the 5 kW modulated stage driving the 22 kW linear stage terminated in a precision load, it was found that the high frequency performance of the 5kW modulated stage was further degraded. This was due to the loading from the 22 kW stage input and arose from poor matching of impedances between the output of the first stage and input of the next. No tuning adjustments were provided for interstage matching. The only way to set-up the two stages was to tune them as a pair. This was done and a further set of measurements were made and the results are also shown in Table 3. The performance although improved slightly at the high frequency end of the band was still not satisfactory. The differential gain had further deteriorated. With the output of the linear stage connected through the filterplexer the response was further degraded at high frequencies as shown in Table 3.

The inadequate power capability at high frequency is a basic characteristic of the original transmitter and could not be overcome without extensive modification.

INSTALLATION WORK AT HOBART

The paramount problem at all stages of the installation work was the essential requirement to keep the existing equipment operational so as to maintain service. This problem effected both the decision as to where to locate the new transmitter equipment and the sequence in which the new equipment installation was to take place.

Location

The transmitter hall at Hobart has a floor area of 300 square metres. However, location of the new equipment was restricted to a relatively small portion of the floor area for the following reasons:

- It was preferable to maintan a similar equipment/building configuration to that existing.
- The switching frame of the new transmitter had to be near to the existing antenna feeder entry point.
- The new equipment could not be located so close to the existing transmitter as to prevent maintenance access.
- It was necessary to have suitable accommodation directly under the transmitter for forced air cooling equipment.
- Any holes that were required in the floor had to avoid the lattice of floor supporting beams.
- Any new rigid coaxial feeders, air ducting or cables had to avoid existing feeders, ducting or cables.

Fig. 6 shows the arrangement adopted. The new transmitter suite is located parallel to and behind the original transmitter. They were spaced apart

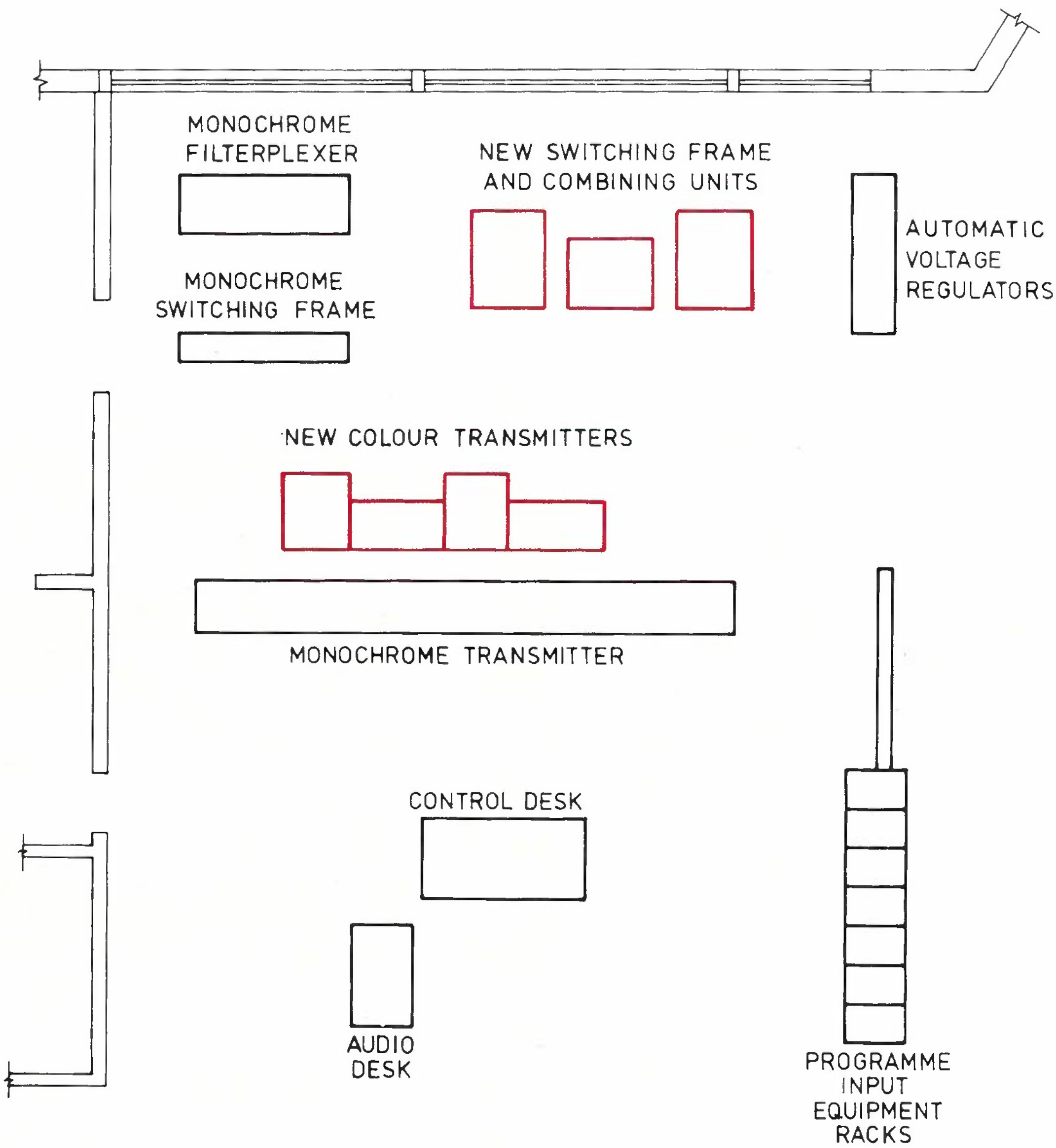

Fig. 6 — Layout of ABT-2 Hobart.

in such a way that the rear doors on the original transmitter could be opened for maintenance access and the front doors and panels on the new transmitter could be opened or removed for installation access. Fig. 6 also gives an appreciation of the reduction in size of the new transmitter units in comparision with the original 15 year old transmitter.

Fig. 7 shows the arrangement at the rear of the original transmitters. The temporary repositioning of the transformers seen to the right of Fig. 7 provided space at the rear of the new transmitters for the new combining units and switching frame. This satisfied the requirement of having the new switching frame close to the area of the old one in order to gain access to the main antenna feeders.

The basment area under the new transmitter was clear of any other air ducting or equipment and no problems were met in locating air blowers directly under the power amplifier cabinets. Fortunately the new positioning allowed for holes to be cut for air ducting and cables without fouling the floor beams. The only spatial problem to arise was that an original set of rigid coaxial feeders passed over the new transmitters and would foul the air cooling ducts above one unit. The location of the feed-

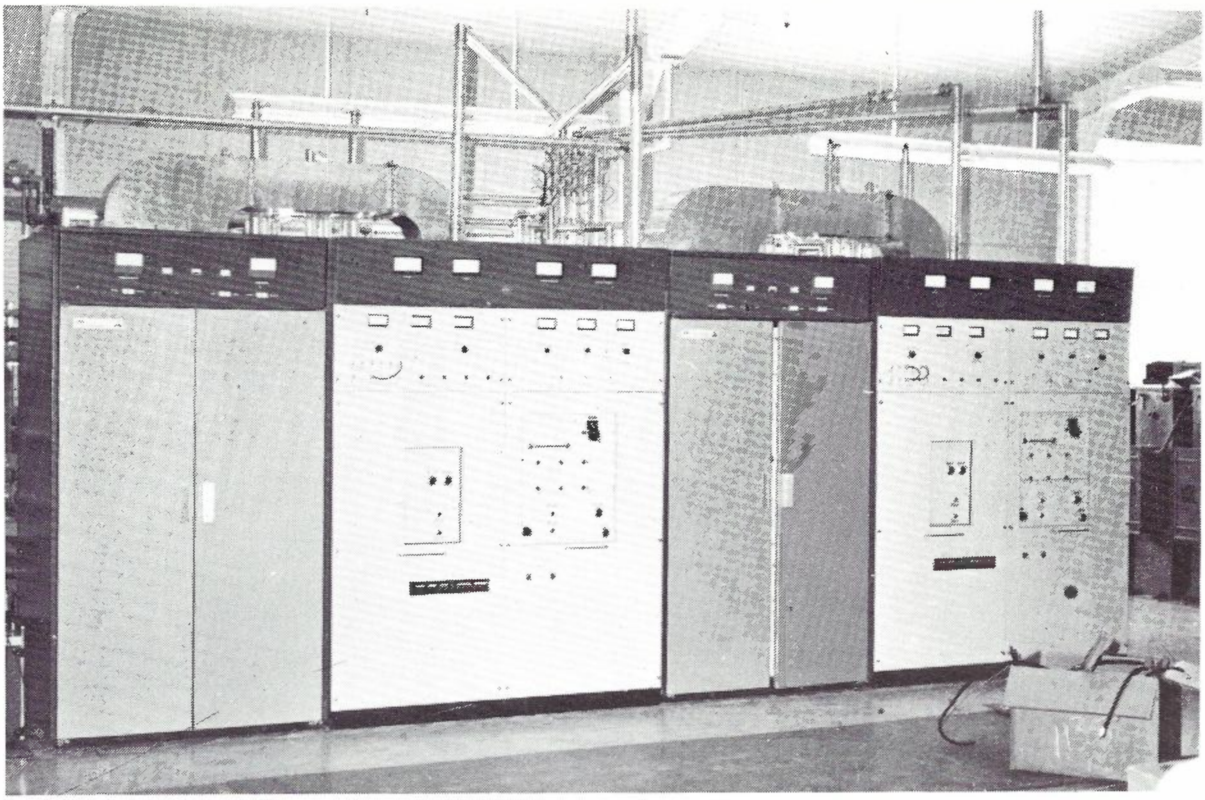

Fig. 7 — Arrangement of Rear of Original Transmitter.

ers can be seen in Figure 7. On closer inspection, it was found that only the bottom pair of feeders would foul the air duct. The bottom two feeders are only used for testing either the sound or vision transmitters into dummy load, without the filter-plexer. Consequently removal of the bottom pair, during the final stages of installation, would only reduce the test facilities of the original transmitter for a short period.

Sequence

It was first necessary to clear the area that the new transmitters and associated equipment would finally occupy. A large portion was already clear as can be seen from Figure 7. However it was necessary to relocate the original power supply components away from the area to be occupied by new frames. It was fortunate that most of the original power supply leads were too long and had been folded back in the cable trunking under the floor. This allowed transformers and chokes to be moved without extensive recabling. The rearrangement was carried out after programme hours and the power requirements were checked and tested before programme the following morning.

Holes were cut in the floor prior to the delivery of the transmitter equipment. The floor thickness is 152 mm (6 inches) and diamond drills were employed. The inevitable hidden conduit was hit by the drilling, successfully extinguishing the whole of the basement lighting system.

It was decided that the new transmitter furthest from the original feeders would be installed first. The second one would then be put in position and when the time was reached for air to be supplied to the second unit the two lower feeders would be removed. This sequence provided a margin of safety in that if a failure in the original monochrome transmitter required it to be tested into dummy load, there would be one of the new transmitters that could be put to air with programme while the two test feeders were being replaced.

Transmission

At the correct stage in the installation, it was necessary to connect the new transmitters to the antenna system. The final arrangement was to connect the main external antenna feeders via suitable reducers to the $2\frac{1}{8}$ in. rigid coaxial feeder used from the new switching frame. The mono-

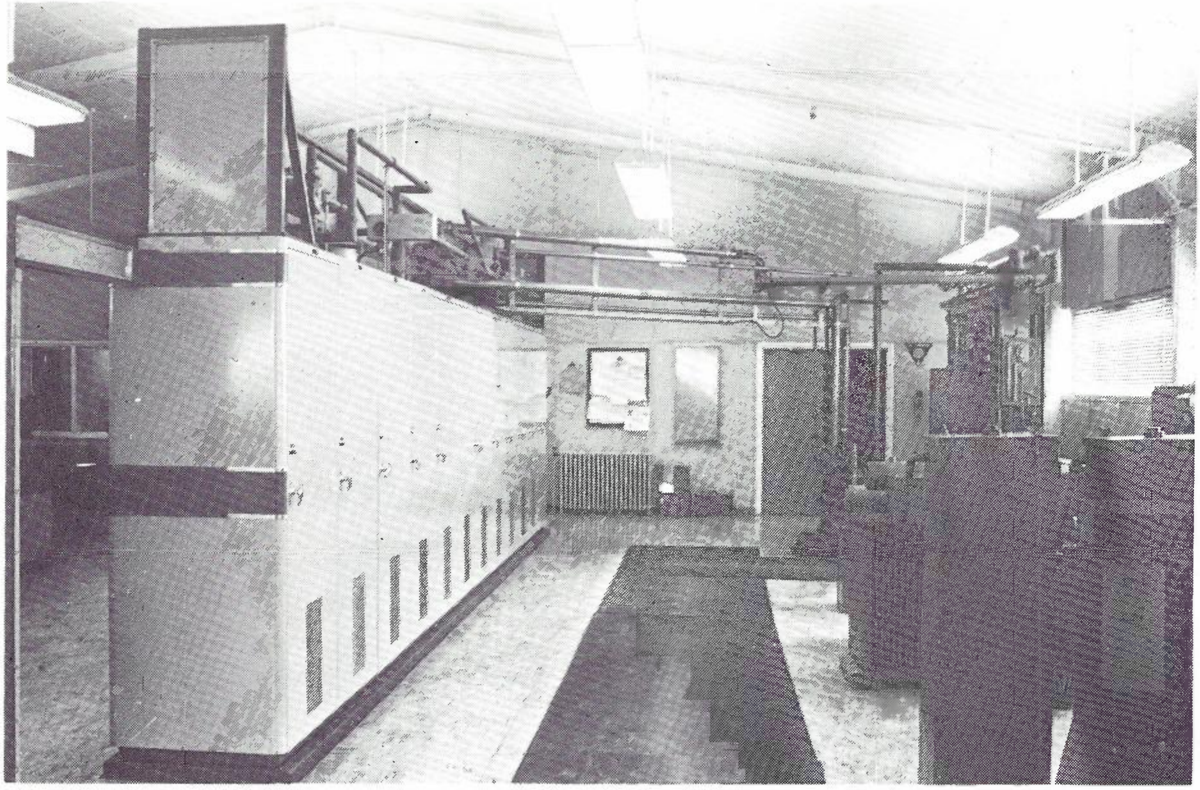

Fig. 8 — New Colour Transmitter at Hobart.

chrome transmitter was connected by $3\frac{1}{8}$ in. rigid feeder to the main external feeder via a switching frame, which contained several electrically operated coaxial switches. This arrangement enabled the output from the monochrome filterplexer to be connected to:

- Dummy Load
- Both halves of the antenna via a power divider.
- Upper antenna only
- Lower antenna only

The new switching frame provides the same facilities but was not brought into full use until the two transmitters had been completely tested and the main antenna feeders connected to the $2\frac{1}{8}$ in. feeder. It was however, advantageous to retain the antenna splitting facilities, in case of a fault. An electrically driven coaxial switch was located in series with the feed from the monochrome filterplexer, for use as a 'change over' switch between the monochrome and colour installations, whilst maintaining full antenna switching flexibility. The main purpose of the changeover facility was to enable the new colour installation, 10kW at first, to be put to air for trade test transmissions of colour test pattern. Normal monochrome programmes were then broadcast using the monochrome transmitter whilst work continued on the new colour transmitters. Finally when the colour installation was complete and the permanent connections made to the antenna feeders, the monochrome installation was removed completely, leaving the final arrangement as shown in Fig. 8.

CONCLUSIONS

The National Television Transmitting Stations have been converted to colour operation by the modification of those items of equipment unable to handle the increased transmission demands of colour signals. If the necessary modifications were expensive or the item was becoming a maintenance liability then the item was replaced. This engineering approach was aimed at providing a colour service in compliance with Australian Standards, at minimum cost. Experience with colour operations is expected to show the areas in which there is an opportunity to improve further the standard of the service in both quality and reliability and to reduce the maintenance costs.

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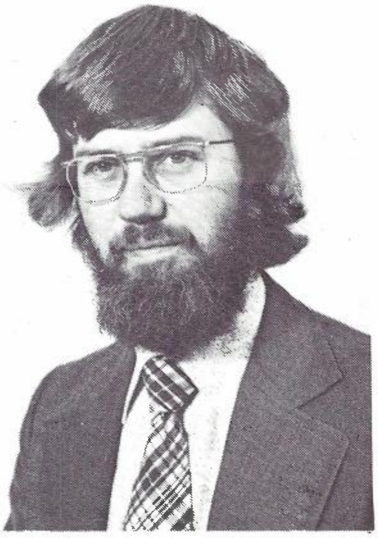

The Long Line Telephone: Telephone 804

W. E. METZENTHEN, F.R.M.I.T., M.E., M.I.R.E.E.

Among the telephones used by the Australian Telecommunications Commission is a special high performance model (Telephone 804) intended for use on high-loss subscribers' lines. The principal features of the telephone are a semiconductor transmitter amplifier with volume limiting and a precision plug-in balance network for sidetone control.

This paper gives some of the background of the development of the telephone and discusses the principles of some of the circuit techniques used. Some aspects of the performance of the telephone are described and some of the restrictions which must be placed on its use are mentioned.

INTRODUCTION

In telephone networks a large amount of capital is invested in cables, and there is always interest in ways of reducing this investment without degrading the performance of the network. From time to time, devices or systems which might be used to reduce this expenditure (e.g., by allowing cheaper cables to be used) are proposed but most are rejected because problems related to technology or integration into the telephone network increase their overall cost.

In the middle 1960's the Australian Post Office conducted a computer aided cost analysis of several possible methods of providing longer than average lines at lower cost. This study indicated that of the methods considered, the use of a more sensitive telephone in addition to the standard telephone would be the most effective. Around the same time transistor technology was becoming "mature", i.e., reliable, cheap, high performance devices were becoming available and knowledge of transistor technology was becoming established at all levels of the electronics industry. The time was ripe for the development of an effective amplified telephone.

Subsequently, a project to develop a sensitive (or "long line" because longer lines of a given gauge would be possible) telephone was commenced. The telephone would be used principally with loaded cables and achieve its cost saving by allowing the use of lighter gauge cables and avoiding the use of open-wire lines. The largest savings would occur in rural areas. Total savings in excess of $2M per annum were estimated with a requirement of around 2,500 long line telephones per annum.

Some time after the development project had commenced a description of a broadly similar Japanese telephone was published (Ref. 1), indicating that at least one other administration was aware of the cost saving potential of this type of telephone.

THE LONG LINE TELEPHONE PROJECT

The basic purpose of the new telephone was to extend existing subscriber line loss limits while retaining the existing order of local system sensitivity. A nominal target set for the performance of the telephone was that limit transmission performance should occur on a line having a loss of about 6dB greater than that of a limit line using standard telephone. To explore means of coping with the sidetone problem resulting from such an increase in telephone sensitivity, the project commenced with the development of two fundamentally different prototype versions of the long line telephone. One version used a compromise sidetone balance network, an amplified transmitter and an attenuator in the receiving path, the attenuation of which was controlled by the transmitter signal level. The other version incorporated an amplified transmitter and several balance networks, any one of which could be selected via a switch in the base of the prototype telephone. After a series of objective and subjective tests, the second version was selected as being more satisfactory. The

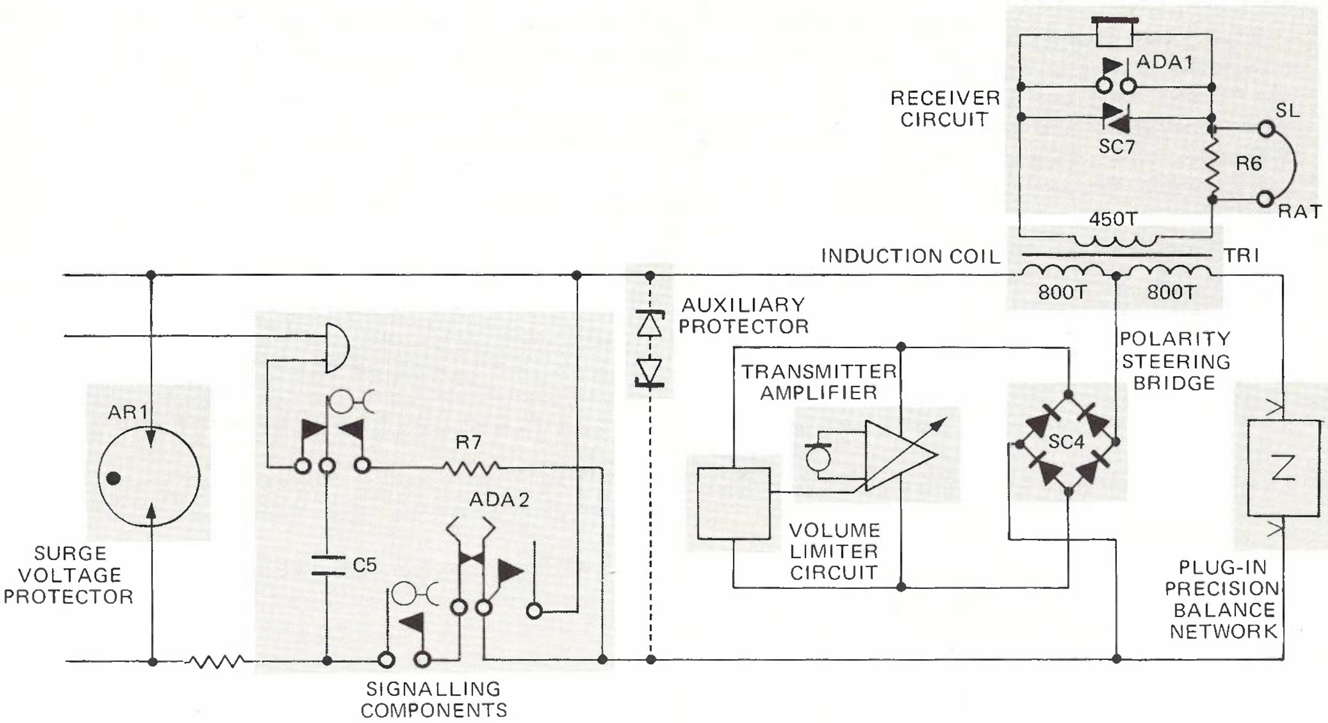

Fig. 1 — Telephone 804 Block Schematic

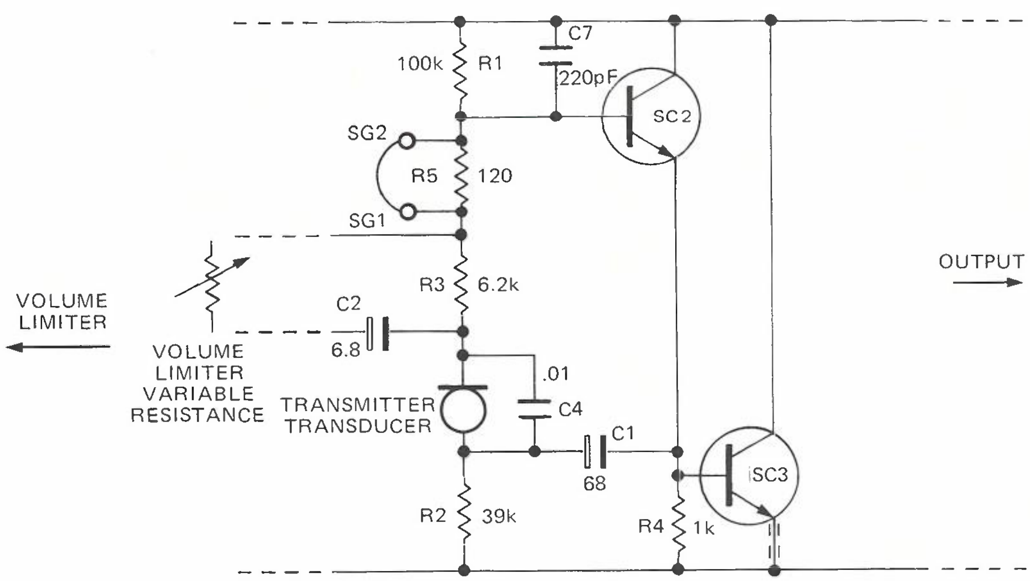

Fig. 2 — Transmitter Amplifier

principles used in this telephone were then embodied in a design for field use.

After some changes were made, such as from a switched to plug-in balance network, the design was "frozen" and one hundred of the telephones were constructed and used in a field trial. The telephones were installed in two areas (Mildura and Armidale/Tamworth) which were selected for such factors as the availability of suitable staff to conduct the field trial and a high lightning-induced damage risk. During the field trial further effort was put into the design of the balance networks and minor improvements to the circuit. Information fed back from the field trial was valuable in this process. By the time the field trial had concluded, the design of the telephone had advanced to the stage where it was considered suitable for manufacture as the long line telephone, "Telephone 804".

TELEPHONE 804

General Description

Telephone 804 is a conventional two-wire handset telephone, indistinguishable in external appearance from the Telephone 802 general purpose telephone (Ref. 2). (It utilises the same case, handset, receiver transducer, connecting cord and plug, dial and calling unit). To simplify maintenance and reconditioning procedures, etc., it is largely an adaption of readily available components and therefore an acceptable rather than an optimum design has been achieved.

Telephone 804 (Fig. 2) features a transmit circuit employing a discrete-component solid-state amplifier powered from the line current and a passive receive circuit. Satisfactory control of sidetone, level to line, received level, echo, and crosstalk are achieved through a combination of measures. These include the use of plug-in precision sidetone balance networks, provision for send and receive sensitivity adjustment by means of removable links and a transmit volume limiting circuit. There are also restrictions on the types of lines which may be used, their installation practices and their minimum loss. In addition, the types of telephone service which can be provided are restricted.

For the longer lines where the line loop resistance may exceed the exchange signalling limit, a dc signalling extender (installed in the telephone exchange) is used in conjunction with the telephone.

Receiving

Most telephones have a speech circuit consisting of a transmitter, a receiver and a passive circuit which is designed to couple the transmitter and receiver to the line but not to each other. Some form of balancing network is an essential part of these circuits. Subject to the usual restrictions of linearity etc., fundamental physical laws dictate that such a (passive) telephone circuit must have losses with power being dissipated in the balancing network. Furthermore if the circuit parameters are adjusted to reduce the losses for sending, then the losses for receiving must increase and vice-versa. A commonly used measure of the degree to which the sending efficiency is favoured is the Y-ratio (Ref. 3). The Y-ratio of Telephone 804 is less than that of the Telephone 802 and although the same type of receiver is used it is selected from normal production for high sensitivity. With these two measures sufficient receiving sensitivity is achieved without recourse to an amplifier.

Sending

The high sending sensitivity required of the telephone dictated that if an available transducer was to be used then amplification was essential. This fact reduced the cost penalty of using a stable, low-distortion transducer (implying low sensitivity, hence requiring an amplifier) instead of the (high sensitivity) carbon type. A rocking armature transducer identical to that used as the receiver was chosen to avoid the difficulties involved in supply and maintenance if a new type of transducer were introduced.

The transmitter amplifier (see Fig. 2) circuit consists of a simple shunt feedback amplifier with an added volume limiter circuit (Fig. 3). The original volume limiter used a half-wave voltage doubler rectifier but this suffered from a deficiency where certain utterances would cause the limiter to overshoot and produce undesirable clicks in the output of the amplifier. A change to the transformer coupled full wave rectifier greatly reduced the problem whilst still allowing the required voltage step-up needed to operate the field effect transistor variable resistance circuit.

The volume limiter is used both to control cable crosstalk with loud talkers by restricting the amplifier output voltage and to ensure that the output does not clip with such signals. The limiter characteristics are shown in Fig. 4. The threshold of gain compression is such that the volume limiter has negligible effect on the transmitting sensitivity with normal talking levels. As indicated by the distortion curve associated with Fig. 4, a 15 dB increase in input level above this threshold is possible before overloading of the transmitter becomes significant.

Because of the feedback used in the amplifier, the sending sensitivity of the telephone is virtually independent of line current. Maximum sensitivity occurs at about 75mA feeding current, dropping by about 0.3 dB at 40 and 110mA, and by about

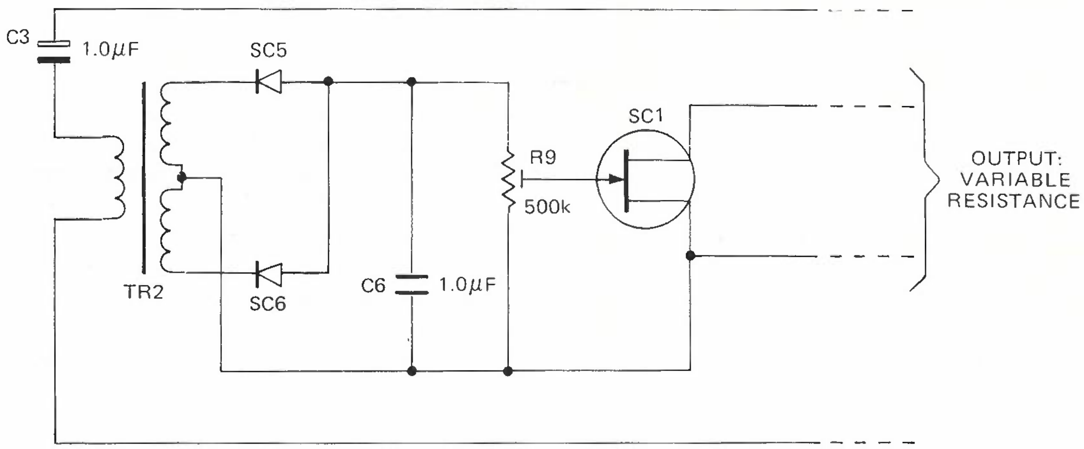

Fig. 3 — Volume Limiter

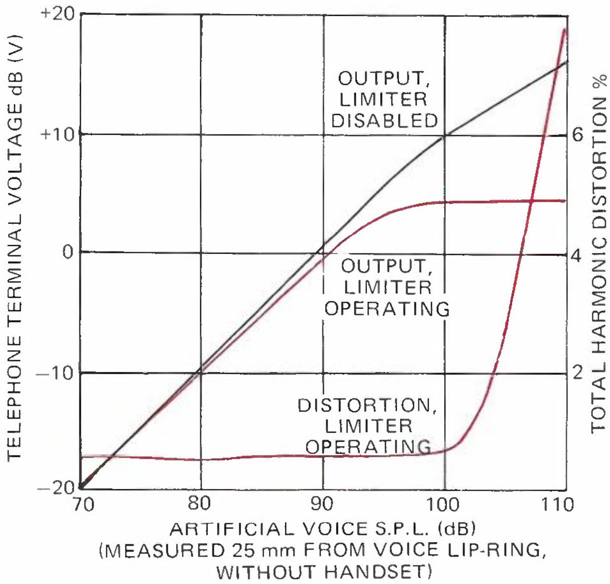

Fig. 4 — Volume Limiter Characteristic (1kHz, typical line conditions)

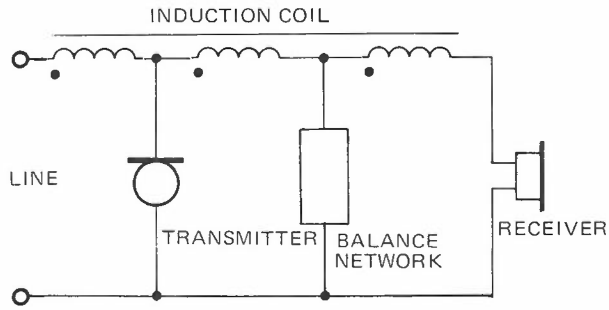

Fig. 5 — Another Type of Induction Coil

0.9 dB at 20mA. An increase in the output impedance of the amplifier can be regarded as the primary cause for the slight drop in sensitivity at low currents.

In common with most other (overseas) telephone transmitter amplifiers, the dc voltage drop of the amplifier in Telephone 804 is largely independent of line current. This characteristic is better than one where the drop is proportional to line current because it ensures that the amplifier has sufficient output swing capability at low line currents whilst not imposing the penalty of very high power dissipation at larger line currents. The dc characteristic of the whole telephone is somewhat similar to that of a constant voltage drop device of 5.6 V in series with a 55 ohm resistor.

Sidetone

The induction coil used in Telephone 804 is a "bridge" type and is somewhat unusual for a modern central battery telephone. The type illustrated in Fig. 5 is more common because it allows the telephone designer more freedom in the choice of Y-ratio and transducer impedances. A similar freedom is available with the bridge type only if an extra matching transformer is used. This means that a telephone using the type of induction coil shown in Fig. 5 will usually be cheaper (particularly if a low resistance carbon transmitter is used). However, it was found in the early stages of the development of the long line telephone that with this type of induction coil it is inherently more difficult to achieve a sidetone balance of the required precision (a similar observation is made in Ref. 1). Hence the bridge type of coil is used, and the 800 turn windings (Fig. 1) are bifilar wound thus ensuring that the contribution of the induction coil to any sidetone circuit imbalance is negligible.

A combination of further measures is used to ensure adequate sidetone control. Operation on short, low-loss lines is not permitted, so that regardless of the terminating impedance offered at the local exchange, the telephone tends to see an approximation to the characteristic impedance of the line. The lowest loss line on which this telephone may be used has a loss only slightly lower than the maximum loss line permitted for the standard (801/802) telephone.

Also, a plug-in balance network is used which is selected to suit the subscriber's line. Each balance network was designed as a compromise to give a high degree of sidetone suppression over a range of the longer lengths of the particular line for which it was intended, with the line terminated at the exchange end by either a 600 Ω or 1200 Ω resistive impedance. (These impedances were chosen to represent a junction link provided by either a carrier system or a loaded cable, respectively, and ensured that reasonable sidetone suppression was obtained over a range of possible exchange impedances). In addition, the balance networks were designed to minimize peaks in the sidetone frequency response and give about equal weight to low and high frequencies, so that the sidetone would sound natural to telephone users.

A tester containing nine different balance networks (all for unloaded cables), a noise source and an ac millivoltmeter was developed and used in the field trial of the long line telephone. It was used to select the balance network which gave the best sidetone at each installation. Although the tester generally worked satisfactorily it was later decided to restrict the number of different balance networks which are required, by specifying strict rules for the techniques (mixed gauges, lead-in cables, cable tees, etc.) which can be used in the provision of the subscribers' line. If these rules are complied with, the correct balance network is easily predicted and a tester is no longer necessary.

For loaded cable, relatively accurate building-out of the line capacitance of the last (subscriber end) loading section must be used. The capacitance is built-out to a full section (1830 metres) from the last loading coil, thus it is never necessary to include a loading coil in the building-out network. The balance network used for loaded cable (Fig. 6) necessarily incorporates an inductor in addition to the usual resistors and capacitors. The balance networks for unloaded cables are similar but with L1 and C4 replaced by a resistor.

By removing two internal straps (see Fig. 1 and 2) the sending and receiving sensitivities can each be reduced by about 3dB, thus reducing the sidetone level by about 6 dB on lower-loss subscriber lines.

In early experimental versions of the telephone the polarity steering bridge was placed nearer the line terminals, ahead of the induction coil. This had the advantage of allowing electrolytic capacitors to be used in the balance network if large capacitors were needed (e.g., to block dc through the network). It was found however that the non-linear diode impedances degraded the sidetone balance, becoming worse at higher sending levels. Hence the bridge was shifted to its present position.

Sending and Receiving Frequency Responses

The sending and receiving sensitivity versus frequency characteristics are governed by the transducers used. Because the main use of the telephone is with loaded cable, no special measures were taken to compensate for the cable frequency response.

Typical send and receive frequency responses on a long loaded cable are shown in Fig. 7. Although the receive frequency response is quite good, the sending response is only just acceptable. The poor low frequency response is a consequence of using as a transmitter a rocking armature transducer which was designed to be used as a receiver, although the interaction between the transducer impedance and the shunt feedback amplified input does improve the response slightly. This improvement is illustrated (fig. 7) by the poorer low fre-

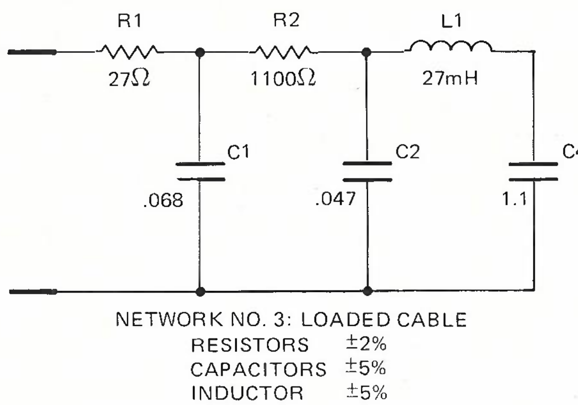

Fig. 6 — Balance Network Example

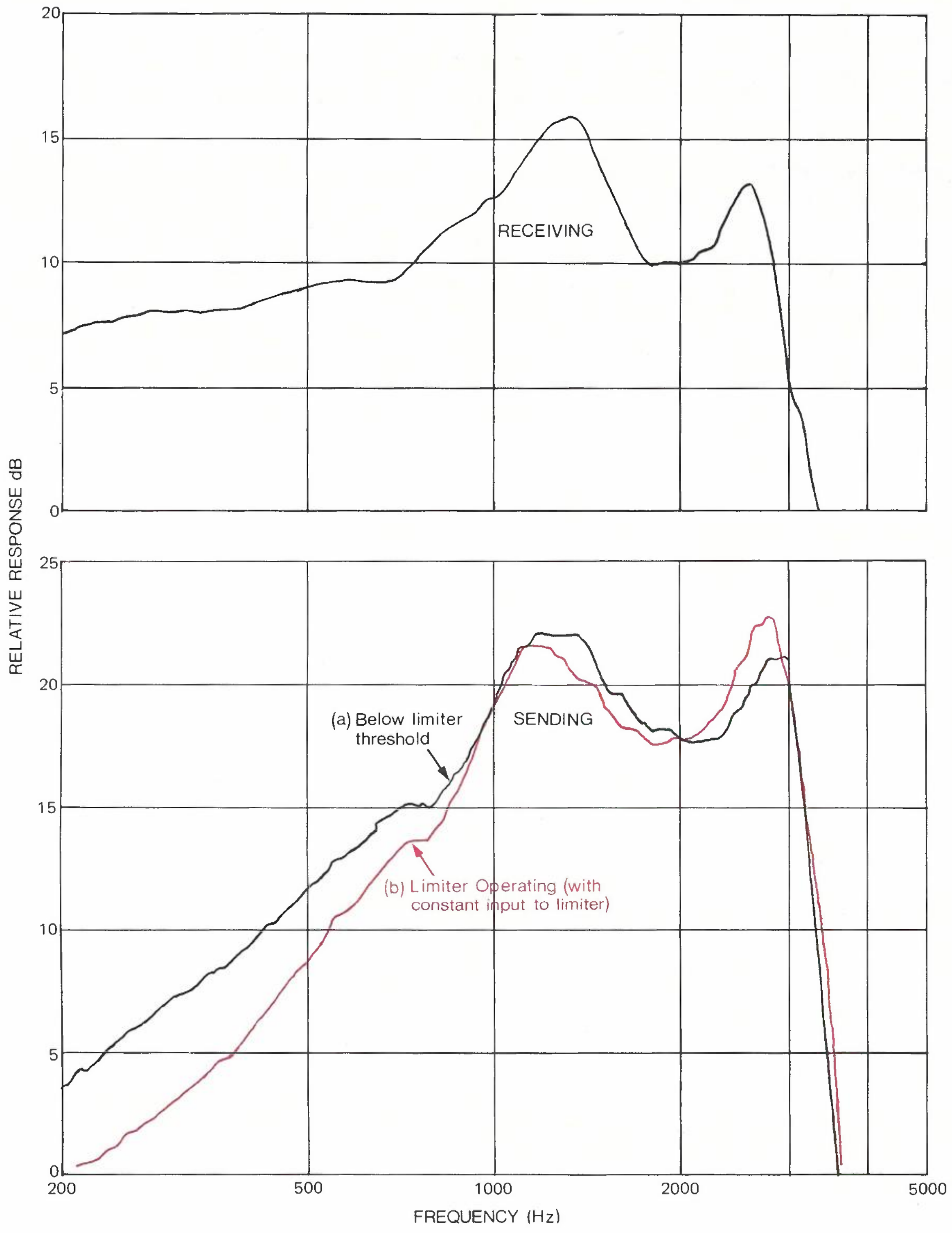

Fig. 7 — Sending and Receiving Frequency Responses (including 39 km. of 0.90 mm Loaded Cable)

quency response which occurs when the limiter operates and swamps the transducer impedance with extra resistance between the transducer and amplifier. The amplifier has insufficient gain to allow the response to be significantly improved by equalization.

Line terminal impedance

With its use restricted to high-loss lines, the line terminal impedance of the telephone is not an important factor determining the return loss at the exchange. This meant that considerations of the line terminal impedance of the telephone had no direct influence on its design. Sending, receiving and sidetone performance were the independent factors and the manner in which satisfactory performance in these was achieved determined the line terminal impedance. It turns out that with a 600 ohm balance network installed in the telephone its impedance essentially rises with frequency and is approximately 500 ohms (angle 20°) at 1 kHz and 600 ohms (resistive) at 3 kHz.

Feed-current sensitivity

As mentioned above, the sending performance of the telephone varies little with line current, for currents between 20 and 110 mA. The line terminal impedance also varies little with line current. The receiving performance is even less affected.

It is common practice to make use of the relationship between line loss and current (via resistance) to make the performance of a telephone plus line virtually independent of line length. To do this the sending and receiving sensitivities of the telephone are made to decrease as the line current increases. This feature is called "automatic regulation" (telephone 802 has this feature). Unfortunately, the relationship between line loss and current depends upon the gauge of cable used and since a variety of cable gauges are normally used a compromise must be accepted. The problem is worst with high loss lines. Automatic regulation is not used in Telephone 804 because this telephone is used only on high loss lines and therefore only a very restricted benefit could be derived, at the cost of increased complexity, price and development time.

Crosstalk

Crosstalk is potentially a serious problem with Telephone 804 because of its high sending and receiving sensitivities. Satisfactory crosstalk is virtually ensured however, by two factors. Firstly, because the telephone is used on lines of higher loss than permitted in the past, it is almost certain that at least the portion of cable nearest the subscriber will be recently installed and therefore have the high crosstalk attenuation of modern cables. These cables have high crosstalk attenuation because the specification for crosstalk attenuation of the plastic cables likely to be used with Telephone 804 was enhanced concurrently with its development. The other contributing factor is that the transmitter volume limiter is set to limit the sending level of unusually loud talkers.

Reference Equivalents

Reference Equivalents are one performance criteria which can be used as the basis for planning the transmission performance of a telephone network. A good discussion of reference equivalents appears in Reference 3.

Basically, a Reference Equivalent is a subjective measure of an aspect of the communication performance of a telephone. Thus there are Sending Reference Equivalents, Receiving Reference Equivalents, etc. Telecom Australia uses the CCITT recommended NOSFER system as one basis for measuring the performance of telephones. With this system a comparision based on loudness is made between an aspect of the performance of a telephone and a corresponding part of a defined reference apparatus. An attenuator in the reference apparatus is varied until loudnesses are judged to be equal. The setting of this attenuator is then called the Reference Equivalent (Sending, Receiving or Sidetone) of the telephone. Thus the greater the Reference Equivalent, the less "loud" is that aspect of the telephone performance.

When the term "Reference Equivalent" is used without a qualifying adjective (apart from "Sending", "Receiving" or "Sidetone") it normally refers to a measurement based upon loudness, rather than other measures such as sound articulation scores.

Telephone 804 is designed to have the following limit Reference Equivalents: Sending + 16 dB maximum; Receiving +3 dB maximum; Sidetone +12 dB (minimum) when connected to maximum loss lines falling to +8 dB (minimum) on minimum loss lines. These figures apply for a telephone having transducers with the minimum permitted sensitivity.

Signalling

The signalling circuit and components of Telephone 804 (Fig. 1) are virtually identical to those of the Telephone 802.

The long (hence high resistance) lines on which the telephone can be used are beyond the limits for looping and dialling of some types of exchange. It is therefore necessary to use some form of signalling extender at the exchange in such cases.

When very long lines are used, e.g. 60 km (of 1.27 mm loaded cable), some problems may be experienced in ringing poorly adjusted bells in the telephone if 50 Hz ringing current is used. No problems should occur with 16 2/3 Hz ringing current.

As mentioned above, capacitance building-out is a necessary feature of using Telephone 804 with loaded cable. The building-out capacitor is placed in a small box underneath the telephone socket and there is therefore very little resistance between the line terminals of the telephone and this capacitor. Resistor R8 (Fig. 1) is included to limit the discharge current from this capacitor thus preventing the serious spark erosion of the dialling contacts which would otherwise occur.

Reliability

Reliability may be a problem with Telephone 804 because of two factors; firstly it contains semiconductors (sometimes derided as fast acting fuses), and secondly it is used on long lines and hence induced high voltages (e.g., from lightning) can be expected to be a greater problem than with other telephones. Some form of protection is therefore necessary.

Following the field trial and a series of laboratory tests it was concluded that a single gaseous arrestor (Fig. 1) was likely to provide the best compromise between cost and reliability. A place has been provided on the circuit board for extra (secondary) protection (the Zener diodes shown in Fig. 1) to be provided if experience indicates that it is necessary. The diodes would work in conjunction with R8.

Interference

In common with most electronic equipment, the telephone is sensitive to interference from electromagnetic fields from radio transmitters, etc. This sensitivity has been reduced to a level which is regarded as acceptable by the inclusion of capacitor C4 (Fig. 2). Doubtless, some situation will exist where this is insufficient and further, ad-hoc measures will be necessary.

Restrictions

Besides the rather basic restrictions mentioned above of maximum and minimum line lengths (to ensure adequate sending, receiving and sidetone performance) there are other restrictions which must be placed on the use of the telephone which restrict the types of service which are provided.

Whilst parallel operation of two of the telephones is possible, if the telephones are used simultaneously then the resulting impedance shunting of each telephone by the other will cause both to have unacceptably high levels of sidetone and weak sending and receiving performance (with respect to the distant subscriber but not to each other, of course). Thus although parallel connection is allowed, subscribers must be advised that simultaneous operation should be avoided.

The relatively high voltage drop required by the transmitter amplifier leads to other problems. For example in one common type of switchboard the operator's circuit, which uses a carbon transmitter, derives its power by being placed across the subscriber's line when the telephonist wishes to talk with the subscriber. In this case Telephone 804 will not draw enough current to ensure its proper operation.

Use of the telephone to solve the problem of a high loss line between a PBX and parent exchange is discouraged. Without treatment of the PBX equipment, inadequate sidetone performance on extension-to-extension calls would be a problem and there would be a large difference between the loudness of internal calls, and those to the rest of the telephone network.

CONCLUSION

A telephone has been developed which will meet transmission performance objectives when used with high loss lines. Where new cables are to be installed it can be used to allow the use of smaller gauge (hence cheaper) cables than would otherwise be used. Alternatively, it can be used with a given cable gauge to provide services which would otherwise not meet performance objectives due to the length of the line. It also allows cable to be used in situations where (relatively expensive) open wire would otherwise be necessary.

Telephone 804 probably has a performance close to the limit which is possible with present cables and an essentially linear, two-wire telephone (excluding techniques such as switching, carrier, etc.). An attempt to design a similar type of telephone to operate on longer lines would soon encounter the problems of higher crosstalk and greater difficulty in achieving adequate sidetone performance. To extend the line attenuation limits by one dB whilst maintaining the same performance requires two dB extra crosstalk attenuation and two dB extra sidetone rejection. The difficulties soon become formidable, with better (more uniform, etc.) cables and more complex installation practices becoming required as well as higher performance in the telephone.

Around the time that the first production run of Telephone 804 was being arranged, a change in policy concerning rural telephone services took place such that demand for the telephone was reduced. Neverthless the telephone is finding significant application in rural areas.

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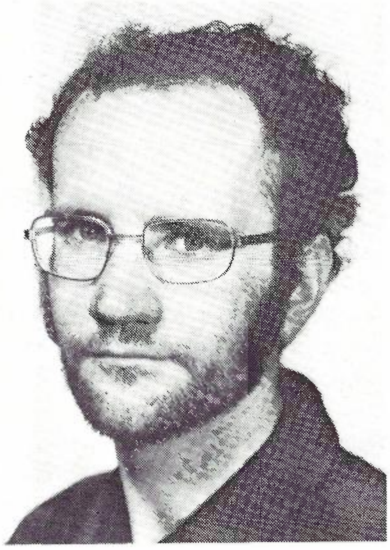
BILL METZENTHEN joined the Telephonometry Division of the Australian Post Office Research Laboratories in 1966 as an Enginner Class 1, after completing a course at the Royal Melbourne Institute of Technology. From late 1968 to early 1970 he studied at the Philips International Institute in Eindhoven, the Netherlands. Returning to the Laboratories in 1970, he became involved in the later stages of the Long Line Telephone project.

He is now a Senior Engineer with the Customer Apparatus Section of the Australian Telecommunications Commission Research Laboratories. Among the projects for which he has responsibility are investigations concerning possible replacements for the carbon transmitter and a study of coding schemes for redundancy in facsimile transmission.



New State Manager, South Australia

Mr. Murray Coleman has been promoted State Manager, Telecom Australia, South Australia.

Mr. Coleman, previously an Assistant Director-General with the former Telecommunications Division at Headquarters, joined the Post Office in 1938 and spent the early part of his career as Telegraphist and Supervisor, mainly in the Chief Telegraph Office, Adelaide. After occupying several administrative positions at Headquarters and the Head Office in Adelaide, he was promoted in 1960 as Superintendent, Telegraph Service Branch in Adelaide. In 1962 he was promoted as Controller, Telegraph Services at Headquarters and later occupied in turn the positions of Deputy Assistant Director General (Service) and Deputy Assistant Director General (Sales).

In recent years Mr. Coleman has represented Australia overseas at a number of International Telecommunications Conferences as a member of the Australian Delegation.

Maintenance Management Performed by NTT

SADAO SAKAMOTO, Maintenance Bureau, Nippon Telegraph & Telephone Public Corporation.

Telecommunications maintenance service currently furnished by NTT has reached an extremely high level. It is believed that the principal factors which contributed to the improvement of this maintenance service are constant actions for improvement taken, such as positive development and introduction of new techniques, establishment of a maintenance control system based upon the quality control method, and the accomplishment of 3-year programs of maintenance affairs.

This article describes how maintenance service is being furnished by NTT and how it has been improved, referring to the measures taken by NTT, such as the introduction of newly developed techniques and a maintenance control system which contributed greatly to the improvement of maintenance service. This article also refers to various matters with which NTT is faced in carrying out maintenance activities and the manner in which NTT will take measures to meet them.

Editorial Note: This article, which appeared in the July 1975 Issue of the Japanese Telecommunications Review, is reprinted by the kind permission of Nippon Telegraph and Telephone Public Corporation. The article should be of interest to many readers, particularly those engaged on service operations work.

The Australian Telecommunications Commission is currently revising the organisation of its service operations work, as mentioned in a recent issue of TJA, and also the methods for managing such work. It is hoped to record the results of this work in future issues of TJA.

INTRODUCTION

As of January 1975, the number of telephone subscribers in Japan exceeded 26 million, a ratio of 26 subscribers per 100 persons. The number of telephone subscribers increased by 13 times compared with 20 years ago, while Japan holds second place, next to the USA, in the number of telephones.

Meanwhile, NTT has positively introduced new techniques developed for the provision of stable and high quality telecommunication service, and has endeavored to improve maintenance service by introducing a maintenance control system in April 1957, which is based on the quality control method. As a result, the maintenance level has risen remarkably year after year, as shown by the fact that maintenance service of subscriber telephones was sufficiently good in 1973 JFY (Japan Fiscal Year) to satisfy the service index in all parts of the country.

This article introduces the present status of NTT's maintenance service and the circumstances which brought about the improvement of this service, referring further to various matters NTT may encounter in performing maintenance affairs.

PRESENT STATUS OF NTT's MAINTENANCE SERVICE

The maintenance service index of NTT is established under a maintenance control system. There are two kinds of indices: one is a maintenance service control value measured by the number of reported troubles or the duration of troubles on subscriber telephones, public telephones, telex, toll dialling calls, television circuits, and leased circuits. The other is extraordinary failures measured by the extent and duration of troubles regarding exceptionally substandard telecommunication service.

The actual status of this maintenance service is set forth below.

Maintenance Service for Subscriber Telephone and Others

Some typical examples of the maintenance service level as of 1973 JFY as shown in Table 1, disclose that, in general, stable and excellent service was being furnished.

TABLE 1 — MAINTENANCE SERVICE LEVEL IN 1973 JFY (EXAMPLE)

Item	Service Control Value	Service Level	Achievement* Percentage (%)	Measured (per month)
Local telephone (Automatic office area)	5	1.0	100	Number of reported troubles per 100 lines
	0.3	0.02	99.1	Number of reported troubles carried over** per 100 lines
Public telephone	10	5.3	99.6	Number of reported troubles per 100 sets
P.B.X.	3.5	0.8	100	Number of reported troubles per 100 telephones
Toll dialling call	0.04	0.003	99.5	Number of reported troubles per 100 lines***
Telex	20	9.5	100	Number of reported troubles per 100 lines
Television circuit	4	0.5	98.7	Duration of reported troubles per circuit (minutes)
Leased circuit (Toll area)	0.3	0.05	99.7	Number of reported troubles per circuit
	15	4.4	97.0	Duration of reported troubles per circuit (minutes)

Note: * Ratio of number of offices or circuits achieving the service control value to the number of overall offices or circuits.
** Trouble reported by 16.00 hours with their clearance carried over the following day.
*** Trouble detected through subscribers' reports.

The number of reported troubles on subscriber telephones at an automatic exchange, for instance, was 5.8 per 100 subscribers per month in average value of overall troubles as of 1960 JFY, as shown in Table 2, but fell below the service standard (5.0 per 100 subscribers per month) in 1963 JFY. Since then, steady improvement has been made in spite of the rise in number of telephones, attaining the value of 1.0 in 1973 JFY. Figuratively speaking, this means that, if trouble was encountered equally by all subscribers, one might occur every 8 years. From this fact it can be said that the service level is extremely good.

Besides, as shown in Figure 1, all the operating offices* achieved the service control value**, reducing, at the same time, fluctuations in service.

Public telephones have also reported a considerable decrease in the number of troubles.

As to the telex, a good maintenance level has been achieved as a result of remarkable improvement of the station equipment, which was responsible for the greater part of the troubles reported.

TABLE 2 — TRANSITION OF LOCAL TELEPHONE TROUBLES (AUTOMATIC OFFICE AREA)

Item	Fiscal Year (JFY)					
	1957	1960	1963	1966	1970	1973
Number of reported troubles (per 100 lines per month)	7.1	5.8	4.8	3.7	1.8	1.0
Achievement percentage (%)	18	40	67	83	99.9	100
Number of subscriber telephones (ten thousands)	151	242	434	753	1,460	2,381

Occurrence of Extraordinary Failures

Telecommunication service has now become a necessity, or something that cannot be done without, not only in national life but also in social activities. Accordingly, even a temporary interruption of telecommunication would cause extreme inconvenience to the public. With these circumstances in mind, NTT, in 1965 JFY, ruled that "troubles causing substandard maintenance service or excessive congestion of telecommunication

* Operating office: office in charge of maintenance of telecommunication facilities.

** Service control value: the standard service value has been changed to the service control value since 1971 JFY (details given later).

TABLE 3 — DESIGNATION OF DURATION AND MEASURE OF "CLASS A" EXTRAORDINARY FAILURES

Department	Degree of Trouble	Duration of Trouble
Local telephone (Local dialling call)	A-1 Inability to place local calls — outgoing or incoming — over 1,000 subscribers per telephone exchange	More than 30 minutes
Toll telephone (Toll dialling call)	A-2 (1) Overall circuit interruption or traffic congestion (probability of loss is greater than one-tenth) — all basic trunks in every circuit section A-2 (2) All common equipment outage and traffic congestion — toll switches of toll switching centre or higher ranking centre (District Centre and Regional Centre) A-3 Inability to place toll calls — outgoing or incoming — over 1,000 subscribers per telephone exchange	More than 30 minutes
Telex and telegraph	A-4 Inability to achieve telex communication — outgoing or incoming — over 1,000 subscribers from total number of subscribers accommodated by telex switching office (including those of telex concentrating office) A-5 Overall circuit outage at telegraph trunks in telegraph transit switching office	More than 30 minutes
Television circuit	A-6 (1) Transmission impossible — signal cannot be transmitted A-6 (2) Wrong programs — undesired program transmitted through misoperation or other causes	More than 10 minutes More than 3 minutes

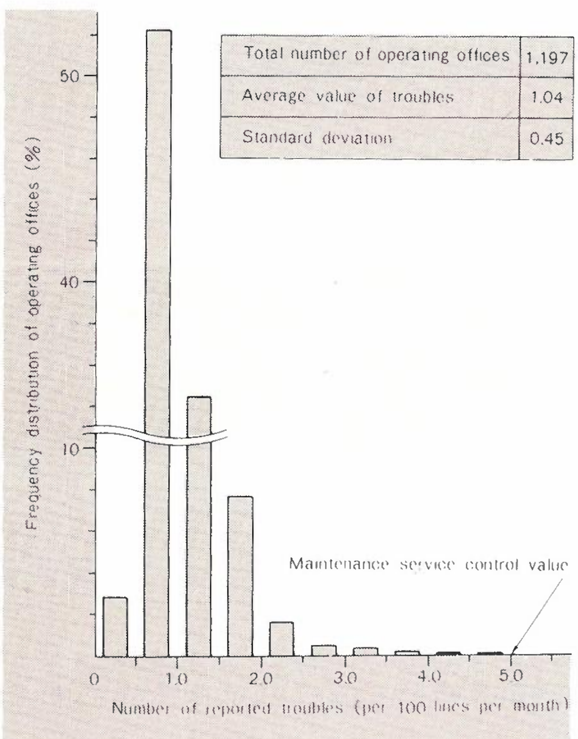


Fig. 1 — Dispersion of Subscriber Telephone Troubles in 1973 JFY.

traffic" was an extraordinary failure. By controlling them separately from ordinary troubles, NTT endeavors to prevent substandard maintenance service and recurrence of trouble through prompt and appropriate action being taken whenever such may occur.

Troubles to be disposed of as extraordinary failures are determined according to the degree of their effect on maintenance service. For instance, a trouble which might significantly damage telecommunication facilities but where the interruption of normal service can be prevented by an instantaneous switch-over to a stand-by system or by taking some other emergency step, does not always fall under the category of extraordinary failure. Extraordinary failures are classified into Class A and Class B, according to the degree and duration of the trouble.

The "Class A" extraordinary failure is as shown in Table 3. Such troubles, whenever they occur, shall be reported to the Head Office. The "Class A", extraordinary failure, which has occurred in recent years, is as shown in Table 4. The number of such troubles decreases year by year in spite of the extension of the telecommunication network.

FACTORS CONTRIBUTING TO IMPROVEMENT OF MAINTENANCE SERVICE

Successful realisation of the remarkable rise in the maintenance level is due to the steady and practical measures taken by NTT, which include (i) introduction of newly developed techniques and accomplishment of various plant stabilizing actions; (ii) promotion of scientific maintenance control based on the quality control method since 1957 JFY; (iii) promotion of various steps such as plant stabilization by means of decentralised installation of toll switches and multi-routing of transmission lines, and various measures against disasters[1]; (iv) accomplishment of three 3-year programs for the improvement of maintenance service and modernisation of maintenance activities initiated in 1966 JFY.

The effects achieved by these improvements are set forth below.

Introduction of Newly Developed Techniques

NTT has carried out five 5-year expansion programs of the telegraph and telephone plant since 1953 JFY, to extend telephone installations and promote direct dialling of toll calls. Under the said programs, telegraph and telephone facilities and circuits have been steadily expanded.

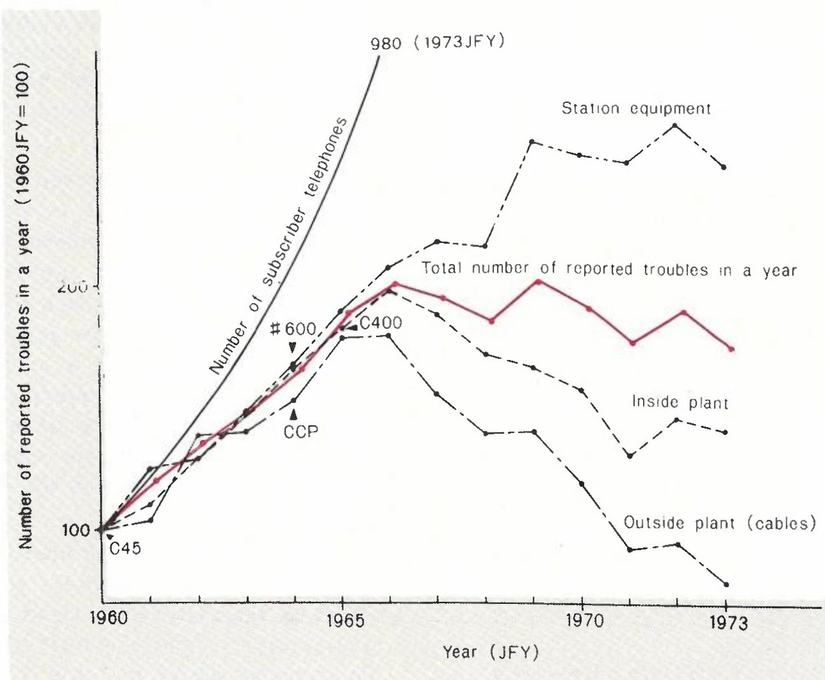
On the other hand, enhancement of investment efficiency and the quality of equipment has been attempted by positive introduction of new techniques.

The relation between troubles on subscriber telephones and newly developed techniques for example, is cited. Figure 2 shows changes in the number of subscriber telephone troubles reported during a one-year period by station plant, outside line plant, and office plant. As shown in Figure 2, the total number of subscriber telephone troubles reported also shows no marked fluctuations in spite

TABLE 4 — NUMBER OF "CLASS A" EXTRAORDINARY FAILURES IN RECENT YEARS

Fiscal Year (JFY)	1971	1972	1973
Number of "Class A" extraordinary failures	183 (47)	184 (52)	144 (42)
Number of subscriber telephones (millions)	17.3	20.5	23.8
Number of toll dialling circuits (ten thousands)	73.3	86.5	100.4

N.B.: The figures indicated in parenthesis show the number of troubles caused by disasters and are included in the basic figure.



Note: ▲ shows the year of newly developed techniques introducing the —
C400: C400 type crossbar switching system
C45: C45 type crossbar switching system
#600: 600 type telephone set
CCP: CCP cable

Fig. 2 — Trend in Number of Reported Troubles (Subscriber Telephone).

of the sharp increase in telephone subscribers since the latter half of 1960.

These phenomena are attributed to the decrease in the trouble rate attained thanks to the introduction of newly developed techniques into the respective plants.

It is possible to name the Type 600 telephone set[2], CCP-cable[3] and C400 type crossbar switching equipment[4] as typical examples of newly developed techniques which contributed to the realisation of the decrease in the trouble rate of subscriber telephones. They have, in general, been introduced since the mid-1960's, bringing about a remarkable improvement in the trouble rate as well as easy maintenance, as shown in Table 5, which could not have been realised to such an extent with the former plant.

The major factors which resulted in the remarkable progress made in NTT's telecommunication service are the introduction of new development techniques and measures for the improvement of reliability which have been promoted in various areas of the telecommunication system.

Adoption of Maintenance Control System

Maintenance is, in a sense, one field in which the telecommunication service is produced. It is furnished chiefly by around 1,700 operating offices (telephone offices, repeater stations, etc.) scattered throughout the country.

The maintenance service control method adopted by the above offices also changed over the years in connection with the increase and varieties of telecommunication facilities.

That is, it changed from the age of corrective-maintenance, of "repair when broken" which lasted until about 1949, to the age of preventive-maintenance, of "to prevent breakage", and finally in 1957, it became an age of controlled-corrective-maintenance when the maintenance control system based on quality control was adopted.

The maintenance control system at the time of its introduction was intended to achieve a synthetic and effective improvement of the maintenance service, adding a control limit value, maintenance reference value* and discrimination standard of plant deterioration, to the standard maintenance service value which was established as the universal standard of maintenance service to be applied all over the country.

The standard maintenance service value was established as a value which should be achieved and held in future by all operating offices, using complaints as a yardstick that could be considered to represent clearly the degree of maintenance service from the standpoint of users. The control limit value was also determined annually by areas, as a way of attaining this standard service value. It is intended to take concentrated steps to upgrade an office which exceeds the value, in order to raise the total service level and to correct dispersion among offices.

A remarkable improvement of maintenance service was realised by the introduction of the maintenance control system together with the effect achieved by newly developed techniques, and the dispersion among operating offices also was remarkably reduced.

As to the trouble reported on subscriber telephones, the operating offices meeting the standard service value formed only 10% of all offices when the maintenance control system was introduced. In 1970 JFY, however, most of the offices met the standard service value (See Figure 3).

With the reduction of dispersion among offices and the remarkable improvement of the service level attained, as stated above, the content of the maintenance control system was revised and changed from 1971 JFY, to lay stress on the control

* Maintenance reference value: a standard service value that is distributed by each constituent plant.

TABLE 5 — EFFECT OF NEWLY INTRODUCED PLANT

Newly Introduced Plant	Year Introduced (JFY)	Rate Extant (End of 1973 JFY)	Improvement in Occurrence of Trouble	Effect on Maintenance Work
Type 600 telephone set	1964	85%	About 1/5 per old type telephone set	Workload has been reduced due to decrease in troubles
CCP subscriber cable	1963	97%	About 1/15 per lead sheathed cable	Workload has been reduced due to decrease in troubles, and efficiency of cable work has been improved
C400 type crossbar switching system	1966	76%	About 1/5 per step-by-step switching system	Work requiring experienced labor now replaced by brainwork
Solid state ringing power supply	1967	56%	About 1/3 per rotary type instrument	Periodical maintenance workload has been steeply reduced

of plant quality in order to carry out effective maintenance, emphasising the safeguarding and stabilisation of the maintenance service which has been in effect up to this time.

The present maintenance control system is briefly outlined as follows:

The present maintenance control system institutes a "service control value" as an index to show NTT's service level to users, in place of the former standard service value. Further, "a plant control value" is also instituted as an index for taking action in place of the former maintenance reference value as a measure to select a plant (or group of plants) exceeding a certain limit in the dispersion of plant trouble.

Examples of the service control value are shown in Table 1. The value is determined by measuring the number or duration of troubles reported per unit and used as a gauge by each operating office. It includes a measure which is useful to prevent substandard service, for example, to specific subscriber telephones, a value being set to check each subscriber line from repeated trouble, so that the number of troubles may not exceed three in six months.

The plant control value of the maintenance level of each plant (or a group of plants) is set at $X + 2\sigma$, in general, for the purpose of average value control. However, an individual control is used for small plants, setting a control value to ensure that the trouble occurrence rate follows the Poisson distribution.

Besides the above, a discrimination standard for plant deterioration is set to promote plant renewal or rearrangement. A large scale fault which causes damage to telecommunication service over a wide area is individually controlled as an extraordinary failure. This is similar to the aforementioned maintenance control system. Further, and in addition to this, it is planned that a control system for new development techniques be added in 1975 JFY.

The flow of the present maintenance control system is shown in Figure 4.

The operating office which performs daily maintenance work carries out a monthly cumulative control in order to plan its own improvements by knowing the maintenance status, such as excesses of the control value. An annual trouble-status report shall be prepared by those offices in the assigned form to send to their administrative organs.

By this means, knowing the maintenance status within its area of jurisdiction through these annual trouble reports, administrative organs will feed this information back to map out further remedial measures.

Consolidation of Network Control Setup

Most toll calls in Japan are direct dialled. With the expansion of telephone service, the nationwide

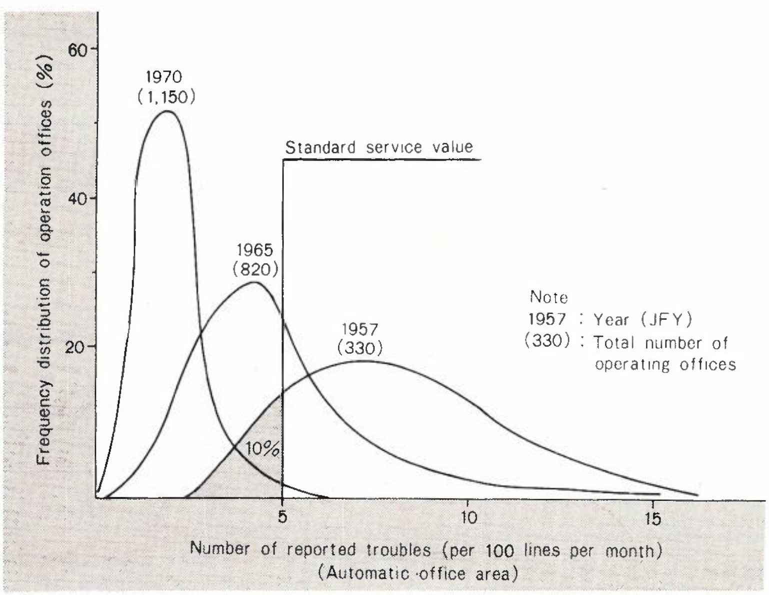


Fig. 3 — Transition of Maintenance Service Level on Subscriber Telephones.

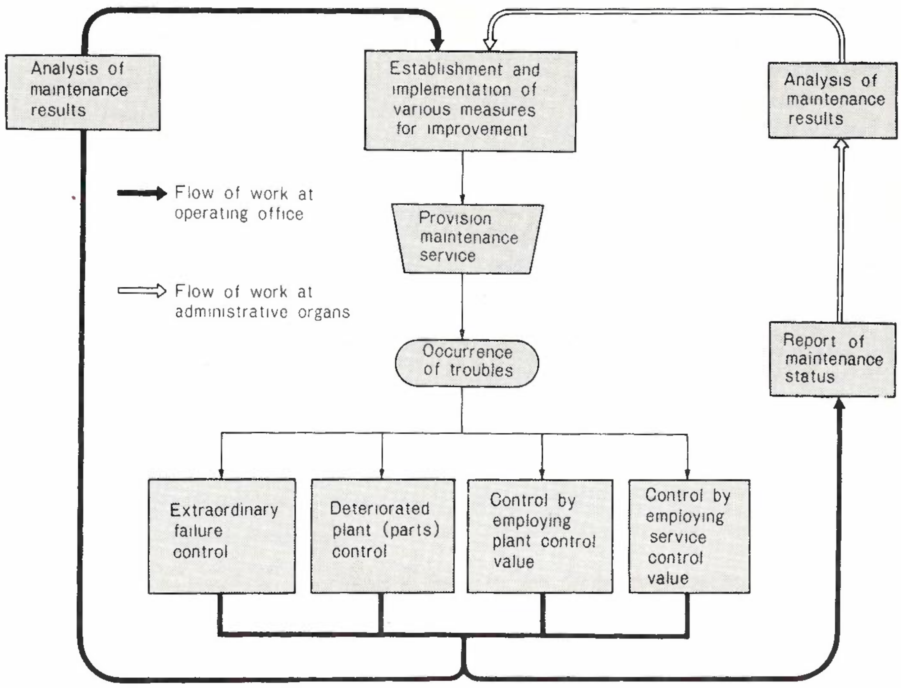


Fig. 4 — Flow of Maintenance Control System.

network lines are becoming more bulky, while the transmission make-up is becoming more complicated. Consequently, in case a transmission route breaks down at a certain point, it is obvious that no toll calls can be made in the section affected. Not only this, it is feared that traffic congestion may spread out like a wave from one toll exchange office to others due to the alternative routing function of the network.

Accordingly, in case of such an abnormal situation occurring, it is necessary to take steps, not only affecting each unit of the network, but also for the entire network, or a synthetic countermeasure for a system is required.

For this reason, NTT established the Central Network Management Centre in Tokyo, in March 1965, to perform overall maintenance of the telecommunication network and traffic control by introducing TTS (toll transit switch) to all Regional Centres, and this started operation in August 1965, introducing a network management equipment[6] for exchange of information and network supervision.

Further, a local network management centre was established in each Regional Centre and the network maintenance control system was arranged and consolidated throughout the country, instituting procedures for network management.

These network management centres function to maintain service in case the network is affected, accomplishing such work as taking steps to dispose of trouble on the network, exchanging information and planning counter measures with the cooperation of telephone offices, repeater stations ranking as Regional Centres, District Centres, etc.

As a result, reported subscriber toll dialling troubles are fairly small in number, as shown in Table 1. The number of extraordinary failures also decreases year after year, as shown in Table 4, due to steps taken to increase the reliability of the telecommunication network[1] coupled with the promotion of measures to counter disasters.

Result of Three 3-Year Programs of Maintenance Affairs

Adoption of the maintenance control system and establishment of such necessary procedures as standard operation practices related thereto have brought about a steady improvement of maintenance service with the average maintenance service level of all operating offices being raised to satisfy the service control value of the 1960's.

However, a survey of the maintenance service level at respective operating office discloses that about 30 % of all operating offices are still unable to satisfy the service control value. Under these circumstances, the Maintenance Division felt it to be vital to correct the nation-wide imbalance in the maintenance service level by upgrading offices which remained below the national average level, and to reduce persistent troubles and carried-ove troubles.

In order to meet this situation a "3-year Program for Maintenance Service Improvement" was mapped out to be implemented from 1966 JFY, which strongly promoted actions for improvement, such as renewal and rearrangement of deteriorated facilities, together with the introduction of newly developed techniques. As a result, this program decreased the rate of operating offices failing to satisfy the service control value of subscriber telephones down to 2%, as of 1968 JFY, which was the last year of the program.

Since 1969 JFY, the "3-year Program for Maintenance Work Improvement" was put into continuous operation, aiming at stabilizing the effects of the former 3-year program. Futhermore, with the experience gained of damage to telecommunication facilities caused by the Tokachi-Oki earthquake of May 1968, NTT further promoted disaster countermeasures for telecommunication facilities with the result that maintenance service was further improved.

As a matter of fact, however, the telecommunication plant is being steadily expanded and enlarged due to the implementation of successive telecommunication plant expansion programs, and there is a growing demand for telecommunication reliability, while rapid progress is being made toward new types of telecommunication services and new techniques. With this situation taken into full account, a "3-year Maintenance Work Modernization Program" was commenced in 1972 JFY following the two previous programs.

The chief objectives of this program are outlined as follows: First, strengthening of stable maintenance service and disaster countermeasures; second, development of the technical capabilities of maintenance personnel for the effective maintenance and operation of communication systems which are now becoming higher in techniques of more intricate mechanism; third, consolidation of the maintenance system and promotion of various procedures for the efficient performance of the increasing maintenance work.

The effect achieved by these three 3-year programs coupled with the effect mentioned above, has contributed greatly to the provision of today's excellent and stable maintenance service and also to the modernization and effective operation of maintenance work.

SUBJECTS AND MANNER OF CARRYING OUT MAINTENANCE WORK

NTT's maintenance service is, in general, stable and advanced, being supported by a more comprehensive setup to maintain good service, as stated before.

It is, therefore, considered appropriate as a basic policy to continue to carry out maintenance work along the lines that have been laid down and followed by NTT.

However, it is considered necessary, hereafter, to pursue a policy of a more sympathetic nature than ever before on problems concerning service for individual users, including prevention of repeated and extraordinary failures, because telecommunication service should have a great influence on national and social activities.

Further, in addition to the foregoing policy, it is important that NTT should be well prepared to preserve important communication routes in case of emergency.

Moreover, positive promotion of relationalization of field work is required, for such user services as relocation of telephones is increasing year by year.

On the other hand, the present situation is developing in such a manner as increase the quantity of maintenance work, the introduction of new techniques, nation-wide expansion, and the growing complication of the telecommunication network. In these conditions, it is necessary to promote, much more than ever before, the raising of the technical capabilities of maintenance personnel and the rational management of maintenance work.

In order to meet the various matters referred to above, NTT has decided to:

(a) stabilize maintenance service;

(b) strengthen disaster countermeasures;

(c) establish a well-prepared work control system for customer service;

(d) modernize maintenance operations,

as important objectives from 1975 JFY, and they are outlined as below.

Stabilization of Maintenance Service

In view of the fact that telecommunication service plays an important role in social activities, it has been decided to further stabilize the current maintenance service, placing importance on the points set forth below:

(a) To promote measures for the prevention of large-scale trouble which would paralyze telecommunication, and that further study should be made of a more precise method of controlling latent troubles. For example, in order to prevent disorder of such a pivotal part of the telecommunication system as power supply equipment, which would cause widespread impairment of telecommunication, it is necessary to improve the method of supervising and checking facilities and to keep stand-by equipment in good condition. Reduction of such defects as wrong connections or repeated troubles is also necessary since they cause users to doubt the reliability of the service.

(b) Traffic congestion is one of the latest problems. This is a phenomenon by which a communication system is paralyzed by requests for transportation reservations by telephone, or by a concentration of enquiry calls to a specific destination suffering from a disaster. It has been decided to promote investigation of countermeasure to prevent the spread of such conditions.

(c) To reflect properly, by accurate plant control, prevention measures against insufficient facilities. This is because it is considered that troubles will increase in proportion to the future increase in subscriber lines, for the present stabilizing measures are reaching their limit, and facilities will be exhausted over the years, although the aforesaid newly developed techniques have contributed largely in raising the maintenance service level.

Strengthening of Disaster Countermeasures

The Tokachi-Oki earthquake occurred on May 16, 1968, and stopped telecommunication for two hours between the Main Island and Hokkaido. This was studied as an indication of the important role played by telecommunication in the national life. Moreover, an earthquake which shook Los Angeles, USA, on February 9, 1971, gave valuable pointers concerning earthquake countermeasures affecting large cities.

In consequence, NTT synthetically re-examined the earthquake-proof aspects of telecommunication facilities and as a result, NTT established a permanent system of countermeasures and put it in steady effect, while taking urgent steps at the same time.

The basic ideas underlying these countermeasures are as follows:

(a) To secure minimum communication measures to prevent complete interruption of communication with affected cities;

(b) To prevent communication between cities undamaged by a regional disaster from being interrupted or paralyzed;

(c) To make it possible to restore the damaged communication facilities as soon as possible.

With these principles, such actions have been put into operation as the physical consolidation of facilities themselves as earthquake countermeasures, raising the reliability of the telecommunication network[1] by dispersion of toll switching equipment and multi-routing transmission lines, and providing transportable telephone systems[7], mobile power generators, and mobile radio telephone systems[8] for emergency use.

It was decided, to make assurance doubly sure, by reviewing the condition of facility setups based on examples of damage, and promoting suitable measures for local conditions, in addition to the arrangement of disaster-proof facilities and raising the operational techniques to keep them always functioning.

Establishment of Well-Prepared Work Control System for Customer Service

To ensure a better supply of telephones in future, it has been decided to carry out a thorough quantity control of plants, which takes the equipment situation into consideration, in addition to the quality control, in order to avoid an imbalance between basic plant demand and traffic, and knowing the exact condition of such telephonic demand and traffic.

Besides, it is intended to promote the positive introduction of measures which will effect saving of labor, in addition to reviewing and trying improvements of the daily routine at operational offices, in order to carry out effective construction directly related to user service.

Modernization of Maintenance Operation

In response to technical innovations and changes in social conditions, it has been decided to promote the arrangement of a maintenance setup, modernize operations, raise techniques, accident prevention to personnel, and so on.

For instance—

(a) To continue the introduction of labor-saving and effective equipment such as a variety of automatic testing equipment, supervisory control equipment for unattended offices, and so on.

(b) To pursue a policy of promoting a synthetic and systematic technique to support the upgrading and complication of the telecommunication network setup and needless to say, training in individual and special techniques of the personnel responsible for maintenance work. In this connection, attention must be paid to improve conditions so that men can develop and find satisfaction through their work.

CONCLUSION

It is believed that the NTT's maintenance service stands at a high worldwide level. The most important factors which aided NTT to attain such a high level are the positive introduction of new techniques, the effect of various stabilization steps, and the steady effort toward modern and rational methods of operation which served to raise the overall maintenance level. All this has contributed a great deal toward the management rationalization of NTT.

It is considered necessary to pay attention to further stabilize and maintain this level, not needing to strive for a higher level. It is understood, to stay in line with rapidly changing social conditions, that constant promotion of operational modernization is important from the long-term viewpoint.

Maintenance, in the telecommunication business, is that which produces telecommunication service by preserving its huge facilities. Contributing greatly to the effective management of future telecommunication business, NTT also wishes to contribute to the growth of society and elevation of the national life through its many telecommunication services.

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(2) "Outline of the Type 600 New Telephone Set", JTR, Vol.. 4, No. 1, 1962.

(3) "New Distribution Method with CCP Subscriber Cable", JTR, Vol. 4 No. 2, 1962.

(4) "The C-400 Crossbar Switching System", JTR, Vol. 8, No. 4, 1966.

(5) "Maintenance Service Control of Telephone and Telegraph Facilities", JTR, Vol. 1, No. 2, 1959.

(6) "Network Management Equipment", JTR, Vol. 7, No. 4, 1965.

(7) "Transportable Telephone System for Emergency Use", JTR, Vol. 15, No. 3, 1973.

(8) "Mobile Radio Telephone System for Emergency Use", JTR, Vol. 16, No. 1, 1974.

Retirement of Mr. A. H. Kaye, MVO

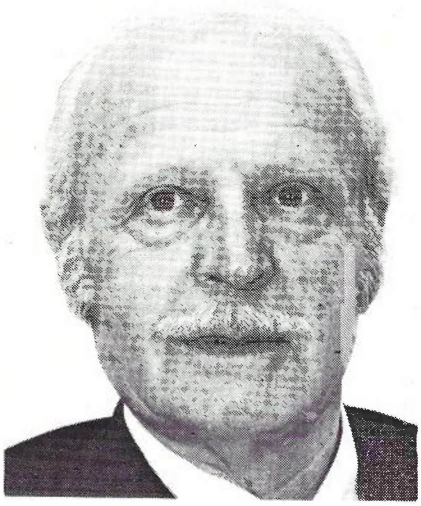
On 19.9.75, the State Manager for Telecom Australia in South Australia and the Northern Territory, Mr. A. H. Kaye, MVO, BSc, C.Eng, FIEE, FIE Aust., FIREE (Aust.), retired after 46 years' service.

After a distinguished career in the Engineering Division of the APO, Mr. Kaye was promoted in 1973 to the position of Director, Posts and Telegraphs and, subsequently, State Manager for Telecom Australia.

For most of his early years as an Engineer, mainly in the Victorian and Headquarters administrations, Mr. Kaye was involved in the radio field including special wartime telecommunications activities with the Armed Services both in Australia and in neighbouring island territories. He then played a leading part in the development of VHF and UHF radio for the national trunk system.

In 1957, he was given the responsibility for the Sydney/Melbourne Coaxial Cable Project, the first inter-capital city broadband system in Australia. During the visit of her Majesty, Queen Elizabeth II and the Duke of Edinburgh in 1963, Mr. Kaye was awarded the distinction of Member of the Royal Victorian Order by Her Majesty for his work as Commonwealth Communications Officer for the Royal Visit.

He was the APO Overseas Representative resident in London from 1964 to 1967, concurrently filling the position of the Australian Member of the Commonwealth Telecommunications Board. On his return to Australia, Mr. Kaye came to South Australia as Assistant Director, (Engineering). In 1972, he presented the Faraday Lecture at some 30 centres throughout Australia.



For a number of years Mr. Kaye was active in the Professional Officers' Association, being General President from 1959 to 1964. Subsequently, he was made a Life Member of that Association.

On behalf of all readers, the Board of Editors wish him and Mrs. Kaye a happy retirement.

Awards of Life Membership by Victorian Division

On December 9, 1975, at a luncheon attended by the Committee, Life Members and a representative group of Agents of the Division, the Victorian Division of the Society awarded Life Membership to Messrs. N. A. Cameron and A. M. Smith. The certificates of Life Membership were presented by the Chairman of the Division, Mr. A. Morton.

Norm Cameron and Max Smith are both well-known figures who have been involved in the Society's activities for many years. Both have served in a number of executive positions in the Victorian Division. Norm Cameron took over the post of Secretary of the Division in 1961 and served continuously until the end of 1968. In 1972 he was nominated as Chairman by the State Director and served the normal term of two years, retiring at the end of 1973. In 1973 he was appointed to the Telecommunication Journal of Australia Board of Editors, a position he still holds. Norm is presently Section Manager, Telephone Terminal Equipment Design Section, Customer Equipment Branch, Headquarters.

Max Smith has the distinction of being elected the inaugural Treasurer of the Victorian Division when the Postal Electrical Society of Victoria was reconstituted as the Telecommunication Society of Australia in 1960. He continued in this role until the end of 1969, when he was appointed as Chairman of the Division by the State Director. Max was always active in promoting the Society's interests in the then Telecommunications Division, and this, and his continuing enthusiastic support of the Society in his present position of State Manager, Victoria has been greatly appreciated by the Committee.

Mr. N. Cameron (left) and Mr. A. Smith (right) with Mr. Morton after the presentation.

Co-ordination of Power and Telecommunication Systems– Joint Conference, Hobart, November, 1975

N. G. ROSS, B.E.E. (Hons)

At least every four years since 1953 there has been convened a Joint Conference between representatives of the Australian Post Office (now Telecom Australia) and the Electricity Supply Association of Australia to discuss problems of power system interference to telecommunications and their resolution. This article describes the events at the November 1975 Conference, which met in Hobart.

INTRODUCTION

On practically every street or highway there exists a network of two completely independent electrical systems. One of these systems transmits the raw commodity "power electrical energy" from one point to the other, where it is used to provide heating and light, and the motive power for appliances of multifarious uses. The system is designed to transmit that power with as little loss as possible. For example, the power transmitted on a 400,000 volt line is of the order of 1,000,000,000 watts.

In contrast, a telecommunication line transmits a finished product, namely a message contained in a complicated waveform. On a telephone line the message is sent with a power of 0.001 watts and due to attenuation of the signal, may be received at a power of 0.00001 watts. When one considers the enormous difference in the power levels of the two systems, sometimes not even a street-width apart, it is not surprising to realise that the systems must be closely co-ordinated, otherwise interference to operation and danger to equipment, personnel and customers may result.

Co-ordination in Australia between power and telecommunication systems has been proceeding on an organised basis since 1953, when there was established in each State, a co-ordinating committee, together with a Central Joint Committee, which gives overall direction. These committees have equal representation from power and telecommunication authorities. At least every four years since 1953, representatives of these committees have met to exchange views and experiences of new problems, to review the charter of work previously set for the Joint Committees, and to establish a programme of investigations for the future. Over the period of 22 years the committees have developed an extensive system of Codes of Practice and Arrangements to control interference and danger in the telecommunications network from the various types of power systems having regard to the nature of the hazard. The booklets perform a necessary part of the co-ordination process within the power authorities, Telecom Australia and the railway authorities of Australia, and are eagerly sought by the developing nations such as Fiji and India. Even highly developed countries who have attempted to control the situation with Acts of Parliament and resort to litigation are envious of the harmonious relationships that have been achieved between the various authorities in Australia.

The Appendix to this article contains an up-to-date list of the publications of the Central Joint Committee.

VENUE IN HOBART

In recent years, the organisers of the Joint Telecom Australia/Electricity Supply Association of Australia Conference have varied the conference venue to enable delegates to undertake joint field inspections and so better appreciate each other's objectives, and problems in achieving those objectives. The location at Hobart was ideal for a visit to the Gordon Power Scheme in course of construction by the Hydro-Electric Commission, Tasmania. Located in rugged mountain scenery on the upper reaches of the Gordon River and Lake Pedder, telecommunications-oriented personnel could not fail to be impressed by the feats of civil and structural engineering being achieved by the HEC. Delegates were transported several hundred metres underground to a huge vault in which the turbines are being installed, and walked in the concrete-lined tunnels which in the not too distant future (mid-1977) will be filled with water rushing at speed towards the turbines. Although Tasmania is physically Australia's smallest State, the Gordon Scheme will create the largest water storage with about 27 times the volume of water in Sydney Harbour.

CONFERENCE OPENING

The Conference held from the 25 to 27 November 1975 was attended by a total of twenty-five delegates from each State and Headquarters of Telecom Australia, and the various power authorities which are members of the Electricity Supply Association of Australia. Mr. H. T. Davis, Superintending Engineer, Transmission Network Design Branch, Telecom Australia, who has a long association with power-telecommunications co-ordination, again most capably performed the function of Chairman (Fig. 1).

The Opening Address was given by Mr. M. R. Dunster (Fig. 1), who is Chief Electrical Engineer of the Hydro-Electric Commission. Mr. Dunster traced the history of co-ordination and cited several cases of interference which had been experienced in Tasmania. He expressed the wish that the Conference be successful and the delegates gain valuable experience from the discussions.

In welcoming delegates to the Conference, Mr. D. J. Robinson, Acting Chief State Engineer Telecom Australia (Fig. 1) referred to the high level of co-operation which existed between the HEC and Telecom Australia in Tasmania. In more jocular vein, Mr. Robinson commented on the enthusiasm for work exhibited by the Telecom Australia delegates at the pre-Conference briefing session.

An introduction to the Conference topics was given by the Convenor, Central Joint Committee (the author) in which he acknowledged the particular contributions made in the past to power-telecommunications co-ordination by Mr. Bill Harvey of the State Electricity Commission Victoria, and Mr. Rudolph Buring of Telecom Australia. They were

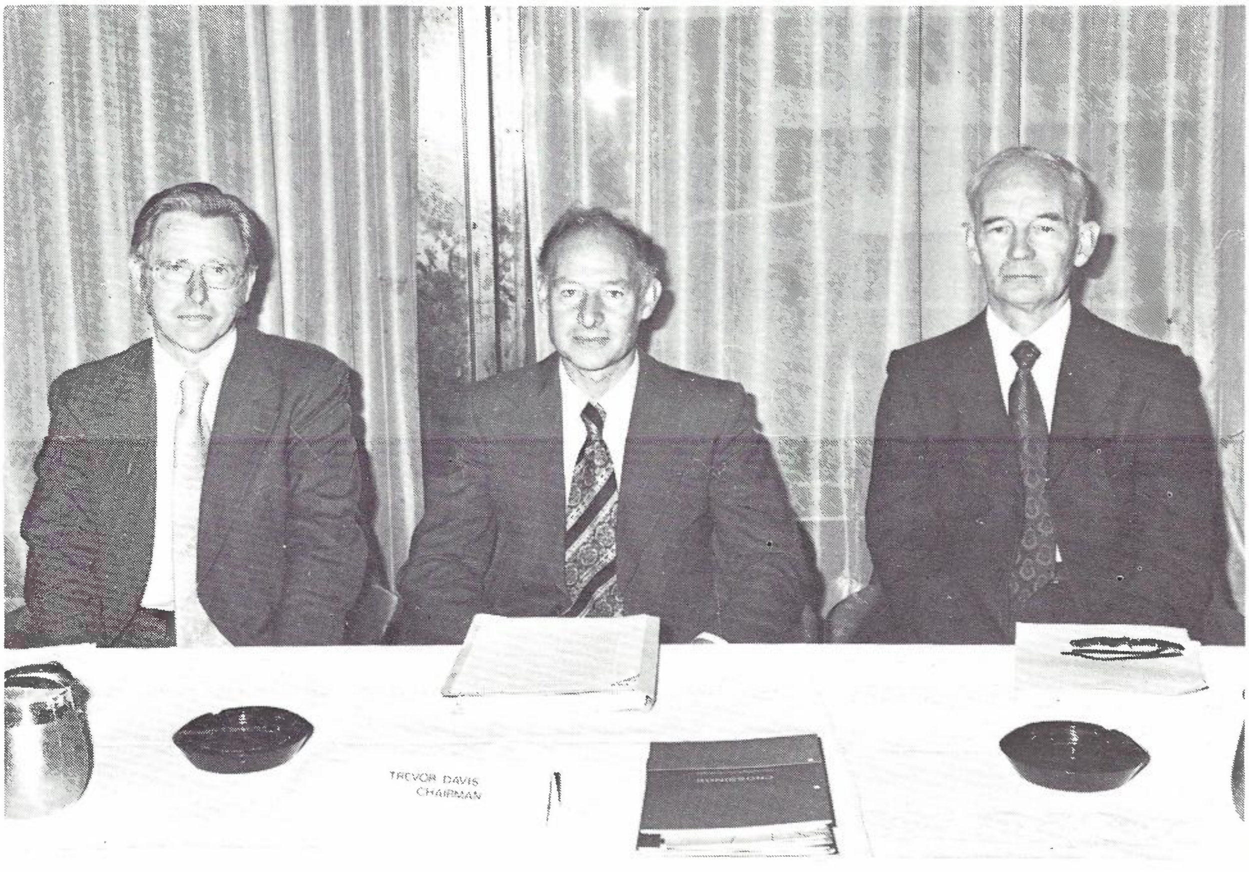


Fig. 1 — The Joint Conference was officially opened by Mr. M. R. Dunster, Hydro Electrical Commission, Tasmania (right), and the delegates welcomed by Mr. D. J. Robinson, Telecom Australia (left). Mr. H. T. Davis, of Telecom Australia, was the Conference Chairman.

both foundation members of the Central Joint Committee when it was formed in 1953, and were present at the last Joint Conference in 1971. Mr. Buring had died in April 1973 following a short illness and Mr. Harvey had retired from his position of Chief Transmission Engineer with the State Electricity Commission, Victoria.

MAIN CONFERENCE TOPICS

Metric Conversion of ESAA/Telecom Australia Codes and Arrangements

Most of the booklets produced by the Central Joint Committee have been in the British Imperial Measurement System. Rationalisation of the values to their metric equivalent required liaison with both the ESAA and Telecom Australia. Rather than the production of new booklets with the consequent wastage of existing stocks of publications, gummed stickers were produced for replacing tables and providing advice on metric equivalents. These have been distributed throughout Telecom Australia and the member authorities of ESAA. The Conference endorsed this approach and agreed that as the Codes and Arrangements are reprinted that they be reproduced in completely metric form.

Introductory Manual on Power-Telecommunications Co-ordination

The 1969 Joint Conference resolved that the Central Joint Committee arrange preparation of an introductory manual to assist field engineers inexperienced in co-ordination. Mr. R. Buring (whose contributions to co-ordination are acknowledged above) undertook the earlier drafts and following his untimely death, Mr. W. Goudie of the Victorian administration of Telecom Australia completed further drafts resulting in the issue of the Manual in early 1975 as Central Joint Committee Report No. 4. The Manual endeavours to give the interrelation between the various Codes and Arrangements and performs the function of an applications guide. It is anticipated that the Manual will be modified more frequently than other co-ordination documents to take account of new codes and to discuss problems which are not yet the subject of codes e.g. co-ordination of electric alternating current traction systems and telecommunications systems.

The Conference noted that there was a high demand for the Introductory Manual amongst engineers in field operations work, and requested the Central Joint Committee to investigate the practicability of developing training modules on co-ordination in conformity with modern course development procedures.

Amendment of the Telegraph Lines Protection Regulations (Post and Telegraph Act)

The 1969 Joint Conference had considered these Regulations to be outdated and had asked the Central Joint Committee to arrange for their updating. However the subsequent decision of the Australian Government to replace the Postmaster General's Department with Postal and Telecommunications Commissions meant that the Post and Telegraph Act and Regulations would be replaced by new Acts of Parliament, and this took place on 1 July 1975. The Telecommunications Act 1975 provides a definition of injurious interference from an electric line or installation (Section 3 (2)), and gives the Commission power to make Bylaws for protection of the telecommunications network (Section 111 (i) (d)). The relevant bylaws are contained in Part XV Division 1 of the Telecommunications (General) Bylaws. In effect, they replace Part 7 of the Post and Telegraph Act and the Protection Regulations. The new wording is more generalised and was drafted from the viewpoint of being compatible with the principles set out in Codes and Arrangements (listed in the Appendix). The financial penalties on power authorities for non-compliance which existed under the previous Act have been withdrawn from the legislation.

Co-ordination of Privately Owned Sections of Telecom Australia Lines and Power Lines

Part privately erected telecommunication lines in rural areas have always presented difficulties from the power system co-ordination point of view because they did not enjoy the legal protection given by the Post and Telegraph Act to departmental lines. The lines have often been constructed to a relatively low standard to achieve economy in installation, or have been poorly maintained, and as a result, show increased susceptibility to interference. Government policies announced in 1970 gave greater concessions to rural country subscribers in terms of the contribution that the Government was prepared to make in taking over and maintaining privately constructed lines, and it appeared at that time that the problems of power interference for these rural subscribers would diminish. However, a policy change took place in 1973 which restricted the extent of benefit. In the redrafting of the Post and Telegraph Act, an attempt has been made to give the Australian Telecommunications Commission more control over the part privately erected (p.p.e.) subscriber and to represent his interests in negotiations with power authorities. There is also an obligation on the Commission to ensure that in the future the proper electrical and constructional standards are applied to p.p.e. lines. Thus the new legal framework is considered to provide a better basis for co-ordination of p.p.e. lines and power lines.

Underground Joint Use

An earlier draft of the Arrangement for Sharing of Trenches had been examined by the 1971 Joint Conference and was accepted in principle subject to certain changes. Approval of the final version of the Arrangement was received from the ESAA and Telecom Australia in August 1973, following which it was printed and issued. Of course joint use of trenches had been proceeding in the various States prior to issue of the final printed document. It was not long before industrial action was imposed by the Amalgamated Postal Workers' Union against the recommendation contained in the Arrangement that, in the interests of efficiency, it is normally preferable for the power authority (or its contractor) to install the pipe and pits for telecommunications use. This has resulted in joint use of trenches being only arranged when each party installs its own plant, significally adding to co-ordination problems and reducing any cost savings associated with sharing trenches. The delegates discussed the degree of application of joint use in each State and within areas of a State, it becoming apparent that the acceptance of the technique depended heavily on the attitude and works practices of the two parties concerned. The Conference agreed that the Arrangement is sound from the engineering point of view and as satisfactory as can be expected on the administrative side. Sharing of trenches offers the advantages of greater safety practices and economy in footway space. Some groups have successfully undertaken joint use projects but there still remains co-ordination problems which mainly stem from the telecommunications staff union insistence that its members install pipe and pits. It was agreed that further efforts should be directed to solving these problems.

Low Frequency Induction

The principles set out in the draft Code of Practice for the Mitigation of Dangerous Voltages Induced into Telecommunications Lines were adopted by the 1971 Joint Conference. Following various minor alterations to the Code and a revised format the Code was finally accepted by both ESAA and the Australian Post Office on the 6th August, 1974. Pending finalisation of the Code, the APO introduced the 1000 volt limit in 1972 when considering the 275kV Brisbane-Gladstone power line proposal. Following its satisfactory experience with this limit and the significant economies realised, the APO in July 1973 applied both 1000 volt and 1500 volt limits in all States.

The Conference discussed several aspects of the Code, where further explanation is desirable to facilitate applications, such as the definition of high reliability power line and the effects of zone protection on the time for clearance of power line faults. Conference also discussed the difficulties of power authorities in supplying information on recorded faults. However it was agreed that these statistics were a necessary adjunct to the revised induced voltage limits and the power authorities would co-operate in their collection.

It was agreed that aspects requiring further clarification could be included in the Applications Guide which was in a fairly advanced stage of completion.

Earth Potential Rise

Conference delegates examined a draft arrangement for the control of earth potential rise at substations and high voltage earthed situations which had been prepared by the Central Joint Committee. While the sections on earth potential rise at substations appeared to be mainly acceptable to delegates, there was some discussion on the principles to be applied when considering metal power poles. It was agreed that a special working party should be formed to examine the draft in association with the comments of the Conference and report recommended practices to the Central Joint Committee.

Code of Practice for Stays

The 1969 Joint Conference had asked the Central Joint Committee to undertake the revision of the Code of Practice for Stays to incorporate the conditions appropriate to HV multiple earthed neutral power lines (used in Western Australia) and to conform with the revised Crossings Code, taking into account present practices. The draft Code prepared by the Central Joint Committee was examined by delegates and following a good deal of discussion on the necessity or otherwise for inserting an insulator in power line stays where they crossed telecommunications overhead routes, it was finally agreed in the interests of uniformity and the infrequent necessity for doing so, that all such stays should be sectionalised with an insulator.

Noise Interference

The 1969 Joint Conference had asked the Central Joint Committee to maintain a watching brief on the use of tone injection control systems which are used by some power authorities to switch power to consumers' night or bulk rate appliances. The levels of transmission developed for these tones however have not proved to be a noise problem for telecommunications.

On a wider scale of use is the application by power consumers of non linear control devices such as thyristors and triacs which may be used for light dimmers, speed control or heating control of appliances etc. When used for phase control these devices develop a large number of harmonics which are reflected back into the power network, and are capable of causing interference to radio, record, cassette and tape players, television sets etc. connected to the power mains, as well as induction into parallelling telecommunication circuits. Because of the wider implications of interference to other than telecommunications, the Standards Association of Australia Committee EL/03 (Electrical Industry Standards) had established an ad hoc Panel on Electric Waveform Distortion which has met several times since the first meeting in October, 1971. The Panel has advised the Australian electrical industry not to use phase control solid state devices in high market penetration devices such as electric ranges and room heaters, and is examining a draft standard prepared by the International Electrotechnical Commission which purports to establish tolerance levels for interference.

The Joint Conference recommended that the

Fig. 2 — N. G. Ross (left) is pictured at the Joint Conference with some of the other conference delegates: left to right, R. A. Read, Headquarters and P. Ferstat, Western Australia (Telecom Australia); and R. Staples, ESAA. Mr Ross is Principal Engineer, Lines Operations Section, Headquarters, and Convener of the Central Joint Committee for the Co-ordination of Power and Telecommunication Systems. He is also General Secretary of the Telecommunication Society of Australia.

Central Joint Committee continue to maintain a watching brief on the activities of the Standards Association of Australia Ad Hoc Panel with a view to the production ultimately of a standard for the control of non-linear devices.

Installation of Plant Underground — Minimum Standards

While Telecom Australia has been installing cables underground in residential areas for many years, it is in only comparatively recent times that power authorities have adopted this practice on a wide scale. The power authorities had tended to adopt individual methods of construction and practices and in view of the safety implications it was seen as desirable that these authorities adopt more uniform practices of an appropriate standard. The Central Joint Committee had initiated proposals with the ESAA and Telecom Australia and had obtained approval by both these organisations to form a joint working party to review the practices of power authorities and Telecom Australia in the underground environment and to make recommendations on minimum safety standards. The Conference endorsed these proposals.

CONCLUSION

The various resolutions made by the November 1975 Joint Conference has established a programme of activity for the Central Joint Committee to be completed in the ensuing four years. The main outstanding matters concerning power — telecommunications co-ordination would appear to be:

- Development of uniform safety standards for power and telecommunications urban construction in the underground environment.
- Finalisation of a draft Arrangement for Earth Potential Rise in the vicinity of HV earthed structures.
- Co-ordination of alternating current traction systems with telecommunications systems.

There was little discussion on this last item at the Conference, since the railway authorities developing electric traction systems presently have diesel-electric systems, and are not therefore members of the ESAA. Negotiations to date have been directly with the railway authorities.

One should not be too optimistic that co-ordination problems between power and telecommunications systems have been well nigh solved. Previous history in this field has demonstrated that new technological developments and practices in the two systems have introduced new facets to be considered and there appears to be no reason why this should not continue in the future.

APPENDIX

PUBLICATIONS OF THE CENTRAL JOINT COMMITTEE FOR THE COORDINATION OF POWER AND TELECOMMUNICATIONS SYSTEMS.

CODES AND ARRANGEMENTS:

Code of Practice for Stays (1962) (New edition imminent).

Code of Practice for Unbalanced Single Phase High Voltage Power Lines (1965).

Arrangement for the Joint Use of Poles (1965).

Code of Practice for Multiple Earthed Neutral High Voltage Power Lines (1969).

Arrangement for the Common Use of Poles (1969).

Code of Practice for Overhead Power and Telecommunications In-Span Crossings (1969).

Code of Practice for Earth Return High Voltage Power Lines (1969).

Arrangement for the Sharing of Trenches (1973).

Code of Practice for Low Frequency Induction (1974).

REPORTS:

No. 1 Record of Joint Conference APO/ESAA Sydney, April 1971.

No. 2 Notes of discussion held between Dr. H. Reidel, Chairman Study Group V CCITT and engineers of APO and SEC-V, Melbourne, 1971.

No. 3 Sharing of Trenches for Underground Power and Telephone Distribution in Residential Areas.

No. 4 Introductory Manual on Coordination of Power and Telecommunications Systems.

N. G. ROSS is Engineer Class 4, Lines Service Section, Operations Group, Network Performance and Operations Branch, Headquarters. For further information see Vol. 20 No. 2, P.181.

The East-West Microwave Radio Relay System – A South Australian Operational Report

D. R. WATSON, B.E. and L. J. WILLIAMS, B. TECH.

The East-West Microwave Radio Relay System was, at the time, the largest broadband project ever to be undertaken by the Australian Post Office. It completed the first broadband link between Perth and the rest of Australia. Special design concepts, outlined in a description of the new system given in Issue 1, Volume 21 of the Journal (February 1971), were used to overcome problems peculiar to the situation.

This first part of the South Australian report reviews traffic performance and reliability aspects of the system in the light of these concepts and changes found necessary to them under operational conditions. The second part, to be published in a later edition of the Journal, describes the maintenance philosophy adopted in South Australia, the staff organisation, and also the modifications found necessary to optimise equipment performance and maintenance costs.

INTRODUCTION

The special issue of the Telecommunications Journal of Australia published in February 1971, set out in some detail the overall design philosophy and equipment development, the installation and commissioning procedures together with some early operation comment on the East-West microwave radio relay system. As explained therein, a great deal of time and effort had gone into ensuring that a high performance bearer for 600 circuits of telephony traffic would be achieved, and following the commissioning results, no further comment is needed on this point. The reliability shown by the equipment, however, can only be judged after a reasonable period of operation and it is to this aspect that most of what follows will be directed.

The design of this system had incorporated a number of concepts which for all practical purposes were new to this type of application. That is, although all of the technical design features employed had previously been tried and tested in other systems somewhere around the world, several of them had never been installed operationally in such an extensive system through a locality as remote or having the physical characteristics of this particular area. At the same time as recognising that it was the availability of new technology which permitted the development of the project in the first place, it must also be acknowledged that complete success of all the new ideas in such circumstances was hardly likely to be achieved, and certainly could not be taken for granted.

Concepts such as:

- Completely solid state radio equipment;
- Ambient temperature and humidity operation for all equipment;
- All units fully aligned in a central depot;
- Wind driven generators as back-up power supplies;
- Remote demodulation and bearer switching stations;

were all put together in one of the most inhospitable and sparsely populated areas of Australia and, indeed, the world. Notwithstanding the amount of research and effort which went into the design and building of the new route it was perhaps inevitable that there would be some elements of the system needing modification as unforeseen operational factors or combinations of factors became evident. Much stood to be gained in any case, by honestly appraising the degree of success of each new concept.

Traffic

The East-West radio system, of course, is only part of a larger State (Fig. 1) and nationwide broadband network, and it is principally for this reason that the operational performance and reliability has been looked at with an overall traffic emphasis, rather than that of isolated radio bearers. The new concepts had both direct and indirect effects on the broadband traffic and this article attempts to explain these effects before any analysis of particular equipment problems. Modifications neces-

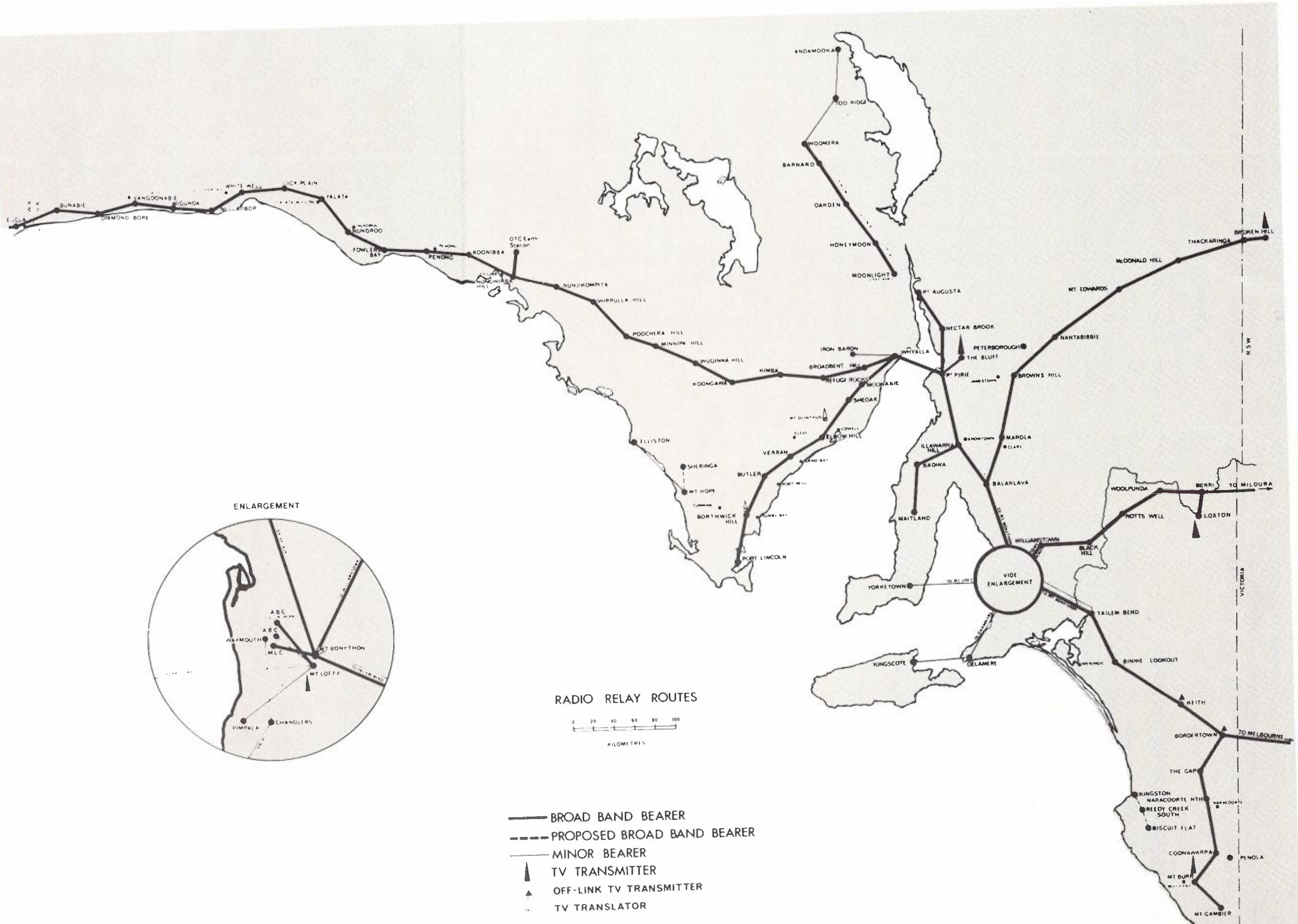


Fig. 1 — A South Australian Radio Relay Network.

sary to provide the required operating margins inherent in framing a reasonable maintenance cost structure, combined with acceptable traffic reliability at the specified performance figures are also examined.

GENERAL DESIGN CONSIDERATIONS

The GEC 5504B microwave radio relay system was designed to carry a telephony baseband of 600, 4 kHz voice frequency telephone circuits on each of five working bearers. In addition, the original contract specified that the protection bearer must be capable of transmitting a monochrome TV signal. It is important to note here that the designers of any broadband radio systems, taking account as they do of such parameters as modulator frequency, frequency deviation, IF and RF band-widths, still depend in large part upon the theories of Holbrook and Dickson (Ref. 1) and the statistical patterns of average telephone traffic channel loading generated more than 25 years ago.

International agreements which have stood for many years accept the principle that broadband telephony traffic can be simulated (for test purposes) by a band of white noise of which the upper and lower frequency limits correspond to the frequency boundaries of the frequency division multiplexed traffic signal. The RMS level of the white noise band is equal to the arithmetic sum of the powers of all the telephone channels, each one of which is assumed to be loaded to 15 dB below normal test tone level.

In recent years, however, traffic signals other than voice telephony have progressively occupied a much greater proportion of the baseband spectrum. While the average power of the total traffic signal may not have changed significantly because of this, the baseband frequency distribution of power has been radically affected. For example, traffic signals such as telegraphs, data and facsimile will cause concentrations of steady state power at specific frequencies (depending upon the line frequency of the channel) and sound programme channels sometimes give rise to widely fluctuating levels dictated by the content of the programme material. Sound channel levels of 10 dB above test tone level have been measured on many occasions.

The end result of these effects is that traffic quite frequently does not conform to the standard white noise signal which has been used as the basis of the design and testing. Consequently, the modern broadband equipment designer has to attempt a transfer characteristic for the transmission system significantly more linear than would otherwise be necessary to minimise intermodulation distortion at all normally occurring levels of traffic. In the case of a frequency modulated broadband radio system, this means that the IF and RF circuits must have the widest possible flat group delay and amplitude frequency characteristics.

Should the specifications for optimum group delay bandwidth in a particular radio bearer be compromised, the whole baseband spectrum may eventually be subject to excessive intermodulation from certain components within the traffic. Not only the live traffic, but the radio system pilot, situated above the traffic band, would suffer from this undesirable interference.

The East-West radio relay system is an example of such equipment with susceptibility to the generation of undue intermodulation from particular traffic components. In effect, the relatively restricted bandwidths of the radio frequency equipment modules for 600 circuit plus 8.5 MHz pilot working, coupled with the long switching sections of this route, means that distortion products accumulate more rapidly than could be predicted by simple noise power addition.

Baseband Allocations

The actual distribution of the multiplexed traffic on each of the radio bearers as they stood in July 1975 is indicated in Fig. 2. Relationship of the traffic carrying supergroups to the full baseband and to other bearers carrying broadband signals such as colour TV, is shown in Fig. 3.

Heavy demand for traffic circuits during 1972/73, resulted in additional supergroups (SG) 11 and 12 being placed on the first telephony bearer between Pt. Pirie and Kongwirra as a temporary measure prior to the commissioning of the second telephony bearer. The multiplex equipment of SG 12 is being prepared for reuse at the time of writing.

Actual traffic as seen on a baseband spectrum analyser display was photographed at Kongwirra (Ceduna) during a peak period in July 1975, and is shown in the Fig. 4 photographs (a) to (e). General distribution of signal power can be clearly seen, although (obviously) impulsive peaks which occur from time to time do not appear.

On a telephony bearer, the frequency spectrum below 60 kHz, the lowest supergroup frequency, is not used for traffic and is thus available for other purposes. Bandwidth from 300Hz to 54 kHz is used to carry time/division/multiplex signals and voice order-wire circuits which are a part of the comprehensive supervisory and control mechanism for this system. Since a TV signal occupies a bandwidth of 50Hz to 5 MHz, obviously no such supervisory signals could be carried when a bearer is used for TV transmission, an important fact when traffic priorities are being determined.

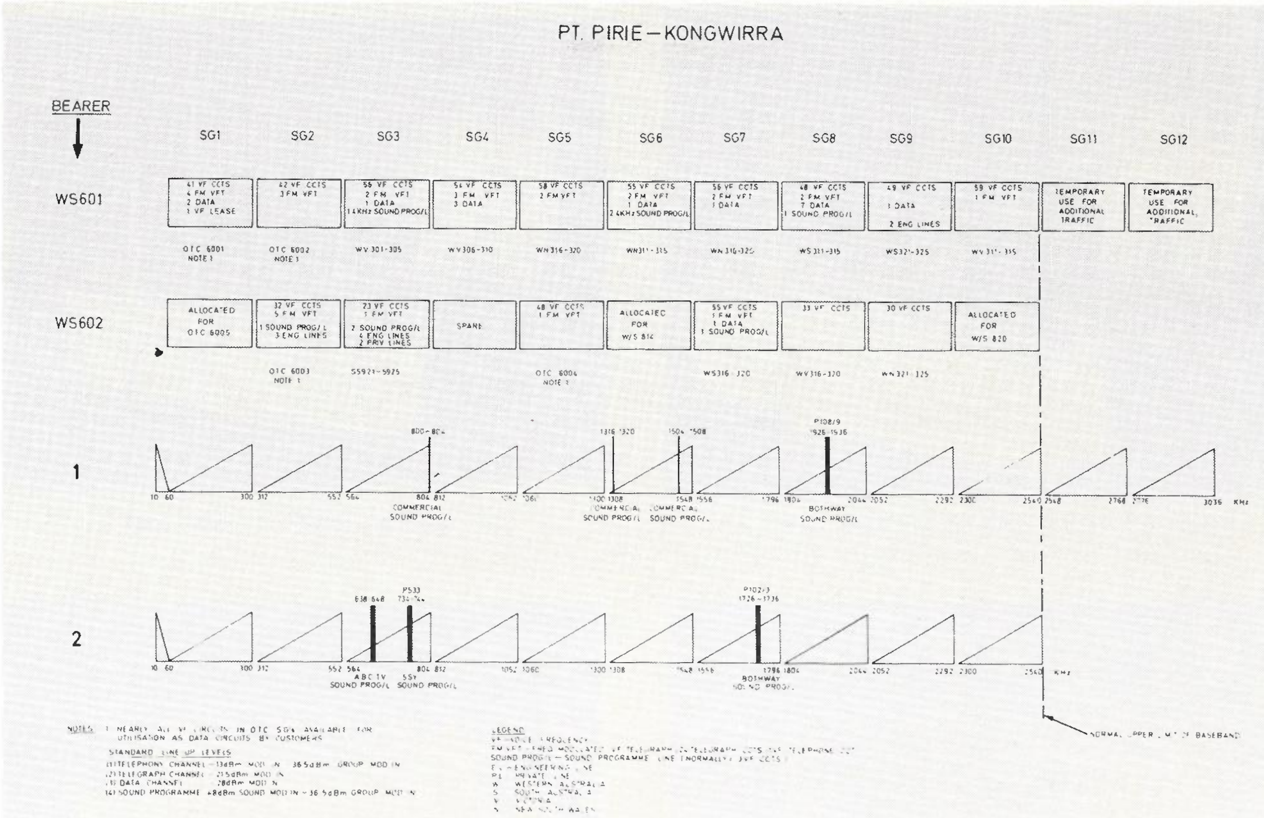


Fig. 2 — Traffic Occupancy by Supergroup — July 1975.

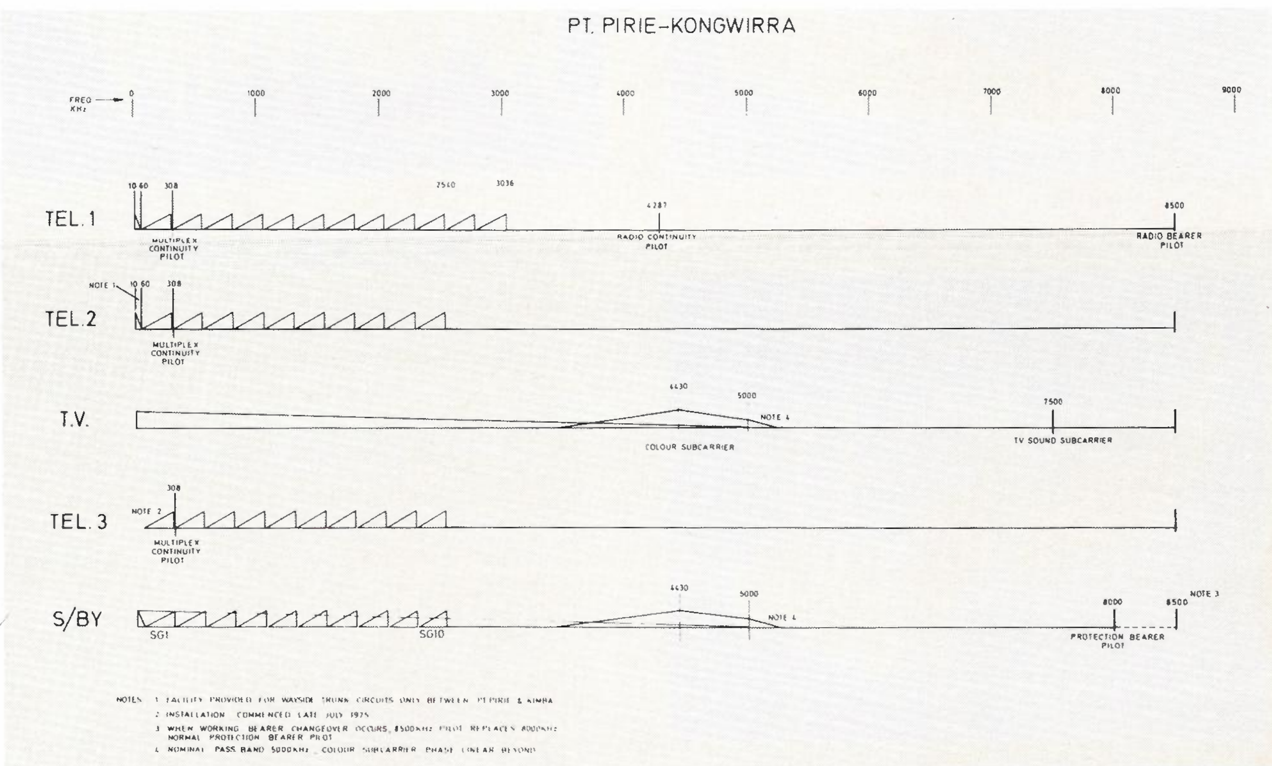
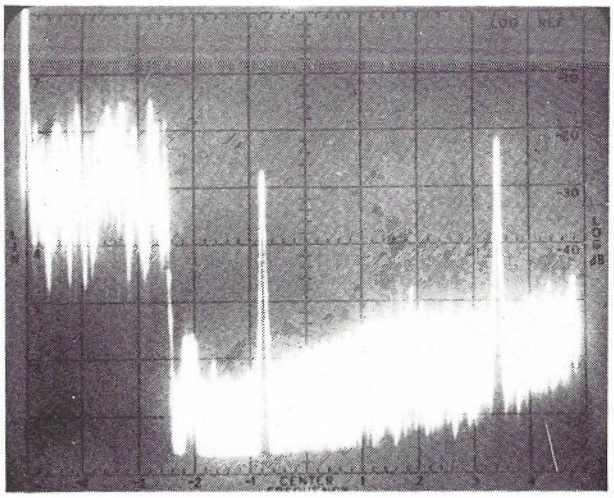
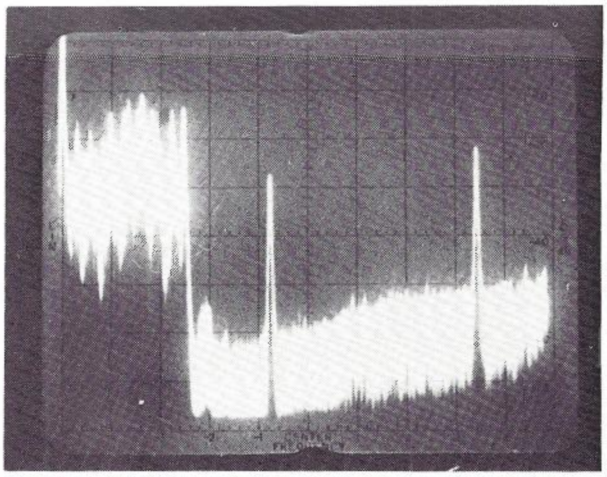


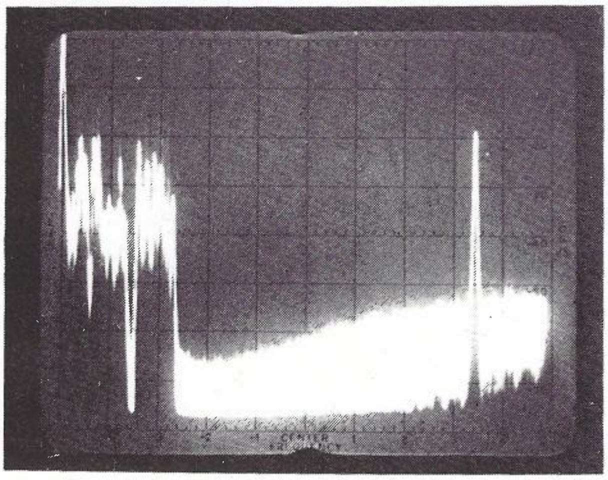
Fig. 3 — Radio System Baseband Layout — July 1975.



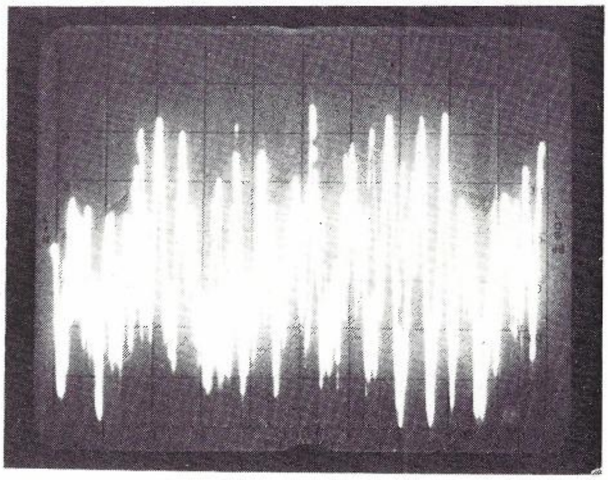
(a) Telephony Bearer 1; Off Peak Load.



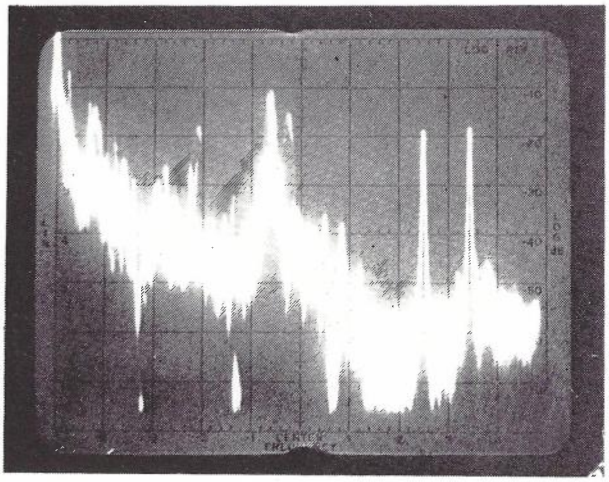
(b) Telephony Bearer 1; Peak Load.



(c) Telephony Bearer 2; Off Peak Load.



(d) Telephony Bearer 1, Supergroup 6; Off Peak Load.
Markers at 1.31 MHz and 1.55 MHz.
Reference OdBmO (-17 dBm)



(e) Standby Bearer; Colour TV Test Pattern.

Scales:
Vertical; 10dB per division
Horizontal: 1 MHz per division except
(d), which is 50kHz per division.

Fig. 4

Multiplexed Traffic Performance

Noise

Normal multiplexed traffic, composed of the types of signals referred to under General Design Considerations, is subject to several types of degradation, namely noise interference, loss of level, phase jumps and complete breaks.

Radio bearer noise performance specifications are generally set to allow a good margin of tolerance between the point at which bearer maintenance is required and that at which noise is objectionable (about 35 dB S/N) in the traffic circuits. Requirement for this route was 2.3 pWOp of noise per kilometre, as measured in the standard 2,438 kHz slot. This allowed a slight margin over the CCIR objective of 3 pWOp per kilometre, which has helped maintenance staff cope with the extreme operating environment.

CCITT objectives for noise performance of traffic circuits recommend that:

- The one minute mean noise power should not exceed 4 pWOp per kilometre for more than 20% of any month;
- The one minute mean noise power should not exceed 50,000 pWOp for more than 0.1% of any month on a system 2,500 kilometres long (very close to that of the East-West system).

In order that all the above conditions for the multiplexed traffic circuits are met, it has been arranged that a typical switching section should not be allowed to degrade to more than 1,200 pWOp of noise (2,438 kHz slot) before maintenance action is taken. Total route noise contribution under ideal conditions would be approximately 6,000 pWOp. Noting that the maximum maintenance degradation in any one section would allow roughly an additional 600 pWOp and that the chances of more than two sections approaching this point at the same time are very low, the route total noise should never exceed a figure of about 8,000 pWOp. This is well within the CCITT, 4 pWOp per kilometre objective which allows up to 10,000 pWOp for each traffic circuit on this route.

Because of obvious measurement difficulties, the assessment of traffic circuits against the 50,000 pWOp for 0.1% of any month recommendation, has in the past often been overlooked as an operational limit. Long term traffic analysis results now available in this State, however, give some cause for concern that the East-West (along with certain other routes) may be performing significantly outside the CCITT objective.

The most prevalent sources of excessive noise short term high in the East-West system have been:

- Premature loss of gain in the tunnel diode amplifiers at the radio frequency input to the main receivers;
- High level spurious tones generated in the transmitter and receiver oscillator circuits which were particularly prone to these unwanted outputs;
- Fading of the radio signal due to multi-path reflection and refraction, median depression, ducting and/or solid object reflections;
- Intermodulation from particular traffic components due to distortion by the band limiting effects mentioned above;
- Cracks in the wave guide filters due to expansion and contraction under ambient temperature conditions.

Continuity

Radio bearer protection arrangements separate the modulators, IF bearer and demodulators for switching purposes, in the manner illustrated diagramatically in Fig. 5.

A pilot level drop of 4 dB at the modulator pilot detection point, 6 dB at the output of the IF bearer and 8 dB at the demodulator pilot detection point will cause a switch of traffic from the main to standby facility in each case. A noise level of 40,000 pWOp (previously 25,000 pWOp) as calibrated to the 2,438 kHz measuring slot, will also cause the traffic on the IF bearer to switch to standby. (South Australian Section only).

Any malfunction of the bearer which fails the pilot or produces sufficiently high noise in the pilot slot, that is, a unit failure, severe fade, etc., will cause a switch to the standby bearer. The changeover in these cases will remove the cause and unless coincident with other problems traffic is rarely effected. In the case of switching produced by intermodulation from traffic or other signals incoming to the switching section (main modulator input) however, the irritant stays with the working bearer and rapid changeover between main and standby bearers will therefore continue while the particular signals remain in the traffic.

The most common types of interference to cause bearer switch chatter appear to be the 2A + B frequency products produced when high level tones occur in general heavy traffic conditions. This was particularly noticeable during the presence of supergroups 11 and 12 on the Pt. Pirie to Kongwirra section of the route in 1972/73.

Because of the suspected situation, a series of two tone tests was especially arranged. Tones A and B, tuned to frequencies which caused an intermodulation product to fall directly into the pilot noise sensing slot, were applied at a test point before pre-emphasis and increased in level simultaneously (See Fig. 6).

All bearers were within the maintenance noise performance specification as measured with standard white noise loading at this time.

The level at which noise fail occurred was recorded, and Table 1 sets out results for three typical combinations.

Although intermittent breaks in traffic, due probably to a confused switching system, have been observed during rapid bearer change-overs, the most serious aspect is the phase dislocation associated with the different electrical transit times of each of the bearers. This phase jump can be as much as one whole cycle of the base-band frequency applicable. When in the vicinity of 30° or greater, it disturbs the FM VF telegraph and data signals because of the shock effect on the telegraph and data demodulators (Ref. 2).

Diversity receiver switches can also produce phase jumps and along with the bearer change-overs have been clearly demonstrated to cause excessive numbers of telegraph and data errors. The problem is cured by transit time equalisation, but while the diversity receivers are relatively easily treated, the IF bearers are more difficult because of practical problems associated with the long lengths of delay cable.

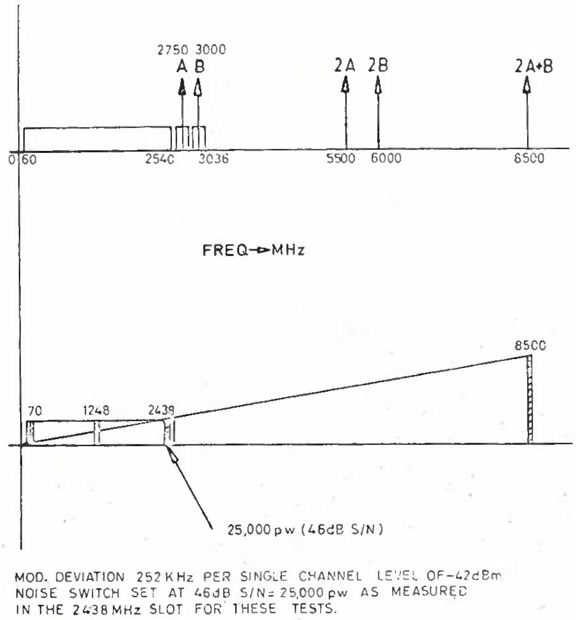


Fig. 6 — Illustration of Two Tone Tests.

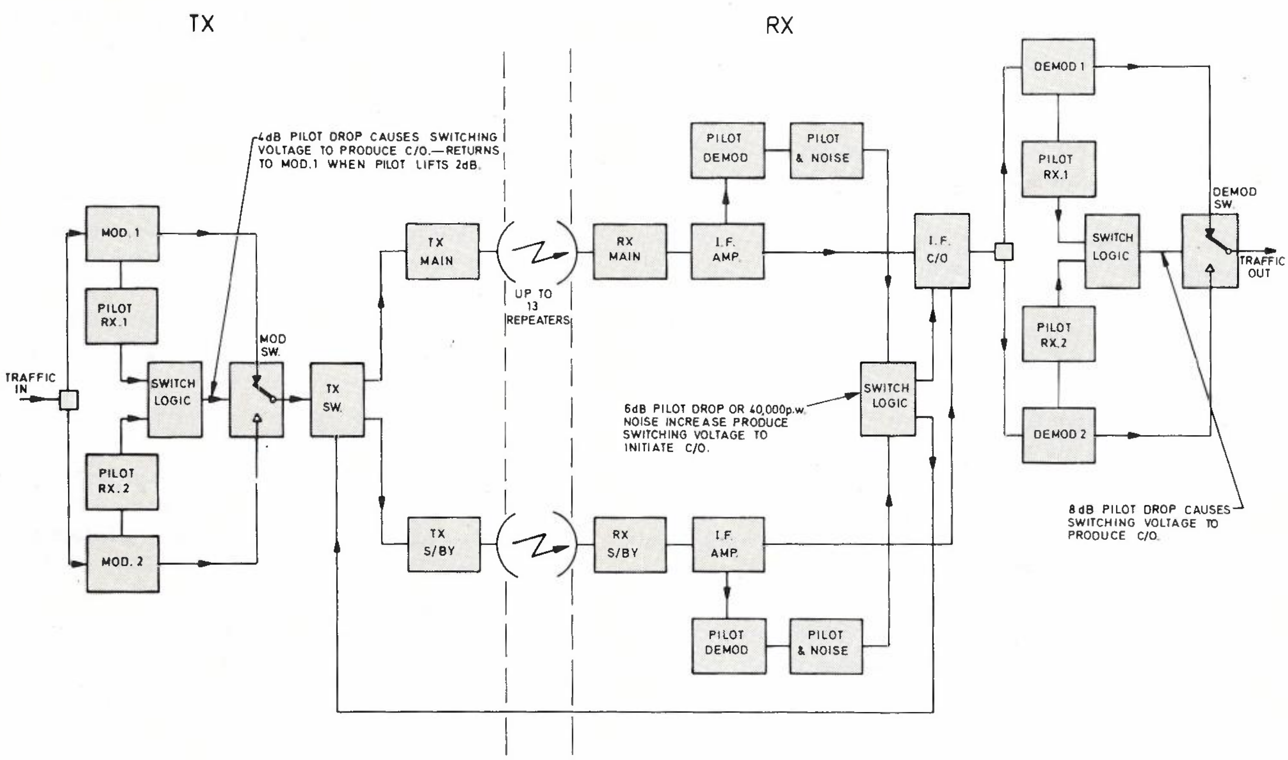


Fig. 5 — Typical Protection Switching Arrangements: Mod; IF Bearer; Demod.

TABLE 1

Tones		I/M Product (8.5 MHz)	Level of Tones A and B Causing Bearer Noise Fail (dBmO)			
A	B		Bearer 411	413	412	414
(1) 2.75 MHz	3 MHz	2A+B	+2	+5	+4	+5
(2) 4.7 MHz	3.8 MHz	A+B	—3	+2.5	—2.5	—2.5
(3) 2.4 MHz	1.85 MHz	2A+2B	+12	+14	+16	+12

Major modifications aimed at reducing protection facility switch chatter, which have been completely or are currenly in progress are:

- Replacement of assembly 'A' modulators with assembly 'E', resulting in reduced incidence of pilot compression under high traffic conditions;
- Reduction of main modulator deviation by 2 dB from 252 kHz to 200 kHz at single channel line-up level;
- Improved panel and bearer alignment procedures resulting in more stable flat amplitude frequency and group delay characteristics;
- Desensitising of the IF bearer noise switch from 25,000 pWOp to 40,000 pWOp.

TV Transmission

Monochrome TV signals were transmitted between the Eastern States and both Perth and the OTC(A) earth station at Ceduna, almost from the day the route was commissioned. The standby bearer had been additionally equipped with TV modem equipment to allow for occasional video programmes to be relayed and its use in this capacity has been somewhat higher than anticipated. Actual standby bearer occupancy by TV programme during the first year of operation was just over 300 hours. It has steadily increased since and totalled 550 hours in 1974.

Although the bearer responded to the standard monochrome TV signals satisfactorily at commissioning, it was difficult in practice to hold it to the high standard of performance considered desirable. Intermodulation products also seriously affected both bearer pilot and sound sub carrier circuits.

The TV sound circuit normally carried on the 7.5 MHz sub-carrier, was found to be very susceptible to such interference at normal signal levels. (See Table 2). Since it was convenient to improve the overall security of the TV and sound programme by placing the sound on an alternative bearer, the 7.5 MHz sub-carrier circuit has been used as a back-up only.

Degradation of TV transmission occurs due to noise marring and short duration interruptions. The noise sources are similar to those referred to in dealing with interference to telephony traffic. Interruptions occur whenever the standby bearer is taken by another bearer or fails itself. Fortunately, most of the extended bearer failures have not coincided with TV transmissions, although there have been several occasions where persistent and annoying short duration switches have adversely affected TV programmes.

TABLE 2

Standard Video Test Signal West to East	Sound Channel S/N Ratio Weighted/Unweighted	
Vision Terminated	—50 dB	—46 dB
2T Pulse and Bar	—46 dB	—46 dB
Test Signal 3A	—29 dB	—32 dB
Test Signal 3B	—25 dB	—27 dB
15 kHz Square Wave	—46 dB	—46 dB
East to West		
Vision Terminated	—54 dB	—46 dB
2T Pulse and Bar	—49 dB	—45 dB
Test Signal 3A	—30 db	—33 dB
Test Signal 3B	—27 dB	—30 dB
15 kHz Square Wave	—45 dB	—39 dB
250 kHz Square Wave	—29 dB	—24 dB

The real problems began, however, when the transmission of colour signals over the whole route was attempted.

Colour TV programmes had been transmitted spasmodically since early in 1970 from OTC Ceduna, but since they were always 'at risk', each one was carefully supervised to ensure optimum performance. When, however, the colour transmissions were extended to Perth and thus involved the whole seven sections of the route, the inherent limitations of the system could no longer be compensated for, on an 'ad hoc' basis.

On a TV bearer, harmonics of the line frequency and associated picture information fall very close to the pilot frequencies. In this case it is 8.0 MHz and the appropriate harmonic coincides precisely (512 x 15625). Amplitude of these luminance harmonics would depend on picture content, colour loading and the characteristics of the bearer.

Colour sub-carrier harmonics are so arranged as to interleave with those of the luminance signal and thus those closest to the pilot will be ± 7.8 kHz on either side. Depending both on the chrominance information and the condition of the bearer, significant amounts of noise can and do very easily fall in the pilot noise sensing circuit pass band and cause noise fail alarm.

The stand-by bearer is thus very susceptible to interference to its pilot and frequent bearer fail indications can occur when carrying colour TV signals.

Another difficulty arose from attempts to optimise the base-band amplitude frequency response to meet video signal specifications, at the same time as ensuring that a satisfactory 8.0 MHz pilot level was obtained. The end result of these adjustments saw the response in the 3 to 5 MHz zone as somewhat higher than at the low frequency end, see Fig. 7.

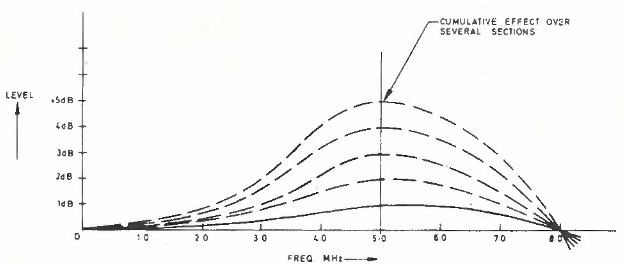


Fig. 7 — Baseband Amplitude — Frequency Response.

Whilst this did not have a very noticeable impact over a single section, its cumulative effect, when added over the seven sections of the route became quite significant, virtually adding 5 to 6 dB emphasis to the higher baseband frequencies.

Clear evidence of the over deviation resulting showed in the severe interference to pilot and noise sensing circuits in the later IF sections.

Bearer re-alignment performed during 1972 and 1973 and circuit modifications carried out

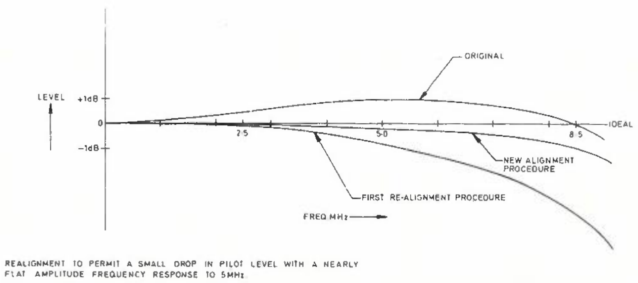


Fig. 8 (a) — Optimum Baseband Amplitude. Frequency Response after Modification.

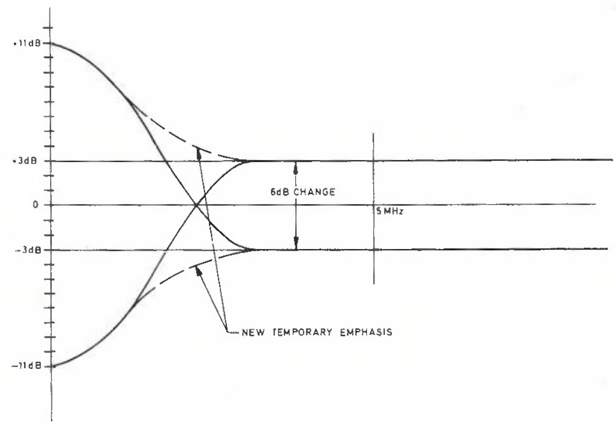


Fig. 8 (b) — Modified TV Pre and De-emphasis.

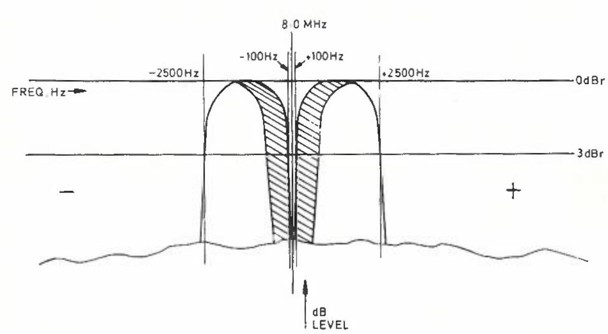


Fig. 8 (c) — 8.0 MHz Pilot Noise Detector Passband Modification.

during 1974 and 1975, gained sufficient improvement to permit colour transmissions to and from Perth on a regular basis. The measures taken in South Australia are illustrated in Fig. 8 (a), (b) and (c). In the first case panel and bearer re-alignment was conducted to achieve best compromise of flat baseband amplitudes response with minimum loss of pilot level.

Secondly, reduction in the span of emphasis from the normal 14 dB to 8 dB decreased the FM sideband energy components, with a tolerable deterioration in chrominance channel noise.

Thirdly, a change in value of the coupling capacitor between the output of the noise sensing amplifier and the input to the noise detector from 6.8 μF to 0.047 μF lessened the interference effect of the line frequency harmonics, which as stated above are very close to the pilot frequency.

Notwithstanding these modifications, very close control of colour TV signal levels is necessary at all times.

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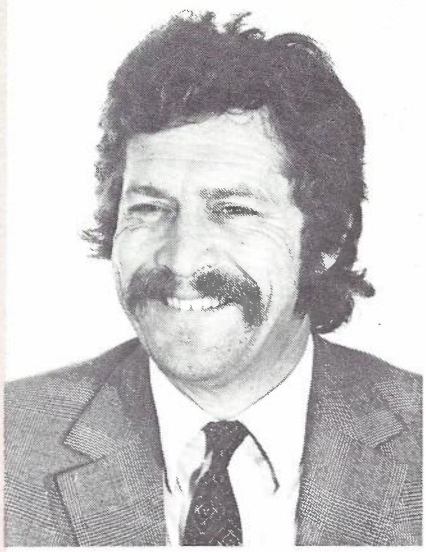
D. R. WATSON graduated B.E Electronics from the University of Adelaide in 1950. After several years as a District and Divisional Engineer in Country Regional Works in South Australia he transferred to the Radio Section where he became involved in major modification work aimed at upgrading broadband microwave radio relay systems in that State. He was actively involved in the acceptance of the first bearers of the East-West radio relay system from the APO/GEC commissioning teams before taking up his current Staff role as Assistant Superintending Engineer, Regional Operations Branch.



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He joined the Department in 1955 and after some years in the technical field at the Woomera Rocket Range, graduated as a Bachelor of Technology (Electronic Engineering) from the University of Adelaide in 1970.

After eighteen months in the Woomera Project Sub-Section as an Engineer Class 1 he transferred to the position of Engineer Class 2 responsible for the operation of the East-West Microwave Radio Relay System. He was appointed to that position in June 1973.

Call State Transition Diagrams for Crossbar Exchanges

H. FEGENT

This brief article describes a Call State Transition Diagram of a local call in a typical ARF Crossbar telephone exchange.

INTRODUCTION

In the design and development of Stored Program Control (SPC) telephone exchanges the usefulness of state transition diagrams has been demonstrated in the application to system specification and design (Ref. 1). In Ref. 2, Gerrand gives a general introduction to a call-state transition diagram (CSTD) based upon processing states rather than network states. The application of these CSTD's as a system-level specification technique for SPC telephone exchanges has been described in a preliminary report to the CCITT Study Group XI (Ref. 3).

As CSTD's are valid and useful in specification of SPC telephone exchanges, they should also be valid and useful for specifying or describing non-SPC telephone exchanges. The purpose of this paper is to describe a CSTD of a local call in a typical ARF crossbar telephone exchange.

FEATURES OF THE DIAGRAM:

A description of a local-to-local call in a typical ARF crossbar telephone is shown in Fig. 1.

The logical processes involved in telephone calls are described in terms of *suspended states*. Transitions from one suspended (or waiting) state to the next only occur in response to external events (line seizure, digit received) or external supervisory events (marker function completed, time out). Suspended states are shown as rectangles, and each state is unique and contains a pictorial representation of the network corrections and supervisory elements associated with the call. Every possible event which can cause a transition to another state is anticipated by the algebraic variable in the pictorial representation (e.g. $\bar{a}$, $\bar{h}$).

Between suspended states some tasks (e.g. meter A) may be performed or decisions (e.g. bypath test OK) may be taken. These are called *Active States*, and are shown as trapeziums. *Transitions* from one state to another are shown as change of sign of the algebraic variable associated with the path joining the two states. The transition is "triggered" by some event such as a digit being received ($\bar{d}$ — d) or a time out occurring (t — $\bar{t}$). The algebraic variables carry a logical true-false meaning (h means handset off hook; $\bar{h}$ means handset on hook) as well as, in some cases, some information content (e.g. t6 means timer No. 6, a 90 second timer, has expired).

CALL DESCRIPTION

The initial state is the "SUB IDLE" state where it can be seen that the subscriber's handset ($\bar{h}$) is on hook and the line is connected to the LR/BR relay set. The only way to exit from this state is for the subscriber to lift the handset to initiate a call. What happens with this transition can be seen by following the output, labelled h to the next state. This new state is in a trapezium which indicates that it is an active processing state, that is, a specific task performed or decision made, in this case it is a decision answering the question "IS MARKER AVAILABLE?" There are two outputs YES and NO and if we assume that there is no marker available we follow this output to state No. 1. The differences between this state and the previous one are:

- The subs handset is off hook. This is shown pictorially.
- The sub is now labelled hA. This indicates two things, one is that the sub has been labelled an A party, the other that the receiver is off hook which is shown by removal of the bar in the original $\bar{h}$.
- The LR/BR is labelled $\bar{a}$ indicating it is waiting for another attempt to call the marker.

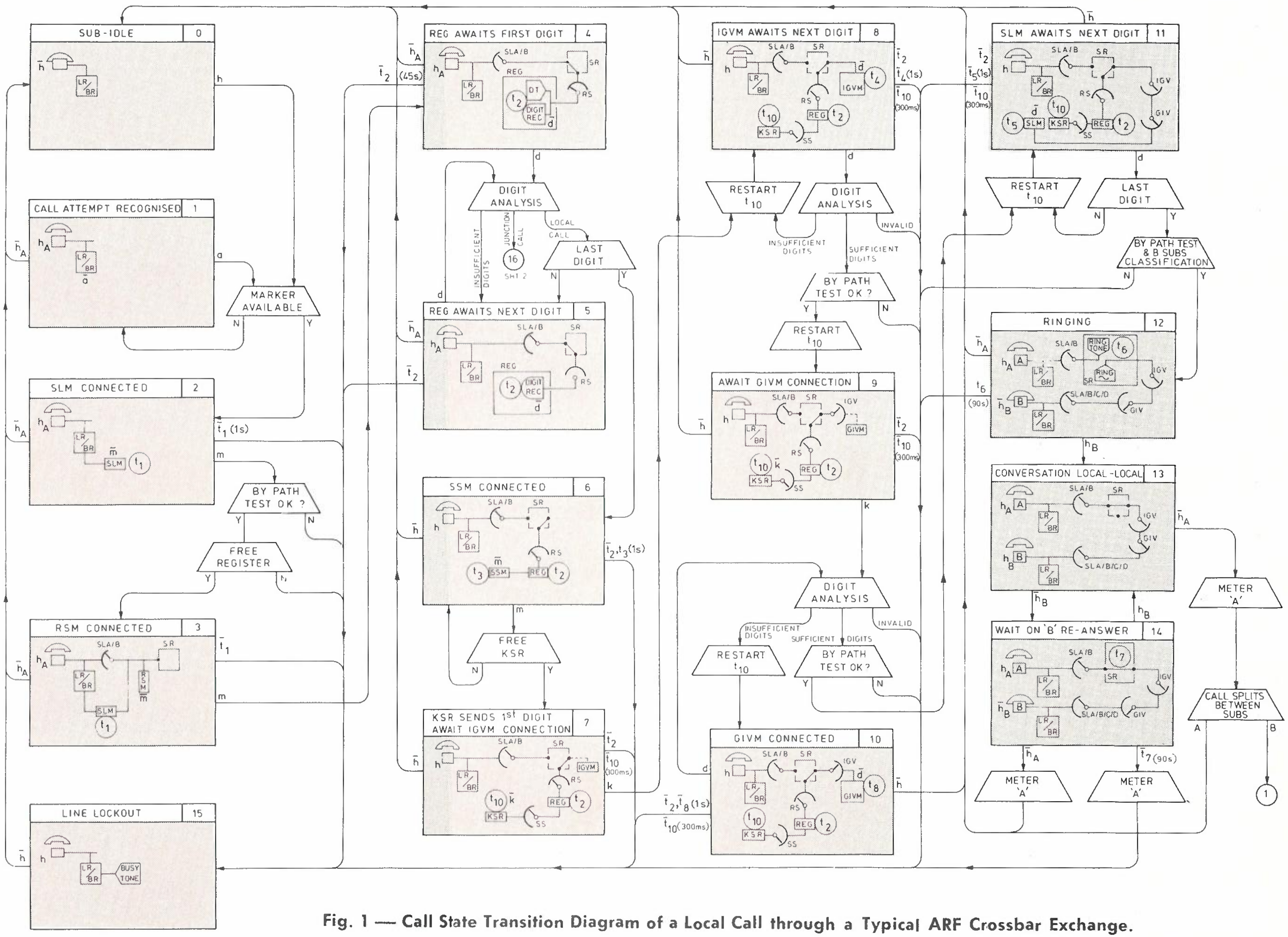

Fig. 1 — Call State Transition Diagram of a Local Call through a Typical ARF Crossbar Exchange.

There are two ways to exit from this state, one is by the subscriber replacing his receiver. This would cause hA to become $\overline{h}$A and following this output would take us to "Sub Idle", state No. O. The other way is for the LR/BR to attempt to call the marker ($\overline{a}$ becomes a) and following this exit the call returns to the active state asking "IS MARKER AVAILABLE?" Again we have the two alternatives YES or NO. This time assume a free marker is available. This leads us to state No. 2.

This is a suspended state and to find out what has happened to the call we compare it to the previous suspended state. We find that an SLM($\overline{m}$) is connected and a timer (t1) is started. There are three transitions which will allow an exit from this state:

- Sub hangs up; hA becomes $\overline{h}$A.
- Timeout; t1 becomes $\overline{t}$1.
- Marker performs its function; $\overline{m}$ becomes m.

If the sub hangs up, the call goes to state No. O "Sub Idle" and if the marker times out, it goes the state No. 15 which is Line Lockout where everything is cleared down except busy tone which is sent to the sub via the LR/BR relays. The other exit m goes to an active process "By Path Test". If this test is OK we then see if there is access to a free register. If either of these tests fail the call goes to Line Lockout.

If there is access to a free register the call will go to state No. 3. This state shows that the Subscriber is switched via the SL A/B to the SR and the RSM. When the RSM has performed its function ($\overline{m}$ becomes m) the call goes to state No. 4 which shows that the SLM and RSM have been released and the sub's line is switched via SL A/B, SR, RS to the register where a Dial Tone Sender and a Digit Receiving Circuit are connected to the line.

The call stays in this state until the sub hangs up, dials a digit or the 45 second timer (t2) expires causing a time out and the call goes to line lockout condition in state No. 15. If the sub dials a digit, $\overline{d}$ becomes d and digit analysis takes place. As this is the first digit there would not be sufficient information to discriminate the local prefix so the call would proceed to state No. 5.

State No. 5 is similar to state No. 4 apart from the dial tone sender which is removed after the dialling of the first digit. As each digit is dialled it is analysed and when the local prefix is recognised a decision is made as to whether it is the last digit. If it is not then the loop is repeated. When the last digit is recognised the call will go to state No. 6 which shows the SSM connected and the digit receiver disconnected. Timer t2 is still active and a new timer, t3 is started to time the SSM.

The SSM attempts to find a free KSR and if it is successful the call moves to state No. 7 where the first forward signal is sent to the KSR, the 1GVM is called and a timer t10 is started. With the reception of the revertive signal from the 1GVM, $\overline{k}$ becomes k. This takes the call to state No. 8 where the 1GVM awaits the reception of the next digit. Timer t10 has been restarted and a timer t4 started. When the 1GVM receives the next digit $\overline{d}$ becomes d and the call goes to an active processing state where digit analysis is carried out. If sufficient digital information is available the bypath test is performed and the G1VM is called in the same manner as was the 1GVM, state No. 9. When the G1VM has received sufficient digital information and the bypath test is successfully completed the SLM is connected. When the SLM has received the last digit a bypath test is performed and the called subscriber's classification is checked. If these tests are satisfactory ringing conditions are set up as shown in state No. 12.

When the B sub answers, $\overline{h}$B becomes hB, the conversation stage is reached, state No. 13.

There are only two transitions which can cause an exit from this state. When hA becomes $\overline{h}$A the A sub is metered and the call splits. The A sub goes to the Sub Idle state and the B sub goes to call attempt recognised, state (No. 1) where he becomes an A sub. If the hB becomes $\overline{h}$B the call goes to a new state "Wait on B Re-answer", State No. 14. If the B sub remains on hook t7 will time out causing A to meter and then to line lockout. If A sub hangs up before the time out he is metered and goes to Sub Idle.

CONCLUSION

A local call through a typical ARF Crossbar exchange has been described using a Call State Transition Diagram. I believe that this method of description could prove valuable in Telecom Australia for training purposes, system understanding and system appreciation.

Call State diagrams have been produced for a number of other ARF exchange functions.

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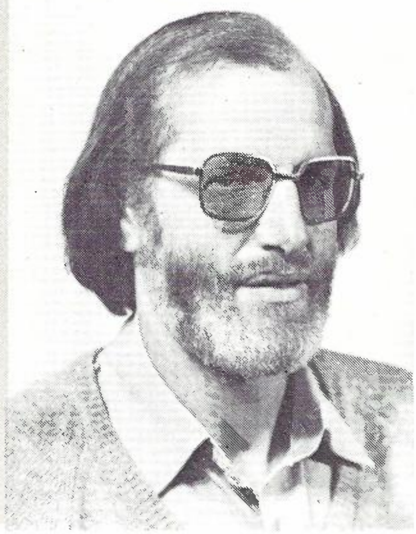
H. FEGENT commenced with the PMG as a Technician-in-Training in 1955 and was appointed as a Senior Technician to the Metro Service Laboratory in 1964. In 1969 he was promoted to a Technical Officer Grade 1 with the Switching and Signalling Branch of the Research Laboratories where he is now a Senior Technical Officer Grade 1.

Whilst in the Research Laboratories he has participated in various projects involving Stored Program Control of exchanges and the application of Micro Processors to exchange testing.



Technical News Item

STRANDS OF GLASS MAY CARRY TOMORROW'S TELEPHONE CALLS

Telephone calls were carried by a beam of light along a strand of glass no thicker than a human hair during a demonstration in London recently.

Tests by the British Post Office have shown that up to 2000 calls can be carried on each tiny strand and experts believe this could be increased to 200,000. British Post Office research teams, working with industry, believe glass fibre cables could replace wire in many parts of the telecommunications network.

Two systems are being evaluated in the United Kingdom. One can send 120 telephone calls at once over single fibre sections four kilometres long without intermediate amplification. For longer distances, sections can be linked. The other system involves signals being sent along a one-kilometre fibre designed to handle nearly 2000 calls. This has been installed in the normal cable ducts of a London building.

The demonstration coincided with the first European Conference on Optical Fibre Communications, which was opened by Professor James Merriman, president of Britain's Institution of Electrical Engineers; 400 telecommunication experts and research workers from all over the world attended.

After ten years' research on the use of light instead of electrical energy for long-distance communications, Standard Telephones and Cables (STC) of London plans to introduce extra production plant during 1976 to step up output of prototype fibre optics cable.

STC says the idea of communications by light was originated in its own laboratories at Harlow, near London. Its fibre optic cables can already carry more than 10,000 simultaneous conversations and new transmission technologies under investigation are expected to offer many times this capacity in the same cable.

CENTOC — Towards Centralised Traffic Measurement

G. O'H. MARLOW, B.E.

The problem of assessing a seasonal correction factor to adjust measured telephone traffic in each exchange to busy season levels has always been an area of difficulty for traffic engineers. Conventional methods are surveyed and shown to be unsuitable. To overcome this problem the CENTOC system, a method to measure traffic in exchanges remote from a central locality, has been developed.

Although a prime, original objective of the system was the determination of more accurate seasonal correction factors, CENTOC has assumed importance as a design control facility for planners and as a network management tool which is capable of development to a real time network management system.

The system is shown to have a favourable cost/benefit relationship and to have important application in the wider sphere of business management of the telephone network.

INTRODUCTION

Traffic measurements of all automatic exchanges are taken at regular intervals to check the adequacy of the existing equipment and to provide a basis for estimates of future requirements. Although the objective is to take traffic occupancy measurements on all traffic groups in the more significant exchanges every two years on average, the actual frequency of measurement of an individual exchange will vary depending upon its size and importance, the rate of subscribers' growth, degree of unpredictability of traffic growth and other factors. For example, because of the high trunk traffic growth rate, measurements of the main trunk switching exchanges in each capital city have often been conducted twice a year, at Christmas and Easter. On the other hand, measurements of metropolitan exchanges in well established residential areas are often satisfactory at intervals of three to four years. However, marked changes in traffic activity level or traffic dispersion may occur in a comparatively short period because of cutovers of major STD centres or infiltration of residential areas by business. In order to detect these changes in traffic patterns at an early stage to avoid possible congestion, regular monitoring of selected traffic groups in every significant exchange is desirable.

Although installed plant capacity is required to meet the busy season traffic level, traffic studies are necessarily scheduled throughout the year to maintain a stable work load for measurement staff. As a result, traffic measurements are taken outside of the annual busy period for many exchanges and seasonal correction factors must be applied to the measured traffic. Correction factors have previously been based on the exchange battery discharge but, particularly for exchanges with common control equipment, this method is not satisfactory. The ideal seasonal correction factor is the ratio of the busy hour traffic calling rate within the exchange during the annual busy season to that during the period of reading. To assess this factor would require regular and frequent measurement of originating traffic in each exchange.

To achieve the above objectives economically, a method of measuring traffic levels in exchanges remote from a central locality has been developed by the Traffic Engineering Section in South Australia. This has been named the CENTOC system, an acronym for CENtralised Traffic OCcupancy studies.

Regular measurements of originating and backbone (final choice) junction traffic from most large terminal exchanges in the Adelaide Telephone District (ATD) and originating and terminating trunk traffic through the main trunk exchanges commenced in July, 1972. The measurement of relevant traffic groups from these exchanges is carried out remotely via cable pairs extended to automatic scanning and recording equipment located at the Traffic Engineering Laboratory in the City trunk terminal building. Measurements are recorded for one session per working day between 0900-1100 hours for five consecutive week days on each alternate week. A morning measurement period of two hours has been chosen as all exchanges in the ATD, with the possible exception of the three City exchanges, have their originating traffic busy hour within this period. Of the other routes, most have a morning busy hour and where this is not the case, the variation from the morning level is normally not significant.

This article discusses the immediate and longer term objectives of the project, describes the method employed and outlines the advantages of the CENTOC system for assessment of seasonal correction factor and as an additional network management tool. It shows how CENTOC can be and has been used to assess the effects of policy changes and could be used to provide a rapid indicator of revenue earnings from telephone traffic.

SEASONAL CORRECTION FACTOR ASSESSMENT

As discussed in the Introduction, the responsibilities of Traffic Engineering Section include the traffic measurement of exchanges at regular intervals. When the measurement is not taken during the busy season of an exchange, a seasonal correction factor is applied to correct the traffic to the level expected during the next busy season. There are several methods for deriving a seasonal correction factor (SCF).

Battery Discharge

The traditional method of seasonal correction has been based on exchange battery discharge readings and has been calculated from the average busy hour battery discharge for the exchange during the busy period of the year and that during the period of reading. The ratio of the average battery discharge current per exchange line during these two periods has been used as the traffic correction factor for all switching stages within the exchange.

The accuracy of the battery discharge method, even with step equipment, has been unsatisfactory. Readings of the exchange discharge current have normally been carried out on one day each week at half-hourly intervals during the busy period. The actual reading is often irregular in timing, and open to subjective interpretation; that is, the maximum reading observed during the scan period may be recorded by one observer whereas the average reading may be recorded by another person. With a crossbar switching system the small current which holds in the switch verticals, and which is proportional to traffic, is masked by the current surges generated from the operation of common control equipment. Under these circumstances, the battery discharge method can no longer be seriously considered.

Exchange Statistical Meters

Various statistical meters are read on a regular (often weekly) basis in all exchanges. In crossbar ARF exchanges AUM and AIM meters record the total calls outgoing from and incoming to the SL (subscribers') stage respectively. There are, however, several disadvantages in using statistical meters for seasonal correction purposes:

- Because there are separate AUM and AIM meters for each SL marker, considerable effort would be involved in recording and analysing the readings, particularly for larger exchanges.
- The meters record SL marker seizures in the total period between successive readings, i.e. over a minimum 24 hour period, whereas a seasonal correction is required for traffic generated during the busy hour.
- The meters record call attempts which do not have a verifiable relationship to traffic. Calls within a unit time period are related to traffic through the average call hold time, a factor which varies between day and evening periods and may be relatively short during periods of localised network congestion when there may be a high percentage of unsuccessful calls of short duration. Instances have also been observed of faults in cable or aerial plant causing intermittent loops which have doubled normal AUM meter readings over a recording period. It is therefore clear that exchange statistical meters are not a satisfactory basis for seasonal correction of telephone traffic.

Erlanghour Meters

Time-switched erlanghour meters (EHM's) provide a continuous busy period traffic record, which is more suitable than previous methods for assessment of a seasonal correction factor. These meters are generally time-switched for a two hour period spanning the exchange busy hour (normally 0900-1100 hours) on Monday to Friday inclusive and the readings are recorded either daily or weekly. However, the electromechanical EHM's currently in use have had a long and unsatisfactory fault history and require regular maintenance and calibration.

Although this method is used in country Minor Trunk Switching centres where no better alternative is currently available, it does suffer from the following disadvantages:

- The meters sum traffic over the daily two hour busy period and thus do not provide a record of variation of busy hour traffic which is the specific requirement for seasonal correction.
- A considerable amount of clerical effort is re-

quired to read the meters regularly and to forward the data to a central point for collation and analysis.

- Although erlanghour meters have been improved in design they still have inherent weaknesses and require regular maintenance and calibration to retain acceptable accuracy of measurement.

Actual Traffic Measurement

Because the fundamental requirement is a factor to adjust or correct busy hour traffic measured at various periods of the year to the level that would be measured during the busiest month, the ideal solution would involve regular measurement of busy hour traffic throughout the year. Limitations to equipment and manpower resources demand that regular observation can be carried out only from a central facility.

Detailed investigation has confirmed that traffic groups in remote exchanges can be successfully extended over cable pairs to a centralised measurement point. By allowing for a known wire resistance between the remote exchange and the central measuring equipment during the computer processing of the traffic data, the actual value of busy hour traffic in each remote exchange can be determined. This is the basis of the CENTOC system.

THE CENTOC SYSTEM

Although the CENTOC system has been shown to have significant inherent advantages over alternative methods of assessing a seasonal correction factor for exchange originating traffic, there are additional important benefits also supporting the adoption of this system. They are summarised below:

- Provide seasonal correction factors for individual traffic routes
- Ease of data handling and data manipulation
- Assist the scheduling of individual exchange traffic occupancy and dispersion studies
- Assist the prediction of more accurate traffic growth factors on both a micro and macro basis
- Enable observation of macro network behaviour, characteristics, and longer term trends
- Serve as a network management tool

The most important attributes of these aspects are briefly discussed.

Seasonal Correction

In addition to exchange originating traffic, it is often necessary to seasonally correct both STD and operator connected traffic on major trunk routes to obtain adequate accuracy in forecasting future circuit requirements. In fact, all trunk routes incoming to and outgoing from the Adelaide trunk switching centres are included in the CENTOC studies which enables more confident forecasts of trunk traffic growth on these expensive routes.

Data Handling and Manipulation

Because the CENTOC system uses automatic traffic scanning and recording equipment with data output on either punched paper tape or magnetic tape, an increase in the number of traffic groups monitored, say from 50 to 200, involves a comparatively small additional staff effort. Indeed, the most time consuming task is maintaining up-to-date records of circuits connected to each traffic group, and ensuring that additions to circuits on relevant routes have their traffic wiring correctly connected to the exchange traffic IDF. Although extra costs are incurred in computer processing of a larger number of groups, the incremental cost is very small.

Busy hour traffic for all routes in each study is held on magnetic tape and further processing of this data can be readily carried out at any time. For example, a graph of the traffic variation on any route over a predetermined period or statistical analysis of relevant data can be easily obtained from information held in computer accessible form. Combined traffic groups (e.g. ATD originating traffic) can be derived from suitable groupings of measured traffics and plotted or graphed directly using a computer plotting routine.

Scheduling and Frequency of Traffic Studies

The regular flow of information from the CENTOC system concerning originating and backbone traffic from each of the 34 larger metropolitan exchanges enables more efficient scheduling of the metropolitan measurement programme, and enables a heavier concentration of relatively scarce resources on those areas exhibiting more dynamic movements in traffic levels. At the other end of the spectrum, exchanges exhibiting a relatively stable and low growth pattern can be measured less frequently than has previously been possible or desirable. Any major changes to traffic levels requiring more detailed investigation will be obvious from CENTOC results and a full traffic study can be scheduled if considered desirable. A proposed development of the CENTOC system will provide similar benefits to the scheduling of country traffic studies.

In addition to indicating a suitable frequency for the measurement of traffic in each exchange, CENTOC assists scheduling so that as many exchanges as possible have traffic studies taken at times that can be expected to be at or close to their seasonal peak levels. This in turn reduces the degree of uncertainty in current and predicted future busy season traffic levels.

Traffic Growth Factors

To predict future levels of telephone trunk traffic, previous measurement data is used to determine the average annual growth rate for each trunk route. Annual growth rates for different types of trunk route vary widely, typically averaging over 15% for interstate routes, about 10% between Adelaide and country trunk centres and 5% between country trunk exchanges.

Measurements of trunk traffic through the Adelaide trunk switching centres are conducted for a week before Easter and Christmas each year. Estimates of future peak traffics on each route are based on previous readings using a curve fitting technique normally based on an exponential least squares best fit pattern. It is known, however, that not all trunk routes carry their busy season traffic during these periods of measurement but it has not been possible prior to the introduction of CENTOC to predict accurately either the busy period traffic or time of occurrence.

By providing more frequent data points through regular (fortnightly) observations of trunk traffic, it should be possible to narrow the range of uncertainty for base year traffic levels which in turn will lead to improved confidence in extrapolation from historical data. The consequent reduction in the margin of uncertainty made possible by more accurate base year and growth rate data will lead to significant economies in the provision of expensive trunk circuits.

In addition to estimating traffic growth on major routes (micro estimates) estimates are required of the annual growth of *busy hour trunk traffic* for larger groupings of exchanges such as for each Closed Numbering Area (CNA) and the State as a whole. These forecasts may then be compared with estimates of *annual trunk call growth* prepared by other specialist groups. Assuming a relatively constant relationship is maintained over the forecast period, then as an approximation the growth rate of trunk calls and trunk traffic for each CNA should be of the same order of magnitude. This uniformity ensures a more consistent approach in planning for future regional development. More confident forecasts of traffic growth factors on a macro (CNA or State) basis have been possible through the provision of regular data from CENTOC.

Long Term Benefits and Special Network Studies

CENTOC data has been accumulated on a regular and reliable basis since late 1972. A series of observations, such as this, recorded over time is a time series. Time series play an important part in empirical economic investigations. One of the objectives of the analysis of a time series is to forecast how the series will behave in the future on the basis of how it behaved in the past. Before sensible analysis of a time series can be attempted, a minimum of some three years data is usually necessary, and CENTOC now fulfils that condition.

An aspect of interest to long term planners is the secular trend (general long term movement) after removal of periodic variations from the data. Important parameters in this respect are the average originating traffic and the average trunk traffic generated per exchange line. Because it can monitor the whole Adelaide network simultaneously, CENTOC will make possible not only a quantitative assessment of these parameters but will enable observation of their long term and seasonal relationships.

When seasonal and secular trends have been removed from the data, the effect and extent of economic or business cycles on telephone traffic will be detectable. This information will be useful to long term planners as it will more readily identify actual telephone traffic conditions at a point in time in relation to other economic indicators. Because of a dearth of information, little investigation has been carried out in this area but CENTOC will provide the means to understand better the relationships involved between economic conditions and various types of telephone traffic.

CENTOC has already demonstrated its value for special network studies. Following the announcement in the 1973 Federal Budget of several tariff rate alterations and a night/day tariff time change, regular CENTOC measurements were commended at 0800 hours for a three month period beginning September 1973. This study was able to demonstrate that total trunk traffic diminished significantly in the 0800-0900 period compared with the 0900-1000 period after the date of the changeover and, moreover, that this comparative reduction occurred during a period when the total originating traffic within the ATD remained stable.

The CENTOC system is extremely useful for conducting network-wide studies. One particular study was a continuous measurement over a seven day, 24 hour period of all CENTOC traffic groups which was first carried out in July 1974. Studies of this type can immediately provide the following information:

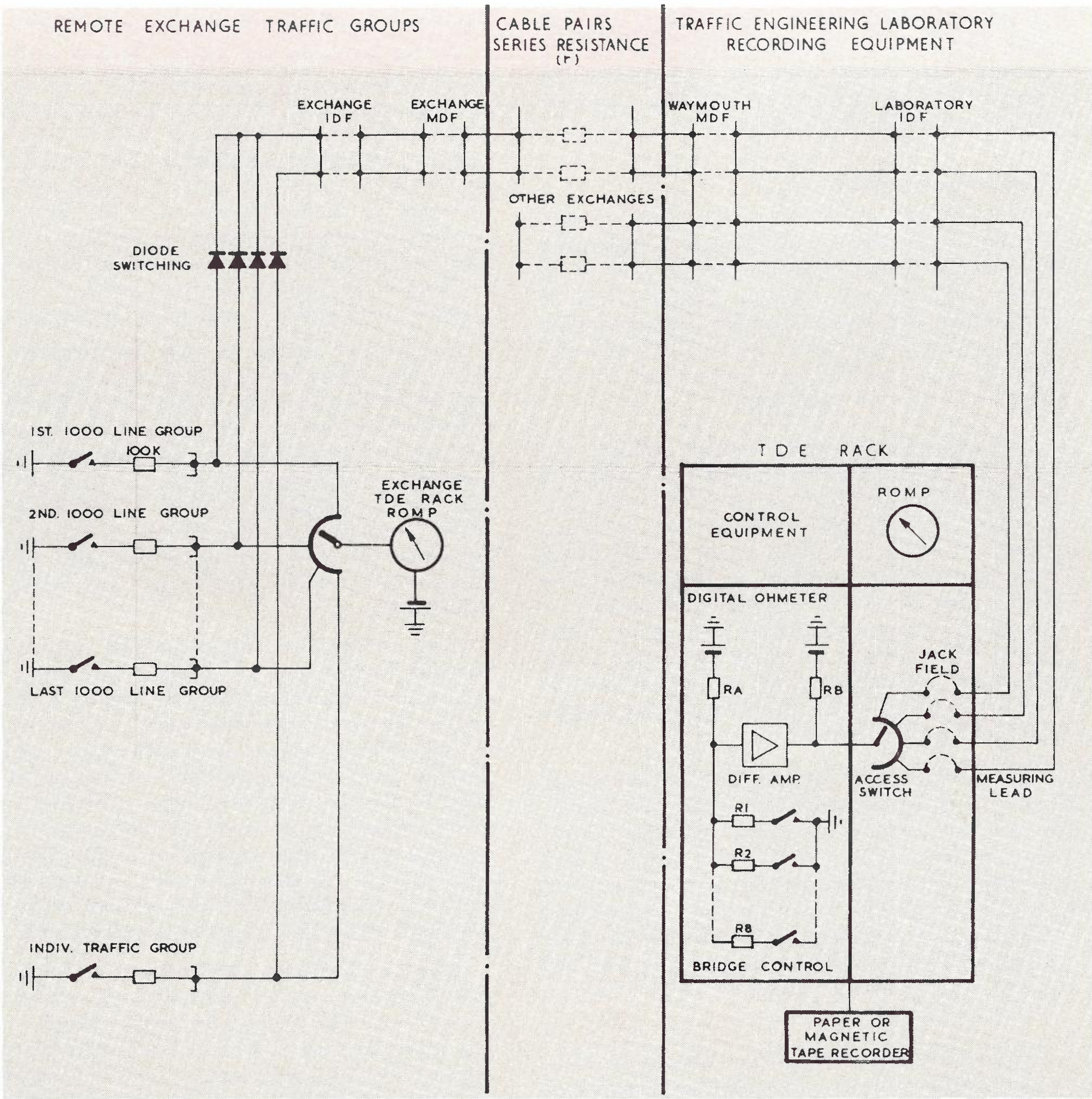


Fig. 1 — Schematic Diagram of the CENTOC Measurement System

- Daily or weekly load factors for both trunk and ADT originating traffic
- Relative variations of trunk traffic compared with subscriber originating traffic
- Amount of 'slack' existing in the network during off-peak periods (including weekends)
- Estimation of revenue earnings

Much of this information, which is invaluable for special network studies, is presently unavailable. However, the principle benefit from periodically programmed continuous studies may prove to be the establishment of an information base for observing future variations to subscriber calling habits and the development of long term trends in the network. In addition, regular 24 hour studies would provide a rapid indicator of trends in revenue earnings from telephone traffic.

A Management Tool

By regular observation of the backbone (final choice) routes, CENTOC provides a means of monitoring the general state of the network. It serves as a network management tool by facilitating the early detection of discrepancies between design and actual traffic values, and enables corrective action to be taken before the occurrence of serious degradation of service standards.

CENTOC has been of considerable benefit to the controlled development of the Adelaide network during the last two years when the strong growth of traffic in the junction and trunk network imposed strains on limited resources. Through regular observation of relevant junction routes within the ATD and trunk routes through the main trunk switching centres, it has been possible to achieve a satisfactory grade of service on all routes by the controlled allocation and re-allocation of the available terminations and circuits only to those routes approaching critical levels of traffic.

To serve as a network management tool, the 'turn-around' time is an important factor. Experience has shown that computer printout of the traffic levels can normally be supplied within two working days of the completion of the measurement phase.

CENTOC has already proved itself as a valuable aid to network management and control from planning and network design viewpoints.

MEASUREMENT TECHNIQUE

In every exchange, the individual 100 K ohm traffic resistors for each device are commoned within a group of similar devices and the group is extended on tie cable to the traffic recorder rack or ROMP panel (Ref. 1). For instance, in crossbar exchanges the traffic resistors in each 1000 line group, comprising 40 to 120 SR relay sets, are commoned. For CENTOC measurements of originating traffic, each 1000 line group is commoned to the exchange ROMP panel via diodes which serve a dual isolating and switching function and the combined group is extended by a wire of known resistance to the Traffic Engineering Laboratory in Waymouth Building. The system is shown schematically in Fig. 1.

Groups that are regularly measured are:

- Originating traffic from all ARF exchanges and large SxS exchanges in the ATD
- Traffic on back-bone (final choice) routes within the ATD crossbar network including terminal to tandem routes as well as tandem-tandem routes. In addition, selected routes from SxS exchanges are monitored.
- Originating and terminating trunk traffic through the Adelaide trunk switching exchanges.

Additional groups are added on a temporary basis from time to time as dictated by design or operational requirements.

In the remote exchange, the diodes maintain the electrical isolation of each CENTOC sub-group (e.g. 1,000 line group) to the exchange ROMP panel on the Traffic Data Equipment (TDE) rack (Ref. 1 & 2), thus permitting exchange staff to read traffic levels on each separate 1,000 line group. In addition, the diodes have a switching function which ensures that local traffic measurements from the ROMP panel take precedence over and are unaffected by remote (CENTOC) measurements. However, centralised (CENTOC) readings which are taken while the same traffic group or a related sub-group is switched to the local ROMP panel will be erroneous. Thus, during the normal two hour recording period, operations staff are requested to avoid monitoring for more than a few seconds at a time any traffic group connected to the CENTOC facility.

Assistance and co-operation is required from both Construction and Operations areas to connect traffic wiring to the appropriate group immediately additional circuits for a CENTOC group are cutover and to advise the Traffic Section of any such changes to these groups. To a large extent the validity of the input data and hence overall benefits of the CENTOC system are dependent on the continuing close co-operation of these other functional areas.

The automatic recording equipment in the central measuring laboratory scans each traffic group in three minute cycles and measures the resistance of the traffic group and line using a bridge technique. The balancing is automatic and, as the balancing resistance is a sum of binary increments, the resistance of the (traffic groups + cable) is available as a binary number which is recorded on paper or magnetic tape. The paper or magnetic tape is processed by a computer to remove the effect of the cable series resistance from each individual reading and to calculate the time consistent busy hour traffic for each route.

If RT is the overall resistance in ohms of the remote traffic group, r is the series resistance of the junction cable (ohms)

RY is the balancing resistance (ohms) in the bridge consisting of appropriate combinations of R1 to R8 in parallel

R is the ratio of the two fixed bridge resistors (RA/RB) and n is the number of circuits in use, then it can be shown at balance that:

RT= RY/R — r ohms and n = 100,000/RT

It is worthwhile noting that although the maximum equivalent traffic reading of the digital ohmmeter is approximately 200 erlangs, the compression effect of the cable series resistance enables traffic of much higher value to be read as a single group (up to 1,000 erlangs).

OUTPUTS AND PROCESSING

Several types of computer output are produced from the CENTOC system, the main ones being:

- CENTSUM — This output is produced for each study. See below for details, and Fig. 2 for a copy of a sample printout
- CENTLIST — A listing of the traffic history for either selected groups or all groups. This printout is normally produced about three times per annum and reference to the latest CENTLIST and CENTSUM outputs will give the complete traffic history of any route. A sample print-out for CENTLIST is shown in Fig. 3. The date of each study is related to the position of the traffic reading in the matrix.
- CENSTAT — This series of programmes, which is still under development, carries out statistical analysis of selected traffic groups which can include graphing of measurements over a given time cycle. The objective is to undertake trend analysis on specified traffic groups and to forecast expected traffic levels up to 12 months in advance.

In CENTSUM, the printout for each traffic group includes TCBH readings for that group for the previous nine studies to enable comparison of the latest reading with recent data in order to facilitate detection of short-term trends. The traffic from the latest study is entered on the right hand side of the printout while each previous study is moved one position to the left. Although not appearing on the printout, earlier study information is retained on magnetic tape and can be recovered whenever desired. Various users of CENTOC information have somewhat conflicting requirements. For example, to be effective as a network management tool the traffic groups approaching grade of service limits or showing significant variation from the normal are high-lighted to avoid the necessity to analyse each group individually to detect such information. This is achieved in the CENTSUM programme by printing out a separate 'Exceptions List' of traffic groups which do not meet predetermined requirements. The aim of the 'Exceptions' printout is to list those groups that require further investigation because of heavy loading or unexpected or erratic behaviour.

Two tests are applied to the latest measurement on each traffic group. A group will be included in the Exceptions List if the reading:

- Exceeds a specified average traffic load per circuit. The level of the constraint varies with the type of traffic group considered, but the value has been individually selected as an appropriate action limit for that group.
- Varies from the mean of the ten previous readings by more than three standard deviations.

This constraint is intended to identify groups that exhibit marked variations from the normal pattern of behaviour which may justify further investigation to discover the underlying cause.

In both the normal and 'Exceptions' listings, a group is indicated as having exceeded the predetermined requirements by an asterisk near the '(E/TK)' value. The position of the asterisk specifies which constraint has been exceeded.

Maximum and minimum circuits occupied in the most recent measurement are listed under the 'NEW MAX MIN' heading of the CENTSUM printout.

Data Handling

The computer processing routine can be followed by reference to the flow diagram in Fig 4. The measurement data on magnetic tape is fed into the computer in conjunction with a deck of cards containing supporting data such as date of study, special comments concerning alterations to traffic groups, route names and number of trunks on each route.

After processing by computer, detailed half-hourly traffic levels and a summary output containing TCBH traffic and time of occurrence for each group are filed on magnetic tape. This detailed information is retained for three studies after which the tape is re-used. The busy hour traffic level for each route is then associated with historical information of previous studies on that route using one of the master files which are rotated in the 'grandfather', 'father', 'son' configuration to maximise security of data.

The CENTSUM programme also produces the normal printout listing of all traffic routes monitored during the study, with the Exceptions List at the end of the printout.

Distribution

CENTSUM and CENTLIST outputs are distributed to relevant Planning, Operations and Network Performance areas.

COST/BENEFIT ANALYSIS

The main points for consideration in a cost/benefit analysis are summarised below.

SEQ.	LAMP	TRUNKING GROUP	AVAIL	TRUNKS	060175	200175	030275	170275	030375	100375	210375	010475	140475	280475
							T.C.B.H. TRAFFICS (E/TK)							
1	9	BLACKWOOD SR FROM-		330	139.5	147.6	148.7 (.60)	143.0	146.9	136.8	143.0	151.8	150.0	149.0
2	10	BRIGHTON SR FROM-		823	332.7	361.5	364.7 (.54)	353.4	371.5	366.4	345.8	379.8	360.8	375.0
3	4	CROYDON U/S FROM-		428	213.7	248.7	263.9 (.60)	256.0	245.2	254.7	254.9	247.6	250.0	251.6
4	8	EDWARDSTOWN SR FROM-		909	328.0	377.4	393.6 (.54)	379.9	408.4	407.7	402.9	388.9	399.8	401.4
5	34	ELIZABETH SR FROM-		402	166.0	199.6	196.2 (.60)	196.7	199.2	202.4	202.3	194.2	198.2	200.4

Fig. 2 — Typical CENTSUM Output

SEQ.	LAMP	TRUNKING GROUPS	TRUNKS (E/TK)	T.C.B.H.TRAFFICS									
1	9	BLACKWOOD SR	330	125.9	125.9	129.9	126.7	130.4	136.9	135.0	131.7	133.6	121.8
		FROM-	(.60)	122.0	126.6	91.9	116.4	121.2	115.8	117.8	111.7	117.2	115.0
				119.8	109.2	115.0	122.7	106.5	115.7	111.9	109.2	110.3	112.6
				109.2	123.2	117.8	117.8	119.0	127	152.5	127.1	144.4	147.4
				139.3	150.5	146.6	143.5	142.3	151.4	159.7	142.8	144.2	145.0
				137.2	150.6	143.3	137.3	148.4	140.0	154.5	150.8	158.0	142.0
				146.6	153.7	157.7	163.0	139.5	147.6	148.7	143.0	146.9	136.8
				143.0	151.8	150.0	149.0						
2	10	BRIGHTON SR	823	307.9	313.6	336.8	317.4	339.1	341.0	336.9	339.3	329.5	328.9
		FROM-	(.54)	337.1	390.4	281.2	329.2	343.1	320.3	341.8	336.5	331.0	343.3
				356.3	324.4	352.7	347.8	332.4	341.1	335.9	345.1	341.5	336.0
				346.3	350.4	359.7	368.6	357.7	360.6	365.3	309.7	349.2	349.8
				348.9	340.9	351.2	356.6	358.9	376.9	369.6	354.2	361.4	358
				355.5	366.1	360.8	370.0	362.6	368.7	365.7	382.2	379.0	333.3
				354.2	361.4	380.0	399.5	332.7	361.5	364.7	353.4	371.5	366.4
				345.8	379.8	360.8	375.0						
3	4	CROYDON U/S	428	.	.	.	.	208.4	218.4	211.0	205.2	209.5	214.0
		FROM-	(.60)	221.5	226.4	167.5	209.4	223.7	220.7	226.5	222.9	223.5	231.2
				228.2	220.9	227.3	236.3	217.5	224.8	229.9	230.3	231.2	228.1
				235.0	250.1	233.6	233.6	238.7	233.7	249.1	201.4	239.7	257.6
				241.3	254.3	249.3	251.6	254.1	254.0	249	244.4	249.9	243.6
				246.5	240.8	237.3	232.2	245.7	237.4	237.1	239.2	237.1	226.5
				250.6	261.0	261.1	270.7	213.7	248.7	263.9	256.0	245.2	254.7
				254.9	247.6	250.0	251.6						
4	8	EDWARDSTOWN SR	909	366.5	374.0	387.4	377.1	385.9	393.7	365.5	369.6	372	375.6
		FROM-	(.54)	384.0	398.9	324.4	378.0	387.4	378.5	383.9	378.5	379.7	396.3
				392.7	373.8	387.2	392.7	391.3	388.7	385.9	385	385	384.5
				398.0	402.8	414.0	393.7	400.1	399.5	418.7	341.0	395.5	399.6
				407.0	415.5	405.3	401.9	403.6	417.5	394.0	389.3	390.2	381.0
				387.6	397.1	400.4	394.4	399.2	392.6	399.4	404.1	417.5	382.7
				391.8	382.9	402.1	407.1	328.0	377.4	393.6	379.9	408.4	407.7
				402.9	388.9	399.8	401.4						

Fig. 3 — Typical CENTLIST Outp'

Cost

The costs of operating the CENTOC system can be sub-divided into three areas:

- Initial Setting-up Costs — rearrangement of traffic wiring in exchanges and installation of isolating diodes etc
- Fixed Costs — permanent use of junction cable throughout the network
- Variable Costs — maintaining records and equipment, conducting studies and computer processing

Benefits

Although the benefits of the CENTOC system are more difficult to quantify than the costs, the following break-down reflects the general picture.

- Reduction in chart study measurements requested on an 'ad hoc' basis to observe critical points in the network
- Reduction in special studies previously required to closely observe and monitor the growth of trunk route traffic
- Savings in trunk and junction circuits made possible by both improved estimates of SCF's and by fine tuning or design control of the network whereby existing circuits are rearranged to maintain satisfactory grade of service on all routes
- Reduced frequency of studies, particularly of exchanges exhibiting a low and stable growth pattern as any variation to the pattern will be observed as it occurs
- Intangible factors, including the increased confidence of the planner that the network is operating satisfactorily and the knowledge that sufficent notification of the development of any undesirable trend will be received to enable corrective action to be taken before congestion becomes too serious.

Other intangible benefits include the opportunity to observe macro network behaviour and changes in subscribers' calling habits, more accurate determination of daily and weekly load factors and the accumulation of other data of benefit to the planning of the network.

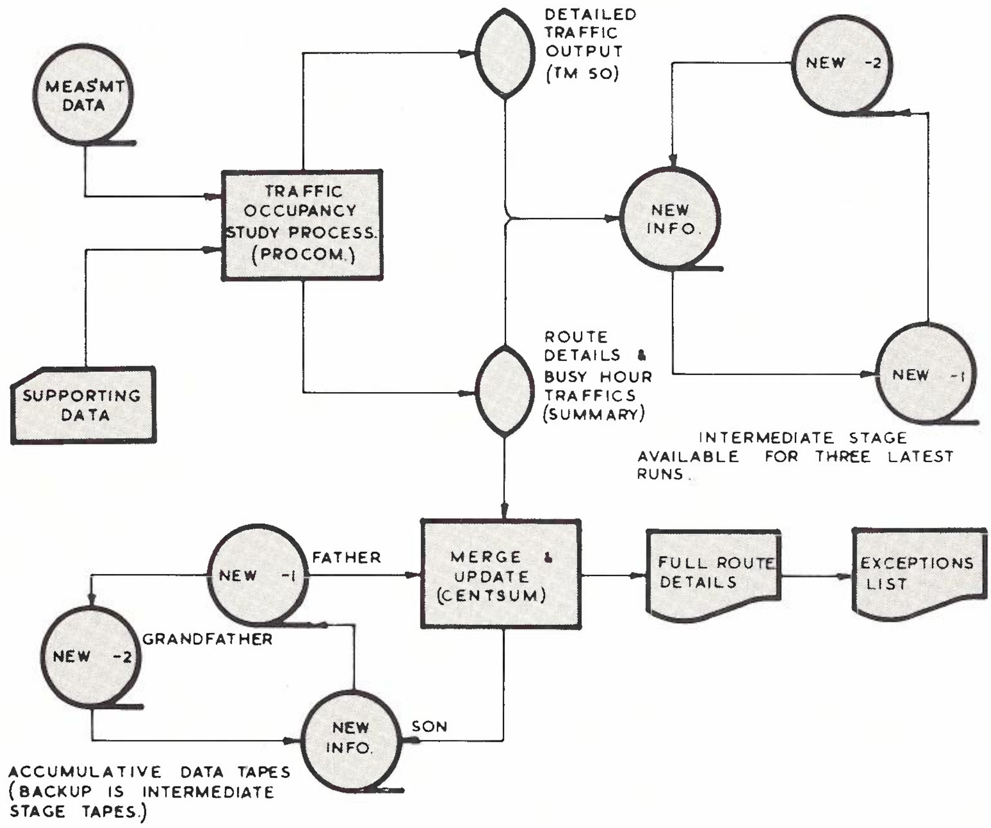


Fig. 4 — Computer Processing Flow Diagram

An economic analysis has shown total annual costs of $20,000 compared with annual tangible benefits of $25,000. Although tangible benefits exceed costs only slightly, the value of the intangible benefits tip the scales heavily in favour of CENTOC.

FUTURE DEVELOPMENT

A logical extension of the CENTOC system will encompass measurements of originating traffic in each country trunk switching centre and of the inter-exchange routes between these centres. To achieve this objective, an economical method of quantifying analogue data into digital form and transmitting the information over carrier derived 75 baud telegraph circuits is necessary.

Although resources are limited, the Traffic Engineering Section has designed and constructed a prototype Remote Traffic Monitor and Recorder which will measure and transmit traffic information on up to eight traffic groups upon command from a central facility. The aim is to develop this device to operational standard during 1976 and then to include the specified additional groups into the system. At that stage all important higher order routes within the State will be monitored on a regular basis.

In addition, the Remote Monitor will have application in the ATD SxS network as it will enable the regular measurement of grade of service routes from SxS exchanges. Many of these are not monitored by CENTOC at this stage because of the existing resource consuming requirement of one wire per traffic group to extend each group to the measurement facility. Looking further into the future, the development of this system has opened the way to the 'real-time' measurement of network traffic. By applying the CENTOC concept and storing the results from each three minute reading cycle in a mini-computer in lieu of on paper or magnetic tape, it would be possible to receive half-hourly or even instant print-outs of telephone traffic on any desired circuit or group of devices. This would be virtually the ultimate network management tool.

CONCLUSIONS

This article has attempted to provide a broad appreciation of the aims and objectives of CENTOC and the method of approach adopted to achieve these targets. While the system was conceived mainly to provide better data on seasonal fluctuations of exchange originating traffic for study correction purposes, it now has another important function, that of monitoring the state of the Adelaide Network. The latter is made necessary because of the truism of alternate routing — the added flexibility designed into the system makes the system more susceptible to congestion. As system congestion first becomes evident by an increase of traffic on the back-bone routes, monitoring of selected routes enables a constant check on the network. CENTOC provides a much required early-warning system in this regard and also assists operations staff to detect trends towards local exchange congestion.

However, the principal benefit may prove to be the opportunity to observe macro and micro network behaviour of local and trunk traffics. An information base has been established from which future traffic variations can be measured and related to policy changes and long term trends. CENTOC has already proved its value for special network studies to correlate tariff changes and subscribers' behaviour but this is only the tip of the iceberg. From the data available growth rates can be determined with more confidence for longer term forecasting, correlation with business activity can be sought to improve shorter term forecasts and relationships between tariff changes and traffic levels can be established and predicted. Finally, when extended to continuous 24 hour monitoring of the network, CENTOC becomes a valuable aid to business management and could provide a clear indication of revenue trends.

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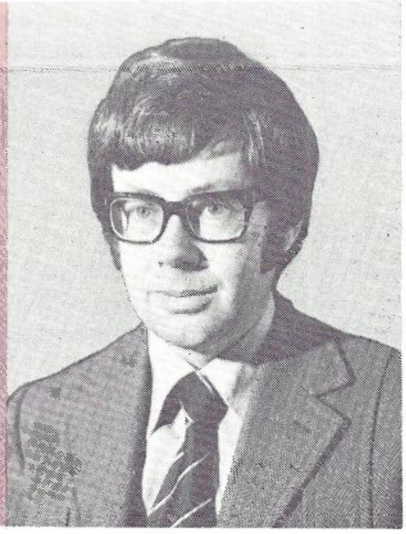
1. Pratt, C. W.: 'Development and Application of Telephone Traffic Measuring Equipment (Part 1)'; Telecom. Journal of Aust., October 1973, Vol. 23, No. 3, pp 205-209.
2. Tyrrell, L. A.: 'Development and Application of Telephone Traffic Measuring Equipment (Part 2)'; Telecom. Journal of Aust., Vol. 24, No. 1, pp 36-43.

GEOFF MARLOW graduated from the University of Adelaide in 1964 as a Bachelor of Engineering after studying under a PMG cadetship. He then worked in the Workshops Section as an Engineer Class 1 and Class 2 for 3 years, including a short period at Headquarters concentrating on conversion of State Workshops to the manufacture of crossbar relays and relay sets. In 1968 he was transferred to Whyalla as a District Engineer where he was responsible for the maintenance of the East-West Microwave System within South Australia. In 1972 Mr. Marlow commenced in the Planning and Programming Branch, where he worked in the Traffic Engineering field for three years before recently transferring to Fundamental Planning. He is in the final year of a Bachelor of Economics course at the University of Adelaide.



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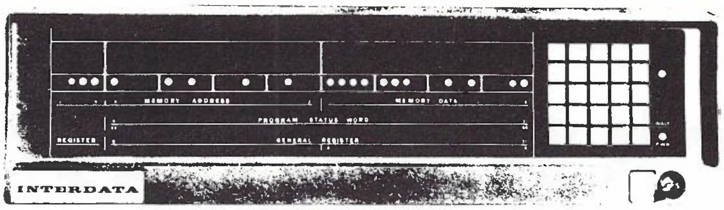

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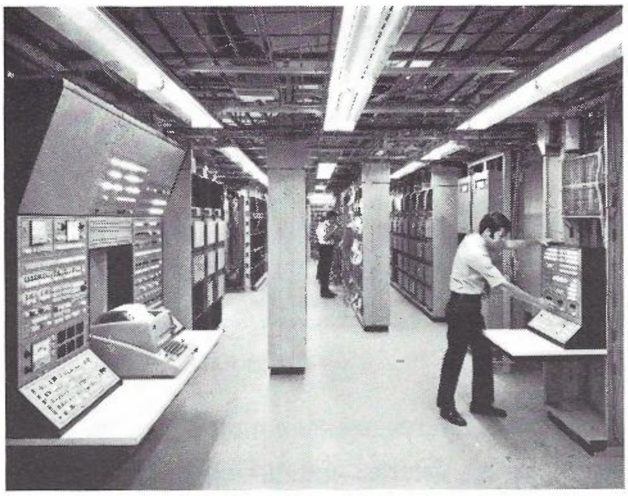

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In addition to these administrations, 35 also have in service or on order the C-1 EAX stored-program controlled system designed for small-to-medium size telephone exchanges.

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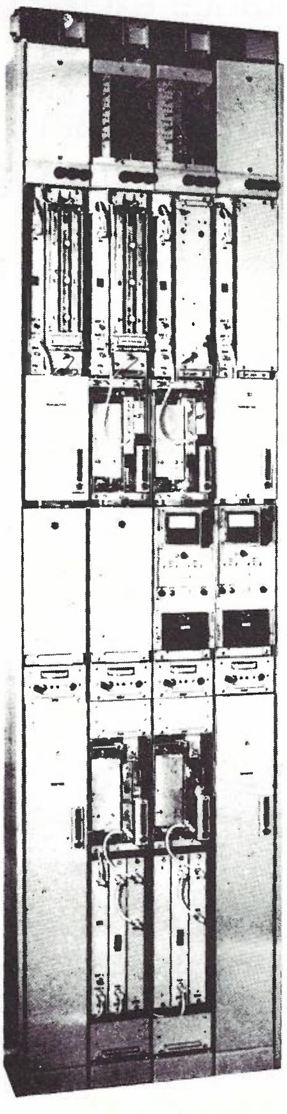

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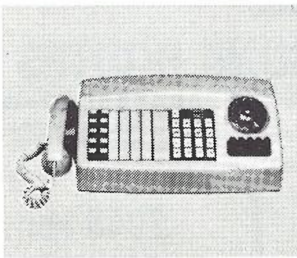
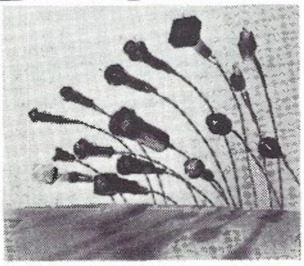
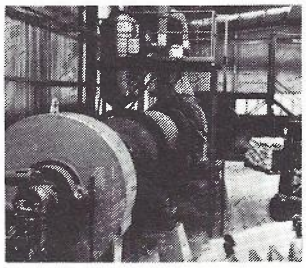


'PABX' — manufactured by Plessey Telecommunications, this private automatic branch exchange system employs crossbar switching and componentry similar to that used by the Australian Post Office in the national telephone network.

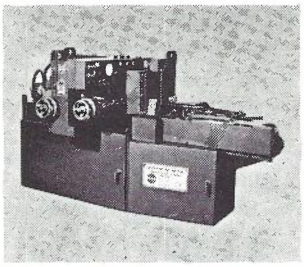


Plessey Rodan indicator lamps designed for compatibility with and to enhance the presentation of electronic, electrical and industrial equipment. These indicator lamps are just some of the vast range available from Plessey Ducon.

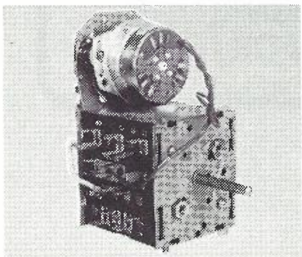
The 'do-it-yourself' stereo amplifier kit from Plessey Ducon. This simple and easy to assemble kit will provide truly first class reproduction at a cost far below that of equivalent powered units.



Plessey Rola is Australia's largest manufacturer of magnetic materials. Under agreement with B.H.P., Plessey have exclusive marketing rights for hematite and ferrite powders produced from Yampi Sound.

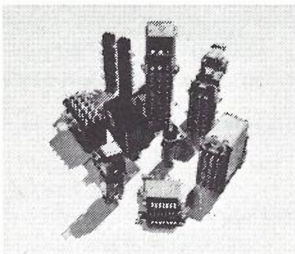


Designed and produced in Australia by Plessey Telecommunications, the 'Computermatic' timber grader completely eliminates the guesswork from visual timber grading. Electronic grading ensures that timber is accurately classified by strength and stability before use.

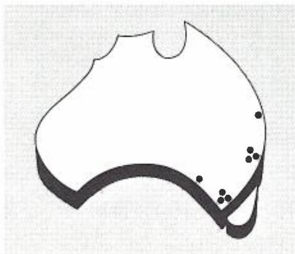


Plessey Mallory interval timer switch — commonly used in automatic washing machines and electric ranges are supplied by Plessey Ducon located at Villawood, N.S.W.

This direct reading digital clock is one of a wide range of models supplied by Plessey Communication Systems. Extremely accurate, the clocks are built for indoor use or weatherproofed and illuminated for outdoors.



Some of the wide range of multi circuit connectors marketed by Plessey Ducon, all of which are reliability and quality proven.



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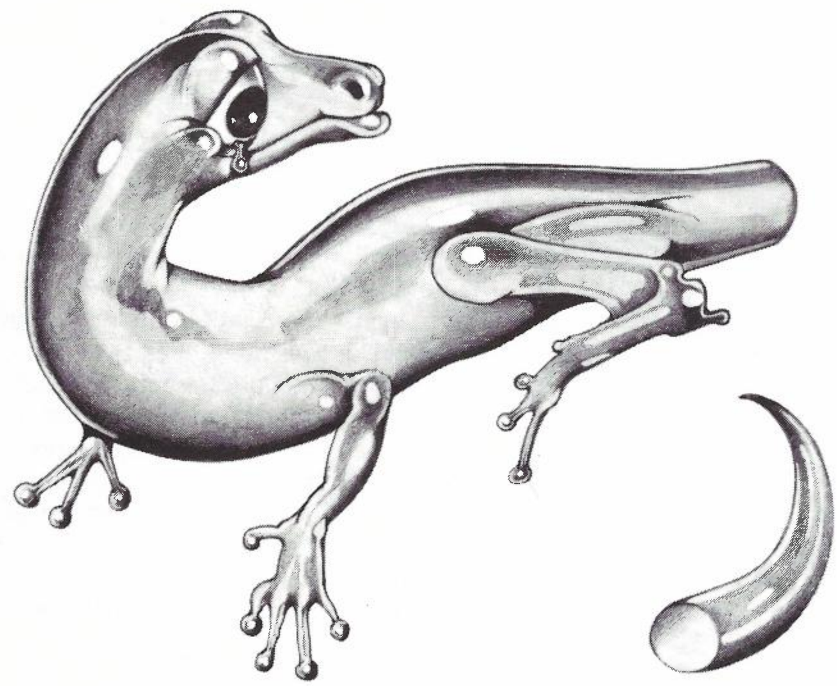

ABSTRACTS: Vol. 26, No. 1 (continued).

SADOA SAKAMOTO: 'Maintenance Management Performed by NTT'; Telecomm. Journal of Aust., Vol. 26, No. 1, 1975, page 41.

Telecommunications maintenance service currently furnished by NTT has reached an extremely high level. It is believed that the principal factors which contributed to the improvement of this maintenance service are constant actions for improvement taken, such as positive development and introduction of new techniques, establishment of a maintenance control system based upon the quality control method, and the accomplishment of 3-year programs of maintenance affairs.

This article describes how maintenance service is being furnished by NTT and how it has been improved, referring to the measures taken by NTT, such as the introduction of newly developed techniques and a maintenance control system which contributed greatly to the improvement of maintenance service. This article also refers to various matters with which NTT is faced in carrying out maintenance activities and the manner in which NTT will take measures to meet them.

WATSON, D. R. and WILLIAMS, L. J.: 'The East-West Microwave Radio Relay System — A South Australian Operational Report'; Telecomm. Journal of Aust., Vol. 26, No. 1, page 58.

The East-West Microwave Radio Relay System was, at the time, the largest broadband project ever to be undertaken by the Australian Post Office. It completed the first broadband link between Perth and the rest of Australia. Special design concepts, outlined in a description of the new system given in Issue 1, Volume 21 of the Journal (February 1971), were used to overcome problems peculiar to the situation.

This first part of the South Australian report reviews traffic performance and reliability aspects of the system in the light of these concepts and changes found necessary to them under operational conditions. The second part, to be published in a later edition of the Journal, describes the maintenance philosophy adopted in South Australia, the staff organisation, and also the modifications found necessary to optimise equipment performance and maintenance costs.

The Telecommunications Journal of Australia

ABSTRACTS: Vol. 26, No. 1.

DURAND, E. L.: 'Metaconta 10C Operator Toll Exchange for Australia'; Telecomm. Journal of Aust., Vol. 26, No. 1, page 10.

The Metaconta 10C stored program controlled Trunk Exchange system selected by Telecom Australia as the new standard switching system for large STD trunk exchanges in Australia also provides a new, highly automated, manual trunk exchange system featuring modern data base information storage and retrieval systems. This article describes the design features of this manual assistance system and relates the manual call handling to the STD call handling system.

FEGENT, H.: 'Call State Transition Diagram for Crossbar Exchanges'; Telecomm. Journal of Aust., Vol. 26, No. 1, page 68.

This brief article describes a Call State Transition Diagram of a local call in a typical ARF Crossbar telephone exchange.

LEES, R. P. and HODGSON, J. D.: 'Colour Conversion of National Television Transmitting Stations'; Telecomm. Journal of Aust., Vol. 26, No. 1, page 18.

Telecom Australia is responsible for the installation and operation of the television transmitting stations providing the National Television Service. This paper describes the approach adopted by the then Post Office in converting these stations for colour, including the performance investigations undertaken and the equipment modifications required to allow the introduction of a colour television service on 1st March, 1975. The paper also describes the configuration of facilities adopted at the converted stations and concludes with a discussion of the problems of converting the Hobart station while maintaining service.

MARLOW, G. O'H.: 'CENTOC — Towards Centralised Traffic Measurements'; Telecomm. Journal of Aust., Vol. 26, No. 1, page 72.

The problem of assessing a season correction factor to adjust measured telephone traffic in each exchange to busy season levels has always been an area of difficulty for traffic engineers. Conventional methods are surveyed and shown to be unsuitable. To overcome this problem the CENTOC system, a method to measure traffic in exchanges remote from a central locality, has been developed.

Although a prime, original objective of the system was the determination of more accurate seasonal correction factors, CENTOC has assumed importance as a design control facility for planners and as a network management tool which is capable of development to a real time network management system.

The system is shown to have a favourable cost/benefit relationship and to have important application in the wider sphere of business management of the telephone network.

METZENTHEN, W. E.: 'The Long Line Telephone — Telephone 804'; Telecomm. Journal of Aust., Vol. 26, No. 1, page 32.

Among the telephones used by the Australian Telecommunications Commission is a special high performance model (Telephone 804) intended for use on high-loss subscribers' lines. The principal features of the telephone are a semiconductor transmitter amplifier with volume limiting and a precision plug-in balance network for sidetone control.

This paper gives some of the background of the development of the telephone and discusses the principles of some of the circuit techniques used. Some aspects of the performance of the telephone are described and some of the restrictions which must be placed on its use are mentioned.

OMOND, D. J.: 'Darwin Cyclone Tracy — Telecommunications Network Survivability and Security'; Telecomm. Journal of Aust., Vol. 26, No. 1, page 3.

An examination of the underlying reasons for the failures which occurred in the Darwin telecommunications network has enabled a number of principles to be recognised relating to the design of such networks to ensure survivability under conditions imposed by natural disasters. The results of applying the contingency planning approach to the Darwin network are then recorded and some possible questions relating to day-by-day network security are discussed.

ROSS, N. G.: Co-ordination of Power and Telecommunications Systems — Joint Conference, Hobart, November 1975'; Telecomm. Journal of Aust., Vol. 26, No. 1, page 52.

At least every four years since 1953 there has been convened a Joint Conference between representatives of the Australian Post Office (now Telecom Australia) and the Electricity Supply Association of Australia to discuss problems of power system interference to telecommunications and their resolution. This article describes the events at the November 1975 Conference, which met in Hobart.

(Continued on page 90)

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