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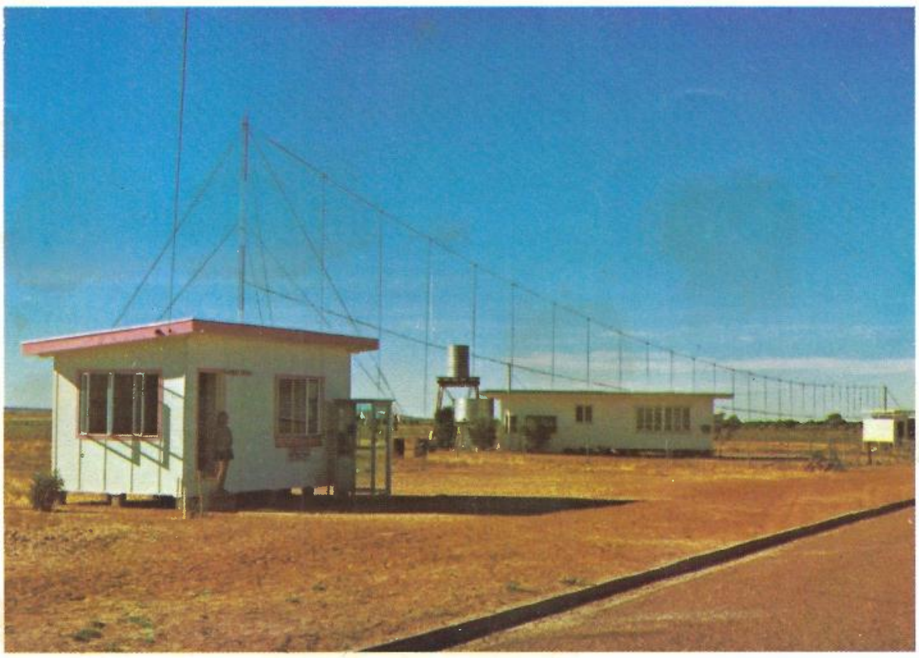

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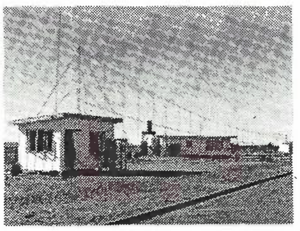

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OVERSEAS APPLICATIONS

The General Secretary, Telecommunication Society of Australia,
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Waymouth 10C Stored Program Controlled Exchange

K. W. ALLISON, M.I.E. Aust. and R. H. WESSON, B.E. (Hons.).

The Waymouth Exchange fulfilled a strategic role in the introduction of the 10C system to the Australian Trunk network as the 'test bed' for the manual assistance facility. The earlier installations at Pitt in Sydney and Lonsdale in Melbourne were cutover late in 1974 and 1975 respectively, switching initially only STD and later ISD traffic. This article will deal briefly with the testing, commissioning and early operational performance of the Waymouth Exchange with particular reference to the concepts used in testing the manual assistance facilities. Readers are directed to the article by E. L. Durand, Vol. 26/1, for design features of the manual system.

INTRODUCTION

The Waymouth 10C Trunk Exchange in Adelaide was the third of its type to be installed in Australia but the first in the world to combine the specialised manual assistance facilities with the STD and ISD traffic switching function.

The equipment was designed at the Bell Telephone Manufacturing Company (BTM) of Antwerp and installed by Standard Telephones and Cables (STC) Pty Ltd of Sydney. The switching equipment, together with the control processors, was installed on the 5th floor of the Waymouth Exchange Building and the manual assistance equipment on the 9th floor. Installation of the equipment commenced early in 1973 and the exchange was commissioned into the network on 13 August 1976.

The manual assistance facilities provide for three services; namely, national and international manual assistance, appointment and reminder (ANR) and an interception service centre (ISC). The unique and complex nature of these facilities presented particular problems to both STC and Telecom Australia in testing the exchange, and involved the use of multi-disciplined teams comprising engineers, technical officers, telephonistes, traffic officers, computer programmers and accountants over a considerable period of time. The need for this was particularly evident with the 10C output to ADP where this was automatically processed by off line computers right through to the preparation of subscribers' accounts, and for traffic and system management information.

THE WAYMOUTH EXCHANGE

The Waymouth Exchange is the main originating trunk switching exchange in Adelaide for STD and ISD and functions as a co-main with the Adelaide ARM exchange for terminating traffic. It also provides the international manual assistance centre for South Australia, the appointment and reminder service for the Adelaide Telephone District and has a capability to provide the Interception Service Centre for South Australia when this facility is required. Fig. 1 is a view of part of the International Manual Assistance Centre. A monitorial group of eight positions, a monitor's position and the supervisor's position can be seen.

The following were the principal dimensions of the exchange at cutover:

- Installed Capacity
  — 4,096 inlets — 4,096 outlets
- Trunk Circuits Connected
  — 2,200 inlets — 2,000 outlets
- International Manual Assistance Centre (MAC)
  — 12 operators' positions
  2 monitors' positions
  1 supervisor's position
- Appointment and Reminder (ANR) and Interception Service Centre (ISC)
  — 14 operators' positions
  2 monitors' positions
  1 supervisor's position
- Operator Training Centre for MAC
  — 1 training control position
  2 operators' positions
- Service Assessment
  — 2 STD positions
  1 manual assistance position.

Fig. 1 — International MAC — 8 Operating Positions with Associated Monitor and Supervisor Positions.

TESTING OF THE MANUAL ASSISTANCE FACILITIES

From a contractual point of view, testing of the exchange was performed in two stages. Initially, STC undertook comprehensive installation testing which was oversighted by Telecom Australia, and when an agreed standard of performance had been achieved, the exchange was handed over to Telecom Australia for acceptance testing. The techniques for testing were developed jointly by STC and Telecom Australia whilst the system was being designed at BTM in Antwerp. The magnitude of this task can perhaps be gauged by the fact that over 40 different test documents, totalling some 2,000 pages in all, were produced for the manual assistance facilities. The testing philosophy employed by both STC and Telecom Australia was similar and could be considered in three basic categories.

Wiring and Hardware Testing

Interconnecting wiring and cable termination were tested for accuracy and continuity by conventional methods. The majority of testing of hardware equipment items was then performed using specially prepared test software using programs run on the exchange processors which had been installed and fully tested very early in the installation phase.

The hardware to be tested was:

- Equipment in the switchroom such as operators' connect circuits, junctors and the switching network;
- Equipment in the processor room such as disc memories and control equipment for data flow to and from the manual assistance centre;
- Equipment in the manual assistance rooms such as operating positions of all types.

Facility Testing of Software Packages

The purpose of this testing phase was to ensure that all the required facilities were provided in accordance with the specifications and that all incorrect position operating procedures and fault conditions encountered were correctly treated.

Tests of the following features were performed:

- Position facilities for national and international manual assistance, appointment and reminder, and interception services centre;
- Call handling for all three services;
- Output of call details for billing of customers and other statistical data to magnetic tape for subsequent off-line processing;
- Takeover and recovery — that is, the action taken by software to minimise the effect, as far as the subscriber is concerned, of failure of hardware items due to either a fault condition or a planned outage;
- Disc handling and recovery procedures — recovery in this situation means the action taken by operation staff to ensure that information stored on the discs can be recovered in the event of disc failure;
- Man — machine communications — the processes by which staff communicate with the system using the teletype;
- 'On Line' and 'On Demand' test programs.

It is interesting to note that there are ten different types of manual assistance positions to provide the facilities for a complete manual assistance centre and thirteen documents were necessary to test them. An additional three documents were prepared detailing all call handling situations where approximately 250 different tests were required. This is most significant when compared with the STD call handling testing for the initial installation at Pitt in Sydney, where approximately 100 tests were required.

While the software package testing was in progress, all translation tables of site dependent data were thoroughly checked as was the translation table associated with call charging for the manual assistance centre. The 'Number to Name' table which is an integral part of the national and international manual assistance had over 6,000 entries covering every destination in Australia and every overseas country. Checks were required for place names, charging, special characters to indicate surcharge and distant end information, and for routing for every table entry.

Integration and Live Traffic Testing

The software package testing revealed problems which resulted in software corrections being made to the package. At times these corrections and individual packages interacted with each other and difficulties were also experienced with timing problems within and between packages which could not always be detected in individual package testing. It therefore became essential to hold 'integration' runs in which as many 'debugged' packages as possible were operated simultaneously. Initially, the runs were quite simple, but as problems were solved and confidence in the system developed, they were increased in complexity until, eventually, all packages could be operated simultaneously for long periods.

Integration runs also became necessary to validate new issues of the system software which were produced periodically by the STC software centre in Sydney.

PROVISION OF TESTING TRAFFIC

Test traffic for the manual assistance centre was provided in four ways, the particular method employed in any situation being dependent upon the overall performance of the exchange at that particular time.

Initially, all calls were generated manually by testing staff using specially provided telephone instruments installed in the manual assistance centre. These instruments were connected via appropriate relay sets directly to group stage (GV) inlets in eight metropolitan crossbar exchanges in the Adelaide area. These inlets had access to routes from those exchanges to the 10C exchange (refer Fig. 2). Test calls could therefore be made from these telephones into the customer queues and the software associated with queue assignment and gathering of queue statistics could be dynamically tested. The traffic could be started, stopped and varied as required, and particular call types booked to test call handling software. Test sheets were prepared for tests to ensure that all operations were checked and all test calls were accounted for. This latter aspect was particularly important in the checking of the ADP output for charging details of the calls.

The next stage of testing involved the use of live traffic from the Telecom Australia PABX in Adelaide and was principally required to increase the volume of test calls. A spare level from the PABX was trunked into the 10C exchange and at pre-arranged times staff throughout the Commission were requested to direct their normal trunk calls via the 10C manual assistance centre.

In the third stage, live subscriber national traffic for bookings and enquiry levels from six selected metropolitan crossbar terminal exchanges was provided. Traffic studies had indicated that national manual assistance traffic from these terminals could fully load the twelve installed operating positions. The trunking of the traffic was achieved by modifying the route parameters (NK switching) in the GV stages of the terminal exchanges. (Refer Fig. 2). Control of the NK switching in each individual exchange was provided remotely in the Mainten-

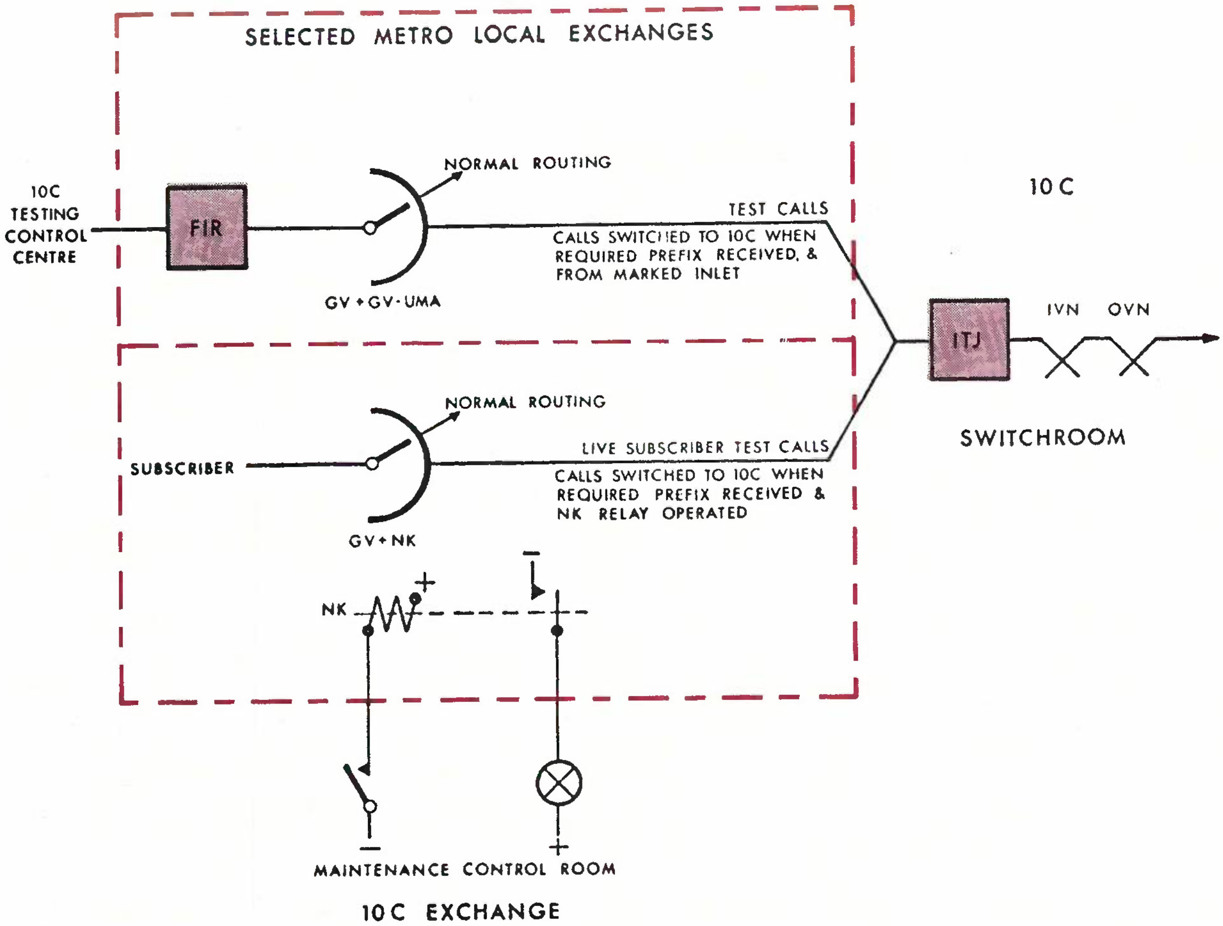

Fig. 2 — Provision of Test Traffic.

ance Control Room of the 10C exchange. This technique enabled rapid switching of traffic into and out of the queues and proved to be most successful during periods when complex software problems developed and it became necessary quickly to divert traffic back to the old manual assistance centre to avoid inconvenience to subscribers.

In the final traffic testing stage the total international manual assistance traffic from the existing trunk exchange in an adjacent building was transferred to the Waymouth 10C Exchange. This was more difficult to achieve as it involved providing access to the 10C Exchange from all Adelaide subscribers and country, interstate, and overseas operators. The transfer was performed by loading appropriate paper tapes into the 10C Exchange to effect the routing, and also by changing relay sets in the former exchange.

During all of the above test traffic stages, arrangements were made to switch live STD traffic through the exchange from the majority of metropolitan exchanges using the NK switching technique in the terminal exchanges as described above for the re-routing of manual calls.

Test traffic for the appointment and reminder service was provided in the same manner as employed in the initial stage of testing the manual assistance facility. The test calls were directed to a series of telephones in the manual centre, thus enabling the one team to initiate and check all calls. Each of these test calls was finally checked against the output to ADP tape as for manual assistance working.

Test traffic for the interception service was more difficult to achieve because of its use of the multi-frequency code revertive signal B8 which is not used in the existing network at the present time.

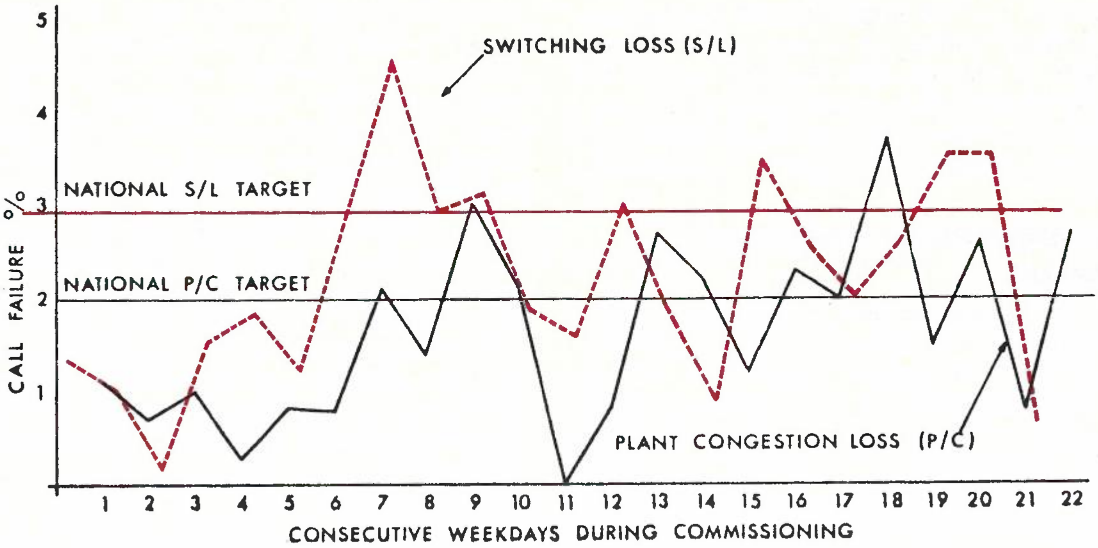

Fig. 3 — Network Performance During Commissioning.

A subscriber stage interception core store (TV equipment) was installed in a 1,000 line group in the local Waymouth ARF Exchange. This could be set, reset or read for its setting of test numbers by the interception operator. The store could also be audited by the 10C exchange software in association with the disc handling programs. Calls could be directed to this store either directly from test telephones connected to the Waymouth local ARF exchange, where the local registers were strapped to interpret the B8 signal as a redirection to the Interception Service Centre, or indirectly from test telephones anywhere in the network that directed their calls via the 10C exchange to test numbers in the Waymouth ARF Exchange, 1,000 line group provided with TV equipment.

COMMISSIONING OF THE EXCHANGE

Prior to commissioning of the Waymouth 10C Trunk Exchange, the switching of STD traffic in Adelaide was provided by an ARM exchange and an ARF Originating Trunk Tandem exchange (OTT). International manual assistance was switched via a Siemens semi-automatic exchange. Planning for the introduction of the 10C exchange provided for the recovery of the OTT for re-use to provide for growth of an outer metropolitan tandem, and the modification of the ARM to operate principally as a trunk switching exchange for calls terminating in the Adelaide area. The International MAC was completely transferred to the 10C positions.

The nature of the commissioning whilst being very sensitive by virtue of the importance of the exchange concerned, was doubly so because over 80% of the circuits connected to the 10C exchange had to be transferred from either the OTT or the ARM exchange. Special attention was given to all aspects of the commissioning process to ensure a smooth cutover with a minimum of network disturbance.

Every detail was pre-planned and completely documented, including traffic levels which could be expected on critical routes at significant stages of the cutover.

The whole process was divided into 36 discrete steps spread over a total period of five weeks. In addition, cutover activity was confined to a maximum of three to four 'off peak' hours on no more than four days in each week. During the remaining time the 10C system was allowed to stabilise and the network performance evaluated.

The total cutover procedure was oversighted by a control group comprised of construction and maintenance engineers and operations personnel. The control group was supplied daily with the results of specially designed traffic route tester (TRT) and manual test call programs, service assessment results and subscriber technical assistance reports. This group was able to keep a very close control of the cutover, making modifications to plans as necessary and directing the urgent follow up of fault conditions.

The success of the commissioning procedures can, perhaps, best be judged by the performance of the network during the cutover. Fig. 3 shows the results of network TRT programs run at the conclusion of each day's cutover activity. The performance of the network did not depart significantly from normal throughout the various commissioning periods.

INITIAL ASSESSMENT OF OPERATIONAL PERFORMANCE

It is not proposed to deal in detail with operational performance as this will be the subject of a later article. Some general observations will be made, however, based on the experience gained during commissioning and the early weeks of operation.

The traffic carried by the exchange at the end of commissioning on a typical weekday was:

- 40,000 STD calls for which the Waymouth Exchange charged;
- 450 International manual assistance charged calls;
- 700 Appointment and Reminder calls.

The daily traffic profile at Waymouth is interesting as the only quiet traffic period occurs between 1.00 a.m. and 3.00 a.m. This prolonged traffic profile is due to the variety of facilities provided by the exchange, which commences with automatic ANR call out in the early morning, followed by STD throughout the day. In the evening, international manual assistance assumes importance followed in the late evening by bookings for ANR calls for the following day.

In general, the call handling capability of the exchange has proved to be good which reflects the very thorough testing in this area. Some minor problems, however, were found in the switching of some less frequently used call types when encountered with particular modes of switchboard operation; but these were rectified early in the operational period. Other faults are known to remain within the manual assistance call handling software, but these faults occur rather infrequently and as yet it has not been possible to reproduce them. The definition and rectification of these conditions will obviously require a much longer period of operation and possibly larger installations.

The overall system performance has been generally satisfactory, although some periods of instability have been experienced in the early months of operation. The factors contributing to this situation are not unexpected and relate principally to some problems of specification, design and testing of massive software systems and to early difficulties brought about by relative operational inexperience.

CONCLUSION

The completion of the Waymouth 10C Trunk Exchange represents a milestone of considerable significance in the introduction of stored program controlled exchange technology into the Australian switching network.

At the time of commissioning, Waymouth was the most complex stored program controlled exchange in Australia. It is proposed that this program be introduced into the existing 10C Trunk Exchanges in Sydney and Melbourne in the near future and also later in Brisbane and Perth so that the operational advantages provided by this technology can be fully utilised by Telecom Australia.

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K. W. ALLISON is the Supervising Engineer, Switching and Facilities in Planning and Programming Branch in Adelaide.

He joined the then PMG's Department as a Cadet Engineer in 1950. After qualifying in 1955 he worked for five years on the installation and maintenance of external plant in the Adelaide metropolitan area. He transferred to country internal plant installation work in 1960, and for the next eleven years was responsible for the installation of all types of long line and switching equipment throughout South Australia and the Northern Territory. In 1972 he was appointed Supervising Engineer, Metropolitan Installation, and in 1973 was transferred to the position of Supervising Engineer, Electronic Exchange Installation in charge of the Waymouth 10C Exchange project team.

R. H. WESSON is the Senior Engineer Switching with Trunk Service, Adelaide. He holds the degree of Bachelor of Engineering (Hons.) from the University of Adelaide.

He joined the Commission in 1956 as a Technician-in-Training. After advancement to Engineer in 1965, he was engaged in the installation of telephone switching and long line equipment in country centres in South Australia. In 1969 he transferred to the Planning Branch and was involved in planning of the South Australian trunk network and in particular the Waymouth 10C Exchange.

In 1972 he transferred to Telephone Switching Equipment Branch in Headquarters and was engaged in the specification of the testing requirements for 10C Trunk Exchange with particular emphasis on Manual Assistance. From August 1972 until March 1974 he participated in the preparation of this testing at BTM, Antwerp, Belgium.

After contract completion of the Waymouth 10C Exchange in 1976 he returned to the South Australia administration.

Elsternwick ARE 11 Exchange

C. J. DOUGALL, A.R.I.M.T., M.I.E. Aust.

On 20 June 1976 the first public ARE 11 exchange to be placed into service in Australia was cutover at Elsternwick, Victoria. This paper describes the installation of Elsternwick exchange which was a new start installation of ARE 11 with ANA 30 control of all ARF switching stages.

INTRODUCTION

On 20 June 1976 the first public ARE 11 exchange to be placed into service in Australia, was cutover at Elsternwick Victoria.

The ARE 11 system comprises ARF switching stages under the control of the ANA 30 SPC register system which replaces ARF electro-mechanical registers. Refs. 1 and 2 describe the ARE 11 system structure and Ref. 2 outlines its proposed application in the Australian network.

Varying degrees of stored program control of the ARF system are available and ARE 11 exchanges can be either conversions of existing ARF exchanges or new start installations. Elsternwick was a new start installation with ANA 30 control of all switching stages as will be the case in all future new start installations in the Australian network (Ref. 2).

This paper aims to provide a description of the installation of the Elsternwick ARE 11 exchange, which was carried out by Telecom Australia staff.

PROJECT DESCRIPTION

The task at Elsternwick was to install 4000 lines of m = 6B ARE 11 equipment as a field trial of a new start installation. The Elsternwick exchange building, which contained 9000 lines of pre-2000 type step-by-step equipment, was extended to provide accommodation for the new ARE 11 equipment. 3000 lines of the new installation replaced the equivalent quantity of step-by-step equipment and 1000 lines was provided for subscriber growth.

The project required the installation of 98 ARF racks, 10 ANA racks and 30 IDF racks; this included 25 racks of three stage (700 availability) group selector equipment. The exchange rectifiers were replaced by two 400 Amp rectifiers and a new 48v distribution system was constructed to the new equipment. A new maintenance control room was established housing subscribers' meters, a PBX interconnection frame (PBX-IDF) and service supervision equipment. A maintenance centre was established at Elsternwick to simulate remote operations functions and contains a teleprinter and visual display unit operating through the switched network via modems. An equipment room layout and a trunking diagram for the project appear in Fig. 1 and Fig. 2 respectively.

HARDWARE DESCRIPTION

The ANA 30 hardware has been designed to blend semi-conductor technology into the electro-mechanical structure and environment of the ARF exchange. The following paragraphs outline the hardware elements of ANA 30 and the methods used to integrate the mechanics of electronic and electro-mechanical technologies:

ANA 30 Components

Integrated circuits and discrete components are used throughout the ANA 30 equipment. Miniature relays are used in units which interface ARF equipment. Components are mounted on printed circuit boards which plug into one, two or four level shelves. Figure 3 shows a one level shelf and associated printed circuit boards.

The processors use integrated circuit random access memories in the data store and programable read-only memories in the program store. Central stores consist of ferrite core memories.

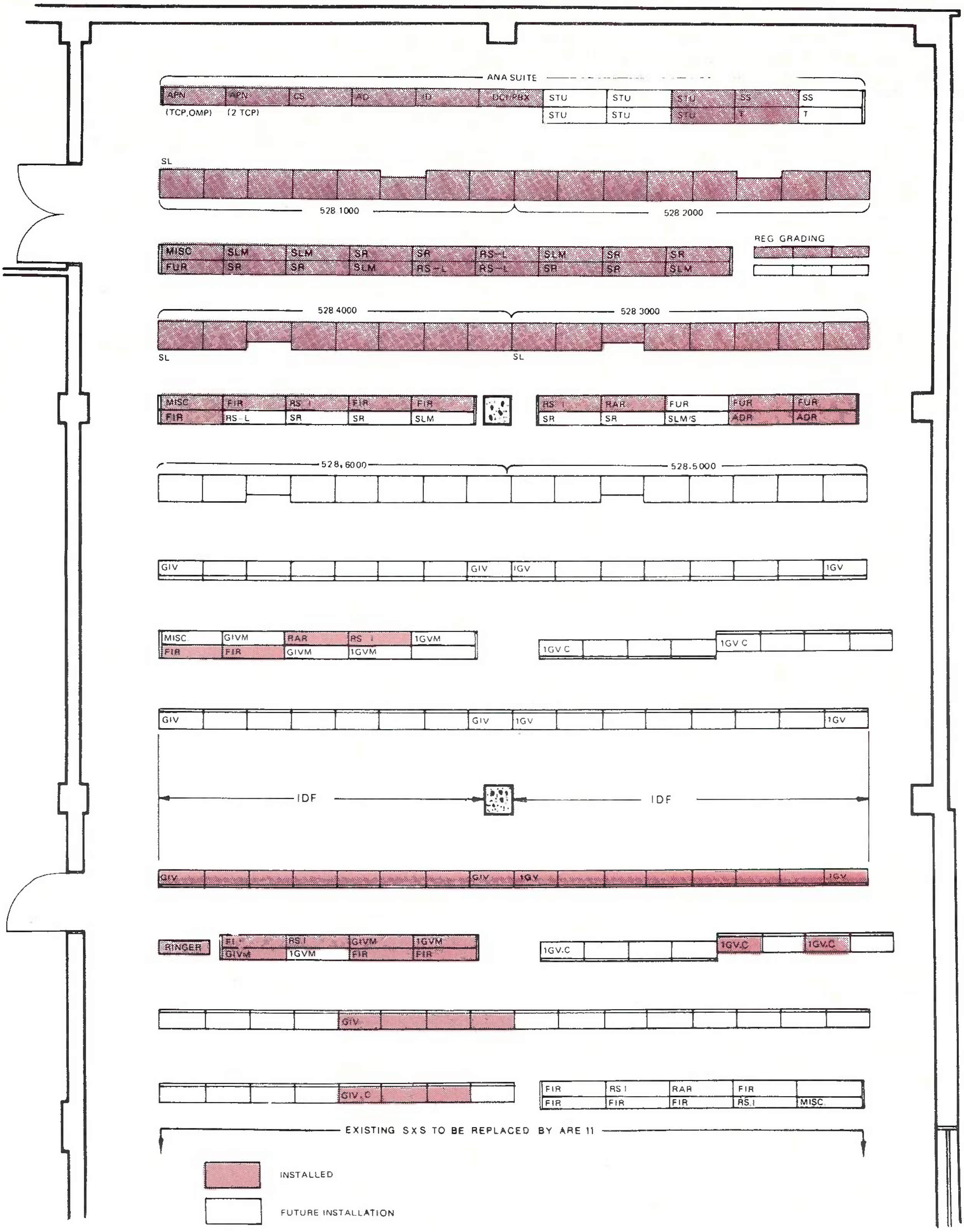

Fig. 1—Equipment Room Layout.

Racks and Shelves

The ANA 30 equipment is mounted on a new BDH type rack. This rack is 23mm deeper than the conventional BDH rack and has only one vertical iron (saw toothed) on the left hand side for shelf mounting; it is secured to the overhead ironwork and floor in the conventional manner. (Figs. 4 and 5).

Shelves mount on racks in the same manner as ARF relay sets and connection is made to 48V rack wiring through 80 point knife jacks on the right hand side of the rack (Fig. 3). To minimise electrical noise problems the conductors for low voltage signalling are connected to shelves by "front cable" connections on the front left hand side of the rack. Components of an equipped ANA 30 rack are illustrated in Figure 6.

Cabling

Cabling from the 80 point knife jacks on racks terminates on 40 point jack units mounted on a jackfield above the rack (Fig. 4). All cabling to ANA 30 racks is terminated by pre-plugged 40 wire cables which connect to these jackfields above the racks and so removes the need for on-site termination of ANA 30 rack cables (Fig. 7).

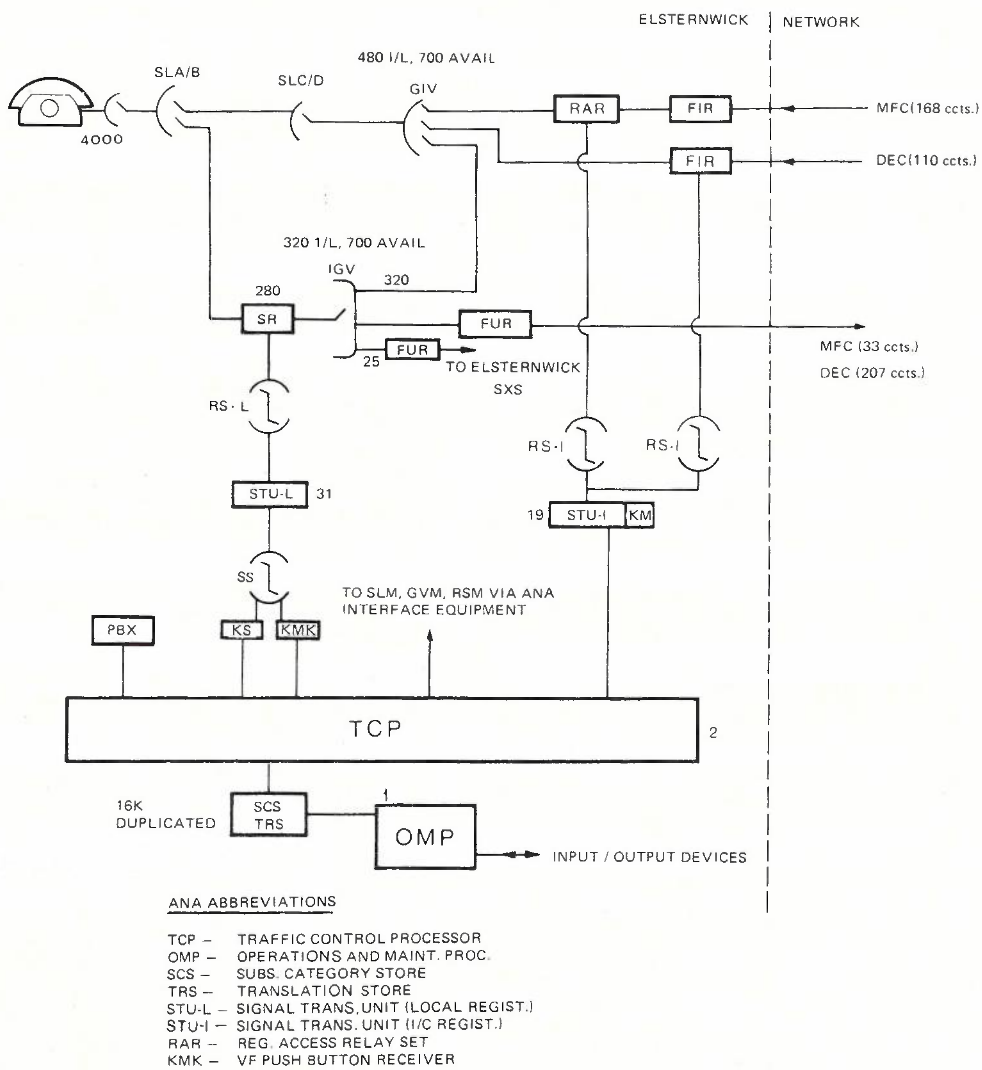

Fig. 2—Simplified Trunking Diagram.

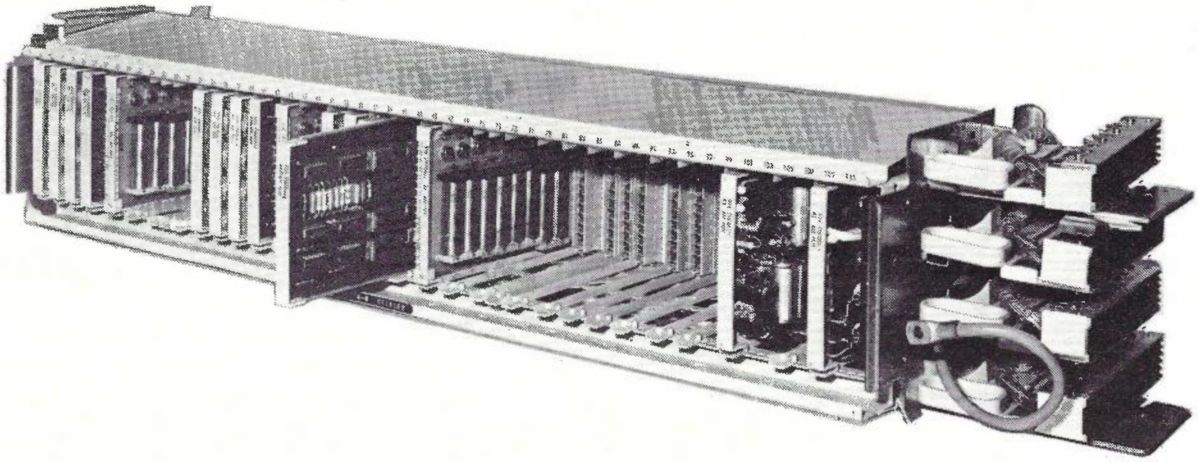

Fig. 3—One Level Shelf and Boards.

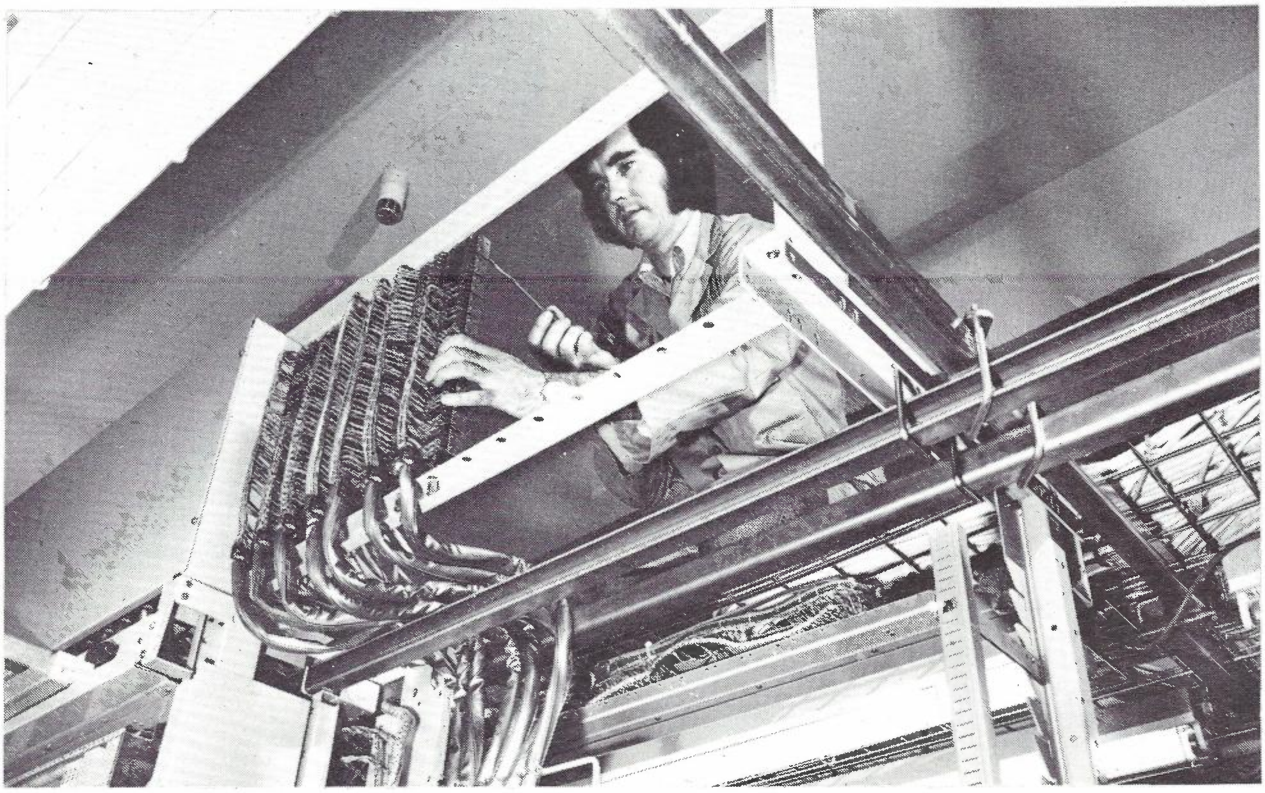

Fig. 4—Jackfield and Ironwork Above ANA 30 Rack.

Cabling between ANA 30 and ARF equipment terminates at the ARF end in either 40 pin plug termination on above-rack jackfields or hardwired rack termination.

Fig. 8 is a simplified cabling diagram of the ARF-ANA 30 interface and demonstrates density of cabling and method of termination in the ANA 30 suite and between ANA 30 and ARF equipment.

PBX jumpering is done on a special IDF where 'c' wires from SLA/B racks are interconnected with wires from new PBXC connect relays. This PBX-IDF, which uses solderless terminations is shown in Fig. 9.

Power

ANA 30 electronic equipment is powered by duplicated rack mounted dc/dc converters (Fig. 6) which are supplied with —48V from the standard exchange distribution system. Capacitor/diode units, however are required at the power input to each rack to minimise the effect of voltage transients which could result from disturbances in the distribution system anywhere in the exchange. These units are secured to the ironwork above each rack.

Exchange Environment

ANA 30 equipment is designed for installation in the same exchange environment as ARF equipment and relies on free convection for cooling of components.

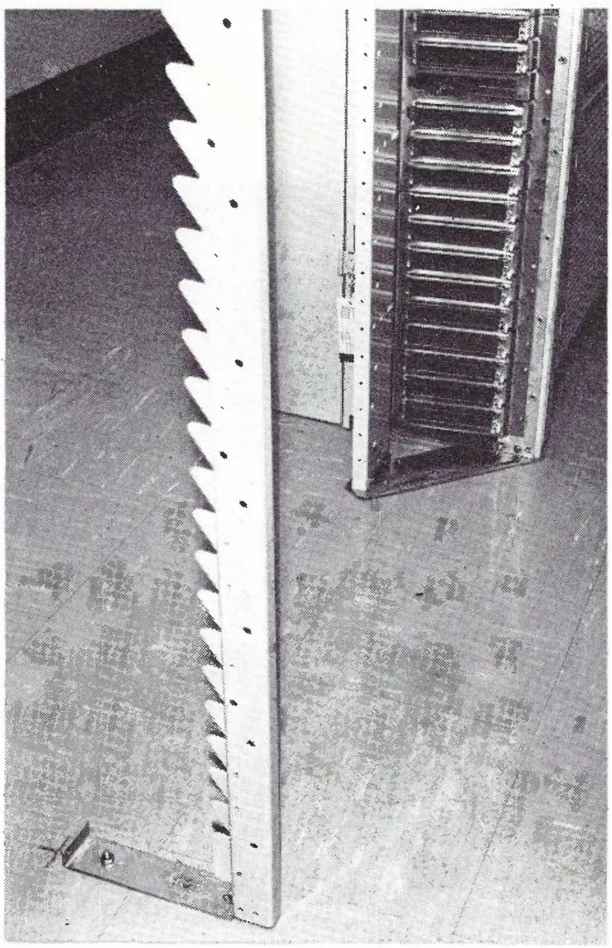

Fig. 5—Bottom Section of Unequipped ANA 30 Rack.

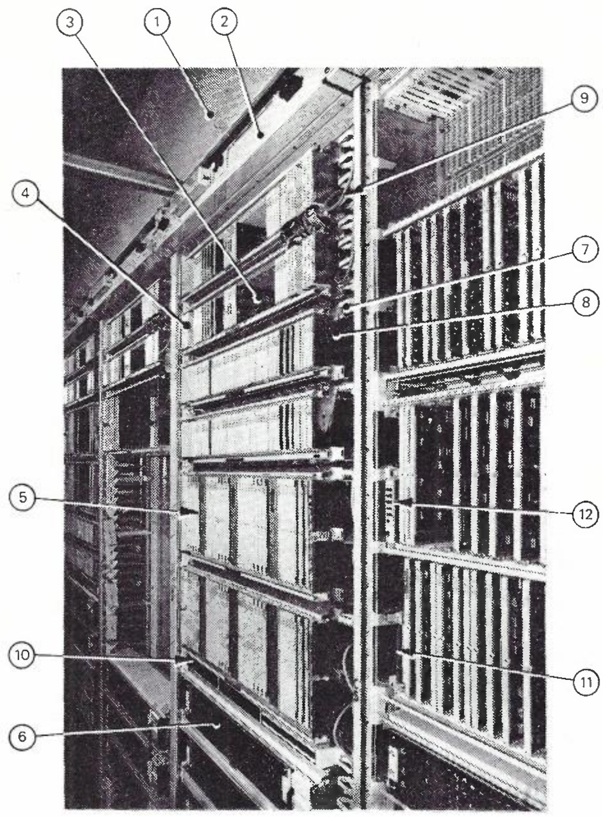

Fig. 6—Components of Equipped ANA 30 Rack.

ARF Subsystem

The mechanical structure of the ARF equipment in the ARE 11 system remains unaltered and crossbar switching stages are retained. However substantial amounts of ARF hardware are made redundant by the introduction of the ANA 30 stored program controlled register system. These changes, which apply to an ARE 11 exchange with ANA 30 control of all ARF switching stages, are briefly summarised as follows:

- Redundant ARF functions:
  - — register system
  - — GV analysis
  - — internal MFC control
  - — subscriber categories
  - — PBX functions.
- The GV marker is simplified and some remaining relay sets are redesigned. One GVM rack (based on 2/160 marker) now contains two markers and controls two groups of 160 GV inlets.
- MFC inlets require access via RS.I to the ANA 30. A new relay set RAR is required to adapt FIR to RS.I.

INSTALLATION

The installation procedure was structured according to the clear demarcation that exists between the ANA 30 and ARF subsystems of the ARE 11 system. Two teams working in parallel were formed to carry out the installation. A small team trained in the ARE 11 system was responsible for the ANA 30 installation and testing and for co-ordination of full ARE 11 system testing. A second larger team was responsible for installation and testing of the ARF and ancillary portions of the exchange.

The ANA 30 subsystem was installed and tested in isolation from the ARF subsystem. Concurrently, the ARF equipment was installed and statically tested in isolation from any ANA 30 control. The ARF and ANA 30 subsystems were then combined to form the ARE 11 system and full functional, load and pre-cutover system testing was conducted.

This procedure divided the project into four distinct stages, viz:

- Ironwork
- ARF installation and subsystem testing
- ANA 30 installation and subsystem testing
- ARE 11 system testing and cutover.

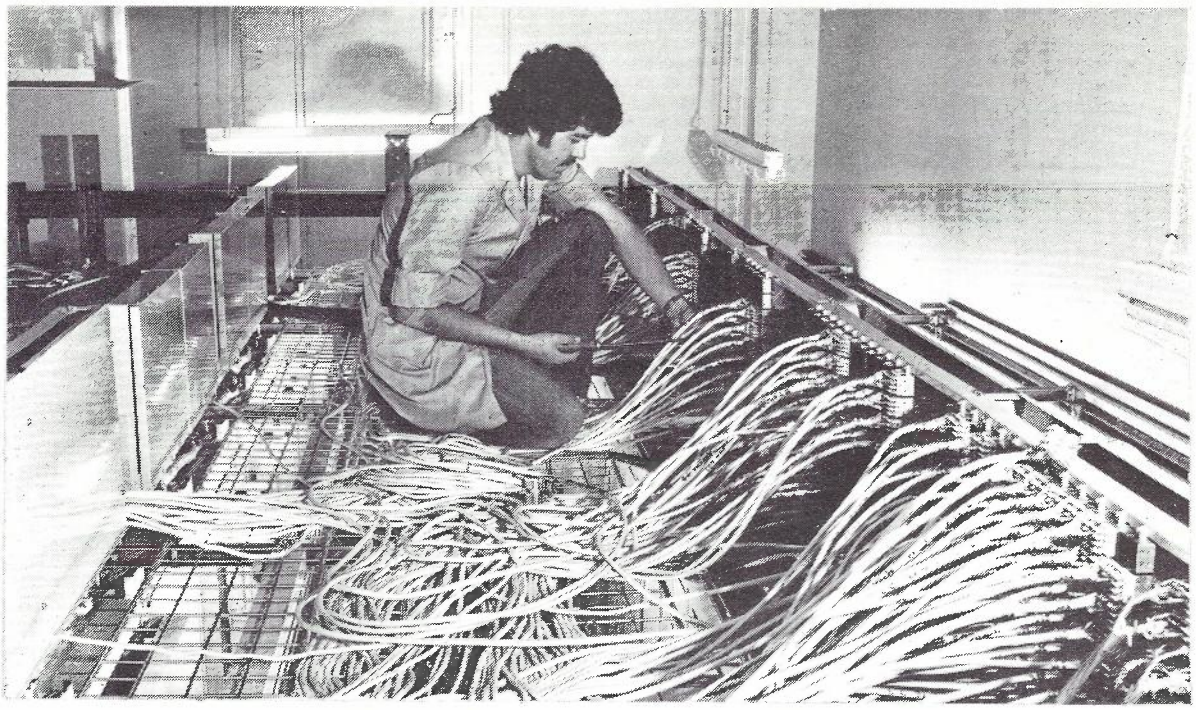

Fig. 7—Jackfield Cabling above ANA 30 Suite.

Organisation of the installation around these stages and parallel installation and testing of ARF and ANA 30 equipment by two teams permitted effective deployment of the limited number of staff trained in the ARE 11 system and enabled completion of installation of this new equipment within a short time period.

TESTING

The ANA 30 testing procedure commenced with separate preparatory functional tests of all units of the subsystem and required the use of special test equipment and diagnostic off-line programs.

Following completion of unit tests, system testing of the ANA 30 group was conducted. This test, called the TCP Group Test, was conducted with all programs and final Translation Store (TRS) and Subscriber Category Store (SCS) data loaded and was a simulation test of ANA 30 traffic handling functions prior to amalgamation of the ANA 30 and ARF subsystems. The TCP Group Test was also used to develop and rigorously test TRS data which was being applied for the first time in Australia to a public exchange. This testing highlighted assembler deficiencies and provided Telecom Australia staff with experience in the writing and handling of TRS data.

Hardware and software testing was pursued at the Telecom Australia Headquarters model ARE 11 exchange in Melbourne prior to and in parallel with testing at Elsternwick. This enabled the early detection and correction of design faults and reduced testing delays by limiting the number of design problems encountered at Elsternwick. L. M. Ericsson personnel participated in hardware and software testing and development at the model and also provided technical assistance, as required, to Elsternwick installation staff.

The majority of faults encountered in the ANA 30 subsystem during testing were software oriented

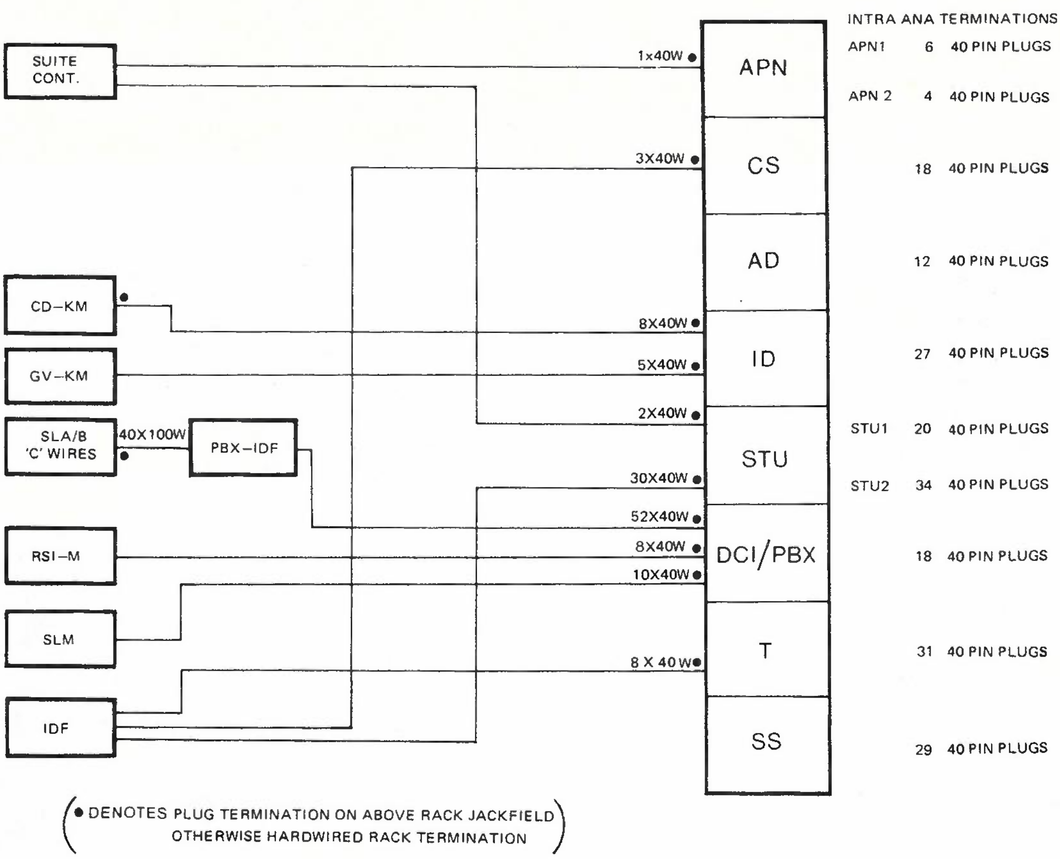

Fig. 8—Cabling Scheme.

and of these the development of TRS data was the most time consuming. Hardware faults did not present a significant problem. These were limited to:

- 27 board faults which included 9 incorrectly programmed PROM boards and 3 RAM board failures (this compares with a total installation of 2200 boards).
- Faulty IC in 4 dc/dc converters.
- 1 faulty store module.
- Minor production errors in rack and shelf wiring.

TIMETABLE

The project commenced in February 1975 and carried through to cutover in June 1976. The bulk of the work carried out during 1975 was involved with the installation of the ARF subsystem.

ANA 30 subsystem and full ARE 11 system testing and the development of SCS and TRS data was concentrated into the last seven months prior to cutover.

The following outlines the major milestones in the installation timetable:

February 1975 — Commenced ironwork and ARF installation.

July 1975 — Commenced ANA 30 installation.

November 1975 — Commenced ANA 30 preliminary unit testing.

February 1976 — Commenced ANA 30 subsystem testing.

March 1976 — Commenced ARE 11 system testing.

May 1976 — Load and network testing.

20 June 1976 — Cutover.

MAINTENANCE FACILITIES

The ANA 30 subsystem is supervised by the Operations and Maintenance Processor (OMP) which monitors disturbances in the system. OMP provides the connection to input/output devices for man-machine communications and enables the following operational functions to be performed via a visual display unit or teleprinter:

- Exchange Supervision.
- Alterations to central store data.
- Traffic statistics.

These functions can be performed at the exchange or at a remote location with input/output devices operating via modems. A remote operations centre has been simulated at Elsternwick to evaluate this facility. This centre is provided with a 24-hour consultative service by a National Support Centre which is also responsible for the preparation of program and data tapes and model verification of new hardware and software designs.

Service supervision facilities for the ARF equipment were also provided as the OMP at Elsternwick only supervised the ANA 30 subsystem.

SERVICE EXPERIENCE

Following the usual settling problems of a new system design, the ARE 11 system has been performing satisfactorily. No significant service disruption due to processor failure has occurred in the seven months to the time of writing. Processor failure only occurred on one occasion soon after cutover when a fault condition resulting from a post-cutover program change caused both Traffic Control Processors to become blocked for 30 seconds.

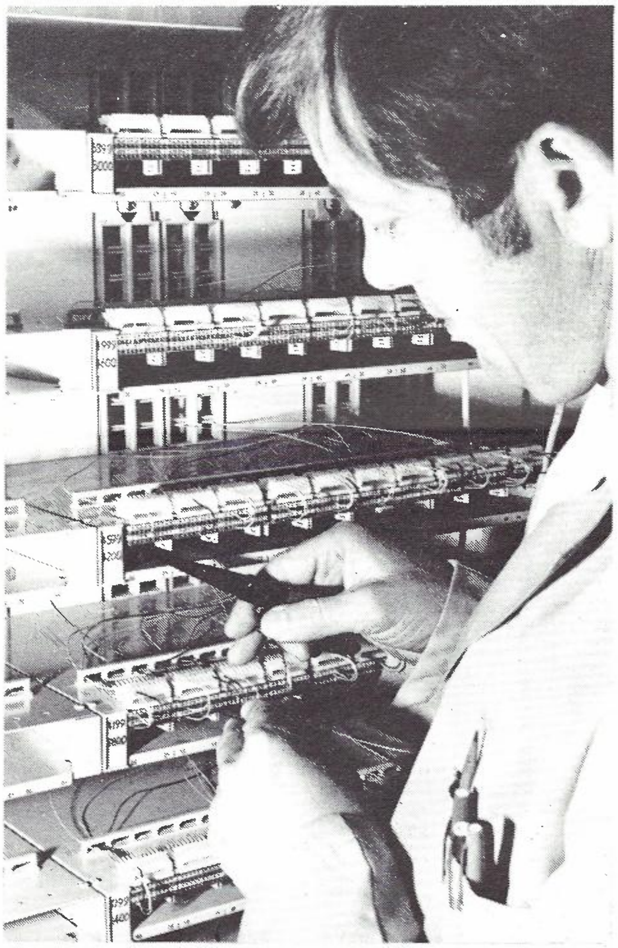

Fig. 9—PBX-IDF.

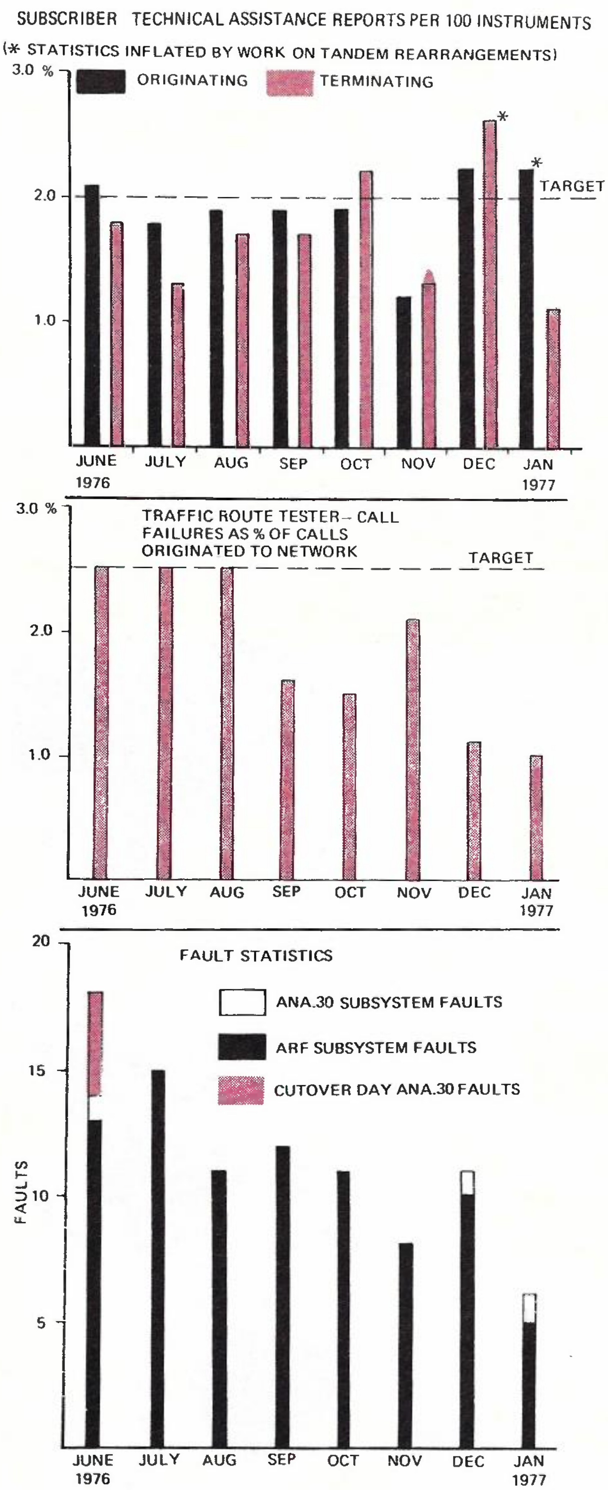

Fig. 10—Service Statistics.

Service statistics (Fig. 10) illustrate that the system is operating satisfactorily within service objectives.

CONCLUSION

Telecom Australia embarked on the Elsternwick project as a field trial to assist in the evaluation of ARE 11 for network wide implementation. Alterations to the ARE 11 system have been made since the Elsternwick installation and these are expected to be incorporated in future installations. These include improved maintenance facilities, higher capacity program and central stores and retention of ARF crossbar SS equipment. ANA 30 testing procedures are also expected to become more automated with the use of new test equipment and software.

Future ANA 30 equipment and maintenance and testing facilities will be improved over those employed at Elsternwick. However the system and hardware structure will remain substantially unchanged and the installation practices and approach adopted at Elsternwick will be applicable at future new start installations.

ACKNOWLEDGEMENT

The author wishes to thank the many people within LME and Telecom Australia whose work contributed to the successful cutover of this project. Considerable credit is deserved by the installation crew whose enthusiasm throughout the project was a particular source of encouragement to the author. Appreciation is extended to Mr. Lay, Elsternwick Operations Engineer, for his assistance with the service statistics presented in this paper.

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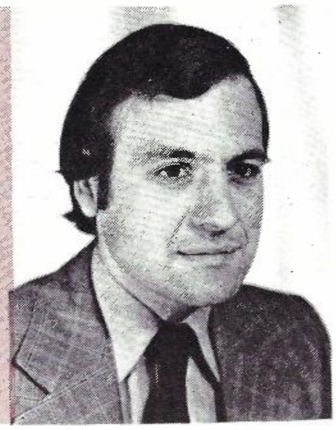

In Brief

TELECOM'S PRACTICAL LEAD IN USE OF SOLAR POWER

The first large capacity multiple solar cell power installation of its type in the world will supply energy for a big new 580 kilometre microwave trunk telephone system between Alice Springs and Tennant Creek in the Northern Territory.

The new solar powered trunk system, which will be linked into the Darwin/Tennant Creek/Mt. Isa/Townsville microwave trunk system and the national broadband grid, would have three bearers — with total capacity equivalent to nearly 3,000 telephone circuits.

One bearer will cater for telephone and telegraph demands, a second will be reserved as an emergency for the first in case of breakdown, and the third will be used for TV programme relays.

There will be 13 repeater stations along the new trunk system and each will obtain electrical power from its own solar unit. The estimated overall cost for solar power for this trunk system is about $500,000.

The radio equipment power consumption for the 13 isolated stations on the Alice Springs/Tennant Creek system (set at intervals of about 45 km) is about 125 watts continuous at 24 volts dc.

Telecom is hopeful that the combination of solar power with low energy use equipment will make a significant contribution to the extension of communication facilities into the outback of Australia.

Investigations have shown that solar power can be justified economically for loads up to 200 watts for such specialised applications as the Alice Springs-Tennant Creek system.

Data Communiction – Basic Facts and Facilities Available – Part 2

R. K. McKINNON, B.E., Dip. P.A., B.A. ENDERSBEE, B.E., Grad. I.E.E. and J. M. BOUCHER.

This is the concluding part of the article of which the first part appeared in Vol. 27, No., 1. The previous part dealt mainly with the problems of the transmission path, and included a glossary of terms. In this part the data facilities offered by Telecom Australia are described.

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FACILITIES OFFERED BY THE DATEL SERVICE

Table 4 shows the datel facilities currently offered and it is important to note the difference in facilities offered by the two types of circuits.

Plan 32 offers the customer a choice of synchronous operation at 600 or 1200 bit/s or asynchronous operation at speeds up to 1200 bit/s. Modems used by Telecom Australia for higher bit rate transmission than 1200 provide for synchronous transmission only, but for the lower bit rate services at 200 bit/s and 300 bit/s only asynchronous transmission is provided.

Asynchronous transmission has the advantage that clock extraction circuits are not required and the disadvantage that transmission is less efficient because every character must be preceded and succeeded by start and stop signals. Synchronous operation has the disadvantage of the time interval required at the beginning of each transmission to

TABLE 4: FACILITIES OFFERED BY THE DATEL SERVICE (AS AT JANUARY 1976)

Data Signalling Rate Bits Per Second	Telecom Plan Number	Type of Circuit			Type of Operation
		Public Switched Telephone	Private Line		(Directions of Data Transmission)
			2-Wire	4-Wire	
200	31	YES	YES	NO	Both-way
300	39	NO	YES	NO	Both-way
	40	YES	YES	NO	Both-way
600/1200	32	YES	YES	NO	One-way or Either-way
		NO	NO	YES	Both-way
2400	33	NO	NO	YES	Both-way
4800	34	NO	NO	YES	Both-way
9600	36	NO	NO	YES	Both-way
48000	37	NO	NO	YES (Wide band width)	Both-way

achieve synchronism before valid data can be received and the need for the synchronisation circuit. The clock signal is required for synchronisation both in the modem and in the terminal but it is usual for only one clock extraction circuit to be used and, therefore, either the modem takes timing from the terminal or the terminal takes timing from the modem.

Considerations regarding the transmission of data over telephone channels determine the choice of synchronous operation at the higher bit speeds. As mentioned previously, in order to compress data signals at 2400 bit/s and over, into the bandwidth of the circuits normally available on Telecom Australia plant binary data has to be grouped in the modem into di-bits, tri-bits, or four bit groups prior to modulation to make use, respectively, of 4 state, 8 state or 16 state transmission methods. The decoding process at the receiving modem must be synchronised with the encoding otherwise incorrect data will be received.

DATA SERVICES ON THE PUBLIC SWITCHED TELEPHONE NETWORK

The public switched telephone network has many advantages for use as a data transmission medium.

- It covers almost the whole of the continent.
- It is available at any time.
- It is economical for short duration transactions on a long distance connection.
- It provides an inherent concentrating capability by being able to funnel traffic from a large number of terminals to a smaller number of terminals or to a single computer.

Two features extend its use — acoustic coupling and automatic answering. Acoustic coupling is intended for use with portable data terminals that can transmit acoustically into a telephone handset. Automatic answering is a facility that is used by the time share computer services to remove the need to manually answer every incoming call.

When using the public switched telephone network there must be a telephone associated with the data modem to set up the call and allow the two parties to converse prior to switching over to data transmission — see Fig. 7.

At a computer installation where automatic answer data modems have been installed, the modems send back an answer tone to the caller, thus effectively "conversing" with the caller. During this "conversation" the caller makes an assessment of the quality of the line for its suitability for data transmission. Occasionally noisy lines are encountered and sometimes the transmission loss when calling from one side of a telephone network to another can be quite high. If these conditions are encountered the caller releases the call and tries again.

The disadvantages of a public switched telephone connection are:

- Call setting up times, which may be as long as

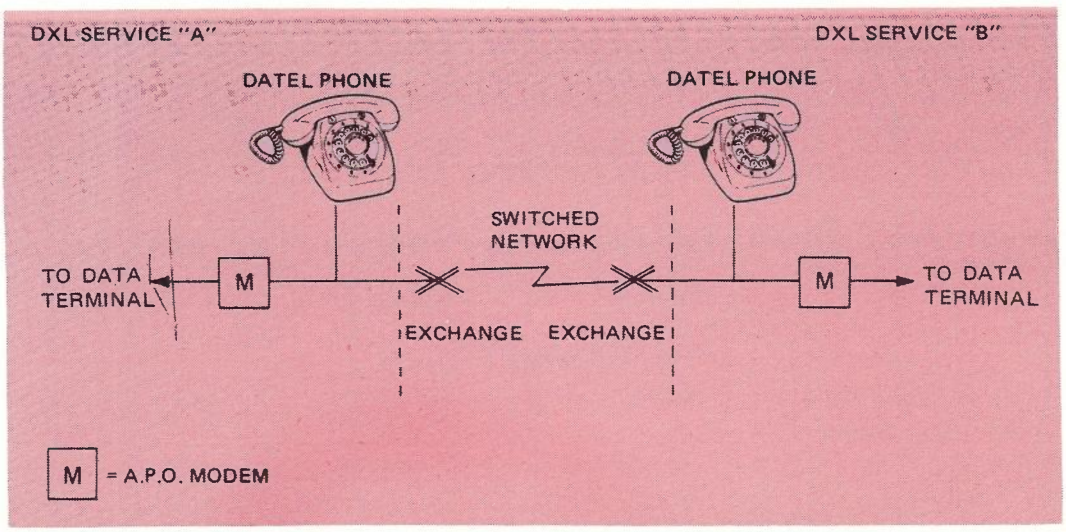

Fig. 7 — Datel Service over a Public Switched Telephone Network Connection.

15 seconds on trunk calls, are a disadvantage for some classes of data traffic.

- It is noisier than a leased line connection because it goes through the telephone exchange switching equipment.
- It is limited in data signalling rate achievable.
- There is a wide spread of transmission performance on successive calls and it is not practicable to equalise each connection by conventional means.
- It is always a two-wire connection and hence:
  (i) It can transmit data in both directions simultaneously up to a data signalling rate of only 300 bit/s. A wider bandwidth than 300-3400 Hz would be required for signalling simultaneously in both directions, therefore only half duplex operation is available.
  (ii) It is subjected to the occasional problems of transmission instability.

Acoustic Coupling

Prior to 1972, it was not Commission policy to permit the use of inductive, electrostatic or acoustic couplings between data terminal equipment and standard telephone instruments or lines.

However as the result of a nationwide survey, a need for acoustic connections of data terminal equipment was seen in the following situations:

- to demonstrate computer time sharing terminal capabilities in a potential customer's premises.
- to transmit data from unpredictable locations, or locations which would be used infrequently.
- for short duration temporary installations of data terminal equipment.

Consequently, the policy was changed to permit both analogue and digital transmission through the switched telephone network via acoustic couplers under the following conditions:

- the equipment did not transmit data at a speed in excess of 1200 bit/s.
- the equipment was not to be used for the transmission or reception of data on a permanent basis at the one location.
- the equipment was not to be used for the transmission or reception of data at the installation, except in special circumstances.

To date, six permits have been issued for couplers.

Data Transmission Through PABX's

Telecom Australia policy for many years would not allow the connection of data equipment to PABX terminations because of the possibility of intrusion by PABX operators or interference to the data from tones used in PABX's. PABX's may be designed to avoid these difficulties and Telecom Australia has recently published a specification of requirements in this area. Provided the requirements of this specification are met and the PABX has been approved by Telecom Australia for the transmission of data, then data terminals can be connected to PABX's.

2400 & 4800 Bit/s on the Switched Telephone Network

Due to recent technological advances, synchronous transmission at 2400 and 4800 bit/s on the switched telephone network is possible, using modems with automatic adaptive equalisation capabilities.

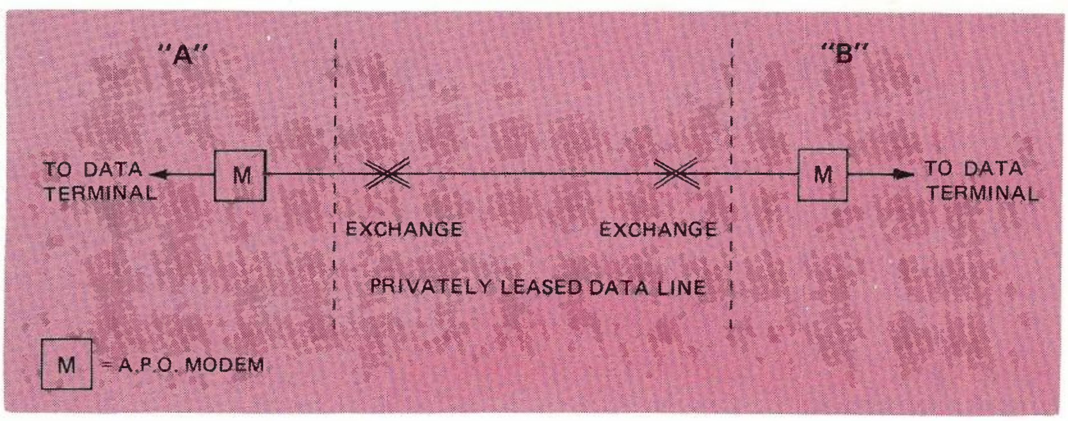

Fig. 8 — Datel Service using a Private Line.

Since a switched network call can be made from many points to many other points via numerous paths, the spread of circuit characteristics is wide. This problem puts some constraints on the data modem design in that any equalisation used must be automatic and adaptive and the modulation method used must be consistent with the line characteristics experienced in switched network transmission.

The Commission is at present in the planning stages of conducting a comprehensive field trial for 2400 and 4800 bit/s transmission using several data modems with different modulation methods, CCITT V 27 and quadrature amplitude modulation (QAM) are two examples. Novel methods of testing are being employed to reduce the work load as a comprehensive test requires a large matrix of interconnections to have validity.

DATA SERVICES OVER PRIVATE LINES

General

The private line connection is available to the customer for his exclusive use for either 24 hours a day or portions of particular days according to the agreed lease (see Fig. 8).

The advantages of a private line are:

- The connection is permanent during the period of lease and call setting up time is not involved.
- For many classes of traffic it is more economic than the public switched telephone network.
- It does not go through the telephone exchange switching equipment, hence it is not subject to the noise induction that can occur in a switched connection.
- As it is a permanent connection it can be equalised and amplified as required.
- It can be two or four-wire.
  The term 4-wire is the transmission description of a pair of transmission channels (one for each direction of transmission). They can be provided over any distance by using conventional transmission means. 4-wire circuits by their very nature are free from the problems of instability and echoes that often occur in circuits that have hybrids to connect the two-wire tail to the four-wire trunk or junction channels.

Classes of Private Lines

There are two engineering classes of private lines:

- Standard quality data line.
- Special quality data line.

The standard quality data line is one in which the cable pairs (which may have been loaded by the installation of 88 mH inductance coils at 1830 metre intervals along its length to reduce the overall cable insertion loss), and the carrier system channels are connected together as required without any special selection tests or equalisation. These lines can be 2 or 4-wire and they are used for the 200, 300, 600 and 1200 bit/s Datel Services.

Special quality data lines are used for all datel services at speeds of 2400 bit/s and above. They are always 4-wire and they are combinations of selected cable pairs and carrier system channels as required. They are amplified and equalised to ensure that all the transmission characteristics are within prescribed limits.

Methods of Providing Private Lines

Private lines are made up of permanent connections of cable pairs and, where necessary, carrier system channels. These cable pairs may be loaded or unloaded. Loaded cable pairs have the advantage of relatively low loss and a flat frequency response over most of the bandwidth, but have the disadvantage of increasing group delay, which increases with the total length of the cable and the proximity of the line signals to the cut-off frequency of the loaded cable. Unloaded cable pairs have the disadvantage of higher insertion loss and a sloping frequency response across the voice frequency band. However these disadvantages can be overcome by using amplifiers and insertion loss equalisers.

The decision to use loaded or unloaded cable pairs depends on the overall design of each special quality data line.

Alternate Voice/Data Facilities on Leased Lines

The Commission offers two basic classes of alternate voice/data service:

- Over 4-wire data lines between different local call areas.
- Over 4-wire PBX tie lines.

Out-of-band control signalling is employed on the more complex networks such as those involving PBX tie lines so that calling and supervisory functions can be realised without interrupting the voice or data communication until the changeover from one to the other is actually made. Alternate voice/data service is also available on multipoint data networks with the capability of "code-ringing" so that individual points on the network may be called as required.

In-band signalling is employed on simple point-to-point data lines with the disadvantage that data is interrupted when a call to speak is made. However, this service is simpler to supply and maintain and is quite suitable for many customers needs.

Datel Service — Ancillary Equipment

The following ancillary equipment is used in connecting datel services.

Datelphone

A datelphone is a telephone with two push-button key assemblies with luminous signals which may be used in conjunction with the CCITT V24 interface for controlling a data modem used for data service over the public switched telephone network.

Two of the following CCITT V24 Interchange Circuits control or status indicator signals may be provided by the illuminated push buttons on the Datelphone, depending upon the requirements of the data terminal equipment.

CCITT V24 INTERCHANGE CIRCUITS

Number	Designation
105	Request to send
106	Ready for sending
107	Data set ready
108/1	Connect data set
108/2	Data terminal ready
109	Data channel receive line signal detector
111	Data signalling rate selector
126	Select transmit frequency

Analogue Splitter/Combiners

An Analogue Splitter/Combiner is a transmission device which enables a data private line to be split at a given point, usually a telephone exchange, and extended to a number of different locations. It is used where a large number of data terminals are required to be linked together in a network configuration.

Present Telecom Australia policy, permits a maximum of eight splits from an analogue splitter/combiner; however by cascading additional splitter/combiners, it is permissible for more than eight data terminals to be connected together on the same line.

Digital Interface Splitter/Combiner (DIS/C)

The Digital Interface Splitter/Combiner, is a device which allows up to four polled data terminals to share a single data modem on a data private line.

However by cascading two DIS/C units together, it is possible for seven data terminals to share the one data modem. These units may be provided under "permit to connect" conditions.

8550 Equipment Practice (High-Density Equipment)

The 8550 Equipment Practice was introduced to allow high-density modem installations to be established for customers such as banks, TAB's, etc., where instation modems are required to be connected to large numbers of outstationed modems at branch agencies. The high-density equipment allows up to 128 dedicated link modems, operating at speeds of 300 or 1200 bit/s, to be installed in a standard cabinet.

The cabinet is equipped with dual changeover power supplies, a power supply control unit and monitoring panel, and up to eight subracks, each containing 16 modem cards.

MAINTENANCE ASPECTS OF DATEL SERVICES

In maintaining Datel Services the most difficult aspect is pinpointing the problem area when a fault is reported.

If it is considered that the data link is faulty, the general procedure is for the repair man to visit the customer's premises and use a test set and test the data link from interface to interface, and subsequently by sections to isolate the fault.

Special test instruments are used to check the performance of data links from interface to interface and the Commission has been buying a range of such test instruments for some time. These instruments have the ability to:

- Transmit test data having data signalling rates covering the speed range from 200 bit/s to 9600 bit/s with signal patterns such as all one's or zero's, alternative zero's and one's and standard pseudo random sequences of 511 and 2047 bit lengths. A 511 bit length pseudo random data block contains all the combinations of 0's and 1's in sequences up to 8 zero's and 9 one's thus giving a data link a test close to realistic customer operating conditions.
- Receive any of the standard bit rates.
- Display the distortion present in the signals (appropriate only to the lowest speed signals).
- Count bits in error and blocks in error over a fixed time.

For testing circuits for their suitability for data transmission or trying to locate fault conditions, the following types of equipment are necessary:

- A conventional transmission measuring set capable of measuring insertion loss and frequency response.
- A relative group delay measuring set.
- A phase jitter meter.
- An impulsive noise counter.
- An interruption meter.

COMMON USER DATA NETWORK

The Australian Common User Data Network (CUDN) is a store and forward message switching system designed to transfer data quickly and reliably from one location to one or more specified distant locations. Magnetic disc packs perform the storage function and computers perform the routing function. Several customers can use the equipment concurrently and continuously without affecting one another in any way. All the usual facilities associated with low speed message switching are provided in addition to new facilities associated with modern data switching requirements for collection, distribution and enquiry using higher speed terminals such as data printers, data entry stations and visual display units.

The CUDN centres were progressively installed in mainland capital cities with completion in late 1975. The system is now handling the data requirements for the Department of Health and Trans Australia Airlines.

The requirements for CUDN services has been reduced because of increased operating costs and the lower tariffs which are now applied for long haul data private line services. These lower tariffs are due to the development of transmission technology and micro processors in new terminal equipment which can perform some of the functions for which CUDN was provided.

Studies are currently being undertaken within the Commission with the object of cutting back to one CUDN centre and using the equipment in other areas associated with the telecommunications system.

TELEX

This service is specifically designed for the interchange of communications between teleprinter terminals. It operates at a speed of 50 bit/s and each telex station with a teleprinter can be used directly to send or receive. On any call transmission can be made in either direction but not simultaneously. The maximum transmission speed is 400 characters per minute. The service uses an internationally standardised code (International Alphabet No. 2) which is limited to 32 character combinations. Special equipment is available to enable changeover to data terminal equipment signalling at 50 bit/s or less, after establishment of the call.

In certain circumstances the Commission will permit a computer to be directly connected to telex to originate or receive calls. The point of connection to the telex system and the detailed method of operation will depend on the number of outstations to work with the computer and the nature of the traffic to be transmitted. A detailed study of the proposed computer service is necessary before the connection points can be determined and a decision made by the Commission as to the mode of operation.

As a general guide, a small system would be connected to that part of the telex exchange where normal teleprinters are connected. The computer would therefore be required to perform to the same standards and in identical manner to a teleprinter terminal during the processes of making and releasing a call.

A large scale system would be connected to a special part of the telex exchange and the computer would be required to perform to the signalling sequences of that part of the telex switching network.

REGULATORY, TARIFF AND POLICY ASPECTS

With the young and growing computer industry reaching further into the Australian business field with its improving technologies, the Commission is required to continuously review its regulatory, tariff and policy decisions to meet its customers' telecommunications needs. The Telecom Australia handbook "Data Facilities" sets out the main lines of approach. Some of the material from that handbook is reproduced in this paper, brought up to date where necessary. There are several important policy issues which have not yet been fully determined (and therefore not covered in the handbook) although the general approach has been decided and these are briefly commented upon below.

Permit to Connect

As a result of a nationwide survey undertaken throughout the computer industry in 1965, it was decided that while Telecom should provide the line and modems associated with an on-line computer facility, private computer hardware suppliers should be permitted to provide the necessary terminal equipment, subject to its examination and approval by Telecom.

With the introduction of the Datel Service in 1969, it therefore became mandatory for the supplier or maintainer of computer peripherals and interfaces to obtain a "permit to connect" before associating any equipment with Telecom lines or modems. Permit examination ensures:

- That the equipment conforms to electrical isolation standards, and thus cannot create a danger to Telecom field staff or damage Telecom plant.
- That the equipment, through possible excessive power output, cannot affect the normal operation of the telephone network nor interfere with the use of the system by other people.
- That the operating features of the private interface equipment are functionally compatible with the modem, or other Telecom plant, to which it is to be connected.

For a permit application to be examined in detail, it is generally necessary for the supplier/maintainer to submit specified documentation to Telecom Headquarters in Melbourne.

When the device is found to be technically and operationally acceptable a permit is prepared in one of the following ways:

- An open supplier's permit, issued to a computer company for both the supply and maintenance of the equipment for any prospective customer.
- A subscriber's permit, issued to a person or organisation that has purchased the equipment and will maintain and operate it themselves.
- A one-off permit, issued to a computer company which may supply and maintain the equipment for a particular customer only.
- A system permit, issued to a computer company, or customer, for a particular system incorporating various items of peripheral equipment on a specified datel network.

Over the past seven years, there has been a steady increase in the range of computers and peripheral devices available on the market, together with an expansion in the range of modems available from Telecom. Consequently, there has been a rapid increase in the number of permits issued by the Commission. The following figures illustrate this growth:

1969 — 53 permits issued
1970 — 90 ,, ,,
1971 — 293 ,, ,,
1972 — 224 ,, ,,
1973 — 366 ,, ,,
1974 — 422 ,, ,,
1975 — 483 ,, ,,
1976 — 550 permits expected to be issued.

Tariffs for Data

Data can be exchanged via the telex network (50 bit/s), public switched telephone network (up to 1200 bit/s) or over private circuits leased from Telecom Australia. At the present time the highest speed of digital transmission in Australia is 48,000 bit/s.

The charges for the telex and telephone switched networks are the same as for normal calls established through those networks.

The charges for private line operation are based on distance, (measured radially) and the speed of operation required from the terminal devices. Because of the necessity to specially balance circuits which operate at higher speeds, circuits are marginally more costly as the speed of transmission increases. Details of charges in respect to private circuits and modems are readily available from any Telecom business office.

Shared Use of Telecom Circuits

Prior to 1 July 1975, the then Australian Post Office, operating under the Post and Telegraph Act 1901-1975, was prohibited under Section 97 of the Act from permitting the lessee of a data private line to share his line with another party.

When the Commission was formed it was considered that some relaxation of this particular legislation should be written into the new General By-Laws. Consequently, By-Laws 205-214 refer specifically to the shared use of private lines, and quote the guidelines under which line sharing may be permitted. Telecom is given the authority to legislate general conditions applicable to shared line usage, based upon its interpretation of the By-Laws, and this aspect is currently under consideration by Telecom.

In general, the conditions require that the sharing of a circuit be on a non-profit basis, and that there be a defined affinity of interest between the parties concerned. These aspects must be proven in the application for a shared line. Until the associated policy work is finalised, all requests for line sharing are being considered individually according to the facts presented to the Commission.

Multiplexing

Multiplexing is the division of a common transmission path into a number of channels over which differing functions may be transmitted simultaneously. Time division and frequency division are the two main multiplexing principles utilised in data transmission technology.

Although Telecom reserves the right to maintain privately supplied multiplexing equipment at a customer's expense, generally speaking, multiplexers may be associated with the Commission's datel lines and modems on a "permit to connect" basis. At the permit examination stage, particular note is taken to ensure that the Commission's common carrier role is not contravened in the usage of the derived circuits.

The Commission entered the multiplexing field with the introduction of the 9600 bit/s multistream datel service at the beginning of 1975. With this modem, it is possible to derive two circuits operating at 4800 bit/s or four at 2400 bit/s or two at 2400 and one at 4800 bit/s. Where a total throughput of less than 9600 bit/s is required, it is normal for the multiplexer or concentrator to be permitted to interface a Telecom 1200, 2400 or 4800 bit/s single stream datel service to be then broken down to the desired sub-channels by a complementary multiplexer at the other end of the circuit. In all cases, a one-off system permit is issued by Telecom.

Looking to the future, Telecom may well become the principal multiplexed datel service provider in the early 1980's with the advent of Time Division Multiplex data networks.

Integrated Modems

Since the inception of the data transmission service in Australia, Telecom has supplied modems to internationally accepted standards, as part of the total end-to-end communication link. This has assisted in the orderly development of data communications.

It is recognised however that technology has now led to the integration of modems into terminal equipment and studies are being conducted with a view to issuing a statement liberalising future policy in this area.

CONCLUSION

This paper is a survey of present data communications facilities. (Other papers deal with applications in networks). The medium and long term future are much more difficult topics to write about than the present.

In terms of requirements the Austdata survey, now almost concluded, will provide medium term guidance; for the long term the Telecom 2000 report raises many points for discussion between the computing and telecommunications industries. Of particular interest is the future of specialised data networks discussed in several papers submitted to this conference.

It may well be true that our present service offerings based upon adapting to the transmission paths developed for the telephone network is an interim phase in the development of comprehensive data communication facilities having wide national and international applicability. The demand for, and commercial viability, of public data switching networks (differentiating these from specialised data transmission networks) is a key question in debates in the future. It is remarkable that data communication growth rates such as those experienced have been possible using the general telecommunications network. This demonstrates the ability of the telecommunications and computing industries to adapt their respective technologies to meet requirements, and augurs well for the merging of technologies which will be necessary in moving toward specialised data networks.

In the meantime the use of modems will continue till well into the 1980's on present world trends. Changes in modem design will advance in line with changes in general production technology in the light electronics field. Already, the volume of modem orders, is leading to the use of large scale integration (lsi) techniques for some classes of modem. Logic design will improve e.g. in the field of automatic adaptive equalisation, in clock recovery circuits and in development of techniques allowing quicker attainment of synchronism on synchronously operated datel links.

Improved equalisation techniques integrated with the modem itself and operating flexibly over a wide range of transmission characteristics will simplify the task of providing datel circuits at the higher speeds. Improved clock recovery design will lead to lower error rates, and faster attainment of synchronisation will benefit some types of multi-station private line networks in terms of reduced "overheads" in time. These improvements in modem technique will reduce some of the constraints upon network development which are at present encountered pending the longer term availability of specialised data networks.

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Brisbane-Birdsville High Frequency Telephone System

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This paper describes the design and installation of the high frequency SSB single-channel radio trunk telephone system which connected Brisbane to the remote town of Birdsville in August 1976. New concepts, facilities and equipment designs are introduced and the total system design maximises performance, reliability and cost-effectiveness.

INTRODUCTION

Birdsville is a small town in the Channel country of Far-Western Queensland. Connection to the Australian telephone network by landline was impractical due to the difficult access to this region in the wet season. It had been hoped to extend the new Boulia-Bedourie aerial route a further 170 km to reach Birdsville but a major flooding of the intervening country in 1973 raised the prospect of outages lasting months for such a system.

A VHF radio system was not teasible as it would require intermediate repeaters. A tropospheric scatter system would locate a complex high power terminal in a town with no technical staff and a total mains power generating capacity of 8 kW.

The only practical solution appeared to be a high frequency system using unconventional techniques to achieve the necessary noise performance and operational facilities.

SYSTEM CONCEPT

Connection to Network

The selection of a suitable town for the network end of the radio system considered:

- the grade of service resulting from the radio path propagation characteristics
- the origins and destinations of calls
- the cost of buildings, sites, roads and power
- the time required for site acquisition and development
- the availability of technical staff.

Fig. 1 shows the location of Birdsville with relation to Bedourie (170 km), Boulia (340 km), Mt. Isa (580 km), Cloncurry (590 km), Longreach (560 km). Windorah (335 km), Charleville (680 km), Brisbane (1400 km) and Maree (SA) (550 km).

Bedourie, Boulia and Windorah are unsuitable due to their own remoteness and the need for new sites. Also, the high angles of fire would require low operating frequencies, with high noise levels and antennas of low gain and directivity.

Mt. Isa, Cloncurry, Longreach and Charleville would all require new sites. Using horizontal polarisation and frequencies from 3 MHz to 7 MHz, an antenna optimised for the 35° angle of fire would also have gain at the 2-hop angle of fire, thus encouraging multipath fading.

Brisbane has existing separate transmitting and receiving stations, thus satisfying the requirements of cost, time and technical staff. The 18° angle of

Fig. 1—Birdsville and the Network.

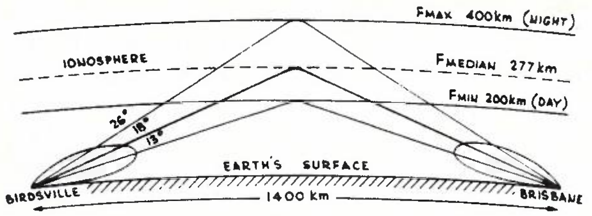

Fig. 2—Angle of Fire Optimisation.

fire for a Brisbane-Birdsville path (Fig. 2) would require vertical polarisation and would operate at frequencies twice those of the medium range paths (Mt Isa, etc.). The antennas specified would be vertical log periodics (Fig. 3) of 12.5 dbi gain, each supported by a single 37 m mast and of comparable cost to the horizontal log periodics used in the medium range case. The antenna gain is relatively independent of earth conditions since the reflected signal is close to the pseudo-Brewster angle.

The low angle vertical pattern and the 14 db directivity discriminate against double-hop propagation at a 33° angle of fire. Compared with the medium range case, the increased path loss due to the greater distance and the higher frequency is offset by the decreased noise at the higher frequencies and the increased antenna gain for a given capital cost.

While the trunk system is of considerable benefit to the Birdsville community, it is also important for tourists and road transport users, since the town is situated at a major road junction for long distance travellers in a very isolated area. Also the Birdsville airport is used by the Brisbane-Alice Springs Friendship service and by many light aircraft. Calls from Birdsville could have destinations to the North, the East and the South. Brisbane is centrally situated with strong trunk access to all these areas.

Two-Frequency Simplex Operation

For a commercially acceptable signal-to-noise ratio, the system requires:

- frequencies appropriate for the path
- high transmitter power
- high gain transmitting and receiving antennas optimised at the median angle of fire
- narrow bandwidth (SSB)
- full modulation by the speech signals

If we assume that typical telephone calls have a spread from 0 dbm to —30 dbm with a median level of —15 dbm and that the associated noise level is —50 dbm, then the median S/N ratio is

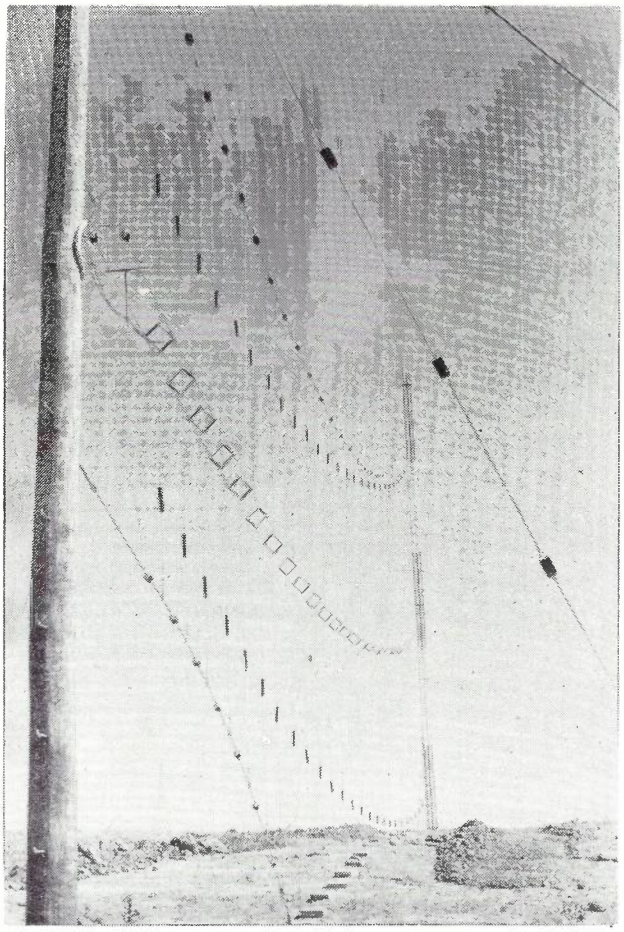

Fig. 3—Birdsville Log Periodic Antenna.

35 db. For the radio system, we should seek a median S/N ratio of 35 db. Heavy compression should be used so that all signals above the median level fully modulate the transmitter. In a full duplex system, expansion of such a "hard" compression characteristic to ensure stability would be difficult. Also, with ionospheric transmission the wide variations of gain cannot be perfectly regulated by the receiver automatic gain control (AGC) action, even if a gain-regulating pilot accompanies the signal. (The pilot may itself be subject to selective fading). Consequently the stability margin will vary and will at times be inadequate, causing performance degradation and ultimately oscillation. Anti-singing devices are available which suppress instability by attenuating the weaker speech path, thus approaching a voice-operated simplex condition. Voice-operated gain variation generally causes unacceptable syllable mutilation.

If simplex operation is inevitable in the quest for noise performance, then it is preferred to open the hybrid loop under all conditions. This can be achieved by a "press-to-talk" switch on each Birdsville telephone which will connect it to either the radio transmitter or the receiver. The Brisbane-connected subscribers would be unaffected and would transmit and receive continuously. Such an arrangement has the following advantages:

- the 15 db expander is not required
- the spread of signal levels is reduced
- syllable mutilation due to voice-controlled switching is avoided
- anti-singing devices are not required
- a single antenna at Birdsville can transmit and receive
- a single site at Birdsville is adequate
- radio transceivers may be used at Birdsville instead of separate transmitters and receivers

Fig. 4 shows the two-frequency simplex system adopted and identifies the main components affecting transmission. The press-to-talk switch loops the subscriber's line and this is detected at the radio terminal, where the switching is carried out.

Pilot Tone System

When single-sideband (SSB) transmission is used, there is no carrier present and the receiver automatic gain control (AGC) voltage is usually obtained from the speech sidebands. Since these are intermittent and varying in level with the speech, the AGC is continually changing, even under stable propagation conditions. The AGC circuit usually has a fast attack and slow recovery. The fast attack operates on the first syllable, causing some mutilation. The slow recovery prevents the AGC from following rapid fades.

In the Birdsville system, an in-band 2 048 Hz pilot at 25% modulation is added to the speech after the compression amplifier and the transmitter is linearly modulated by the combined signal to avoid intermodulation.

The receiver AGC circuit is modified to have fast attack and recovery. The AGC voltage is derived mainly from the pilot, thus giving a constant volume reference level. The speech signals are thus reproduced at the same relative levels as at the compression amplifier output, regardless of ionospheric variations. If the pilot suffers a selective fade while speech is present, the speech itself will momentarily hold the AGC and prevent a rise in receiver gain.

The Birdsville pilot is sent while the "press-to-talk" button is operated. Each time the pilot is received in Brisbane, it sets the receiver AGC and also operates a squelch relay to connect the receiver output to the exchange. Since the system gain stabilises before speech is transmitted, syllable mulilation is avoided. Also, during long pauses in

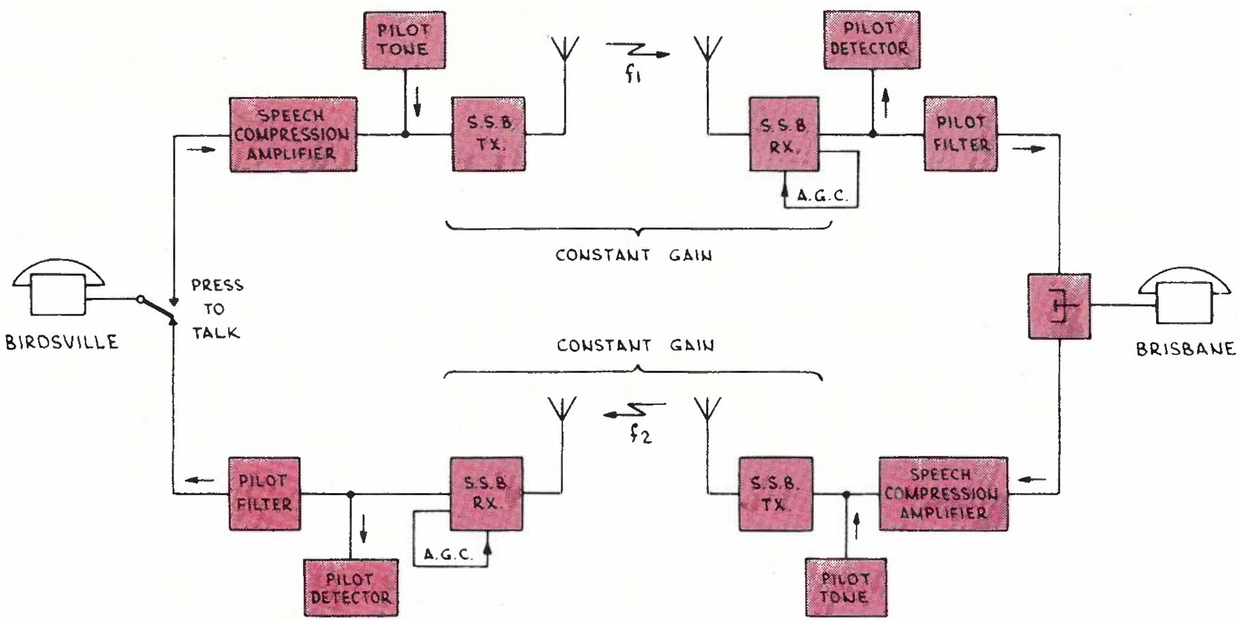

Fig. 4—Birdsville System.

speech, the pilot prevents the rise in noise level experienced in conventional systems. The Brisbane pilot is sent for the duration of the call, but is only received at Birdsville when the "press-to-talk" button is not operated, since the antenna is switched alternately between the receivers and the transmitters. A squelch relay at Birdsville connects the receiver output to the exchange when pilot is received.

The pilot tone is removed by a notch filter. The loss of some speech harmonics in the vicinity of the pilot does not cause significant degradation of quality.

Since the pilot frequency will sometimes experience deep selective fades, the squelch relay should respond to the presence of the pilot at the smallest possible level but should not respond to noise signals. To achieve this result, the squelch detector is a tone decoder, which responds only at the pilot frequency.

The squelch relay has a slow release to avoid breaks in the speech if the pilot is lost due to rapid selective fades or to overloading of the system by impulsive noise. Such a delay however is still quite small and is not noticeable in the alternation of conversation between parties.

The operation of the squelch relay is also used in control and supervision, to indicate the status of the system.

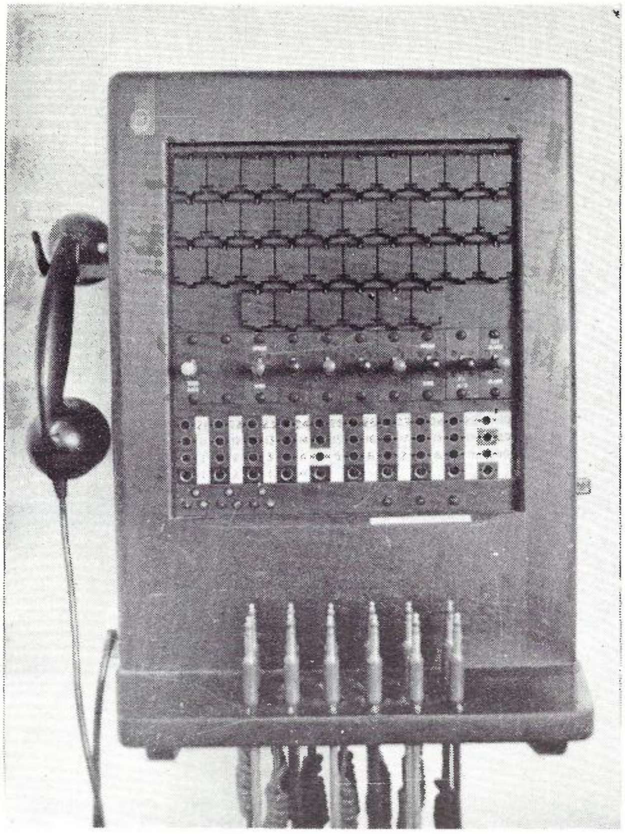

Fig. 5—Birdsville 30 Line Switchboard.

Operational Facilities

A magneto local telephone system is used with a wall-mounted 30-line switchboard in the Post Office (Fig. 5). A public telephone is located outside the Post Office (Fig. 6) and the radio hut and antenna are on a nearby site.

Local calls are limited to office hours. All telephone handsets are fitted with press-to-talk buttons for use on trunk calls only. They have no effect on local call operation.

During office hours, the Birdsville operator uses a cord circuit to connect any subscriber or the public telephone to the trunk system and the Brisbane operator controls the charging. Similarly, incoming trunk calls to Birdsville are connected via the switchboard to the called party.

Outside office hours, the Birdsville operator operates the "night-switch public telephone" key and also uses a cord circuit to connect the selected "night-switched subscriber" to the "Brisbane night-switch" jack. Under these conditions, either of these two users will seize the trunk system if it is not busy and will busy it for the duration of the call, during which time busy tone will be sent to the other user. Incoming trunk calls will all be switched automatically to the night-switched subscriber.

Three frequency channels are available for use but only one at a time.

In the Birdsville radio hut there are three transceivers (Fig. 7). Each operates normally on one of the three pairs of frequencies but is capable of being switched manually to the other channels in the event of an equipment failure.

Each frequency channel appears at a separate switchboard jack. The speech circuits of these jacks are connected in parallel, since there can only be one call at a time. The sleeve circuits of the three channel jacks, however, provide dc control to select the appropriate transmitter and to inhibit reception on the receivers for the other channels. Associated with each of the three channel jacks are three lamps. The amber lamp lights if that channel is in use or was the last used and is operated by a channel memory circuit. The green lamp lights if the channel is in use in the receive mode and the red lamp if in the transmit mode.

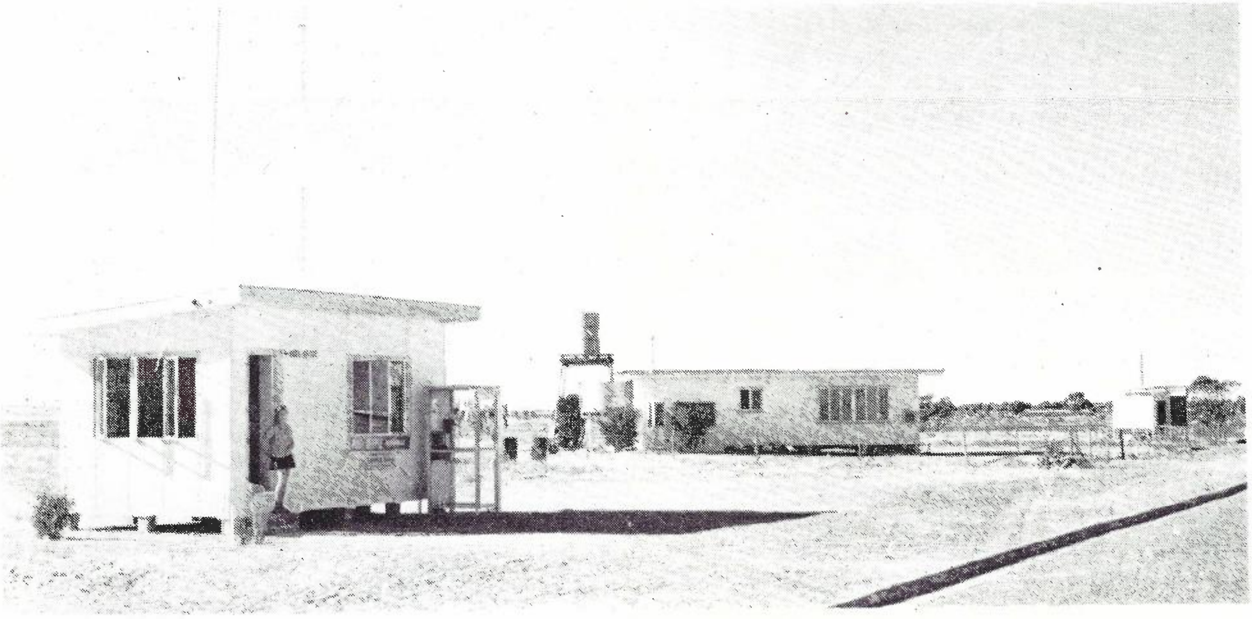

Fig. 6—Post Office and RT Terminal.

An incoming pilot tone from Brisbane causes the correct receiver to be connected to the switchboard and the appropriate green channel lamp to be lit. A ring signal from Brisbane alerts the operator with a distinctive audible alarm.

When the Birdsville operator plugs into a Brisbane channel jack, the sleeve circuit updates the channel memory, which selects the equipment appropriate for that channel. When the press-to-talk button is operated the appropriate transmitter is switched to the antenna and energised and pilot tone is transmitted. When the operator rings Brisbane, a ring detector in the radio hut switches the system to transmit and transmits a ring tone.

In Brisbane, the system terminates in the Central Manual Assistance Centre (MAC). Calls to Birdsville may be connected from any position. Calls from Birdsville are accepted at a single position. There are separate jacks for the three channels, the speech circuits being connected in parallel. A lamp similar to a free lamp is associated with each jack and lights if that channel was the latest in use. As for Birdsville, this is a guide to the operator and avoids a search for the best channel each time a call is made.

When a plug is inserted into a jack, the sleeve circuit sends dc signalling information to the Hemmant transmitting station where the appropriate transmitter is switched to the antenna and energised and a pilot tone is transmitted. When this pilot tone is received at Birdsville, the logic circuits recognise it as a new call and generate and transmit a distinctive "acknowledge" tone to the Birdsville operator for 1.5 seconds. This enables the Brisbane operator to assess the circuit quality and determine by comparison which is the best channel, without assistance from the Birdsville operator. By plugging into the best channel last, the Brisbane operator may update the Birdsville memory. This is necessary for frequency changes outside office hours, particularly over weekends, so that the public telephone and the night-switching subscriber may use the best channel, since they have no control of channel selection themselves. The memory lamps in Brisbane guide all operators to the last channel memory updating carried out.

When the Brisbane operator sends ring, it is dc signalled to Hemmant where ring tone is then transmitted.

Birdsville transmissions are received at Capalaba where the pilot tone is recognised and the appropriate receiver is connected to the MAC. When ring tone is received, this information is dc signalled to operate the call lamp on the appropriate channel jack.

Once contact is established between the Brisbane and Birdsville operators, they can if necessary change channels by mutual agreement without further ring signals.

A multi-coin public telephone is used at Birdsville. It is necessary to operate the press-to-talk button while inserting coins. Operation of the B button simulates the press-to-talk condition so that the warning tone can be sent to the Brisbane operator. When the public telephone is night-switched, the normal public telephone tone is generated and accompanies any speech for 44 seconds after the initial ring, to enable the Brisbane operator to recognise the PT during the setting up of the call. It has normally ceased by the time the called party answers. This system is simple and positive.

When switching between the normal and the night-switched conditions the Birdsville operator must ensure that no call is in progress. By observing the amber, green and red lamps it is unnecessary to monitor the line.

Night-switched incoming calls are sent to the selected subscriber which in this case is the Police Station. Ringing current is sent on the line. Ringing current received from either the night-switched subscriber or the night-switched public telephone operates directly the ring circuit to Brisbane.

Clearing of a call may be carried out at Birdsville if the clearing shutter falls or if both the red and green lamps extinguish. In Brisbane the call will be cleared when the network-connected subscriber hangs up.

Maintenance

In the event of an equipment failure at Birdsville, there is sufficient redundancy in the equipment provided to restore service by changing units. Faulty equipment is returned to Brisbane for repair. First-in maintenance is provided by the Charleville technical staff.

The transceivers are quite small and portable, as seen in Fig. 7. Each is tuned for all three channels, which may be selected by a front panel knob. The transceivers may be easily disconnected. A fourth transceiver is provided as a spare to permit one to be away in Brisbane for repairs.

The control equipment is mounted in a sub-frame (Fig. 8) which is removable as a unit and has a multicon plug connection. A second fully-equipped sub-frame is provided as a spare.

Individual circuit blocks, such as receiver decoder, tone generator or master logic, are constructed on plug-in printed circuit cards (Fig. 9). These may be interchanged between the working sub-frame and the spare unit.

Substitution of units could be carried out without difficulty in an emergency to restore service, but in normal circumstances this work would be carried out by a visiting technician in consultation with the Radiocom staff in Brisbane.

Alarms for high and low battery voltage and for fuses are extended to the switchboard. The operator has instructions on fault reporting procedures.

In Brisbane, Hemmant has three transceivers operating as transmitters and Capalaba has three transceivers operating as receivers. All the transceivers are tuned for both transmitting and receiving and may be interchanged between the two stations. The control equipment is simpler than that at Birdsville. Spare plug-in cards are held.

SYSTEM ENGINEERING

Propagation and Noise Performance

An initial study of maximum usable frequency (MUF) and absorption limiting frequency (ALF) for the Brisbane-Birdsville path suggested that a frequency range 7 to 15 MHz would satisfy most propagation conditions and three frequencies would provide full coverage with some overlap. The design sought to achieve commercial performance

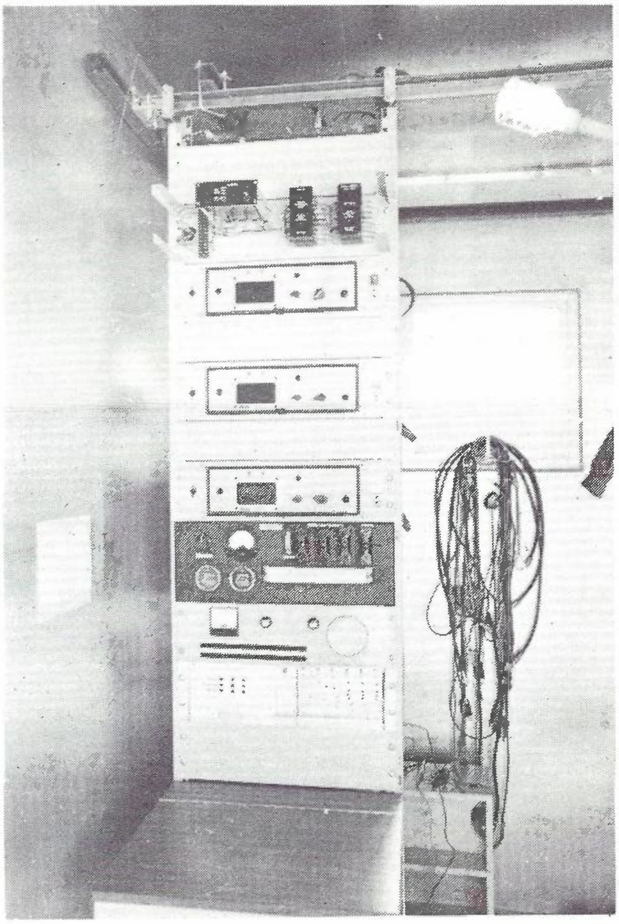

Fig. 7—Birdsville R/T Rack.

on the second-best channel to provide a margin of performance and to ensure an alternative channel if radio interference degraded the best channel.

The optimum channel is selected by the operators on a trial-and-error basis.

During the design stage, the expected noise performance was calculated for all conditions (Ref. 1). The Ionospheric Prediction Service provided computer predictions of median path loss and angle of fire for each propagation mode for the Brisbane-Birdsville path, for each hour, the four seasons, the sunspot years 0, 50, 100 and 150 at frequencies from 7 MHz to 15 MHz in 1 MHz steps. Generally the path loss increases from night to day and with increasing frequency.

The median atmospheric noise power available from a loss-free receiving antenna was calculated for the frequencies of interest for each hour and each season, using CCIR data on the world distribution and characteristics of atmospheric radio noise. Generally this noise decreases from night to day and with increasing frequency, the variation being similar to the variation in path loss, so it is possible for the signal strength to vary 10 db with little change in the signal-to-noise ratio. It also follows that the strongest signal does not necessarily produce the best S/N ratio.

Table 1 shows the calculation of a typical median signal, noise and S/N ratio for the "second-best" channel. The best channel would be about 4 db better.

The SSB transmitter has a peak envelope power (PEP) of 100 watts (+20dbW). The average signal modulates to 50% (+14dbW). Assuming a uniform distribution of noise sources, a directive receiving antenna has the same available noise power as an isotropic antenna. Allowance is made for the antenna efficiency by subtracting the directivity from the gain. Note that the receiving antenna gain and the receiver line and distribution losses affect signal

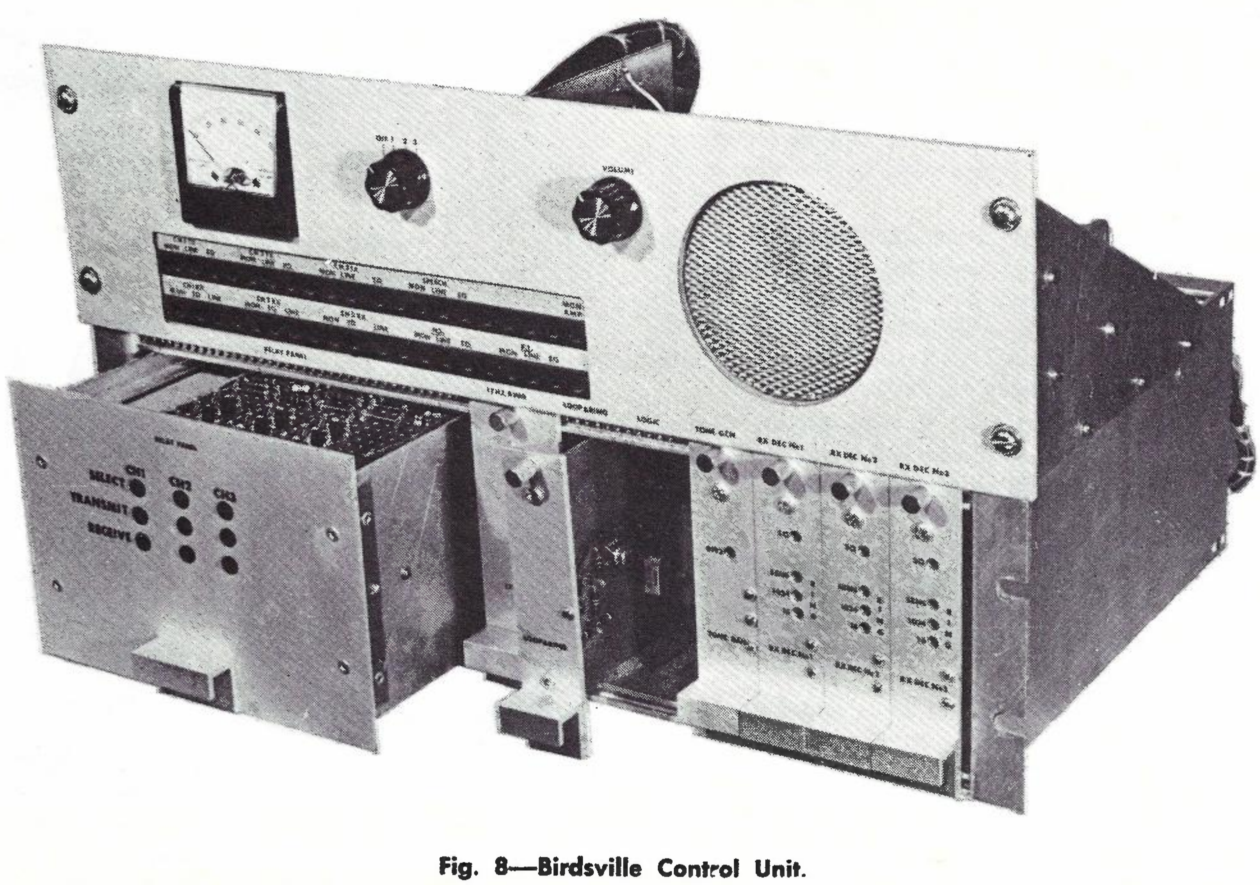

Fig. 8—Birdsville Control Unit.

TABLE 1—SIGNAL/NOISE CALCULATION

Received Signal (Median)		Received Noise (Median)	
TX Power (50% Mod.)	+14.0 dbW		
TX Line Loss	—1.5 db		
TX Antenna Gain	+12.5 db	Lossless Antenna Noise (Typical)	—131.0 dbW
Path Loss (Typical)	—130.0 db	RX Antenna Directivity	—14.0 db
RX Antenna Gain	+12.5 db	RX Antenna Gain	+12.5 db
RX Line Loss	—1.5 db	RX Line Loss	—1.5 db
RX Distribution Loss	—6.0 db	RX Distribution Loss	—6.0 db
Received Signal	—100.0 dbW	Received Noise	—140.0 dbW
Signal-to-Noise Ratio (Median) =	40 db		

Signal-to-Noise Ratio Distribution with Time (Typical)

50%	60%	70%	80%	90%	95%	Time
40 db	37 db	33 db	28 db	21 db	15 db	S/N

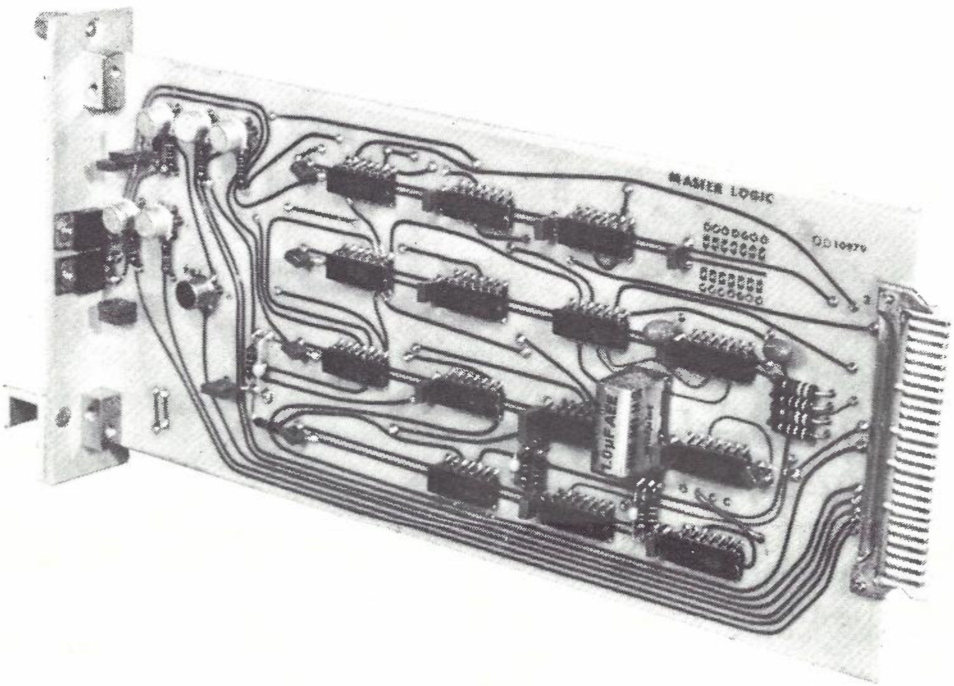

Fig. 9—Master Logic Card.

and noise equally. In this case a median S/N ratio of 40 db is obtained. (For the best channel it would have been 44 db).

Radio signals experience slow and rapid fades. Slow fading, which varies the median signal at any hour from day to day, follows a log-normal distribution with a typical standard deviation of 7 db. Rapid fading, which varies the median minute signal within an hour, follows a Rayleigh distribution with a typical 90% value of 8 db. Noise variations follow a log-normal distribution. CCIR data on upper decile values for time of day, season

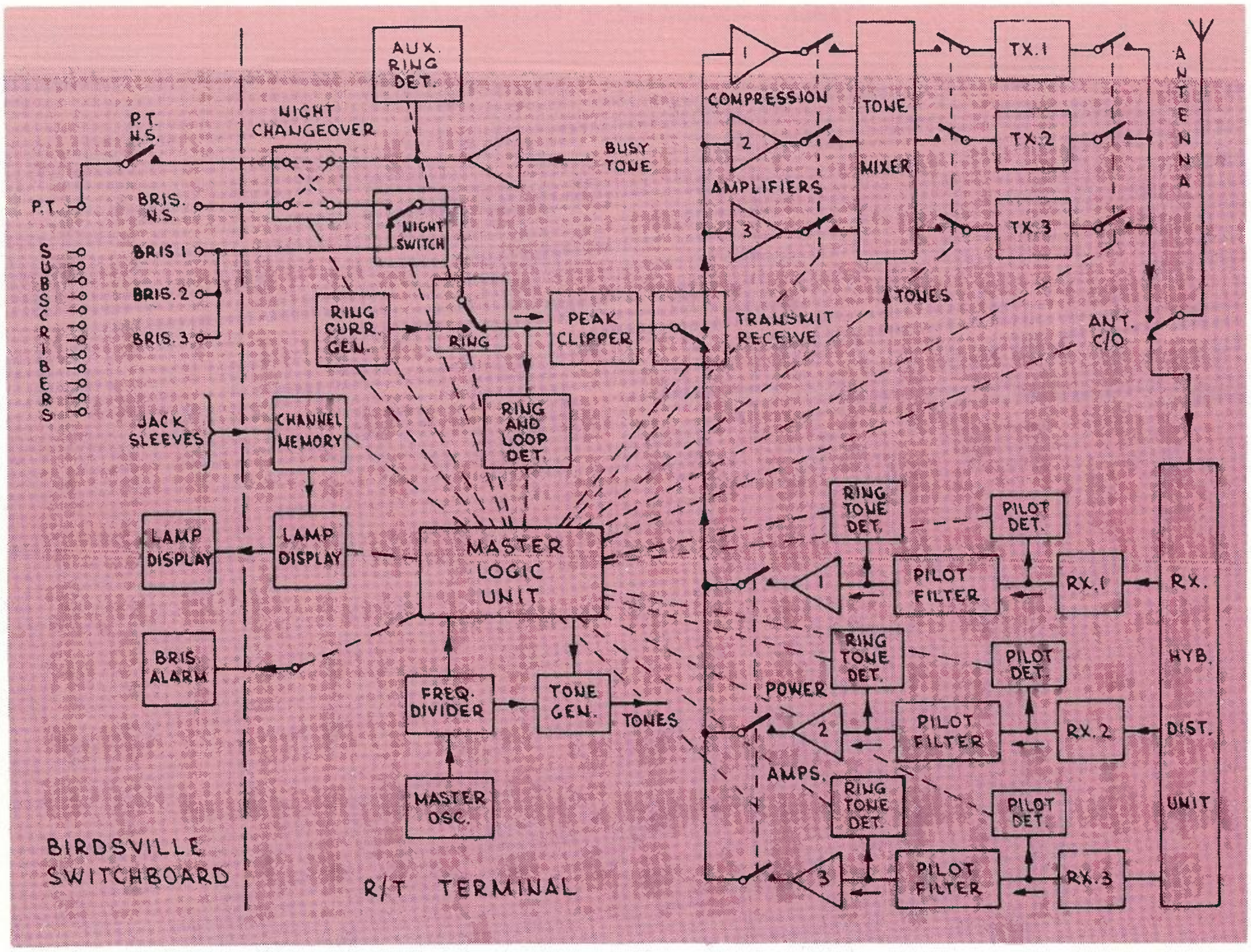

Fig. 10—Birdsville Block Diagram.

and frequency were interpolated on a probability graph.

The slow and rapid signal fading and the noise variations were combined to calculate S/N ratio tables for 50%, 60%, 70%, 80%, 90% and 95% time for each hour, each season, the sunspot years 0, 50, 100 and 150 and for each of the selected frequencies. A typical time distribution for the second-best channel is shown in Table 1. The 40 db median value decreases to 15 db at 95% time.

For radio systems, CCIR specify a S/N ratio of 33 db as "good commercial" and 17 db as "marginal commercial."

The system should therefore have good commercial performance on its best and perhaps also the second-best channel for 70% to 80% of the time and should degrade below marginal commercial for the last 5% of the time. In practice, the lack of correlation between the short-term behaviour of the three channels will provide some "diversity" and the operator may well take advantage of the real performance at any time rather than the statistical averages used in the design.

It is impossible to calculate the S/N ratio degradation caused by co-channel interference from other transmitters, or to ensure that a selected channel will remain clear. The use of high gain antennas, however, has been found essential to reduce such interference to acceptable levels.

Antennas

Vertically polarised log periodic dipole antennas (Antenna Engineering Model 698C) are installed at Birdsville, Hemmant and Capalaba. These antennas maintain the vertical pattern shown in Fig. 2 over all channels used. Baluns couple the antennas to 50 ohm FHJ4 coaxial cables.

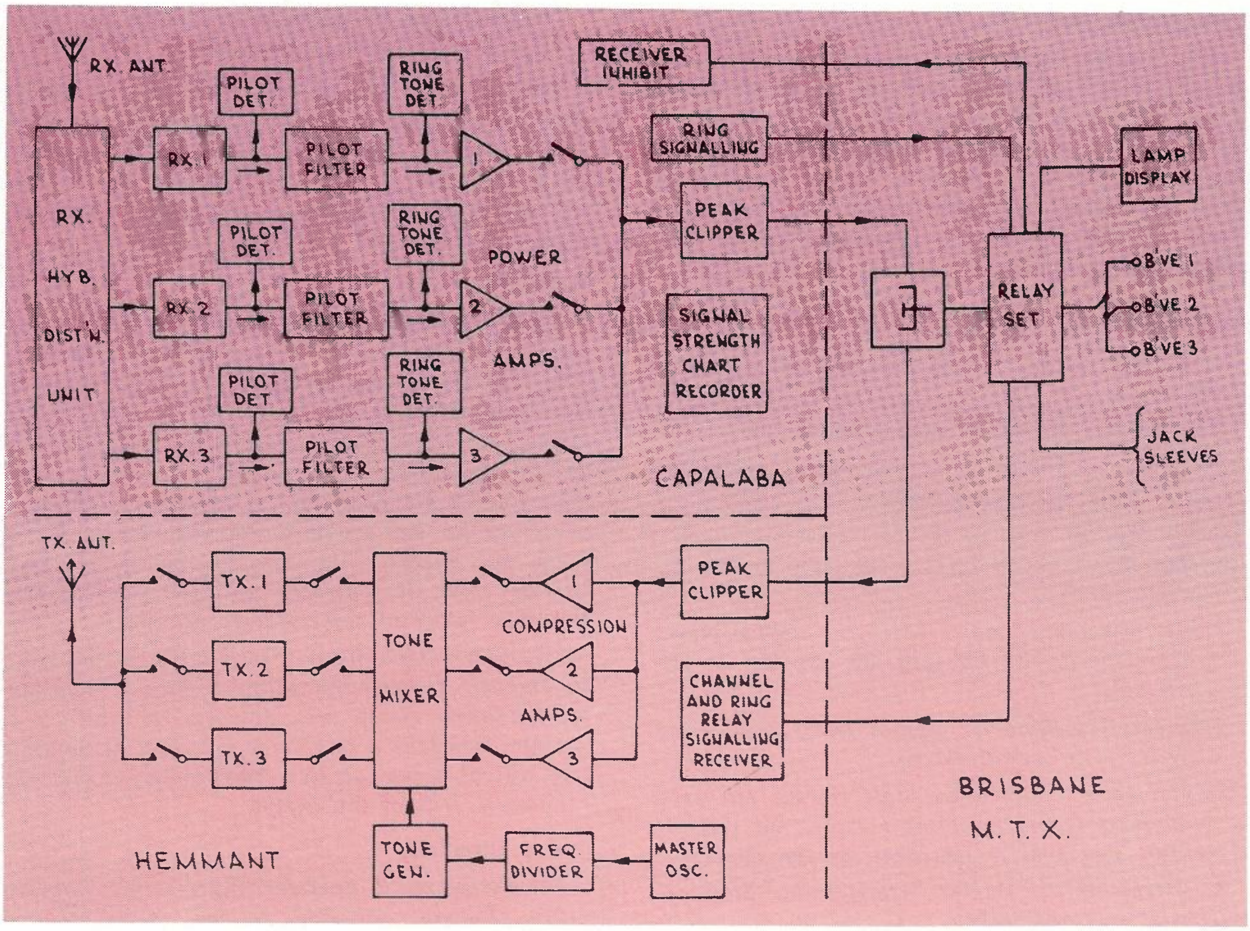

Fig. 11—Brisbane Block Diagram.

Block Schematic Diagrams

The total system operation is shown in block schematics for Birdsville (Fig. 10) and Brisbane (Fig. 11). The heart of the Birdsville equipment is the Master Logic Unit, which is a single card of TTL logic connected to give the required behaviour patterns. A master oscillator at 8 192 Hz is fed to two divider chains to produce many frequencies to be used in tone synthesis and timing. The channel memory uses relays, since the multiple contacts are useful for switching audio and keying transmitters. An antenna changeover relay switches the antenna to the transmitters when required. The appropriate transmitter is switched to a common output bus. A receiver hybrid distribution unit feeds the signal to the three receivers while isolating them from one another. Each receiver has its own pilot detector, pilot notch filter and ring tone detector. When a pilot tone is detected, the receiver output is switched to a common bus.

During a call, the antenna switches regularly between the transmitter and the receiver. Each time it disconnects from the receiver, the received pilot disappears and the receiver is disconnected from the line. When the antenna is again connected, the pilot is again detected but the logic can distinguish between this condition and a new call and no acknowledge tone is sent.

The ring and loop detector is connected across the Brisbane circuit. An auxiliary ring detector is used in conjunction with the night-switched circuit to monitor the other output of a bi-stable night changeover switch connected to the public telephone and the night-switched subscriber.

The Brisbane schematic is seen to be simpler, while using similar techniques. DC signalling on the lines interfaces with E & M signalling at the Brisbane Trunk Exchange. A hybrid separates the send and receive speech signals. A signal strength chart recorder at Capalaba on each receiver samples the signal voltage during calls to provide a maintenance indicator of fading and channel usage.

Master Logic Unit

The master logic takes input data comprising the conditions of many parts of the system and processes it to produce output data which controls the Birdsville terminal. To design this device, all required behaviour patterns were documented separately using intermediate data and then combined. Timing delays are generated using clock pulses and counters.

Tone Generation

The following tones are generated at Birdsville as required:

Pilot tone — 2 048 Hz square wave

Ring tone — 1 024 Hz square wave, modulated by 17.07 Hz square wave

Acknowledge tone — 409.6 Hz square wave, modulated by 34.1 Hz rectangular wave, 1:2 mark/space.

Public telephone tone — 819.2 Hz square wave, 88 mS (on), 176 mS (off), 88 mS (on), 2 461 mS (off).

Busy tone — 409.6 Hz square wave, modulated by 0.71 Hz square wave.

Digital gates enabled by logic signals are used to synthesise these waveforms from the outputs of various stages of a frequency divider chain.

At Hemmant, a similar arrangement produces pilot tone and ring tone.

Ring and Loop Detector

Relays cannot be used as line loop detectors as the 12 volt dc supply would feed too small a current through a line of 1 500 ohm maximum loop resistance. Also, the press-to-talk action would make heavy demands on a relay, particularly in dusty conditions. Instead, the line currents are detected by opto-isolators, which drive trigger circuits to produce digital outputs. Ringing current is recognised when the line voltage exceeds the 12 volt battery voltage.

Receiver Decoder

Each receiver is fed to a separate decoder which:

- detects the presence of pilot tone (using a tone decoder)
- detects if the received signal strength exceeds a specified value (using an AGC comparator)
- provides a low impedance drive for the S-meter and the chart recorder
- filters out the pilot tone (2 048 Hz) with a notch 200 Hz wide at 3 db down and 20 Hz wide at 40 db down
- detects the presence of ring tone (using cascaded tone decoders at 1 024 Hz and 17 Hz and checking signal strength).

Pilot tone on the channel currently in channel memory is accepted without delay for the press-to-talk action, even during signal fades. Pilot tone on a different channel is subjected to a signal strength check and time delay, to improve immunity to spurious signals.

Transceiver

The Codan Model 6801 transceiver used is fully solid state and has an output PEP of 100 watts. The circuit is broken between the audio compression amplifier and the modulator to insert a tone mixing amplifier and to modify the original levels so that the audio compression occurs at lower levels than the RF compression, to maintain linearity in the RF section and prevent intermodulation between tones and speech. The receiver section is broken between the demodulator and the audio power amplifier to insert the receiver decoder.

The transceivers are not fitted with crystal ovens. To maintain frequencies within 5 Hz a temperature compensation circuit was devised, in which a dc voltage, which is a non-linear function of temperature, drives a varicap to approximately correct the frequency drift of the crystal.

Power Supplies

All equipment is operated from +12V (negative earth). Voltage regulators on the circuit cards of the control unit provide +5V (digital) and +8V (analogue).

At Birdsville two 10A rectifiers in parallel float two 200AH batteries in parallel, giving a 5 day reserve with typical usage. After a mains outage, a 20A boost charger is automatically applied to restore full charge.

Capalaba and Hemmant have 10A rectifiers and 200AH batteries.

Equipment Accommodation

The Birdsville equipment is housed in a small hut with additional sunshade roof and wall screens on the sunny sides. There is no air-conditioning. The equipment is designed to operate at 50°C.

Installation and Commissioning

The portable hut was wired and equipped with the rack and power equipment before being transported to Birdsville. The Brisbane installations were completed first. The Birdsville installation was then built in the Brisbane installation depot with a simple antenna and actual radio transmission tests carried out with Hemmant and Capalaba to simulate as closely as possible the final conditions. A relatively short time was then required at Birdsville for final testing.

Future Development

With the introduction of the 10C SPC trunk switching to Brisbane, it will be desirable to automate the channel selection on this system. It is proposed to develop equipment which will interrogate the Birdsvile circuit at frequent intervals when idle, compare the S/N ratios for the three channels and set a channel memory in Brisbane to the best channel.

CONCLUSION

The Birdsville system is a departure from the normal methods of trunk circuit provision and is justified by the lack of a viable alternative. The project was dominated by cost, time, performance and reliability. The available technology was exploited and the technical resources of the Commission directed to achieve a commercial service to meet the needs of this remote community.

ACKNOWLEDGEMENT

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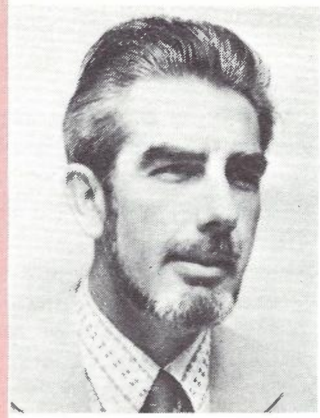
Mr Tolmie was the designer of the Birdsville system and leader of the project.



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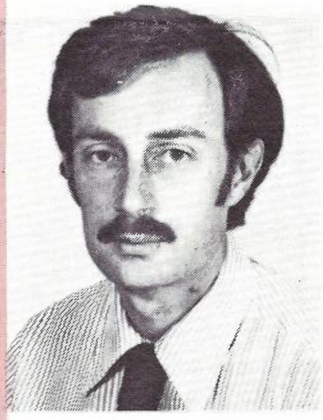


An Investigation into Cable 'Make' on Wooden Drums

T. S. CODY, B. Tech., Grad. I.E. Aust.

When wooden cable drums are rotated at any significant speed and accompanied by moderate to severe vibration, a phenomenon known as cable 'make' occurs. This is a condition where the inner end of a cable creeps out from the barrel of a drum. The amount of make is dependent on a number of factors and can vary from one or two metres up to 20 or 30 metres and is a cause of field down-time.

This article describes investigations undertaken by the South Australian Administration of Telecom Australia for overcoming this problem.

INTRODUCTION

From the days of lead sheath cable up to the present polythene and nylon jacketed lead cables, these types of cable when wound on wooden drums have exhibited the problem known as cable 'make' or cable 'creep'.

Cable make is a condition where the inner end of the cable creeps out from the barrel of the cable drum as it rotates The amount of cable 'made' is dependent on. a number of factors and can vary from one or two metres up to 20 or 30 metres depending principally on the length of the cable and the condition of the drum.

However, when cable is wound on steel drums, cable make is almost non-existent.

The factors which determine the amount of cable made on wooden drums are:

- length of cable;
- type of cable;
- original tension of cable as it is wound on a drum;
- tension in cable as it is unwound;
- speed of rotation of a drum;
- any vibration to which a drum is subjected;
- age and condition of a cable drum and the resulting co-efficient of friction between the cable sheath and the barrel of a drum.

THE PROBLEM

Depending on the type of cable in use, the cable make will either emerge from the side of a drum for small size multipair cables, or around the inside edge of one of the flanges of a coaxial cable as illustrated in Fig. 1. If the cable is being ploughed, the cable make causes a problem as the cable has to be continually worked free or it will kink inside the layers. As the cable make increases, the cable tends to wrap itself around the drum support spindle in the case of small diameter cables necessitating the fixing of this cable to the drum with straps around the periphery. For coaxial cables, the cable make causes the inner end tail to ride over the cable layers thus interfering with the cable laying operation.

On coaxial cables, approximately 20 minutes work by two men is required to prepare a drum for handling the cable make, and in most cases during ploughing the tractor has to be stopped at least once to re-adjust the rubber thong holding the end of the cable.

During the early stages of the Ceduna to Cobar coaxial cable project, a detailed history of the cable make of all drums ploughed and hauled was kept. Table 1 details results of this history.

On five steel drums ploughed, there was no cable make.

It can be seen from these results that due to the lower speed of rotation and lack of vibration in cable hauling, cable make is about half that experienced when cable is ploughed. This is to be expected as the predominant factor in hauling is the co-efficient of friction. When the cable is ploughed, the other factors come into force causing an 80% increase in the make.

TABLE 1 — CABLE MAKE ANALYSIS

	No. of Drums	Range of Lengths (metres)	Average Length (metres)	Average Make (metres)	Standard Deviation (metres)	Average % Make
PLOUGHED	51	170-760	670	1.24	0.10	0.185
HAULED	28	176-500	323	0.32	0.056	0.102

INVESTIGATION

In investigating the reasons for cable make, each of the factors mentioned above were checked:

- the length of cable usually determines the magnitude of make; that is, generally, the longer the cable length the greater the cable make;
- the type of cable does have some influence on cable make. Lead sheath cable is particularly prone to this problem be it with or without a polythene or nylon sheath. Moisture barrier cables do not appear to be affected and plastic cables are sometimes affected but to a much smaller degree than for lead;
- a possible explanation for cable make is that due to the weight of lead cables, the timber barrel of the drum deflects reducing the area of contact between the cable and the drum. The older the drum, the more pronounced is this effect. However, the co-efficient of friction between the cable sheath and the barrel was found to be the main determinant for cable make on wooden drums. The original tension, the unwinding tension, the speed of rotation and the effects of vibration only highlight the differing co-efficients of friction.

An example of cable make experienced is illustrated in the ploughing of two 1500 metre lengths of 4-tube polythene sheathed coaxial cables. On a steel drum, approximately 0.6 metre of cable was made; on a wooden drum, some 20 metres was made. Since this trial, a further six 1500 metre lengths on steel drums have been ploughed with no cable make.

If the make is excessive on a drum, it can entail the stopping of a plough to re-fix the rubber thong retaining the end of the cable. In the example quoted, the ploughing was stopped six times to take up the amount of make with approximately an hour lost for the tractor and six men at a cost of $90. However, for drums in good condition, no more than two stops would be expected over the 1500 metres.

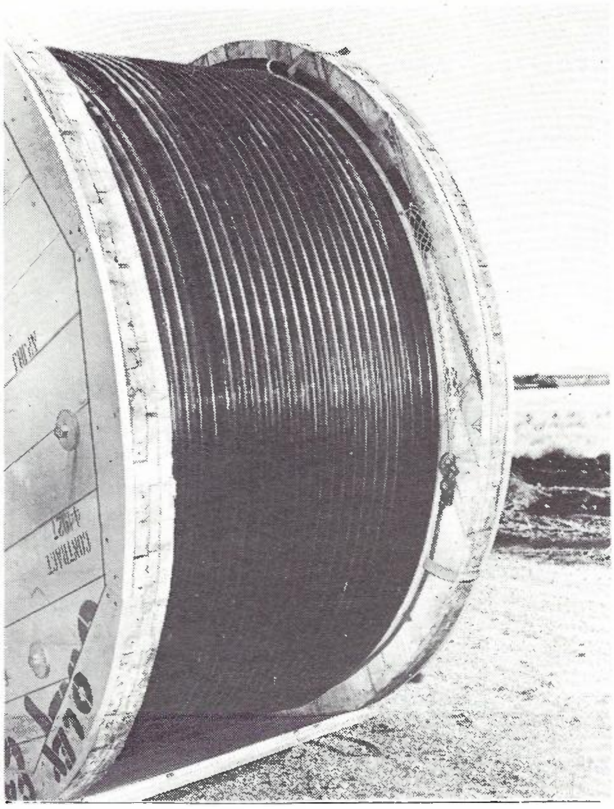


Fig. 1 — Wooden Cable Drum Wound with Coaxial Cable.

If the cable make can be reduced to zero on wooden drums, the system when applied to coaxial cable is one of the factors which will enable the length of cable on a drum to be increased from 750 to 1500 metres without resorting to all steel drums. In addition, if the proposed system is applied to small diameter lead cables, where cable make is often a hazard, the efficiency of ploughing by small country based teams will be considerably increased.

Any make greater than 0.2 metre is costly and undesirable due to the need to additionally treat the drum in the field to handle the cable make by the addition of the cable retention device. If the make can be reduced to between zero and 0.2 metre, the make can be taken up by the existing fittings on the drum installed by the cable factory.

To verify that the lack of friction between the cable and the drum barrel was the predominant factor in the problem, co-efficient of friction tests were carried out on the various materials used on cables and drums. Table 2 details the results obtained.

TABLE 2 — CO-EFFICIENT OF FRICTION RESULTS

Material Combination	Co-efficient of Friction
Nylon/galvanised mild steel	0.36
Polythene/galvanised mild steel	0.57
Alloy lead/galvanised mild steel	0.69
Nylon/timber	0.22
Polythene/timber	0.40
Alloy lead/timber	0.37
Nylon/vinyl fabric	0.55
Polythene/vinyl fabric	0.52
Alloy lead/vinyl fabric	0.71

It can be seen that there is a substantial difference between the co-efficients of friction of the timber/sheath combinations and the galvanised mild steel/sheath combinations. If the co-efficient of friction can be increased on the timber to that of steel, it would be expected that the cable make would be greatly reduced.

Following a number of trials of various materials, vinyl coated fabric was found to provide a co-efficient of friction greater than that of steel.

PRACTICAL TRIALS

Using five drums of 2000 metres of 10/0.90 PIUT APJ HJ (paper insulated unit twin, alloy sheath plastic jacket, hard jacket) cable, the barrels of the drums were coated with vinyl fabric at the cable factory. The cable was then ploughed and the cable make measured. This was found to vary from zero to five metres over the five drums. This was not a satisfactory result as the dynamic co-efficient of friction was not as great as the static co-efficient. The second trial was then arranged on the following basis.

Five coaxial cable wooden drums had their barrels coated with a tar paint then sprinkled with course sand on the treated surface. Five 750 metre lengths of 4-tube APJ HJ coaxial cable were then re-rolled onto the five treated drums. During the re-rolling it was observed that it was almost impossible to move the cable across the surface once it was wound on the treated drum. By contrast it was quite easy to move cable across the surface of an untreated wooden drum.

The five drums were then ploughed and the cable make was found to vary from zero to 0.2 metre over the five drums, the desired range for standard drum fittings. No damage was found on the cable sheaths due to the non-movement of cable relative to the drums. Damage would only occur if there was any differential movement between the two surfaces.

The tar paint used in this trial was found to be unsuitable for general application because it reacts with some of the materials in polythene sheath cables. As a result an alternative material had to be found.

Further investigation has revealed that a commercial brand marine quality non-skid paint is generally available. This is a non-butuminous paint incorporating pumice as the high friction component. This appeared ideal as its application was the same as for any other paint. Table 3 shows the co-efficient of friction results after one application of this substance.

TABLE 3 — NON-SKID PAINT CO-EFFICIENT OF FRICTION RESULTS

Material Combination	Co-efficient of Friction
Nylon/non-skid paint	0.57
Polythene/non-skid paint	0.62
Alloy lead/non-skid paint	0.81

These figures are substantially higher than any previously measured. The grain is so fine that it will not damage the sheath of the cable during transportation as may possibly occur if coarse sand were to be used.

The non-skid paint was then applied to another wooden drum and a 750 metre length of cable re-rolled and then ploughed. A make of 0.15 metre occurred. This was an ideal result as it was in the same range as that achieved when using the tar paint and with the steel drums. Following this field test, a full scale trial on six 1500 metre lengths of coaxial cable was initiated. The trial consisted of four lengths of cable wound on treated drums and two on untreated drums. The cables were wound at the factory and then transported approximately 600 kilometres to the installation site.

Three of the treated drums were ploughed in with an average of 2.8 metres make and the two untreated drums had an average of 4.8 metres make. This was a reduction of 42% and was not as great as was expected. However, it was noticed during the ploughing of these lengths that the cables were very loose on the drums. To check and see if this was the reason for the increased cable make above that expected, the fourth treated drum was reverse spun for five minutes. This had the effect of tightening the cable on the drum. When this length was ploughed, a make of 0.2 metre was experienced, being a reduction of 96%.

It was noted particularly on these drums but also on other wooden drums previously ploughed that a tail of approximately six metres around the periphery of the inside drum face (being over three quarters of a turn) existed on the inner end of the cable. (See Fig. 1.) This had the result that only cable make of about a quarter of a turn needs to occur before the cable tail completely encircles the drum making it more difficult to handle. To fully exploit the field productivity gains from suitably treated wooden drums, it would be essential during production to keep the inner end cable tail reasonably short — say about one metre. Steel cable drums are generally not greater than 0.3 metre.

COST EFFECTIVENESS

Two litres of non-slip paint are required to treat each coaxial cable drum at a material cost of $1.60. Allowing $10 for application costs and an average life for the drum of three deliveries, the cost of the treatment is $4 per length of cable ploughed. This compares with a total cost of $20 for field preparation of a drum to accept cable make and for one stop of the tractor to refix the rubber thong.

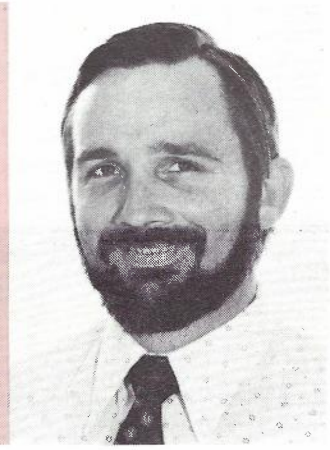
On the Ceduna to Cobar Coaxial Cable Project the reduction of the cable make would allow the laying of up to two additional drums each day depending on the mix of wooden and steel drums. Thus for a project of this size, additional financial advantages would occur from savings in overheads (e.g. travelling time) and from the earlier generation of call revenue.

CONCLUSION

Cable make on wooden cable drums has been a problem for many years. Its presence has caused difficulties in the field requiring ad hoc methods to overcome it as it occurs.

Cable make can mainly be traced back to a lack of friction between the cable sheath and the barrel of the drum. By increasing the co-efficient of friction between the two and ensuring the cable is tightly wound on the drum, the cable make with 4-tube coaxial cable can be reduced from an average of 1.4 metres to a nominal 0.15 metre on a 750 metre cable length at which point it ceases to be a problem. Overcoming this difficulty would result in a modest improvement in the productivity of cable ploughing activities.

TERENCE CODY joined the APO in 1960 as a Technician-in-Training. In 1968 he became a Trainee Engineer and graduated from the University of Adelaide with a Bachelor of Technology degree in electronic engineering in 1971. His first appointment as an Engineer Class 1 was in Building Engineering Services where he spent two years. In 1973 he transferred to the Primary Works Section as project engineer for the Ceduna to Cobar coaxial cable project. He has also been involved in the design and installation of major trunk cables for country areas.



The Trans Sumatra Microwave System — Part 2

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Part 1 of this article in the previous issue of the Journal described the basic plannng and design aspects of the system. This second part briefly describes the project management, installation, commissioning and operation of the system.

PROJECT MANAGEMENT

Role of the ATM

The role of the ATM was originally envisaged as that of a consultant to PERUMTEL staff who would carry out the detailed planning and supervision of the project. Because insufficient experienced PERUMTEL staff were available ATM involvement progressively widened to include direct negotiation with contractors and virtually direct responsibility for ensuring that installation standards and system performance were achieved.

The relative responsibilities of PERUMTEL and ATM were covered by "Memoranda of Understanding" which were reviewed and expanded as the project progressed. Contractor's responsibilities were defined by the specification, the contract and in the agreed minutes of subsequent negotiations.

Training

A major ATM responsibility was to train PERUMTEL staff: theoretical and on-the-job courses were conducted in the following fields:

- Microwave system surveying
- Project planning and management
- Equipment familiarisation and function
- Tower erection supervision
- Equipment installation supervision and acceptance testing
- Maintenance procedures
- Use of test equipment

As well as these courses, thirteen system maintenance engineers were sent to Australia for a year, to revise basic microwave techniques and obtain practical experience on operational NEC equipment similar to that being supplied for the Trans Sumatra Microwave System (TSMS).

Throughout the project all activities and procedures were thoroughly documented with instructions on most of the topics listed above being prepared.

Field Supervision

Just prior to the commencement of installation, seven technical officers were seconded from the APO to act as field supervisors in the following areas:

- Tower erection (2)
- Radio equipment installation and testing (2)
- Radio equipment, antenna, and feeder installation and testing (1)
- Power plant installation and testing (1)
- Multiplex equipment installation and testing (1)

In addition to providing guidance to PERUMTEL staff in field supervision techniques, the supervisors assisted in their training. In all areas attempts were made to relate activities to the eventual mainenance of the system.

The field organisation was set up so that a PERUMTEL inspecting officer accompanied each of the contractor's installation and testing teams, while the ATM staff served in a supervisory and advisory capacity. All of the PERUMTEL inspecting officers had attended the courses in Australia and the other courses conducted in Indonesia. As PERUMTEL was the customer, theoretically the ATM staff could only

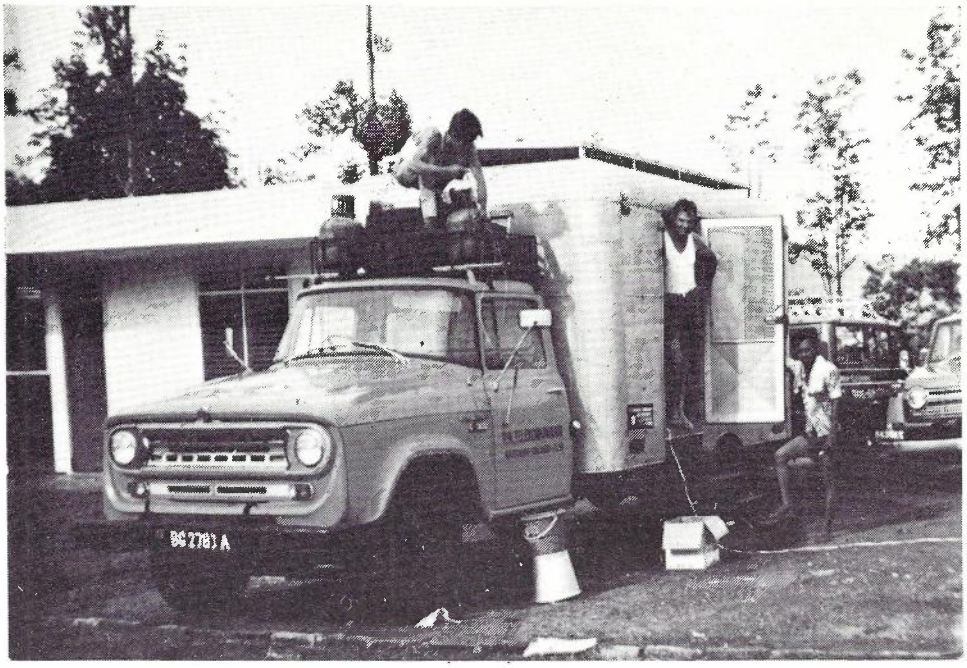

Fig. 8—Caravan on Site in Central Sumatra.

direct the contractors through a PERUMTEL counterpart. Parallel reporting procedures thus became established to ease communication and at the same time to preserve the contractual obligations.

In general the PERUMTEL staff were keen and eager to learn and it is satisfying to hear that after eighteen months they are still maintaining the system to a respectable standard. However the operation was not altogether without problems. For example, towards the end of the financial year PERUMTEL petrol funds were exhausted with the result that ATM staff had to transport the PERUMTEL officers from site to site.

Field Staff Support

Quite a logistic exercise was mounted to support the ATM field staff. Each ATM field supervisor was provided with a fully equipped self-powered caravan and a Landrover (Fig. 8). The caravans were parked at TSMS sites and the Landrovers were used to visit PERUMTEL inspecting officers at adjacent sites. Drivers for each vehicle were locally engaged.

As ATM's work in Sumatra expanded, permanently staffed messes were progressively established at major centres to accommodate the telephone exchange installation supervisors. At these messes the TSMS field staff could replenish food supplies and gain respite from the confinement of the caravans. Stationed in Sumatra were both an admin/catering officer and a motor mechanic. The mechanic, who serviced the mission's Sumatran fleet, also provided valuable assistance during power plant exercises. For security, and to facilitate contact with Headquarters staff, an HF network was established with bases in Bandung, the messes, and with mobile transceivers installed in the vehicles.

Contractors Field Organisation

SSK's field organisation was arranged to allow work to be performed sequentially at each station. The project was controlled by a small project team based in Jakarta with field teams arranged as follows:

- Tower Foundations
- Tower Erection
- Power Plant Installation
- Waveguide and Antenna Installation and Testing
- Radio and Supervisory Equipment Installation
- Power Plant Testing
- Radio Testing and Commissioning

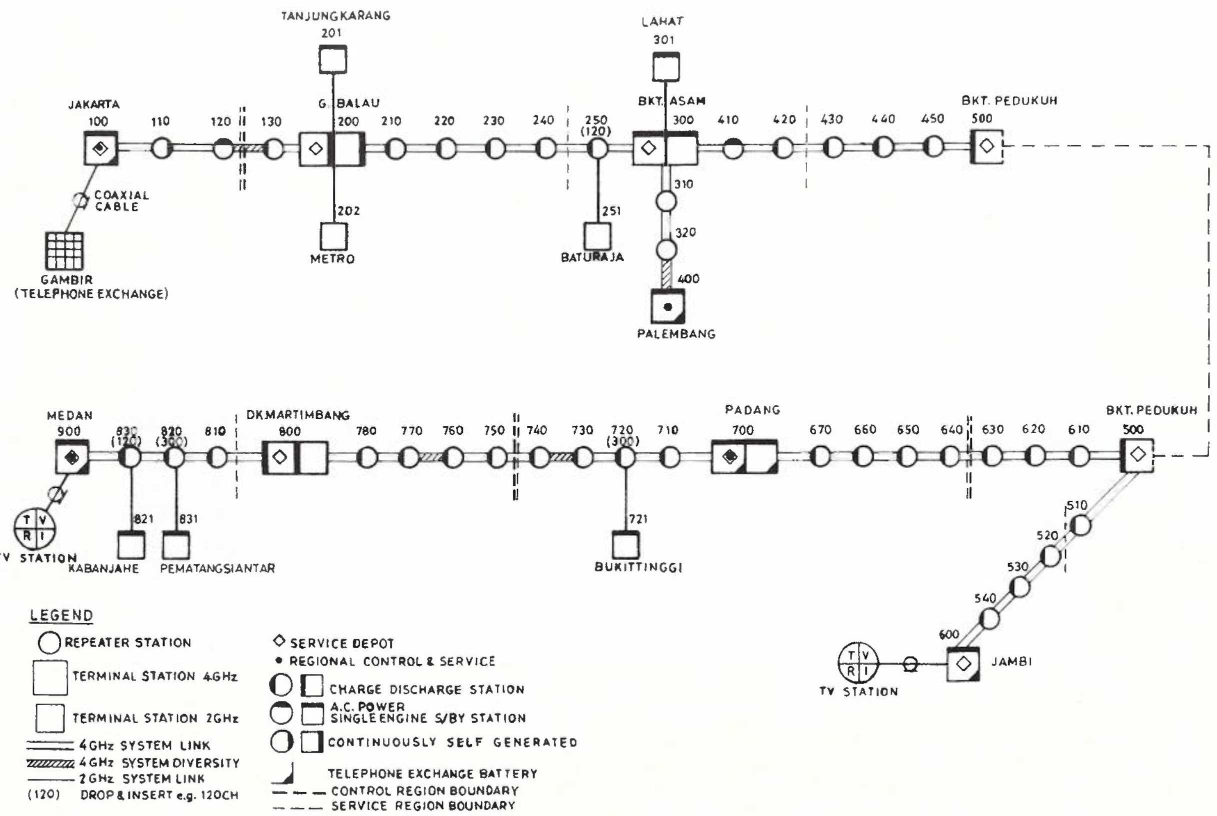

Fig. 9—TSMS System Function Schematic.

Because of the size of the project and the tight time schedule it was frequently necessary to utilise several teams in each of the categories. Tower foundations and erection was carried out using local sub-contractors and, since mechanical aids used were few, work was at one stage in progress on all sites on Phase III. In this way delays were minimised.

CIT was responsible for installation and commissioning of the multiplex equipment only. Hence its field organisation was much simpler and consisted of three CIT engineers and three locally hired assistants. For commissioning, four CIT engineers in conjunction with PERUMTEL and ATM staff were utilised.

SYSTEM DESCRIPTION

A Simplified Function Schematic of the system is given in Fig. 9. Brief descriptions and summaries of major sub-systems of the TSMS with emphasis on innovations or differences from Australian practices follow.

Power Plant

Provision of reliable and continuous power is of paramount importance in maintaining a reliable broadband Radio Relay System. To meet the various requirements three types of power systems were installed:

- Charge/Discharge System
- Single Engine Standby System
- Continuously Operating System

There are differences in generating capacity within each of the three types, but principals of operation and maintenance within each category are identical.

Charge/Discharge System (C/D)

Most repeaters on the TSMS employ this system of power generation. The C/D system uses duplicated diesel generators supplying 2 KVA of A.C.

power and, depending on station requirements, either 4, 6 or 8 kW of D.C. power. Continuous power for the radio and associated equipment is provided by a station battery which is cyclically charged and discharged. The diesels are alternatively and automatically started at the end of the discharge cycle by an electronic timer or, should this fail, by a low voltage sensor. The charge cycle is similarly controlled. To prevent damage to equipment by high voltages during the charge or boost cycle, a silicon diode dropper is used which ensures that voltage supplied to equipment is always below the allowable maximum.

Based on Australian experience traction batteries using 'tubular' plates rather than 'pasted' plates were used and the batteries were not discharged as 'deeply' as is the case in similar Australian installations. The ratio of charge to discharge cycle time is 3.5 with battery loads and capacity being based on a fully equipped 4GHz system to still give at least 48 hours of reserve capacity at the end of a discharge cycle. This is to allow staff time to reach the station and effect repairs before the system fails completely. Early experience showed that provided the batteries are 'boost-charged' once every six months they should achieve their design life. The diesels used are Mitsui-Deutz (Type F2L-912) modified to allow them to run unattended for long periods. Site visits for diesel servicing on C/D stations are scheduled at six-monthly intervals with major engine overhauls falling due every seven years. After some teething problems associated with the coupling for the auxiliary trochoidal oil pump, the six-monthly servicing is now being achieved.

Fig. 10—Jakarta Power Plant Installation.

Single Engine Standby System

This type of plant is installed at seven stations of the TSMS as well as at Sibolga, the terminal station of the Australian supplied and installed 120 channel system using aerial integral bearer single quad-cable. This system uses the commercially available A.C. supply to 'float' the station battery at 2.2V per cell. The engine operates only when the commercial supply fails and hence its maintenance requirement should be much lower. Fig. 10 shows the Jakarta installation.

Continuously Operating System

This system, in addition to providing power to the microwave and ancillary equipment, provides a continuously available A.C. supply in locations where, at the time of contract negotiations, commercial A.C. supply was not available. The A.C. supply is used for aircraft warning lighting as well as providing power for normal station use. The stations are powered by duplicated diesel generators which 'float' the station battery. The engines operate alternately on a 48 hour on/48 hour off cycle.

Antennas and Feeders

Antennas used were of N.E.C. manufacture similar to those used on the Seacom route. At major branching stations where low side lobes were vital Cassegrain antennas were utilised.

Contrary to current Australian practice, bulk reels of feeder could not be used. The low standards of Sumatran roads, bridges and ferries together with a blanket, but seldom adhered to, limit of three tons ensured this. Instead each feeder run was cut to size, terminated one end, tested in the factory and shipped individually. In each phase of the project some feeders suffered transport damage and finally to stay on schedule the contractor was forced to air-freight approximately 270m of replacement waveguide from Germany.

Radio Equipment

The radio equipment was supplied by NEC and is similar to that provided in Australia on the Townsville-Mt. Isa-Darwin link.

Main System (4 GHz)) (TR-4G1260)

This system utilises NEC FDM/FM microwave equipment capable of providing 1260 telephony channels or a television bearer with sound channel per radio bearer. Except for a high efficiency low noise travelling wave tube the equipment is all solid state and utilises compact modular construction. Provision of drop and insert modulators of up to 300 channels capacity allows circuits to be provided to major towns along the route from repeaters as well as from baseband stations. TV can be carried on the standby bearer on a non-priority basis. In this mode IF switching is used at all intermediate demodulating stations so that the complete route is effectively a single video section. If required, the TV signal is derived at intermediate points from an IF split with the addition of normal sound/vision separating equipment. Except for programs of national importance the telephony bearer has switching priority. Fig. 11 shows a representative back to back demodulating station.

Spur Systems (2GHz) (TR-2G300)

These systems utilise all solid state 2GHz NEC equipment capable of carrying up to 300 channels.

Supervisory and Sub-Base Band Equipment

Supervision and control of the complete system is centralised on a 24 hour staffed overall control centre (OCC) in Jakarta and three normally staffed regional control centres (RCC) in Palembang, Padang and Medan. At the OCC, provision of individual displays for each station would have resulted in over 2200 separate lamps grouped in an unworkable 'wall of lights'. Instead provision was made in the control desk (Fig. 12) for:

- Indication of route status by a mimic diagram
- Indication of faulty station
- Allowance for detailed display of any failed station
- Individual 32 lamp displays for all demodulating stations
- A common 16 lamp display of all repeaters within a demodulating section. The station to be displayed may be manually selected
- A set of 16 remote control switches to allow full control of the system from Jakarta.

If a change of alarm status occurs at a station the mimic display indicates the station and if it is a repeater the alarm indications are automatically displayed on the common lamp strip of the relevant switching section. By using station select switches the operator can overide the automatic function and display the alarm conditions at any repeater on the

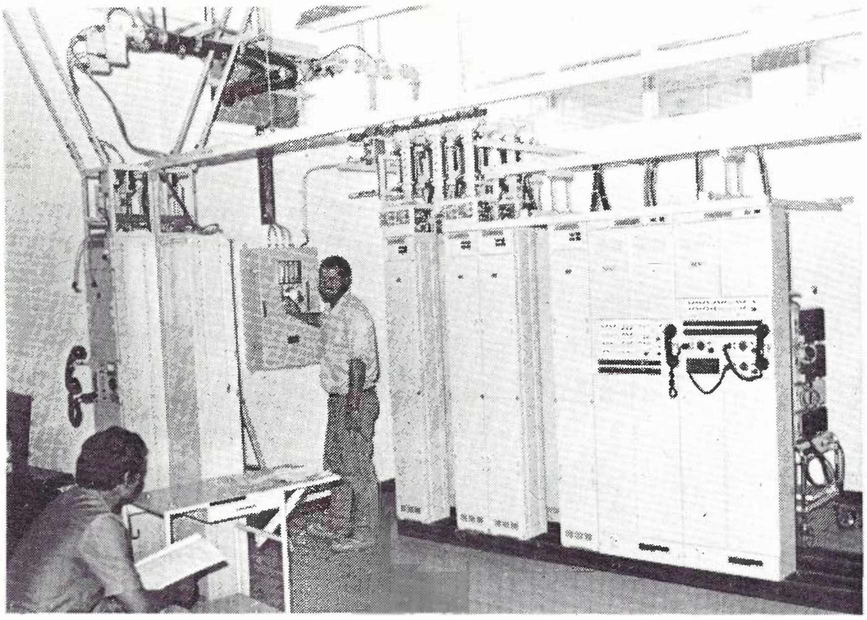

Fig. 11—Typical Back to Back Demodulation Station. (Dolok Martimbang).

route. A lamp in the mimic display shows which station has been selected. Remote control is accomplished by operating the station select switch, the relevant remote control function switch and an execute key. The desk also contains the orderwire telephone sets and switching status indications for the Jakarta switching section.

At the regional control centres the desks provided the following facilities:

- An individual lamp strip for each station in the control region which continuously displays the alarm status at the station.
- An individual set of eight (repeater), 16 (terminal) remote control switches and lamps for each station.

As well as providing the normal engineering orderwires and supervisory channels the sub-base band also provides for up to four wayside channels per demodulating section. These have been, or can be, used to replace out-dated and difficult to maintain open wire lines to minor towns located near repeaters.

Multiplex Equipment

This equipment was provided by Compagnie Industrielle des Telecommunications of France (CIT) and is their Type 70 Analogue Multiplex System SMA7. The system uses modular construction with these modules grouped in racks according to system heirachy.

In addition to technical advances a particular design improvement using a single premodulation carrier for all channels, followed by individual channel carrier supplies, permits the use of one type of module for channel modulators.

This has resulted in a marked reduction in the spares holding required and also permits improved maintenance procedures and facilitates post installation equipment rearrangements

In major stations, carrier supplies are derived from twin 128 kHz master oscillators which through fully duplicated derivation and distribution equipment, supply fully protected carrier frequencies to all modulators.

All super-groups are supplied with level regulators which maintain levels at ± 3 dB incoming for system level deviations in the range ± 10 dB. Group regulators are provided on groups which are through filter connected at an intermediate point and on groups which carry program circuits.

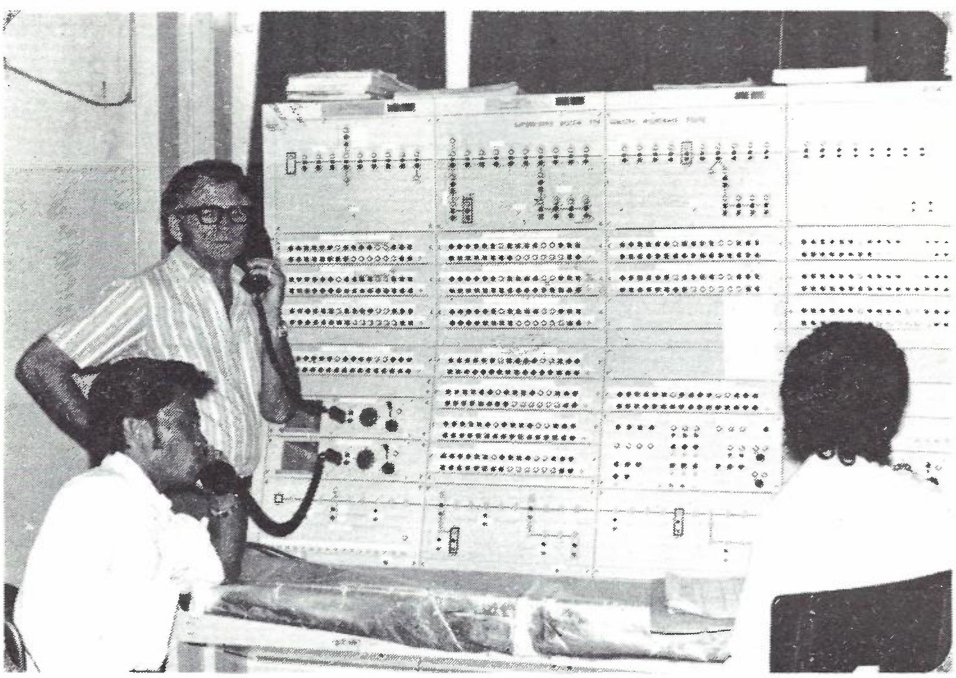

Fig. 12—Control Desk at Overall Control Centre, Jakarta.

CIT also provided their TGI 120 Harmonic Telegraphic System. This provides an up to 24 channel point to point V.F. telegraph system on a four wire telephony circuit. VFT circuits can readily be provided in groups of six channels.

Transportable Emergency System (TES)

The remoteness and possibility of catastrophic damage to the system due to sabotage or natural disasters such as earthquakes or volcanic eruptions made provision of an emergency system imperative. The system consists of compact, miniaturised and ruggedised separate transmitters, receivers, modulators, demodulators and service modules, as well as snap-up 30m guyed masts, 1.2m casegrain antennas and feeders. Sufficient modules were bought to completely replace any repeater or back to back terminal station with an unprotected 960 channel emergency link. If necessary power can be provided by 1KVa Honda portable generators and 24V unregulated rectifiers. All equipment can be readily transported by the maintenance vehicles or even by aircraft and the actual equipment modules are small enough to be man-portable. The equipment is housed in weather-proof containers so that it can be used without any additional weather protection. Fig. 13 shows the TES undergoing field tests.

Sibolga Spur

Initially the Spur System to Sibolga from Dolok Martimbang was originally intended to be a radio system but an extremely difficult access road to the intermediate repeater costed at $A1.5 million ruled this out.

As an alternative Australia offered to provide and install a 51km long (12 repeaters) 120 channel system on aerial integral bearer single quad cable as part of the overall Colombo Plan aid.

INSTALLATION TESTING AND COMMISSIONING

Installation started in Jakarta in July 1973 and progressed sequentially along the system. The system was installed, commissioned and placed in traffic in three discrete phases:

- Phase I — Jakarta to Palembang (in traffic June '74).
- Phase II — Palembang to Padang (in traffic Jan. '75)
- Phase III — Padang to Medan (in traffic Aug. '75).

Prior to 1974 there were slippages in the completion date, due mainly to survey problems discussed earlier, but during 1974 customs and shipping problems were encountered which further delayed com-

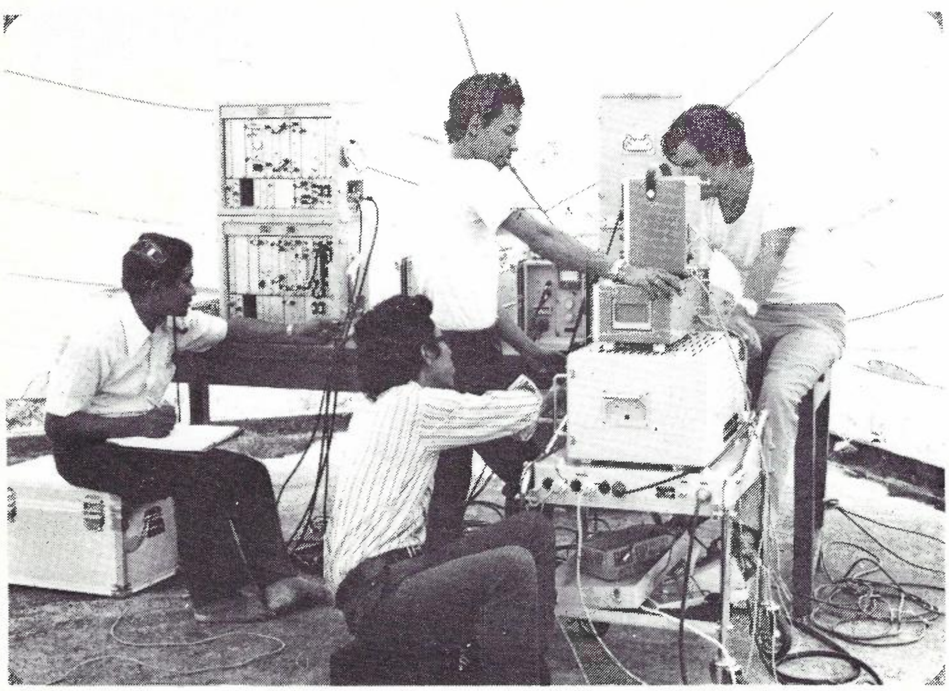

Fig. 13—Field Testing of Transportable Emergency System.

pletion. One of the customs clearance delays of more than four weeks was due to incorrect customs papers caused by lack of formal World Bank (IDA) approval of agreed loan increases and shipping date extensions. The 'oil crisis' with its drastic effect on ship movement compounded these delays. Congestion at Tanjung Priok, the port of Jakarta, caused one of the ships to lie at anchor for six weeks prior to discharging its cargo.

Late delivery of some Phase III equipment coupled with a forced change of port of entry from Padang to Medan caused severe installation and logistic problems during Phase III installation. In an attempt to minimise delays Phase III was installed and tested 'in reverse', i.e. from Medan to Padang. The overall effect of these 'force majeure' occurences was to delay completion from December '74 to June '75.

The complete system was officially opened by President Suharto on 7 August 1975, and interim STD circuits provided between Medan (Sumatra)-Jakarta, Bandung, Surabaya on Java and Den Pasar on Bali.

OPERATION AND MAINTENANCE

Ensuring continuous maintenance of equipment in any developing country is always a problem. In most cases sophisticated technology is introduced in a short period in contrast to the gradual evolution of technology, and with it a growing appreciation of the need and purpose of maintenance, that has taken place in developed countries.

System operation and maintenance was thus a major consideration during all stages of system specification, design, tender evaluation, pre and post contract negotiation as well as during installation, testing and commissioning of the system.

Maintenance Philosophy

The basic purpose of maintenance is to reduce equipment failure to an acceptable level and at the same time ensure that system performance lies within specified limits. To achieve this in the most economical manner considering both technical and environmental factors the basic maintenance approach was:

- Staff only control centres (Jakarta, Palembang, Padang, Medan) and Service Depots (Gn. Balau, Bkt. Assam, Bkt. Pedukuh, Dk. Martimbang).
- Repair at unattended sites to be on a replacement basis.
- Staff will attend in response to supervisory indications and will normally take only replacement modules for indicated failed equipment plus some associated test equipment.
- Repair of faulty units, including diesels, will be carried out at repair centres set up at the Regional Control Centre.
- Stocks of spare modules as well as spare bays will be held in the repair centres.
- Consumable spares (i.e. lamps, fuses, etc.) only are held on unattended stations.
- Routine maintenance visits to all unattended stations are scheduled on a six monthly interval.
- Adequate power plant spares, including engines and special service vehicles, are provided at control centres to facilitate regular and systematic engine servicing and overhauls.

Maintenance Organisation

Centralised system control and associated maintenance organisation was for PERUMTEL a radical change from established practice. Until then normal procedures for all types of station, but especially microwave stations, had been to staff them all on a 24 hour basis. However remoteness of many of the repeater sites, reliable equipment and shortage of experienced staff led to the acceptance of the proposed maintenance organisation.

The overall control centre (OCC) in Jakarta is staffed continuously and is responsible for controlling and co-ordinating all aspects of system maintenance. One of its major functions is to undertake systematic analysis of faults and spares usage.

The Regional Control Centres in Palembang, Padang and Medan are staffed on a normal working day basis and during that time assume direct responsibility for their own regions.

The Service Depots are staffed to reduce the time taken to attend a fault at the remoter stations of the system. Staff at Service Depots attend to fault clearance under direction of their respective regional control or the overall control centre.

Repair and Training Centres

Repair and Training Centres for Radio and also Power equipment are an integral part of the TSMS maintenance organisation. System maintenance is based on the concept that no equipment repairs will be undertaken at unstaffed stations.

To realise this and to achieve a viable maintenance system it was essential to establish repair centres for radio equipment and power plant at each of the Regional Control Centres.

Radio Repair Centres

These were equipped with sufficient test equipment, spare components as well as spare modules and racks to allow repair of all panels, and their subsequent testing and realignment under realistic conditions. All spare racks were installed, powered and equipped so that they could be used for staff training as well as checking of repaired modules.

Power Plant Repair Centres

These workshops as well as providing adequate work area for diesel overhauls also contain a complete operational Charge/Discharge System installation. This again is used for testing repaired units or units prior to dispatch to the field as well as a vital training aid for staff.

The charge/discharge system used on the TSMS is the first of its type used by PERUMTEL and to give basic training to its future technical staff an additional operational unit was installed in their Technical Training College in Bandung.

Vehicles

Vehicles, as may be appreciated, are of vital importance in providing effective maintenance. To overcome internal problems of supply and to ensure that suitable vehicles were available for maintenance they were provided on SSK's contract. A total of 13 Toyota Landcruisers were provided for system maintenance and an additional three modified 1-ton Toyota four-wheel-drive trucks for power plant maintenance.

Contractor's Technical Support

As each Phase of the project was completed a contractor's maintenance technician was stationed at each Regional Control Centre for a period of 12 months. This staff proved invaluable during the system 'burn in' period as well as in training PERUMTEL staff and establishing maintenance and panel repair procedures.

CONCLUSION

The consultancy services provided for the TSMS was the first exercise of this type undertaken by Telecom (then APO).

The successful completion of the project not only assisted a near neighbour in establishing a modern regional communication network but also significantly broadened the background and experience of Telecom Australia and the staff involved.

ACKNOWLEDGEMENTS

Throughout the project close and cordial relations existed between PERUMTEL, ATM and the Contractors and this helped considerably in resolving the numerous problems, both technical and financial.

Special mention must be made of the ATM field staff. Not only did they perform their duties competently, often under difficult conditions but they also served to enhance Australia's reputation with the Indonesian people (which after all is a prime objective of any foreign aid). The authors experienced many examples of the field staff's "ambassadorial" achievements when subsequently passing through villages in Sumatra.

The authors wish to acknowledge the help of their ATM colleagues and also of Telecom/APO staff both in Australia and on short-time assignment.

B. J. CLEARY is Engineer, Class 3 Radiocommunication Branch and V. W. LANGE is Engineer, Class 3, Broadcasting Branch, Headquarters, Telecom Australia. (See Vol. 27, No. 1, page 61).

Apparatus for Mobile Measurement and Recording of Electric Field Strength at VHF and UHF

I. C. LAWSON, B.E.E., A. J. STEVENS, B.E. (Elec.), M.I.E.E., M.I.E.E.E., and R. W. HARRIS, B.Sc. (Hons.), B.E. (Hons.), B. Com.

This apparatus has been developed to make measurements of the spatial distribution of radio field strength at VHF and UHF as received in a moving motor vehicle. Sampled measurements are made at small intervals along the road (as small as 5cm). These measurements together with other information to facilitate analysis, are recorded on a digital magnetic tape recorder. This record is later analysed by computer to obtain the required information.

The capacity of the sampling and recording system provides for eight data inputs. Currently the apparatus is fitted for measurement of two field strength points and the audio noise level from an FM demodulator.

The vehicle can be driven at ordinary road speeds with no particular restriction.

The equipment operates directly from the vehicle battery.

INTRODUCTION

In a typical VHF and UHF mobile radio situation, transmission is between a fixed station with an antenna at a height of tens or hundreds of metres and a motor vehicle with an antenna at a height of one to two metres. Generally, there will not be a line of sight between transmitter and receiver and transmission will be by signals scattered from objects such as buildings, trees and power lines. The received signal will be the sum of these scattered signals. Should there be a significant direct signal, then the received signal will be the sum of this and the various scattered signals. As the mobile antenna moves, the amplitude and phase of the various components will vary and hence the sum will vary. These variations can occur rapidly and be substantial in magnitude and may have a significant effect on the performance of a mobile radio system.

The refined mobile radio systems that are now feasible require in their planning an estimate of the extent of, and reliability in, the service area. The established and generally satisfactory methods of predicting service areas for VHF and UHF broadcasting cannot be always extended to mobile systems where, for example the receiving antenna will generally be surrounded by local obstructions.

There is extensive literature on many aspects of mobile transmission but relatively little which has direct engineering application in the local situation. Various models and prediction methods have been proposed (Refs. 1, 2, 3, 4, 5, 6) but confidence in their application to the local scene has not yet been established. Therefore, in order to test the available theories and also to detect effects which may not be predicted by theoretical models, actual measurements must be made.

The amplitude of the signal received in a moving vehicle can vary up to 30 dB over a distance of half a wavelength. It has been established that generally the field strength patterns are statistically stationary over small areas of about 1 km square. To establish the parameters of the field strength distribution over such an area to sufficient accuracy, some 100-200 measurements are required. Therefore, conventional techniques for measuring field strength are not satisfactory, and this special receiver and recorder has been constructed for these measurements.

The technique is basically as follows. Measurements are made with the receiving and recording equipment in the motor vehicle. A speedometer attachment generates a signal at small intervals along the road. This signal generates a sampling signal at intervals as small as 5 cm. On each sampling signal the field strength is measured and recorded on the digital tape recorder. This record is later analysed to obtain the information required. The sampling may be so dense as to enable re-

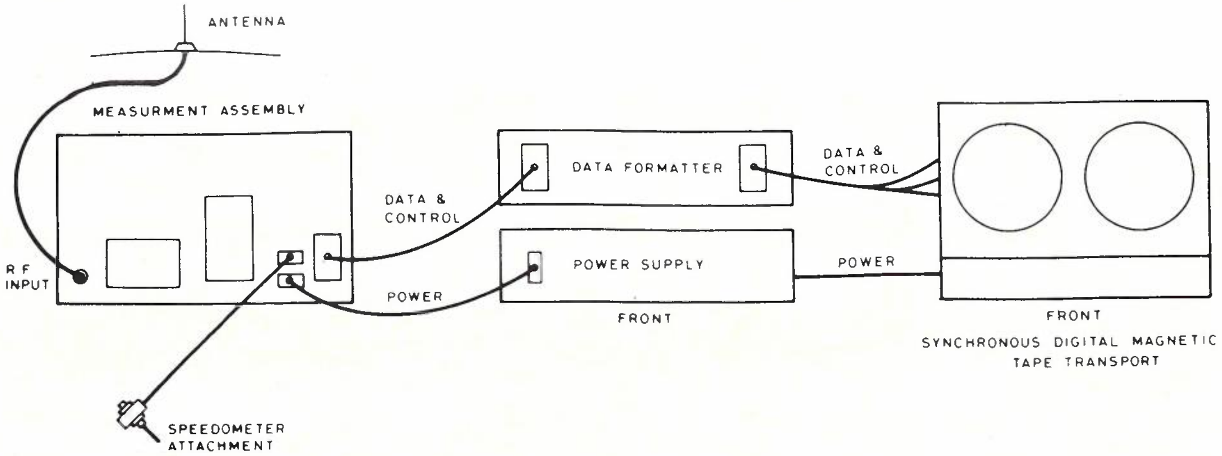

Fig. 1 — Mobile Field Strength Receiver, General Arrangement.

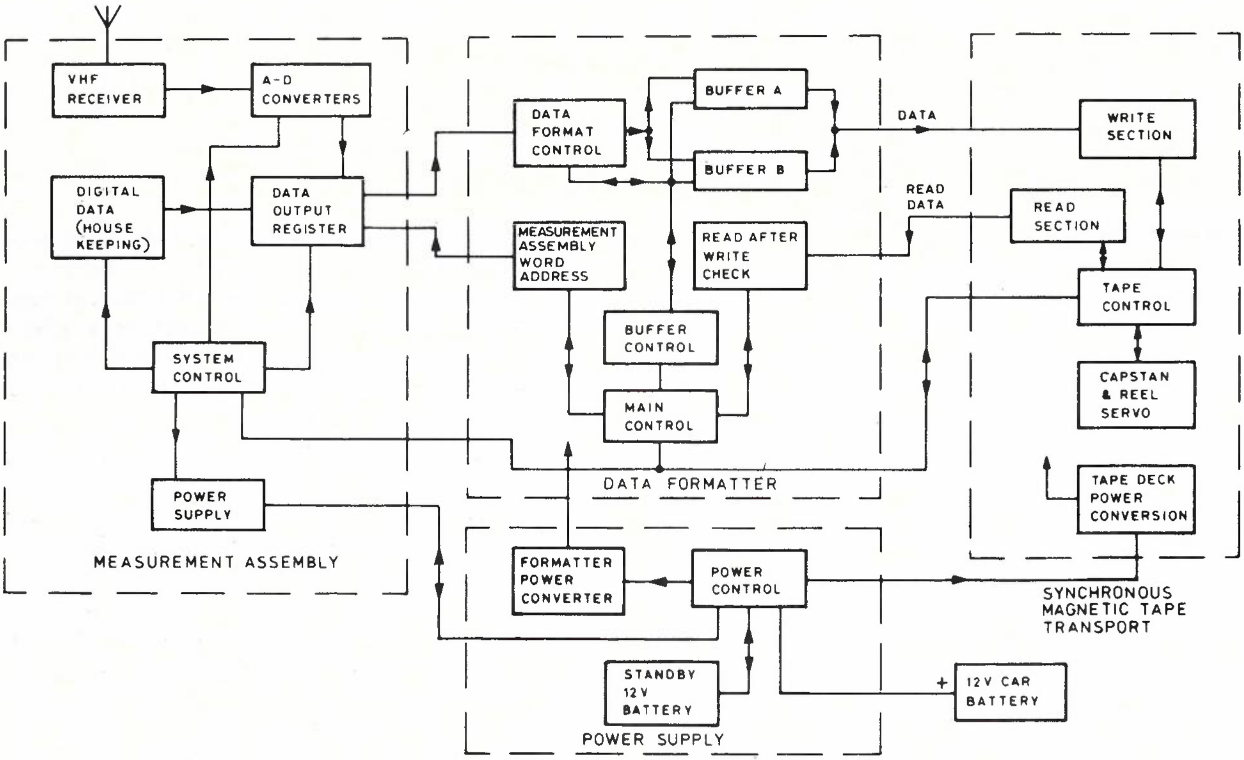

Fig. 2 — VHF Mobile Field Strength Receiver, General Block Diagram.

construction of detailed field strength patterns so that particular events may be detected, or if required, only sufficiently dense to enable measurement of the basic parameters of the field strength distribution.

A service area may be defined in terms of the (Signal + Noise + Distortion)/(Noise + Distortion) ratio (SINAD ratio) of the output from some typical receiver rather than in terms of field strength directly. For this purpose a wide dynamic range

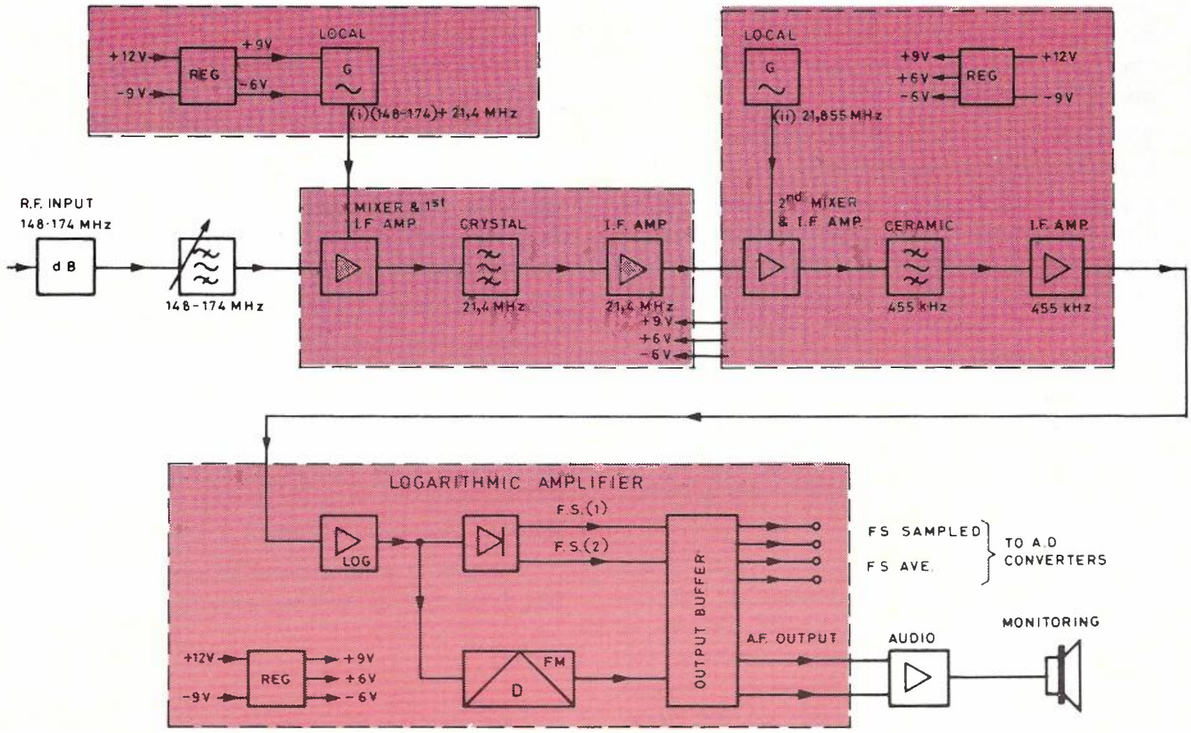

Fig. 3 — Field Strength Receiver, VHF Measuring Assembly, Block Diagram.

audio noise level meter has been constructed to enable an estimate of the SINAD ratio to be measured simultaneously with the field strength measurements at ordinary road speeds. This apparatus is fitted within the Measurement Assembly. It is described in detail in Refs. 7, 8.

The field strength may also be sampled at regular time intervals, by means of an internal clock.

EQUIPMENT DESCRIPTION

The equipment consists of two major assemblies, the Measurement Assembly and the Digital Tape Recorder (see Fig. 1).

The Measurement Assembly consists of a VHF (or UHF) receiver and circuits for power supply, digitizing the received data, control, counting, registering, display, as well as a chart recorder. The assembly is essentially a digital data source and a controller which generates and presents data to a digital tape recorder under its control.

The other major part of the equipment is the Digital Tape Recorder. It comprises three units. A Data Formatter which operates on the data from the receiver and controls the operation of a synchronous digital magnetic tape transport; the Synchronous Digital Magnetic Tape Transport which makes the actual record of the field strength measurements onto tape; finally, a Power Supply which supplies and controls the power from the car battery to the units of the Digital Tape Recorder and the Measurement Assembly.

Other components are the receiving antenna and a speedometer attachment for generating the sampling signals

A general block diagram is shown in Fig. 2.

Measurement Assembly

Receiver

Two receivers are available for the measurement of field strength, a VHF receiver for the frequency range 148-174 MHz and a UHF receiver for the frequency range 450-512 MHz. These receivers are interchangeable in the Measurement Assembly. In this paper we will describe the VHF receiver in detail and only briefly mention the UHF receiver, as the operation is similar for both receivers except for the bandpass filter and the inclusion of a RF amplifier.

The VHF receiver is intended for fixed frequency operation within the range 148-174 MHz, the actual frequency depending on the frequency of the RF preselector filter and the local oscillator. It is a super heterodyne with IF's at 21.4 MHz and 455 kHz. The 455 kHz IF is amplified in a logarithmic amplifier and the detected output is the measure of field strength.

An FM demodulator is fitted and the audio output can be monitored in a loudspeaker.

Two signal level outputs are generated, one of a short time constant so that it may follow detailed variations in the input level and another of a time constant of about 1 second as a general indication of average signal level. A block diagram of the VHF receiver is given in Fig. 3. The VHF receiver is made up of six sub-assemblies as described below.

Input Attenuator

The input attenuator is a commercial device modified so that it may be operated from a switch on the front panel.

RF Preselector Filter

The preselector filter is a bandpass filter consisting of four helical resonators coupled directly at input and output, and by apertures between the resonators. The resonators are tuned by variable capacitors adjustable from the sides of the filter. The tuning range is 148 MHz-174 MHz with a maximum insertion loss of 2 dB.

Local Oscillator

This consists of a crystal oscillator, doubler, low level amplifier and power amplifier.

Mixer and First IF Amplifier

A high level mixer, using a local oscillator power in the range 300-500mW has been chosen, with a crystal filter placed at the output of the mixer so that inaccuracies of measurement due to adjacent channel signals, blocking and intermodulation are at a practical minimum.

Second Mixer and IF Amplifier

The function of this sub-assembly is to convert the 1st IF at 21.4 MHz to the 2nd IF at 455 kHz, to provide some gain and further bandpass filtering.

Logarithmic IF Amplifiers and Detectors

The function of this stage is to provide an analogue signal representing the input level on a logarithmic scale and also to FM-demodulate the input signal.

The effective dynamic range is 75 dB. The compressed IF output from the amplifier is detected and this signal is the measure of field strength. Two outputs are taken from the detector, one is an indication of "instantaneous" field strength, and another via a low pass filter, is an indication of "average" field strength. This assembly also includes the FM demodulator. The level of the noise output from this demodulator may be measured by the noise detector. It may also be monitored by a front panel loudspeaker. The VHF receiver performance figures are detailed in Table 1.

A-D Converters

The analogue field strength outputs from the receiver are digitized and corrected so as to generate digital codes, binary for recording and BCD for display, representing the field strength on a scale dB relative to 0.1 μV/m.

System Control

The system control has five main functions. These circuits control the powering up of the equipment and the turn-off procedure. It controls the File-to-File and Block-to-Block operations, and the sampling procedure. This Section also includes the system clock.

Display and Control Unit

This unit is a demountable sub-assembly containing those control switches required during recording

TABLE 1—VHF RECEIVER PERFORMANCE

Input Power: Minimum detectable input power is —117 dBm corresponding to a field intensity of 1.5 μV/m at 150 MHz using a ¼ wave monopole antenna.

Frequency Range: The frequency range is determined by the range of the preselector filter and the tuning range of the local oscillator. The range is 148-174 MHz.

Dynamic Range: 75 dB.

Input Attenuator: 0-30 dB in 10 dB steps.

Adjacent Channel Rejection: For a desired signal within the range 148-174 MHz at a level of —100 dBm [+40 dB (0.1 μV/m] and an interfering signal at $f_o + 22$ kHz or $f_o - 22$ kHz, the level required for an error of 1 dB in the field strength indication is greater than —6 dBm.

Desensitising: For a desired signal within the range 148-174 MHz at a level of —100 dBm [+40 dB (0.1 μV/m)] and an interfering signal of frequency $f_o + 200$ kHz or $f_o - 200$ kHz, the level required for the interfering signal to cause an error of 1 dB in the field strength indication is greater than —2 dBm.

Two Tone Intermodulation: For a desired signal within the range 148-174 MHz at a level of —100 dBm [+40 dB (0.1 μV/m)] and two interfering signals of frequency $f_o + 25$ kHz and $f_o + 50$ kHz or $f_o - 25$ kHz and $f_o - 50$ kHz, the level required for the interfering signals to cause an error of 1 dB in the field strength indication is greater than —30 dBm.

IF and Image Rejection: Greater than 100 dB.

Bandwidth: —1 dB, 12 kHz.

Passband Ripple: Less than ± 1 dB.

Power Supply Sensitivity: The receiver will operate satisfactorily when the power supply voltage is within the range 10.5 V to 15 V.

and a LED display of various quantities required for supervision by the operator (see Fig. 4).

Chart Recorder

The chart record can be used to display field strength as a function of distance or time. The drive for the chart recorder's stepping motor comes from either the distance measuring equipment attached to the vehicle's speedometer or from the time clock of the Measurement Assembly. On each signal from the speedometer attachment, at 5 cm. intervals along the road, the chart recorder motor makes one step, advancing the chart so that it moves as a scaled replica of the vehicle's forward motion. When it is connected the maximum permissible vehicle speed is 32 km/h. It should be noted that the chart record is intended for occasional illustration only and not for the normal recording process.

Power Supply

The Receiver and the Digital Tape Recorder have been designed to operate directly from a 12 V dc negative ground vehicle battery. Most of the logic circuits run directly from the supply via regulators. For other circuits, dc-dc convertors provide voltages which cannot be obtained from the vehicle battery.

The Digital Tape Recorder incorporates an emergency battery to power the system during brief periods of low voltage. This battery is automatically recharged during normal operation.

If the vehicle battery voltage drops below 10.5 V, the equipment is automatically switched to operate from the emergency battery. If it operates continually from the emergency battery for more than 20 seconds, an automatic sequence is started to end the experiment, to complete the tape record and to switch the power off.

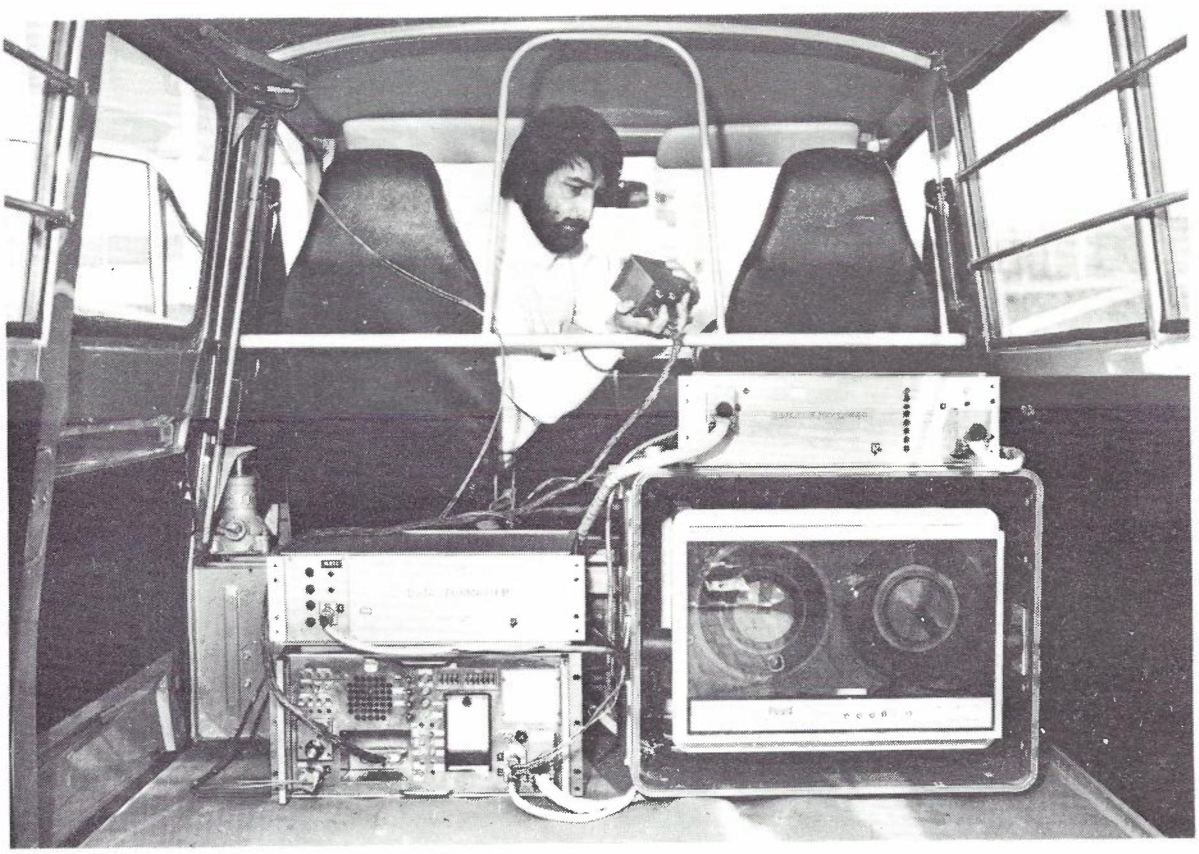

Fig. 4 — Mobile Field Strength Receiver. The Measurement Assembly is located on the bottom left, with the Data Formatter Power Supply on top. The Data Formatter and Synchronous Magnetic Tape Transport are on the right. The Display and Control unit is shown removed from the Measurement Assembly and can be operated from the front seat of the vehicle.

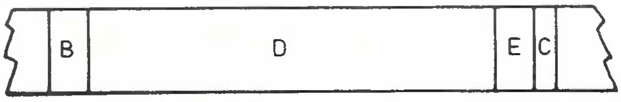

Fig. 5 — Tape Format.

Digital Tape Recorder Assembly

This assembly consists of three main parts, a synchronous magnetic tape transport, data formatter and power supply. The tape transport is a commercial item modified in some detail for this application. The data formatter, the major item developed for this assembly, has those circuits for compiling the data as required for recording, circuits for control of recording and other operations and two large buffer memories. The power supply has the standby batteries previously mentioned, convertors, contactors etc.

The data generated by the Measurement Assembly is a function of distance and therefore, as the vehicle will be in normal traffic, will be presented at irregular time intervals. The recording method used must be such that it can accommodate this feature and still allow practical road speeds. The most satisfactory method available is a synchronous tape recorder operating in a "burst" mode.

The tape record made by such a recorder must follow various established standards and is consequently of the form described here.

Tape Format

The record consists of a series of files, each file defining an experiment and consisting of a number of blocks. A file is started under control of the operator, recording continues automatically in a series of blocks. These blocks may be of length determined by the Digital Tape Recorder (about 2048 frames, determined by the detail of a particular experiment), or may be foreshortened by a signal from the receiver. A file is ended by a manual signal from the operator or automatically if there is a power failure or if the on/off switches are operated during recording. All of the information required for analysis as well as the sampled data is recorded in each block. A block is shown diagramatically in Fig. 5.

A block has four parts:

- B — The beginning housekeeping data.
- D — The sampled data made up of a number of sets of frames, one set for each sample.
- E — The end housekeeping data.
- C — A check frame required by the Data Formatter.

Recording Method

The interface between the Measurement Assembly and the Recorder Assembly is an output register in the Measurement Assembly. On each sample all the data that is generated is placed in this register and is read by the Recorder as required.

On each sample, when the contents of the output register are updated, the data is read and placed in one of two buffer memories. Each of these is of capacity 2048 words, equal to the largest tape block that may be recorded. Sampling proceeds, perhaps quite irregularly, and the buffer gradually fills. It is declared to be full either on reaching capacity or on a prior signal, generated automatically or by the operator, from the Measurement Assembly. Then the tape transport is activated and the contents of the buffer memory, one complete block. are recorded into the tape. As the Measurement Assembly continues its operations, further data is placed in the second buffer memory. The tape record, as it is being written is checked by a read after write facility which tests for correct parity. If an error is found then the record is erased and rewritten. The buffer is cleared only after a complete block is finally recorded. Then the tape transport is deactivated and awaits the completion of the next block now being entered into the second buffer.

This process continues with blocks being recorded from each buffer alternatively as they are filled, the tape transport being activated and deactivated on each block.

This method allows the speed of recording available from a synchronous tape transport to be exploited, while recording data that is generated at irregular intervals Therefore, the test vehicle can be driven at normal road speeds without restrictions due to the operation of the digital tape recorder. As mentioned previously, on occasions when the chart recorder is connected, there is a speed limit of 32 km/h.

OPERATION

Fig. 4 shows the equipment installed in a vehicle. An antenna is fixed to the roof and a sampling generator is fitted to the speedo cable. The Display and Control Unit is held by the operator.

The tape record includes details of the equipment switch settings etc. However, it must be accompanied by a log kept by the operator by means of which correlation can be made between the record and, most importantly, vehicle location as well as other relevant events.

The tape record is a series of Files, each File representing one run and made up of a series of Blocks. A File is started by the operator then measurement and recording continues Block by

Block without further intervention. Files are numbered by switch settings and Blocks numbered automatically from counters within the equipment. These numbers are displayed and are entered in the log as required. The operator may enter "Event Marks" or "Doubtful Signal" marks onto the tape record for precise location, or record verification as required.

An experiment is ended by the operator manually, or automatically under various fault conditions, such that a complete tape record is always made.

The records from the measurements must be analysed by a computer. Initially the tape recorded in the field must be decoded and the decoded data re-recorded on tape in a conventional computer format so that it may be accessed by conventional programmes.

A program has been written for this function. Programs have also been written to calculate first order statistics such as mean, standard deviation, cumulative distribution, plotting and simulated space diversity. Future programs will include calculation of statistics of fade duration and depth, level crossing rates etc.

Initial Results

Two test routes are shown in Fig. 6. These are in the Eastern Suburbs of Melbourne. The transmitter is at point X at a height of 95 m above sea level. On each of the two routes the field strength has been sampled every 1 metre. Marked on the route are calculations from the tape record of the mean over a distance of a 100 metres.

The total route length is about 130 km. Both these routes were measured within the one day.

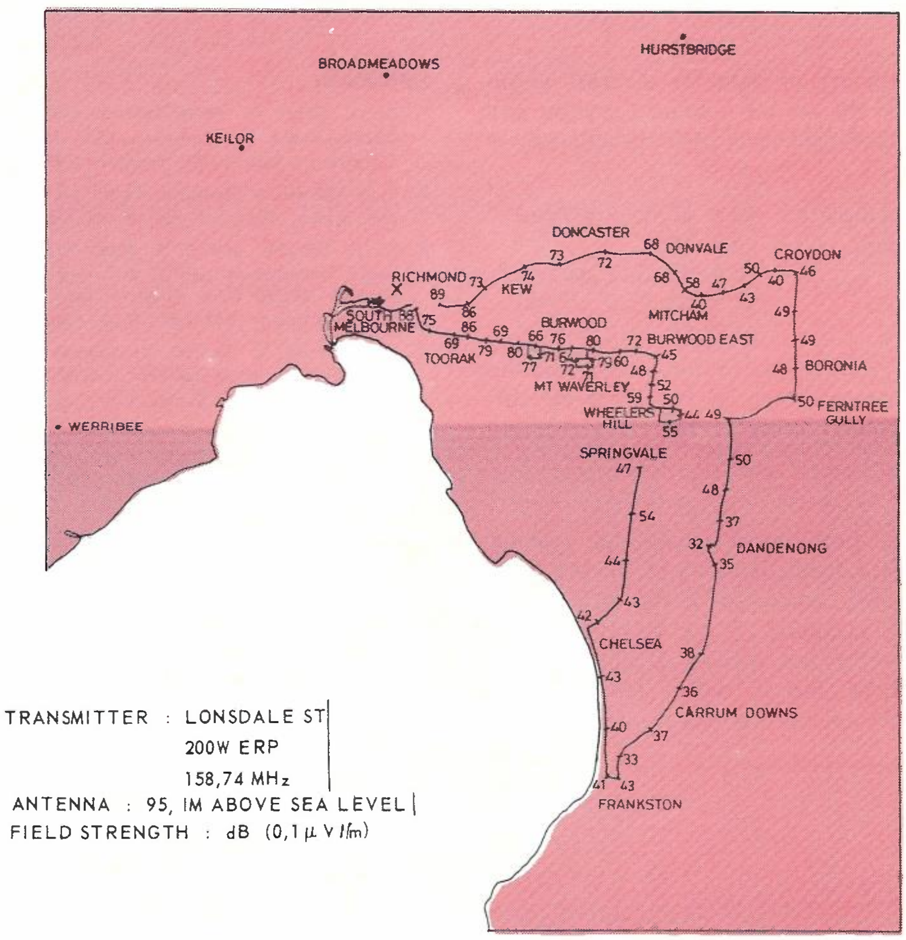

Fig. 6 — Results from Two Test Runs in the Suburbs of Melbourne.

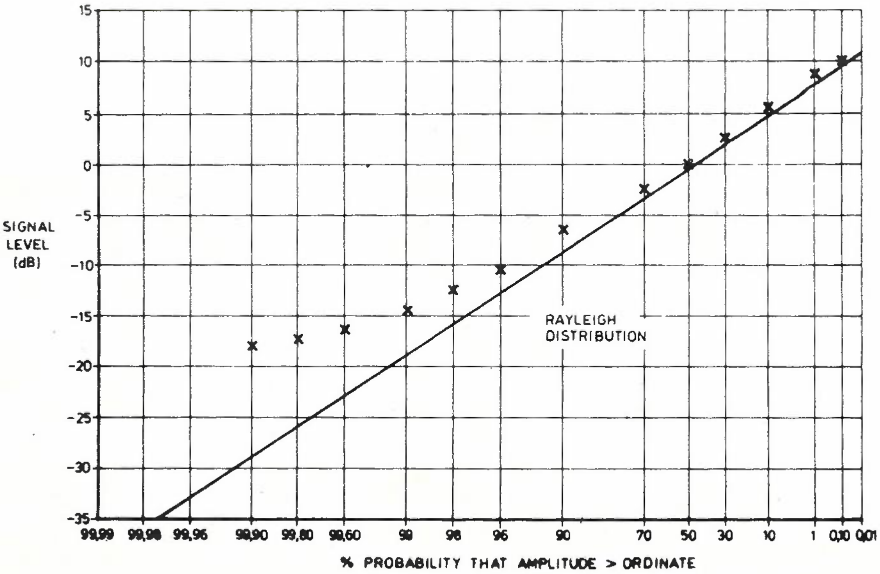

Fig. 7 — Cumulative Probability Distribution Plotted on Rayleigh Paper. The classical Rayleigh cumulative distribution is a straight line.

From a typical Block of data for a route length of about 1 km, (at the corner marked Croydon and 46), first order statistics have been calculated —

Mean (of 1095 samples)	46.6 dB (0.1 μV/m)
Standard Deviation	4.9 dB
Lowest sample	28.5 dB (0.1 μV/m)
Highest sample	57.5 dB (0.1 μV/m)
Median	47.0 dB (0.1 μV/m)

A cumulative distribution of this Block plotted on Rayleigh paper is shown in Fig. 7; 0 dB corresponds to the mean value of the field strength samples.

CONCLUSION

This equipment provides a means for making quick and automatic measurements of electric field strength over areas where a large number of measurements are required. It will provide an invaluable tool to test the available mobile radio transmission theories and to detect effects which can not be predicted by the theoretical models.

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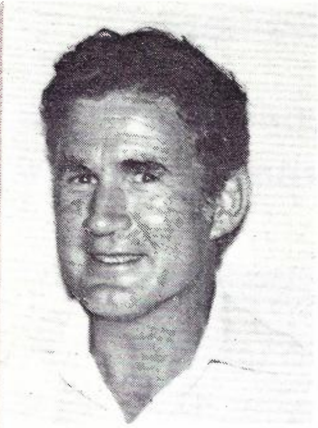
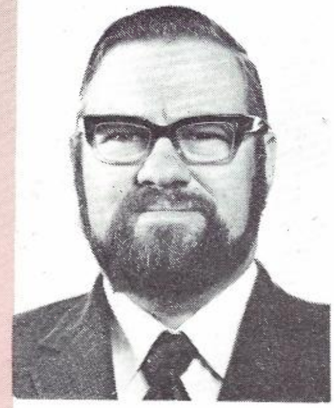
IAN C. LAWSON graduated with a B.E.E. from the University of Melbourne in 1954. He joined the then Postmaster Generals' Department, Research Laboratories in 1955. He has occupied positions in the Primary Frequency Standards Division, Plant Applications Division and the Radio Equipment Division. He is currently working in the Radio Systems Section. His main activities have been on the design and development of special apparatus for various projects and functions conducted by the Laboratories and by other sections of the Commission.

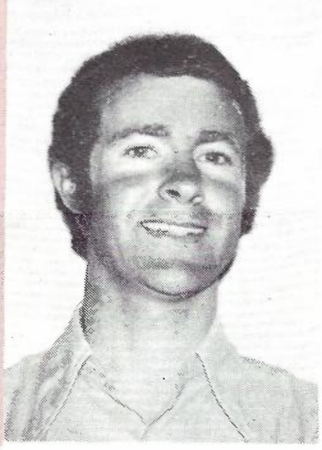


ANTHONY J. STEVENS was born and educated to a secondary level in Launceston, Tasmania, completing his tertiary education at Melbourne University, where he received a B.E. in Electrical Engineering in 1965. Since this time he has been working in the Laboratory Instrumentation Section of the Research Laboratories on the design and development of special instrumentation, including modification and setting up of data logging systems and the design of automatic calibration systems. Mr Stevens also has a keen interest in technical photography including its application to high speed motion analysis.

Mr Stevens is a Member of IEE (London) and a member of IEEE (U.S.A.).



ROBERT W. HARRIS graduated from Adelaide University in Science and Engineering in 1968 and 1970, and from Melbourne University in Commerce in 1977. He commenced work as an Engineer with the APO Research Laboratories, Radio Equipment Division in March 1971. Following the restructure of the APO in February 1972, when the Radio Equipment and Radio Systems Division amalgamated, his work has mainly been concerned with the design and development of special equipment to evaluate the performance of mobile radio systems.



Book Reviews

DIGITAL TRANSMISSION SYSTEMS.

P. BYLANSKI and D. G. W. INGRAM; Peter Peregrinus Ltd.

This book is a welcome addition to the literature on digital transmission systems. It has brought together the theoretical and practical aspects of digital transmission systems; subjects which hitherto could only be studied by reading numerous technical papers.

The book has 16 chapters which cover theoretical, planning and practical aspects with a nice mix of all three. The planning aspects covered in this book are welcome and illustrate the importance of various committees of the International Telecommunications Union in the area of transmission system design and philosophy. The theoretical and practical treatment deals mainly with baseband digital systems, which probably reflects the authors' main interest in which they have previous publications. The treatment of digital modulated-carrier systems occupies only one chapter of thirty odd pages and is much less comprehensive; but this topic is already covered in numerous texts.

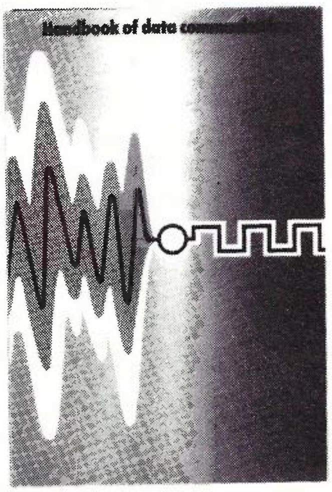
Topics considered range through multiplexing, transmission lines, regeneration, timing extraction and jitter, line coding and practical system realization. These topics are all considered in adequate detail and the text is supplemented with an extensive bibliography. The problems associated with the design of digital systems for coaxial cables and twisted pair cables are considered, with perhaps a slight emphasis on the former. The important aspect of penetration of PCM systems in twisted pair cable is given only little attention, but the pertinent technical papers are referenced.

The authors intend the book as a reference and review work for workers engaged in the research, development and planning of digital communications, and as a background work for academic staff. The book fulfils these intentions. The publisher is Peter Peregrinus Limited, on behalf of the Institution of Electrical Engineers, U.K.

Reviewed by A. J. GIBBS, Research Laboratories, Telecom Australia Headquarters.

HANDBOOK OF DATA COMMUNICATIONS.

BPO and NCC.



This book was produced by the British Post Office in conjunction with the UK National Computing Centre. Its aim is to provide a detailed technical understanding of data communication for ADP programmers and analysts, and non engineering management. It can also serve as an introductory text for technical staff entering the data communications field.

Within 400 pages, the significant subjects covered are:

- Transmission characteristics of the public switched networks and private networks in terms of losses, frequency and phase distortion, and noise in its various manifestations.
- Modulation methods; error control; synchronization; line control procedures; code transparency.
- Error Corrections methods — block check, polynominal check and forward error control.
- Data concentrators and multiplexors; front end pro-

cessors; intelligent terminals; circuit switching; message switching; packet switching; message formats.

The book is logically presented, well illustrated and easy to read. Although it is intended for non-technical people and therefore starts from a more fundamental basis than the usual technical reference, it develops its arguments to a mature technical level. For example polynomial error correction is explained clearly and in detail.

Liberal extracts from the CCITT books are included; this is of particular value because CCITT information is not readily available in the field.

One of the twelve chapters details BPO data facilities and practice and will therefore need to be read with caution when relating to the local scene.

'Handbook of Data Communication' is recommended reading for ADP staff, data service management staff and technical staff entering the data communications field. It is of limited interest to practicing data engineering people. No local price is available but the price in the UK of £8.50 represents good value.

Reviewed by M. D. BURNS, Customer Networks Branch, Telecom Australia Headquarters.

PRINCIPLES OF DIGITAL DATA TRANSMISSION.

A. P. CLARK; Pentach Press Ltd.

This book aims to provide an introduction to the techniques of digital data transmission over voice-frequency channels formed both by telephone circuits and HF radio links. The author has adopted the device of dividing the book into two parts where the first part presents a non-mathematical introduction to data transmission techniques while the second part gives theoretical analysis over a comparison of various techniques. In my opinion this approach has merit for some readers but tends to make the book somewhat fragmented.

I approached the book with interest as there are very few books providing an indepth treatment of data transmission techniques; my reaction after reading the book was mixed. On the positive side, there were many sections in the book which indicated that the author had clearly understood the problem and had a clear grasp of the implications of the various solutions. For example, he stresses that it is the small frequency shift of an FDM derived channel rather than its bandpass nature which makes carrier modulation techniques almost essential for this application. Similarly Chapter 4 is a very brief but informative Chapter on noise and other impairments in the telephone network.

In contrast I found some of the material and presentation unbalanced. For example there are relatively long derivations of results for 2 and 4 level data systems and for particular partial response data signals when general results should have been derived and the particular cases then discussed. The author has avoided any treatment of equalization techniques, including adaptive equalizers, which in my opinion is a serious omission in a book of this nature. The author claims that such topics require a high level of mathematical knowledge but I believe such topics could be treated at a comparable level to much of the material in Part 2 of the book. It may be that the author has reserved the treatment of these topics for a second volume (included in the references is a book by the author entitled, "Advanced Data Transmission Systems"); if this is so. the reader should be aware of this.

A misleading implication that recurs several times in the book is that only 100% roll-off raised-cosine spectral shaping is widely used, whereas high-speed commercial data modems use roll-offs as low as 10-20%.

This book will obviously invite comparison with the books by Bennett and Davey, and Lucky, Salz and Weldon on the same topics. I find that this book in no way replaces these two books but rather provides a readable and less mathematically motivated approach to data transmission principles which many readers might find useful. However in my opinion the unbalanced choice of material would need to be kept in mind for somebody studying the principles of data transmission for the first time. This book could not be recommended as the basic text for the practising engineer in data transmission but nevertheless still has value in that it should refresh his ideas on some of the fundamental assumptions underlying data transmission.

Reviewed by B. M. SMITH, Transmission Systems Branch, Telecom Australia Headquarters.

A Television Transmission System for Single Quad Carrier Cable

R. J. DEMPSEY, B.E.

A baseband colour television transmission system is described, which is intended to utilise 1.27mm conductor single quad carrier cable as a bearer. The use of this system is seen in providing short, high quality video links where it is more economic or convenient to use the single quad cable rather than standard co-axial cable (2.6/9.5mm). The use of a single quad bearer allows the transmission of two television signals in the one cable, either in the same or opposite directions. The transmission limit of this system for duplex mode is 1.0 km, determined by near-end crosstalk at the colour sub-carrier and the transmission limit for the double simplex mode of operation is 1.8 km, determined by the effect of random noise in the chrominance channel.

INTRODUCTION

Long distance television relay circuits in the Australian television network are mainly provided on microwave radio links, the remainder are provided on 12 MHz frequency division multiplex (FDM) cable systems where one television channel replaces some 1500 voice circuits. On the other hand on short routes of only a few kilometre such as between a television operating centre (TOC) and television studio or a link between a microwave radio terminal and a TOC quite different equipment is usually used. In this case very high performance objectives are required to maintain an adequate performance between distant states where many individual links are involved. These short high quality links are known as local video links.

The required performance objectives for local video links are given in Table 1. It should be emphasised that the standard of performance required is well in excess of that obtained in most applications involving closed circuit television, conference television or industrial television links. Up until recently these local video links have been provided by 2.6/9.5mm standard coaxial cable or in some cases microwave radio systems. Previous cable systems had the television signal transmitted at baseband frequencies, but in some respects the performance, particularly with the introduction of colour television, failed to meet the desired performance objectives. To overcome these objections a new high performance coaxial cable television system was introduced. This system, suitable for distances up to 35 km, employs double sideband amplitude modulation centred on 21 MHz and gives a performance which comfortably exceeds the objectives.

A disadvantage of the 21 MHz system is its high equipment cost and also cable cost, this is especially so in an area where there are no spare coaxial tubes available. It was seen that there was an application for a low cost system using a high quality pair cable as a bearer rather than standard coaxial cable, for situations where a link of only one or two kilometre was required. A system based on this concept has been designed in the Telecom Australia Research Laboratories; it is designed for use with polythene insulated single quad carrier cable with 1.27 mm conductors (PEIQC).

The use of a single quad bearer allows three different modes of operation. The terminal equipment is normally configured to use both pairs of the quad for signal transmission in a duplex mode. Alternatively, partially equipped terminals may be used in the simplex mode, in this case utilising only one pair of the cable. If minor changes are made in the terminals the third mode of operation, double-simplex, may be used. The system does not employ repeaters and is thus capable of operating over only a short distance. Using the local video link performance objective, the transmission limit for duplex mode is 1.0 km and for simplex mode is 1.8 km. Though it results in some design difficulties baseband transmission of the television signal was chosen for its ultimate simplicity. As is usual in these types of links no provision is made for the transmission of a corresponding sound channel. If a degradation in performance were acceptable, the system length could be extended appreciably by cascading a number of individual links.

PERFORMANCE STANDARDS

Typical performance standards achieved by an operating system are given in Table 1. The figures given in Table 1 were taken from measurements made on a newly installed single quad system at Bendigo, Victoria. This system operates over a distance of approximately 400 m between the BCV8 Television Studios and the Bendigo Relay Station; two video circuits operating in the same direction are provided. The majority of the transmission parameters are well within the objectives for a local video link. The exceptions were the parameters for 50Hz signal distortion, bar shape and pulse shape though this may have been due, in part, to the difficulty of measuring such small values of distortion.

TABLE 1—TYPICAL SYSTEM PERFORMANCE

Transmission Parameter	Local Video Link Specification	BCV8 Studios to Bendigo Radio Terminal	
		Bearer A	Bearer B
Gain	0 dB	0 dB	0 dB
Gain Variations	0.1 dB (minutes) 0.2 dB (hours)	0 dB	0 dB
Line-time Non-linear Distortion			
Intermediate lines:			
White	2%	0	0
Black	2%	0	0
+ 3 dB White	4%	2%	0
Black	4%	2%	1%
Continuous Random Noise			
Luminance channel	62 dB	69 dB	69 dB
Chrominance channel	56 dB	69 dB	68 dB
Periodic Noise			
Power supply	7 mV p.t.p.	1 mV p.t.p.	1 mV p.t.p.
1kHz to 5.5 MHz	— 57 dB	not measurable	not measurable
Impulsive noise	40 mV p.t.p.	<10 mV p.t.p.	<10 mV p.t.p.
Bounce Swing	1.9 V	1.7 V	1.7 V
Bounce Distortion			
Sync. pulse	2.5%	0	0
Picture	5.0%	0	0
+3 dB Sync. pulse	5.0%	0	0
Picture	10%	2%	3%
Sync. Pulse Distortion	2.5%	0	0
+ 3 dB	5.0%	0	0
Differential Gain	2%	1%	1%
+ 3 dB	4%	1.3%	2%
Differential Phase	2°	0.6°	0.9°
+ 3 dB	4°	1.3°	2.0°
50 Hz Signal Distortion	0.5%	<1.0%	<1.0%
Bar Shape	0.5%	<1.0%	<1.0%
Pulse to Bar Ratio	0.5%	0%	0%
Pulse Shape	0.5%	<1.0%	<1.0%
Gain Inequality	2%	0%	0%
Delay Inequality	20 nS	5 nS	10 nS
Far-end Crosstalk	2.3 mV	2.0 mV	2.0 mV
Intermodulation	1%	0	—
Chrominance-Luminance Intermodulation (+3 dB)	2%	0	0.25%

SYSTEM ENGINEERING

The maximum circuit length is determined by either the effect of near-end crosstalk at the frequency of the colour sub-carrier (4.43 MHz) in duplex mode (Ref. 1) or by the effect of thermal noise in the chrominance channel in the double simplex mode (Ref. 2). Far-end crosstalk is not a limiting factor in simplex mode, for the system lengths under consideration. In order to achieve local video link performance objectives the circuit length limit for simplex mode is 1.8 km while the limit for duplex mode is 1.0 km.

The parameters of the terminal equipment are virtually independent of temperature variations likely to be encountered in practice (10°C—45°C). However, there is no compensation for the effects of temperature variations occurring in the cable. The system parameters most dependent on cable temperature variations are those relating to linear distortion: that is, K factor of the 2T pulse, gain inequality and delay inequality; of these the variation of gain inequality becomes the limiting factor.

The effect of cable temperature variation on gain inequality is easily calculated. The temperature coefficient of the cable attenuation calculated from figures given by Sargeant (Ref. 3) is 0.0016% per degree centigrade for 1.27 mm PEIQC and the attenuation at 4.43 MHz is 13.5 dB/km. For this calculation the cable temperature variation has been assumed to be ±8.5°C. This is similar to the variations occurring where single quad cable would most likely be installed and is based on figures obtained on the Perth-Carnarvon Coaxial cable route (Ref. 4). The variation in cable loss at 4.43 MHz for a temperature variation of ±8.5°C is then 0.33 dB for a 1.8 km link; this corresponds to a gain inequality of ±3.8%. It is therefore necessary to adjust the system at least twice yearly to maintain the local video link objective of ±2%. As the cable temperature cycle is assumed to lag the average ambient surface temperature by about 2 months (typical for cable buried 1.2 m in earth), a suitable strategy for Southern Australia, for example, would be to adjust the gain inequality to −2% at the beginning of June and to +2% at the beginning of December. This is based on the cable temperature peaking between February and March and reaching a minimum between August and September. Because of the large temperature variations encountered, the use of an aerial strung cable with this system is not recommended except on very short links of less than 200 m.

CASCADED SYSTEMS

The terminal equipment may also be used to provide longer links if a degradation in performance is acceptable. Increasing the link length without repeaters is of little advantage as the noise increases rapidly (Ref. 2). A more attractive solution to providing longer links is to cascade single links by using terminal equipment as repeaters. The limitation in system length in this case is determined by either non-linear distortion or excessive gain inequality due to cable temperature variations.

Gain inequalities due to cable temperature variations would add systematically and there is therefore an arithmetic addition from each link. The addition law for the non-linear distortion parameters is not known exactly but would lie between and RMS addition and an arithmetic addition. Table 2 shows an estimate of maximum system length for different performance objectives as determined by the more critical transmission parameters. Except for random noise, arithmetic addition has been assumed. The table applies for simplex operation and individual links of 1.8 km span, each with a performance equivalent to the local link objective.

TABLE 2—TOTAL SYSTEM LENGTH—CASCADED LINKS*

Parameter Determining System Length	Performance Objective			
	Local Video Link	Main Video Link	National Reference Video Connection	National Main Video Connection
Gain Inequality (System adjusted twice yearly)	1.8 km	3.6 km	9.0 km	12.6 km
Differential Gain	1.8 km	3.6 km	9.0 km	18.0 km
Differential Phase	1.8 km	3.6 km	5.4 km	9.0 km
Continuous Random Noise	1.8 km	3.6 km	18.0 km	90.0 km

*(Simplex operation, 1.8 km individual links)

This table is a guide only to the transmission performance obtainable and does not necessarily represent the optimum performance for any particular application. The values given in the table indicate that the system length is limited by the accumulation of differential phase. However, it is more likely that the differential phase would add on less than a strictly arithmetic basis and the ultimate restriction on system length is expected to be determined by an inability to meet the required gain inequality objective.

REJECTION OF LOW FREQUENCY INTERFERENCE

The frequency response of the system extends from less than 1 Hz to beyond 5 MHz. The low frequency response has been chosen so that there is no significant distortion of 50 Hz field information, as a result there is no need to use black level clamping. The disadvantage of the system responding to low frequencies is that it becomes susceptible to low frequency interference. This exists mainly as a longitudinal signal, making it necessary to design the receive input amplifier with a high common mode rejection. Typically this is 80 dB and is sufficient to remove any 50 Hz or low frequency longitudinal signals.

The pick-up of low frequency transverse signals in the cable is suppressed by its very good balance. Because the shielding of co-axial cable is poor at low frequencies there is an advantage in using pair cable rather than co-axial cable systems for base-band transmission. The poor low frequency shielding of co-axial cables is due to the increasing skin effect depth of the outer conductor allowing the penetration of electro-magnetic fields at frequencies below 300 Hz (Ref. 5). Shielding the cable with mild steel tapes reduces the effect but does not eliminate it completely.

Interference at high frequencies is minimised in this system by the copper sheath enclosing the single, quad cable. The copper sheath together with the good balance of the cable also prevents cross-talk between different single quad cables over the whole video frequency range where more than one system shares the same duct.

SYSTEM OPERATING LEVELS

The terminal equipment input and output signals are sent unbalanced at a level of 1 volt peak-to-peak for the composite video signal at an impedance of 75 ohm. The balanced line signal is also transmitted at 1 volt peak-to-peak. The terminal equipment input and output signal level were chosen to be compatible with external equipment levels whereas the level of the line signal was chosen as a compromise between too high a level causing excessive non-linear distortion and too low a level resulting on a poor signal to noise ratio.

TABLE 3—TERMINAL POWER REQUIREMENTS

Terminal Equipment Fitted	Input Mains Current (mA)	DC Input Current to Cards (mA)	
		Positive supply	Negative supply
Send only	50	105	20
Receive only*	90	200	100
Send and receive*	105	305	120

*Three equaliser cards fitted

REMOTE POWERING OF TERMINALS

The terminals are normally individually powered from the 50 Hz mains. The remote powering of a distant terminal may be possible on an unused pair of the single quad cable (supplying ±30V dc) and using the sheath as a common conductor. The power requirement per duplex equipped terminal is 305 mA on the + 28 volt rail and 120 mA on the −28 volt rail (see Table 3). However, a lightning strike or power distribution fault causing excessive voltages or current on the cable pairs or sheath would most likely damage the remote terminal regulated power supplies. For this reason remote powering is not recommended unless additional protective devices are used with the regulated power supplies.

CIRCUIT DESCRIPTION

The block diagram of the complete terminal equipment is shown in Fig. 1. Each section is described in the following paragraphs.

Impedance Simulating Networks

It was decided that the terminal equipment should be image matched to the cable impedance. This has an important practical advantage of simplifying the equaliser design because the overall shape of the insertion loss characteristic remains the same regardless of the cable length. The use of image matching is worthwhile in any line transmission system of appreciable line loss where the cable impedance varies widely over the signal frequency range. The characteristic impedance of 2/1.27 mm PEIQC cable varies between 320 ohm and 112 ohm at frequencies of 1 kHz and 2 MHz respectively.

A minor disadvantage in using the impedance simulating networks is a slight degradation in high frequency performance due to the presence of resonances occurring in the necessarily large capacitors used. The effect of this is negligible in terms of the local video link performance objectives and would only become important for a high per-

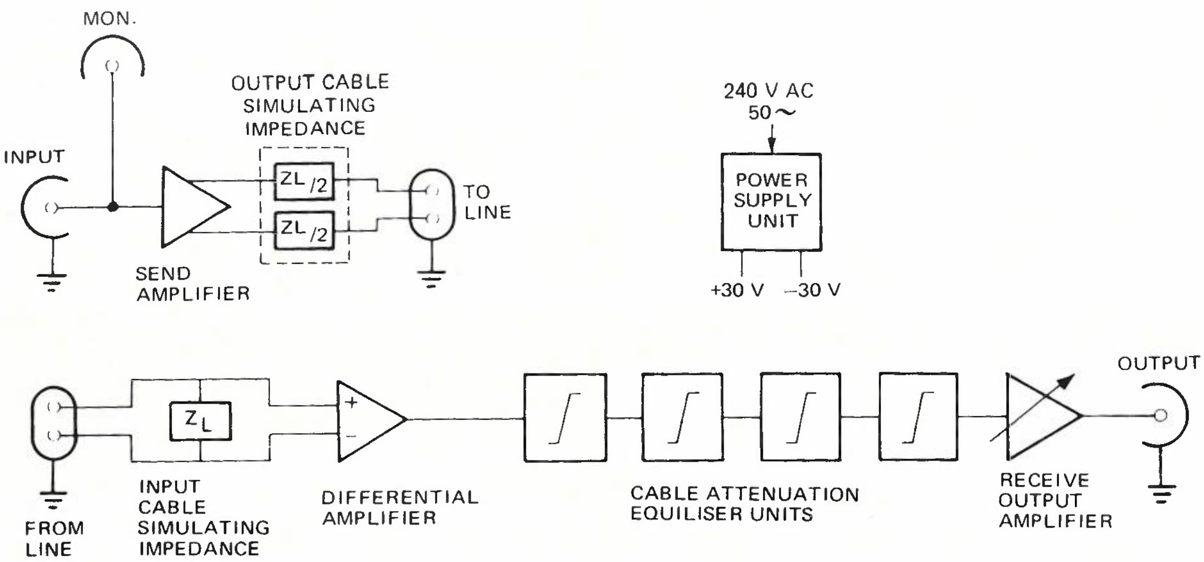


Fig. 1 — Terminal Equipment Unit.

formance system with many sections in cascade.

Circuit diagrams for the input and output impedance simulation networks are shown in Figs. 2 and 3 respectively. The design of the networks is discussed by McGregor (Ref. 6).

Send Amplifier

This amplifier is used to convert unbalanced composite video signals to balanced signals for transmission over the cable. The amplifier input impedance is 75 ohm and the output impedance approximately zero. Image impedance matching to the line is achieved by passing the signal through the output matching network described above. A long tail transistor pair is used to provide the unbalanced to balanced conversion. The balanced output of this stage is followed by trans-admittance buffer stages, which give a zero output impedance. The overall gain of the amplifier is determined by feedback to give an approximately 2 volt peak-to-peak balanced output for a 1 volt peak-to-peak input signal. The addition of the image matching network between the amplifier and line reduces the signal voltage swing sent to line to 1 volt peak-to-peak. A potentiometer adjusts the gain of one side of the amplifier to give an accurately balanced signal to line. The input to the amplifier is ac coupled. However, it was not practical to ac couple the output so that, in practice, a small dc offset voltage will be sent to line, with a magnitude dependant on the setting of a potentiometer included to minimise this offset.

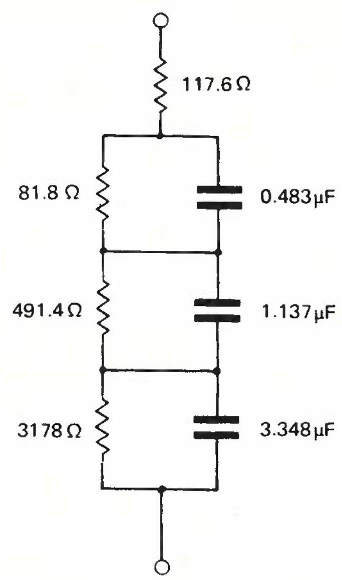


Fig. 2 — Input Cable Simulating Impedance.

An on-board regulated power supply ensures stability of the amplifier dc operating conditions and reduces mains borne interference and power supply ripple.

Diodes shunt the output of the amplifier to give additional protection against remaining surge potentials not removed by the lightning protection box.

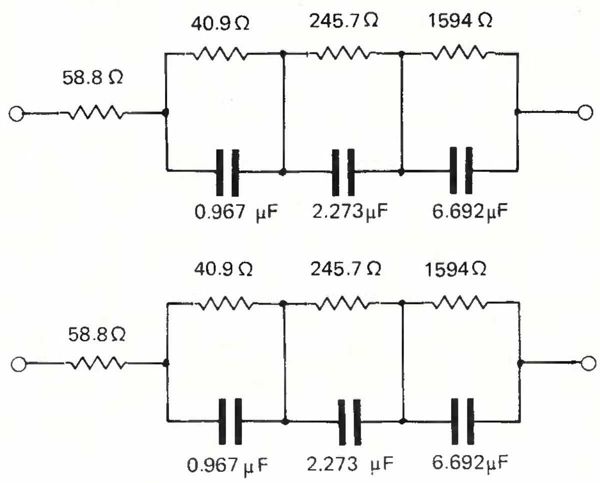


Fig. 3 — Output Cable Simulating Impedance.

Differential Input Amplifier

This amplifier converts the balanced incoming line signal to an unbalanced signal suitable for the equalizer and following stages and it is also the definitive circuit in determining the overall noise and non-linear distortion performance of the system. This results from the compromises involved in the requirement that the amplifier have a high longitudinal rejection (about 80 dB), a low noise figure, low differential gain and phase distortion, a large octave bandwidth and input protection against surge voltages. A simplified diagram of the amplifier is shown in Fig. 4.

The amplifier is designed to have a high input impedance. This is necessary for two reasons: firstly, to allow the use of reasonably sized non-electrolytic input coupling capacitors whilst retaining the desired low frequency response to 50 Hz field frequencies (this requires the low frequency −3 dB point to be of the order of 0.2 Hz) and secondly, to retain a high longitudinal rejection at low frequencies. To retain high longitudinal rejection at low frequencies with an ac coupled circuit it is necessary to have a high degree of matching between the low frequency time constants of each input side or alternatively, if good matching cannot be obtained, reduce the cut-off frequencies to well below the interfering frequencies. This latter course was chosen as it was also necessary to minimise linear distortion of the field signal. Metallised lacquer capacitors were chosen for the 10 microfarad input coupling structures because of their relatively small size yet good reliability for the capacity provided.

The use of complementary transistors in the input stage allows the realisation of a circuit configuration which is effectively a long tail pair but in which the tail is absent. Consequently, the common mode rejection ratio is increased over that of the conventional long tail pair where the tail impedance is finite. A disadvantage of the circuit used is that it is more difficult to match the characteristics of the transistors on each side of the circuit. The effect of mismatch is reduced by using NPN/PNP feedback pairs which also improves the performance of the local series feedback due to R_E and also helps to attain the high input impedance, at low frequencies, of the order of a few megohms. The overall input impedance is then determined almost solely by the shunt bias resistors. It is not possible to increase these in value to reduce the value of input coupling capacitors without running into difficulties biasing the input transistors. The quiescent currents flowing in the input transistors must be maintained in value so as not to degrade the frequency response or increase the non-linear distortion.

Input protection from voltage surges greater than 20 volt is provided by series input resistors and shunt diodes. Unfortunately these series resistors together with the series feedback resistor R_E degrade the noise performance of the amplifier and due to its position, the overall system noise performance. It is difficult to resolve the noise problem and still provide input protection, obtain gain stability and sufficiently low non-linear distortion.

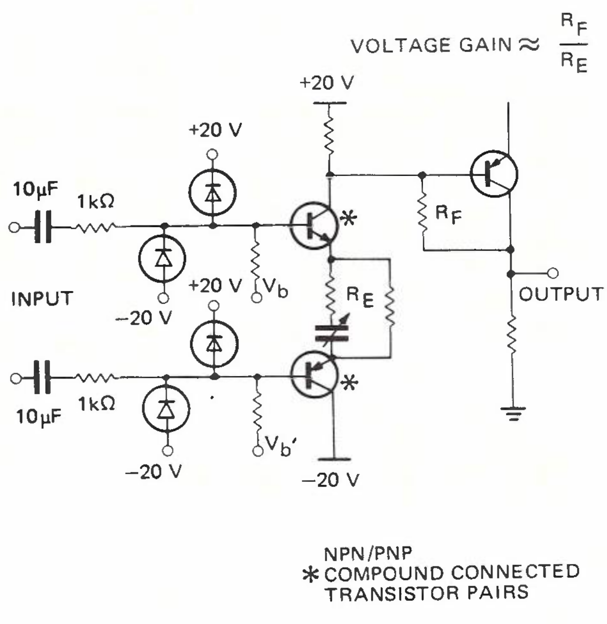


Fig. 4 — Differential Input Amplifier.

It was not possible to determine a suitable alternative overall feedback configuration which lowered the noise figure whilst maintaining the remaining performance criteria. This is a common problem with differential to single-ended amplifiers where the use of a transformer is prevented because of the need to operate over a large number of frequency decades.

The second stage of the amplifier employs shunt feedback which stabilises its gain and forces the output impedance to zero. The trimmer capacitor in the emitter stage of the input stage is a useful control to trim the gain inequality of the sysem without substantially affecting the overall short-time response. A potentiometer is provided to adjust the circuit bias current so that non-linear distortion may be minimised. In practice it is best to carry out the adjustment to give a compromise of minimum differential gain and phase distortion over the full range of average picture levels.

Attenuation Equaliser

An active equaliser design has been used for this system. As mentioned above the terminal equipment is image matched to the cable, therefore there is no mismatch loss dependant on frequency and cable length. Hence, the required equalisation always has the shape of the cable attenuation and is proportional to the length of cable in the link. This allows the use of an equaliser with a single adjustment for cable length.

The simplified circuit of the equaliser is shown in Fig. 5. The potentiometer P1 in the emitter circuit of TR1 controls the amount of equalisation. When the wiper of P1 is next to the emitter of TR1 maximum equalisation occurs, when it is at the earth end of its travel no equalisation occurs and the overall gain is unity. The RC network in the emitter of TR1 is optimised to equalise 2/1.27 mm PEIQC cable and may not accurately equalise other cable types. A limitation of this equaliser is the maximum equalisation slope of 6 dB/octave that may be provided; for 2/1.27 mm PEIQC this limits the length of cable that can be equalised to approximately 500 m. It is therefore necessary to cascade additional equaliser cards to provide for links greater than 500 m. Four cards are needed to provide equalisation for the maximum system length of 1.8 km.

It will be noted that only attenuation equalisation has been carried out with no attempt at phase (or delay) equalisation. Even though a television signal is sensitive to delay distortion, equalisation is not required because after attenuation equalisation has been carried out the phase response rolls off relatively slowly and does not cause significant delay distortion. The design of equalisers of this type is discussed by McGregor [Ref. 6].

Receive Output Amplifier and Gain Control

This amplifier incorporates the system gain control and provides a 75 ohm unbalanced 1 volt peak-to-peak composite video output signal suitable for connection to external video equipment. A second isolated monitoring output is also provided, this is included to show the presence or otherwise of a signal and it not intended as a measurement point. The source impedance of this output is 3.3 k ohm.

The gain control potentiometer is connected between the emitters of two transistors in a long tail pair. In this position it can be dc coupled and thus its inclusion has no effect on the low frequency response of the circuit. To stabilise the gain, series/shunt feedback is used in the two stages of the amplifier.

Power Supplies

The power supplies are mains operated with no provision for battery powering. Positive and negative regulators are used, simplifying the biasing and improving the performance of amplifiers used in the terminals. To minimise ripple and mains borne interference two stages of regulation are used. Pre-regulators provide plus and minus 27 volt to all cards which in turn have regulators producing plus and minus 20 volt.

The main regulators are conventional in design with the exception that they feature foldback current limiting [Ref. 7]. This protects the series pass transistors from excessive power dissipation under overload conditions. Current limiting begins at approximately 350 mA.

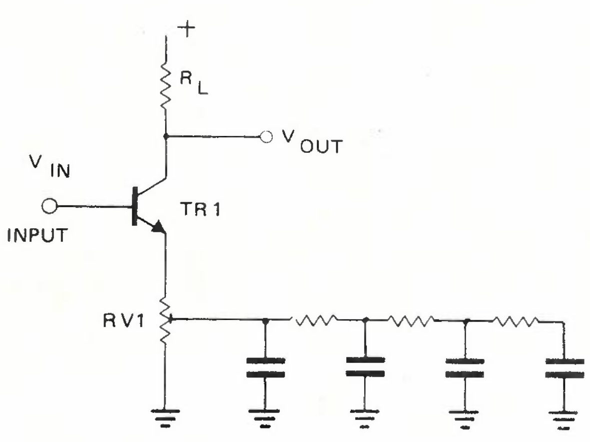


Fig. 5 — Attenuation Equaliser.

With the exception of the equaliser cards, all amplifier cards use μA 723 and LM 304 integrated circuit regulators with external series pass transistors where necessary. The negative regulators are operated in tracking mode to minimise the effects of supply variations. The equaliser cards have a single +20 volt regulated supply employing a μA 723 integrated circuit.

Terminal power requirements are shown in Table 3.

SURGE PROTECTION

This protection is mainly aimed at nullifying the effects of direct lightning strikes on the cable.

The primary protection against line surge voltages is carried out by gas discharge devices. The circuit arrangement depicted in Fig. 6 is used; this circuit is fitted inside a cast alloy box at the point of physical termination of the cable. Both transverse and longitudinal protection is provided with equalising coils (drainage coils) used with the lower voltage protectors to minimise the generation of transverse voltages from longitudinal surges. The surge arrestors have dc firing voltages of 90 volt and 350 volt. The dc firing voltage of the arrestors is above the point where damage may occur to the amplifier input circuitry. Also, the peak voltage across the arrestors when they first fire rises for surge waveforms having steep frontal slopes; with the arrestors used it is 1 kv for a frontal slope of 4 kv/μsec. As a result secondary protection is needed at the amplifier input. This is provided by placing 1 k ohm resistors in series with each input terminal after the gas discharge arrestors and connecting small-signal low capacitance high frequency diodes from the input terminals to the $\pm$20 V power rails as shown in Fig. 4. These diodes have a 1 μs peak current of 4000 mA and 1 sec rating of 500 mA. Consequently, when used with a 1 k ohm series they can protect the input against short term surges of up to 4000 V and 1 second surges of 500 V. The combination of gas discharge devices and shunt diodes therefore adequately suppresses a wide variation in surge voltages.

The equipment has withstood simulated lightning surge conditions when tested according to a Tele-

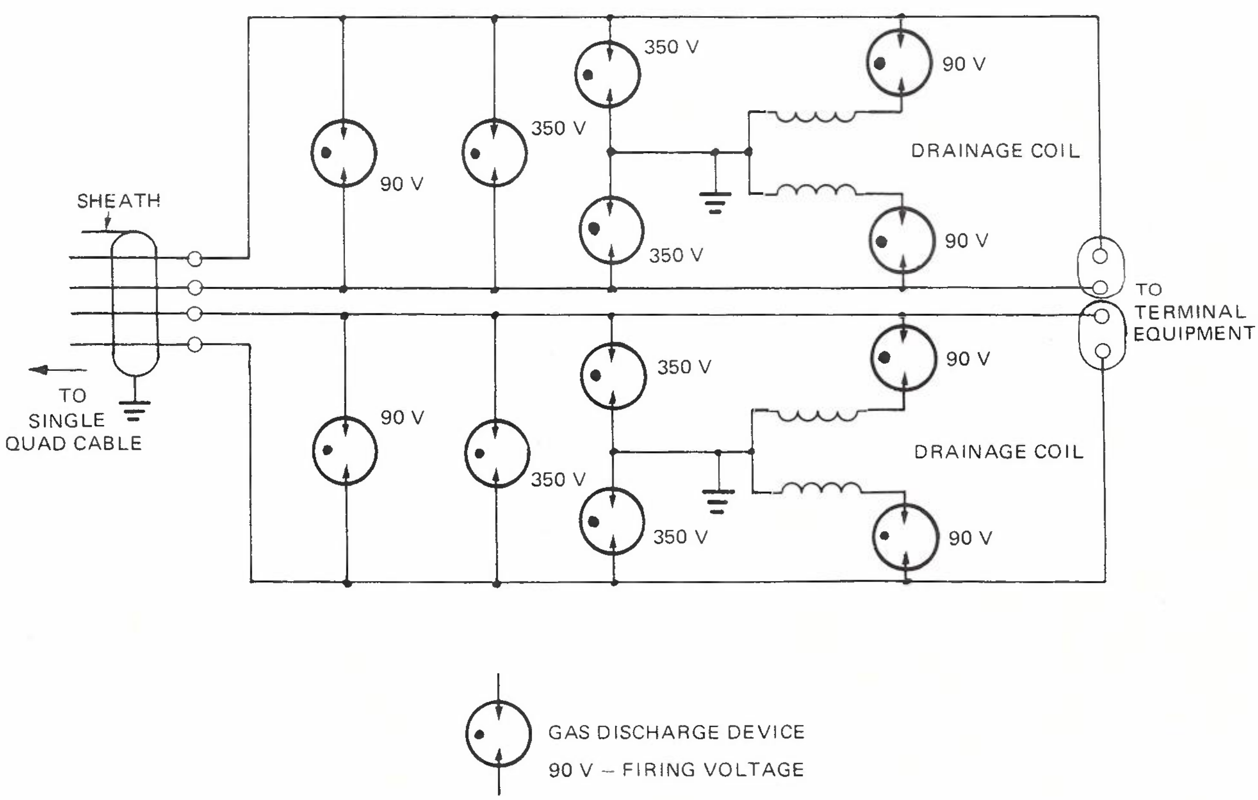


Fig. 6 — Lightning Protection.

com Australia Specification (Ref. 9).

To protect personnel working on Telecom lines from any risk from mains voltages the power transformer mounted in the terminal has an earthed conductive screen separating the primary and the low voltage secondary windings.

RELIABILITY

The reliability of the system has been calculated from component reliability figures given by Dummer [Ref. 8]. In the calculations a weighting factor of 1.0 has been chosen for environment, rating and temperature. The calculated mean time between failure (MTBF) for one channel in one direction which includes a send unit, receive unit and power supplies in both terminals is 12.8 months. The calculated MTBF for a send unit, receive unit and power supply is 5.4 years, 2.1 years and 7.4 years respectively. In the case of receive units the calculation is based on a receive unit equipped with three equaliser cards, sufficient to equalise 1.5 km of cable.

CONCLUSION

A television transmission system designed to operate on single quad carrier has been described. The use of baseband operation of the system leads to economy and simplicity of the terminal equipment. The relatively low cost, ruggedness and ease of laying of single quad cable, combined with its excellent electrical properties suggested its use as a bearer. The application of the system is seen in providing short high quality television links of up to 1.8 km in length, particularly in areas where the provision of standard coaxial cable is economically unattractive or its installation difficult.

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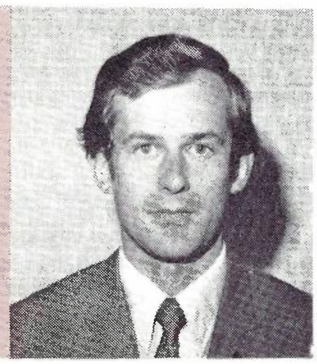

The Eighth International Teletraffic Congress

P. S. BETHELL, B.Sc., D.P.A.

The 8th International Teletraffic Congress which was held in Melbourne in November 1976 was sponsored by the Australian Telecommunications Commission in association with the Australian Telecommunications Development Association. It was attended by 235 delegates including 146 from overseas countries and 135 papers were presented. This article briefly outlines the background and history of the Teletraffic Congresses since the first was held in 1955. It also gives some account of the topics covered by the technical programme and summarises some of the more important aspects which were brought to notice in the papers presented.

INTRODUCTION

On the 10th November 1976 Hon. Eric Robinson as Minister for Posts and Telecommunications, formally opened the 8th International Teletraffic Congress in the Ballroom of the Southern Cross Hotel in Melbourne. This was a notable international event involving, as it did, delegates from no less than 27 countries and it was a privilege for Telecom Australia together with the Australian Telecommunications Development Association to have the opportunity of acting as hosts. Teletraffic Congresses have been held at three year intervals since the inaugural meeting in 1955 but the Melbourne Congress was the first to be held in the Southern Hemisphere and only the second outside Europe.

HISTORY

The idea of arranging a meeting of Traffic Engineering theorists to enable them to present the results of their work and discuss them with other experts evolved in the early 1950s. A small group of these people banded together to form an organisational committee for the first meeting in 1955 at Copenhagen. A total of 69 delegates from 13 countries attended this meeting and 26 papers were presented.

It was very fitting that the first meeting, which later became known as an International Teletraffic Congress, was held in Denmark which was the native country of A. K. Erlang who is now generally recognised as the founder of telephone traffic research as a science. His name is perpetuated as the name of the unit of traffic flow which is now used almost universally.

TABLE 1: PARTICIPATION BY COUNTRIES

Country	No. of Delegates	No. of Papers Presented
Algeria	—	½
Australia	89	17
Belgium	2	3
Brazil	1	—
Bulgaria	—	2
Canada	11	4
Denmark	3	1
Finland	3	3
France	3	1
Germany	25	20½
Greece	1	1
Hungary	—	2
India	4	—
Israel	1	1
Italy	6	5
Iran	1	—
Japan	8	7
Malaysia	2	—
Netherlands	4	6
Norway	2	4
Philippines	1	—
Spain	7	7
Sweden	14	13
Switzerland	5	1
Thailand	1	—
Tunisia	1	½
Uganda	1	—
United Kingdom	12	13
U.S.A.	26	21½
U.S.S.R.	1	1
	235	135*

***Note:** In the case of joint authorship with authors from two different countries, each country is credited with half a paper.

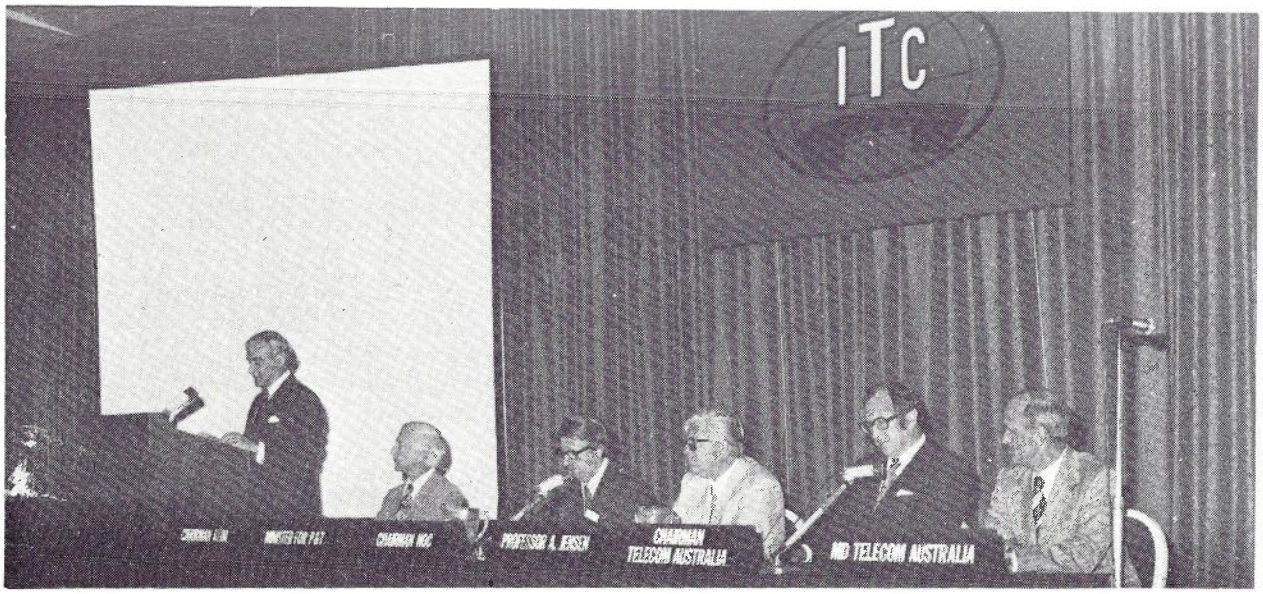

Fig. 1 — Hon. Eric Robinson, Minister for Posts and Telecommunications (at rostrum) Formally Opening the Congress. Others on the dais from left to right are Messrs. E. Hodgkinson and I. A. Newstead, Professor A. Jensen, Messrs. A. D. Somervaille and J. Curtis.

The success of the first meeting led to the formation of an International Advisory Council, chaired since its inception by Professor Arne Jensen of Denmark. The council has been the guiding body for all subsequent Congresses which have been held successively at The Hague, Paris, London, New York, Munich, Stockholm and Melbourne. Interest in the work of the Congresses grew steadily until the Stockholm meeting which was attended by 328 delegates from 30 countries and considered 130 papers. Owing, perhaps, to the long travelling distance involved for many potential delegates to attend the Melbourne meeting, the attendance at the 8th Congress fell to 235 but the number of papers considered (135) was the highest to date. Table 1 lists the number of delegates and papers contributed from each of the countries represented.

ORGANISATION

The detailed organisation of the Congress has been the responsibility of the host countries which in each case have formed an organising committee and established a secretariat. For the Melbourne Congress an organising committee was formed in 1974 soon after the 7th Congress formally accepted Australia's invitation to host the meeting. The National Organising Committee, which was chaired by Mr. I. A. Newstead, consisted of a number of representatives from Telecom Australia together with a member from an Australian University and two members nominated by the Australian Telecommunications Development Association to represent the industry.

The organising committee was supported by a Technical Programme Committee which was charged with the responsibility of selecting topics and the classification and grouping of submitted papers into a balanced and interesting programme for discussion at the Congress. The Technical Programme Committee, chaired by Dr. C. W. Pratt, consisted of representatives of Telecom Australia, Universities and Industry and included overseas members who participated by correspondence.

The ITC is probably unique in that there is no formal membership and the congresses are open to anybody who has an interest in the subject. Delegates attend as individuals and do not represent either organisations or countries. The attendance at the Melbourne Congress, as with previous meetings, provided an interesting blend of academics with personnel from Administrations and the Telecommunications Industry. Table 2 shows that these three groups provided more or less equal contributions by way of papers although personnel from Administrations and Operating Agencies predominated amongst the delegates.

TABLE 2: PARTICIPATION BY ORGANISATION CATEGORIES

	Delegates	Papers
Academic Institutions	54	43
Administrations and Operating Agencies	122	56
Industry and others	59	36

Note. In the case of joint authorship with authors from different categories, each category is credited with half a paper.

SCOPE OF THE CONGRESS

The invitation to the Melbourne Congress advised prospective delegates that it would deal with "the application of probability theory to telecommunication research, engineering and administration". It then proceeded to outline a comprehensive list of topics relating to teletraffic theory and practice applying to telephony, telex and data communications, and invited contributions on these topics. Contributions were received on most of these subjects, but it was noted at this Congress that there was a trend towards a larger proportion of contributions covering the more practical aspects such as Data Measurement, Traffic Data Management and Forecasting. As one might expect, these contributions tended to come from delegates in Administrations.

TECHNICAL PROGRAMME

The working programme, which considered the 135 papers, consisted of 25 sessions spread over six working days; in addition, there was the final panel discussion session, intended to review the work of the congress. Six papers were invited review papers presented by leading world figures in teletraffic and two invited papers were tributes to two notable personalities who had died since the previous congress—namely E. P. G. Wright of United Kingdom and Dr. Yngve Rapp of Sweden. Of the papers considered, 93 were classified as "Read" and were briefly presented by the respective authors, while 42 were classified as "Non-read" and were summarised by the discussion leader nominated for the session. Part of each session was devoted to discussion which consisted of questions arising from the papers and responses from the authors.

It would not be possible in this article to comment on all of the papers presented or even to give a detailed summary of the proceedings in each session. Those readers who may be interested in obtaining more detail about particular topics or papers should refer to the special ITC8 Issue of Australian Telecommunications Research (Volume 11 No. 1) which includes abstracts of all papers and prints in full the papers which were contributed by Australian authors. However, to give readers an outline of the state of the art and of some of the problems which are currently occupying world experts, the topics have been grouped into eight broad subject headings which are covered in the following sections. For the sake of the general reader more emphasis has been placed on practical aspects, and only a brief review is given of the range of the more complex theoretical work which was presented at the Conference.

Traffic Data Measurement, Administration and Forecasting (Sessions 21, 24, 26)

One session was devoted to forecasting methods and two sessions to data measurement and administration. However, since traffic measurements were generally considered as the base for forecasting and planning purposes, all topics were referred to at all three sessions and will be considered together.

Although it is not generally intended to identify and discuss the contents of individual papers, mention will be made of an invited paper on forecasting. This paper, which was presented by an author from A.T. & T. Company, reviewed forecasting practices in the Bell System. The paper covered techniques and practices adopted for forecasting of subscribers, traffic usage rates, local network traffic, trunk network traffic and operator loads. These cannot be reviewed in full but the following points are worth noting:

- The forecasting technique which is used in each application depends on the item being forecast and the time span of the forecast. In the Bell System, techniques vary from simple manual extrapolation to the use of complex mathematical models involving large volumes of data and computer processing. Comparatively simple projection techniques involving considerable individual judgement are often used in projecting usage rates whereas on the other hand trunk forecasting can involve a complex curve fitting process and econometric modelling.
- Whatever the techniques used, there is a need to monitor forecasts against actual growth and to continually revise the techniques being used when forecasts are found to be unsatisfactory.
- Forecasting is and probably always will be an art and its accuracy will depend on the forecaster's judgement and his knowledge of the business.

A number of themes emerged from both the invited and considered papers presented. One area on which there was considerable discussion was

Fig. 2 — Dr. C. W. Pratt (Australia) Chaired Discussion at the First Technical Session. Also on the dais are authors D. Bazlen and W. Lörcher (Federal Republic of Germany), J. W. Cohen (Netherlands) and P. Le Gall (France) and discussion leader L. E. N. Delbrook (Canada).

the question of determining the appropriate traffic base for forecasting and dimensioning purposes. Whilst the use of the Time Consistent Busy Hour is general and widespread, some Administrations are now using peak or extreme values for dimensioning small exchanges and PBXs.

One paper drew attention to the importance of establishing confidence limits on forecasts. Whatever the techniques used, up to half of the forecasts wil be less than actual growth and unless some overprovisioning is deliberately planned, underdimensioning or late relief will result. It was proposed therefore that relief dates should be planned by systematic use of the upper forecast limit of growth at a prescribed level of confidence.

Another paper outlines a comprehensive practical exchange traffic forecasting system which is based on mathematical trend forecasting techniques but using the 95% confidence limits to guide forecasters in exercising subjective judgement in determining design forecasts. The authors stress the importance of effecting a reconciliation between "top-down" and "bottom-up" forecasts i.e. by separately forecasting the total exchange traffic and the elements from which it is constituted.

Several papers considered economic aspects of data collection and forecasting. One such aspect is the length of the recording period which is necessary to ensure reliable base data, bearing in mind that the cost of collecting and processing data must be balanced against the risk of over or under-provisioning. One author demonstrated that there may be an optimum recording period for which the total cost in minimised. Another paper outlined a study designed to evaluate the cost penalties arising from poor forecasting. Although the financial penalties arising from high forecasts, and hence over-provisioning, can be readily evaluated this study was able to show that under-forecasts and under-provisioning also resulted in losses of the same order due to rush jobs, overtime, customer complaints, etc.

It is clear from the papers submitted that most administrations recognise a need for the collection of more data and most are obviously suffering from the inadequacies in the historical data available. Because of the high cost of collecting data by traditional means, all advanced administrations are moving towards greater automation in data collection and processing and many traffic engineers are giving consideration to more extensive use of micro processors for remotely controlled data logging. One author proposed that volumes of data to be processed would be considerably reduced by the extensive use of overflow measurements to avoid the need for scanning vast numbers of individual lines.

Finally the rapid increase in volumes of data being collected is leading to the recognition that large and complex computer systems are necessary to handle the large volumes of measured data and to validate and process it into the appropriate forms for the various applications. To some extent the introduction of stored programme control alleviates these problems by undertaking some pre-processing internally, but this information still needs to be made compatible with data collected from other sources.

Subscriber Behaviour Problems (Sessions 32, part of 34)

One session was devoted to subscriber behaviour problems and dealt mainly with two particular aspects of subscriber behaviour which affect traffic flow patterns. The first of these is the effect of repeated attempts to complete a call which fails on the first attempt. The second is the effect of tariff changes on both the number of calls and their holding times.

Repeated attempts affect traffic patterns by increasing the usage of common controls and also by making it difficult to assess the genuine traffic offered without knowing the number and frequency of repeated attempts. This complex phenomenon has occupied traffic theorists for many years and two new theoretical studies which attempted to describe observed results were presented. One paper identified differences in the behaviour patterns for various categories of subscriber (e.g. business, residential) and also demonstrated that there was a change in the pattern with the time of day. Similar results are demonstrated in another paper which analysed calling subscriber behaviour in relation to causes of failure (called subscriber busy, not answering etc.), distance of call and time of day.

The second phenomenon, which is not well understood and about which there is a dearth of published data, is the change in traffic patterns due to traffic variations. A useful contribution was made in a paper which described the "before and after" traffic flows in an area where timing of local calls was introduced in the daytime, with flat charges remaining at night. The study showed that there was a substantial decrease in both the number and holding times of day calls for all subscriber categories. Some increases were recorded for the night traffic, but in total these were small compared to the reduction in day traffic.

Another author developed an empirical model to describe the likely changes in traffic patterns which would result by varying both rental and call charges. This model may be useful but needs testing against some real data. In another paper the author described the data base of subscriber characteristics which was being assembled for areas where it was proposed to introduce call charges to replace the existing flat rate charging system. It was proposed to make further measurements after the tariff charges have been introduced and to analyse these in relation to the existing data base.

Two papers addressed themselves to the problems of subscriber behaviour as its affects originating call dispersion particularly in multiexchange urban networks. One of these described measured calling patterns in terms of a modified "gravity" model which can be used to formulate a future matrix from the subscriber connection forecasts. The second paper dealt with the same problem by developing a more theoretical model to enable a consistent traffic distribution matrix to be produced.

Network Planning & Dimensioning (Sessions 13, 14, 22, 33, part of 34, 51, 53)

There were 35 papers presented dealing with these aspects of teletraffic. It is significant that modern trends in planning deal with whole networks rather than exchanges or parts of exchanges; these trends were reflected in a number of the papers. The key concepts of optimisation and modular engineering were well represented, as was the design and application of mathematic models. All of these concepts imply that a digital computer will be used to manipulate data. The complexity of alternative routing networks requires the use of a computer sufficient size to allow large volumes of data to be stored and retrieved quickly.

Another feature of this congress was the emphasis on the use of the hand-held programmable calculator. One paper concentrated on this aspect while others specified programs for dealing with particular problems.

Teletraffic theory began with Erlang's pioneering work in 1917. Most of our dimensioning methods have been based on that theory, which assumes that calls are generated in a random fashion by a large number of sources. This assumption does not always hold, and recent congresses have seen new theories devised to cater for variations to this assumption. The Equivalent Random Theory (ERT), introduced by Wilkinson in 1956 has been an important tool in the development of alternative routing networks, dealing, as it does, with the behaviour of traffic which overflows from a group of circuits. Such traffic is said to be "rough", because it varies more rapidly than "random" traffic. This theory has recently been extended to cater for "smooth" traffic, such as might be generated by a limited number of sources. Interest in smooth traffic at this Congress was high and several papers were devoted to its study.

Two papers discussed the effects of particular characteristics on the efficiency of switching machines. One of these dealt with the effects of non-uniform distribution of traffic within the machine and the other on the effects of traffic peakedness (roughness).

A whole session of the Congress was devoted to papers dealing with international network problems. This included a paper which dealt with the economics of satellites in the provision of circuits for the international network.

Network Management and Reliability (Sessions 41 and 44)

A total of nine papers was presented on the subjects of network and system reliability, network performance, and network management and supervision. Papers on one or the other of the above subjects came from many different parts of the world—U.K., Sweden, Italy, Spain, U.S.A., Japan and Australia. Curiously, only one paper dealt with aspects of dynamic network management; the rest were concerned with network performance, reliability and the effects of faults on the grade of service. For convenience these papers were divided into two sessions (41 and 44) in the technical programme.

Of the two papers which discussed system reliability, one presented mathematical models and methods to analyse software reliability as measured by failure rates. Failure liability was proposed as a parameter to be used as a figure of merit for comparative reliability. The authors of the other paper proposed the concept of "serviceability" to cover all aspects of system performance, such as transmission quality, traffic characteristics, flexibility, etc., which were previously treated separately. It was suggested that "serviceability" could be evaluated in terms of delay on communications as it affects the subscriber, whether through delays in setting up calls, repeating bits of lost information, or having to repeat calls because of congestion.

The effects of faults on the grade of service was investigated in two papers. The authors of both papers developed mathematical models, but followed different approaches in their investigations. One developed the equations governing the behaviour of the fault population in a telephone exchange and stressed the importance of considering both the fault incidence and fault duration: rapid correction of a severe fault would have the same effect on the standard of service as the continual prevention or correction of several less serious faults. The other paper discussed the effect of plant faults on circuit holding times and discussed suitable statistical tests to detect faults by counting the numbers of individual circuit seizures per unit time. A more comprehensive report on this technique was given in another paper, where not only the efficiency of the technique but also its cost effectiveness was described. The authors show that Individual Circuit Measurements are a very effective, although costly, means of detecting faults in the exchange. Since the fault detection rate generally declines after the initial clean-up the authors suggested periodic relocation of the monitoring equipment.

The remaining papers discussed factors influencing call completion rates, continuous traffic load measurements to provide business information, and criteria for network management action. The first two described the analysis of longer term observations of traffic data, while the last one was concerned with reliable detection of critical traffic conditions in real time by statistical analysis of route occupancy data obtained by periodic scanning.

Traffic Engineering Theory (Sessions 12, 23, 25, 31, 42, 54)

There were a number of sessions which dealt with theoretical aspects of traffic engineering, and they included wide-ranging discussions of busy signal systems, delay systems, link systems and the properties of overflow traffic. In addition, there was a special session to highlight new methods of analysis. The sessions involving general traffic engineering theory included an invited paper which considered the application of operational research techniques to the solution of problems in telecommunications theory, and in particular, the author examined the use of various optimising methods in network design.

In the session dealing with busy signal systems, authors discussed a range of different topics, which included conditional blocking probabilities in a link system, Erlang's formula for loss systems with a general service time distribution, and the difficulties associated with repeated attempts in busy signal systems. Finally, one paper considered the effects of preceding selector stages upon the loss from gradings.

Two sessions were devoted to the subject of delay systems, and once again a wide variety of different problems were discussed. In an informative paper a solution was presented for the case of a queueing system where the customers faced time-outs from equipment in the telephone network or made random departures from the system before service was completed. Other contributions considered the effects of interruptions to service on a regular basis, the development of approximate formulae for single server queueing systems, "Nearest-in-First-out" service discipline, the analysis of complex queueing systems using a decomposition principle and the dimensioning of signalling equipment. One paper considered a very wide variety of different queueing models with one or more queues, and which may have full or limited access to servers, and another considered multi-queue systems with priority service to customers. Two papers discussed delay in link systems and one dealt with problems associated with the accuracy of observed values of certain queue parameters for multi-server systems.

In the session dealing with new methods of analysis, authors introduced the theories of "general point processes" and "cumulative processes" in order to analyse teletraffic problems. Call state transition diagrams were introduced by one author to assist with the specification of systems in such a way that they may then be analysed more effectively. Other authors applied decomposition techniques to the problem of network reliability, and presented an uncertainty model for a simple single-server queueing system. A number of papers which investigated the properties of overflow traffic extended known results by introducing new and novel approaches. Other topics discussed were the accuracy of some overflow traffic models, overflow traffic from simple gradings, and cyclic overflows from groups of lines.

Three papers examined congestion in link systems for a variety of different selection criteria and another investigated the special case of a three stage switching array with "multiple connection attempts". Other contributions involved "wide sense non-blocking networks", blocking probabilities in networks allowing rearrangements, and finally, the "design of mixed analogue and digital switching networks".

To summarise, although these papers are primarily of interest to traffic engineering theoreticians, it is clear that many will have direct application in practical designs and most of them will lead to a clearer understanding of new and existing systems.

Simulation Methods (Session 43)

Simulation methods have been used from the earliest days of traffic engineering and have greatly assisted the evaluation of complex switching systems. The subject has attracted numerous authors at the previous ITC's and was well represented at this congress also. The session on simulation techniques included one invited paper and four other papers. It was evident from the papers presented in this session that rapid development of simulation techniques is continuing. Among other work, three novel approaches were reported: sub-call simulation, the use of interactive methods through VDU graphic display, and an SPC system simulator involving the exchange processor as well as a general purpose computer.

The invited paper presented a statistical analysis of the variability of simulation results, the number of lost calls, the mean waiting time, the proportion of delayed calls, and the mean queue length. Formulae were derived for the variance of these random variables, permitting the calculation of confidence limits for the results obtained. An interesting interactive simulation system (ICANDO) was described in another paper. The system was composed of several computer programs, associated data base, and an interactive graphic display. It has been developed as a tool for the planning and design of data communications networks. The next two papers described computer simulators for the investigation of SPC switching systems. One was concerned with a time-saving technique of sub-call simulation of the control system, while the other described a real time environment simulator which incorporates also the SPC system processors and actual switching control software. The environment traffic simulator (ENTRASIM) permits a realistic evaluation of the complete exchange or any part of it. Finally, an Australian paper described analytical and computer simulation studies of a store and forward message switching system.

Data Traffic Networks (Session 52)

The five papers in this session encompassed a range of topics related to the analysis and operation of data-traffic networks. The particular aspects covered were:

- Hierarchical design procedures to be used for large data-communications networks, and the effect of hierarchical routing on network through-put and delay.
- Development of a queueing model for a data-switching centre within a store-and-forward switching network, and the application of the model to the iterative analysis of whole networks.
- Two alternative methods for improving the traffic-handling capability of data channels carrying data streams having different bit-rates — re-arrangement of low-speed data to accommodate high-speed data, and dynamic sub-channel allocation with regard to their time-slot position.
- Measurement and analysis of data traffic associated with display and teletypewriter terminals in a general-purpose time-sharing computer system.

SPC Switching Systems (Session 61 and 62)

A total of seven papers, which covered analytical and simulation methods for studying the performance of stored-program controlled (SPC) switching systems, were included in these sessions. The invited paper presented an overview of the broad range of traffic studies in the field of SPC systems, including the manner in which processor capacity is defined. The author drew attention to four typical traffic problems, viz the steady-state capacity problem, the transient-overload capacity problem, the optimum queueing-strategy problem and the queue-dimensioning problem. Some of these problems were inherent in previous types of common-control switching systems, but their nature has changed appreciably with the introduction of SPC systems.

The various aspects of SPC systems discussed were:

- Dimensioning of multiprocessing systems using several analytical and simulation approaches.
- Traffic performance of common control in single-processor systems using hybrid simulation, full-scale simulation and analytical techniques.
- Waiting-time distributions for peripheral devices in single-processor systems using analytical and simulation methods.
- Effect upon processor traffic of interdependence between various tasks performed by communications processors.
- Limitation upon useful processing power as a result of several processors in a large multi-processor system competing for access to the store modules.
- Scheduling strategies for communication processors.

ACKNOWLEDGEMENTS

Owing to the volume and complexity of the papers submitted to the Congress, this article could not have been written without the assistance of traffic engineering experts in Telecom Headquarters. The author therefore gratefully acknowledges the general assistance given by J. Rubas in the production of the article and the contributions by A. V. Helm, W. D. Eccleston and R. J. Harris who prepared substantial parts of the technical summaries.

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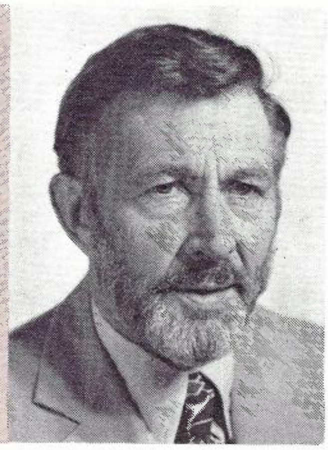
2. Australian Telecommunications Research (Special 8th ITC Edition) Vol. 11 Number 1, 1977.

Fig. 3 — Mr. A. D. Somervaille, Chairman, Australian Telecommunications Commission, Hands Back the Official ITC Flag to Professor Jensen, Chairman, International Advisory Council at the Final Banquet.

P. S. BETHELL joined the Postmaster-General's Department in 1940 as a Clerk and after 3½ years of war service he became a cadet engineer in 1945, completing his training in 1949. He was appointed an Engineer in the Telegraph Maintenance Division in Victoria and after two years joined the Telegraph Section, Headquarters, where he remained until 1962.

Following three years in the London Office as Liaison Engineer he joined the Fundamental Planning Section in Central Office which has now become Planning Services Branch. As Superintending Engineer of this Branch, he is responsible for the Traffic Engineering Section whose members were heavily involved in the organisation of the technical programme and facilities for the Teletraffic Congress. Mr Bethell was a member of the National Organising Committee for the Congress.



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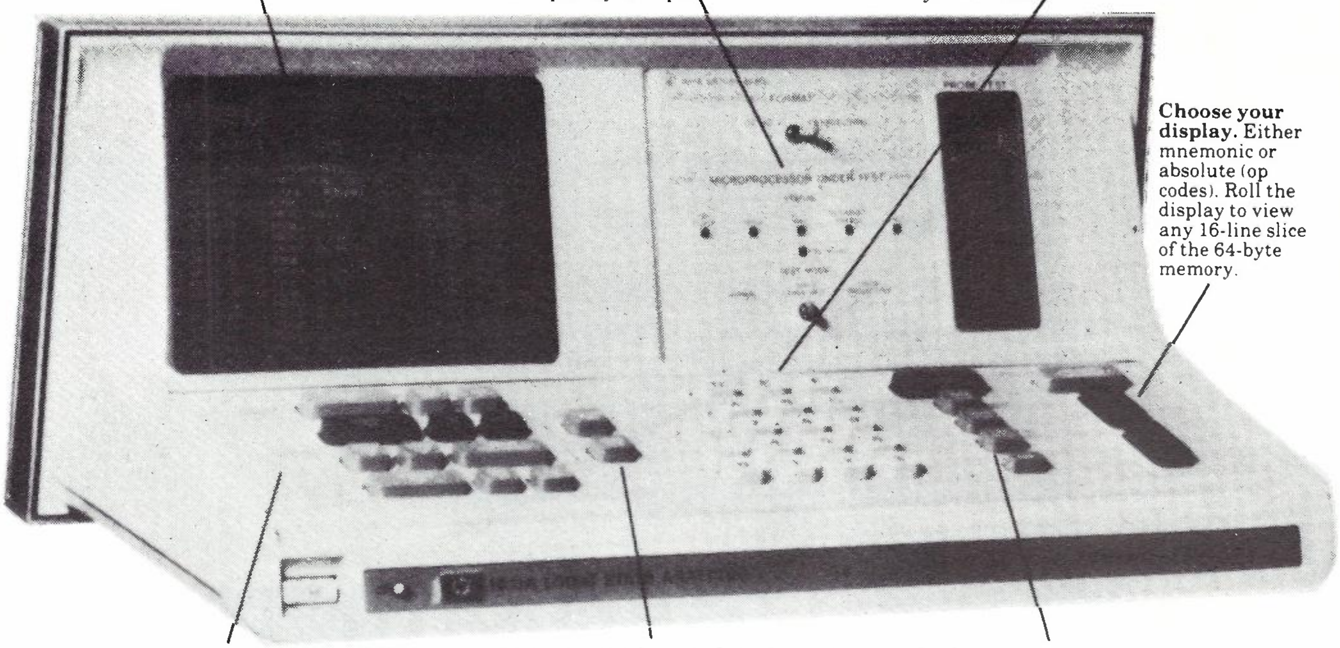

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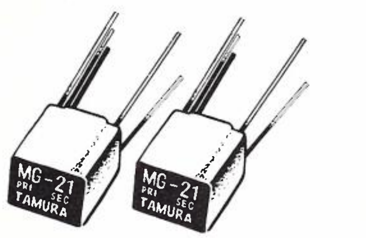

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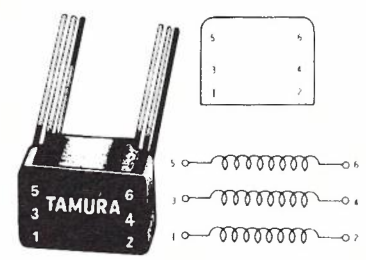

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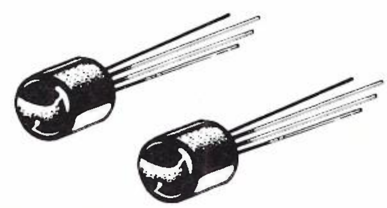

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The Telecommunications Journal of Australia

ABSTRACTS: Vol. 27, No. 2

ALLISON, K. W. and WESSON, R. H.: 'Waymouth 10C Stored Program Controlled Exchange'; Telecomm. Journal of Aust., Vol. 27, No. 2, 1977, page 103.

The Waymouth Exchange fulfilled a strategic role in the introduction of the 10C system to the Australian Trunk network as the 'test bed' for the manual assistance facility. The earlier installations at Pitt in Sydney and Lonsdale in Melbourne were cutover late in 1974 and 1975 respectively, switching initially only STD and later ISD traffic. This article deals briefly with the testing, commissioning and early operational performance of the Waymouth Exchange with particular reference to the concepts used in testing the manual assistance facilities.

BETHELL, P. S.: 'The Eighth International Teletraffic Congress'; Telecomm. Journal of Aust., Vol. 27, No. 2, 1977, page 173.

The 8th International Teletraffic Congress which was held in Melbourne in November 1976 was sponsored by the Australian Telecommunications Commission in association with the Australian Telecommunications Development Association. It was attended by 235 delegates including 146 from overseas countries and 135 papers were presented. This article briefly outlines the background and history of the Teletraffic Congresses since the first was held in 1955. It also gives some account of the topics covered by the technical programme and summarises some of the more important aspects which were brought to notice in the papers presented.

CLEARY, B. J. and LANGE, V. W.: 'Trans Sumatra Microwave System—Part 2'; Telecomm. Journal of Aust., Vol. 27, No. 2, 1977, page 144.

Part 1 of this article in the previous issue of the Journal described the basic planning and design aspects of the system. This second part briefly describes the project management, installation, commissioning and operation of the system.

CODY, T. S.: 'An Investigation into Cable "Make" on Wooden Drums'; Telecomm. Journal of Aust., Vol. 27, No. 2, 1977, page 140.

When wooden cable drums are rotated at any significant speed and accompanied by moderate to severe vibration, a phenomenon known as cable 'make' occurs. This is a condition where the inner end of a cable creeps out from the barrel of a drum. The amount of make is dependent on a number of factors and can vary from one or two metres up to 20 or 30 metres and is a cause of field down-time. This article describes investigations undertaken by the South Australian Administration of Telecom Australia for overcoming this problem.

DEMPSEY, R. J.: 'A Television Transmission System for Single Quad Carrier Cable'; Telecomm. Journal of Aust., Vol. 27, No. 2, 1977, page 164.

A baseband colour television transmission system is described, which is intended to utilise 1.27mm conductor single quad carrier cable as a bearer. The use of this system is seen in providing short, high quality video links where it is more economic or convenient to use the single quad cable rather than standard co-axial cable (2.6/9.5mm). The use of a single quad bearer allows the transmission of two television signals in the one cable, either in the same or opposite directions. The transmission limit of this system for duplex mode is 1.0 km, determined by near-end crosstalk at the colour subcarrier and the transmission limit for the double simplex mode of operation is 1.8 km, determined by the effect of random noise in the chrominance channel.

DOUGALL, C. J.: 'Elsternwick ARE 11 Exchange'; Telecomm. Journal of Aust., Vol. 27, No. 2, 1977, page 110.

On 20 June 1976 the first public ARE 11 exchange to be placed into service in Australia was cutover at Elsternwick, Victoria. This paper describes the installation of Elsternwick exchange which was a new start installation of ARE 11 with ANA 30 control of all ARF switching stages.

LAWSON, I. C., STEVENS, A. J. and HARRIS, R. W.: 'Apparatus for Mobile Measurements and Recording of Electric Field Strength at VHF and UHF'; Telecomm. Journal of Aust., Vol. 27, No. 2, 1977, page 153.

This apparatus has been developed to make measurements of the spatial distribution of radio field strength at VHF and UHF as received in a moving motor vehicle. Sampled measurements are made at small intervals along the road (as small as 5cm). These measurements, together with other information to facilitate analysis, are recorded on a digital magnetic tape recorder. This record is later analysed by computer to obtain the required information. The capacity of the sampling and recording system provides for eight data inputs. Currently the apparatus is fitted for measurements of two field strength points and the audio noise level from an FM demodulator.

McKINNON, R. K., ENDERSBEE, B. A. and BOUCHER, J. M.: 'Data Communication, Basic Facts and Facilities Available—Part 2'; Telecomm. Journal of Aust., Vol. 27, No. 2, 1977, page 120.

This is the concluding part of the article of which the first part appeared in Vol. 27, No. 1. The previous part dealt mainly with the problems of the transmission part, and included a glossary of terms. In this part the data facilities offered by Telecom Australia are described.

TOLMIE, R. P. and ELLIS, D. J.: 'Brisbane-Birdsville High Frequency Telephone System'; Telecomm. Journal of Aust., Vol. 27, No. 2, 1977, page 128.

This paper describes the design and installation of the high frequency SSB single-channel radio trunk telephone system which connected Brisbane to the remote town of Birdsville in August 1976. New concepts, facilities and equipment designs are introduced and the total system design maximises performance, reliability and cost-effectiveness.

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