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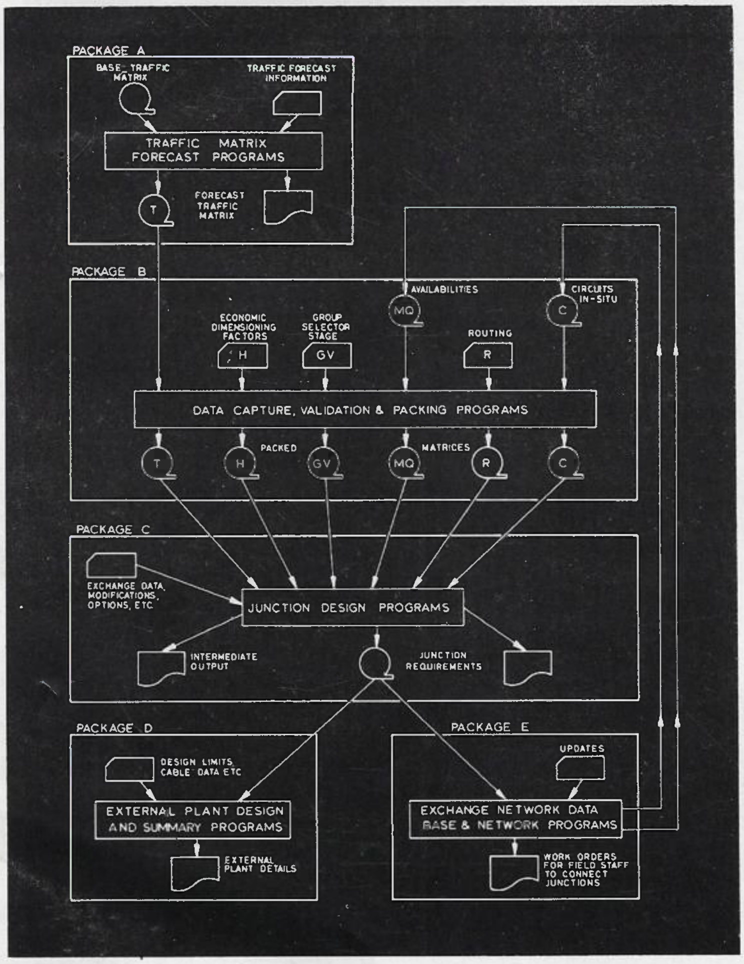

IN THIS ISSUE

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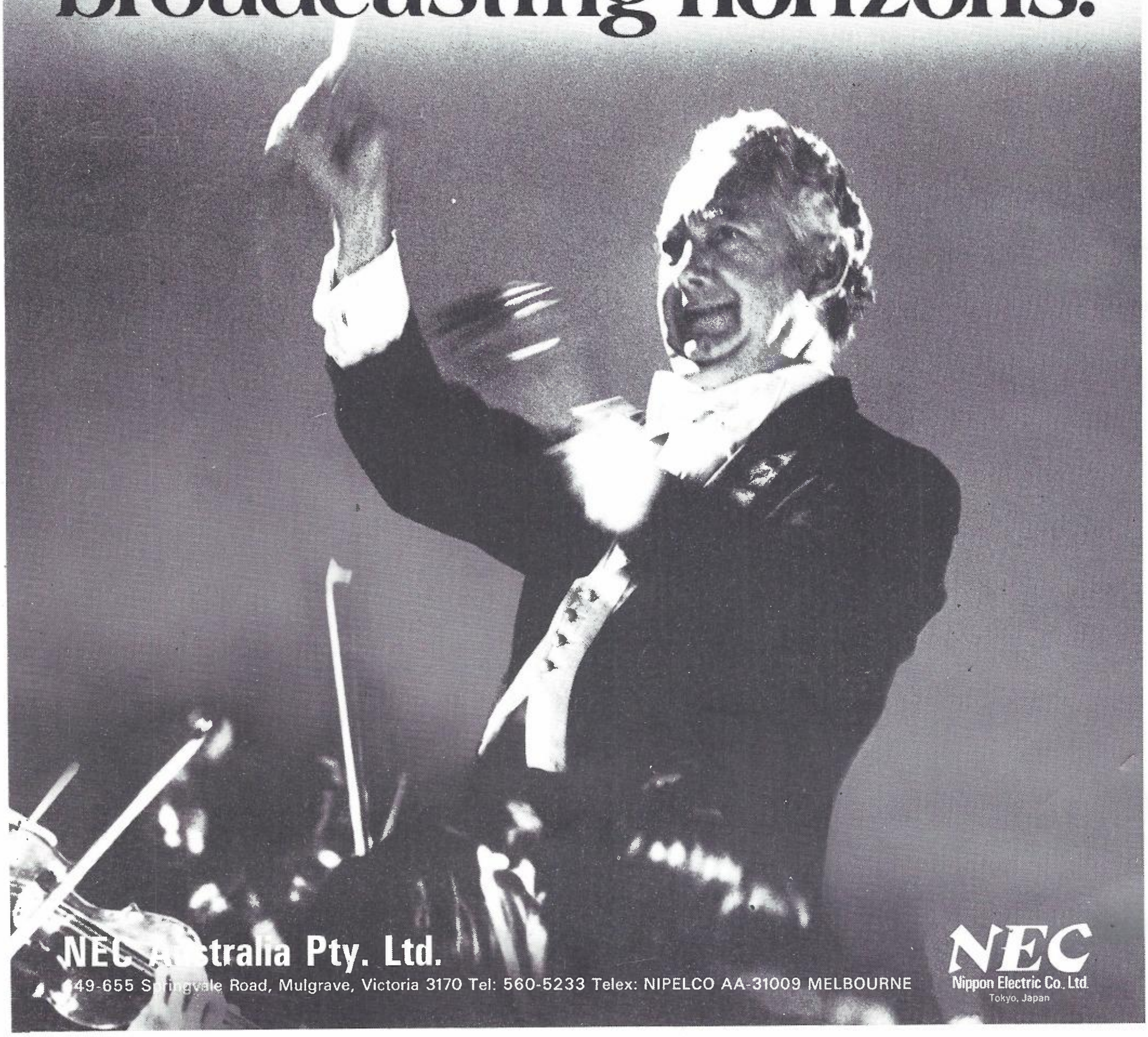

THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

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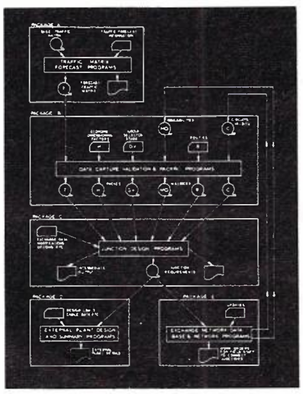

COVER

COMPUTERISED TELEPHONE NETWORK DESIGN

The Telecommunication Journal of Australia

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A Computer System for Designing Telephone Networks

J.P. FARR, B.E. (Hons.), B.Ec, M.A.Sc, C. Eng, M.I.E.E.E.

The paper describes a set of five software packages which assist in the process of dimensioning the junction routes which interconnect the network of telephone exchanges which serve the Perth (WA) metropolitan area. The system is used for medium and long-term planning as well as for the basic application of detailed short-term network design. The packages perform the following functions:

- *produce a forecast in matrix form of future point-to-point traffics for the complete metropolitan network;*
- *data capture, validation and packing;*
- *dimension the circuit requirements to handle the forecast traffics at a satisfactory grade of service, and in the most economical way;*
- *external plant planning and specification;*
- *produce detailed work orders specifying the changes to be made to junction route sizes.*

EDITORIAL NOTE: This is a revised version of a paper presented at the Institution of Engineers, Australia, 1976 Conference on Computers in Engineering.

INTRODUCTION

Telephone networks are composed of terminal exchanges linked together either directly, or else indirectly via switching centres. The links which interconnect exchanges must be re-dimensioned about every two years because the traffic flowing from one exchange to another changes with time. The dimensioning process is both complicated and tedious as thousands of decisions and calculations have to be made.

Up to the mid 1960's network designs were performed manually by Engineers utilizing design graphs and simple hand calculators, and the design of the Perth network took about 2-3 months. With the advent of computers, engineers in Australia and overseas were able to produce computer programs which simplify the complicated operation to such an extent that the Design Engineer is relieved of all the calculating load and the great majority of the decision making, thus permitting him to concentrate on the longer term considerations in network design. (See Refs. 1, 2 and 3).

This paper describes a group of five software packages which have been used by Telecom Australia for some years to assist in the process of redimensioning the Perth metropolitan telephone network to meet changing traffic needs. For ease of reference the packages are referred to in this paper as A, B, C, D and E.

The first package (A) makes a forecast of all traffic flows in the network for a future date.

The second package (B) assembles input data to be used by the main design package. The data is made up into matrices with all data packed to minimise the space required in the computer's central memory.

The main package (C) computes the circuit requirements and traffic actually carried on all routes and allocates any overflow traffic to the next choice route in the switching hierarchy. The processing is done in a strictly logical order so that no parcel of traffic is overlooked.

A fourth package (D) uses the output data from the main package to plan the optimum choice of junction cables to be used to achieve the junction connections between exchanges.

Finally (E), the output from the main package is fed into a data base which is then used to produce work orders from which field staff can

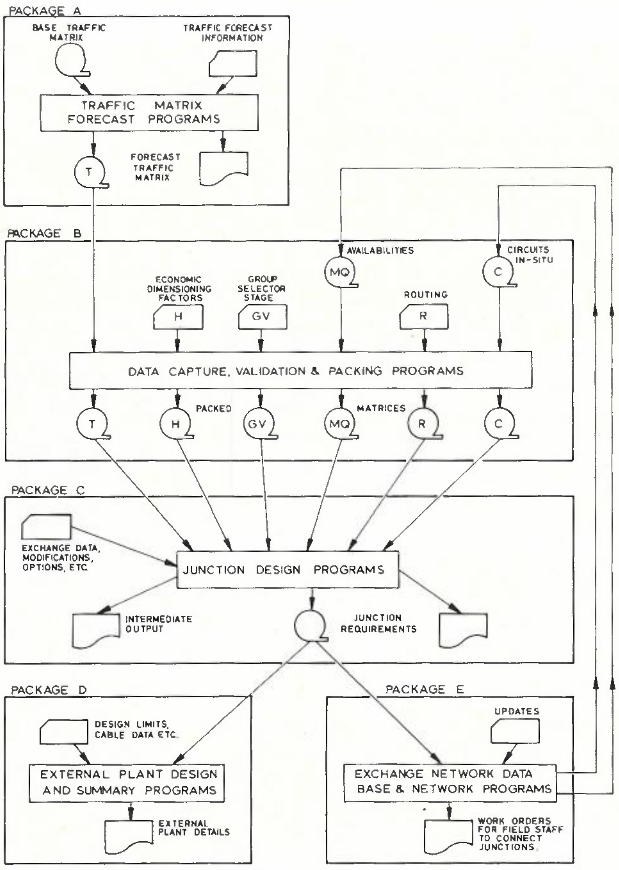

Fig. 1 — Computerised Network Design System.

carry out the required additions and changes to the network.

The overall system is depicted in the information and processing flow diagram, **Fig. 1.**

SOFTWARE PACKAGE A

The first package is used to produce a forecast for a future point in time of all point-to-point offered traffics in the network. This would be a mammoth task to do manually. The Perth telephone network, for example, includes about 65 exchanges which can originate or terminate traffic and the traffic matrix therefore comprises $65^2 = 4225$ elements.

The forecast matrix is arrived at by a procedure in which one starts with a base matrix for some past dates and each row and column is modified in a succession of iterations until the external constraints on row and column totals are satisfied. As this takes about 6 iterations, a minimum of $6 \times 4225 = 25\ 350$ calculations must be performed. This is a trivial task on a computer and the main forecasting program takes about 25 seconds of CPU time on a CDC Cyber 73 computer at a cost of $3.

The method of doing the forecast is as follows:

a. Start with a matrix of point-to-point offered traffics for the existing network — this is called the base dispersion matrix. The matrix is based on extensive traffic measurements and its accuracy is crucial to the end result.

b. Sum the traffics in each row and column to get the total originated and terminated traffic, respectively, for each exchange at the base date.

c. Compute estimates of the total originating (and terminating) traffic for each exchange at the forecast date from the product of the forecast number of telephone subscribers and the forecast average calling rate (terminating rate) per subscriber.

d. Compute the estimated total originating and total terminating traffic for the whole network by summing the originating and terminating traffics, respectively, for all exchanges.

   The two totals will not agree due to the arbitrary nature of the forecasts of calling and terminating rates which were used in Step (c).
   Since in fact the terminating traffic in a well engineered network should be only marginally less than the originating traffic, the program slightly adjusts the estimates for each exchange so that for the network as a whole the total originating traffic equals the total terminating traffic.

e. Using an iterative procedure, the rows and columns of the base matrix are multiplied successively by scaling factors until eventually the individual row and column totals of the new matrix agree, as closely as desired, with the forecast originating and terminating traffics respectively; this takes about 6 iterations. The procedure just described is called the Kruithof Balancing Method (Refs. 3, 4).

Although the Kruithof Method is purely a mathematical manipulation of numbers it produces an acceptable result for short term (and some medium term) telephone traffic forecasts. The method must be modified by introducing further constraints when a long term forecast is required, as otherwise some of the elements tend to become too large and others as a consequence end up being too small (Refs. 2, 3 and 5).

When the forecast produced by the program is acceptable to the user the output is written onto a magnetic disc file for input to Software Package B.

SOFTWARE PACKAGE B

This package performs data capture, validation and packing of the six matrices which form the major part of the input to Package C.

In each of the sets of raw data the items are of different format — one matrix is composed of elements which are single digits, another contains positive and negative three-digit numbers and another is comprised of decimal numbers of the form XXX.XX. These differences are overcome in the input subroutine by preceding each set of data with a card which specifies the format of the data to be used on input cards and the format to be used for output reports.

About 25 000 items of data are input via Package B and the program checks each item to see that it falls within pre-specified upper and lower bounds; offending data is flagged for attention.

Having passed the validation tests the data is packed in the most compact manner possible prior to storage on magnetic disc. This is necessary since the main program in Package C has eight matrices each designed to handle a network of up to 100 origins and 120 destinations. Without packing, 96 000 words of central memory would be required for data storage alone to retain the undoubted benefits of storing all data as matrices in central memory; this would be beyond the scope of commonly available computers.

The packing procedure used is as follows:

a. If the set of raw data contains negative numbers add a positive number (= X) sufficiently large so that even the largest negative number is now positive.

b. If the raw data contains decimal numbers multiply the number (= Y) which is a power of 10 so that the numbers become integers (e.g. XXX.XX $\times$ 10^2 = XXXXX.

c. Now that the set of data is composed entirely of positive integers, and knowing the largest number in the set, compute how many bits (= NB) will be needed to store the largest number from the relation —
   Largest data item $\leqslant 2^{NB}-1$
   e.g. if the maximum data size is 13, NB = 4.

d. Knowing the number of bits per word in the computer's central memory (= NBW) compute how many data items (= ITW) will pack into one word from the relation —
   ITW = NBW/NB

e. Pack the data at the rate of ITW data items per computer word using the 'OR' and 'SHIFT' functions (which are available through FORTRAN on CDC computers).

f. Record the values of X, Y, NB and ITW as they are needed for unpacking.

g. The matrix is stored in the packed form as a magnetic disc file.

The unpacking process reverses Step e using 'AND' and 'SHIFT' functions. The resulting set of data is divided by Y if the original data contained decimal numbers, and X is subtracted from each item if the original data contained negative numbers.

In this case the first benefit achieved by packing is a reduction in data storage requirement for Package C from 96 000 words to 14 000 words. Secondly, the fact that all the data for Package C can now be fitted into central memory simplifies data manipulation since temporary off line storage does not have to be used. Thirdly, programming is more straightforward. The program also executes more quickly on account of not having to continually read from, and write to, magnetic disc.

On the other hand, data has to be unpacked before it can be used and repacked before being put back into the matrix. As far as possible the programs in Package C do this for a whole row at a time rather than for individual elements, and it would appear that the packing/unpacking process does not appreciably increase the running time.

SOFTWARE PACKAGE C

The purpose of Package C is to compute the number of circuits required on all routes which link exchanges in the Perth metro and outer metro area to carry the expected point-to-point busy-hour traffics at a specified future date. Modern telephone exchanges have intelligence built into their switching equipment so that the exchange may attempt a number of routes in turn in order to switch a call towards the required destination exchange. This facility is called alternative routing. It eventuates that in order to handle traffic in the most economical manner one can make use of alternative routing by introducing a number of transit (also called tandem) exchanges to which no subscribers are directly connected, but which assist in passing traffic between terminal exchanges. A simplified network showing the application of alternative routing is shown in **Fig. 2.**

As is evident from **Fig. 2** the logical order in

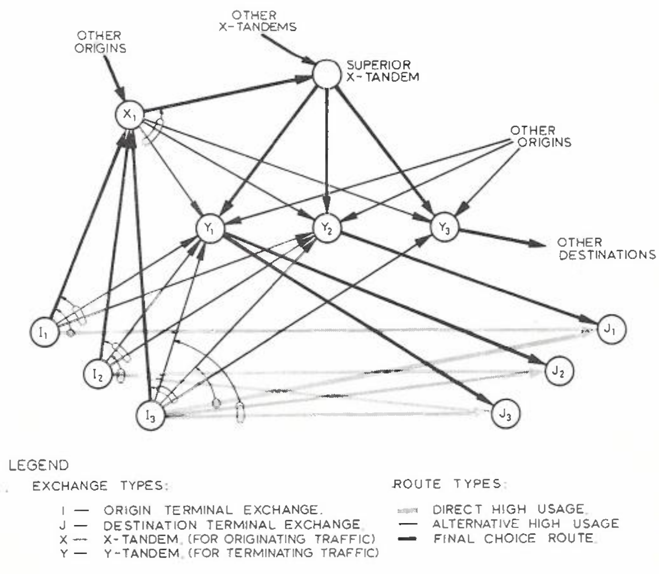

Fig. 2 — Traffic Flows in a Network with Alternative Routing.

which to dimension the exchanges is: Terminals — first; X-tandems — second; Superior X-tandems — third; Y-tandems — last. Within each category it is also apparent from the Figure that routes have to be processed in the order: Direct high usage routes — first; Alternative high usage routes — second; Final choice routes — last. By processing according to this hierarchy the program needs only one pass to handle each parcel of traffic at the proper time.

A matrix called the routing discipline is used to specify for each origin-destination pair how the traffic should be routed. This is organised in the matrix very compactly by the following method of coding:

> All origins are coded with a number in the range I to N, and all destinations with a number in the range I to M. For each origin-destination pair (I,J) the routing discipline shows one of the following values:
>
> CODE MEANING
>
> Blank No traffic is possible from I to J.
>
> K All traffic from I to J is to be switched via the tandem whose destination code is K.
>
> -K A direct high usage route is permitted between I and J and the overflow traffic is to be switched via the tandem K.
>
> 999 I and J are linked by a final choice route which is to be provided at the standard grade of service.

Another matrix contains (for those origin-destination pairs between which routes will be permitted) a specification of the economic dimensioning factors (also called marginal occupancies) for high usage routes, and the grades of service for final choice routes — these being the parameters which largely determine the number of circuits required to handle a given amount of traffic.

The traffic tables for dimensioning circuit requirements are built into individual subroutines in the form of equations.

Route sizes are initially calculated to the nearest circuit, but may, at the option of the user, be rounded by the program to the nearest preferred size (e.g. 5, 10, 15, 20, . . . etc.). High usage routes are rounded up or down with the breakpoint controlled by the user, final choice routes can only be rounded up. Details of this method, which is called "modular engineering of junctions groups" can be found in Ref. 6.

In order to detect errors and omissions in data input the program prints diagnostic messages when data appear to be missing, or are inconsistent with other data or the capabilities of the program and its dimensioning subroutines.

The program maintains running totals of traffic into and out of each exchange and prints this information after all processing has been completed; ideally there should be an exact traffic balance for each exchange, but small unbalances do occur in practice due to the cumulative effect of rounding errors.

At the user's discretion the program will print out intermediate values of key items of data at various stages of the processing of an exchange.

The final printout comprises detailed information for each route (e.g. circuits in situ, circuits required, traffic carried, overflow route, if applicable, etc.). The information about each route is given under both the originating and terminating exchanges for the route.

At the option of the user the program will write all the "circuits required" data to a magnetic disc file for subsequent input to software packages D and E.

The programs in this package are written in FORTRAN, comprise approximately 2000 lines of code, require 32K words of central memory, and take about 60 seconds of CPU time on a CDC Cyber 73 computer to process and print out all results for the Perth network, as a computing cost of less than $10.

The package is generally run a few times with the same basic set of data but making refinements each time to remove errors and if necessary to orient the results to meet external constraints. For example, the printout may indicate that a particular tandem exchange is to have a number of circuits coming into it which in fact exceeds the intended capacity of the equipment at that exchange; parameters in some of the input data could then be changed to send more traffic on routes lower or higher in the hierarchy, thus reducing the number of circuits coming into this tandem.

Since the computer is accessed from a remote batch terminal in the same premises as the users of this package, and a turnaround of less than two hours is usual, the user can run the program two or three times each day if necessary, and can thus produce an acceptable design for the complete network in the space of one week.

The manual system used up to 1967 on the much smaller network which existed then took about two months to complete a design for the overall network, and quite a few days extra if the design of any exchange had to be revised. One particular problem with the manual system was that since the design is done in terms of junctions outgoing from exchanges it took a great deal of extra effort to compile the lists of junctions incoming to each exchange; by contrast, since the computer program stores all data in the form of matrices, the lists of incoming circuits are very easily obtained from the columns of the appropriate matrix.

Package C is used to produce short, medium or long term designs for the network (e.g. 2, 5 and 15 years). The accuracy of the calculations performed in this package is not in doubt but the results are totally dependent on the input traffic data obtained from Package A. As the traffics are derived from estimates of the number of subscribers for each exchange, their average calling and terminating rates, and the dispersion of traffic from each exchange to every other exchange, there is considerable room for error in the longer term forecasts. However, packages A and C have been in use for several years and are known to produce acceptable designs for up to two years ahead which is the case where accuracy is most important.

SOFTWARE PACKAGE D

Whereas the previous package determined the number of junctions required on each inter-exchange route, Package D takes this information a step further and chooses which junction cables should be used for each route, what (minimum) gauge wire in each cable will satisfy the transmission loss and resistive loss limits, and what additional equipment (e.g. amplifiers and impulse repeaters), if any, will be necessary. The package also computes the costs (annual charges) of the internal and external plant components of each route in the network, and the costs (annual charges) for the total inter-exchange junction network.

The quantities of each gauge of wire to be used in each junction cable are summed, compared against the quantities available, and warning messages printed out when the occupancy exceeds a specified percentage. A warning message could lead to re-running the program after manual re-arrangement of choice of gauges or cable links for some junction routes, or set plans in motion for the provision of an additional cable.

For the Operations Districts the package permits the external network of junction cables (and associated plant) to be utilised in a planned and efficient manner, whilst meeting the technical requirements of transmission loss and resistance limits. For the Planning Sections the package permits alternative plans to be considered on the basis of technical and cost effectiveness.

Prior to the advent of the package, additional circuits on existing junction routes, and circuits for new routes, were added on a piecemeal basis and without ever going back to consider the optimisation of cable pair allocations for the network as a whole. In particular, whatever geographical route and gauge size was used for the first-in circuits on an inter-exchange junction route tended to be used for all subsequent additions to the group, even if (as often happened) a cable on a more suitable geographical route or with a more satisfactory gauge of wire had become available in the meantime.

The programs in this package are written in FORTRAN, comprise about 600 lines of code, take 32K words of memory (even with data packing), and require about 45 seconds of CPU time of a CDC Cyber 73 computer to process the complete Perth junction network at a cost of less than $7.

SOFTWARE PACKAGE E

This package produces detailed orders for the field staff to implement changes to circuit quantities in order to carry the traffics which were forecast by the first package in this series.

Unlike the previous packages which process a complete network at one run, and for this reason have large amounts of data input and output and are run from a remote batch terminal, Package E is used to process one route at a time and the access is via a medium speed teleprinter (120 characters per second) located in the office of the Installation Section responsible for implementing the changes.

The computer used is a DEC System 10 located at the same bureau as the Cyber 73 computer used for the other programs. Fortunately, magnetic tape files are interchangeable between these two computers (see **Fig. 1**).

Package E includes an on-line data base (designed for this application) which contains all the required information about the existing junction network and is updated from Package C with the forecast circuit requirements. The data base can be accessed with simple commands to print out details of any single route or all routes into or out of a particular exchange.

Apart from the inherent uses of the data base itself, another program in the package produces the work orders for field staff to implement changes to routes. In most cases the circuit quantities recommended by Package C will be used but the installation group can vary the quantities if it sees fit. The program derives the magnitude of the change in route size by subtracting the existing circuit quantity from the proposed quantity, and the cable pair code numbers, amplifiers, etc., are allocated according to the external plant specification obtained as output from Package D. Copies of the order covering the change are run off on the terminal printer for the different parties who will be involved in implementing the change. Finally, when the change is completed the data base is updated by overwriting the previous details of in-situ circuits with the new details.

The data base programs are written mainly in FORTRAN, but assembly language (MACRO) is used for inputting and analysing commands put in from the terminal, and for packing and unpacking (because the computer does not offer an intrinsic SHIFT function in FORTRAN), and for the disc random access routine. The use of MACRO to analyse data base input commands obviates the possibility that is ever present with FORTRAN that a typing error could cause the program to abort with consequent loss of all updating done up to that point of the run. With packing, all 19 items concerning each route have been fitted into four 36-bit words. The package comprises 18 FORTRAN programs, totalling 2500 lines of code and 12 MACRO programs, totalling 1500 lines of code. Running costs are low:

e.g. i. to modify the data base details about a route and then print all details about the route costs about 15 cents.

ii. to produce a detailed report on all junctions outgoing from an exchange costs about 40 cents.

FURTHER DEVELOPMENTS

Recently, the Planning Division at Telecom Australia Headquarters has been developing a computerised trunk and junction network planning system which will perform the functions embraced by the packages A, B, C and D of this paper. The system is being designed so that it will be suitable for use in all types of Australian networks; namely urban, rural and transit.

There are to be three packages:

- TRAFNET — this does network traffic forecasting.
- SWITCHNET — this dimensions switched traffic networks.
- TRANSNET — this dimensions transmission bearers.

These will be able to be used as an integrated planning system, or as independent programs. SWITCHNET is already operational, and is being used in the planning of several Australian networks. The development of the other packages is progressing.

CONCLUSIONS

Five software packages have been described which, although developed separately, form an efficient, integrated system for forecasting, designing and implementing changes to a large and complicated telecommunications network to keep pace with the ever changing traffics.

The packages have enabled engineers to hand over the day-to-day responsibility for this work to technical officers. This has enabled the engineers to spend a much greater proportion of their time investigating broader issues and other aspects of their work. Because the packages have been properly documented the systems described are able to survive changes in staff much more successfully than would be the case if manual procedures were still in force. Furthermore, the computer systems will be able to handle the growth in work volume which is a function of the growth of our telecommunications network without needing additional office staff. All in all, a very high benefit-to-cost ratio is being achieved by the use of this system. Simlar systems are used in other State administrations of Telecom Australia (Ref. 1), and overseas (Refs. 2, 3).

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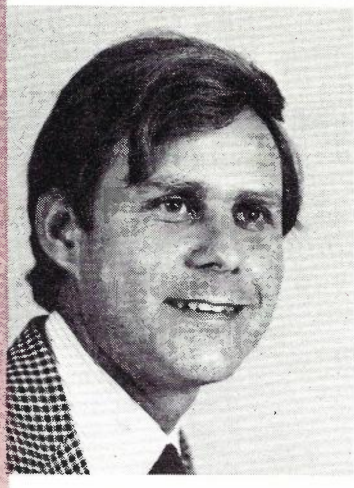
JOHN PETER FARR joined the Postmaster-General's Department as a cadet engineer in 1959, and graduated with Honours in Electrical Engineering in 1963. He then completed a Master of Applied Science degree at the University of British Columbia with a thesis on the use of holograms for compressing the bandwidth required for the transmission of television signals. He also holds a degree in Economics.

In 1966 while working for the British Columbia Telephone Company he developed one of the first computer-based methods of optimising the location of tandems in metropolitan telephone networks employing alternative routing. Returning to Telecom Australia he spent some years in Planning and laid the foundation for computer utilisation in such fields as processing traffic measurements, forecasting network traffics and dimensioning junction circuit requirements. In the last few years he has worked in the fields of exchange installation, radio, and telegraphs and data; in the latter area he was the Project Manager for the installation of the Perth centre in the Common User Data Network. Currently he is Senior Engineer (Switching Standards), Regional Operations Branch, W.A. and has a special involvement in the introduction of ARE-11 stored program control exchanges in Australia.



Style 72A—New Generation Carrier Multiplex and Line Line Transmission Equipment—Part 2

J.T. COLLINSON, A.R.M.I.T., M.I.R.E.E. Aust., T. Klink, Dipl. Ing. and H.W. LUECKE, Ing. (Grad.) M.I.R.E.E. Aust

The first part of this article described the mechanics and the electrical features of channel modems, carrier system Z12 and through filters of Siemens new Style 72A generation of carrier and line transmission equipment. This part of the article continues this description for other orders of carrier multiplex sub-systems, carrier program and coaxial line systems.
The article concludes with a brief section describing quality assurance and automated in-factory testing and describes the approach taken by Siemens Industries Limited to fulfil the requirements of Telecom Australia for a complete family of analogue multiplex and line transmission equipment.

GROUP MODEM

Five CCITT basic groups B (60 to 108 kHz) are translated in the group modem. The lower side bands, produced after modulation by the group carriers 420, 468, 516, 564 and 612kHz, are used to form the basic supergroup band 312 to 552 kHz (60-channels).

The Style 72 group modem is characterised by a new modulation filter arrangement. With this a reduction in filter costs has been achieved and the number of different units reduced. In the conventional method each modulator is followed by a bandpass filter with the outputs of the filters connected via a common decoupling circuit. Each filter, therefore, has to suppress the unwanted sideband to the level required. With the new arrangement, the filters are cascaded via buffer amplifiers. **Fig. 17** shows the principle block diagram for the transmit direction. The stopband attenuation required to suppress the unwanted sidebands for modulators 1 to 4 is derived from several low pass filter sections. As the stopband attenuation of each filter is added to the next, each filter has to provide only the difference between the stopband attenuation required and the total attenuation of the previous filters (see **Fig. 18**). The filter in group 5, however, is not aided by other filters and therefore its characteristic is similar to the modulation filters used in previous equipment.

Group Modem Panel

Due to the cascade filter principle, all the main filtering required for one direction of transmission can now be located on one slide-in unit. All the modems are made identical, except the one which contains the pilot stop filters which is located in the circuit path of group 3 (stopband 104.08 kHz) to suppress any spurious products before injection of the supergroup pilot frequency of 411.92 kHz

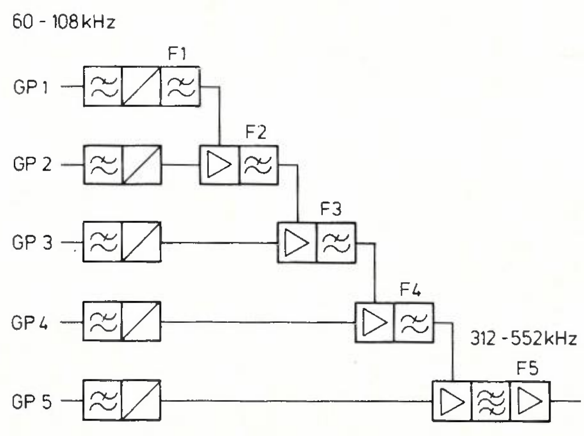


Fig. 17 — Block Diagram of Cascade Filter Principle.

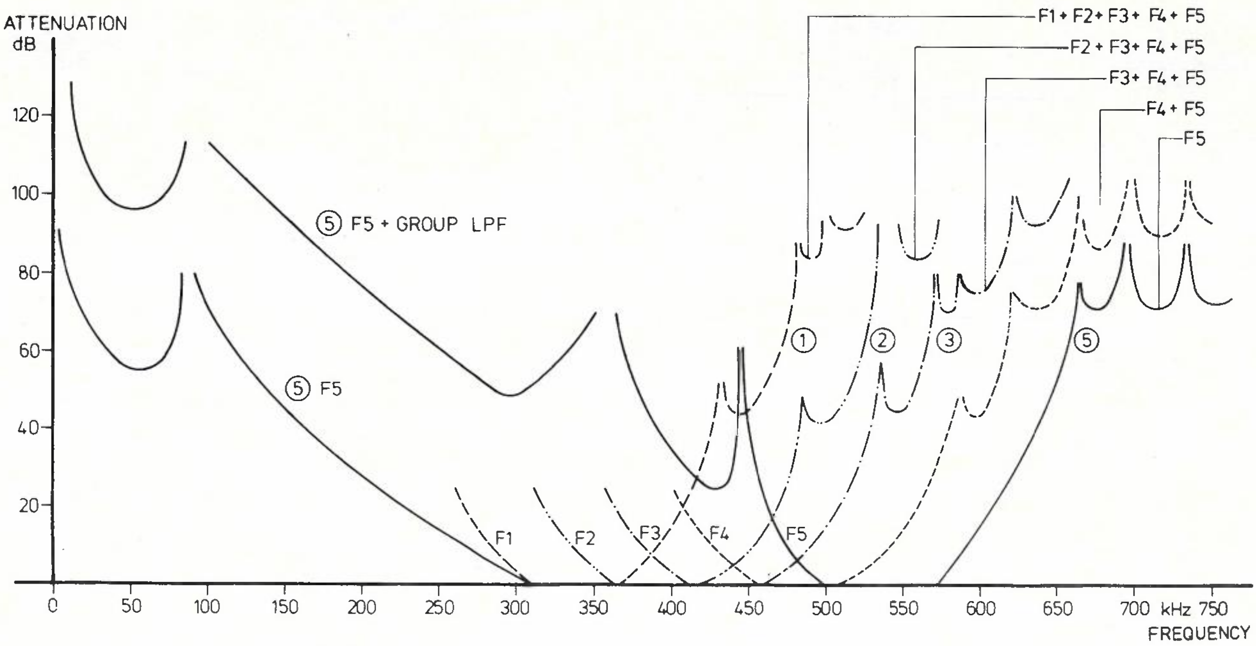


Fig. 18 — Frequency Response of Cascade Filter Arrangement.

via the transmit amplifier. Pilot stop filters at 64.08 kHz fitted to group 5 are employed, when the pilot frequency of 547.92 kHz is injected. This pilot is normally used for wideband data and satellite transmission. Each modem contains the modulators for the transmit and receive direction, as well as the continuous level adjustments and the decoupled monitoring points for both directions of transmission. The low pass filter in the transmit direction provides suppression of unwanted sidebands and tones above 108 kHz from lower order multiplex equipment. The supergroup transmit and receive amplifier slide-in units contain the cascade filter sections. These units also contain the standard level monitoring points and the supergroup pilot injection circuit. **Fig. 19** shows the schematic diagram of the group modem equipment.

Fig. 20 shows a panel for three supergroup ends together with a card extender used for maintenance measurements.

Carrier Supply Panel

All frequencies are derived from a 12 kHz station control frequency or an optional crystal stabilized master oscillator unit. A symmetrical square wave pulse is formed from this 12 kHz voltage to synchronize phase locked carrier oscillators, which are followed by power amplifiers. The pilots are derived from group carriers, by frequency division and modulation. All output voltages are continuously supervised. An alarm is activated if their level deviates out of the permissible limit or if a fault in the frequency synchronization occurs. The carrier supply is then electronically switched to the standby units (if provided). The outputs of the normal carrier supply amplifiers are connected in parallel with the corresponding outputs of the standby carrier supply.

An alternative panel, housing two supergroup ends and an unduplicated carrier supply, serves a small station where 120 channels only are required.

The nominal rack capacity is 30 basic supergroups or 10 group modem panels together with a carrier supply panel and associated power supply equipment.

SUPERGROUP MODEM

Line frequency bands of 60, 120, 300, 900, 960, 1800 and 2700 voice channels are commonly used in long haul networks. In the Telecom Australia network they are composed from standard basic groups of 60 and 900 voice channels. **Fig. 21** shows the frequency modulation plan for forming broad bands from the basic supergroup. All 16 supergroups make up the 960 channel band. The 2 to 16 supergroup band is the basic building block for 2700 channel systems.

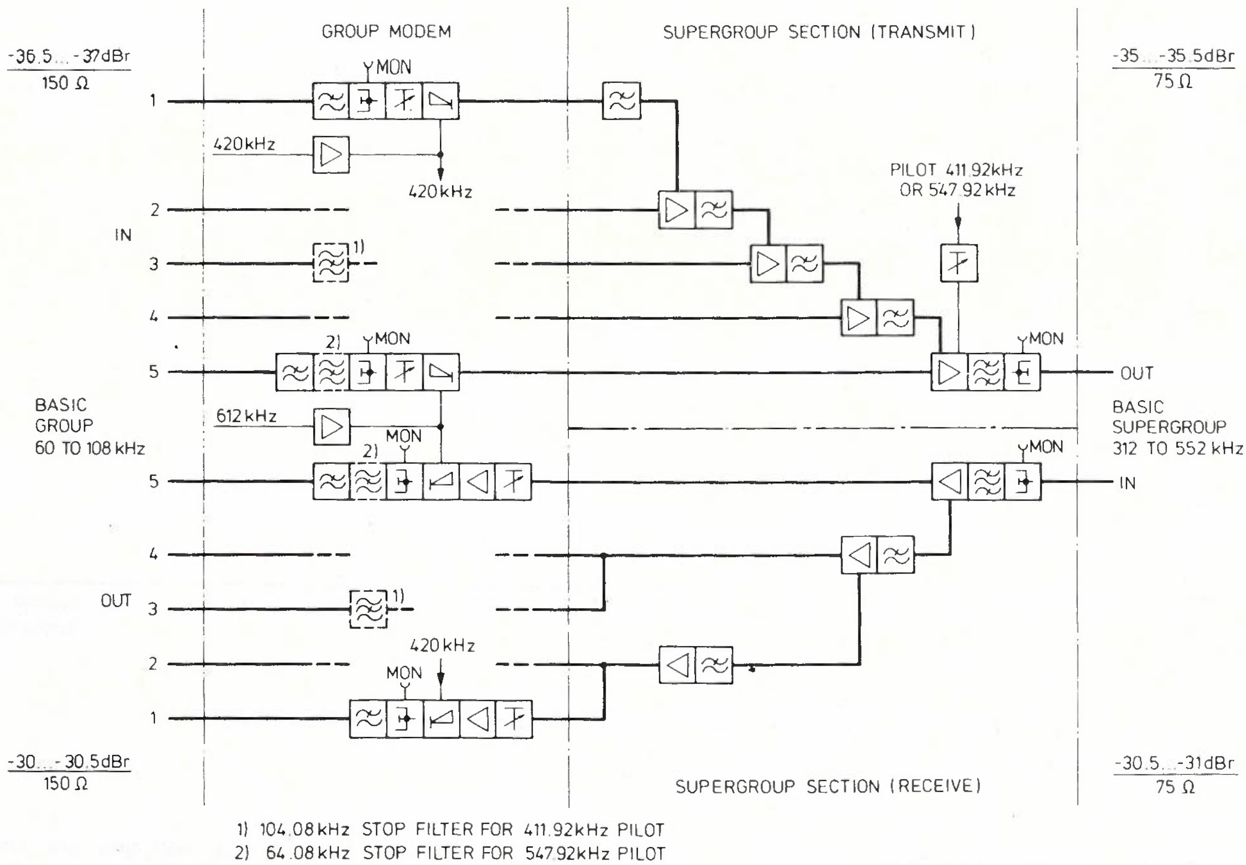


Fig. 19 — Schematic Diagram of the Group Modem Equipment.

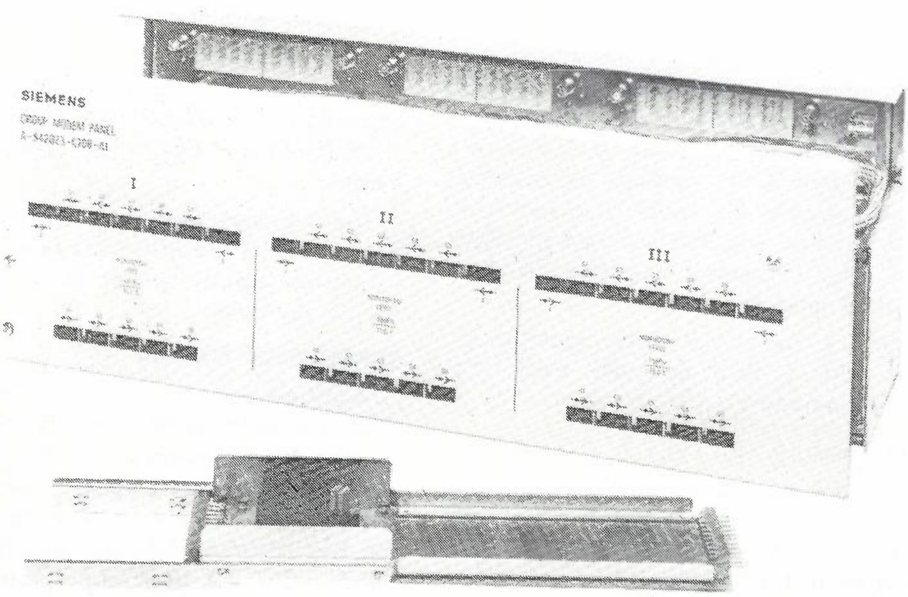


Fig. 20 — Group Modem Panel with Card Extender.

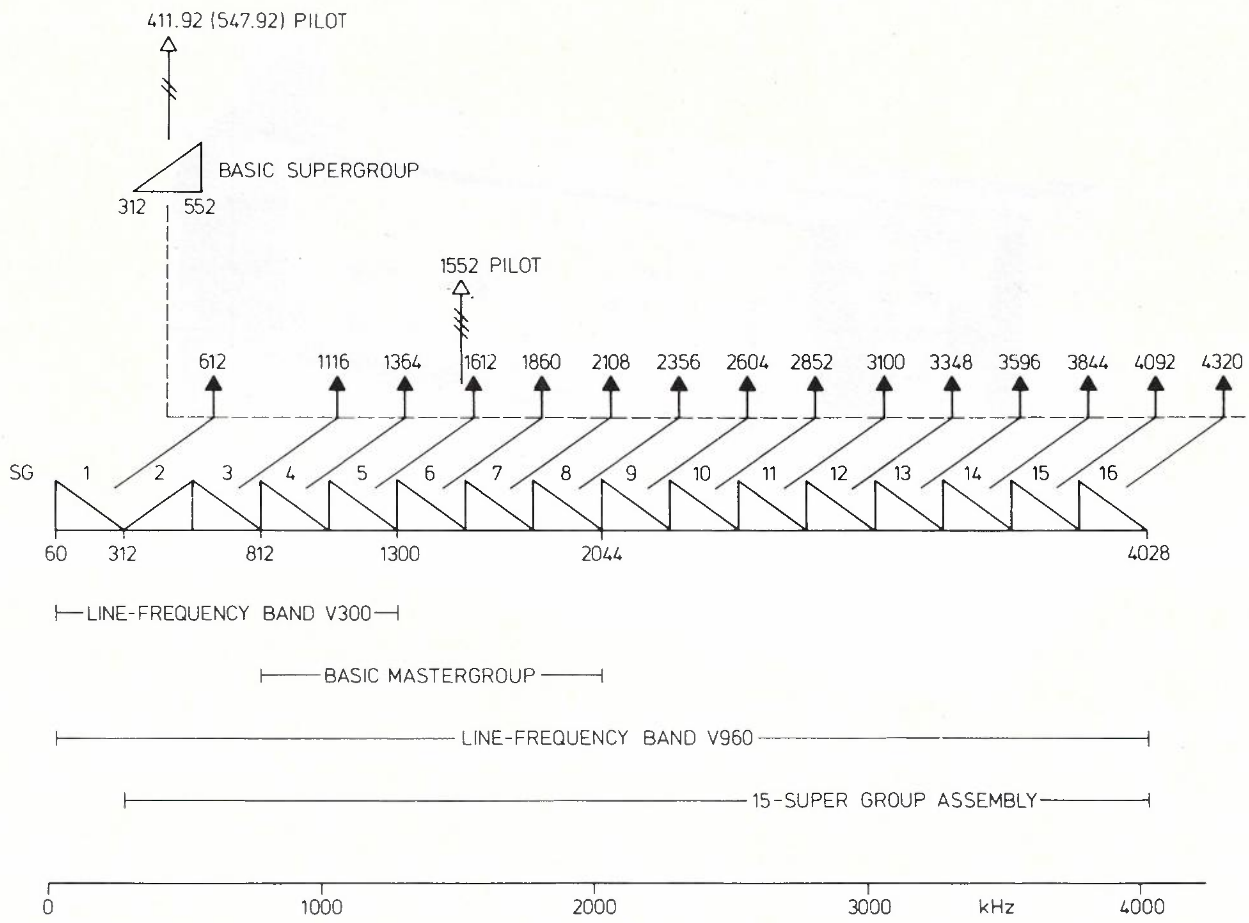


Fig. 21 — Frequency Modulation Plan for Supergroup Modem.

Panel

One supergroup modem panel accommodates, when fully equipped, the modems and supergroup pilot receivers for up to 8 supergroups (**Fig. 22**).

It also houses the transmit and receive amplifiers together with the line band pilot receiver. The V960 line frequency band is formed by interconnecting two supergroup modem panels.

Modems

The modems for supergroups 1 and 3 to 16 are each made up of three mechanically and electrically interconnected module units — the modulator, demodulator and the carrier supply. In the carrier supply unit the individual supergroup carrier required is derived from the 124 kHz control frequency fed from the supergroup carrier supply panel. Each carrier generator incorporates a frequency multiplier, followed by a carrier filter and amplifier. Because of this arrangement any position of the panel can be equipped with any supergroup modem. This is of advantage in stations with branching of supergroups from broadband systems. Supergroup 1 is an exception to this; the unit has a dedicated position in the panel and the 612 kHz carrier is supplied directly from the carrier supply panel. The matching unit for supergroup 2, transmitted without translation in the basic supergroup frequency band, is similar in design to the modem units, but does not contain modulators or a carrier unit.

The multi-supergroup transmit and receive amplifiers contain the decouplers for connecting the supergroups on the transmit side and splitting up the band on the receive side. One branch of these hybrids is used to combine two transmit and receive amplifiers housed in two panels to form base bands with more than 8 supergroups. The 1552 kHz line pilot frequency can be injected at the input of the transmit amplifier and in the receive direction

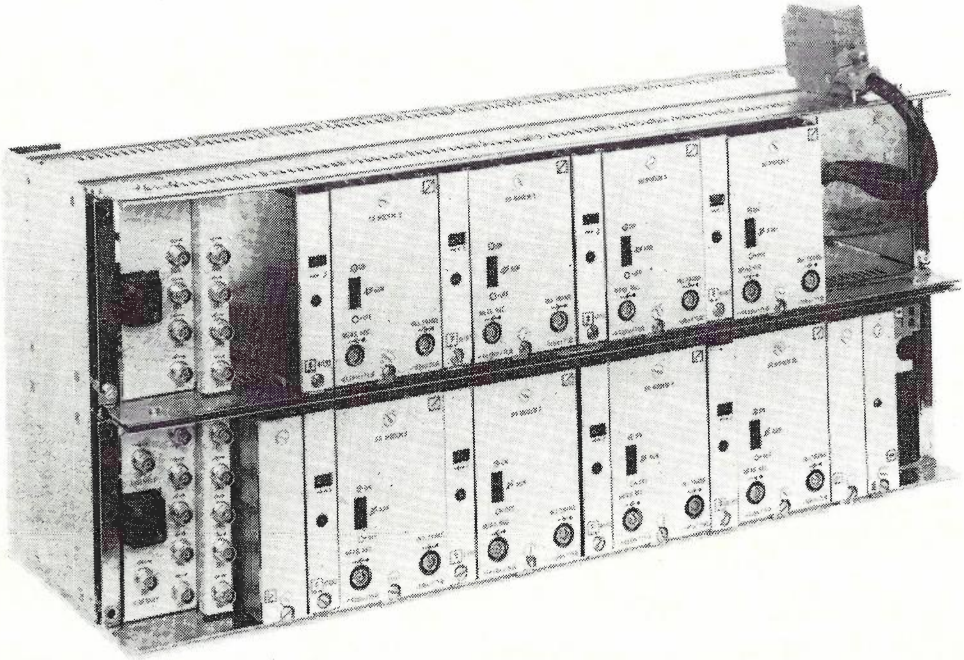


Fig. 22 — Supergroup Modem Panel for Eight Supergroup Modems with Pilot Receivers.

is extracted at the output of the receive amplifier and applied to the pilot receiver for evaluation and supervision.

Supergroup Pilot Receiver

Level regulation by the supergroup pilot 411.92 kHz (or 547.92 kHz) is provided in the receive path to correct level deviations of up to $\pm$ 4 db automatically. The supergroup pilot receiver incorporates a field effect transistor, which operates as the regulation control element and acts on the negative feedback path of the relevant demodulator. In the case of modem 2 the gain is varied as a function of the pilot level.

15-SUPERGROUP ASSEMBLY MODEM

The 15 supergroup assembly modem or supermastergroup modem equipment inset contains the facilities for translating and combining three basic 15-supergroup asemblies to form the 2700 channel line band and its demodulation in the receiving direction, as well as individual pilot receivers and pilot stop filters, if required. Up to four system insets can be housed in one subrack (see **Fig. 23**).

Modems

The frequency plan is composed according to CCITT plan 2. Two basic 15-supergroup assemblies (312 to 4028 kHz) are modulated with the carriers 8432 kHz and 12648 kHz. The lower sidebands produced are combined with one basic 15-supergroup assembly band to form the 2700 channel group in the frequency range 312 to 12336 kHz. The basic 15-supergroup assembly band corresponds to the supergroups 2 to 16 of the supergroup modem equipment.

Every modulator and demodulator slide-in unit pair has its own respective carrier generator. The generators receive the control frequency 2108 kHz from the fundamental/supergroup modem carrier supply panel via buffer amplifiers. These employ free running crystal oscillators locked to the applied control frequency.

The adaptor unit for the non-modulated 15-supergroup assembly is of similar design to the modem slide-in units. It contains, however, no modem and carrier generator section.

Fig. 24 shows the schematic diagram.

Fig. 23 — Subrack for Four 15-SG Assembly Modems equipped with Four System Insets.

Pilot Receivers

15-supergroup assembly band supervision or regulation is provided in the receive direction by individual pilot receivers. In case of a fault, the gain of the regulated amplifier is set to mid gain. The pilot receivers give an alarm in case of high or low level conditions.

Control Frequency Amplifier

The 2108 kHz control frequency buffer amplifiers are housed in a panel of 4 units height, which is normally mounted directly above the modem sub-rack.

Two amplifiers are provided to allow change-over of the unswitched normal station control frequency feed to the standby amplifier in case of a fault. The output power of the amplifiers is sufficient to feed up to five 15-super-group assembly modem systems.

FUNDAMENTAL CARRIER SUPPLY EQUIPMENT

A single master oscillator for an entire station is used from which the control frequencies are derived. These control frequencies are fed to the individual equipment carrier supplies, in which the required carriers and pilot frequencies

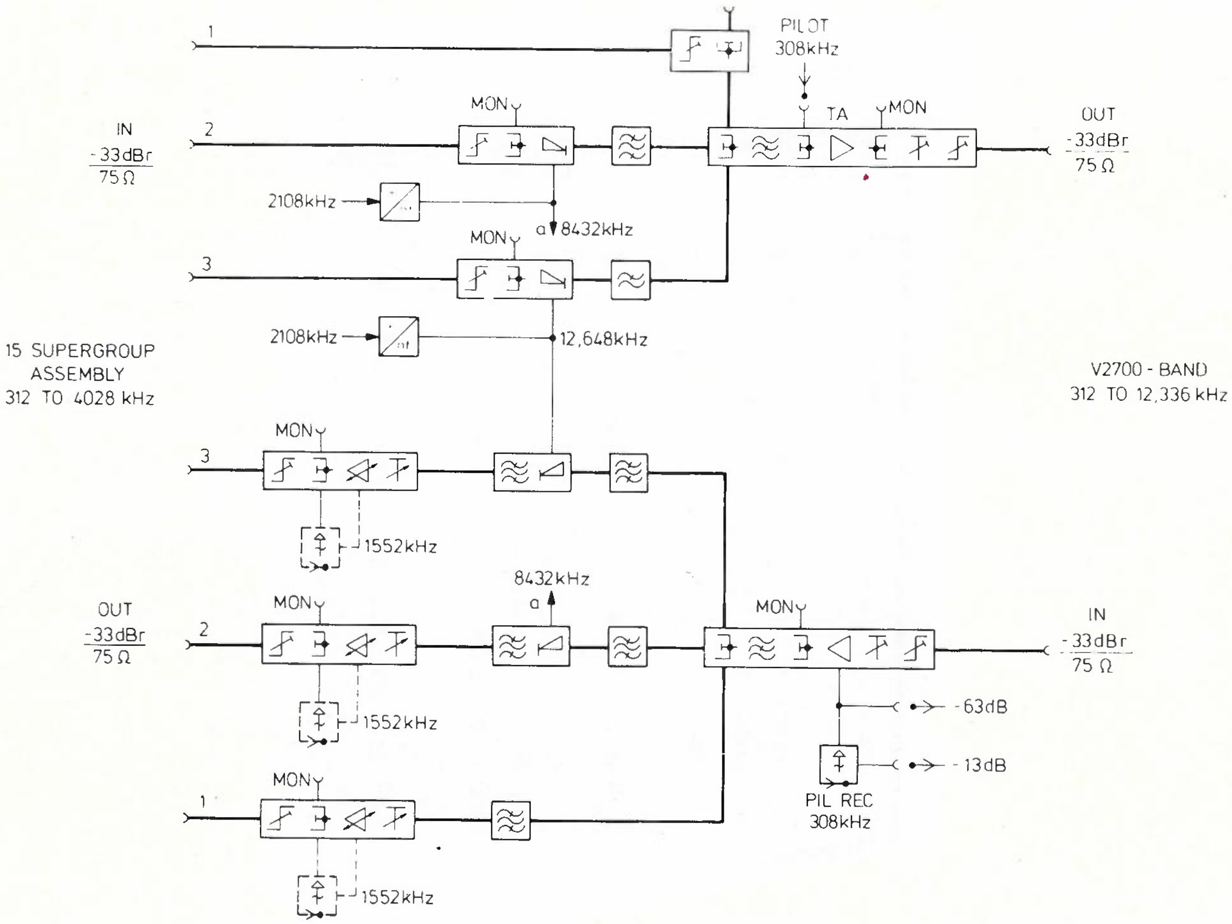


Fig. 24 — Schematic Diagram of 15-SG Assembly Modem.

are generated by frequency division and multiplication. All carriers and pilots have the frequency accuracy required for the highest modulation stage and for 12 MHz systems the frequency error must be $\Delta f/f \leq 5 \cdot 10^{-8}$. The feeding capacity of one fundamental frequency panel is limited to a block of 20,000 voice channels. In larger stations further fundamental carrier supply panels can be operated from the master panel.

Fundamental/SG Carrier Supply Panel

A fully equipped panel contains duplicated carrier supplies (with changeover switching unit) for the generation of the carrier, control and pilot frequencies for supergroup modems, facilities for control frequency distribution and alarm circuitry. (See **Fig. 25.**)

For supergroup carrier supply applications, the panel is driven by an external, duplicated 124 kHz control frequency and contains duplicated slide-in units for carrier (612 kHz), control (124 and 424 kHz) and pilot (1552 kHz) frequencies, that are required for supergroup modem equipment.

For fundamental carrier supply (master carrier supply) applications, the panel is equipped with master oscillators and corresponding control frequency slide-in units for 4, 12, 124 and 2108 kHz.

The left hand side section of the panel contains the connector for interconnection of an optional automatic frequency control (AFC) panel. All frequencies are derived from a crystal stabilized master oscillator by dividing and multiplying the resonant frequency of 1488 kHz.

The panel, which is of 6 units height (265 mm), contains at the top the alarm unit and station alarm distribution wire-wrap terminals.

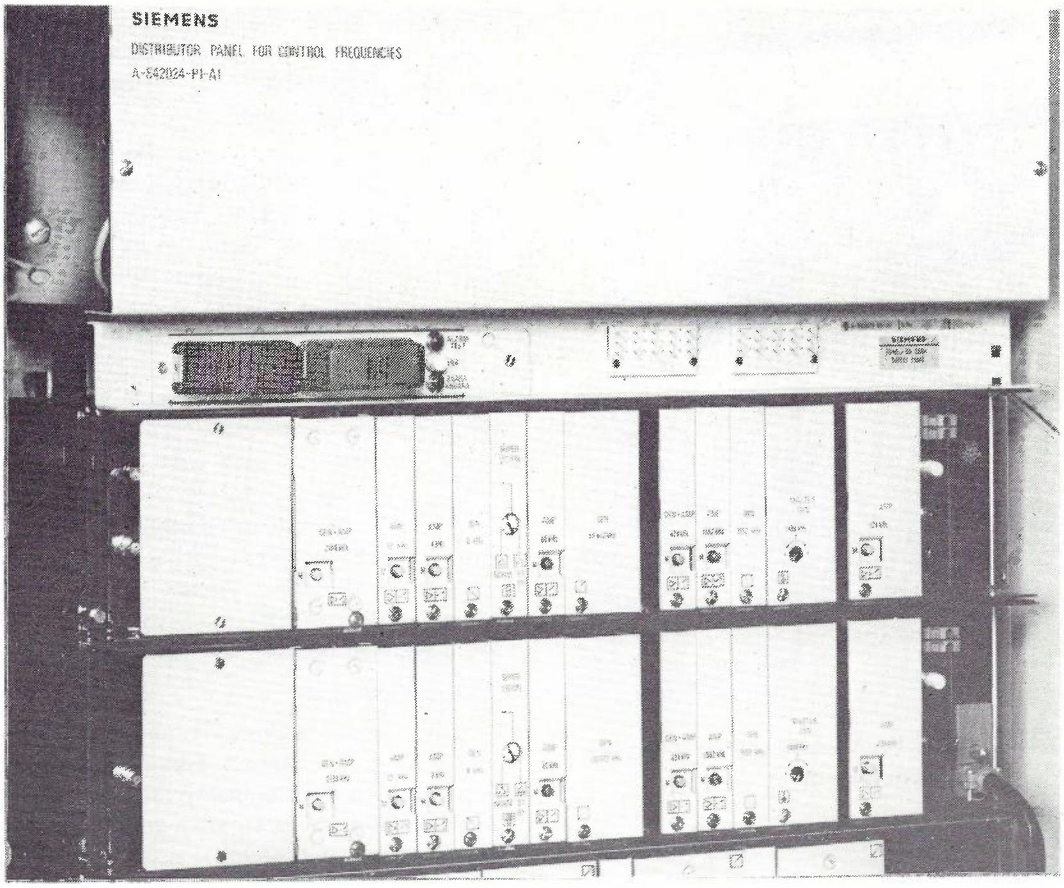


Fig. 25 — Fundamental Carrier Supply Panel with Distribution Panel.

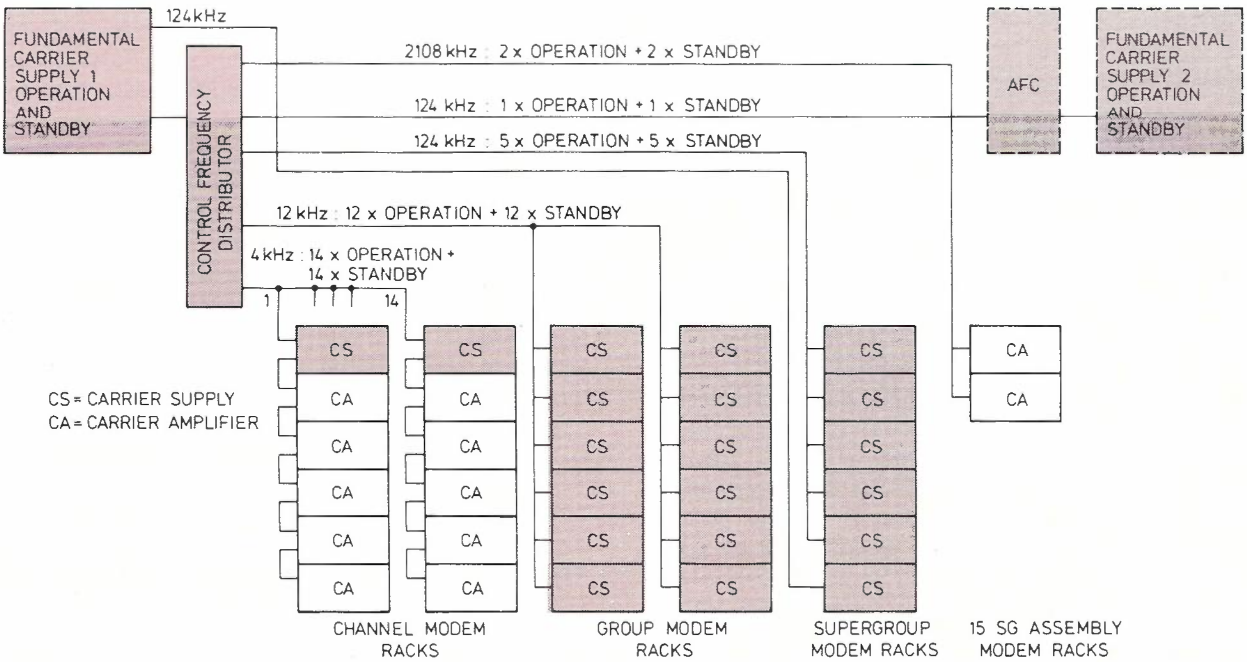


Fig. 26 — Control Frequency Distribution Arrangements for 20,000 VF Channels.

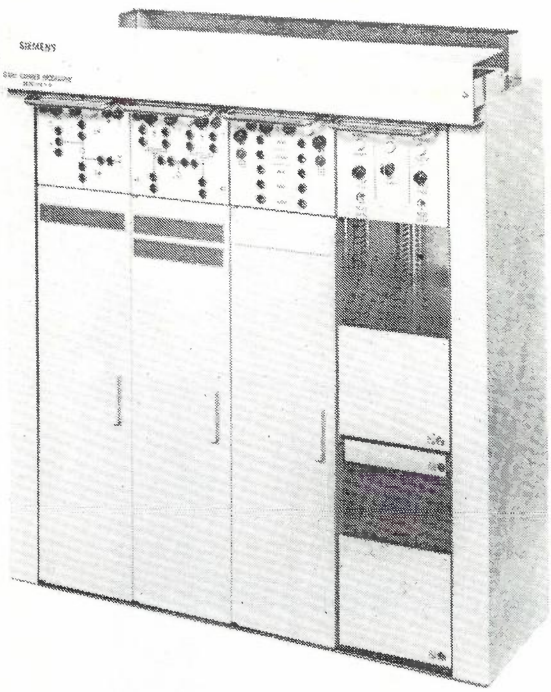


Fig. 27 — Subrack for 15 kHz Carrier Program Equipment.

Distributor Panel

This panel is used for distribution of control frequencies 4, 12, 124 and 2108 kHz.

Two rows of wire-wrap terminal blocks are fitted. Additionally provided (on the right hand side of the panel) are two coaxial sockets (1.6/5.6) for the duplicated output of the 2108 kHz frequency for 15 SG assembly modem equipment.

The duplicated control frequency arrangements for 20,000 VF channels available at the distributor can be seen in **Fig. 26.**

CARRIER SOUND PROGRAM EQUIPMENT

With the recent introduction into Australia of stereo FM radio transmission, the Siemens 15 kHz stereo (or mono) carrier sound program system is used as the subsystem relay bearer.

The equipment, which meets the CCITT Recommendations J21 and J31 for sound program transmission, provides two sound program channels with a bandwidth of 15 kHz for stereo operation, or alternatively, one mono sound channel plus six voice channels in the basic group band of 60 to 108 kHz.

Mechanical Layout

Regardless of whether the sound program channels are to be operated singly or as a stereo pair, a two-channel terminal station for the transmit and receive modes of operation requires two modulators, two demodulators, an IF converter, a power and carrier supply unit.

All these equipment units are constructed in the 'vertical inset style'. Each equipment inset incorporates a series of plug-in units, depending upon the mode of operation. These can be easily added and removed and may be supplemented by slide-in units for stereo operation or optional slide-in units for the second sound program channel when assigned to six voice channels. U-connectors on the supervisory panels of the equipment insets permit the checking of measurements at the audio and carrier frequency inputs and outputs.

The equipment insets are accompanied in a subrack which can accommodate up to four equipment insets. **Fig. 27** shows a subrack for 15 kHz carrier program equipment. Power, carriers and alarms are connected to each inset position and therefore the insets can be inserted into any subrack position.

System Operation

In the system a group is made up of two 15 kHz sound program channels. **Fig. 28** shows the modulation plan and the frequency range of the two sound channels and the alternative six telephone channels plus one sound channel.

In the modulator insets which are identical, a modulator translates the audio signal plus a pilot of 16.8 kHz to the IF band of 78.7 to 95.5 kHz. In the IF inset the two outgoing bands are modulated in two additional steps, resulting in the line bands of 65.2 and 82 kHz and 86 to 102.8 kHz including the two translated pilots. The demodulation process is the reverse of the modulation process but using separate but identical demodulator insets.

For stereo operation there must be absolute phase coincidence between the two channels, i.e. any frequency shift must be exactly the same in both channels. This is ensured by the two program channel pilots of 16.8 kHz which are introduced and extracted in the IF band. The frequency of each pilot is compared in an associated phase discriminator and differences in frequency or phase act upon the demodulation carrier frequency until a negligible phase error exists.

In addition to the frequency/phase control, the pilot facility supervises and regulates the level of the system. The basic block diagram is shown in **Fig. 29.**

Separate carrier and power supply insets provide duplicated supplies for added security. A service supervision unit is also installed in the latter inset for converting the alarms from the various insets

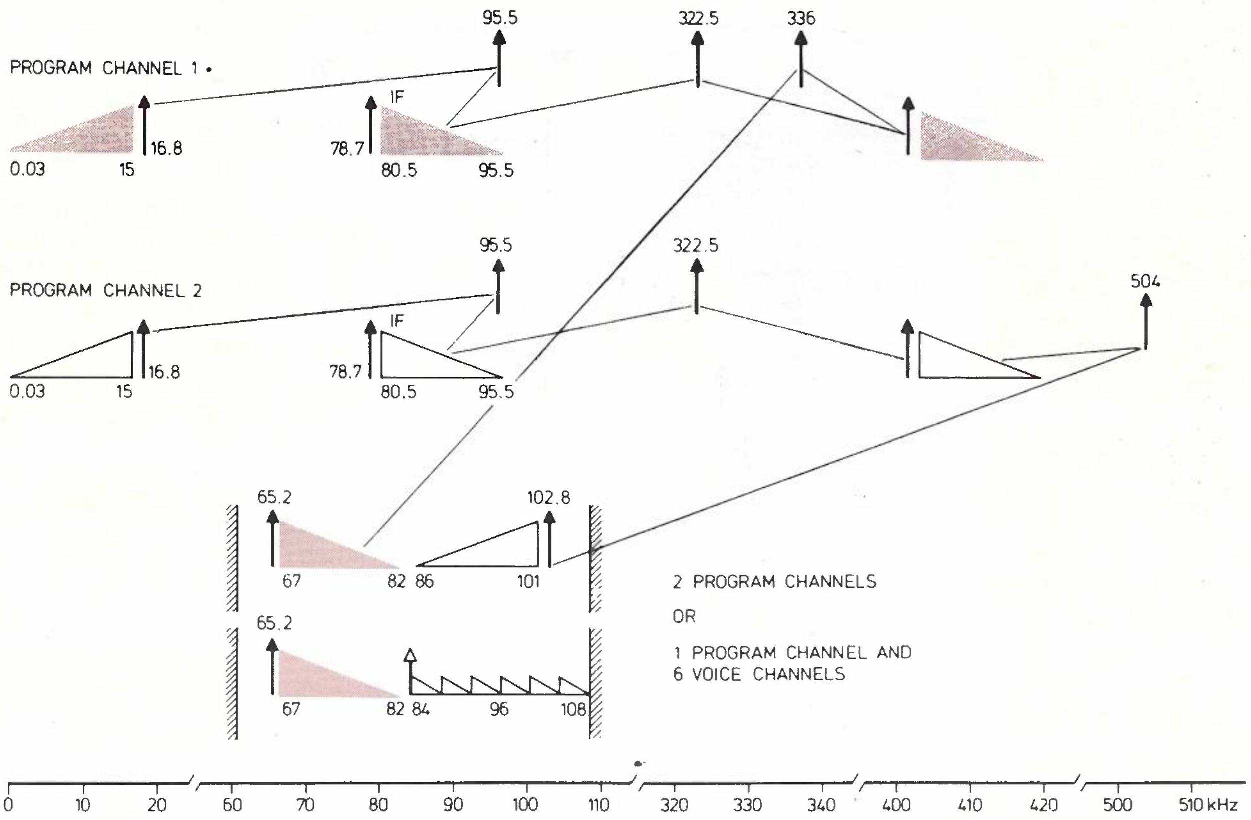


Fig. 28 — Frequency Modulation Plan for 15 kHz Carrier Program System.

and extending them in urgent and/or non-urgent states. The control panel of the inset contains the alarm lamp, keys, fuses and voltage measuring sockets.

COAXIAL LINE TRANSMISSION EQUIPMENT

Siemens 4, 6 and 12 MHz coaxial systems have been used in Australia since 1961, for classic long haul transmission as well as for coaxial tails which connect Radio and Carrier Terminals in the same city. Such links include the routes Melbourne-Morwell, Geelong-Warrnambool, Launceston-Smithton, Perth-Carvarvon-Port Hedland, Adelaide-Berri, Port Augusta-Cobar and many others. The latest family of Siemens coaxial line systems, both 4 and 12 MHz, using vertical insets at terminal stations, and temperature and/or pilot regulated repeaters in underground housings along the route, are at present in the process of being installed.

It is not the purpose of this article to describe their transmission characteristics or particular electrical features in detail. This has been done elsewhere (Refs. 6, 7, 10, 11, 12). Instead, a short description is given of our newly designed Style 72A coaxial terminal equipment, in which the "Design Guide" principals have been extended to the equipment units with the highest frequencies so far used in the Australian long haul line transmission network. Because the required quantities of such high channel capacity and consequently complex coaxial terminal stations are indeed very

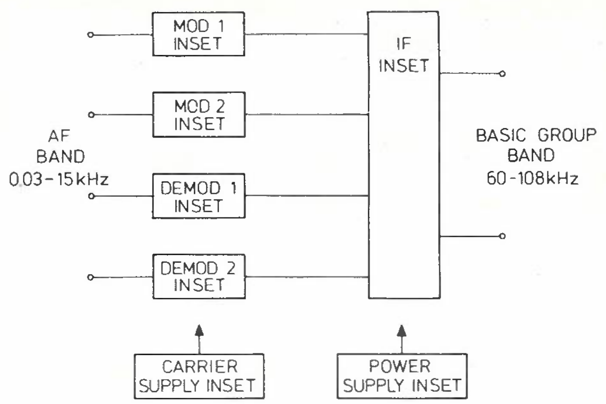


Fig. 29 — Block Diagram of 15 kHz Carrier Program System.

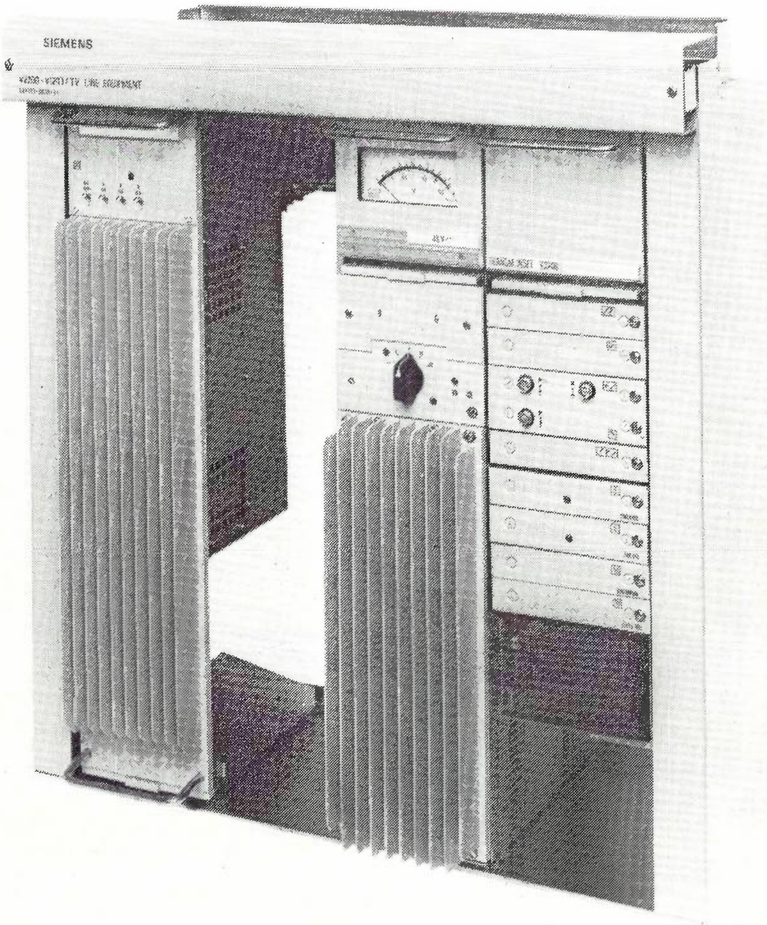


Fig. 30 — Coaxial System Subrack equipped with Terminal Insets.

small, one has to find an economic compromise with a new design. In order not to jeopardize high equipment performance, units of proven overseas design have been used unaltered where possible.

Fig. 30 shows a photograph of a special system subrack, similar to that used for 15 kHz carrier program equipment, which accepts the various vertical insets. Basically, such a concept can also be applied to higher frequency systems, in particular the 60 MHz transmission system (Ref. 8), if it should one day find a use in Australia.

Mechanical Design

Two basically different mounting arrangements are used for the coaxial line equipment.

The *Power Separating Filter Panel* mounts up to three filter units, one filter unit containing a separating filter pair, one filter for each direction of transmission (See **Fig. 31**). At the rear, the filter plugs into the two angle connectors terminating the semi-flexible cables from the U/G cable pothead. Similarly the transmission cables connect to the terminal equipment.

The same panel can be used to house a fault location attachment for providing d.c. fault location facilities in an intermediate repeater station through which a power feed circuit is connected. When the power feeding current is supplied from one end, the power feeding loop may be closed at the non-feeding terminal or intermediate repeater station by means of a short coaxial cord between the low pass sections of the power separating filters.

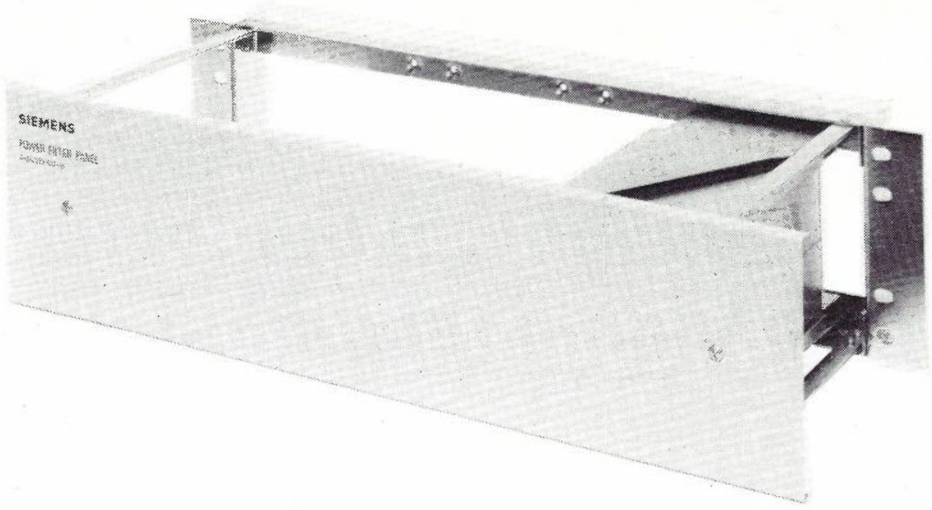


Fig. 31 — Power Separating Filter Panel.

The *System Subrack* mounts the system equipment insets. On the left side of the subrack frame an alarm unit for concentrating the equipment and system alarms can be fitted (one per terminal or intermediate main repeater). The alarm unit is the same as used for the channel modem and other equipment.

The subrack is wired for power and alarms and the inter-inset cables with connectors are selected according to the equipping option and relevant wiring diagram.

The *Equipment Insets* for the terminal equipment are in the vertical style 7R.

Equipment Layout

The equipping options of the system subracks are diverse. Because the inset connections have been rationalized, one subrack design caters for many options. The subrack inset positions are wired for power and alarms but inset positions 1 and 3 (L to R) are wired especially for the power supply insets and/or remote power feeding insets. **Fig. 32** is a sketch showing one of these options, i.e. a terminal with single remote power feeding insert mounted in a Type 72 equipment bay.

In addition to other options, the same subrack can be used to house branching insets and coaxial tail system insets. A similar subrack can be used for TV modem, FB40 supervisory and service channel equipment.

Fig. 33 shows the electrical function of equipment insets used for a 12 MHz, (V2700) coaxial line terminal.

RACK CAPACITIES

Table 1 shows the Telecom Type 72 rack capacities of some of Siemens new generation of Style 72A equipment compared to the rack capacities of the previous generation of equipment. One of the aims during the development of the new equipment has

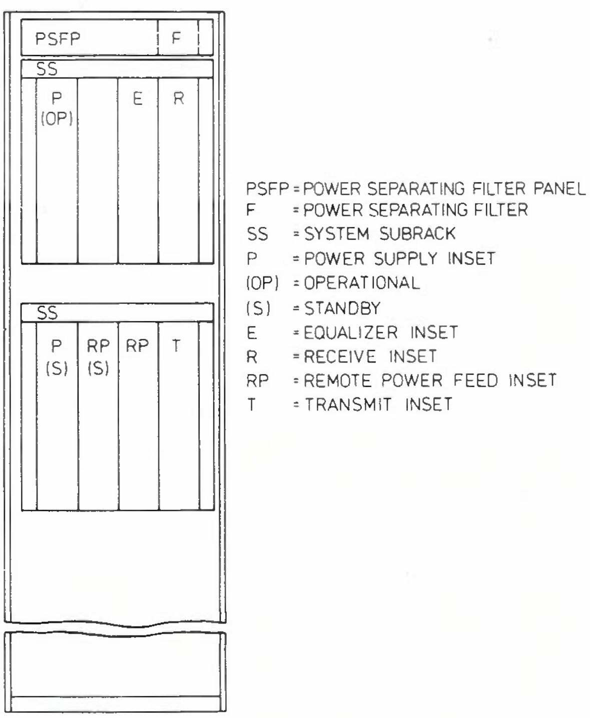


Fig. 32 — Type 72 Rack equipped with a Terminal using Single Remote Power Feeding.

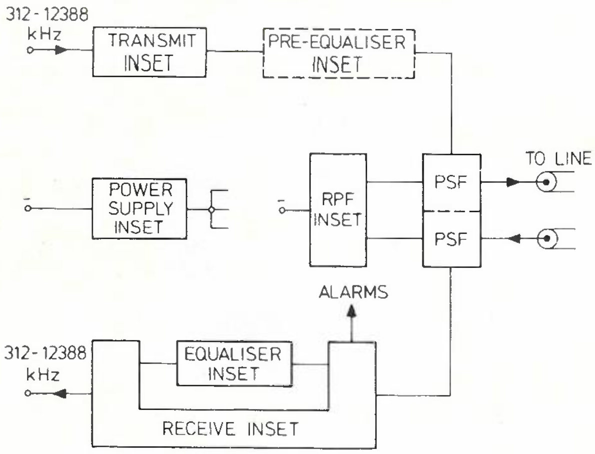


Fig. 33 — Electrical Function of Coaxial Terminal Insets.

been to increase the rack capacity and generally this has been achieved. Future generations of equipment may be limited in this regard due to the restrictions of station cable sizes and available cabling space.

QUALITY ASSURANCE

During the manufacture of the equipment described above, absolute care must be taken to ensure that the designed equipment parameters are maintained even when production quantities are varied and of diverse type.

A problem inherent in the manufacture of sophisticated equipment described in this article is to maintain the production and testing repeatability. In order to overcome this problem, extensive use is made of a number of automated processes. **Fig. 34** shows the assembly of a printed circuit board aided by an optical assembly table. This table utilizes a photographic display synchronised with a component delivery system. This system, used for all types of printed circuit boards, eliminates any assembly error. Use is also made of computer controlled automatic test systems, e.g. the Pegamat transmission test set-up, which can be programmed for the testing of all carrier equipment at high speed and with high repeatable accuracy. **Fig. 35** shows the final testing of channel modems using the Pegamat system. Other computer-controlled test systems are used for the testing of components and sub-assemblies, such as

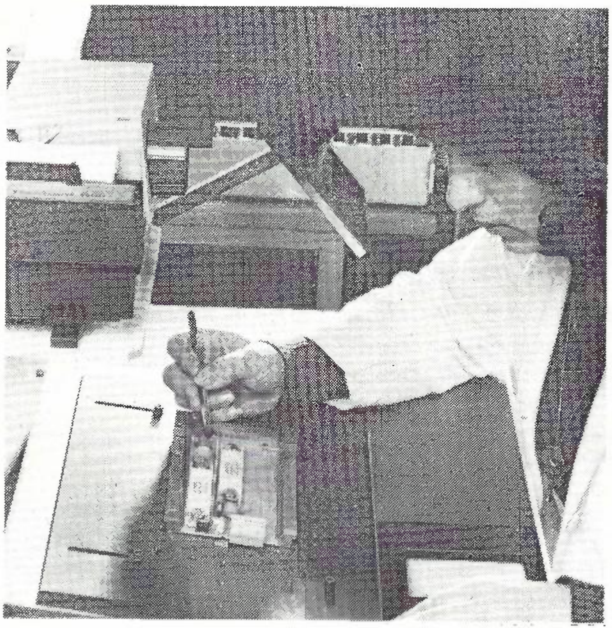


Fig. 34 — Assembly of Printed Circuit Boards using an Optical Assembly Table.

TABLE 1 — RACK CAPACITIES OF THE NEW GENERATION EQUIPMENT

Equipment	Unit	Capacity	
		Previous Generation	New Generation
Channel Modem	Channel Bank	10	40
Group Modem	Group Bank	20	30
Supergroup Modem	SGM	64	64
15-SG Assembly Modem	15-SGM	9	15
Coaxial Line	V2700 Terminal	2	3

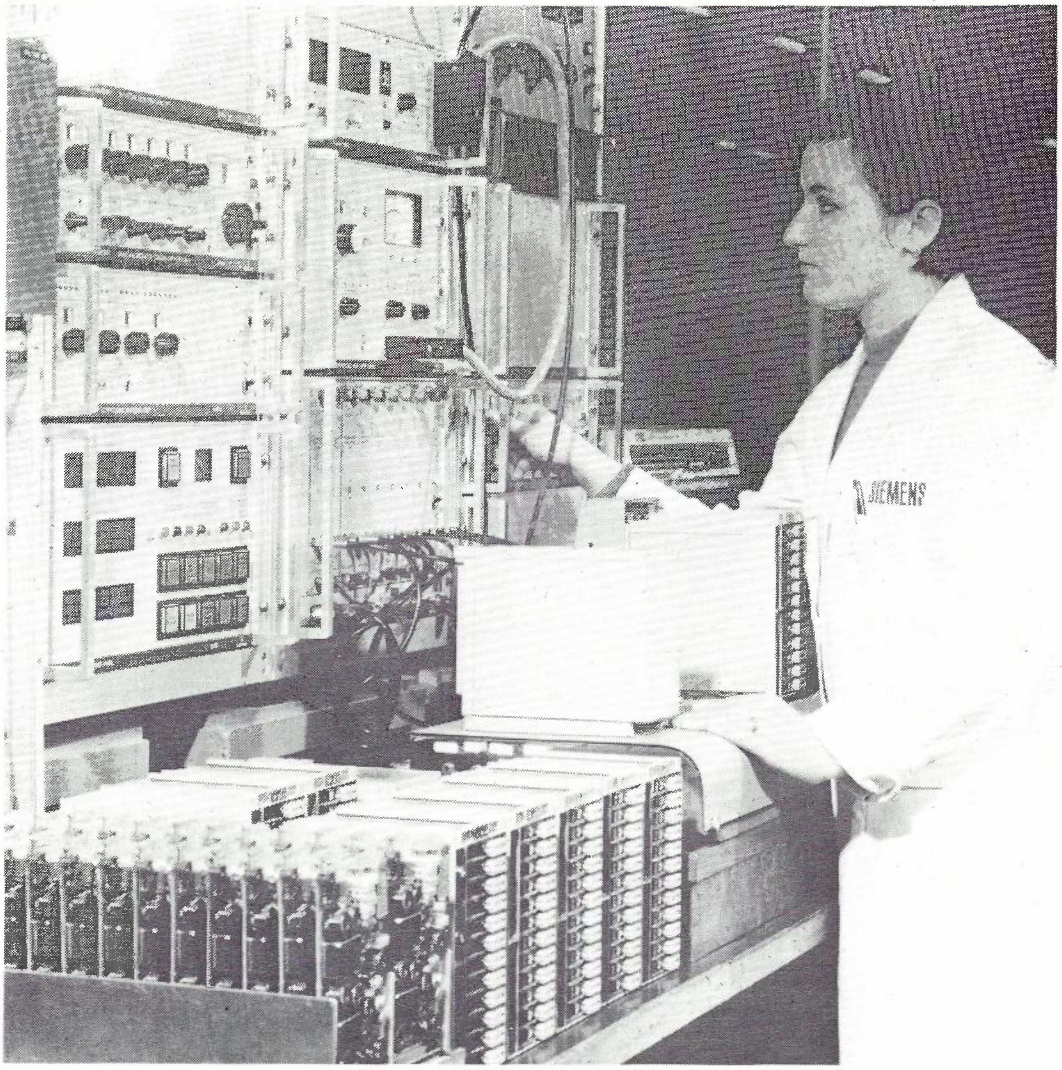


Fig. 35 — Final Testing of Channel Modem Equipment using a Computer Controlled Pegamat Automatic Transmission Test System.

thick-film circuits and power converters and the wiring harnesses of subracks, etc. All systems provide a printed output for fault analysis.

CONCLUSION

This paper has described the approach by Siemens Industries Limited to fulfil the requirements of the Telecom Australia "Design Guide" for a complete family of analogue multiplex and line equipment up to the 12 MHz transmission band.

The close co-operation between Telecom Australia and the Australian industry in general, and their common aim for economy and rationalisation, by selectively using new technologies and procedures and by introducing standards close to their application needs, has yielded excellent results so far. Not only has there been a strong development of local engineering resources and local manufacturing knowhow, but in the two decades up to 1975/76 when the number of circuit ends in the Australian network multiplied 17 fold, considerable cost savings by Telecom Australia have been achieved. In this period the procurement cost per circuit end has been reduced in spite of substantial inflation; the maintenance effort measured in annual man-hours per circuit end has fallen by a factor of 20; space requirements have fallen by a factor of 5 to 10 and power consumption per channel end has fallen by a factor of 20. All this has been achieved without any loss of quality and reliability;

on the contrary, the new components have given an overall equipment performance which is more stable than that of 20 years ago.

Finally, it may be said of the local industry that, besides its economic and national benefits, the Sfyle 72A equipment it is supplying today under the "Design Guide" is, in comparison with the present worldwide state of the art, of such an electrical design as to remain adequate until the early eighties, before significant design changes can be expected.

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Metaconta 10C SPC Exchanges — An Operating Approach

J.D. SMYTH, B.E. (Elec.), M.I.E. Aust., M.I.R.E.E., M.I.E.E.E.

A new technology means a change in demands on the staff who are required to operate and supervise the equipment which uses it. New capabilities may also mean new problems. The introduction of Stored Program Controlled (SPC) switching with the Metaconta 10C Trunk exchange brought such changes; an operations viewpoint is given of the work involved in introducing this type of exchange to the Australian network.

BACKGROUND

From the 1969 decision to introduce Stored Program Controlled (SPC) switching to the Australian telecommunications network by placing a contract for a single large trunk exchange, there ensued a gradual recognition of the consequent impact on exchange operation and a challenge to gain operational advantages from the new technology. Eight years later, efforts to realise the most efficient operation of these exchanges still need to be devoted to the solution of some operational problems. This article looks at some of the problems in determining an operating approach for a new technology, and the effort required to implement it, as revealed by the history of the introduction of the Metaconta 10C Trunk exchange system. (The broad background of design features and installation has been covered in previous articles — References 1, 2, 3).

Specification of Operations Facilities

Specification 1079 defined the requirements for large trunk exchanges with no reference to SPC exchanges in particular. Maintenance features were only covered briefly, with requirements such as "Reliability — not more than one failure in 40 years". Thus when the 10C system was selected, it became necessary to examine the system in technical detail and specify in terms of the selected system, the approach required in terms of operating facilities, maintenance aids, servicing and support requirements and repair facilities. Numerous meetings with the supplier were held over the ensuing two years and a liaison team was established at the supplier's headquarters in Antwerp, Belgium in 1970. This team was comprised of representatives from Design, Construction and Operations interests, whose job it was to provide on-the-spot assistance, as the system emerged from the design to the production stage, in meeting the detailed requirements of the Australian network environment. Of the 9 team members, 3 (including the author) were concerned exclusively with operational requirements, including the following key aspects:

- The numbers of staff required to operate the exchange, and the levels of training required.
- The methods to be employed in monitoring the exchange equipment and facilities.
- The facilities to be provided for administration and supervision of exchange performance, including any necessary maintenance aids.

At the time of commencing this work there were very few Stored Program Controlled exchanges in use in the world, none of them particularly large, and certainly not of the size proposed for the Pitt exchange. The team was then in the position of having to determine an operating approach virtually in isolation, with only the extrapolation of existing world experience with SPC local exchanges as a guide.

The system at the time of offering existed only as a small skeleton or trial exchange, the only firm piece of equipment being the computers themselves. The opportunity to influence the design during its evolution was an opportunity to realise the greatest possible gains from the new technology, and a challenge because of the lack of precedent from which to work.

The formal discussions with the company were designated Technical Meetings, and took place within the framework of the contract between APO and the supplier. The main functions of these meetings were to obtain details from the Company on the progress of design and on facilities provided, to clarify the reasons for the requests of particular facilities, and to obtain from the company information on expected system performance to enable planning for operations and maintenance activity.

Because of the size, complexity and novel technology associated with these exchanges, operations became a key issue as work developed. Discussions on maintenance and operations could best be described as vigorous — a reflection of their vital importance in compensating for the lack of operating experience with this kind of exchange. But it was through this process that the concensus was reached for the operational facilities that were finally incorporated in the system.

The areas of main interest, that is, where significant operating economies were expected, were the switching equipment maintenance, liaison with the outside network, and administration of the exchange. These areas are the basis of this article.

SWITCHING EQUIPMENT MAINTENANCE

It may be useful to re-state the equipment environment:

- basically solid state components of high reliability and therefore a low rate of faults;
- all speech contacts are of the reed relay type sealed in glass tubes filled with inert gas;
- all of the equipment is mounted on plug-ended printed circuit assemblies (PCAs) which are easily replaced;
- all equipment servicing more than a few lines is duplicated.

The failure rate of the equipment was such that only one fault per day was expected in an exchange the size of Pitt. This result could be calculated because the designer had made an estimate of the mean - time - between - failures (MTBF) for each type of PCA in the exchange (about 400 in all). This, combined with the large number of types of board, and the wide range of test and repair equipment necessary to cover all the different types of circuit techniques used, indicated that there would be problems in maintaining the necessary repair skills in each exchange, both through the diversity of knowledge required and the lack of opportunity to frequently use and thus refresh it.

The supplier had proposed a repair scheme based on having at least one spare PCA of each type located in each exchange. A fault would be indicated by error reports printed out by the Man-Machine Communication system. A Fault Dictionary would allow analysis of these reports to produce a prognosis of the location of the fault to within a few PCAs. These would then progressively be replaced until the fault disappeared. The last board replaced would then contain the fault, and the spare board would be left in its place while the faulty one was sent away for repair. The repair centre would contain all the necessary test equipment to enable the fault to be rectified, and the repaired PCA to be tested to ensure that the board had been restored to original performance before being returned to the exchange.

This meant that the spares stock became critical in determining the maintenance of the exchange. The balance had to be struck between too many spares, meaning money unnecessarily tied up in equipment not earning revenue, and the risk of not having a spare available when a fault occurred, increasing the risk of loss of service to part of the exchange. The supplier offered a statistical solution to this problem, based on the theory of Markov chains, and calculated using the following information:

- the MTBF of each type of board
- the number of boards of that type in service in the exchange
- a turnaround time through the repair centre for faulty boards of 28 days
- an allowed average delay for each repair of ½ hour due to no spare available in stock.

The adoption of this procedure is considered a major advance in handling of spares dimensioning, and was made possible only because the supplier had a bank of failure rate data on which to draw. The system has been used to dimension spares for all 10C exchanges, and is now being refined to include provision for a national spares holding ("buffer stock") to further improve the economy and security of the scheme.

The experience with this scheme has encouraged Telecom to apply a similar process to all new switching systems and other items of non-switching equipment where the use of replaceable plug-in items makes this feasible.

MANPOWER PROVISION

Labour is a dominant component in operational costs, and early in the development stage an important task was to determine a manpower target for the new exchange system. After overseas experience was considered in relation to achievements with similar systems and allowance made for the Australian environment, an initial target was determined of 3 manhours per working termination per annum for overall operations effort. Attention was then turned to the type of staff skills required to achieve this. Considerations that had to be borne in mind were:

- the high reliability of the equipment implying a low number of faults and hence infrequent use of diagnostic skills.
- the wide range in complexity of equipment comprising the exchange.
- the nature of the exchange, with all system logic contained in a large and complex software package.
- the small number and dispersed locations of these exchanges and the consequent lack of flexibility in assigning staff.
- the potential availability of a large amount of fault information which could be used in conjunction with documented step-by-step procedures to diagnose a large percentage of the expected faults.
- the technique of fault isolation by PCA replacement and repair at a remote specialised centre which meant that the required range of manipulative skills on-site would be reduced compared with conventional electro-mechanical exchanges.

With this in mind, a staffing approach involving three levels of skill was determined:

- staff of tradesman level for routine administration and fault-finding work where clearly laid-down documented procedures existed. This level would have training aimed specifically at developing familiarity with the functions of equipment, and the use of documentation and the man-machine communication system.
- staff of Technical Officer level, with in-depth training in the system, for supervision of the exchange, and back-up in fault finding situations where diagnostic documentation was inadequate. This level would have particular responsibility for the performance of the common-control (computer) system, but would not have responsibility for system software.
- higher-level specialist assistance would be provided from a central software group. The basic objective was to maintain a common or generic program in all exchanges, supported by a staff whose full-time responsibility is software, thus ensuring that their expertise in this complex area is not diluted through concern with other aspects of exchange administration.

MAINTAINABILITY DEMONSTRATION

There was a strong tradition (arising from necessity) in the electromechanical exchanges that all repairs were carried out on site at the exchange. It was foreseen that if the new approach were to succeed, then system training and documentation would have to be geared accordingly. Because of the critical nature of this aspect of maintenance, it was agreed with the supplier that a Maintainability Demonstration would be held in the first exchange prior to acceptance, to ensure that the system could be effectively maintained in the manner proposed.

The purpose of the Maintainability Demonstration was to evaluate:

- the system's ability to detect a fault and describe it in an output fault message.
- the use of the diagnostic guide to interpret the message and localise the fault to an acceptably small group of PCA.
- the ability to isolate the fault to a single PCA by successive replacement of PCAs in that group with known fault-free boards.
- completion of repair by replacement of the faulty board with one from the spares stock and restoration of the equipment to service, without further disruption to traffic handling by the exchange.

The demonstration was held using a representative selection of faults, and the location procedure was demonstrated by the Supplier's personnel. Their actions were followed by two Telecom operating staff of different training levels, who had to indicate that they were able to follow each successive step in the isolation procedure. The process was observed and recorded by two engineers (who had been members of the Antwerp Liaison Team) and subsequently evaluated against the previously-developed maintenance approach. The demonstration proved that the basic approach of "output fault message leading of PCA replacement" would work, but it highlighted the critical dependence on the Diagnostic Guide and attendant documentation. Some revision of the documentation was quickly carried out, and revision is still continuing as operational experience is expanded.

This was the first occasion where a Maintainability Demonstration had been included in the acceptance of a new switching system. The practice was considered so rewarding that it is now being applied in the specification and acceptance of all new switching systems. It is seen as an all-embracing test of the maintenance approach proposed by the manufacturer for the system, and enables an assessment of how well it will meet the targets set for it in terms of maintenance effort, the number of staff required and the level of training necessary to maintain the required standard of service (see Ref. 5).

NETWORK MAINTENANCE

Because these exchanges are located at the pinnacle of the switching hierarchy (the Main Switching Centre function), they are connected to a very large number of exchanges and carry traffic of a large range of types. It follows naturally that a large part of the operating workload at one of these exchanges is co-ordination of activities with staff in other exchanges. The activities may cover commissioning of new circuits, the correction of circuit faults or tracing the cause of poor switching performance.

In analysing the expected workload, it was recognised that adequate aids were needed to allow this work to be carried out efficiently, at the same time exploiting the SPC technique of the exchange where possible.

Test Consoles

Based on the test consoles established in some Australian ARM's, the 10C Test Consoles serve as the focal point for communication and circuit testing in the exchange. As shown in **Fig. 1,** switching networks of the exchange (IVN, OVN, RSN, SSN) are used to enable the following functions to be carried out:

- from two dedicated ITJs on each console, obtain test access to any outgoing junctor, and signal on this junction to obtain further access to a distant exchange technician on test base;
- to answer incoming calls from other exchanges to the "1172" test console code, and to co-operate with circuit testing;
- to obtain access to any incoming junction by use of a special key using the 1172 junctors ("meet me on . . . . " facility);
- to obtain monitoring access to junctors which are busy, on which a series of calls have to be observed;
- gain test access to Manual Assistance positions, and transmission equipment such as Echo Suppressors, etc.

Each console is equipped with an A-215 Transmission Measuring Set to perform standard measurements in conjunction with other manual tests or in conjunction with distant TCARS bases. (See **Fig. 2**). Jacks allow the connection of other specialised measuring equipment to utilise the access facilities of the console. There is also a test multiple appearing on every rack in the exchange for both communication and testing, and these also appear on the consoles. Also there is provision for terminating exchange lines and order wires on the console.

The test console operator controls the access process by functional control buttons plus a hexadecimal keyboard used for:

- input to the computer of the identity of the OTJ or ITJ to be accessed.
- input to the computer of the destination number to be sent in the case of access to an OTJ.
- dialling out on the local exchange lines using a built-in MOS key-sender which shares the same key pad.

The pad is also used to generate, via the computer, line signals on accessed junctors; the line signalling seen by the exchange is also monitored by the computer and displayed on the console lamps.

One feature that could not be incorporated in the consoles due to the heavy demand on memory space was provision for a record system which would allow such functions as translation of the hexadecimal junctor identity into route and circuit number which is the form required in dealing with areas outside the exchange. The problem of maintaining such records up to date by the usual Rotadex on card system becomes very time consuming in an exchange of 10,000 or more terminations.

In the Pitt 10C a separate Automatic Trunk Records system, based on a mini-computer has been provided to make this type of information instantly available at each console.

The only administration operations that are not performed at the test console are blocking and unblocking junctors, and letting routes in and out of service. These are carried out on a Teletype using the Man-Machine Communications system.

The basic concept of the test console is not new. The fundamental difference from existing consoles is the use of the exchange computer to perform the control of testing and monitoring. The flexibility exists to have new functions added as experience in the use of the facility is accumulated.

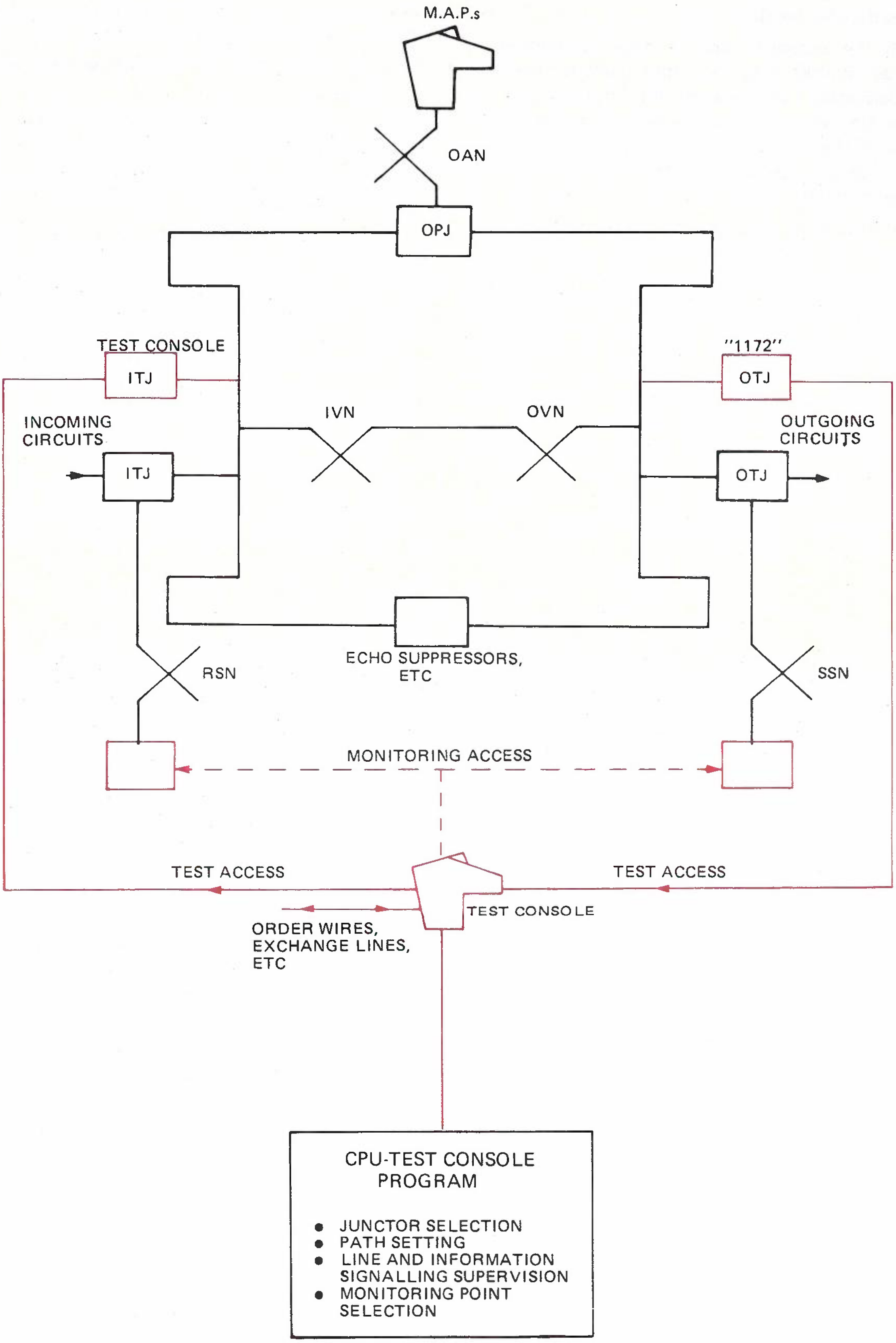

Fig. 1 — 10C Test Console — Functional Diagram.

Automatic Call Sender

With the potential size of these exchanges as large as 30,000 outgoing trunk circuits, the task of adequately supervising the transmission of circuits for which the exchange has responsibility was such that it could only be handled by automatic means, using the TCARS facility found in most exchanges.

The Automatic Call Sender (ACS) evolved as a device in two distinct parts — a general device for obtaining access to outgoing circuits in an ordered manner, with modules added having facilities for carrying out a particular test on the outgoing junctors so accessed. The only facility so far included is that of the transmission test, though provision exists for a total of 10 different tests (the photo in **Fig. 3** shows the buttons for including a particular test in the test cycle). The test is under complete control of the computer for access and for initiation of the test cycle. The transmission test itself is under hardware logic control. (See **Fig. 4**).

In the control program facilities are provided to conduct a test routine as follows:

- a complete test of circuits of all routes in sequence.
- test of all circuits in nominated routes.
- test of up to 10 nominated junctors.
- repeated testing of one particular circuit (to detect intermittent faults, etc.).

If any circuit is found busy at the time of testing, its identity is stored, and the outlet is retested after all other circuits in the route have been tested, and if still busy, marked for retesting at the end of the test cycle. If it is busy on each occasion its identity is printed out on the teletypewriter (TTY). There is also provision for routining the echo suppressor pool using the exchange's own TCARS route.

The ACS uses the IVN and OVN to provide access to any outgoing junctor, and does not use a special access network. The normal path selection process in the computer is used to establish a connection

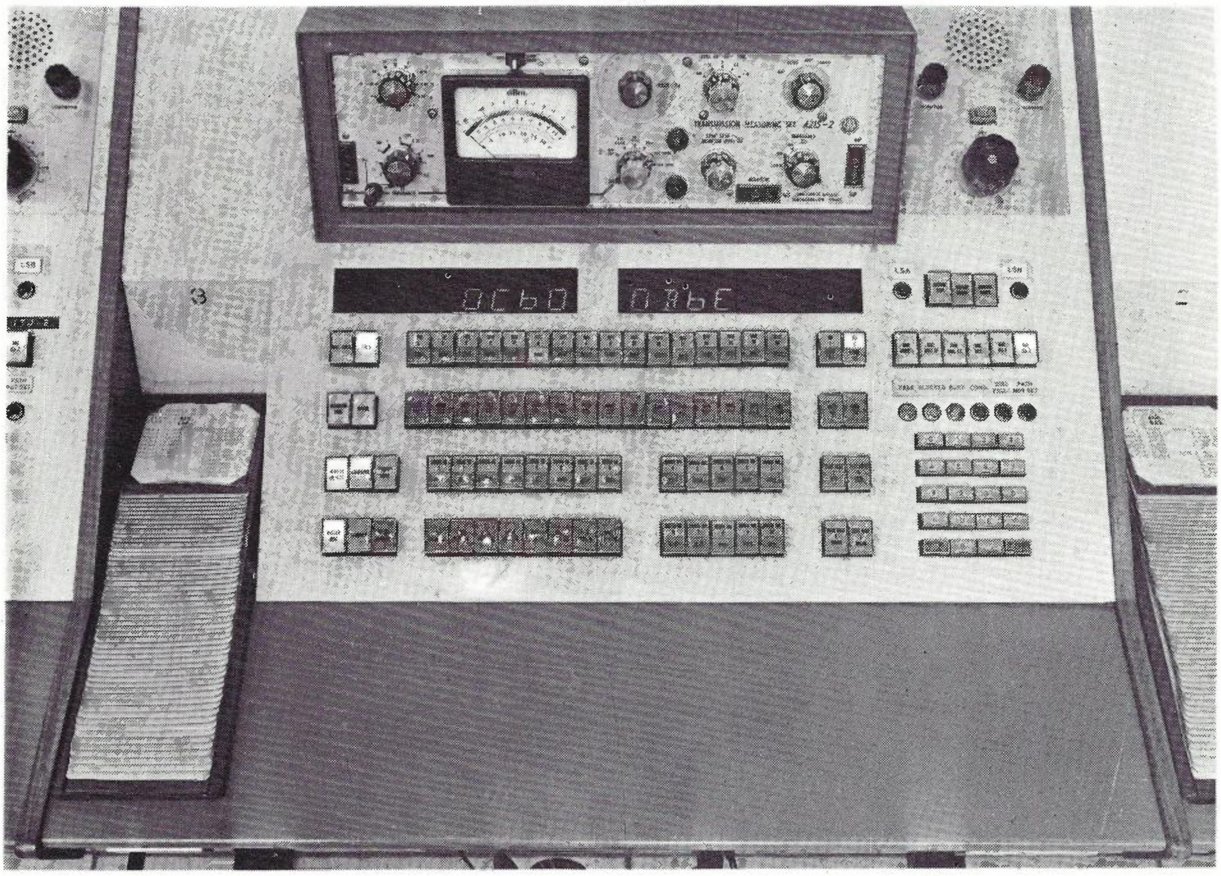

Fig. 2 — 10C Test Console with Connection from Test ITJ OC60 to OTJ OB6E.

Fig. 3 — 10C Automatic Call Sender Control Panel.

between the ACS IT and the selected OTJ, and the normal outgoing signalling facilities are used to send the TCARS access code on the outgoing circuits, which is obtained from a table in computer memory. This table also contains the values for the variable attenuators in the ACS to enable correct setting of the upper and lower limits of the Transmission Test, both in terms of the expected level and the tolerance, which can be set to 1 dB, 2 dB or 3 dB above or below this level both on send and receive. A facility is included in the control program to start and stop the ACS at a nominated time if the exchange is not staffed during the low traffic hours when these routine tests are normally conducted.

The ACS hardware includes the logic for recognising the TCARS identification code, conducting the test and memorising any failures, including a repeat of the test cycle if any failure is detected on the first. After each test, the results of the tests are read by the computer and stored in memory, to be eventually printed out in batches of up to 16 reports. If call failure rate is excessive, or a hardware failure occurs in the oscillator or receivers, the ACS is inhibited and an alarm is given.

The development of further tests for the ACS will depend to a large extent on other automatic test bases, e.g., for noise, frequency response, etc., being established in the rest of the network.

Traffic Route Tester (TRT)

In essence, the 10C TRT (See **Fig. 5**) has the same function of service observation as the existing TRTs located at terminal exchanges. The fundamental difference is that the normal input to a

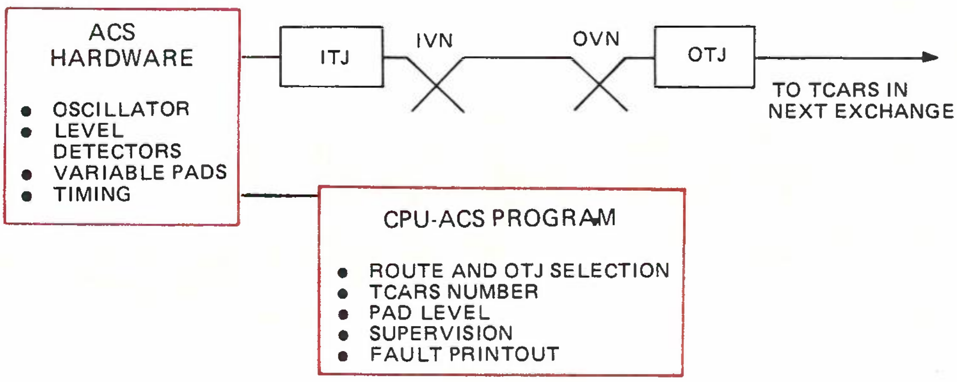

Fig. 4 — 10C Automatic Call Sender — Functional Diagram.

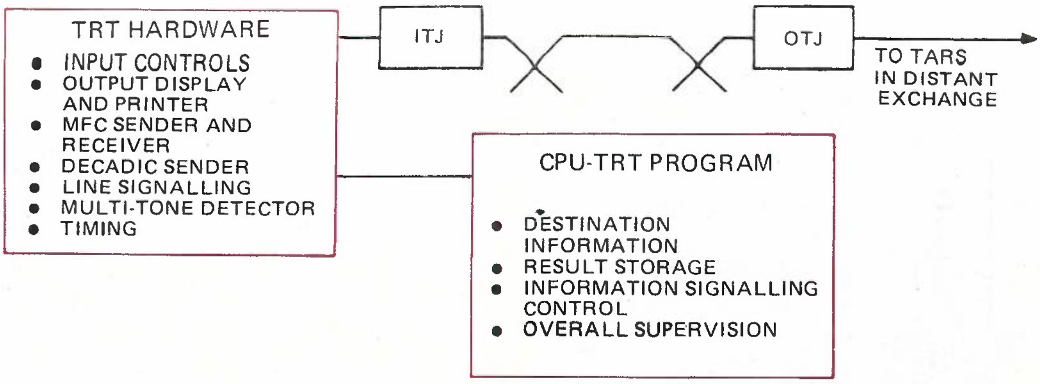

Fig. 5 — 10C Traffic Route Tester — Functional Diagram.

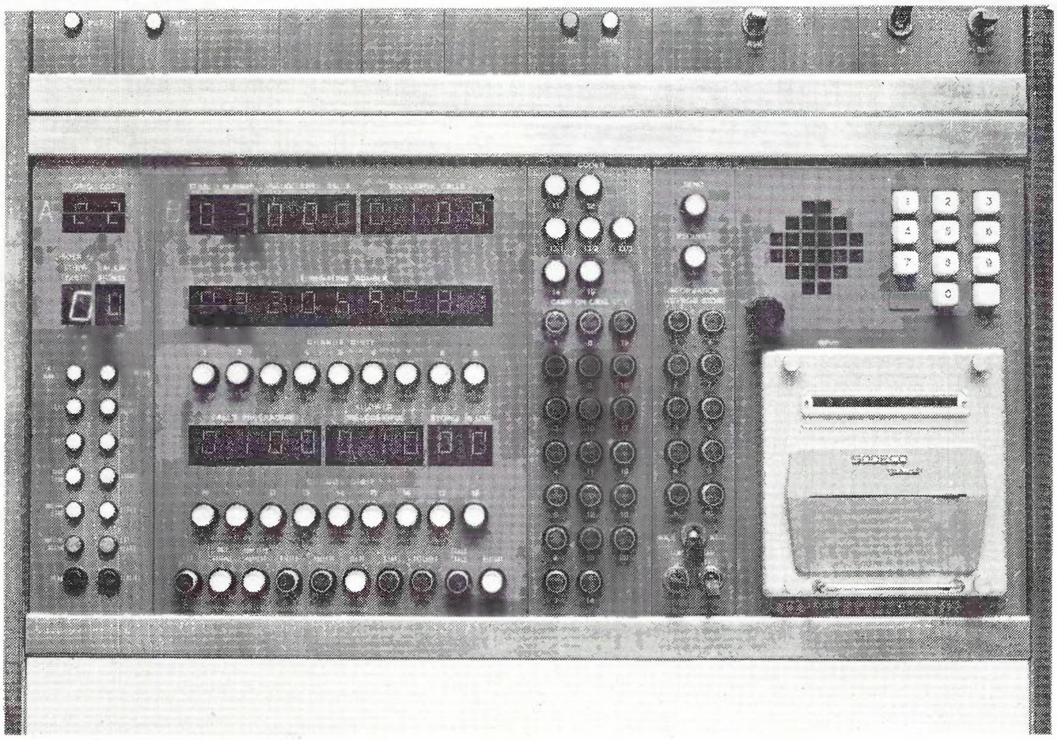

Fig. 6 — 10C Traffic Route Tester control panel.

trunk exchange is not a subscribers telephone, but another exchange. The aim of establishing a TRT at the 10C exchange was to examine the grade of service as seen from a point inside the trunk network to enable a separate assessment of the contribution to grade of service at various stages of the network associated with the 10C. This would enable call programs to other trunk exchanges (terminating at their TARS or TCARS) and to the local terminating network, as well as answer bases throughout the rest of the network. The benefits are more accurate supervision of call results and the ability to generate a wide range of call types.

This meant an expansion of the usual TRT facilities, the major one being the addition of an MFC signalling facility, and the ability to simulate a large range of call types and correctly respond to backward signals including "B-party interception"

(B8 category). The signalling capability includes the sending of all special forward signals (Codes 11-15) enabling the grade of service offered using these signals to be individually monitored.

As the TRT can be set to operate in "Fault Trace" as well as the "Observe Service" mode, it can be a useful trouble-shooting tool, and can also be used to test new facilities introduced into the exchange.

The control panel (shown in **Fig. 6**) offers the facilities to program calls to a maximum of 10 destinations, presetting the number of calls to each destination, and the maximum number of failed calls for each before an alarm is given. A maximum of twenty ITJs can be connected to the TRT, using either MFC or decadic signalling, and which can be set for MFC calls at either "multi-metering" or "switch-hook" mode for line signalling. Provision is made to "camp-on" a particular ITJ, and to distribute calls to each destination in succession ("Call Mixing"), or to complete all calls to one destination, before moving on to the next ("Call Batching"). Displays also include the order of the digit being sent, and in the case of MFC, the value of the backward signal being received. In the case of "no progress" or other call failure, these will indicate the point at which the call failed.

Details of all failed calls are printed out via the Sodeco printer included in the control panel, including the time of failure detected, the time of the failure, the destination being called, and the TRT junctor being used. (Where necessary additional information can be printed out from the computer via Teletype).

Summary

All the devices for network maintenance described above are adapted from existing devices in the network, but have been extended to cater for the new requirements associated with a large trunk exchange and for the requirements associated with supervision of performance of new network facilities. Where possible, advantage has been taken of computer control to provide flexibility for future development. In some areas, experience has shown the appropriateness or otherwise of the balance between hardware and software realisation of the various aids, but it has to be stated that these decisions were made on the basis of evidence at the time of design. The degree of software control involved will allow the extension of facilities in these aids as dictated by operating experience.

EXCHANGE SUPERVISION AND ADMINISTRATION

Telephone exchange equipment presently in use in the Australian network has usually been designed so that it would give information to the operating staff in the form of lamp displays, alarms, counter readings, and so on. Similarly, the staff could give instructions to the machine (to affect its behaviour) by means of key operations, strapping changes, etc. If extra information was required, then extra components had to be added to the equipment, and even then, information could only be obtained (or other changes made) in a simple form, because the system logic and control was spread through a number of places in the system.

An SPC exchange, such as the 10C system, has most of the system logic and information located in the one place (i.e. the program and data stored in memory). It becomes much simpler to obtain access to information, or to affect the behaviour of the exchange, by obtaining access to its memory. While this could still be done by using lamps and keys (such as the computer control panel) such a system would be as difficult to operate as in the electro-mechanical case.

A better system is to use a teletypewriter to communicate with the computer program, using messages (usually in some form of code) typed on the keyboard. The computer program can recognise groups of characters, (letters or figures) as requests or instructions to perform certain operations. The program can also arrange for messages to be printed out on the same teletype. This capability forms the basis of the Man-Machine Communication system in 10C exchanges. There can be more than one teletype attached to the computer, and it is possible to arrange that each teletype is associated with a different type of work, e.g., maintenance, traffic recording, test equipment. Also, because the nature of the TTY is similar to that of a Telex machine, a TTY need not be located in the same building as the exchange, but may be placed remotely, e.g., in a fault reporting centre or administration office (to obtain details of traffic figures).

The range of tasks that is possible using Man-Machine Communications via the TTY is limited only by the range of codes that the computer is programmed to recognise. If new control or information facilities are needed, an addition to the Man-Machine program is the basic requirement. (Of course, changes to other programs may be required to enable the requests to be carried out after they are recognised):

In the Man-Machine program package associated with the 10C exchange, the following facilities are provided:

- *Interrogation of the Operational System.* For example it is possible to obtain information about a junctor, request the numbers of junctors busy on a route, or find the identity of an outgoing junctor connected to an incoming junctor. In the case of existing exchanges this required going to equipment racks, looking at individual circuits or physically tracing the connection across the exchange.

- *Changing the Operational System.* In this case, by means of a teleprinter message, staff can change a particular peripheral device from one processor to another, change any junctor from free to blocked condition or vice versa, or change the routing for a particular destination code. In existing exchanges, this would require the staff to go to the individual circuit and operate a key, or change the strapping or grading, say in each register in the exchange.
- *Output of Fault and Status Reports.* One important difference in the operation of 10C exchanges compared with previous types of exchanges is that most of the fault conditions are detected by the computer program rather than in individual devices. While it would be possible for the computer program to give an order to light an alarm light associated with a particular fault, it is easier to put out a message on the teleprinter stating that the fault has been found and where. An associated alarm may be given for those messages where urgent or semi-urgent attention is required.
- *Control of the On-Demand System.* There are certain tasks and specialised facilities required in an exchange which are not used very often, and as a result it would be too expensive to provide space in memory to keep them in store all the time. Instead, they are stored on tape, a spare area is left in the core memory and a control program is provided so that each of these programs can be loaded when it is required to be used, i.e., "On-Demand". The program that controls the loading and running of these programs is part of the Man-Machine communication program package. Through Man-Machine, requests can be made to see if the program is available, to load the program from the tape, to give the program the data it needs to start it running, and to receive the results from the running of the program. (A classification system exists so that certain programs may only be controlled from correctly classified TTYs).

The effect of the use of these facilities is to enable all exchange operation and supervision to be concentrated in one area, which is designated the Maintenance Control Room. (For a photo of such an arrangement, see Ref. 2, pp 6-7). The result of such centralisation was the subject of a large number of discussions amongst the maintenance and operations members of the 10C team during the evaluation of the system.

Fault Handling Approach

One of the prime concerns was the ability of operating staff to handle efficiently the information that the exchange would provide. The nature of the fault printout as a means of information, its decoding and use in a diagnostic process were studied closely as detailed information progressively

```
.. CQ 04 02E2 44E8 0E24 0411 0E11 10H 43M 22S 304 B
.  CQ 04 02E2 84C8 0E28 0411 0E11 10H 43M 22S 304 B
...SN 02 145 29 1 34 85 10H 43M 32S 304 B
.. EA 08 5001 3000 0400 0000 FFFF FFFF 10H 43M 32S 304 B
.. EA 08 5008 3000 0400 0000 FBFF FFFF 10H 43M 38S 304 B
.. EA 03 01F3 1300 10H 43M 52S 304 A
.. EA 08 5000 4000 0400 0000 DFDF FFFF 10H 43M 55S 304 B
.  CQ 10 020A 2242 0000 10H 43M 23S 304 B
```

Fig. 7 — Typical Printout from Maintenance TTY 2 over a Period of one Minute.

became available. The documentation to be used in association with the printout was obviously a key element in achieving the desired objective. Because this documentation could only be finalised after conclusion of the design, it was understandable that the maintainability demonstration should show development in this area to be not as complete as in other areas.

An early development was the use of a number of TTYs in the Maintenance Control Room, each with a particular function. Three teletypes were foreseen for control, divided as follows:

COMPUTER TTY — all information dealing with the computer equipment itself, (memory, peripheral equipment, busses, etc.).

MAINTENANCE TTY 1 — all requests for information, and control of the "On-Demand" facility.

MAINTENANCE TTY 2 — reserved exclusively for automatically-generated fault reports.

An example is given in **Fig. 7** of the form of fault messages as printed out on maintenance TTY 2. The main features of the printout are as shown:

- a priority indicator — low, medium or high priority indicated by 1, 2 or 3 dots respectively.
- the report code and identifier which indicate the type of fault, and form the index for Diagnostic Guide.
- the fault data, in the form of hexadecimal characters, which can be interpreted using the Diagnostic Guide to point to the probable location of the fault.
- a message tail giving the time of detection of the fault, the day of the year, and the identity of the computer that produced the report.

(Note that in **Fig. 7** the last message, being low priority, has been delayed until all higher priority messages have been printed).

In the example shown the reports deal with the following:

- the CQ messages deal with failures detected during setting up paths in the various switchblock networks. (Note here that depending on the type of fault the same type of report can have a different priority).
- the SN reports deal with traffic supervision facilities. In the example, final choice route number 145 has an average of 29 circuits occupied out of 34 available for traffic (with 1 circuit blocked) and this exceeds the occupancy alarm figure of 85%.
- the EA reports show faults detected by internal routine "on-line" tests. e.g. EA03 deals with devices which have failed to release normally after use; EA 08 shows where the state of the switching network as shown in memory does not agree with that shown by the Busy Free Tester.

It should be emphasised that these are *failure reports* and a number of these may have to be corelated to point to the existence of a particular fault. This corelation has to be performed by the maintenance staff under the guidance of the Diagnostic Guide. For example, to diagnose a failed reed relay in the voice network, two or three CQ 04 reports may have to be combined with one or two EA 08 messages before a diagnosis may be made.

Another category of fault report would arise from events in the surrounding network, such as line signalling irregularities (false seizures, remote blocking, failure of release guard) and MFC signalling failure such as timeouts. The detailed control and supervision by the computer at each stage of every call through the exchange, meant that a large amount of information could be made available about every call failure detected in the 10C exchange. This information could give a valuable indication of the performance of traffic through the exchange, and its analysis could lead to early detection of poor switching performance in the surrounding network. (However, this "network surveillance" function was not considered to be a direct function of the 10C operations staff, and it was considered that arrangements should be made to supply this information to the local NPAC for analysis.)

One of the prime concerns in the design stage was the ability of the operating staff to handle such information. As designed, all fault printout came through the one teleprinter, and the only regulation on output was the priority order. Because a report is originated each time a failure is detected, one fault can give rise to a large number of failure reports. A study was made of the expected failure rates and the consequent number of fault printouts that would arise based again on experience at 10C local exchanges, as well as available information on ARM exchange performance in the Australian network.

The outcome of the study was an estimate that a daily output of 500-1000 failure reports could be expected initially in each exchange, growing gradually as the number of lines in service increased. The accuracy of this estimate was qualified as being "somewhere between an engineering approximation and an astrological prediction". Unfortunately, the latter has proven to be the case, with daily output in each exchange being in the vicinity of 5000 to 10,000 fault reports. A large proportion of these arise from call failures in the outside network, as indicated above. Naturally, detailed supervision of this output by manual means is an undesirably large workload. Other means of handling this information have to be found to avoid the prospect of the maintenance staff becoming submerged under the flow of teletype printout. The problem is seen to be one of control and digestion.

While the amount of information that the 10C exchange is capable of producing can result in great benefit to the performance of the network, assimilation of this information must be considered part of the task of maintaining a large trunk exchange. The development of a control strategy for such an exchange is not easy if there are no relevant precedents for guidance. Add the inevitable compromises that must be made in any design process, and the chance of securing perfection at first attempt is not high. However, SPC technique does offer the opportunity to implement operational improvements far more readily than with hardware-based systems, and systems for more efficient handling of fault information are now being investigated.

CONCLUSION

During the period of development of the Australian application for the Metaconta 10C Toll system, the maintenance approach was able to evolve only as familiarity with the design and its capabilities increased. The high reliability of solid state equipment, and the ability of SPC technique to provide a high degree of supervision were recognised early and these qualities have been used to reduce the demands on the operating staff. The administration techniques initially adopted may have to be refined in terms of operational experience, reflecting on both the facilities provided in the exchange design, and the external support systems provided.

The experience gained during the realisation of the operations features of these exchanges has been valuable in terms of future implementation of SPC technology. This may be illustrated by noting that, whereas the technical content of the schedule and specification for these exchanges was about one hundred pages, that for the SPC Local exchanges ran to over 500 pages, with substantial portion being operational, maintenance and administration requirements.

This article covers the period up to the placing

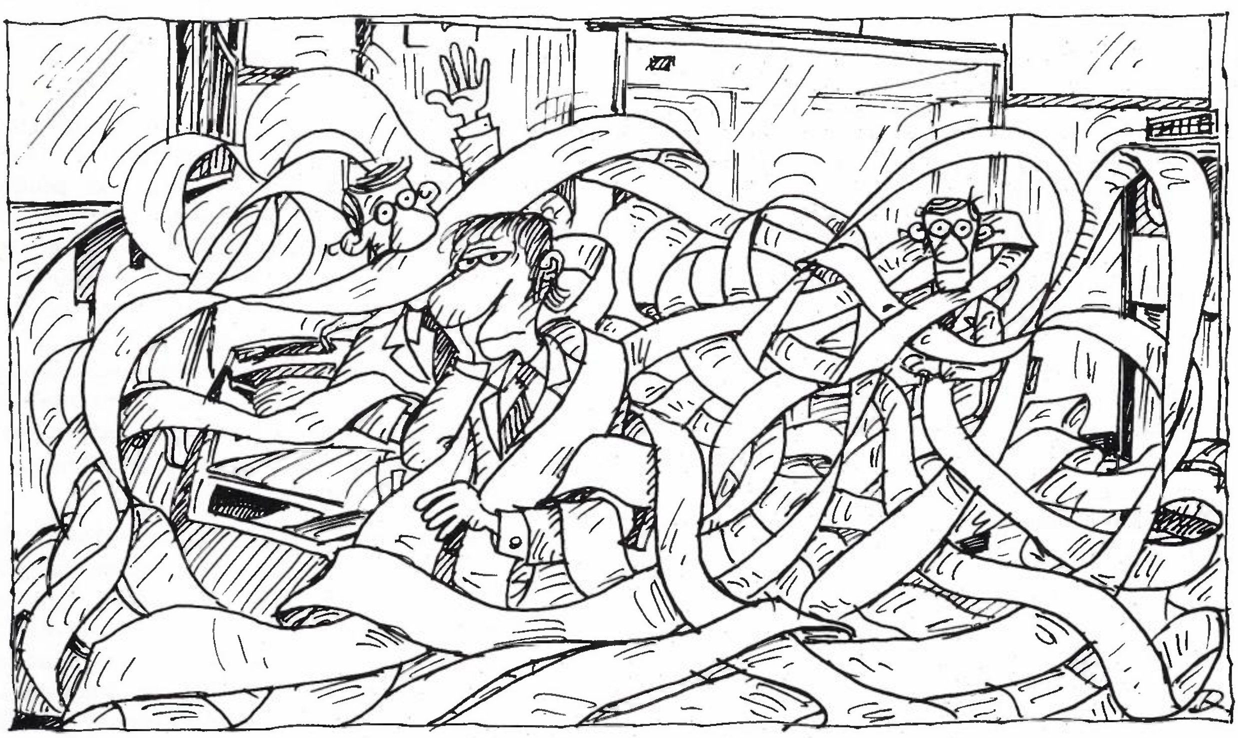

Fig. 8 — "The prospect of the maintenance staff becoming submerged under the flow of Teletype printout."

in service of Pitt 1OC exchange. A later article will outline operational experience with the first three exchanges and the effect this has had on operational development.

ACKNOWLEDGEMENT

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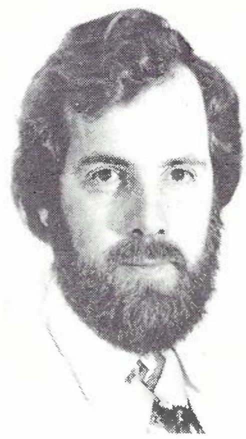

Cable Television

G. LINDENMAYER, B.Sc., B.A., Dip. P.A. M.I.E. Aust.

The technique of feeding television signals to a number of receivers via a cable reticulation system, common in some other countries, is little used in Australia. Cable Television Systems have a place in meeting certain special needs, such as in areas of poor off-air reception or where there is a call for additional programmes. Some of these applications and the technology they employ are described here.

Editorial Note: The author addressed the Institution of Engineers, Australia, Victoria Division, on this subject in February, 1976. With some updating, the material presented in that address forms the basis for this article. It is reproduced here with the Institution's permission which is gratefully acknowledged.

INTRODUCTION

In Australia we expect to receive our television signals by an antenna, attached either directly to the television set, or to the roof of the house and connected to the set by a short length of ribbon cable. There is, however, another way of getting the signal to the set, that is by a cable distribution network.

Systems of this kind were introduced into the U.K. and the U.S.A. and subsequently to other countries, as a means of providing television service to communities beyond the range of their nearest television station. Known as community antenna television (CATV), they consisted of an antenna situated so as to receive the wanted signal, and a cable network to reticulate it to the community.

To such a system it is practicable to add:

- antennas pointed to transmitters in other centres
- a local studio
- a local videotape input
- a microwave relay system to bring in distant programmes
- outside-broadcast links.

When a cable system distributes television programmes obtained from any of these sources it is referred to by the generic name "cable television". CATV is one particular case.

There are a few other techniques in which television-type pictures are transmitted via cable; these should be distinguished from cable television. Perhaps the best known is closed circuit television. It is generally a single chanel system, in which the input of a camera is displayed on one or more television monitors. Typical uses are to allow a large audience to see a process closely (e.g. a surgical operation), or to serve an overflow audience of an auditorium, or in surveillance. Occasionally in an electrical goods sales room you may see your surprised image in one of the television screens through a simple closed circuit television system. A somewhat longer closed circuit system has operated for some time between Sydney and Melbourne race courses, showing in colour each other's race events.

Systems more closely related to CATV are used in large buildings, such as hotels and blocks of flats, where it is not feasible for each receiver to have its own external antenna. Known as master antenna television (MATV) this type of system consists of a master antenna, typically on the roof of the building, and cable distribution, but in more ways than one it is an "in-house" system. Its service area is generally small, so there is not much need to provide an elaborate amplification system. Moreover, all the cables and equipment are housed within the protective environment of the building, and this is taken into account in their design.

There are also cable television systems in use that supply only educational programmes to schools and similar institutions.

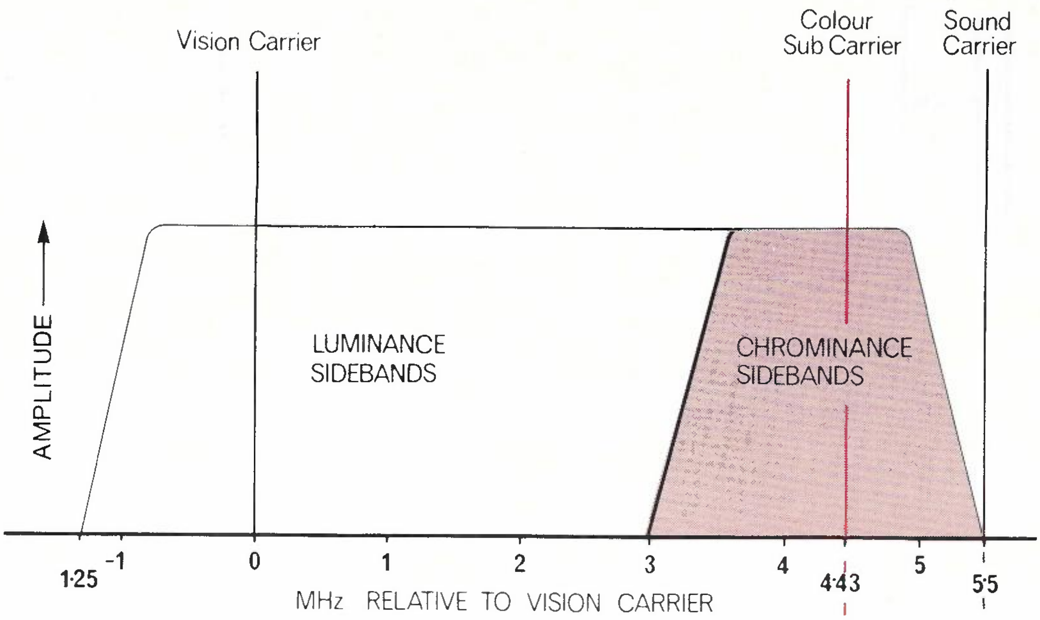

Fig. 1 — Transmitted Spectrum of Colour Signal

EXTENT OF CABLE TELEVISION IN VARIOUS COUNTRIES

The USA has the greatest number of CATV subscribers, about 15 million. Growth has been at the rate of more than 20% per year for the past 20 years. The largest system, in San Diego, California, has about 100,000 subscribers, and the largest operator, Teleprompter, has more than a million in its several systems across the country, Although fewer in number, the Canadian CATV subscribers comprise about 50% of the total viewers, which is the highest penetration of all countries. This high penetration does not mean that 50% of Canadian viewers are beyond the range of their local transmitters. They are, however, beyond the reach of stations in the USA and it is the programmes of these additional stations, brought in on the cable system, that accounts for the high penetration of cable. For similar reasons, some European countries, notably Belgium, have significant cable television penetration, supported by foreign programmes.

Some American systems carry more than 20 programmes, many of which are not available to viewers receiving directly from air.

Needless to say, the subscribers pay the cable operator for the service, the North American rentals varying from about $7 to about $30 per month.

In other countries different social, legal and economic conditions have led to quite different results. In Britain, for example, the cable systems may not, except in very special circumstances, transmit any programmes except those of the local stations.

In Australia, cable television systems are by law permitted only in areas of inadequate reception, and may not carry programmes received from stations serving other areas. Exceptions are made to these restrictions where residents have community of interest with the area served by the distant station, or where roof-top receiving aerials are prohibited, e.g. by a local authority.

In Australia there are fewer than a thousand television receivers connected to CATV systems, and the largest system has fewer than 400 subscribers.

SOME SIGNIFICANT CHARACTERISTICS OF TELEVISION SIGNALS

Before touching on the technology of cable television, a reminder of some of the characteristics of television may be in order. **Fig. 1** shows the frequency distribution of the components of a television signal. The cable system must be able to transmit such a signal and present it to the receiver in a form that will give a good picture. For a colour picture, the phase and amplitude distortion

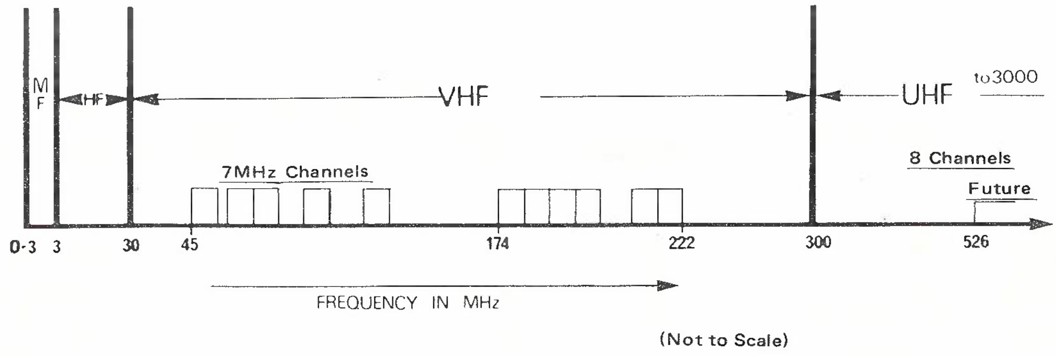

Fig. 2 — Broadcast Television Frequency Bands in Australia

of the chrominance carrier must be kept within fairly close limits. Other impairments that must be controlled are the introduction of noise and other unwanted signals, and echo. An important potential source of unwanted signals is the non-linear product of other signals carried. Indeed, this is a major restriction on the allocation of television channels for broadcasting, although in that area the intermediate frequency of the receiver is a significant additional factor.

Fig. 2 shows the radio-frequency spectrum with the Australian broadcast television allocation. In other countries the arrangement is roughly similar. The intermodulation products fall into the part of the spectrum between the bands, and this is used for other services such as mobile telephones and air navigation. Technical limitations on the use of channels restrict the number of channels broadcast at VHF in any one area in Australia to about 5 or 6. This prevents the use of additional VHF transmitters (on additional channels) in metropolitan areas to service "pockets" of poor reception. In most countries, some frequencies in the UHF are allocated to television. In Australia, only a few translator stations are transmitting at UHF, and a large proporion of television receivers cannot tune into the UHF band. In the future, UHF translators are more likely to be used than cable television in upgrading poor reception in Australia.

CABLE SYSTEM TECHNOLOGY

In cable television systems the equipment for connecting the programme signals to the cable is called the "headend". In simple systems the headend is at the antenna site. However, the headend often contains monitoring and testing equipment and is located at a central point in the system, which may not be suitable for receiving off-air signals. An antenna-to-headend link is then provided.

There are two basic technologies employed in cable television, the predominant one being coaxial cable, usually operated at VHF. The alternative is symmetric pair cable operated at HF.

VHF Coaxial Systems

The coaxial system duplicates, as far as practicable, the conditions of broadcast television. However, some of the restraints are removed, and additional requirements are placed on the transmission system. As shown in **Fig. 3** a coaxial system has amplifiers at frequent intervals, and these must amplify over the full bandwidth being transmitted, which may be from 50 MHz to 220 MHz. With the types of cable presently in use the insertion loss at 220 MHz is of the order of 50 dB per kilometer, requiring amplifiers of about 20 dB gain every 400 metres or so.

Given the transmission performance objectives for a cable system, there is an economic trade-off between the attenuation of the cables and the gain of the amplifiers. Systems therefore generally have no more than about 20 amplifiers in cascade, but up to 80 in cascade are known. When systems serve too large an area for desirable amplifier cascade lengths, they are divided into sections with a hub at the centre of each, the hubs being interconnected to the headend by SHF radio links. Often there is only one hub, centrally located and some distance from the headend antennas.

A cable system has many tapping-off points. Taps into suscribers' premises are connected to "distribution" cables, which in turn are tapped out of the main ("trunk") cables, usually at distribution amplifiers (DA).

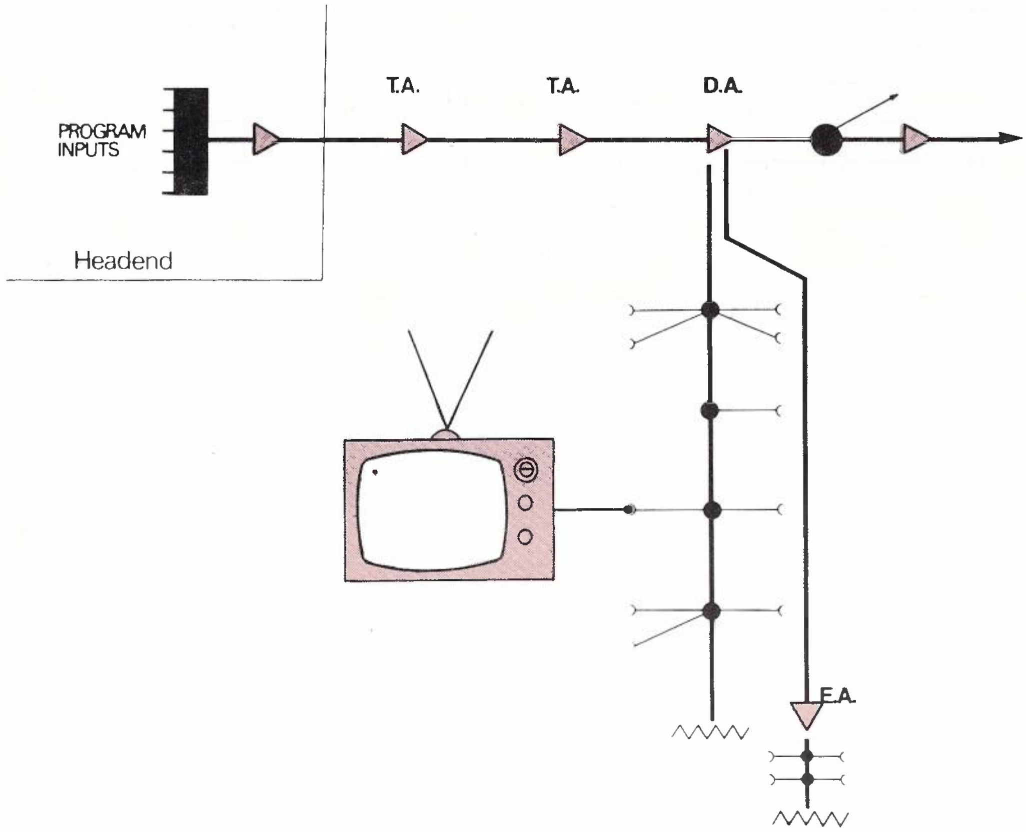

Fig. 3 — VHF Coaxial Cable Television Reticulation

It is necessary to engineer the system to obtain the best balance between noise and non-linear effects, and to obtain an adequate impedance match along the system to keep echo levels low. Also it is necessary to keep extraneous signals out of the system, e.g. power harmonics and radiation signals.

In the optimum design, the contributions to signal degragation are shared equally between the trunk and distribution sections. The trunk sections are longer and contain several amplifiers, each serving many subscribers. The trunk amplifiers (TA) are operated at a relatively low power level to obtain optimum performance with respect to non-linear distortion. Distribution cable sections are shorter, but must supply signal at suitable level to the inputs of several television receivers. There is generally no more than one extension amplifier (EA) in each distribution section, and it operates at a relatively high level. It delivers the signal to the subscriber through a hybrid type tap, which has a low insertion loss to the through cable, but a high loss, of the order of 20dB, towards the subscribers. The precise loss towards the individual subscriber is chosen according to the loss in the distribution cable between the amplifier and the tap. The signal to the television receiver is about 1 mV (at 50 ohms) per channel. The tap preferably has a higher loss in the subscriber-to-cable direction, to reduce the effect of echo from mismatch at the receiver.

New systems most commonly have capacities of either 12 or 20 channels. The 20 channel systems use the full range of frequencies from about 50 MHz to about 220 MHz, and require a high degree of linearity in the amplifiers.

Most new amplifier housings contain fittings for the addition of filters and of reverse direction ("up-stream") amplifiers, in case the system should eventually transmit in both directions. The upstream channels lie below 40 MHz.

The existence of so many devices along the cable gives rise to three problems — radiation from the cable, radiated signals being picked up by the cable and ingress of moisture. Signals radiated from a cable at the same frequency as local television stations can cause interference to nearby television receivers, while signals picked up by the cable from television transmitters can

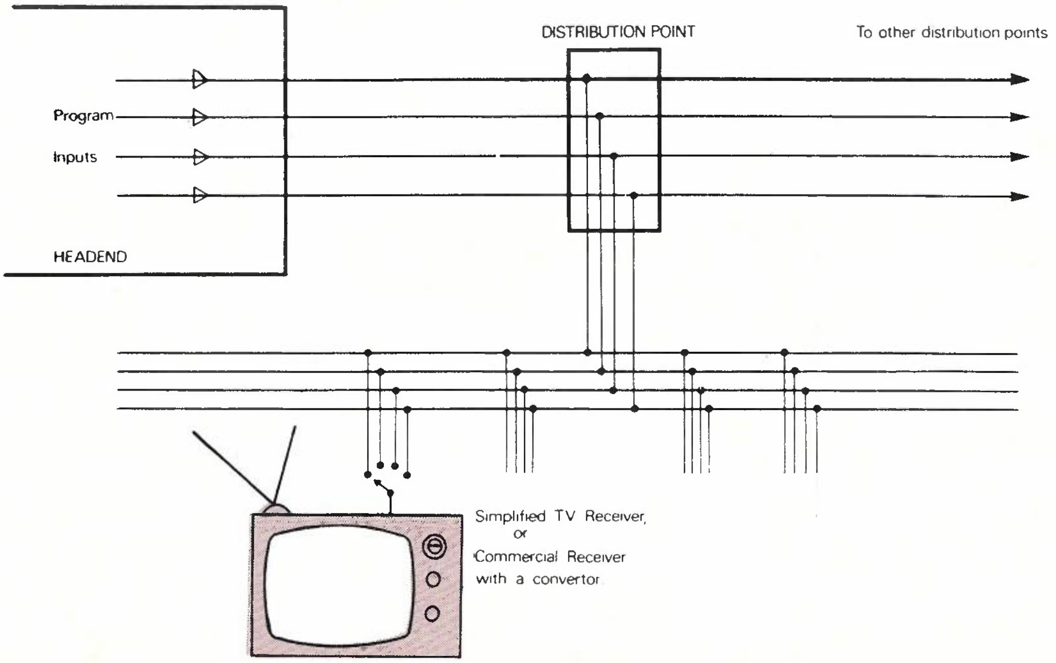

Fig. 4 — HF Cable Television Reticulation

interfere with the channels in the cable. This is a more serious problem where the cable is strung on poles (as in most systems in North America), particularly since aerial construction does not need such water-tight fittings as underground construction.

The subscribers' television receivers should be considered as part of the cable system. Even in countries with high cable penetration many more receivers take programme off-air than from cable. There has not yet been produced a commercial television set designed specially for a coaxial cable system. Such systems must therefore be compatible with the commercially available sets designed for off-air reception.

This poses problems where most receivers are capable of only UHF reception (as in the UK), or where adjacent television channels, or channels in the intermediate (non-television) band are being transmitted by the cable. Transmission over a coaxial cable at UHF undergoes higher attenuation than at VHF, and so it is usual to convert to VHF for transmission, and to re-convert to UHF close to the subscriber. Intermediate-band channels and adjacent channels cannot be tuned in commercial receivers, so converters are needed between the system and the sets if such channels are carried. Converters are generally placed on top of the television set, and may be connected by a cable to a remote control. They consist of a tuner which gives an output at one of the VHF channel frequencies, and may provide additional functions, for example the sending of a signal from the subscriber to the headend.

HF Symmetric Pair Systems

The HF systems carry one programme per cable pair. Most of those in use are in the UK, where there are only three available channels. Three pairs are needed, but more may be used for radio programms, and for the television sound, which is not always carried on the video pair. The pairs are tapped into each subscriber's premises, one pair per programme. A special simplified receiver is used, and a selector switch connects it to the desired pair. Because of the much lower attenuation at HF, even with symmetric pair cable, subscribers may be almost two kilometres from the nearest amplifier. The configuration is illustrated in **Fig. 4.** Special cables have been produced to reduce crosstalk ("crossview") to acceptable limits.

It is obvious that the reticulation of, say, 20 channels would need at least 20 cable pairs, with at

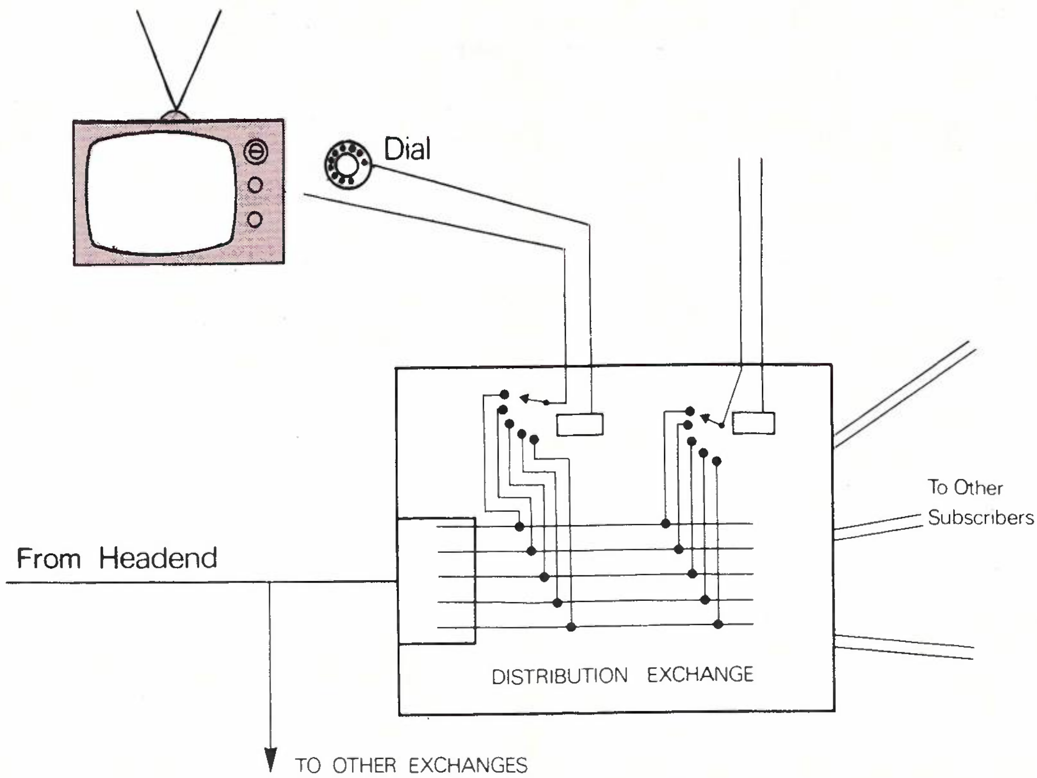

Fig. 5 — Dial-a-Programme Type Cable Television System

least 20 pairs in each lead-in to a subscriber. An alternative HF system has been developed for large numbers of programmes. Each subscriber is served by two individual pairs from a distribution point. A switch controlled by the subscriber over one pair connects the required programme to the other pair. Switches have been manufactured which are capable of handling very large numbers of programmes. The system, called "dial-a-programme" because of the use of telephone-type dials to control the switches, is illustrated in **Fig. 5.**

Digital Techniques

Digital techniques are not used in cable television because the signal is always obtained in analogue form and must always be delivered to an analogue receiver. However, in the television industry, there is an increase in the production and processing of programmes in the studio in digital form. This is likely to lead to further increases in programmes relayed in digital form, and to the production of digital monitors, and eventually digital receivers. The major problems in using digital transmission in cable television are:

- the extremely high bit rates needed for capacities of 12 or 20 channels, and the effect of echo at such rates, and
- the cost of regenerators at high bit rates, compared with the cost of analogue amplifiers.

Reduction of redundancy is unlikely to reduce the bit rate enough to overcome these problems, unless a dial-a-programme type system is used.

SPECIAL CABLE SERVICES

Additional facilities, ranging from local neighbourhood television programming to computer-controlled two-way educational routines, have been postulated and occasionally added to cable television systems.

To date, the more sophisticated facilities have proved to be far too costly to be attractive to potential users. The local-interest programmes have had reasonable ratings but have not always been commercially justifiable. There has been only minimal use, really, of anything but entertainment programmes on cable television.

Pay-television is the favourite at present among the hopeful new services, and it is growing rapidly in the USA. Recent films and live coverage of major sports events, not available from broadcast television, can be obtained by cable subscribers who pay an additional fee. In coaxial systems, the pay programme may be transmitted in a scrambled form, with the pay subscriber renting an unscrambler. Alternatively, band-stop filters may be put in the taps to the standard rate subscribers. Electronic ticketing, a means of charging for the individual programme rather than for access to the channel, is reported to be at an advanced rate of development. The dial-a-programme type distribution offers advantages for a wide choice of pay programmes, including the pay-by-programme option.

One postulated development of cable television is its marriage with advanced telecommunications, to produce the "wired city". Newspapers and mail would be delivered electronically to the home, and access would be available to vast repositories of computerised information and processing, and to libraries of movie films. Associated with the wired city is the concept of the home office: A more modest, but still very advanced experimental approach to the wired city has recently become operational in the new residential area of Tama, outside Tokyo.

THE FUTURE OF CABLE TELEVISION

In the 25 years since its inception, the technology of cable television has reached a high degree of refinement. A probable development is the replacement of conducting cables by optical fibres. The advantages of optical fibres are the much lower attenuation, isolation from electro-magnetic radiation, posible lower cost, smaller cable cross section, and possible improved signal quality. The technology has not yet firmed sufficiently to predict the ultimate pattern, but a reticulation with several fibres dedicated to each subscriber and somewhat akin to the dial-a-programme system, is one possibility. Such a configuration has been spoken of as being suitable for telephony (visual as well as aural if necessary) and for data services, as well as for television. At least one cable television operator is already using optical fibres, but in a system designed essentially for conducting cables.

In Australia, the position of cable television does not look very promising, at least for the immediate future. Only a very small proportion of residences are unable to obtain good off-air reception, and there seems to be little demand for additional programmes. The more distant future may well be different. Perhaps pay television for special interest groups may promote a wider interest in cable generally, and perhaps advances in telecommunications technology may help cable television. One school of thought contends that the radio frequency spectrum will become so valuable for mobile services that extensive cable systems are inevitable. An opposing view is that radiated transmission, perhaps by satellite, will make cable obsolete.

Whether the extensive use of cable television will eventuate in Australia will depend on the needs and priorities of society as much as on the developments of technology.

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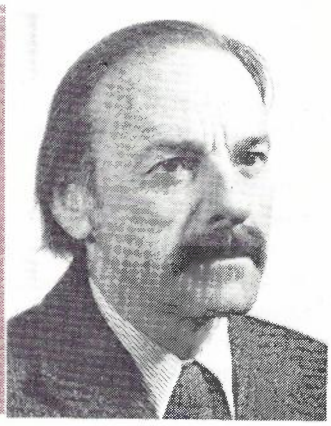

Converting a Working ARF 102 Exchange to ARE-11

K.R. DOUGLAS, B. Tech (Electronic Engineering)

The first public working 10,000 line ARF 102 exchange converted to ARE 11 control in Australia was cut-over in June 1977. This paper describes data preparation and the date changes necessary at each level of control to convert Salisbury, near Adelaide, South Australia, to direct control of all switching stages. Readers are directed to previous articles by W. Close, vol 27/1 and C. Dougall, vol 27/2 for a system appreciation.

INTRODUCTION

The Salisbury Telephone Exchange was selected as a national field trial to evaluate the installation techniques associated with converting a working ARF 102 crossbar local exchange to ARE 11.

Salisbury exchange is located approximately 20 km north of Adelaide in the Outer Metropolitan area of the Adelaide Telephone District. It serves a mainly residential population and has an average growth rate of approximately 1000 lines per year.

The crossbar equipment was installed from 1965 onwards, and at the time of conversion, had 10,000 lines of ARF 102, m=6A, subscribers' equipment installed. All incoming junctions employed MFC signalling and, consequently, the conversion of incoming decadic junctions was not included in the trial. An in-dialling PABX of 8,000 lines, which provides service for the Department of Defence, Weapons Research Establishment, is trunked from the GIV stage and uses a separate 10,000 line code having a mixture of six and seven digit numbering.

Installation work on the ARE 11 equipment was carried out solely by Telecom Australia staff. This included rack erection, cabling, modifications to the existing ARF racks to permit operation in both the ARF 102 and ARE 11 modes, data preparation, testing and cutovers. The testing of the individual processors, devices and finally the overall system, required approximately six months to prove the procedures and documentation but this time should be reduced considerably in future installations using pre-tested equipment. Staff employed consisted of a Technical Officer in Charge (TOIC), Telecom Technical Officer Grade 1 and two Technicians. Only the TOIC had any ARE 11 background, having previously been involved with the installation of the Telecom Model ARE 11 Exchange in Melbourne.

Cutover commenced with the initial phase on the 27th of February 1977, with the final phase being completed on 3rd June 1977. All conversions took place in periods of light traffic, either on Sunday mornings or between 5 a.m. and 8 a.m. on a week day. A detailed account of the cutover phases is given in **Appendix 1.**

ARF EQUIPMENT MODIFICATIONS

Some items of ARF 102 equipment require modification to work in the ARE 11 mode. These modifications are designed such that the equipment will still work in the ARF 102 mode thus permitting them to be modified and tested in advance of cutover.

The equipment requiring modification is:

• SR	required	for	level	1	control
• SLM/S	"	"	"	1	"
• GVM	"	"	"	3	"
• GIVM	"	"	"	4	"
• SLC/D	"	"	"	4	"
• PBX 'C' Wires	"	"	"	4	"

The SLM modification was carried out on working equipment and was assisted by previously ensuring that the adjacent rack was spare or could have the relay sets removed without affecting service. Each SLM modification was tested, in the direct control mode, in a light traffic period using the MTE (Marker Test Equipment).

Each GVM was also removed from service in turn, in a light traffic period, modified and tested for direct control operation with the MTE. Normal ARF test instructions were used to ensure that the ARF functions were satisfied for both SLM/S and GVM.

All the 'C' wires, from the SLA/B racks, had to be wired out to a new PBX, 'C' wire, IDF and a single wire jumper used to connect the required 'C' wire to the cabling of the PBXC equipment. Apart from wire testing, no functional testing of the PBX 'C' wires could be performed until the SLA/B's were converted to direct control.

DATA PREPARATION — CENTRAL STORE

Data for the Central Stores, that is the Translation Store (TRS) and the Subscribers' Category store (SCS), was prepared by office based staff. This work requires a sound network knowledge and a reasonable understanding of the ARE 11 system.

A series of proformae was developed by Telephone Switching Construction Branch HQ, to assist with the gathering and formatting of data for the TRS and a further set for SCS data collection. These proformae were found to be very useful during the installation to give the installers an appreciation of the meaning of particular data words and the analysis required. During the cutover phases, when editing of the data was necessary, they were indispensable.

From the data compiled on the proformae, a TRS loading tape for Salisbury was produced by the National Support Centre staff using an assembler programme on an IBM 370 computer. The TRS tape was required early in the testing phase to test the addressing functions of the store and, as its production took several months, a modified version of the Telecom ARE 11 model exchange tape was used in lieu for the initial testing. Approximately 3-4 months were required to establish all the 'B' number analysis data, but this time would be reduced for subsequent exchanges in the same local network as the codes used would be common to all exchanges.

The data for the SCS is subject to daily change due to the variations of subscribers' requirements, and should not be prepared until the latter stages of testing. At Salisbury, a modified version of the Model Exchange tape was also used for SCS store address testing.

TRANSLATION STORE (TRS)

This store is made up of 4K, 9-bit ferrite core modules, as required, up to a maximum size of 16K. The store is duplicated, for security reasons, with one store being 'executive' and the other on 'standby' to take over in case of executive store failure.

The TRS is divided up into 64 'Base Areas' which contain data tables used in the setting up of a call (TRAFFIC DATA) or for defining the configuration of the ARE 11 equipment (REFRESH DATA). Data defining the location of each Base Area, in TRS, is contained in the first area called the BASE ADDRESS AREA. To obtain the actual start word address of a Base Area, the data word in the BASE ADDRESS AREA is modified with the appropriate store size multiplication factor. The multiplication factor for a TRS store size of 4K, 8K and 16K is X16, X32 and X64 respectively.

Traffic Data

Data tables such as BNRAN ('B' NumbeR ANalysis), DESTDATA (DESTination DATA), ESDATA (End of Selection DATA) and ROUTECODE (route data), are used in the analysis of dialled digits to determine TOTE (Type Of Terminating Equipment) and routing information. All the network codes, including barred and unallotted codes, must be specified to obtain analysis tables for all possible codes.

Digit and routing analysis can be performed in two distinct areas; BNRAN 1, DESTDATA 1, or BNRAN 2, DESTDATA 2. At Salisbury, the required codes were split into two groups so that approximately one half were contained in each of the separate areas. If analysis starts in the first area, it is possible to point out (that is; provide the address of the next data table to be used) a DESTDATA table, CALLTYPE 3, which allows for further analysis, and the second area can be specified for this analysis. Local calls must use the DESTDATA 1 area because of the continued digit analysis required to define the thousand group route, a feature which permits PBX numbers to be allocated throughout the 10,000 line group.

Once the codes for each area have been decided, the DESTDATA tables can be specified against a particular code and the pertinent barring categories (AO value). The DESTDATA tables are numbered in sequence, TDA001 being the first DESTDATA table in the first area and TDB001 the first DESTDATA table in the second area. The first DESTDATA table, in each area, is used to point out the local NUT route.

In the DESTDATA table, the following is specified:

- Call type.
- Requirement for further analysis for local codes.
- Further analysis to define the 'B' number length for mixed length codes.
- Type of call — DESTDATA (DESTination DATA).
- GV call point — STARTLOC (START LOCation).
- 'B' NumbeR Length — BNRL.
- Send method, MFC, decadic or both at different stages.
- Address of tables for further 'B' number length or GV analysis.
- Table address of the route of the GUV (STARTROUTE).
- Table address of the route of the GIV (SECROUTE).

The STARTROUTE and SECROUTE words are defined in the DESTDATA table but are not used, for determining routing, until the corresponding GV stage is converted to direct control (at levels 3 and 4), when the routing analysis function is removed from the GV markers.

The DESTDATA information is read by the TRAFFIC CONTROL PROCESSOR (TCP) and an image of the data is stored in its REA (REgister Area) page of the DAS (DAta Store). It is then available readily for the TCP, without further bus connection, to process the set up of the call.

At Salisbury, it was found necessary to specify a SEANADR table (SEnd ANalysis ADdRess) rather than a SENDDATAADR table (SEND DATA ADdRess) as a number of MFC destinations had decadic in-dialling PABX's connected, and these are not catered for if a SENDDATAADR MFC table is used.

For a normal call, digit and routing analysis proceeds from the AO (barring category) value of the subscriber to analysis of the dialled digits in BNRAN to DESTDATA. From DESTDATA, the start route word points out a ROUTEADR (ROUTE ADdRess) table. Specified in this table are, all the available routes for the dialled code, the address of the ROUTECODE table, further alternatives (if available) and the first digit of the 'B' subscriber's number to be sent to line in each case. The ROUTECODE tables pointed out contain data specifying the send method required on the route (either MFC or direct control), and the W, R and CR relays required to switch to the selected route.

Interpretation of TRS Printout

Two outputs are available from the application of the Assembler Programme to the TRS data; the TRS loading tape as described earlier and a TRS printout which describes the data loaded into TRS in a legible form. An explanation of a TRS printout containing the TRS word addresses, Base Areas and data information is shown in **Appendix 2.**

Refresh Data

This data defines the configuration of the ARE 11 equipment and is used as permanent data to refresh the TCP and OMP data stores (DAS). 'Refreshing' is executed, by programme RTS, at regular intervals and after any processor disturbance, to ensure the data stores contain correct information. During installation, a fuse alarm can be used to trigger a 'Refresh'. The Random Access Memories (RAM) in the processor data stores are then reloaded with the permanent data stored in TRS.

The Refresh Data contains information concerning all the racks that are in use and how many devices of each type are installed on the racks. This involves data detailing the rack address, called Device Group Address (DGA), and DEvice Address (DEA) so that the processors can access the devices via the MUltipleXors (MUX). Time supervision, disturbance counter values and alarm conditions for the devices are also specified in this area.

When allocating STU's for TCP O, their position in the rack must be considered. The STU's need to be in a continuous group and situated either at the start of a rack or in the end positions. The range of addresses for the STU's controlled is defined by the minimum and maximum DEA values, together with the row inhibit data (ROWINH). A split range is not acceptable as the processors can only define a start and stop address. This must be considered when setting the ROWINH bits to define which groups of five STU's are controlled by TCP O and any other TCP which has access to the same STU rack.

At Salisbury, the DGA for the first STU rack was set to 02 instead of 00. If the first available DGA, for STU's, 00, is used it can cause confusion as all spare data words are written as 00. Hence specifying 02, DGA, makes it unique and limits mistakes when reading data printouts.

The refresh data prepared for Salisbury initially specified additional equipment required for a later extension and this caused a problem. These words had to be written out of TRS as they caused BCU (Bus Control Unit) alarms when the MUX routine tests were performed by the processors.

SUBSCRIBERS' CATEGORY STORE (SCS)

This store also consists of 4K, 9-bit ferrite modules and a discrete SCS is required for each 10,000 line group.

The store is divided into three parts. In part one a hexadecimal character (O-F) is entered for each installed line in the 10,000 group. This hexadecimal character, (the CO value), is used to address the Translation Table (second part of the store) to read out the subscribers' category parameters, B1, BO, A3, A2, A1 and AO. The most common subscribers' categories are obtained in this manner and constitute approximately 90% of subscribers. Other unusual categories require a list search, in the third part of the store to obtain the required category.

An initial list of all the subscribers connected, with their corresponding categories, was obtained from Customer Services Department and used for comparison with the exchange records. All variations were examined and when the list had been updated, with the current information, it was used to prepare the SCS proformae. The exchange service staff maintained a record of all subsequent subscriber variations from that date and, after the SCS input paper tape had been prepared and loaded, all the changes recorded by the service staff were loaded manually via a teleprinter.

It was found that two 4K modules of ferrite store in both SCS A and SCS B provided sufficient capacity to cater for 10,000 subscribers in this exchange. Because of the large number of applications for International Subscriber Dialling (ISD), it was necessary to make this category one of the more common and to change it from a list search. (A list search was wasteful in terms of store usage and required a longer time to obtain a result).

CONCLUSIONS

A national field trial to evaluate the feasibility of converting a working 10,000 line, ARF 102 Crossbar, local exchange to ARE 11 was successfully completed at Salisbury, South Australia.

The trial provided experience on the proposed installation techniques, testing procedures, modifications to working ARF 102 equipment and the network implications of the various levels of control. The discrepancies found in the documentation during installation were fully investigated and procedures revised which will benefit future installations.

A sound knowledge of the network is necessary to prepare the data for the Central Stores, and this work should be commenced early in the installation period. Network changes due to other exchange variations necessitate a continual review of the prepared data which must be edited as the changes occur.

Conversions of the various switching stages are easily controlled by converting each unit of a particular switching stage separately. Converting in this manner restricts faults to with a definable area and minimizes subscriber disturbances.

FURTHER READING.

1. CLOSE, W.; "ARE 11 System Appreciation," Telecommunication Journal of Australia, Vol. 27, No. 1, 1977.
2. DOUGALL, C. J.; "Elsternwick ARE 11 Exchange," Telecommunication Journal of Australia, Vol. 27, No. 2, 1977.

APPENDIX I — DETAILS OF CUTOVER STAGES

Cutovers were arranged to occur in six distinct phases.

- Phase 1 — conversion of outgoing register functions.
- Phase 2 — direct control of GUV stage.
- Phase 3 — conversion of incoming junctions.
- Phase 4 — direct control of GIV stage.
- Phase 5 — direct control of SL stage.
- Phase 6 — conversion of local FIR-P and FDC access relay sets.

This arrangement allowed the conversion of discrete switching functions to be carried out, fully tested and the effect on the overall system carefully evaluated before proceeding to the next phase. It was thus possible to revert to the preceding phase if any particular stage of conversion presented extreme problems. This condition did not eventuate and the complete conversion progressed from one phase to the next as planned. However, the ability to revert to a preceding phase was checked in each phase to confirm the validity of the concept.

Pre cutover

After the ARE 11 racks and devices had been functionally tested and the TCP 'group tests' performed, the direct control functions of each switching stage were tested to prove procedures and traffic handling data. This was achieved by converting, in sequence, one GUVM, one GIVM and a 1000 line group, not carrying traffic, to direct control in periods of light traffic. The tests allowed all the new type marker relay sets to be functionally tested in their appropriate rack positions, and the software network analysis function to be tested into the actual network using the ARE 11 Automatic Exchange Tester.

During functional testing the RSL's were double jumpered, on the IDF, to both the REG-LM's and STU-L's. The STU-L's were left unplugged at the jackfield until the REG-LM, part 2, relay sets were unjacked at Phase 1 of cutover. This was necessary to prevent voltages from the REG-LM's damaging printed circuit board components in the STU-L's.

As the TRS data had been prepared on the basis of the final condition of full direct control of all switching stages, this data required 'editing' for each cutover phase. The technique adopted here was to edit data in the 'stand-by' store and changing it to 'executive' for the cutover. Subject to satisfactory operation, the other store was then edited and returned to the 'executive' state. Prior to Phase 1, it was possible to edit both stores, TRS A and TRS B, as they had no effect on switching at that stage. Temporary analysis tables for Phase 5 cutover were also established, in the TRS, so that each 1000 line group could be converted to direct control one at a time. This restricted the planned outages to a single 1000 line group and limited fault conditions to that group.

At this stage the CD-KME's and GV-KME's were not used and were left unplugged at the jackfield. As these KME's had been specified in data as being available, numerous alarms occurred and it was necessary to 'write-out' the KME's, in the OMPDATA area of TRS, to clear the alarms. Subsequently, as each switching stage was converted the appropriate KME's were 'written-back' into the store and the cables plugged into the jackfield.

Phase 1 — Outgoing Register Functions

At the end of this phase the TCP's processed the outgoing traffic and obtained the 'A' subscribers number, via IDS (Identifier Data Sequencer) and the subscriber's category from SCS. Incoming calls to the SLC/D were handled in MFC signalling and the 'B' subscriber's category obtained from the ARF KAN. A 4 a.m. start on a Sunday was selected as the most suitable time for Phase 1 conversion because of traffic considerations.

Data Changes. As previously mentioned, the TRS data was prepared on the basis of full direct control and in this Phase normal signalling between switching stages was required and the following data changes were necessary:

- DESTDATA — CONKS (CONnect KS), in each DESTDATA table, word 01 half character '1' (HI) was changed to a value of 2 to connect an MFC type KS.
- OMDATA — SRSENDMETHOD, refresh data, word 36 character 'O' (CO) was changed to a value of 2 to indicate MFC control of the GUV.

Cutover Procedure. One half of the SR's in each 1000 group were busied and the associated RSM-L's were modified with the required strapping changes. Then one half of the GUVM's were blocked and the KMR strapping blocks replaced to introduce '3A' series signalling. The REG-LM's, part 2, were unjacked and the STU-L cables plugged in at the jackfield. The busied SR's and GUVM's were unblocked and the other half blocked in readiness for conversion. At this stage, traffic was using the STUL's and TCP's to control setting up of calls, and after satisfactory testing, the remaining racks were converted. Comprehensive testing of the outgoing traffic functions proceeded in accordance with the cutover document.

Faults

- IDS failure to identify calls due to:
  - — faulty 'g & f' wires (call and acknowledge) in most 1000 groups. It is essential to thoroughly pretest all the 'g and f' wire paths to ensure continuity and to detect transpositions before cutovers commence.
  - — incorrect strapping of RSM-L's in the 1000 line groups with two SLM's.
  - — earth from KAN being applied to several DCI hundreds leads for subscribers with the same service classification and tens and units digit. Blocking diodes were inserted in all hundreds leads in the KAN.
  - — errors in existing grading affecting 'g and f' wires.

  Because of these fault conditions, subscriber identification could not be completed and the call progressed as category unknown and, as the dial type was unknown, KMK 'dial' tone was sent to the subscriber. To minimize disturbance to the subscriber, resulting from this strange tone, the time supervision, of the KMK 'dial' tone, was reduced (by software changes in TRS) to one second while the faults existed.
- Subscribers' dialling habits — time supervision, before the first dialled digit and between digits, reduced to 10 seconds in ARE 11. Subscribers previously were allowed 45 seconds and their slow dialling habits caused the DPR (Dial Pulse Reception) programme to time out.
- Unallotted network codes were to have been directed to a NUT route off the GIV stage. This function was inoperative until all the GV stages were converted to direct control and to overcome the problem the first DESTDATA table was changed to a Call type 2 (re-route) and these codes were re-routed to a local PBX number connected to NUT.
- Indialling, step-by-step, PABXs in the network caused a problem as the SEND-DATA for many codes specified MFC only. This was overcome by specifying SEANADR (send analysis address) table for all codes thus allowing MFC and decadic signalling to be used as required.
- Some network codes had changed from step-by-step to crossbar after data compilation in the office, and stores had not been updated.
- Outgoing relay sets at the Weapons Research Establishment PABX could not accept a fleeting test reversal. The SCS data for these incoming lines was changed to inhibit the fleeting test reversal.

Phase 2 — Direct Control of GUV

In this phase, the GUV was converted to direct control. At Salisbury, the five GUV marker groups were converted one at a time in a light traffic period. One GUVM was blocked, the ARF relay sets removed, and the strapping blocks in jack positions 66 and 65 inserted to complete wiring for the new KMR relay set which was inserted. This marker was then unblocked and all others blocked so that the entire traffic was being carried by the one converted marker. After satisfactory testing of all the routes, by dialling codes which used all the ROUTE-CODE tables, the other markers were converted and tested in a similar manner.

Data Changes

- DESTDATA — CONKS, as the GUV is direct controlled no MFC KS is required. Change all DESTDATA tables, word 01/H1 value, to '1' meaning no KS is to be connected before the GV marker is called.
- OMDATA — SRSENDMETHOD, refresh data word

36/CO changed to '4' to indicate direct control of GUV.

- ROUTECODE DATA — SENDMETHOD, for every GUV to SLD route and the GUV to GIV route, change word 00/CO in their ROUTECODE tables to '2' to indicate MFC signalling on these routes.
- OMPDATA — The required GUV KME's were 'written back' into this area of TRS.

After the data changes were made and the 'stand-by' TRS made 'executive', a 'refresh' of the TCP's was necessary. This ensured that the data changes were loaded into the TCP data stores.

Converting one GUV marker group at a time proved to be a most satisfactory and easily controlled method. The only problem that existed in this phase was again concerned with the unallocated codes.

The RRDATA (Re-Route DATA) table established to process the unallotted codes in Phase 1 pointed out the local DESTDATA table which requires further digit analysis in GVAN (GV ANalysis) table to determine the route to the appropriate 1000 line group SLD. With a re-route condition, no further digits are available for analysis, hence the STARTROUTE word for the route could not be determined. A new DESTDATA table, pointed out from RRDATA, was established in which the GUV-GIV route was specified directly as the START-ROUTE word. The RRNR (Re-Route NumbeR), previously specified, was changed to a code that caused the GIV to switch to the NUT route.

Phase 3 — Introduction of RAR's

In this phase of cutover the RAR's (Register Access Relay set) and the STU-I's (Signal Translation Unit — Incoming) were introduced one at a time. The RAR's were connected between the incoming MFC junction FIR's and the GIV inlet to provide access, through an RSI introduced for ARE 11 working, to the STU-I.

The first digit was received by the STU-I and analysed in the RECAN (RECeption ANalysis) table to point out a 'transit call' RECDATA (RECeption DATA) table and a 'rejection' DESTDATA (call type 1) table. The DEST-DATA table contains the data word SROCASE (SR Operate CASE) and ORDATA yields ORCLASS (ORigin CLASSification); these two words determine the end of selection analysis tables. The ESDATA (End of Selection DATA) table, pointed out from the above analysis, ensures that the RAR will be through connected, without a MFC 'B' signal sent to line. This ensures that the first digit is received by the MFC controlled GIV-KMR.

Previous to this phase of cutover all the RAR marking leads were strapped to provide MOOFIR (MOde of Operation FIR), which addresses a word in the ORAN (ANalysis of ORigin marks) table to define the type of incoming junction. This preparatory work was carried out during Phase 1 acceptance testing and arranged as a separate project to strap all RAR's instead of individual changes as each junction was connected.

The incoming junctions of each junction group were converted one at a time and tested, using an ARF AET connected to the FIR, calling all local codes. When the junctions of one group were completed, TRT runs were carried out from remote locations. Work on this conversion commenced at 6 a.m. each day so that more than one junction could be taken out of service and converted during light traffic periods. This increased the number of junctions converted each day with approximately 13 days being required to convert 300 junctions.

Data Changes

- RECAN — incoming digit analysis was changed to point out new incoming 'transit call' RECDATA and DESTDATA tables, so that rejection occurs after analysis of one digit, causing the RAR to through switch to the GIV inlet.
- Establish the new incoming RECDATA table with the following data words.

  BANW: = Result address to the new incoming DEST-DATA table.

  ANLOC: = O, indicates, in zero numbering the next digit to be analysed (in this case the first digit).

  RECASE: = 4, to indicate a transit call and hence reception analysis completed.
- Establish the new incoming DESTDATA table with the following data words.

  CALLTYPE: = 1 (rejection case)

  SROCASE: = 6 (idle charging) used to address ESANO table, together with ORCLASS value of 2, to obtain address of ESDATA table required for end of selection information.

  BNRL: = O, one digit before rejection.
- ORAN — change ORDATAADR word for the FIR-P, to point to the MFC ORDATA table, because REG-IP connected and signals in MFC to the STU-I.
- ORDATA — SENDMETHOD-I, change to 2 as the converted FIR's are connected to a MFC controlled GIV.
- ESANO — for ORCLASS: = 2 and SROCASE: = 6 set data to point out ESDATA table number 28; RAR(MFC) to local (MFC).

The data changes were made in both TRS's prior to the commencement of this conversion as the data is not used until junctions are converted.

Phase 4 — Direct Control of GIV

Following conversion of the incoming junctions to access the STU-I's, it was possible to change the GIV stage to direct control. As in Phase 2, each GIV marker group was converted, one at a time, by blocking out one GIVM, replacing the KMR relay set, plugging in the cables to the associated KME's and indicating their availability in OMPDATA area of TRS. Once the required data changes, listed below, were made in TRS, and the TCP data stores 'refreshed', the converted marker group was unblocked and all the other marker groups blocked so that only one marker group carried the traffic. The functions of the converted marker group were then tested by making test calls from an FIR to each 1000 line group code, and by making local calls with the direct GUV-SLD routes blocked to prove the direct controlled GUV-GIV overflow route.

After satisfactory testing, the other marker groups were converted in turn with only one marker group in traffic at any one time until all marker groups were completed. With direct control of the GIV, the first two digits are received by the STU-I and analysed in RECAN. From the resultant DESTDATA table, addressed by RECAN analysis, the SECROUTE word is used to determine the route relays required by the GIV-KMR for switching. As the SL stage is still MFC controlled, a revertive is required after the first two digits so that the last three digits are received by the CD-KMR in MFC. The required revertive must be specified in ROUTECODE data for each 1000 line group.

No faults were found in the equipment or data during this conversion. However, some exchanges in the network were sending the 'C' digit on the direct routes and as RECAN tables were designed to analyse only the 'D' and subsequent digits these calls failed. This resulted from the retention of dual code strapping, in terminal exchanges, introduced to facilitate the conversion of the Adelaide network to 7 digit working in 1973. Highlighted is the need to ensure that such redundancy is removed at the earliest possible time to avoid later problems when other seemingly unrelated changes to the network are being made.

Data Changes

- RECAN — changed to **two** digit analysis to point out the new incoming 'transit call' RECDATA table.
- In 'transit call' RECDATA table established in Phase 3 change data words.

  ANLOC: = 1, with zero numbering means that 2 digits are to be analysed.

  STARTLOC I: = 8 (STARTLOC value in DESTDATA table to be reduced by 3).
- Change new incoming DESTDATA table to

  CALLTYPE: = 0, meaning normal call and contains routing information for incoming calls.

  CATAN: = O, meaning no 'B' category available from the SCS in this phase.

  All other data words to be the same as the normal incoming local DESTDATA table.
- ORDATA — SENDMETHOD-I, set to 5 as the FIR's are now connected to a direct controlled GIV.
- ROUTECODE — GUV-GIV route, SENDMETHOD: = 5 for direct control of GIV.

  — GIV-SLD routes, SENDMETHOD: = 2 for MFC control, and ROUTETYPE: = A to send an AI revertive.
- ESANO — restore, for ORCLASS: = 2 and SROCASE: = 6, comparison, resultant to normal data value.

Phase 5 — Direct Control of SL

This Phase was carried out on one 1000 line group at a time and the associated GUV and GIV routes to the SLD were changed, in TRS, from MFC to direct control as the 1000 line group was converted. To facilitate this approach the temporary analysis tables, as shown in **Fig. 1**, were established prior to Phase 1. This arrangement made the conversions easier to control, by restricting faults to within the 1000 line group and associated devices, and reduced the disturbance of service to a minimum.

One SLC/D rack was busied, and straps changed, the SM, KMR, KMT relay sets removed and the new ARE 11 KMR installed. The CD-KME plugs were inserted into the jackfield and the KME data 'written-in' the OMPDATA area of TRS. The SLC/D changes were carried out, before the SLM changes, so that the 1000 line group remained operative with traffic being handled by the remaining SLC/D rack(s). Preparing one SLC/D rack first allowed the 1000 line group to be converted to direct control immediately after the SLM rack(s) were converted.

The SLM was busied, straps changed, a new SLMS-K relay set installed, the existing 'C' wire cables from the SLA/B's removed and cables to the PBX 'C' wire IDF inserted in the same plug positions. During this time, outgoing calls could still be made, with reduced facilities, but incoming calls were not possible. Urgent incoming calls were diverted to an interception route, established off the GIV, by changing the SECROUTE word to address this temporary route. It was thus possible for the exchange staff to be informed of any urgent call so that the subscriber could be contacted if necessary.

The second SLC/D was then changed and the overall functions tested. Also at this time the PBX subscribers were tested by calls to each PBX directory number, within the 1000 group, to prove that each auxiliary line was seized, in the correct sequence, by blocking out each line in turn after seizure. This aspect of the cutover was very time consuming particularly in 1000 line groups with a high concentration of PBX numbers.

Data Changes — Refer to Fig. 1

- RECAN — change result of 'E' digit analysis, for particular 1000 line group being converted, to address normal RECDATA table.
- ROUTECODE — SENDMETHOD, was changed to 'C' for each, GUV-SL and GIV-SL, route associated with the 1000 line group being converted to direct control.
- BNRAN 1 — change result of 'E' digit analysis to address 'Continue Analysis' DESTDATA table.

Before all the 1000 line groups are converted the 'E' digit is used to determine the address of the 'continued analysis' DESTDATA table and is also required for analysis in GVAN table, for route selection, and the 'continued analysis' DESTDATA table is used to indicate that analysis is to re-commence at the 'D' digit (i.e. ANLOC = 2). This digit is analysed in BNRAN 1 to address the normal local DESTDATA table which contains the address to GVAN and indicates that B category information is now obtained from the SCS (i.e. CATAN = 1). All other, non converted, 1000 line groups have 'B' category determined in the KAN relay set.

- ROUTE LIST — SECROUTE word of 1000 line group being converted changed to point out Interception route temporarily.

Faults. The major number of the faults, found in this phase of cutover, were associated with the PBX equipment as this was the first opportunity to test this facility. Faulty printed circuit cards were found in the PBXE shelves and incorrect springset adjustments in the PBXC shelves. A software programme fault caused the PBX line test words to be set, blocking out the auxiliary lines, and has since been rectified.

A number of DIC printed circuit cards were found to be faulty, after each 1000 line group conversion, with a burnt out diode setting the tens digit word in the REA page to 'F'. The possible cause was commoning of tags, during soldering, when the SLM/S straps were being changed as insulating the adjacent tags during the latter 1000 line group conversions eliminated the problem.

Phase 6 — FIR-P Access

Until this Phase, the FIR-P circuits were connected to a REG-IP and so appeared as MFC junctions to the processor system. They accessed STU-I's via RAR relay sets strapped to address the same ORDATA information as all other MFC junctions.

In this Phase, after all the 1000 line groups were converted, the data in the ORAN table was changed to address the FIR-P, ORDATA table. The straps in the FIR-P were changed to suit the ARE 11 mode and the FIR-P connected to an RSI inlet to permit access to STU-I's. The RAR and REG-IP relay sets were then

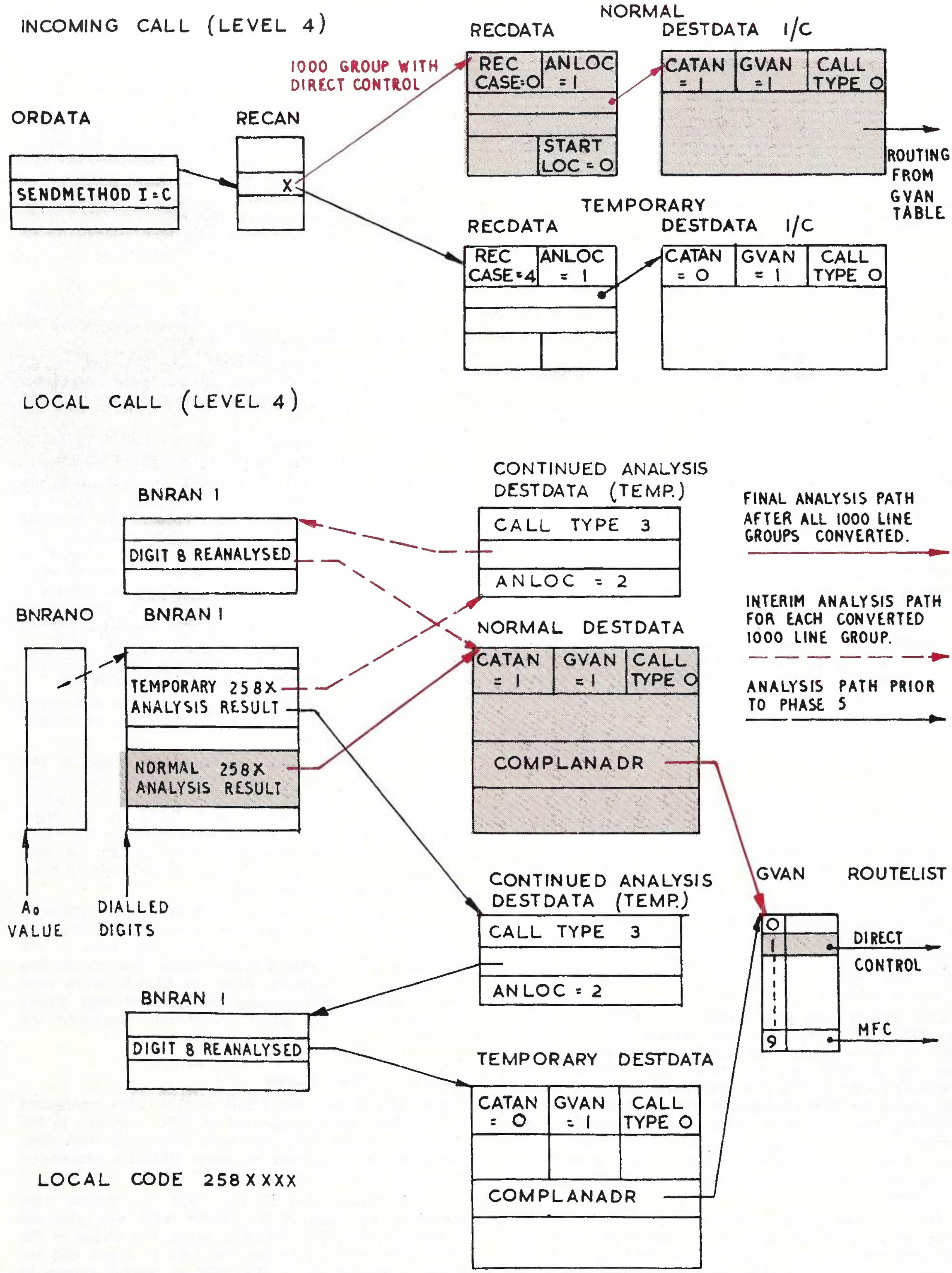

Fig 1 — Digit and Route Analysis

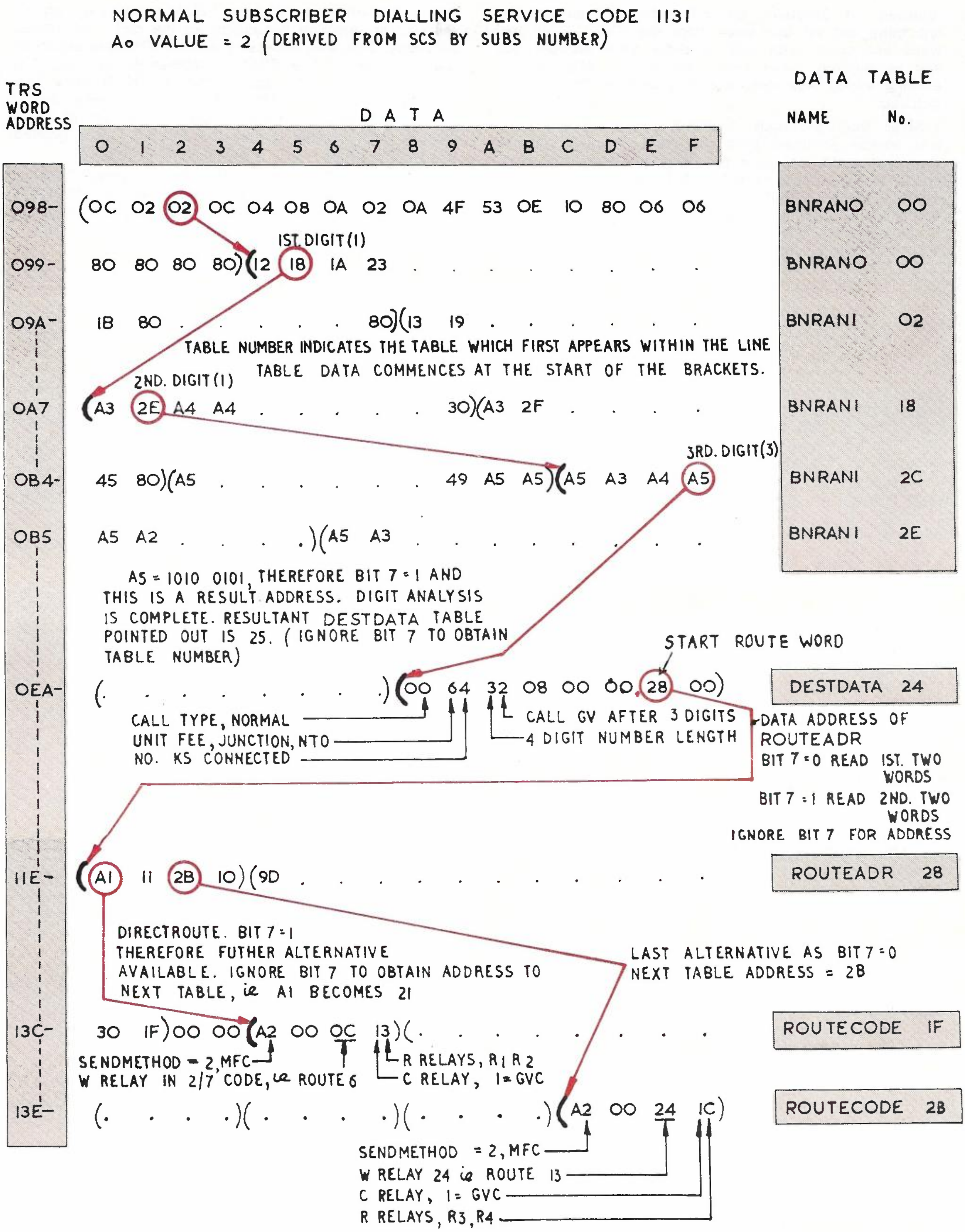

Fig. 2 — Phase 5 Analysis Changes

removed. At Salisbury, the FIR-P to IDF cabling did not bring out all the wires from the FIR-P. Only the wires concerned with ARF working were brought out and as different wires were required for ARE 11 the existing wiring was re-arranged to provide the required outputs.

Apart from the code '1100' FIR-Ps, incoming MFC test access junctions from the Fault Despatch Centre were converted. To cater for these junctions the associated RAR's were strapped to indicate a separate start address in the ORAN table to obtain ORDATA information. In ORDATA, the ORCLASS word was set to 'l' to address the ESAN O table, normally used for the incoming step-by-step junctions, and the fixed data in ESAN O changed to address ESDATA tables to specify the end of selection conditions for the MFC test access junctions. This was necessary as the TRS data assembly only allowed for four ESAN O tables, viz outgoing, I/C SxS, I/C MFC, FIR-P and a fifth ESAN O table was required to define the MFC test access junctions. As incoming step-by-step junctions were not in use at Salisbury, it was decided to use the ESAN O table pointed out by ORCLASS — = 1 as an interim solution.

When the TRS is re-assembled the additional ESAN O table will be incorporated and pointed out by ORCLASS = 4 so that the standard incoming step-by-step, ORCLASS = 1, ESAN O table can be re-established.

APPENDIX 2 — EXPLANATION OF PRINTOUT FROM TRS ASSEMBLER

The TRS data is presented in hexadecimal form and consists of two 4-bit words, numbered bit 0 to bit 7 from right to left, e.g. hexadecimal A5 = 1010 0101. Bit 7, in most cases, is used as a result indicator and, if set to '1', indicates that the analysis is complete.

In **Fig 2** the table numbers specify the first table that appears on that line and the extent of the table is defined by the brackets with data starting at the left hand bracket.

In the BNRAN area, zero numbering applies; that is the dialled digits are considered as numbering from 0 to 9.

The example shown in **Fig. 2** is for a subscriber, with a normal category, dialling Service Code 1131. The AO value is obtained by addressing the SCS with the last four digits of the 'A' subscriber's number, and is the BNRAN O table. The BNRAN O table consists of two ten word tables to cater for the 16 possible AO values with the spare words set to point out the first DESTDATA table to provide N.U. tone.

An unrestricted subscriber has an AO value of 2, so the third word of BNRAN 0 is the starting point, that is, TRS word address 0982. This address contains the data 02 which means that the first digit will be analysed in BNRAN 1 table number 02, which starts at TRS word address 0994 after considering the position of the brackets.

For the first digit (1) the second word of the table is pointed out and reads data 18 (= 0001 1000). Bit 7 = 0, so further digit analysis is required in BNRAN 1 table number 18. The second digit (1) addresses the second word of that table and the data reads 2E, (= 0010 1110) and again bit 7 = 0, so no result has yet been achieved. The third digit (3) dialled addresses the fourth word and data read is A5 (= 1010 0101). Here, bit 7 is set to one, digit analysis is complete and a result address obtained.

This 'B' number analysis result points out DESTDATA table 25, as bit 7 is ignored to obtain the table number. As indicated in **Fig. 2,** this table contains the data pertaining to code 1131, viz a normal call, unit fee junction, 4- digit number length and the STARTROUTE word which points out the address of the ROUTEADR table. Bit 7 of the STARTROUTE word is used as an indicator to start reading data at either the first or second two words of the ROUTEADR table. In the example, bit 7 = 0, therefore the starting point is the first two words of ROUTEADR table 28.

All ROUTEADR and ROUTCODE tables are four words long and frequently more data is required to define all the alternative routes available to the dialled code. This means that more than one table number is used and this needs to be considered when calculating the start point of the required table. The additional table used is never addressed. An example of this condition occurs when considering the start point of ROUTECODE table 21. The first two words in line, ROUTECODE 1F, are the last two words of table 1F, which has also used the first two words of table 20. The other words in table 20 are left spare and are shown as data 00. Table 20 is therefore not addressed and the next table 21 starts at address 13C4.

As shown the ROUTEADR table, number 28 has two routes, A1 being the direct route and 2B the first alternative. Here bit 7, when set to 1, is used to indicate the availability of a further alternative route. Bit 7 is deleted to obtain the ROUTECODE table number. The word following the ROUTECODE address defines which 'B' digit is sent first. (Zero numbering).

The ROUTECODE tables pointed out from the ROUTEADR data specify the send method, W, R and CR relays for each alternative route. The R relays, R1 to R4, correspond to bit 0 to bit 3 and a bit is set for each R relay required for the connection.

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Design Principles of a New Telephone Apparatus Measuring System — Part 2

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The examination of problems associated with the measurement of telephone apparatus for transmission quality assurance purposes is continued, leading to the enunciation of design principles for a new telephone apparatus measuring system for use by Telecom Australia.

ACCEPTANCE TESTING

A Pitfall!

We have seen that one of the advantages of testing telephones in production by speaking and listening, is the opportunity to pick up faults such as frying, distortion and instability. The convenience of having a single quickly obtained reading from an instrument, which immediately determines acceptability, has sometimes blinded us to the fact that major faults might be escaping our notice.

On one occasion a manufacturer's transmitter production line developed a carbon leakage fault; 100% of these transmitters were tested on the TET for resistance and efficiency before despatch; about 1% were discarded. Each week many more were being reported as noisy by customers. Hence a number of important principles arise:

- With experience gained from manufacture, the specification of a product should be amended from time to time to take account of production faults which may not have been expected when the product was initially designed.
- Each clause of the specification must be supported by a valid test procedure and suitable testing equipment.
- The extent of testing for any particular fault, i.e. 100% or less, should be related to the health of the production line in respect of that fault in the immediate past.
- It is essential that samples be taken at weekly or lesser intervals and dismantled and checked by experienced production staff to make sure that all processes are being carried out properly. The transmitter problem previously mentioned could have been found weeks earlier had this been done.

Even if some tests are destructive or difficult to carry out, no part of a specification can safely be ignored forever or dismissed under the guise of "type approval". These tests should at least be performed whenever approval to change the design, materials or method of construction is sought by the manufacturer. This has generally been the policy of Telecom Australia.

WRITING THE SPECIFICATION

In writing transmission specifications for telephone components, we are attempting to ensure that the complete telephone will function satisfactorily in the network, even under the worst conditions allowed by the planning rules. Originally these planning rules were experimentally derived from the performance of our primary telephone standards and limits were set which ensured reliable telephonic communication.

The actual acceptance values for production can be stated in a number of ways, which can have an influence on the performance of the manufacturer and of the network. The TETs R1A were set to show 0 dB equal to the mean of the Working Standard Handset calibrations. These were calibrated in terms of dB better or worse than the APO standard. It was required that the average of any batch should be higher than 0 dB and that no item should fall below a "worst sample" value. The difference between the two values was usually 1 dB for transmitting and 2 dB for receiving. The reason for there being two different values is no longer known; typically 1 dB represents about 1.4 standard deviations for both transmitters and receivers.

This form of specification ensures that the purchaser will theoretically receive no items below the worst sample value because the manufacturer will have to test 100% of his product to remove every substandard item. If even one such item turns up in the purchasers' test sample his entire lot will be rejected. It also requires a high degree of consistency between the manufacturer's and purchaser's TETs, if the risk of incorrect rejection is to be avoided. The manufacturer will probably safeguard himself by using a higher worst sample value in his own testing and set his price accordingly.

Current quality assurance procedures are based on statistical estimates of the risks to manufacturer and purchaser. They provide for the delivery to contain a small fraction defective and are based on sampling procedures. On the TET R3 the minimum acceptable value is usually adjusted to be 0 dB for the convenience of the testing officer.

This type of specification also makes considerable demands for consistency between testing stations. Errors may arise in the TETs, the product is subject to thermal drifts and instability — particularly the carbon transmitter. Testing officers have different ways of conditioning the telephone for test, and frequency response interactions, as discussed above, may ocur.

Electrical measurements on scaled instruments can be relied on to about 2% in factory conditions. With electro-acoustic devices 0.2 dB or roughly 2% represents very good accuracy. This may not be achieved when calibrations can only be carried out at half yearly or longer intervals. TETs R3 in good order can normally be held well within ± 0.25 dB of standard, i.e. two TETs could be 0.5 dB apart on occasion.

A typical standard deviation for transmitter and receiver production is 0.7 dB. If two testing stations gave readings 0.5 dB apart, one might show a sample to have a fraction defective of 0.5%, the other could show the same sample to have 3%. This would certainly create doubts about the acceptability of the batch.

To avoid doubts about the acceptability of a sample tested on two different instruments, it is necessary that the errors in the instruments be much less than one standard deviation of the sample.

To achieve consistency between TETs is therefore not a simple problem and considerable care must be taken to ensure their correct use and regular calibration.

A third method of specification has been adopted by L. M. Ericsson. The average value for a sample must lie within fixed limits and the maximum standard deviation is specified.

It is of interest to consider what effect such a specification might have. In order to keep his standard deviation low, the manufacturer will have to carefully control accuracy of his piece parts. This must result in a better quality product. The tolerance for the mean allows for long term variations due to raw material and seasonal and other variations beyond his control. It also relieves the designer of the test equipment from having to provide a degree of accuracy and reliability which strains current technology. From Telecom Australia's point of view there is much to be said for such a specification.

TEST SIGNALS AND ARTIFICIAL VOICES

Many different methods have been proposed for the generation of a speech-like signal for telephone testing. A comprehensive technical discussion would require an article on its own. For our present purposes they may be divided into three general types:

- A sine wave swept over the required frequency range in a rhythmic manner.
- A saw-tooth wave, similarly swept.
- A random noise source.

The frequency range considered necessary has varied from 600 to 1600 Hz in the earliest days to typically 200 to 4000 Hz today.

Apart from stability and ease of generation, each type of source has certain advantages. The necessity to closely resemble the characteristics of speech has often been discussed, however for factory testing, where ensuring uniformity of the product is the major requirement, relatively simply generated signals have been considered sufficient. In the laboratory, where it is desired to simulate subjective testing by objective measurements, these other considerations are highly significant.

The swept sine wave was the earliest type of signal to be used. At sweep rates up to about 1 Hz it is possible to use a reference microphone and feedback loop to control the signal to an artificial voice to ensure that it gives a constant acoustic output at all frequencies. Artificial voices may be constructed using small commercial quality loudspeakers on this principle and it is claimed by a typical manufacturer that the response can be maintained within ± 2 dB from 200 to 4000 Hz.

This sweep rate also lends itself to displaying the frequency response of the product on an oscilloscope. At this rate, a reasonably accurate presentation of steady-state response can be expected, depicting the resonances in typical telephone transducers.

A disadvantage of a low sweep rate is that the output meter follows the frequency response of the telephone under test. This makes it difficult to determine the average reading and special rules have to be devised.

If the artificial voice is equalised, instead of regulated through a feedback loop, a faster sweep rate may be used and a steady and unequivocal reading obtained. A reliable frequency response display will not however be obtained with telephone components having sharp (i.e. high Q) resonances.

A swept saw-tooth wave was used in the TET R1A, chiefly because it could be easily generated electronically. A motor driven capacitor was used in the early BPO TETs in a beat frequency oscillator circuit and it was desired to avoid mechanical equipment for maintenance reasons. The saw tooth wave had no special advantage apart from this and it proved to be difficult to obtain good frequency stability.

Band-limited Gaussian random noise has been used, but the meter reading tends to be too unsteady for the operator to obtain any real precision unless a long time constant averaging voltmeter is used. Pseudo-random-noise, provided a suitable repetition rate is used, also gives a reasonably uniform spectrum and has the advantage of giving completely steady meter readings with meters with typical mechanical time-constants. Care must be taken however, that every component of the testing circuit can adequately handle the fairly high ratio of peak to rms voltage associated with noise signals.

Noise sources require the use of an equalised artificial voice. TAMS-4 will use a pseudo-random noise source.

REFERENCE EQUIVALENTS FOR PRODUCTION TESTING

When making Reference Equivalent measurements subjectively, the observer attempts to ignore all other factors except loudness. The reference system has inherited from its early days a considerable high frequency peak and transmits a wider band than a typical telephone. This makes it sound very different to the telephone circuit under test and produces some bias in the observers' decision.

When Dr. Braun in 1940 developed measuring equipment to simulate the results of subjective Reference Equivalent measurements, (Ref. 9) he inserted a network having an inverse characteristic (known as a SFERT Filter) between the oscillator and the artificial voice to correspond to this high frequency bias (See **Fig. 13** Curve a). He also gave the spectrum an effective speech weighting by using a logarithmic frequency/time sweep (Curve b). The combined effect of these two characteristics (Curve a + b) has a marked effect on the assess-

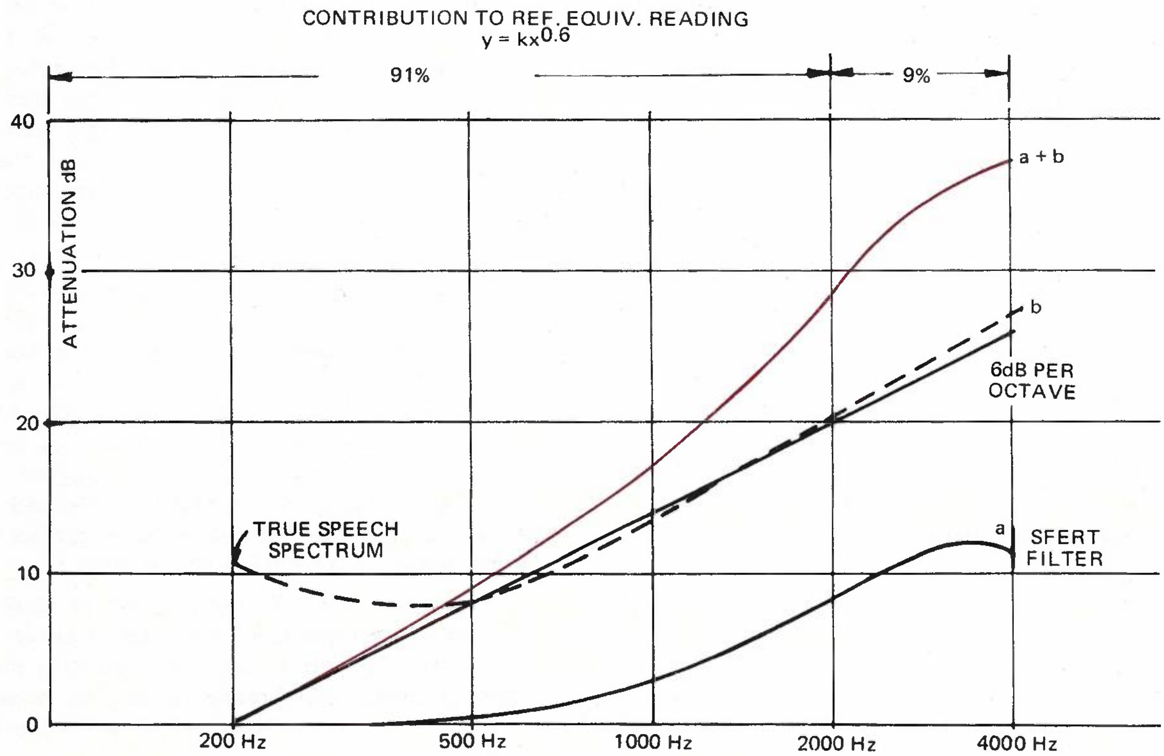

Fig. 13 — Effect of Weighting on Transmitting Reference Equivalents.

ment of transmitters. It can be shown that if all the frequencies above 1500 Hz were removed, the effect would only be a 1 to 2 dB change in reading for a typical No. 13 transmitter. Receivers are measured with a speech-weighted signal, but without the SFERT Filter. His instrument in principle survives in the modern Bruel and Kjaer Electroacoustic Measuring System, which is in use throughout the world.

The performance of transmitters and receivers is affected by variations in their basic components, e.g. carbon granules, magnet strength, diaphragm stiffness and acoustic networks. The effect of such variations may be more marked at high frequencies and therefore not show up in a Reference Equivalent measurement.

Also in the production testing of receivers it is often difficult to obtain a consistent seal to the artificial ear. The effect of this is to cause a spread in Reference Equivalent readings which while relevant to subjective loudness performance, does not assist product quality assessment.

For these reasons, and to preserve continuity with our past methods of test and specification, TAMS-4 will use an unweighted spectrum for the measurement of broadband sensitivity. This measurement, when made in a telephone circuit, is commonly known as "efficiency" in Australia.

In those countries where objective reference equivalent measurements are used to control production, it is considered essential that a frequency response check must also be made of every sample tested.

MEASURING FREQUENCY RESPONSE

There are two basic methods for production control of frequency response which have briefly been mentioned above, namely by oscilloscope display and narrow band analysis.

The first technique requires a swept sine wave source, the sweep rate being sufficiently low for resonances in the product to be correctly displayed. It is usual to display the logarithm of the amplitude of the response vertically, i.e. in decibels and the

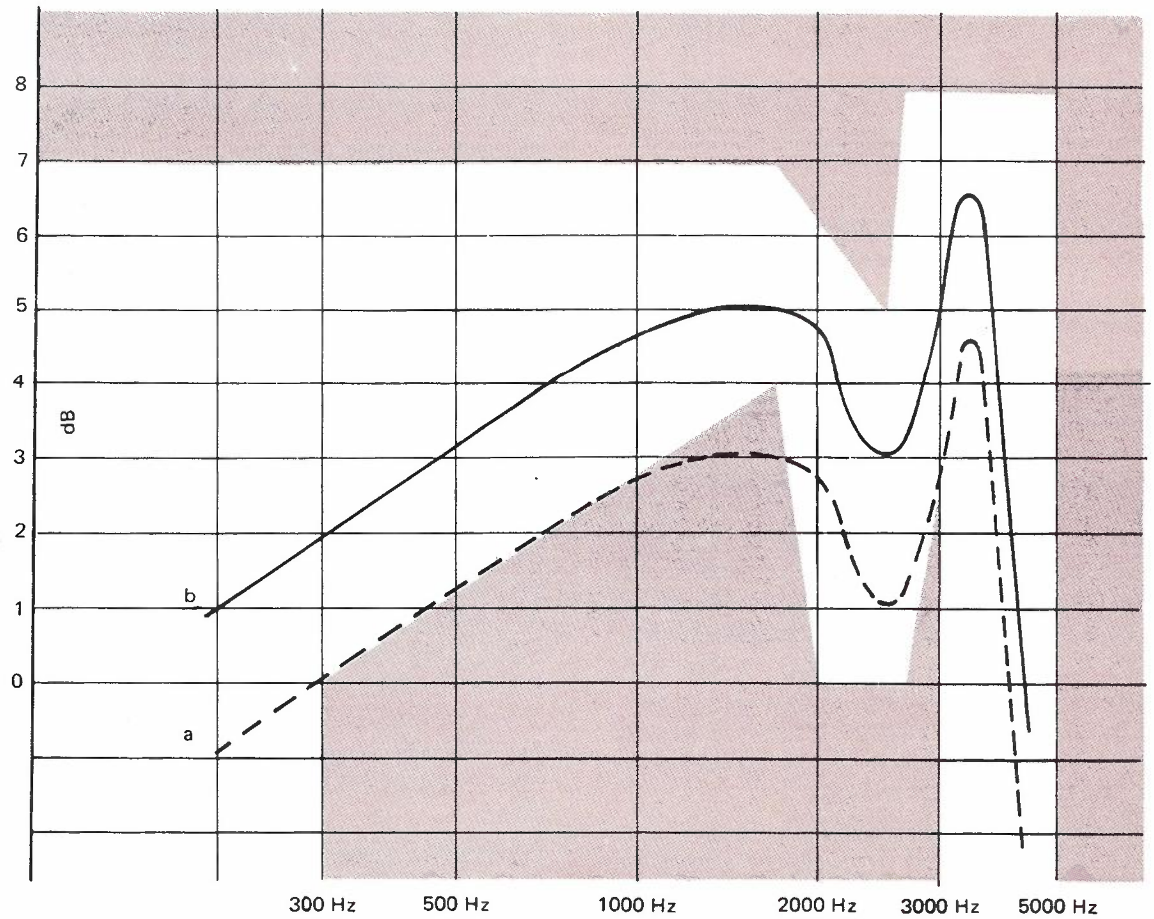

Fig. 14 — Typical Frequency Response Target for 4T Receiver.

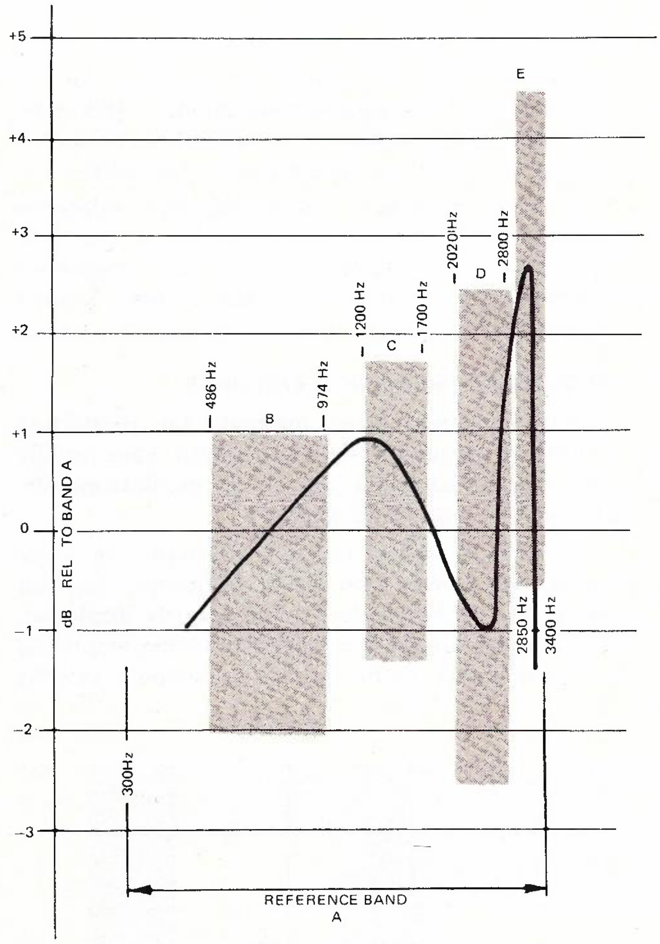

Fig. 15 — Typical Band Response Specification for 4T Receiver.

logarithm of the frequency horizontally. A target diagram (see **Fig. 14**) is attached to the face of the oscilloscope. If the trace transgresses the target, the sample is rejected. If the target is to give a meaningful assessment of frequency response it is necessary to remove sample-to-sample variations in mean sensitivity from the display. Curve a of Fig. 14 illustrates a response which would be acceptable if moved upwards to position b. It is usual to provide the operator with a gain control in the vertical input to the oscilloscope to enable this to be done.

Production engineers have noted, that in fact, operators seldom adjust the control and make a guess to save time. A further criticism is that unskilled staff have difficulty in describing how a particular sample has failed this test.

The second technique uses a number of band pass filters with cut-off frequencies strategically placed to control critical portions of the response. The choice of frequencies is usually guided by known problems which may arise in the construction of the item. The BPO for example control the response of 4T receivers by means of four such bands. (See **Fig. 15**). The bands are presented sequentially and read on a voltmeter marked with coloured bands corresponding to the maximum and minimum values permitted for each band.

The advantage of this method is the unequivocal nature of the readout and the ease with which a failure can be described. The disadvantage lies in the possibility that quite large variations of response can be accepted within each pass-band. This problem diminishes as the number of filters is increased, but this increases the cost of the instrument and can complicate the readout.

For TAMS-4 a six band tester has been designed. The effect of sensitivity variation is removed by comparing each band with the total band response. Each filter's output is shown by a display of three vertically arranged light emitting diodes. The top LED indicates "failed high" (red) the bottom "failed low" (red) and the middle "pass" (green). The six displays are arranged side by side and the operator can see at a glance that the sample is acceptable by a straight line of six green lamps.

Neither type of measurement is completely adequate. The use of band testing in production, backed by laboratory frequency response tracing, is thought to provide the best solution.

CHOICE OF TEST CIRCUIT

Some administrations measure transmitter and receiver efficiency in simple non-reactive circuits. This allows a close control of the components to be obtained and the test conditions are easily reproduced from place to place. This may become an issue when buying from overseas.

Unfortunately telephone components interact with practical telephone circuits quite markedly. Impedance, frequency response and d.c. interactions occur. As a result, components have been known to be acceptable in the simple circuits, but give significant failure rates in complete telephones under limit line test conditions. This is troublesome to a manufacturer, but is even more aggravating if allegedly satisfactory components give rejections when sold to another manufacturer, or are used on a reconditioning line.

It is current Telecom Australia practice to measure the efficiency in practical limit line conditions and use simple non-reactive circuits for frequency response.

TESTING A COMPLETE TELEPHONE

A complete telephone contains a number of separate components, each of which has its own performance variance. Assuming random assembly, the variance of complete telephones can be expected to show the statistical summation of these variances, plus the effects of the interactions mentioned above.

In addition some items, e.g. transmitters, have a legitimate range of 5 dB, whereas the transmitting performance of correctly assembled induction coils seldom exceeds 0.2 dB. Clearly, reliance on a final transmitting test of the whole telephone would give virtually no indication of large and potentially serious faults in induction coil performance.

It is nowadays considered good practice to rely on careful control of the quality of components and subject the final assembly only to a functional test. This demonstrates that components of assured quality have been assembled without damage and that all of the circuit connections have been correctly made. Test limits for complete telephones may still be required for audit purposes and on the reconditioning line, but the main emphasis should be on producing good quality components.

SOME HUMAN FACTORS

It has been a convenient assumption in quality control that the test equipment is sufficiently accurate and its operator sufficiently reliable for both to be ignored. We have, to some extent, examined the first factor; the second is now being seriously questioned by some overseas writers. (Ref. 10).

A peculiarly difficult problem arises with the No 13 transmitter. Because of its flat parallel electrodes and partially filled carbon chamber, it is very sensitive to the manner in which it is conditioned prior to reading its efficiency.

A trained operator taking ten successive readings may obtain a standard deviation of about 0.7 dB, corresponding to a possible range of 2 to 3 dB. On the production line three readings are required to be taken. The first is discarded, as it has been found to often be atypical, especially after a period in storage. It can thus be seen that the confidence limit of the result is relatively large for a single sample. Fortunately, the mean of a sample of 20 or more transmitters can usually be repeated after 24 hours to within 0.3 dB, although individual transmitters often shift considerably.

Much thought has been given to mechanical means of conditioning carbon transmitters. However, the requirements of speed, reproducibility and freedom from the effects of vibration and the behaviour of the operator are very difficult to meet. The most essential feature appears to be strict control of the manner in which the transmitter is brought to rest in front of the artificial voice. The current technique of conditioning by hand in a test handset, if correctly followed, has to date proved the most satisfactory for production testing.

Receiver measurements are less sensitive to operator performance. Here the most important factor is the seal between the artificial ear and the receiver cap. If the operator does not hold the receiver firmly and flat on the ear, small leakages may occur which can cause errors of 1 dB or more, through Helmholtz resonance effects.

Another source of error arises from over-hasty reading of the TET voltmeter. As a consequence of the leisurely rise of meter reading, operators under the pressure of an all-day repetitive task have been observed to estimate the chance of the meter passing 0 dB, rather than wait until they are sure. They are also under some stress when they get a marginal failure. To cause a transmitter to pass it may be shaken harder and tested again a few times until it does pass.

The danger of these practices lies in the possibility of producing more than a statistically permissible fraction defective in the batch. Subsequent audit sampling, done under more critical conditions may result in the batch being rejected. It is felt that production line operators should not be subject to these stresses and that the test equipment should give unequivocal pass or reject decisions. Consequently, TAMS-4 will be provided with an interchangeable voltmeter and Go - No Go Indicator, the latter normally being used on the production line. An analogue of the voltage reading will be available from the indicator for processing by computer if required.

A further advantage of the indicator is that for many tests, automatic step-on to the next test is possible, as soon as a pass indication is given. This can be used to speed testing and lighten the operator's task.

While it is desirable to reduce the stress on the operator and minimise physical movements, it is realised that the operator must be able to control the equipment and make real decisions, otherwise he or she may become bored or dehumanised.

Production engineers have also pointed out the need for maintaining operator alertness. With a healthy production line, the number of failures seen may be less than 1%. It has been observed that operators become so conditioned to seeing successes, that they do not respond to a failure when it does occur, and may put the faulty item into the box of good ones.

In TAMS-4 it has been arranged that the equipment will stop stepping whenever a test is failed. If it is appropriate to complete the test run, a "step after fail" key may be used, which will light a display to remind the operator that the sample has failed one or more tests.

A NEW APPROACH TO ACCEPTANCE TESTING

As has been said previously, every part of a specification should be applied to a product, but in proportion to the known likelihood of a fault occurring. This is not convenient with the present TETs with their fixed test sequence.

Currenly under development is a test equipment controller which enables this to be done. Take, for example, the testing of a new active transmitter. Certain tests might be considered mandatory, e.g. limit line efficiency and operation on reversed voltage. The controller can be programmed so that every sample is subjected to these tests. On the other hand, faulty insulation to frame might be highly unlikely, but the test, if failed, might indicate that some damage was occurring during assembly. Tests such as this can be programmed at a lower level, i.e. only every *n*th sample would receive the complete range of possible tests. The value of *n* can be set anywhere between 1 and 100 at will.

This technique ensures that no test which can be performed by the tester, can be overlooked long enough for large quantities of faulty items to accumulate, or worse still enter the field. Any test which is failed at the lower level can be reverted to the 100% level until the product becomes healthy again, by simply inserting a diode pin in a matrix board.

Means are also provided for permanently marking tests to which every sample is to be exposed so that these tests cannot be removed on the production line. The reason for making *n* completely variable and under the production engineer's control is to avoid the problem of testing say every 10th sample and discovering later that the 9th cavity of a 10 cavity die was producing a faulty item which never became the one tested. The value of *n* should be set, so that it differs from any cyclic factor in the production line as it stands at the time.

MAINTAINING ACCURACY IN THE FIELD

The TETs R1 were hard wired, rack mounted instruments. Repairs and modifications were generally carried out in situ by local staff. As a result many additions and modifications occurred, some of which interfered with their accuracy.

The TETs R3 were designed so that each individual panel or item could be readily unplugged and returned to a TET Calibration Centre when required. As a result much better accuracy has been achieved and faulty items can quickly be replaced. The electrical accuracy of the instrument can be verified by local inspecting Officers, but the Artificial Voice and Ear are still dependent upon acoustical standards held by the Calibration Centre. Where a number of these items exist in the one State, intercomparison is used as a means of detecting a maverick. It is considered undesirable that these items should have to travel long distances by air, after they have been adjusted, therefore it is planned for TAMS-4 to make use of relatively inexpensive acoustic calibrators, which will derive their calibration from a group of capacitor microphones held in each Inspection Laboratory. In this way it will be possible to acoustically standardise the TAMS-4 testers daily if necessary.

The Inspection Laboratory standard microphones will be periodically checked against primary standards in the Calibration Centre. Cross-checks with similar acoustic standards in universities and other local laboratories should also be feasible. This was not possible when the TET R3 system was set up, there being no primary acoustic standard in Australia at that time.

The role of the Calibration Centre in the future is envisaged as providing basic standards, maintenance facilities and oversight of the installations.

TAMS-4, A FLEXIBLE DESIGN

With the TETs R3, their facilities could only be extended by adding on extra panels, as new types of telephones were introduced into the network. Realising that a testing system is an evolving thing, TAMS-4 has been given a modular basis. Each module is designed so that it can readily be modified or replaced when this becomes necessary. Also, the content of the modules has been kept relatively small, to minimise the cost of making such changes. The modules can be assembled to meet the requirements of individual production lines and laboratories in a variety of different ways.

Means have been provided for altering test programmes readily, particularly the acceptance limits. It is sometimes necessary to allow temporary concessions to a manufacturer, particularly if problems with raw materials and processes occur. So far, for development purposes programming has been by diode-pin matrix boards. (The system is such that alternative methods may be readily substituted. It is envisaged that hard wired logic will be used on long run dedicated installations and some form of electrically alterable solid state memory where frequent re-programming is required, for example in the Inspection Laboratories.) To ensure that pins are correctly inserted, punched overlay cards may be used. In the case of acceptance levels these cards can be issued by the Inspecting Officer and signed and dated. A tester would then be considered invalid if the card was missing or any hole was unfilled. With the TET R3, there is some difficulty in measuring to relaxed limits, in that 0 dB is no longer the pass value and the operator has to remember a figure of merit.

In quality assurance and inspection laboratory environments, there may be a need to reprogramme the TAMS-4 testers for samples of several different products within the space of a day. Provision is being made for a number of programmes to be stacked.

CONCLUSION

In these two articles we have looked at some of the problems of telephone testing and seen how with improvements in technology more effective instrumental methods have been evolved. Nevertheless in some areas, especially in the field of acoustic standards, precision is still relatively difficult to obtain; but alternative methods of specification would be advantageous in reducing the problems arising from this and other inherent errors in testing.

Where choices of technique exist, there is seldom a clearcut answer. For TAMS-4 we have tried to adopt solutions which do not break too much with our past, using simple tests in production, backed up by more complex testing in the laboratory.

TAMS-4 is offered as a flexible system, adaptable to different environments, capable of evolution and and more easily kept accurate than its predecessors.

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R.W. KETT is at present employed as a Class 3 Engineer in the Customer Apparatus Section of the Telecom Australia Research Laboratories. (See Vol. 27 No. 3 page 206)

The Brisbane Terminating Trunk Tandem Exchange

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This article outlines the background for the need to develop a temporary trunk switching tandem exchange in the Brisbane Trunk Network. It describes, the unique design of the Terminating Trunk Tandem (TTT) using two switching disciplines, the resulting necessary equipment modifications, and finally the installation of the Brisbane TTT.

INTRODUCTION

The Brisbane Terminating Trunk Tandem (TTT) has now been working successfully in the Brisbane trunk network for three years. The TTT and its sister exchange the Brisbane Originating Trunk Tandem (OTT) were originally conceived as a temporary expedient to provide originating and terminating trunk traffic relief for the Brisbane ARM, then at full capacity, until the Brisbane No. 2 SPC 10C trunk Exchange at Woolloongabba was brought into service.

When the SPC 10C exchange is commissioned in 1978 Brisbane will be served by the ARM and 10C working as Co-Main trunk exchanges. At this stage the TTT exchange will become redundant and the equipment will then be recovered.

Because of the temporary nature of the terminating tandem and hence the requirement to terminate and switch four wire trunk circuits cheaply the TTT has a unique trunking which combines two different switching disciplines in the one machine. The combination involves the use of ARM register control equipment combined with a three stage ARF group selector stage. The equipment modifications to allow the successful interworking of ARM and ARF equipment were designed in Brisbane by the local installation staff in Metropolitan Installations No. 2.

The initial TTT installation of 480 inlets was brought into service in November 1974 and it has since been extended twice to the present capacity of 960 inlets.

BACKGROUND PLANNING ASPECTS

Projected Trunk Traffic Growth

In 1971 Queensland, then equipped with a single Main Trunk Exchange in Brisbane was experiencing a period of relatively stable growth in trunk traffic. The state could look back on a six year period with an average annual compound growth rate in trunk calls of 10.5% and also look forward to a projected compound growth rate of 10.4% up until the year 1980.

Late in 1971 an estimate was made that at June 1977 Brisbane would have a requirement for 10,800 trunk switching terminations to handle originating and terminating traffic associated with the trunk grid. This requirement was made up 5,100 trunk terminations, 4,000 network terminations and 1,700 terminations associated with the AFG Cordless Manual Assistance Exchange.

The switching capacity of the existing ARM Trunk Exchange was 7,600 terminations (4,000 inlets and 3,600 outlets) with no option to expand; this left a shortfall of 3,200 terminations if the projected requirement of 10,800 terminations was to be met.

The Tandem Proposal

As the 10C Brisbane No. 2 trunk exchange was unlikely to be in service in 1977, it was therefore proposed to overcome the termination shortage by establishiing over a 24 month period two two-wire tandem switching blocks with the purpose of switching as much trunk traffic as possible in and out of the network clear of the ARM. In the early planning stages the two tandems were known as the Trunk X and Trunk Y tandems, however common usage changed the names to the more descriptive Originating Trunk Tandem and Terminating Trunk Tandem.

The above proposal formed the basis of Amendment No. 5 to the Brisbane Metropolitan Plan submitted by the State to Headquarters in November 1971. Approval in principle was received in March 1972 and design work on equipment modifications commenced in Queensland Construction Branch.

TTT DESIGN CONSIDERATIONS

Early Trunking Options

The TTT by reason of its relative position in the trunk network was required to switch incoming circuits directly to terminal exchanges in the Brisbane area and as an ultimate objective the trunking called for final routes to all metropolitan terminal exchanges in accordance with the National Transmission Plan.

The initial trunking envisaged an installation of 640 inlets and a three-stage GV stage with an outlet availability of 1,000. The exchange was to grow ultimately to a capacity of 1,000 inlets and 1,000 outlets.

The Brisbane metropolitan area consists of the Brisbane Inner Telephone Zone (BITZ) and the Brisbane Outer Telephone Zone (BOTZ). In the Brisbane Outer Telephone Zone network, the objective of final routes to all terminals was found to be uneconomic and not practical. This was because terminating STD traffic offered to ARK521s, 511s and APO "B" and "C" type exchanges in the zone was very small and necessitated provision of many small inefficient routes from the TTT to these terminal exchanges. Since the TTT was only a temporary facility it was decided to tolerate a violation of the National Switching/Transmission Plan and adopt a non-standard trunking method of trunking outlets of this tandem to inlets of local network Y tandems. The TTT design was therefore modified to provide high usage routes to all BOTZ ARF Terminals with traffic overflowing on final routes to Metropolitan 'Y' tandems. Small terminals would be served solely via the 'Y' Tandems. The size of the initial installation was then reduced to 480 inlets and a three stage GV stage with an outlet availability of 700. The inlets were to cater for routes from Sydney, Melbourne and from Queensland ARF Terminals, Minors and Secondaries.

Selection of a Register

Two types of register were investigated for use with the exchange. It was desirable to be able to perform number length (NL), type of terminating exchange (TOTE) and waiting place (WP) analysis in the TTT for terminating trunk traffic in order to free distant centres from performing Brisbane numbering analysis. This would have been a daunting prospect with the Brisbane plan to convert from six to seven digit working in 1975-76.

The first register considered was the then new two wire terminating register REG-Y1LP. This register is capable of all necessary analysis and is able to work into the same GV stage with the same signalling scheme as REG-LP, also it could share the common register equipment such as analysers, decadic senders and Multi-Frequency Code (MFC) senders in an existing LP installation. However information concerning the design and delivery of this register indicated that it was too late for the TTT.

Another alternative was the REG-Y1LM, a two wire MFC terminating register which had been installed in Melbourne tandems. This register was unsatisfactory in that it was considered an obsolete type which, when recovered, would find no use within the network and it was undesirable to purchase a relatively large quantity of equipment which would have no recovery value after only a few years life.

Use of an ARM Register

With no suitable two wire terminating MFC register available consideration was given to using the four wire ARM type register REG-Y1. Use of this register dictated that incoming routes would be four wire ARM routes with LME T pulse signalling terminated with an ARM type incoming relay set.

The Final Solution

The trunking of the TTT **Fig. 1**, can be considered as two separate parts, a four wire ARM exchange with no switching stages followed by a two wire ARF tandem which provides the interface between ARM circuits and terminal exchanges in the network.

The incoming line relay set used in the ARM section is the FIR-TM-Y1 which has access to REG-Y1 registers. The REG-Y1 is connected to a code-sender relay set KS via a code-sender finder stage SS and to an analyser AN via an analyser finder RA. In an effort to offset the cost of establishing a second group of analysers with full Brisbane ARM analysis capability to be used just by the TTT, it was proposed that registers in the TTT share analysers already existing in the ARM.

Having only one incoming analysis point for terminating trunk traffic has considerable administrative advantages during a complicated network upheaval such as the six to seven digit conversion which was planned for Brisbane during the life of the TTT. The proposal that the Tandem use the ARM analysers depended on both exchanges being physically close together. This was satisfied by the TTT being located in the same building and two floors below the ARM.

For 'incoming' international traffic the FIR-TM-Y1 has the facility to connect via an SNR-LM-ES a terminating end half echo-suppressor ES(B). The TTT, unlike the ARM, is not equipped with echo-suppressors and the REG-Y1s in the TTT send a revertive signal to the Pitt 10C exchange in Sydney indicating this terminating state and requesting the

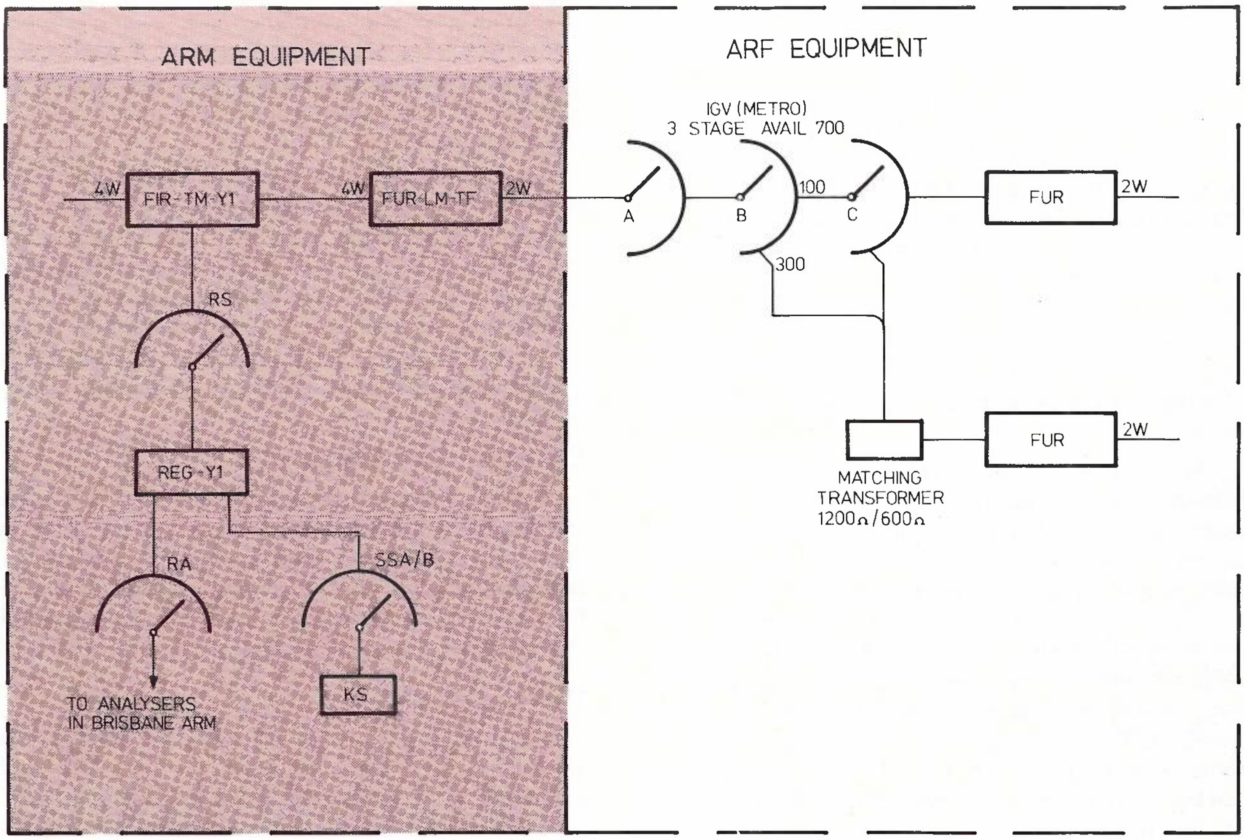

Fig. 1 — TTT Trunking Diagram

10C to leave its ES(B) in circuit. The ARM REG-Y1s on the other hand signal back that local echo suppressors are available in the ARM and that the 10C ES(B) should be switched out of circuit.

The FUR used as the outgoing line relay set of the ARM equipment is the FUR-LM-TF which provides interfacing between the ARM and ARF sections. It converts four-wire to two-wire for connection to ARF equipment, and also gives a 600 ohm to 1200 ohm impedance transformation.

In ARM trunking each FIR may be connected to each FUR through ARM and usually the FIR-TM-Y1 would be connected to the FUR-LM-TF by switching through the GIA/B and GUA/B stages. Control of the switching equipment is effected by a route marker and associated relay sets. For the TTT, no GIA/B or GUA/B switching stages are used. Each FIR-TM-Y1 is hard-wired to one FUR-LM-TF and has access to no other FUR-LM-TF. Thus no route marker or marker equipment is required to connect the FIR-TM-Y1 relay sets to the FUR-LM-TF relay sets.

The REG-Y1 receives signals via an FIR-TM-Y1 on an ARM route, analyses the signals using an AN relay set, and signals forward in a form suitable for ARF equipment via an FUR-LM TF. To enable the REG-Y1 to function without a route marker connected to it, the REG-Y1 must be given appropriate responses when the route marker is called. The method of accomplishing this is described in a later section.

Following the FUR-LM-TF relay sets, ARF group selector stages 1GVA/B/C are then used to direct the various Brisbane codes to the required outgoing routes. The REG-Y1 signals forward in MFC to the GV-KMR to control the switching of the 1GV stage.

Four types of outgoing line relay set are used following the 1GV stage, FUR-LF-W to circuits within the same building, FUR-L1F-L, FUR-TF-C and FUR-T5F-C.

The TTT has been nominated as a 1200 ohm exchange, therefore incoming carrier circuits require a 600/1200 ohm matching transformation. This is provided in the FUR-LM-TF as mentioned previously. Outgoing circuits to terminal ARFs using loaded cable (1200 ohm) do not require matching, however circuits using unloaded cable (600 ohm) require 1200/600 ohm matching as do circuits to exchanges within the Edison building.

Operation of Reg-Y1 Without Route Marker

In ARM trunking the REG-Y1 is connected to a route marker VM by a relay switching stage RM. When the analyser AN has been called and information about number length and type of terminating exchange has been received in the REG-Y1, the VM is called. The REG-Y1 transfers to the VM the digits which are necessary to decide the traffic direction and the tariff. When the VM has received this information it switches the selector stages of the ARM to a free line in the required direction, interworking with the test block TB and marker M. From the VM the REG-Y1 receives indications about:

- the way in which the digits are to be sent over the outgoing line; MFC sending, decadic pulsing
- the place at which digit sending begins.

When the VM, M and TB have completed their functions, the REG-Y1 receives a ready connection signal from the VM and releases the VM.

For the TTT there are no ARM switching stages and hence no VM, M and TB. However, the REG-Y1 still requires the information normally provided by the VM to enable it to operate. For the TTT, when the REG-Y1 tries to call the VM, the only responses required for the REG-Y1 are a ready connection signal followed by—

- sending of MFC over the outgoing line (to the ARF GV stage of the TTT)
- use of a P1 start for digit sending

By providing these responses, the REG-Y1 is made to believe that it has been connected to a VM and received instructions from the VM, then it releases the imaginary VM and continues as in an ARM exchange.

All the above responses are provided by very simple, minor additions to rack wiring for the REG-Y1 and FUR-LM-TF. No relay set modifications were made.

EQUIPMENT INSTALLATION

The TTT was constructed at one end of the third floor of the Edison exchange building in Brisbane. The initial installation of 480 inlets commenced early in 1974, about two years after the original idea was conceived, and cutover into service in November 1974. The 'first in' installation has now

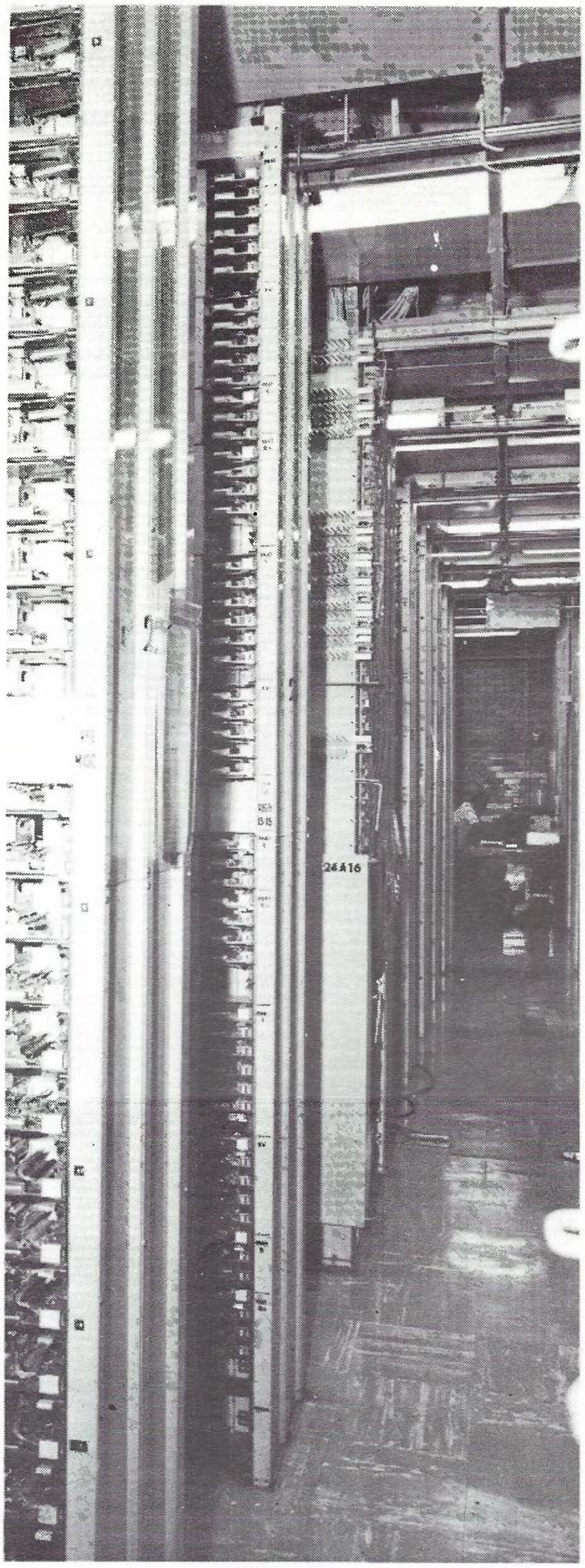

Fig. 2 — Terminating Trunk Tandem Equipment

been extended twice to a total size of 960 inlets. The first extension of 320 inlets to 800 inlets was commissioned in March 1975 and the second extension of 160 inlets to 960 inlets was commissioned in June 1976.

Equipment Layout

The overall layout of the tandem covers 14 suites which would allow expansion if needed to approximately 1,900 inlets. At present the tandem

INLETS 1-60

REG. MISC	REG 1	FUR 31-60	FIR 31-60	RS-1	FIR 1-30	FUR 1-30
REG 2	REG 3	FUR 61-90	FIR 61-90	RS-1	FIR 91-120	FUR 91-120

INLETS 61-120

Fig. 3 — 120 Inlet Module

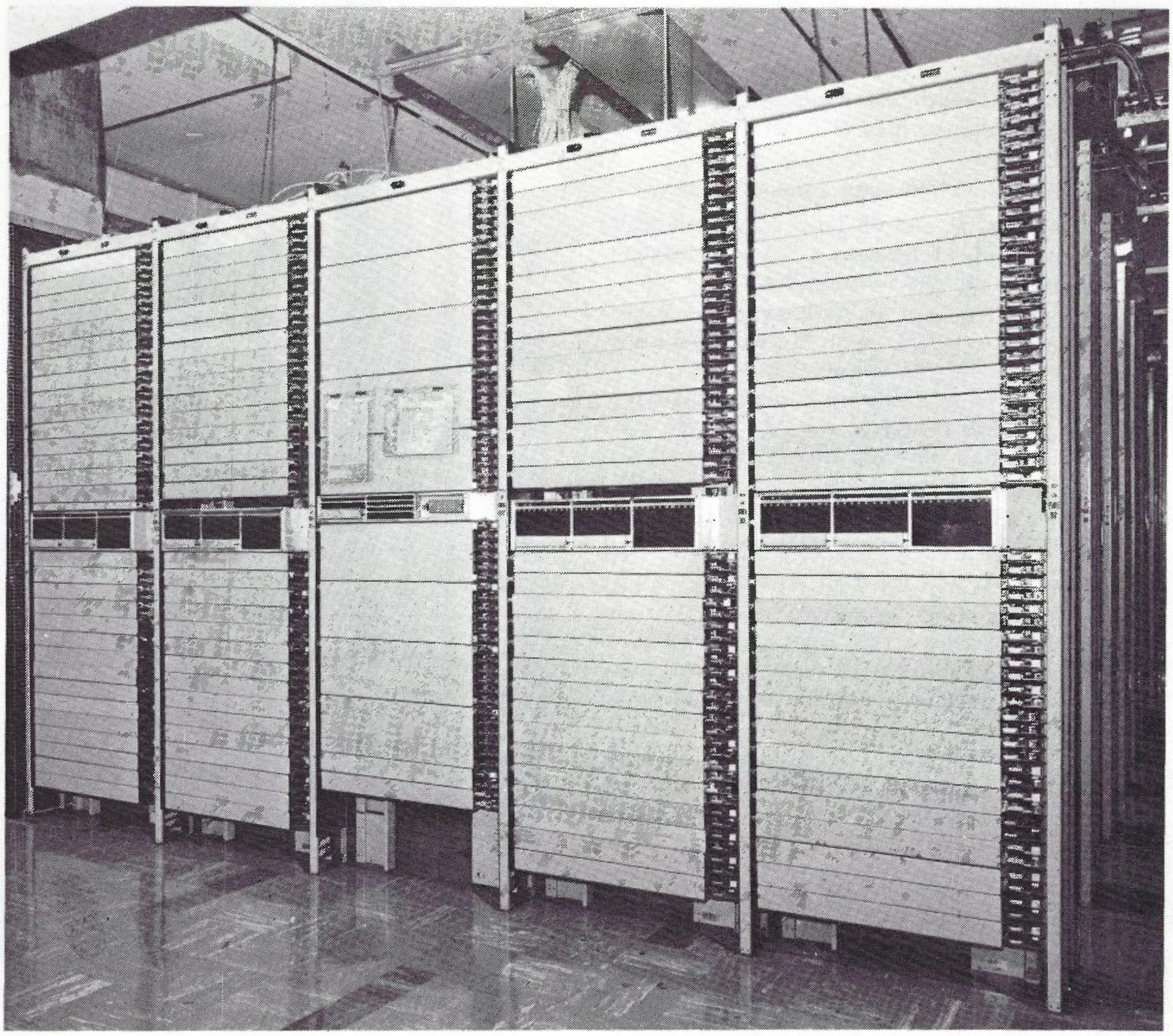

Fig. 4 — 120 Inlet Module and Reg-Y1 Racks

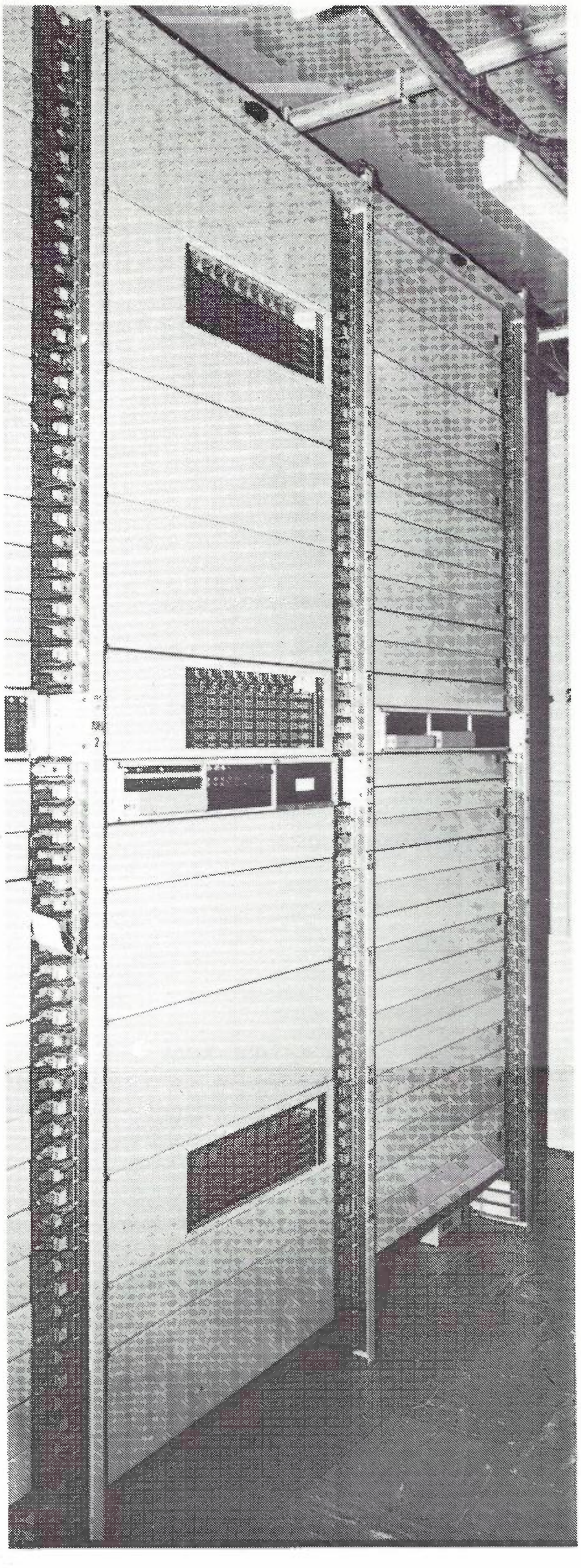

Fig. 5 — Reg-Y1 and Reg Miscellaneous Racks

at 960 inlets occupies 9 suites (see **Fig 2**). The ARM equipment (FIR, FUR, RS-I and REG-Y1) is grouped together at one end of each suite and the associated ARF equipment including FURs and GV switch racks at the other end of the suite. A full suite of IDF racks was planned with the rack allocations arranged to minimise inter-rack cabling.

In comparison with more usual two wire tandems the design of the TTT using two relay sets for each incoming junction requires considerably greater racking capacity, and is therefore expensive of floor space. In the ARM section, to optimise rack locations relative to each other, the FIR-FUR inlet combinations were laid out in modules of 120 inlets comprising 10 BDH racks in a back to back configuration. **(Fig 3 and 4).** The two centre racks of the module carry the RS register finder equipment, while the four BDH racks at the end of each module carry the REG-Y1 registers **(Fig 5).** In this way the run-lengths of cable used in hard wiring through the ARM stage between the FIR-TM-Y1 and FUR-LM-TF were minimised, as was cabling between the FIR and RS stage and registers to RA stage.

The ARF section follows a standard equipment layout for a three stage group selector with provision for two GVC switch racks per four GVA/B switch racks. To date only one GVC rack has been installed which gives an outlet availability of 700. The two GVC rack layout was adopted to allow expansion of outlet availability to 1,000 if needed.

Cabling

In the main the cabling schedule for the TTT used standard cable runs and where these were used the wire termination sheets were standard CE and CSK drawings. Special drawings and termination sheets were produced to cater for the hard wiring, from FIR to FUR through the ARM stage, cable runs to and from the 1200/600 ohm impedance matching transformers and additional rack wiring on the FUR-LM-TF and register racks mentioned previously.

MAINTENANCE CONTROL FACILITIES

Maintenance control equipment comprising a service control rack and meter rack were installed with the equipment on the third floor. The alarms may be switched to local control but are normally extended to the ARM two floors above as part of a more convenient service alarm centre for the ARM and TTT.

FUTURE DEVELOPMENTS

10C and ARM as Co-Mains

The most important single event in the Brisbane Trunk Network in the near future will be the com-

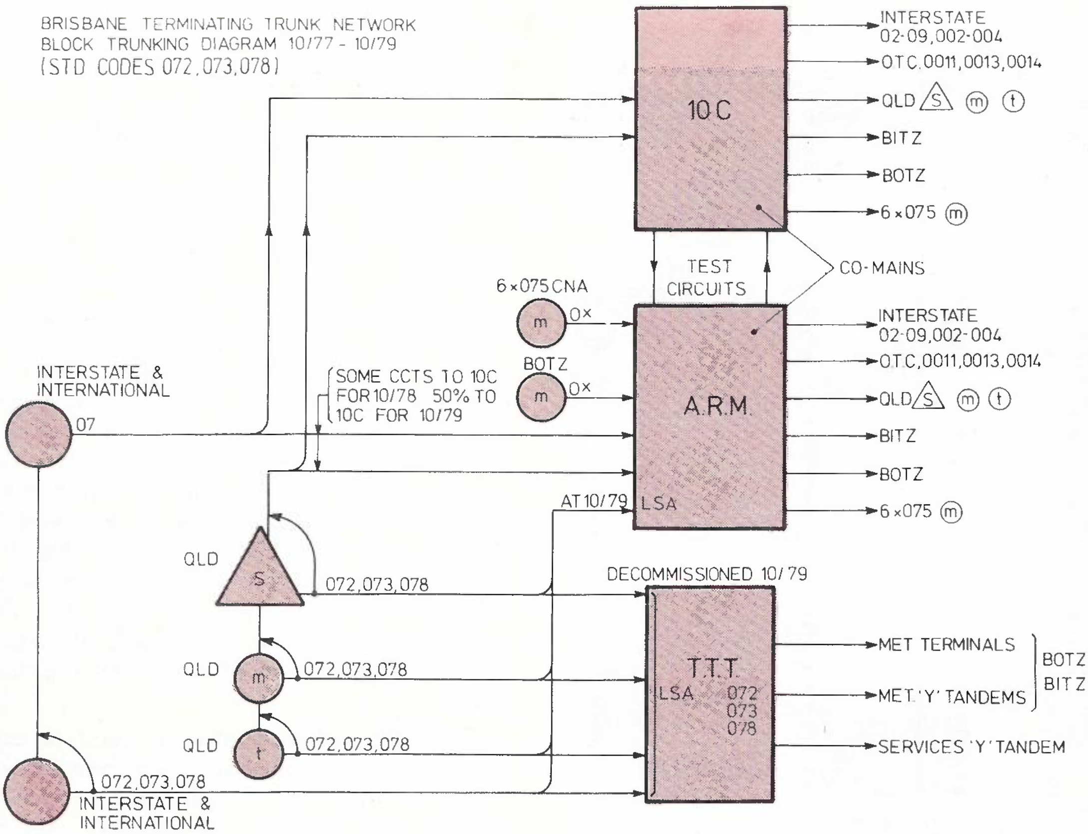

Fig. 6 — Block Diagram Terminating Trunk Network

missioning of the Woolloongabba 10C trunk exchange. The 10C and existing ARM will then work in parallel as Co-Mains **(Fig 6).**

A gradual cutover is planned for the 10C with some live traffic from interstate and intrastate flowing through the exchange by October 1978. The switching load in the 10C will then grow over a twelve month period until incoming 07 code traffic from interstate and international origins will be offered to both the 10C and ARM on a sharing basis.

TTT Role

During this period the TTT will be switching Brisbane local service area (LSA) traffic with codes 072, 073, 078 from interstate and intrastate origins including terminals, minors and secondaries to the Brisbane inner and outer telephone zones (BITZ, BOTZ). By 1979/80 incoming traffic destined for the Brisbane LSA will be offered on direct routes into the ARM and will overflow from these routes onto 07 code routes to the ARM and 10C. On completion of this changeover the temporary role of the TTT will have been completed and the tandem will be decommissioned. The equipment will be reused where needed; the ARM equipment is still current and could be used in ARM extensions in Queensland or interstate. The ARF equipment will probably form part of the Brisbane tandem complex in the Edison exchange building.

CONCLUSION

The proposal developed in 1971, to switch Brisbane's originating and terminating trunk traffic clear of the ARM exchange, when it became apparent that the ARM would not be able to cope with the trunk traffic load over the period until the 10C SPC trunk exchange was commissioned, has been amply justified. Three years' service from the trunk tandem exchanges has proved the economic and engineering feasibility of adapting ARF Group Selectors to this purpose.

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Integrated Power Suites (IPS) for Telephone Exchanges

N.K. THUAN, B.E., M.I.E. Aust., M.I.E.E.E.

Integrated Power Suites, a local name for the well known multiple rectifier-battery float system, are the standard d.c. power supply for Telecom Australia telephone exchanges. This paper sets out general information necessary for the understanding of the power system, its performance features and its limitations.

INTRODUCTION

DC Power Systems provided for Telecommunications centres should have good regulation, high efficiency, low electrical noise, low transients, good overload capability and must be capable of operating within wide-ranging environmental conditions without requiring special air treatment. The systems should also be capable of coping with wide input voltage swings and reasonable load swings and have adequate protection in the control circuit and the power circuit so that no damage will be caused to the telecommunication equipment or the power supply itself.

Above all, the systems should be reliable and should provide an uninterrupted source of power to the exchanges under all operating conditions for 24 hours a day.

These are the requirements that have been met by the Integrated Power Suites.

BASIC FLOAT BATTERY CONCEPT.

Float operation is defined as a method of operation in which the batteries are theoretically preserved in a fully charged state by maintaining all cell voltages above, but close to, the true open circuit potential (Ref. 1 and 2).

A dc equivalent circuit for a lead acid (LA) battery could be simplified as shown in **Fig. 1.** It consists of an Electromotive Force (emf) E, a series internal resistance Ri (low value) and a self discharge resistance Rs (high value) in parallel with the emf.

It can be seen that a charge current Iin will flow, where $Iin = (Vin - E)/Ri$

if a power source is impressed across the battery terminals. Battery self-discharge effect due to Rs gives rise to a self-discharge current Is, where $Is = E/Rs$.

A small charging current is required to prevent this and in the float battery system the battery is normally kept in a fully charged state, except during short term peak demands when it may discharge a little. The energy used will be made up after the disturbances have ceased.

The main advantages of the float operation is that batteries can have very long lives (15 to 20 years). Furthermore, if for some reason the battery has been substantially discharged, it is quite safe for the rectifier to partially recharge the battery on line (at 52 volts for a 24 cell system).

The battery cannot be damaged by a high charge current when the rectifier voltage is set at a float level well below the gassing point. The charging mode in this initial period is essentially *constant current,* but the battery voltage will climb reasonably quickly to the constant potential level of the rectifier. As the battery reaches the float level in about 10-15 minutes, the charge current will taper off to a low value. This kind of behaviour is quite typical in a float battery constant potential charger system; interception by maintenance staff is usually not needed, unless the battery has been completely discharged.

BACKGROUND HISTORY

The IPS is based on the full float automatic rectifier-battery principle with off-load charging facilities. It is a conventional 48 volt nominal system employing 24 cells of lead acid (LA) battery bank. It is a relatively new concept, introduced in the 1960's to allow for the standardisation of dc power supplies in telephone exchanges.

There are several arrangements of dc power supplies in use in telephone exchanges; these are based on either rectifiers designed to Telecom Australia Specification 849 or to Telecom Australia Specification 1063 (modified). Systems based on Specification 849, employ a number of 3 phase rectifiers connected in parallel, with or without load sharing facilities and supply power through dc discharge panels. The "849" rectifiers were used in older type exchanges and a few are still being used in PABX systems and smaller exchanges.

Also in use in telephone exchanges during the 1960's were several generations of Integrated Power Suites designed to Telecom Australia Specification 1063 (modified). The first of these IPS's were supplied by STC for Edison Exchange (Qld.) and Franklin Exchange (SA) around 1965. These are similar to the dc No-Break suites currently provided for broadband repeaters.

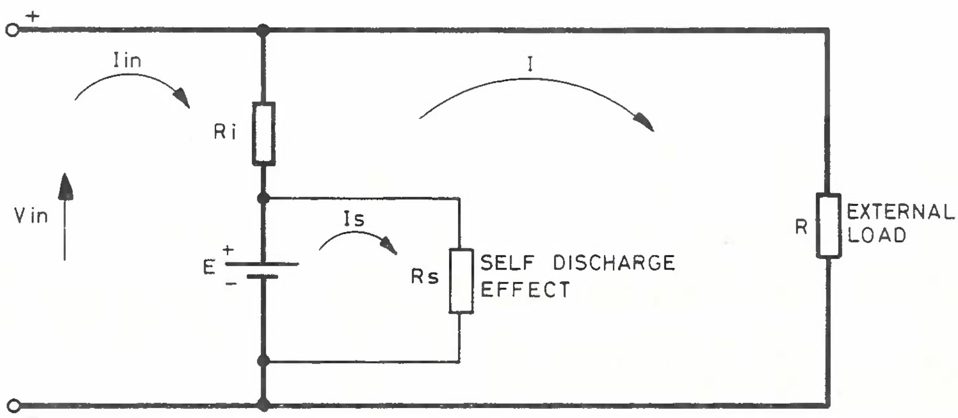
The turning point for modern IPS's coincides with the introduction of equipment of Schedule C.5070 in the early 1970's. The design of the IPS was then rationalised in two Telecom Australia Specifications, 1131 and 1141. Equipment supplied under Schedules C.5847, C.6657 and C.8006 constitutes the bulk of the IPS nowadays.

POWER ARRANGEMENT

The IPS, incorporating two buses — a float bus and a charge bus — requires at least two rectifiers, a dc output cubicle and two battery banks. This is basically a parallel redundant or duplicate system. In general, n rectifiers and n battery banks could be connected, the limiting factors being the capacity of the buses, the number of battery selector switches and the difficulty of controlling a large number of rectifier units.

IPS's are currently provided with up to 4 rectifiers as a self-contained suite and used to power entire smaller exchanges or grouped Telecom loads on one or two adjacent floors of major exchanges.

Connection between suites, or to the rest of the



NOTE :
OPEN CIRCUIT E.M.F. = 2 VOLTS PER CELL FOR LEAD ACID BATTERY
CHARGE CURRENT Iin = (Vin − E) / Ri
DISCHARGE CURRENT I = E /(Ri + R)
SELF DISCHARGE EFFECT Is = E / Rs
R... LUMPED EXTERNAL RESISTANCE INCLUDING ALL WIRING.

Fig. 1 — DC Equivalent Circuit for Lead Acid Battery.

exchange dc power supply system, is not required.

The criterion for system design is based on the n + 1 redundancy concept, i.e., n rectifiers to cater for the busy hour load and one spare rectifier to replace a failed unit or for off load battery charging. All rectifiers are of equal rating, automatic/manual type, and must have matched control circuitry. Each rectifier must be capable of recharging the battery bank at the 10 hour rate. In the past, it has been common practice to provide a manual rectifier as a spare. However, it is now more desirable to provide an automatic/manual rectifier as a spare, hence making the IPS fully automatic. This greatly simplifies the operation and servicing of the system.

The arrangement is shown schematically in **Fig. 2,** which is applicable to the IPS supplied since 1970 by various major Australian manufacturers.

OUTPUT VOLTAGE VARIATIONS

The IPS is a nominal 48 volt dc power system; its normal operating voltage is tied to the operation of a 24 cell LA battery bank on full float. The float level is set at 52 volts approximately (2.17 volt/cell). This operating level of the IPS is quite close to the upper permissible limit of Telecom systems (55-56 volts dc).

Similarly, operation of the IPS under mains-failed or rectifier-failed conditions will depend on the discharge capability of the reserve batteries, the voltage level of which is much lower and is quite close to the minimum permissible limit required by Telecom systems (44.4 volts at the battery terminals).

Typical variations of voltage as seen by Telecom loads at the output of the IPS are shown in **Fig. 3.**

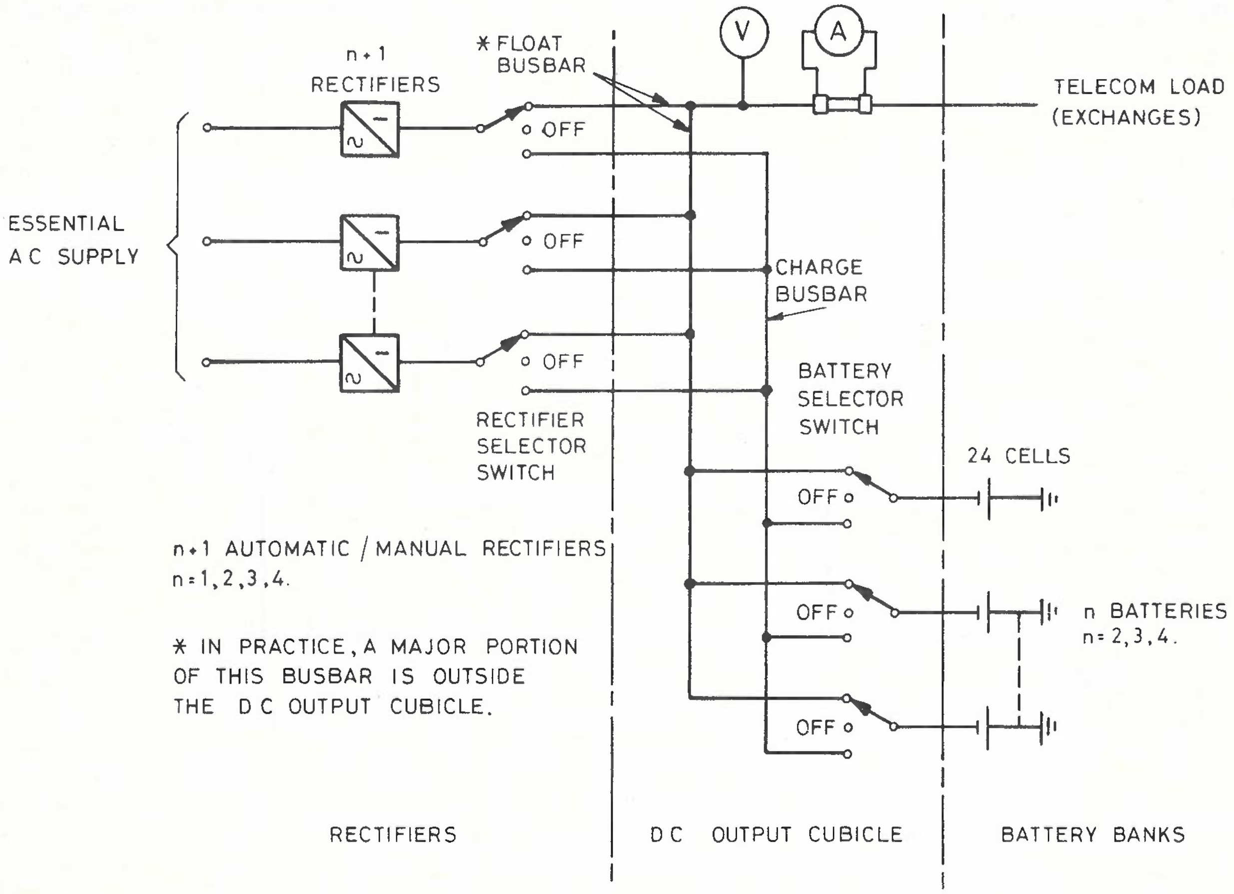


Fig. 2 — Integrated Power Suite Arrangement.

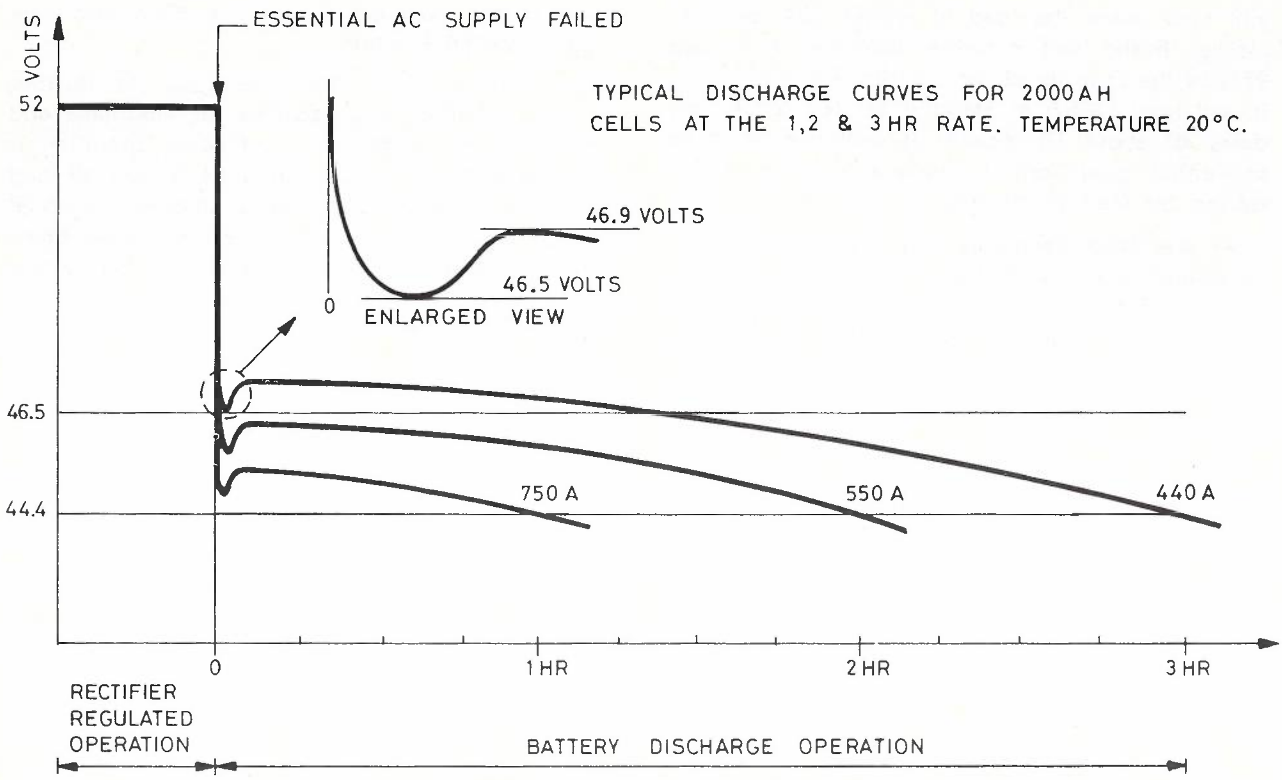


Fig. 3 — Output Voltage Characteristics under Different Modes of Operation.

The steady state initial voltage of the 3 hour reserve battery, and hence of the IPS, is about 47 volts. This is usually the figure published by battery manufacturers. The true picture of this situation is much less understood and is seldom recorded (Ref. 2). When a constant current discharge is required of the *float "fully charged"* LA battery, a ***minimum point*** is usually observed at the beginning of the discharge curve. For batteries on 3 hour discharge, this minimum point could be 46.5 volts within the first couple of minutes. The battery voltage will then recover to about 47 volts and, as the discharge progresses, will fall again to an end point of 44.4 volts (1.85 volt cell), at which time the Telecom equipment will commence to lose specified performance characteristics.

Thus, the battery operates within a very narrow useful voltage range; 2 volts or 80 milli-volt/cell for a battery of 3 hour reserve capacity. This requires very close control in the alarm circuit to avoid spurious shut-downs on low voltage. A critical examination of the low voltage shut-down function may be required for the IPS operating with very heavy load demands and low battery reserves.

SEQUENTIAL AND LOAD SHARING CONTROL

Under normal operation, all rectifiers and batteries are connected to the float bus. All rectifiers are adjusted so that a voltage level of 52 ± 1% is impressed upon the exchange. The current limit circuit is set to 110% rated load, at which point the output voltage will collapse to about 45.6 volts.

The IPS can be operated in various modes depending on the position of the mode selector switch on the rectifier meter panel. When arranged for Duty-Standby 1-Standby 2 operation, one rectifier is selected to be the duty set, a second rectifier Standby set No. 1. The duty and standby rectifiers No. 2.

Under this sequential forced current sharing mode of operation, the duty rectifier will normally be energised and will carry the load. If the load reaches 95% of the duty rectifier capacity, it will extend a signal to switch in automatically the Standby set No. 1. The duty and standby rectifiers will now share the load to within 10% of their ratings. If the load is further increased to exceed 95% of the capacity of the Standby Rectifier No. 1, it will now switch in Standby set No. 2. A time delay of about 10 seconds is provided in these sequential operations to reduce spurious action caused by load fluctuations.

As the load decreases, the standby sets will be sequentially switched off one after the other in reverse sequence when the load of the *controlling* rectifier drops to 40% of its capacity. At the point of switching off, the remaining rectifiers must carry whatever load is required without any oscillation or hunting.

The IPS can also be arranged for Duty Parallel Operation. In this mode, all rectifiers required to supply the total load are in "Duty" mode and will share the load to within 10% of their ratings.

The rectifiers can also be arranged as group of duty sets and group of standby sets with sequential control as described. All the control facilities are provided in each rectifier — the dc output cubicle does not contain any control circuitry common to the rectifiers except the High and Low volt switch off function.

In addition to the float operation, the rectifier is also provided with facilities for automatic and manual boost modes. The autoboost operation is a convenient way of recharging the battery off load with the rectifier acting as a constant potential charger (± 1% regulation) while the manual boost facility enables the boost charging of a flat battery under staff control. Care must be taken to avoid overcharging the battery under automatic boost mode, however, as the rectifier has charging capacity many times the 10 hour rate of the battery.

PROTECTION AND INSTRUMENTATION

IPS's are provided with standard protection as normally required for this class of plant: fuses, overload, high volt and low volt sensing and shutdown facilities. Alarms are extendable from both the rectifier and the dc output cubicle.

Each rectifier is provided with a voltmeter and an ammeter of class 1 accuracy. The dc output cubicle is provided with an ammeter of class 1 accuracy which indicates the total dc load delivered

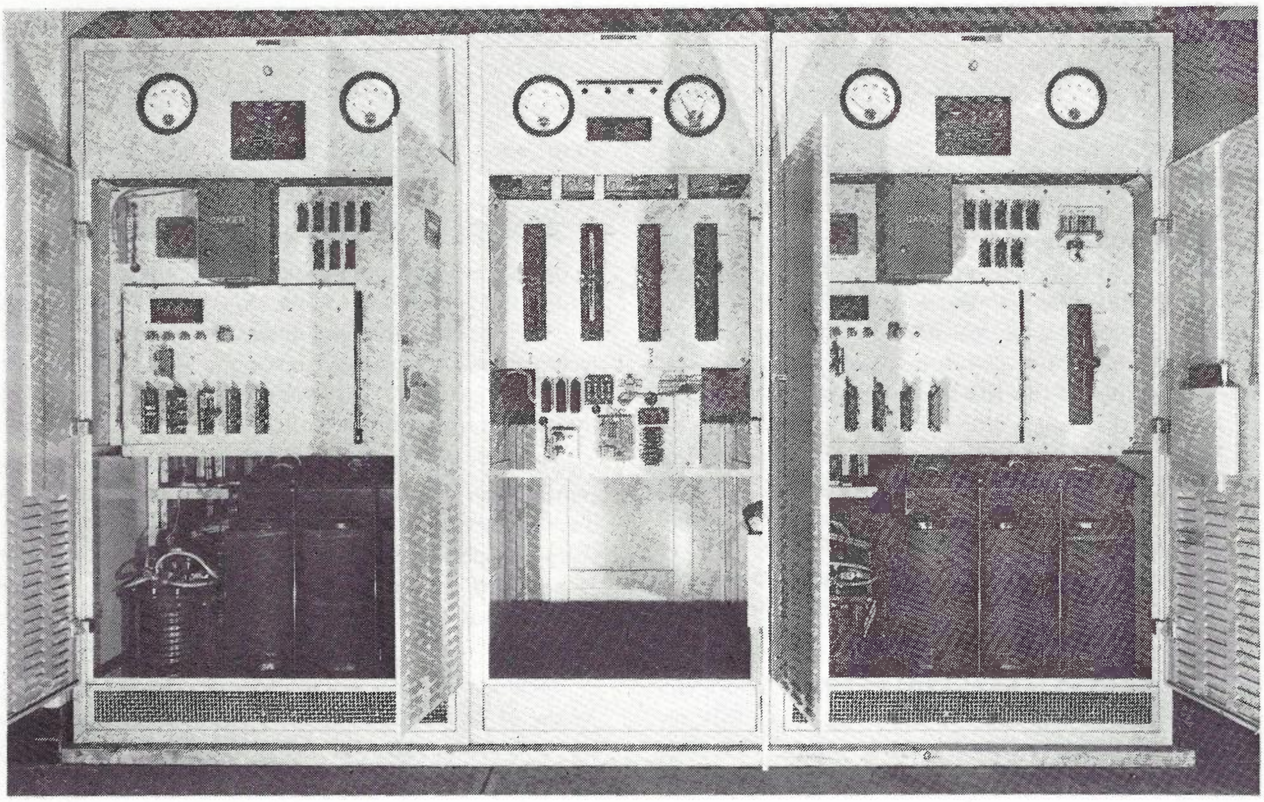


Fig. 4 — Typical Modern IPS—Front View.

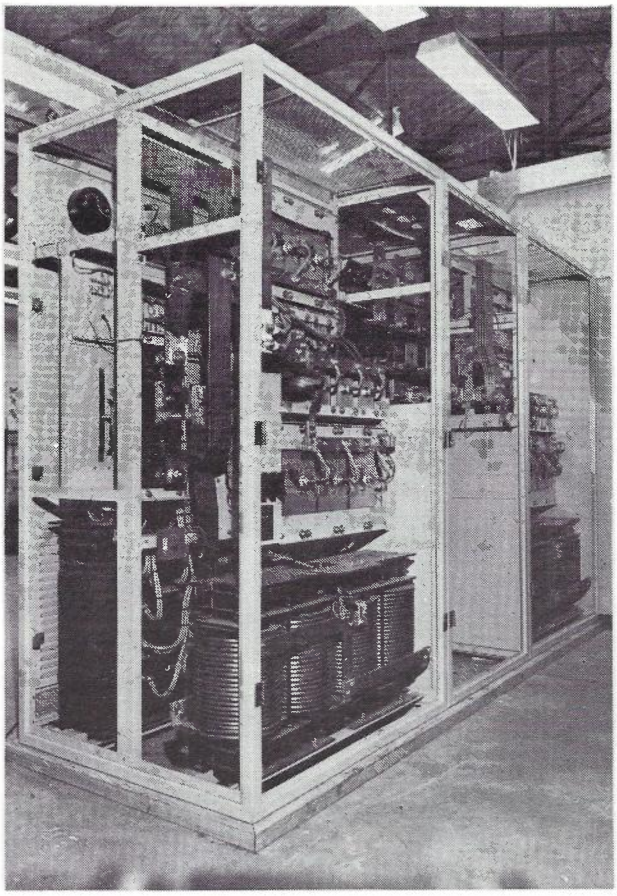


Fig. 5 — Typical Modern IPS—Rear View with Doors Removed.

and with a contact voltmeter of class 0.5 accuracy, the scale of which is specially marked with float limits and alarm indications. The contacts on the contact voltmeter provide the overall system high and low volt alarms; the alarms will result in IPS shutdown and lock-out and must be manually reset before the IPS can be restarted.

BASIS FOR IPS PROVISION

IPS's are available in the following basic rectifier ratings: 100, 200, 400, 800 and 1600 Amp.

The output voltage is nominally at 48 volt, although a 24 volt nominal version is also available. With those five basic ratings of rectifiers, any dc power requirements of 100, 200, 300, 400, 600, 800, 1200, 1600, 2400, 3200 and 4800 Amp capacity, using matched rectifiers, could be realised. The selection is made with due consideration to power room size, floor space cost, initial load and ultimate load of the exchange. Installation charges of rectifiers, batteries and busbars are substantial, relative to equipment cost. Over-provision is undesirable because it leads to unnecessarily high capital costs; under-provision is also undesirable because it leads to unduly high equipment replacement costs.

As a useful rule of thumb, provision of IPS should aim for enough capacity to cater for the busy hour loads of the first 10 years, allowing for the possibility of adding extra rectifiers to cope with the ultimate loads.

For telephone exchanges and similar stationary applications, Telecom Australia pure LA Batteries, designed in accordance with Specification 662, should be used. Depending on the size of the exchange, 200 AH, 500 AH and 2000 AH cells could be used. For large load demands, it is not advisable to use 500 AH battery because this will lead to too many 500 AH banks in parallel. If the battery capacity required exceeds 4000 AH in total, 2000 AH batteries are recommended.

Battery reserve time should be selected with the priority of the exchange in mind and will depend on whether or not a standby diesel alternator set is installed at the exchange. For a majority of exchanges in metropolitan areas and larger country towns with diesel standby, 3 busy hour battery reserve is normally provided. For exchanges without standby diesel, up to 8 busy hour battery reserve may be considered. Battery reserve longer than 8 busy hours may be required for hard-to-get-to places.

In very large telecom centres, where the dc loads per floor are high and where multi diesel generating sets are provided, battery reserve of 1 hour may be allowed.

Because batteries are rated at the 10 hour rate, discharge rates at any values above this rate will effectively be at a reduced reserve capacity. For example, the capacity of the largest size LA Batteries at this stage is 2000 AH at the 10 hour rate, i.e. the batteries will deliver 200A for 10 hours down to an end voltage of 1.85 volt/cell (44.4 volts for 24 cells); the capacity extracted during the discharge is 100%. At the 3 hour rate, it will deliver 440A for 3 hours down to 1.85 volt/cell; the capacity extracted during the discharge is 66% approximately. At the 2 hour rate, it will deliver 550A for 2 hours down to 1.85 volt/cell; the capacity extracted is 55% approximately. At the 1 hour rate, it will deliver 750A for 1 hour down to 1.85 volt/cell; the capacity extracted is therefore only 38% approximately. A new range of pure LA Batteries in accordance with Telecom Australia Drawing CZ 2054 and Australian Standard AS 1981 will become available in 1978.

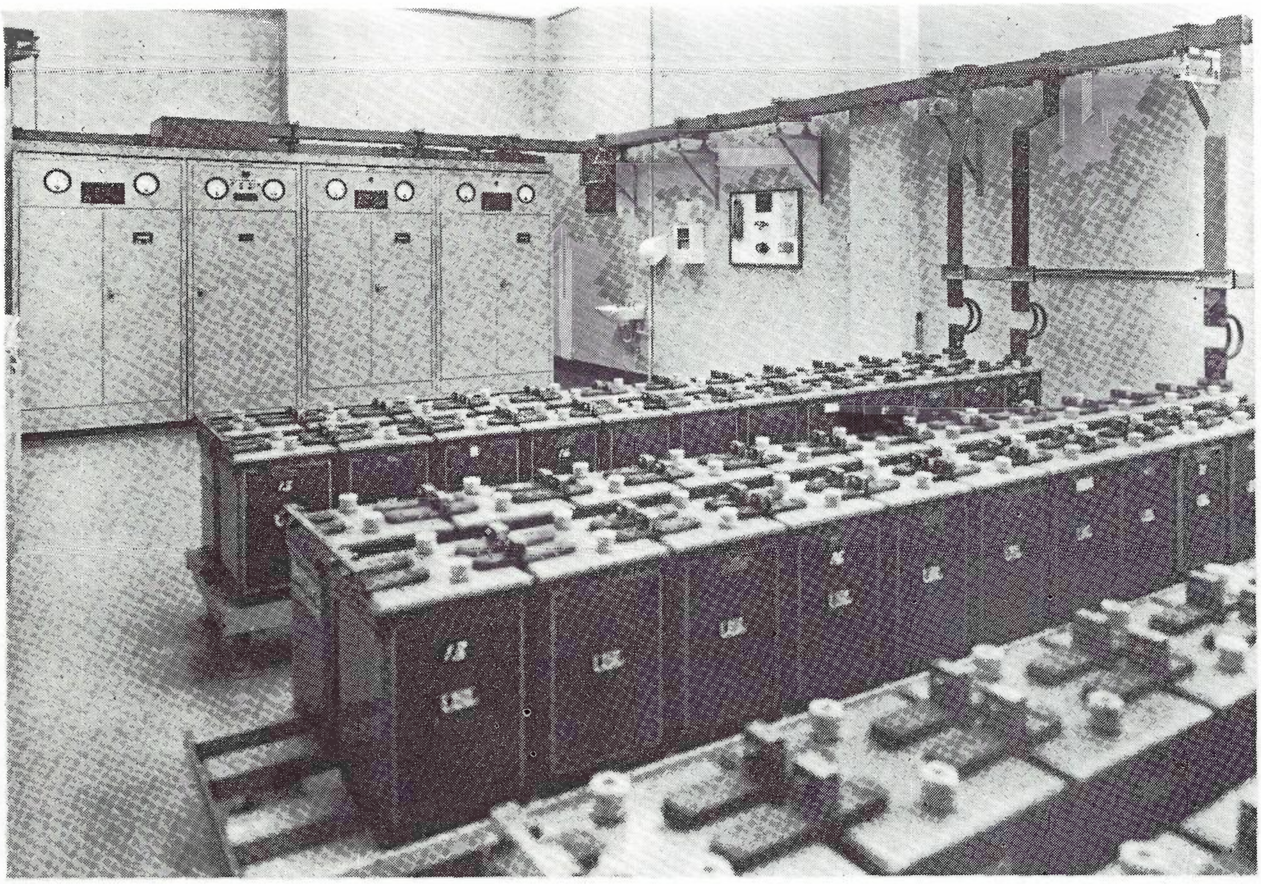


Fig. 6 — IPS at South Melbourne Metropolitan Exchange.

MAINTENANCE ASPECT

Except for the motor driving the regulator in the electro-mechanical type, all IPS's are fully static.

Silicon power devices are universally used in all conversion stages, the control circuits are solid-state based, employing transistors, thyristors and IC's, etc.

The design has aimed for minimum maintenance and servicing. Routine maintenance is negligible for the fully static types such as Transductor or Thyristor Rectifiers; the electro-mechanical type may require more attention because of regulator motors and brushgears. On the average, it has been estimated that about 3-5 hours are spent annually on each rectifier set.

To service these IPS's, staff need to have a good background in power and electronics, especially power semi-conductor technology. It is, however, not beyond the scope of competent staff to apply knowledge in an allied solid-state electronic field to look after the control circuitry and the dc side of the IPS. The ac side may require the attention of specially qualified or authorised staff.

Five significant areas in which changes are being considered are:

- **Battery Routine Maintenance**

There are several banks of batteries in association with each IPS, the number of cells to be maintained could be anything from 48 cells to over 100 if 500 AH cells are used. It requires substantial time and effort to keep them in serviceable condition (Ref. 1). A new policy touching on float level of LA cells and other routine maintenance matters which will reduce the burden on operational staff without sacrificing the performance capability of the LA Batteries is to be considered.

- **Duty-Standby Operation of IPS**

There is a serious misconception about the duty-standby operation of the IPS. It is a common belief that the standby set will automatically take over if the duty rectifier has failed. This is not so. The

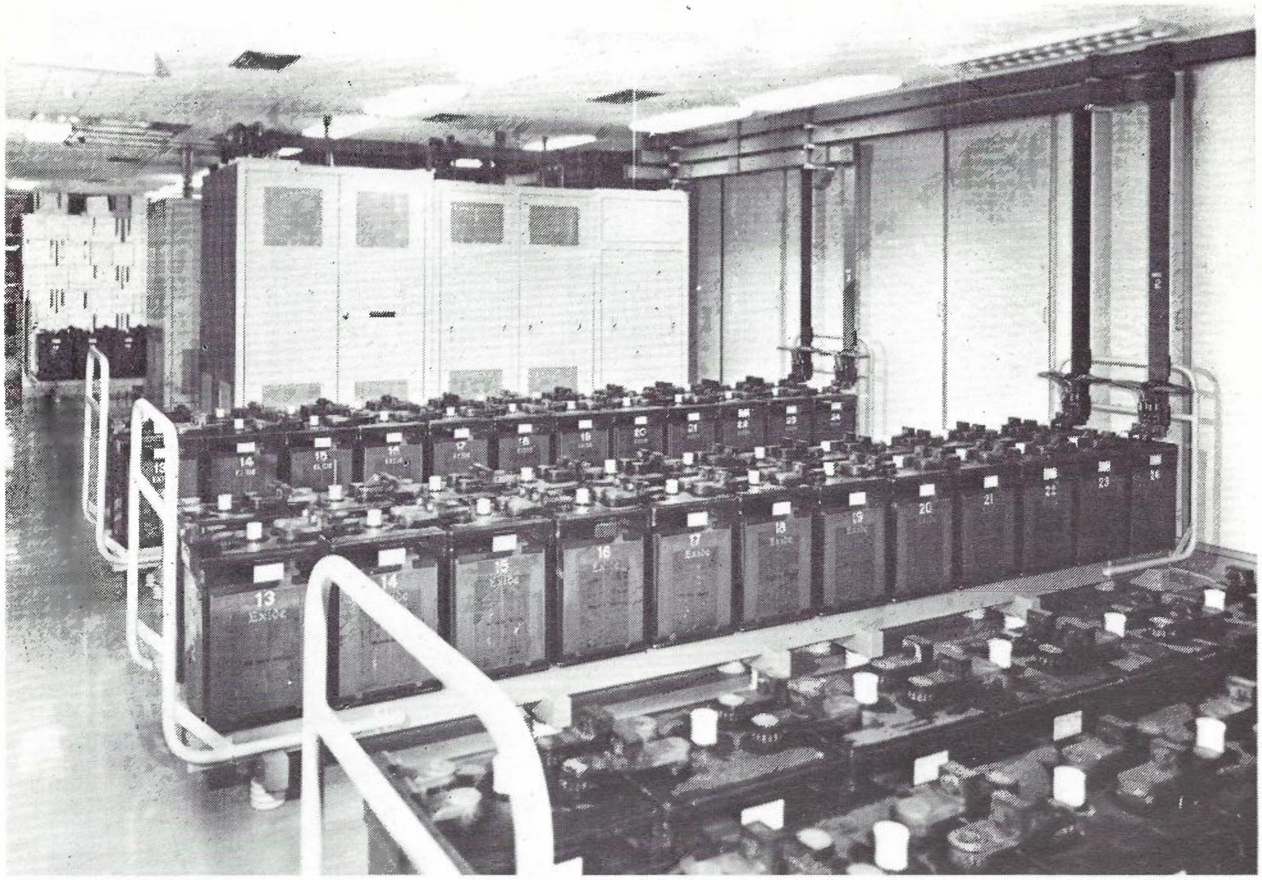


Fig. 7 — IPS at Lonsdale 10C Electronic Trunk Exchange—Overall View.

duty set of the IPS can only call the standby in to *share* the load. If the duty set fails, the rest of the system will shut down. The design of the IPS is being reviewed to enable it to have both standby functions, i.e. under load increase and duty rectifier failure.

• Alarms and Protection

The performance characteristic of LA Batteries exhibits a minimum voltage at the beginning of the discharge curve (Ref. **Fig. 3).**

Spurious low volt shut-down of IPS's on mains failure could occur; this is not only a nuisance because it involves staff recall, but also operationally undesirable because the batteries are required to discharge for an unnecessarily long time. Further, an emergency could arise if rectifiers are not restored in time.

Mains fluctuations could also actuate the high volt sensing alarm causing spurious system shut-down. To avoid spurious system shut-down the high volt alarm needs to have a built-in time delay and the low volt alarm should not cause rectifier shut-down.

• Interference Caused by Rectifiers on Charge Bus

A rectifier on the charge bus could interfere with the operation of rectifiers on the float bus in some IPS's. This is because the current sharing loop between this rectifier and the float rectifiers has not been broken. A solution for this problem has been to provide microswitches in conjunction with each rectifier output selector switch to isolate the current sharing loop as well as transfer the voltage sensing point from remote (load) to local (rectifier), when this selector switch is moved away from the float position.

• Overheating of Neutral Connection

A substantial number of IPS rectifiers are based on the star-primary configuration, with the neutral connection made between the star point or points of the power circuit and the neutral of the ac supply. Neutral current much larger than rated active currents could flow when partial or com-

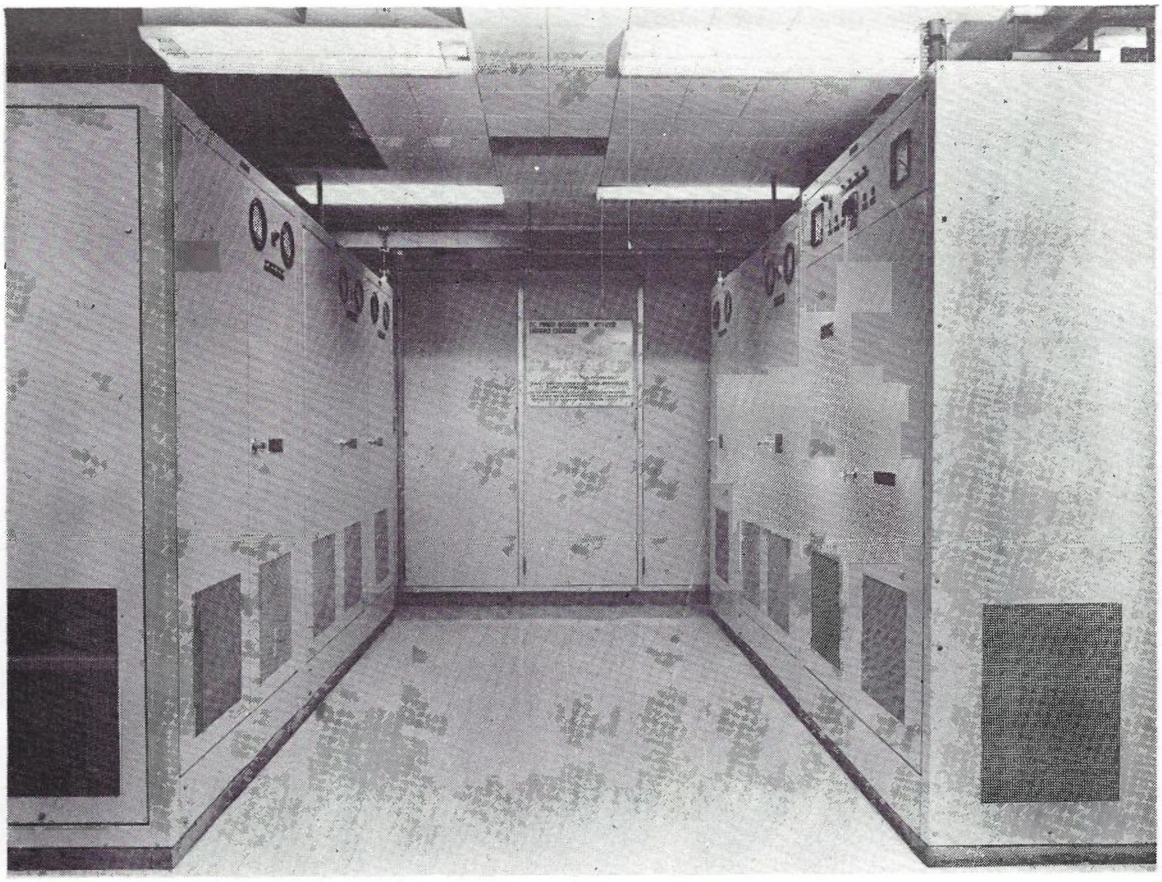


Fig. 8 — IPS at Lonsdale 10C Electronic Trunk Exchange—Two Suites Face-to-Face.

plete failure of one phase occurs. One economic solution has been to isolate the star points of the power circuit from the neutral of the ac supply.

CONCLUSION

IPS's are versatile dc power systems and can cater for wide application in telephone exchanges for both switching and transmission equipment.

IPS's are comparable to, if not better than, many other similar arrangements employed by overseas administrations, in the following respects:

- IPS's keep batteries continuously at the optimum float potential; the battery does very little work during its life and hence can be expected to last from 15 to 20 years.
- IPS's are flexible and modularised. Flexibility and modularisation enables IPS's to be used as central power system for the entire exchange or as self-contained suites distributed throughout the exchange. This latter ability is one of the IPS's most desirable features in regard to powering telecom systems in multi-storey buildings with different types of equipment in different floors.
- Flexibility also means that the suite capacity can be extended by adding extra rectifiers in the future.
- The battery banks of the IPS's are hard-connected to the load and as they have extremely low internal impedance, they act as a very effective filter against unwanted electrical noise, ripple and transients which may appear on the load bus.
- Operation of IPS's under mains failure/diesel standby/mains restoration is automatic; smooth and also safe. The batteries cannot be damaged as they are recharged partially on line at the float potential well below the gassing point of LA Batteries.
- Off-load charging facilities are also provided which simplify the battery boosting process.

The IPS systems with sequential control and current sharing have been designed for, and are particularly suitable to telephone exchanges of the step or crossbar types where the load pattern has long periods of light current demands and relatively short peak demands during busy hours.

It is clear that the battery capability to hold the voltage above a minimum permissible limit is the critical factor which determines the satisfactory performance of the IPS's during battery discharge operation. This margin of safety is severely reduced with low battery reserve time — a common feature of large load applications.

With the speedy introduction of Electronic/SPC Exchanges where the loads are high and more or less constant throughout the day and where improved power supply characteristics are essential, up to date designs of power supply systems will have to be undertaken as a matter of exigency. A new approach to power systems for large telecommunications loads, tentatively named 1000 Amps Modular Power Supply, is an Australian design which can supply a constant voltage of 48 volt to the exchange under all service conditions, and is particularly suited to larger load applications.

ACKNOWLEDGEMENTS

Integrated Power Suites discussed in this paper have been supplied to Telecom Australia by the following Australian Manufacturers: L. M. Ericsson, Power Electronics (formerly Natronics) Standards Telephones and Cables, and Westinghouse Brake & Signal (formerly McKenzie-Holland).

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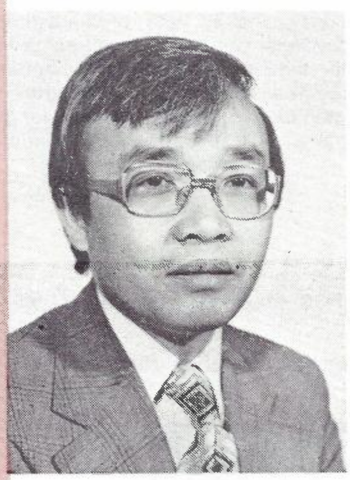
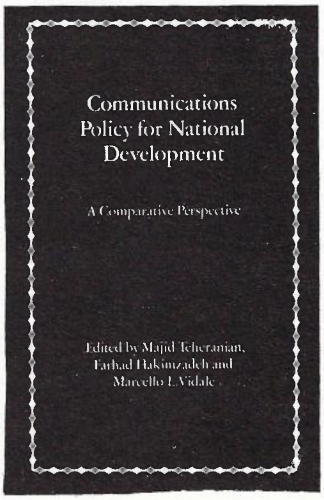
Mr Thuan was educated at Monash University in Melbourne, graduating in electrical engineering in 1967 and has since served in the Australian Post Office and Telecom Australia. He is Telecom Australia representative on the Power Electronics standing committee of the Standards Association of Australia, which formulates Australia Standards for Semiconductor Converters and Power Supplies.



Book Reviews

COMMUNICATIONS POLICY FOR NATIONAL DEVELOPMENT

Majid Teheranian, et al., (Eds.), London, Boutledge and Kegan Paul, 1977.



This publication is a collection of 13 papers by 15 authors, based on an international symposium in Teheran in 1975. It deals mainly with broadcasting rather than telecommunications, and almost entirely with control and content rather than technology, with emphasis on underdeveloped countries. However, for countries like Australia, where communication issues are no longer being regarded as more or less settled, the fundamental topics discussed in this book are of increasing interest. And there is increasing recognition that the nature of technology is dependent on, and influences, social and political issues. This applies to telecommunications as well as to broadcasting. There is a consistent assumption throughout the papers that the direction of social development in a country should be planned, at least to the extent that this is possible through the planning of the communications systems.

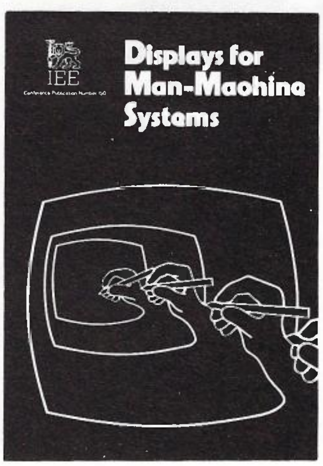
The subjects covered in the book range from the processes of economic, cultural and political development, to options for the control of and type of communications arrangements in a country, to particular examples of experience in the use of broadcasting in underdeveloped countries. Because of the range of subjects covered, and the origin of the material, the treatment is intended to be more of a summary than an indepth analysis of any topic. This is acceptable because most of the authors are of world standing and there are adequate references to more detailed works. The book is, of course, intended to be a guide to policy formation rather than an academic text.

It is inevitable that only selected portions of a book of this nature will be of interest to most individual readers. Nevertheless, for those concerned with policy matters there is much that would provide food for thought and new perspectives. The book therefore ought to be given a place in communications libraries.

Reviewed by G. Lindenmayer, National Telecommunications Planning Branch, Headquarters, Telecom Australia.

DISPLAYS FOR MAN-MACHINE SYSTEMS

IEE Conference Publication Number 150



This book contains a collection of 37 papers presented to the recent International Conference on Man-Machine Display Systems sponsored by the Institute of Electrical Engineers, UK. Its main function is to report on new developments in the field of man-machine interfaces and, therefore, a substantial amount of prior knowledge is assumed.

The topics covered range from the design and evaluation of new display hardware to studies of the psychological factors associated with operating a computer terminal. Most of the examples are drawn from scientific and industrial applications such as air traffic control and steel mill operation rather than commercial data processing systems. In many of these situations environmental and human constraints require the use of specialised hardware so that an effective system can be achieved.

In addition to innovations in display design some interest ing alternatives to the alphanumeric keyboard for data input are described. These include the 'touch-screen' display and an electronic pad and stylus system for entry of graphic data. The touch-screen display uses a matrix of wires or light beams to enable an operator to carry out menu-selection type input by simply touching the screen with a finger. It is particularly suited to applications where operators with little training are to be used. The graphic data input device would be useful in computer aided design applications. The advantage of this particular device is that the stylus contains a ball-point pen and a paper drawing pad may be placed on the electronic base without affecting the accuracy of input. In this way a hard copy is produced at the same time as the data is entered into the computer. Other topics covered include an automatic software generation system for dialogue programs, an evaluation of various colour coding systems for air traffic control and a simple enquiry system using a push-button telephone and synthetic speech.

This book is a valuable reference for anyone designing or evaluating a man-machine interface system, especially one for which the standard visual display unit with alphanumeric keyboard might not be suitable. While some of the papers contain a large amount of technical detail, they are generally quite readable, well illustrated and no more than three or four pages in length. The price is £9.70 outside the UK.

Reviewed by G. L. Bull, ADP Branch, Telecom Australia Headquarters.

ELECTRONICS OPENS NEW WORLDS TO THE DEAF AND THE BLIND

Advances in electronics promise a fuller life for the deaf and blind, with devices that give them new means of communication.

The introduction of "teletext", in which requested information is displayed on the home television screen, will be of particular value to the deaf and hard of hearing. This has been pioneered in Britain, where a group of researchers and engineers have now got together to form a charitable organisation called Deaf-fax with the aim of providing teletext units for deaf people.

These can be fitted to the ordinary television receiver and allow the users to pick up the new information services which are being run by the British Broadcasting Corporation and the Independent Broadcasting Authority, as well as the telephone linked service to be set up by the British Post Office. Deaf-fax hopes to be able to provide the deaf with the teletext service at a nominal rent by using volunteers to assemble the units.

TRANSCRIPTION UNIT

Another effort to help the deaf is being conducted right at the heart of the British nation — in the Houses of Parliament. A Member of the House of Commons recently became the first deaf person to use a transcription unit that allows him to "hear" what is being said by his colleagues without the strain of trying to lip read.

The unit was designed at Southampton University and it displays on a television type screen a shorthand version of speech almost as quickly as the words are spoken.

This system uses a modified stenographer's machine and a computer display screen joined together by an electronic processing unit, and following the experements in the House of Commons it is now hoped to develop the unit for volume production.

SONIC SPECTACLES

Electronics is also being applied to devices to help the blind. Many such projects in Britain are receiving support from the National Research Development Corporation (NRDC), a government sponsored body set up to provide funds and facilities to help in the development of inventions which might not otherwise be fully exploited.

At present the NRDC is involved with a company that has invented spectacles that give the blind person "sight" by means of sound. These spectacles hold a miniature transmitter that sends out a signal that acts as a kind of range finder for the blind wearer.

The signal is ultrasonic, which means that it is so high pitched that the human ear cannot detect it. But when it bounces off objects in the path of the blind person the reflected signal can be heard, and the pitch indicates how far away the object is.

Blind people often develop an extremely sensitive ear and they can use these sonic spectacles to help them move about in unfamiliar surroundings.

BRAILLE COMPUTER TERMINAL

But true independence only comes with the ability to hold down a job and there is now increasing effort to design office and factory equipment which can be used by the blind. One such development — again supported by NRDC — is the braille computer terminal.

Conventionally, braille is produced by embossing the symbols on to a page to produce a suitably raised surface which the blind person reads through his fingers. However, an electronically controlled version of braille is used for this computer terminal and for other office equipment, such as an electric typewriter, produced by the same company.

In electronic braille the characters are formed by groups of pins which are moved to high or low positions to give an effect similar to that of embossing. The system is extremely flexible and information already presented can be re-read simply by replaying the magnetic tape which controls the display.

On the computer terminal and the typewriter the electronic braille display is used to allow the operator to check his or her own work as it is done.

A more traditional use of electronics in the service of the blind is the "talking book". The British Talking Book Service was first introduced in 1935, using long playing records. But nowadays this service, which inspired many similar units around the world, has updated its technology.

Books are recorded on magnetic tape cassettes and specially designed recorders are employed to make the thousands of copies needed to serve the 45,000 users of the service.

The NRDC is currently supporting a project which it is hoped will lead to cheaper and quicker methods of performing multi-recordings for this important service. This should allow the production of talking magazines and newspapers, as well as more books.

(National Research Development Corporation, Kingsgate House, 66-74 Victoria Street, London SW1.)

Queued Access System for Information Positions (Q.A.S. 1)

J. MORE, B. Eng. and R.C. BEVERIDGE

The Queued Access System is a crossbar queueing system for information services and is currently in use at the Brisbane Directory Assistance Centre. The system configuration allows for flexible trunking arrangements to suit the demands of various services, and can expand from a single marker-group system of typically 40 inlets and 24 operators to 5 marker-groups. The equipment can be placed in ordinary commercial buildings, allowing Information Centres to be located remote from an exchange building. Plug-in cabling ensures minimum installation time and maintenance features assist fault tracing. This article discusses the features and operation of the system.

INTRODUCTION

The development of a crossbar queueing system in Queensland arose from a need to queue calls incoming to the Directory Assistance level. An increasing demand for such assistance and the creation of new access codes, 0175 for intrastate information and 0170 for interstate information, necessitated considerable up-grading from the previous line finder system.

Existing queueing system designs were available as an alternative but were based on an earlier technology which was becoming uneconomical to maintain or construct. In 1972, a survey was undertaken in Construction Branch by the Metropolitan Installations No. 2 design team for a suitable crossbar queueing system to meet the immediate requirements. The lack of such a system led to a re-appraisal of queueing requirements in general.

As a result a project was launched to design and construct a service level queueing system with the initial application being for Directory Assistance. The main emphasis was on the following criteria:

- Configuration of a queueing system to suit both small and large installations and a variety of levels.
- Improved operating facilities.
- Improved installation and maintenance aspects.
- Circuit components and switches to consist essentially of crossbar equipment, and where complexity warranted it, solid state components.

The outcome of the project was the Queued Access System No. 1 (QAS-1) commissioned in July 1977 at the Brisbane Directory Assistance Centre.

DESIGN CONSIDERATIONS

Associated with a Manual Assistance Centre are various information services. These may include:

- Directory Assistance.
- Enquiries.
- Changed number information.
- Phonograms.

For each of these services, calls are terminated at the Operator and information is transferred between Operator and Subscriber. No further switching of calls is required. Therefore direct access to a 4-wire trunk exchange or a 2-wire minor switching centre for through-switching is unnecessary. As a result, the queueing system may be an independent system accepting calls over a normal 2-wire junction.

Accommodation for the Operators and the equipment need not be confined to an exchange building; an information centre may be established in any commercial building.

Queueing requirements for miscellaneous services call for flexibility in trunking capabilities to accommodate the requirements of various services and Manual Assistance Centres. For example several codes may be queued together and handled by a common group of operators or alternatively some operators may require access to more than one queue. Queue lengths must also be variable in relation to the system size and to the variations in traffic.

The Queued Access System has evolved from these general design considerations and the basic requirements of a modern queueing system.

FEATURES

Design features were drawn from those areas involved in the planning, installation, maintenance and operation of the system.

Planning Aspects

The queueing system is designed to accept calls over a two-wire junction and terminate them at an operator or supervisor. The system structure comprises one or more marker-groups. A single marker-group queue will handle a maximum of 40 inlets switching to 27 operators, and 3 transfer circuits. For queueing systems requiring greater than 40 inlets, further marker-groups are paralleled. In this manner 17 operators from each marker-group are dedicated to their own marker-group and five operators have access to both groups. The latter are automatically switched from one marker-group to the other depending on the number of calls queued in each group, to achieve an even distribution of calls to operators. A maximum of five marker-groups can be paralleled constraining the queue system to a maximum of 200 inlets and 95 operators. Generally one supervisor is required for 12 operators. **Fig. 1a** illustrates the typical trunking for a single marker-group system, and **Fig. 1b** the trunking of a multiple marker-group system.

Further flexibility may be achieved by the use of *dual operators*. In the case of two separate queue systems, up to five dual operators can access either queue by manual control from the operating position. This configuration is beneficial in periods of light traffic when only the dual positions are staffed and also allows for fluctuations in traffic to the two queues to be handled by a variable number of operators in each queue. **Fig. 1c** illustrates the trunking arrangement.

Priority trunking is available for any of the trunking arrangements and ensures that priority calls, such as enquiry calls incoming from international operators, are placed ahead of any queued calls. Also up to four different dialled codes can be trunked into a queueing system. Each code is distinguished by an identification lamp on the operator's position which indicates the called code before the call is answered.

Installation Aspects

The system is designed for stand-up, plug-in, test-out installation. The equipment racks are suitable for installing in buildings of low ceiling height and are free standing. A raised floor is recommended both in the equipment room and operator's room for cabling between racks and operator positions. The majority of cables are plug ended so that very little terminating is required at the installation site. Flexibility is provided at the MDF between external cabling and the line relay sets, and at the IDF between the transfer circuits and the Supervisor's relay sets. To minimise jumpering on-site, IDF jumpering is in the form of plug-ended cables manufactured to a particular grouping plan.

Equipment is grouped into four racks:

- Incoming line relay sets (FIR-Q rack).
- Switches and common control (SL/MARKER rack).
- Operator relay sets (OPR rack).
- Overseers relay sets and transfer equipment (OVERSEER rack).

A typical single marker group queue with 40 inlets, 24 operators and 2 supervisors would consist of two FIR-Q racks, one SL/MARKER rack, two OPR racks and one OVERSEER rack. Beyond 24 operators, an additional OPR rack is required. A typical installation is shown in **Fig. 2.**

Maintenance Aspects

The equipment consists essentially of crossbar relay sets and switches. Many of the functional relay groups used in the relay sets are based on standard designs found in ARF, ARK, AFG and AFM exchanges. These systems are well established and familiar to Telecom staff. Where electronic circuitry is used, the circuits are mounted on L. M. Ericsson type ROE printed circuit boards located in an electronic shelf. Spare printed circuit boards can be kept in the shelf to facilitate substitution as a means of rapid fault diagnosis and repair.

A DK rack is provided to simplify maintenance. This wall rack consists of permanently connected meters and 80-point jacks. Program plugs allow a Portable Meter Set to be connected in various configurations. The permanent meters cater for three marker-groups and record information from line relay sets and markers such as:

- Total calls received.
- Total calls lost due to full queues.
- Marker time-outs.
- Total calls transferred.

More detailed analysis of particular relay sets may be achieved by extending one of the DK jacks to a Portable Meter Set containing 40 resettable meters. For example, all leads from fuse relays are commoned to one permanent meter for general recording. The commoning is achieved by a pre-strapped plug on DK jack-1. By removing the plug all individual leads can be extended to the Portable Meter Set for analysis. Traffic readings are also taken from four of the DK jacks. **Fig. 3** is an illustration of the DK rack and Portable Meter Set.

Reliability features have been designed into the system. In the event of the queue circuitry failing, calls will still be switched to free operators independent of a queue but not necessarily in order of arrival. Also, calls which have waited in queue for one complete cycle, due to a fault in receiving or

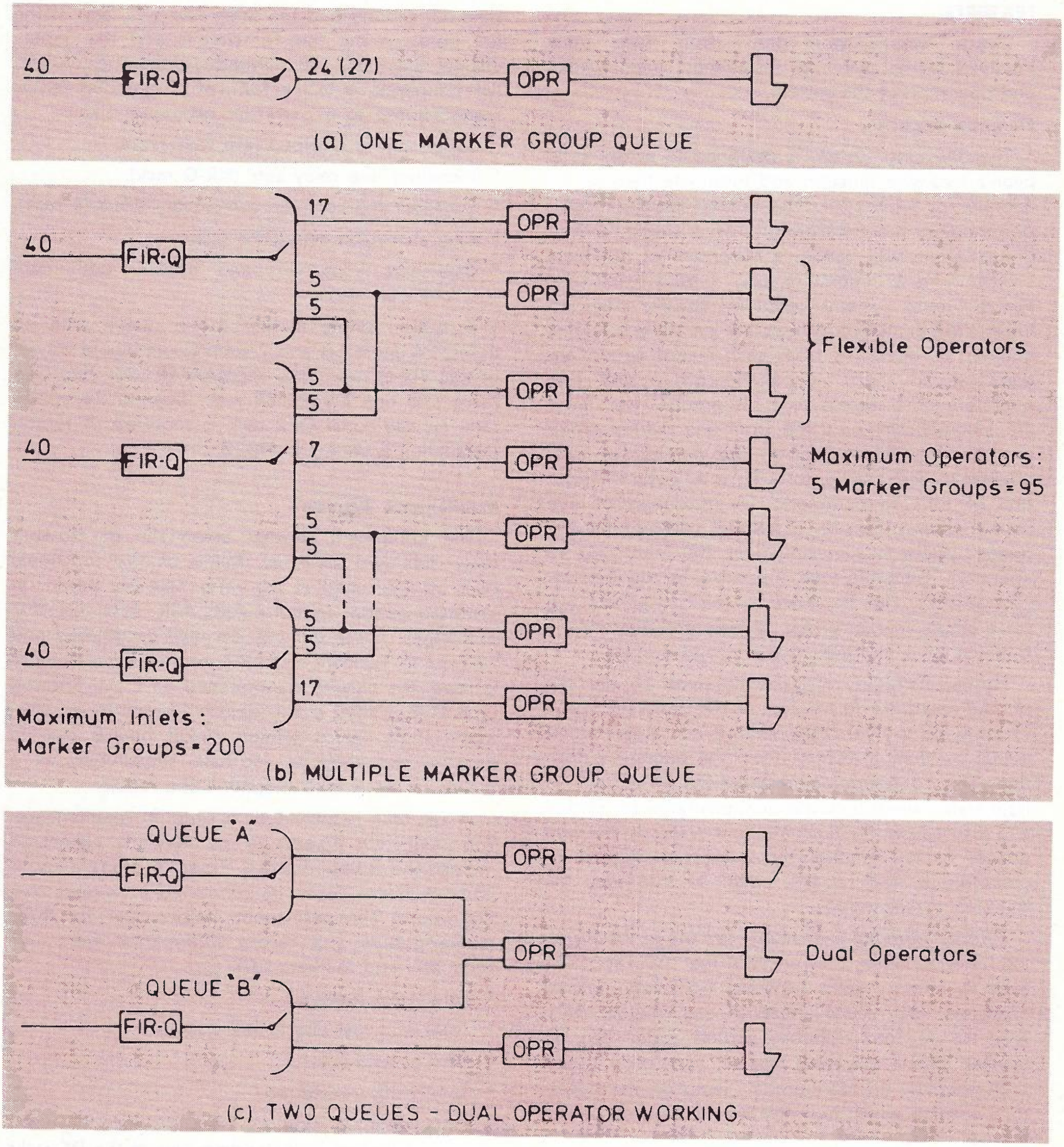


Fig. 1 — Trunking Configurations.

recognising a code, are treated as a priority call during the next cycle.

Operational Aspects

Incoming calls are queued in order of arrival and are distributed from the queue evenly to operators free to accept them. A caller receives ring tone while waiting in the queue, and if the queue is full, will receive busy tone. Operators are aware of the number of calls waiting in a queue by a digital display located on the wall.

Various queue lengths are available. For small queueing systems (i.e. one marker-group) the maximum queue length can be preset to either 31, 23, 15 or 7, and for larger systems, each marker-group will queue up to 15 calls. The Overseer has the facility to reduce the queue size by key operation from 31 to 15, 23 to 15 or 15 to 7 depending on the maximum preset length.

Each operator has one incoming circuit for receiving calls. Three keys control the handling of the call:

- Speak Caller.
- Isolate Caller.
- Force Release.

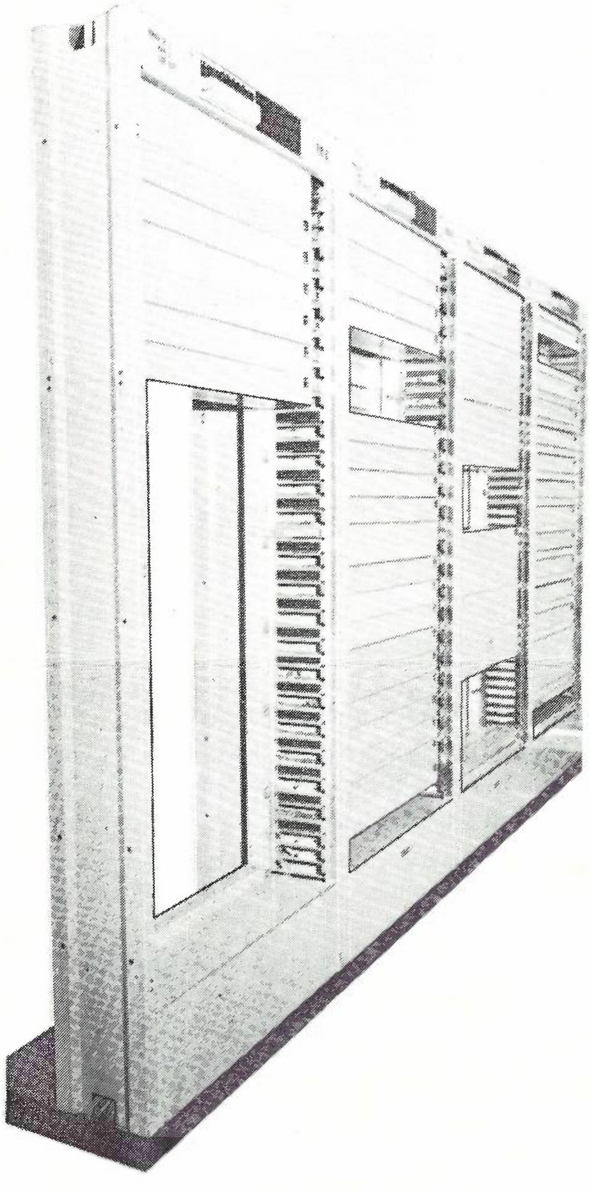


Fig. 2 — Typical Installation.

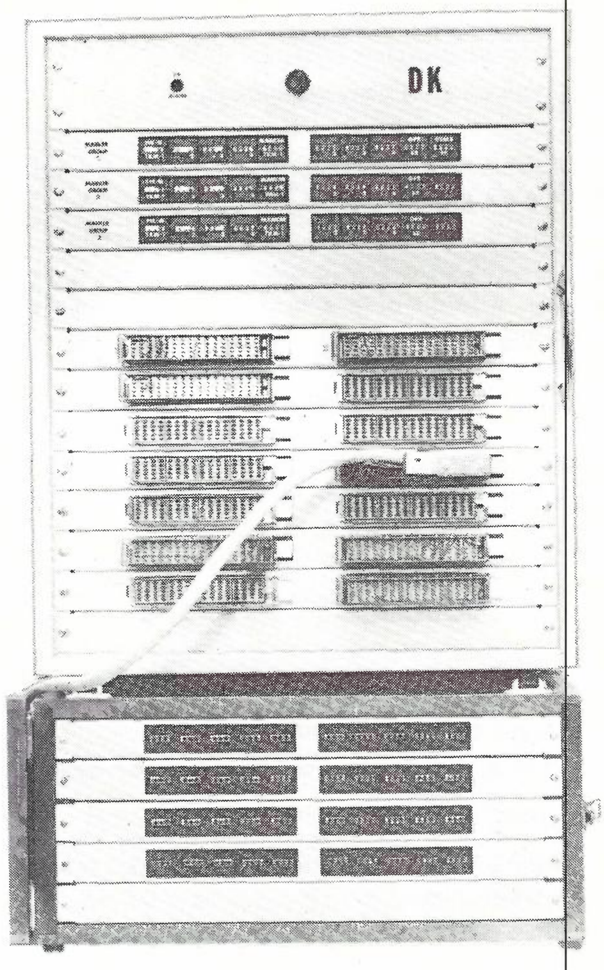


Fig. 3 — DK Rack and Portable Meter Set.

The lamp of the Speak Caller key flashes when a call is switched to the position and is steady when answered. Each operator has access to two shared outgoing exchange lines for enquiry purposes and an individual circuit to a Supervisor. A call to the Supervisor lights a large visual indicator on the originating operator's position and operates a gong and lamp on the Supervisor's post. Any incoming call may be transferred to the Supervisor in which case the operator's circuit is cleared and free to accept another call. **Fig. 4** illustrates the layout of a dual operator's panel with access to two queues. A key is provided for queue selection. A code identification lamp indicates an incoming call from an international operator. Up to four lamps are available for code identification. A 'Close Position' key allows an operator to block further calls while preparing to vacate a working position.

Operators are organised into groups of up to twelve, and each group is assigned a Supervisor. Facilities available on the Supervisor's position include:

- Duplication of each Operator's 'Speak Caller' lamp to indicate call status.
- Monitoring of conversations.
- Speak to operator while monitoring.
- Twelve incoming call circuits, one from each of the 12 operators.
- One bothway call circuit to the Overseer.

Supervisors will only receive calls from subscribers as a result of a transfer, and each Supervisor has up to four circuits for receiving these calls. Transferred calls are not placed in a queue.

Overall supervision of operators is achieved from the Overseer's desk. Duplicate observation facilities are provided as for the Supervisors, however the Overseer has no access to incoming calls. Facilities of this position include:

- Observation of 144 operators (maximum).
- Indication of transfer circuits status.
- Queue length reduction capabilities.
- Indication of queue full.
- Night switching control.
- Access to supervisor call circuit, order wires and exchange lines.
- Statistical information for calls offered, calls answered and calls exceeding a preset speed of answer time.

The initial Overseer's panel has facilities for observing 72 Operators. An additional panel is required for observation of a second group of 72 operators.

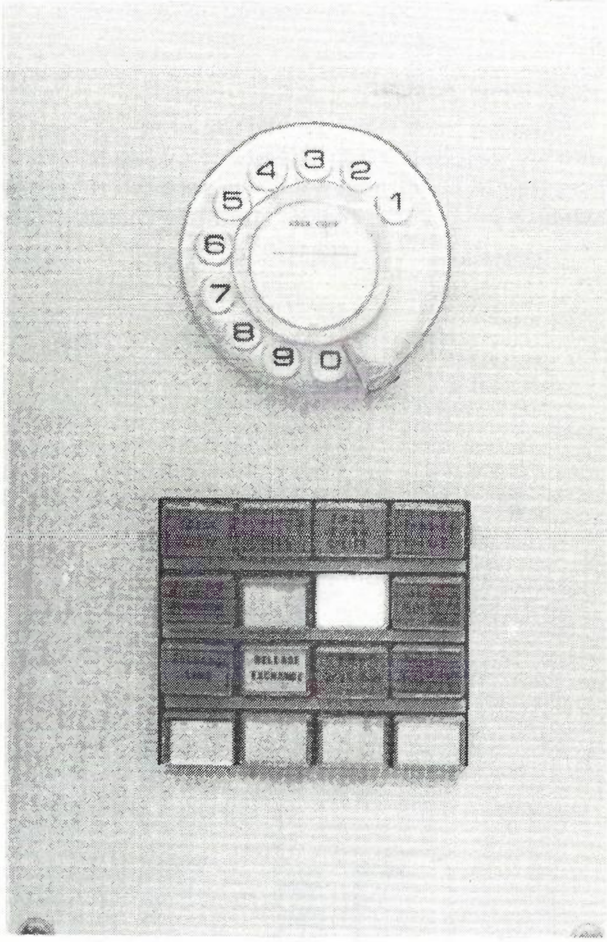


Fig. 4 — Operators Panel.

SYSTEM CONFIGURATION

For explanatory purposes the equipment may be grouped into four functional areas:

- The incoming interface between the network and the access switching equipment.
- The switching devices.
- The common control equipment consisting of selection circuits, queueing equipment and a marker.
- The Operator, Supervisor and Overseer interfaces.

Each of the main elements within these areas is shown in the system block diagram of **Fig. 5.**

Incoming Interface

The FIR-Q line relay set performs normal repeater functions for calls extended over a two-wire, 2000 ohm junction from the parent exchange. The relay set extends ringing tone to the caller while the call is queued and during the transfer of a call to the Supervisor. Busy tone is connected if the queue is full or the operator force releases. Standard line signalling applies for the duration of the call.

To establish a position in the queue once an FIR-Q is seized, a five digit binary code is received and stored in the relay set. This code is retained until the queue position code of the next call to be switched corresponds to the stored code. The call is then switched to an Operator.

Switching Device

Calls are switched from line relay sets to Operators or Supervisors via a standard 10 inlet, 30 outlet crossbar switch (SL). The line relay sets are tied to the verticals of the switch, and the Operators and Supervisors Interface relay sets to the horizontal outlets. Up to four SL switches are provided for a marker-group giving access to 40 inlets with the 30 outlets of each switch in full multiple, of which 27 are dedicated to Operators and 3 to Supervisors.

Common Control

The common control relay sets consist essentially of a Marker, queueing circuitry and selection circuitry.

The main function of the Marker is to recognise a request to switch from an FIR-Q, pre-select a free operator or transfer circuit and control switching of the call via the SL stage to the required outlet. A normal call to an Operator is switched to the appropriate OPR-O relay set, and for a transferred call, to a FUR-M relay set. A stepping allotter in the Marker ensures that calls are distributed to all free Operators in a fixed sequence. Selection of a free transfer circuit, one of a maximum of three, is achieved by a fixed priority selection chain.

Time supervision relays in the Marker force release calls which are not switched within a pre-

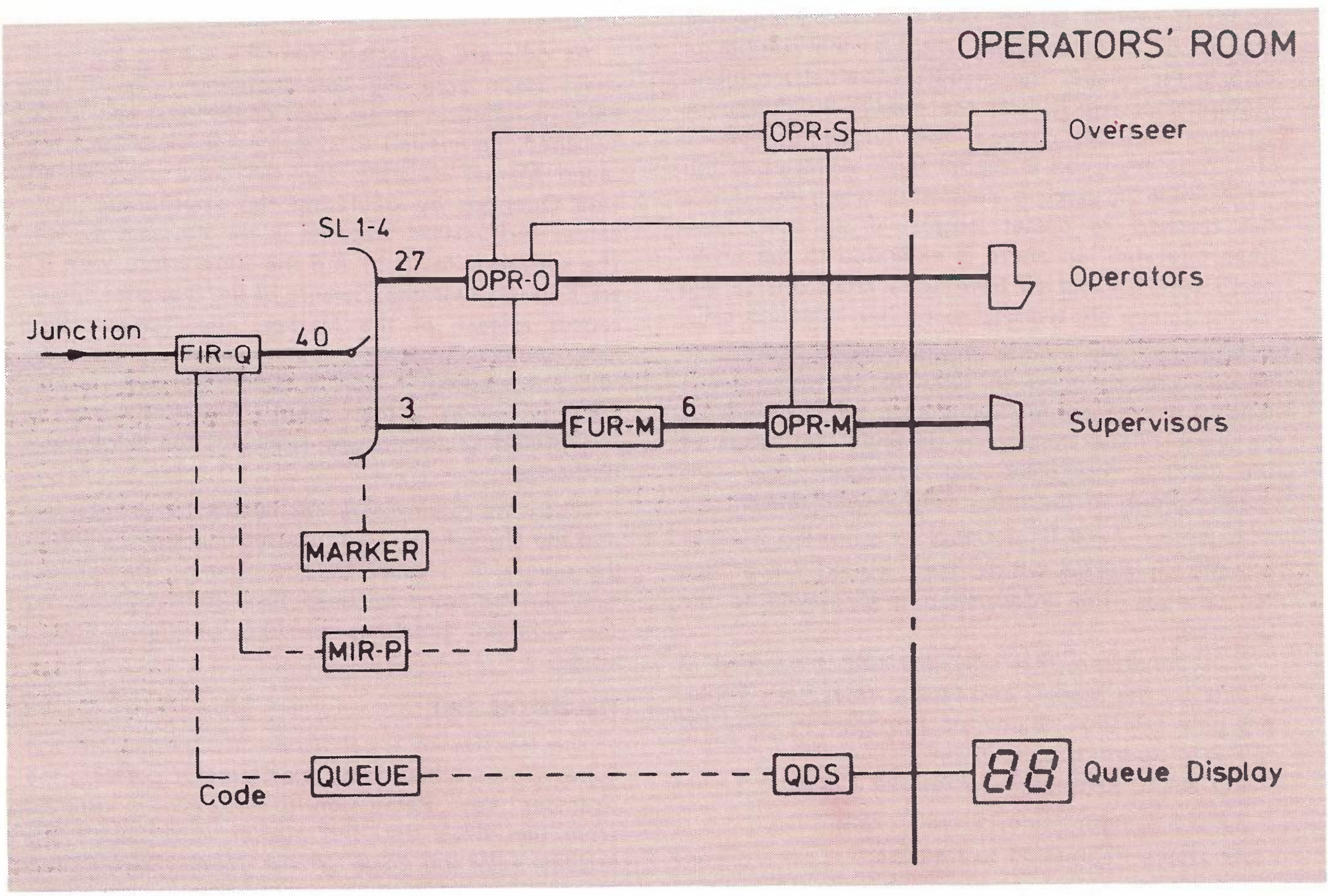


Fig. 5 — System Block Diagram.

set time. Calls not allocated a queue position within the time supervision period are switched as for a priority call.

The Queue relay set consists primarily of two binary count circuits known as the write chain and read chain. These chains can count independently to a maximum of 31 using a five bit binary code. Write chain codes are written and stored in five relays in each FIR-Q after seizure of a call. Once a code is stored the write chain steps to the next code, and the rate at which the chain counts is entirely dependent on the rate of incoming calls. The read chain performs the complementary function. Calls are queued in order of arrival and are extracted in the same sequence. The read chain steps from 1 to 31 and each code is compared with all FIR-Q stored codes. When the corresponding code is identified the FIR-Q is switched. The read chain steps at a rate determined by the time taken for a Marker to switch a call and the availability of free operators. Automatic stepping of the read chain is possible if a code is not identified or switching is delayed.

Associated with the Queue relay set is the electronic Queue Display System (QDS). This device performs several control and supervisory functions and as the name suggests, displays the number of calls in the queue. The circuitry essentially contains multiplexors which scan the FIR-Q's to determine whether they are queued. The number of queued FIR-Q's is displayed in digital form. Analysis of this information is used to determine when the queue has reached its preset length. If all seats have been allocated, an alarm is extended to the Overseer's position and all free FIR-Q relay sets served by the queue are blocked to further incoming calls.

With multiple marker-group working, additional circuits are included in QDS to compare queue lengths of adjacent marker-groups. When imbalance between queue lengths is detected test leads of the flexible operators are switched from one marker-group to the other via external relays.

A timing circuit is provided to count the number of calls in queue which have waited more than ten seconds. This information is displayed to the Overseer.

It is imperative that only one call is handled at a time by the Marker and Queue relay sets. Three, one-only selection chains are provided in relay set MIR-P to control this condition:

KQ chain: Permission to receive a code.

KP chain: Permission to switch calls.

KT chain: Permission to transfer.

The former two are associated with FIR-Q relay sets. The latter chain is associated with Operators.

Operator, Supervisor and Overseer Interfaces

Operator circuit elements providing headset and dial connections, side tone and monitoring tap are incorporated into relay set OPR-OI. Since most of these functions are also required by Supervisors and the Overseer, identical circuits are used for these positions. (Coded OPR-MI and OPR-SI).

Interface circuitry (OPR) is required to interpret key operations, initiate the required function and extend information to the key lamps. Relay sets OPR-O and FUR-M interwork directly with the switching stage to mark free operators or transfer circuits, and receive or transfer calls. A transfer on one circuit may be directed to any of six Supervisors if required via relay set FUR-M.

BRIEF SURVEY DESCRIPTION

Incoming Call

The incoming junction to FIR-Q is looped from the parent exchange. FIR-Q on seizure applies to the MIR-P for permission to receive a queue position code. On receipt of this from the write chain, a binary code is stored in the FIR-Q. The call is now in queue and the subscriber receives ringing tone.

As calls are extracted from the queue, the read chain steps until the corresponding code of the FIR-Q is identical to the code of the next call to be switched. Permission to switch is obtained and the called Marker switches the call to a pre-selected free Operator by operating the appropriate horizontal and vertical magnets in the crossbar switch. The speech wires (a,b) and the supervisory wire (c) are through switched. Seizure of the Operator circuit causes release of the Marker. The 'Speak-Caller' lamp on the Operator's position flashes. When the call is answered a loop is extended back to the FIR-Q initiating a line polarity reversal which is interpreted as an answer signal at the originating exchange.

When the caller clears, the connection is released and the Operator is free to accept another call from the queue. If a caller fails to release, the connection can be force released back to the FIR-Q, by the Operator breaking the loop on the a and b wires.

Transferred Call

The transfer of a call from an Operator to the Supervisor is achieved by the Operator pressing the 'Transfer' key. Permission to reswitch is granted from the MIR-P and the marker is re-called. The priority selection chain in the Marker determines the transfer circuit to be used and as for an Operator call, the transferred call is switched to a free

Fig. 6 — Directory Assistance Operators Position.

FUR-M. Subsequently the Supervisor is signalled by a flashing 'Speak Caller' lamp.

DIRECTORY ASSISTANCE CENTRE

The development of the queued access system was aimed initially at improving the grade of service offered in Brisbane for directory assistance. The previous system had reached its capacity both in incoming junctions and switched paths. No additional Operators could be connected.

The task of providing directory information to subscribers with a minimum of delay is becoming increasingly difficult due to the large number of directories. The previous Operators positions were overtaxed with directories to the extent that the search for numbers was slow and inefficient. Therefore in conjunction with the development of the Queued Access System opportunity was taken to develop a new design of Operators position.

The main objectives of the new design were:

- Fast access time to all directories.
- Ease of handling directories.
- Minimal eye fatigue when reading.
- Improved comfort for the Operator.
- Attractive appearance.

Fig. 6 illustrates the new Directory Assistance Operator's position. A smaller version of this position was also designed for Operators handling Queensland directory information only. To complement the new positions special attention was given to room decor and lighting. An illuminated ceiling consisting of polarising panels provided the ideal solution to the problems of glare and reflections.

The designs of the Supervisor's and Overseer's positions were adapted from the AFG System. The main differences were in the panel layout and slope angles.

As the number and size of directories increase, so does the difficulty in providing directory assistance from this source of data. In future we may expect that directory numbers will be stored on computer file or microfilm. Access will be gained by the Operator requesting information from a keyboard and the directory listings will be displayed on a screen. Irrespective of the type of retrieval system used, a Queued Access System, such as the QAS-1 described in this article, is still required to inter-connect the telephone network to the Directory Assistance Operators.

CONCLUSION

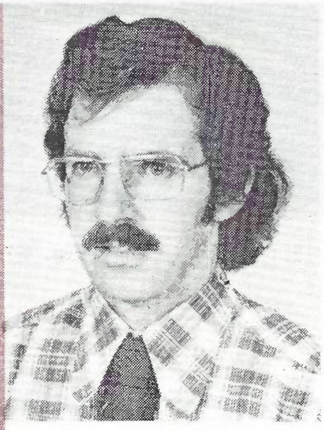
The Queued Access System was designed to queue calls incoming to a terminating service level. Considerable flexibility has been built into the system to ensure that it has an application at various information services.

The queueing system is structured in marker-groups which may be paralleled as the system expands. Up to four codes may be queued together, and Operators may accept calls from two independent queues.

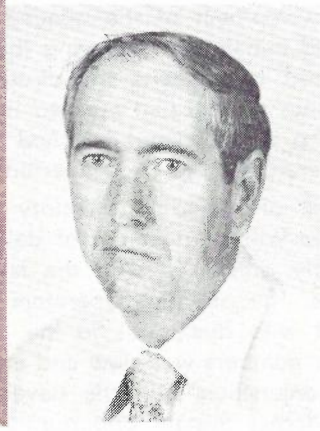
The installation time has been minimised by the use of free-standing racks, plug-ended cables and pre- formed IDF jumpering. The equipment circuit design features standard crossbar circuitry and switches wherever possible. Maintenance aids have been incorporated for ease of analysing faults. The use of PABX type racks allows placing equipment and Operators in commercial buildings of normal ceiling height.

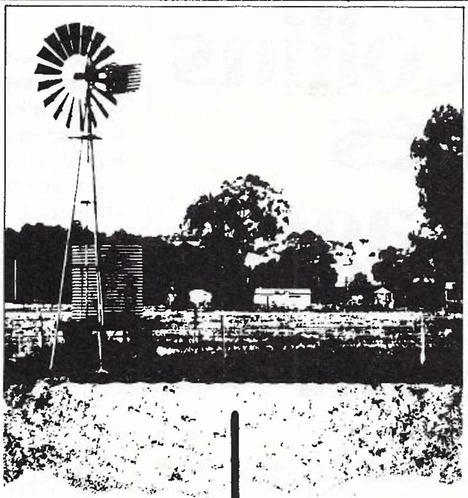
The development of QAS-1 was based on current requirements with the full awareness of new facilities which may be required. For this reason the design is flexible and sufficiently open to allow for future development.

JIM MORE commenced with Telecom Australia in 1971 as a Cadet Engineer and obtained his Bachelor of Engineering Degree from the Queensland Institute of Technology in 1973. Since graduating he has worked in Construction Branch as Engineer Class 1 in exchange installations. He was involved in the early phases of the QAS-1 development during the design, construction and testing of a prototype and also the development of the operators position. Presently he is Engineer, Trunk Exchange and Gold Coast installations.



BOB BEVERIDGE joined the PMG Department in 1952 as Technician-in-Training. As a Senior Technical Officer he has worked for Headquarters (2 years), as Technical Advisor Fiji (2 years), and on loan to L.M. Ericsson (2 years). Whilst with L.M. Ericsson he visited many overseas countries studying design and installation techniques. His present position is STO2, Metropolitan Installation No. 2, Construction Branch, Brisbane.





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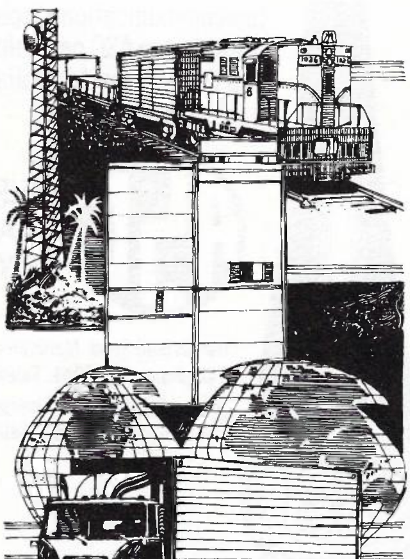
MDR-11-N/MDR-11-5N 11-GHz Microwave Digital Radio
MDR-11/MDR-11-5 11-GHz Microwave Digital Radio
MVR-11C 11-GHz Microwave Video Relay System
MVR-6C 6-GHz Microwave Video Relay System
MVR-2S 2-GHz Microwave Video Relay System



COMMUNICATION SWITCHING SYSTEMS

Rockwell-Collins communication switching systems have solved a lot of tough problems for leading organizations all over the world: airlines, banks, government agencies and financial institutions — organizations whose very existence depends on the efficiency with which they handle their voice or data communications. We offer an unusual blend of advanced technology plus the experience necessary to harness it

efficiently and economically, plus total immersion in the theory and application of communications techniques per se. The result is communication switching syste. capability that's unmatched by anyone anywhere.

Automatic Call Distribution (ACD) Systems

Within just two years of its introduction, a Rockwell-Collins digital voice switching system was adopted by almost the entire U.S. airlines industry, as well as by a number of airlines throughout the world. The reason: it provides such effective handling of high volume telephone traffic. These systems' more efficient use of people and facilities results in increased productivity and lower operating costs.

Front End Message Switching Systems

These systems are for businesses that depend on extensive message and data communications over a distributed network.

Our C8500 system is for companies whose message and data transactions run into millions every day; our intermediate-sized C900 is for somewhat lower volumes.

Telephone Special Services

Our digital voice switching systems are direct applications of the ACD function within an operating telephone company. Ideal for business services, repair services, traffic services, and subscriber services. A single Rockwell-Collins switching system can be functionally aligned to distribute a variety of types of incoming calls to the appropriate service positions. A remote service option permits the service positions to be located in neighborhood service centers and/or the customer's premises for commercial subscriber ACD functions.

SATELLITE COMMUNICATION SYSTEMS

We were the first company to transmit a photo and voice by satellite. Since then, the voice of every American astronaut has come back from space over

Rockwell-Collins equipment. We're currently installing earth stations for the largest satellite communications network in the world. When completed, the system we're providing will interconnect all the member stations of the Public Broadcast Service — 163 of them.

That's the kind of experience we have behind our satellite communication ground systems. And that's why we can make such a system practical for any organization or country — regardless what size system is required.

Earth Stations

Our ground systems can provide improved communications for distribution of TV, AM/FM radio programming or teletype . . . or for voice channel requirements — thin route (1-24 channels) or heavy route (360-28,000 channels).

DATA COMMUNICATIONS EQUIPMENT

Modems, network management systems and automatic testing systems are among the many devices and systems we design and manufacture to simplify communication systems and make them more reliable and efficient.

TE-2400 Data Modem

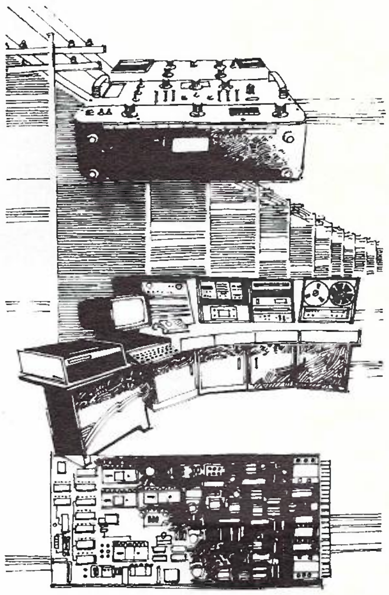
Probably the most complete modem anywhere — all on one compact card. This MOS/LSI data modem includes: • Unconditioned or dial circuits • On-line compatibility with other PSK modems, including WECO 201B and C • Full or half duplex operation • Compact single card design • Built-in diagnostics • Custom configuration to meet your needs (special packaging, etc.) • PSK Conventions: U.S. and CCITT (strap selectable) • Superior performance. (Bit error rate with the equalizer is less than 1×10^{-6} on typical schedule 3002 unconditioned or dial lines.)

RTS-100 Network Management System

The adaptability of RTS-100 to any size communication network comes from a building block approach. A small network can start with a manual system (a test panel and a few remote terminal controllers) and add to it as the network grows. A large, complex system can start right out with a fully automatic RTS-100.

ATRS-2000 Automatic Trunk Routiner System

Our recently introduced ATRS-2000 provides completely automatic computer-controlled access and testing of trunking plants, eliminating time-consuming manual testing. It uses one central control site to provide access via a dial network to any number of remote offices for comprehensive trunk testing and comparison of results against customer specifications. Interface arrangements and measurement techniques are all compatible with Western Electric 105 generators and other similar responders.



For more information, contact a Rockwell-Collins sales office in one of the cities listed below. Or Collins Commercial Telecommunications Group, Rockwell International, Dallas, Texas 75207. Phone: 214/690-5340.

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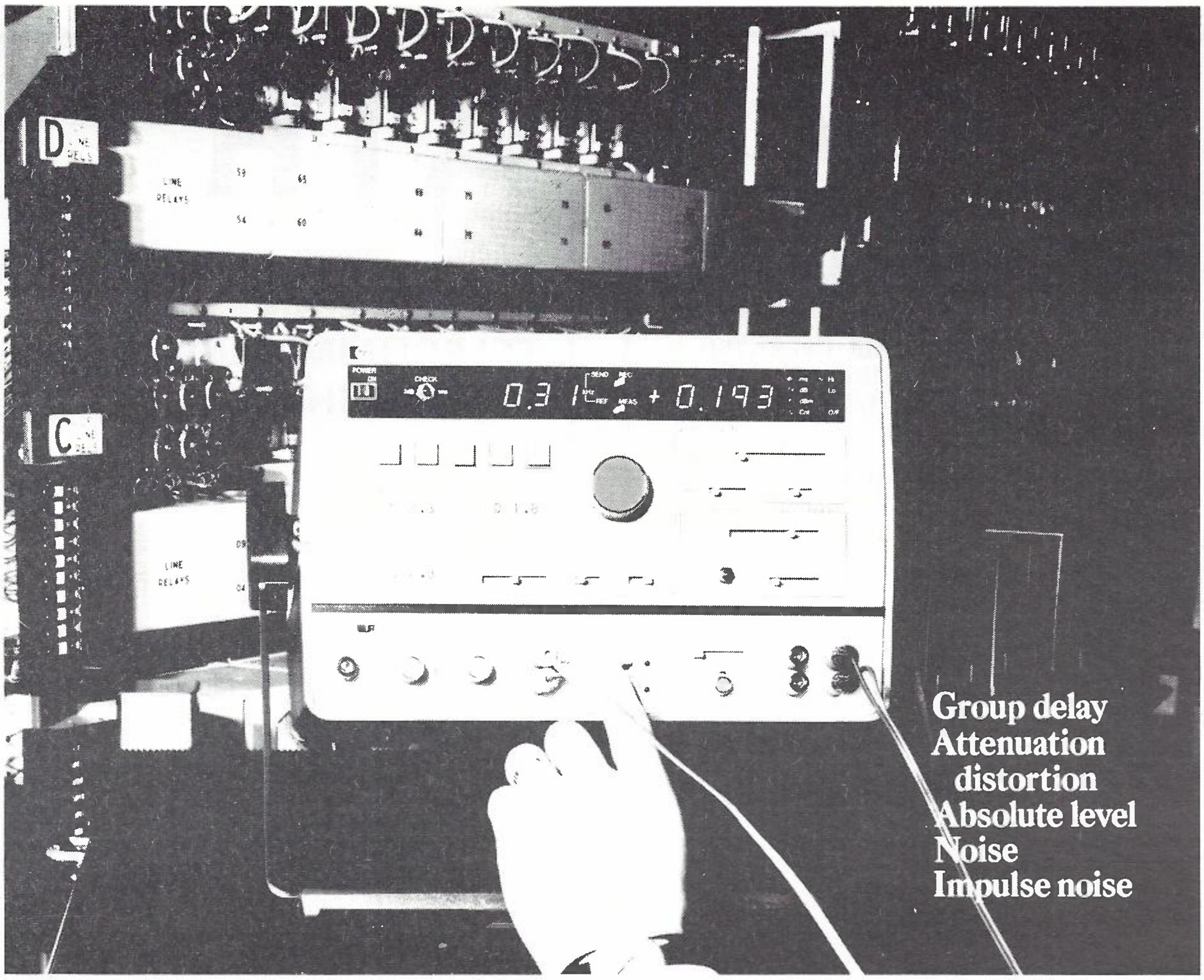

Data line problems? Hewlett-Packard has the answer

Hewlett-Packard has designed two instruments for audio data line characterisation to CCITT standards – the 3770A Amplitude/Delay Distortion Analyzer and the 3770B Telephone Line Analyzer.

The 3770A measures group delay, attenuation distortion, and absolute level in the frequency range 200Hz to 20kHz. Linked to an HP portable X-Y recorder, it will produce a permanent swept record of the measurement within minutes of switch-on. Other features include automatic ranging, zeroing, and synchronisation, with simultaneous LED readout of measurement result and frequency.

The 3770B, in addition, measures weighted noise, noise-with-tone, and impulse noise. It provides – in a single, portable unit – all the routine maintenance measurements recommended by CCITT for high-speed data lines. Further, an optional slave facility for group delay and attenuation distortion measurements allows the measurement results for both directions of transmission on a 4-wire circuit to be displayed at one end of the circuit.

Both of these easy-to-use, portable instruments have a wide range of options, allowing you to select only the measurements and facilities which suit your needs.

For further details of these and other Hewlett-Packard telecommunications test instruments, contact your local HP Field Engineer, or write to us at the address below.

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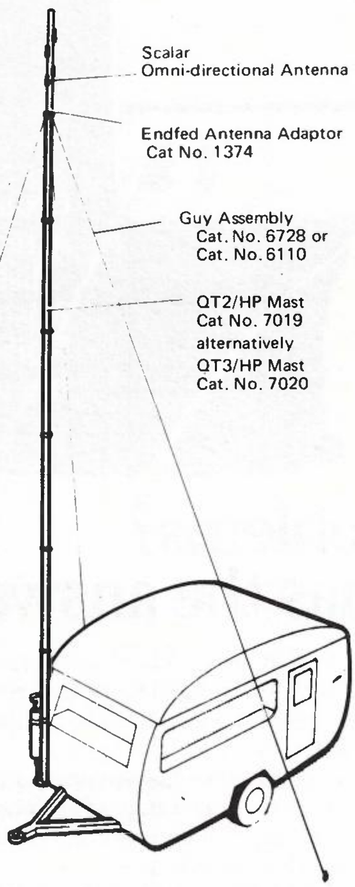

Q.T. Series Masts 'The Light-weight Mast with 101 applications'. The QT air operated telescopic mast has always been a very popular series. It's so portable and easy to operate. Vital for field radio communications, supporting temporary flood lights, meteorological instruments, survey equipment and microphones. There are four models — 5 metres (16 ft), 7.5 metres (25 ft), 9.2 metres (30 ft) and 12 metres (40 ft).

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TELECOMMUNICATION SOCIETY OF AUSTRALIA

The Telecommunications Journal of Australia

ABSTRACTS: Vol. 28, No. 1

COLLINSON, J. T., KLINK, T. and LUECKE, H. W.: 'Style 72A — New Generation Carrier Multiplex and Line Transmission Equipment — Part 2'; Telecomm. Journal of Aust., Vol. 28, No. 1, 1978, page 10.

The first part of this article described the mechanics and the electrical features of channel modems, carrier system Z12 and through filters of Siemens new Style 72A generation of carrier and line transmission equipment. This part of the article continues this description for other orders of carrier multiplex sub-systems, carrier program and coaxial line systems.
The article concludes with a brief section describing quality assurance and automated in-factory testing and describes the approach taken by Siemens Industries Limited to fulfil the requirements of Telecom Australia for a complete family of analogue multiplex and line transmission equipment.

DOUGLAS, K. R.: 'Converting a Working ARF 102 Exchange to ARE 11'; Telecomm. Journal of Aust., Vol. 28, No. 1, 1978, page 45.

The first public working 10,000 line ARF 102 exchange converted to ARE 11 control in Australia was cut-over in June 1977. This paper describes data preparation and the data changes necessary at each level of control to convert Salisbury, near Adelaide, South Australia, to direct control of all switching stages.

FARR, J. P.: 'A Computer System for Designing Telephone Networks'; Telecomm. Journal of Aust., Vol. 28, No. 1, 1978, page 3.

The paper describes a set of five software packages which assist in the process of dimensioning the junction routes which interconnect the network of telephone exchanges which serve the Perth (WA) metropolitan area. The system is used for medium and long-term planning as well as for the basic application of detailed short-term network design. The packages perform the following functions:

- produce a forecast in matrix form of future point-to-point traffics for the complete metropolitan network;
- data capture, validation and packing;
- dimension the circuit requirements to handle the forecast traffics at a satisfactory grade of service, and in the most economical way;
- external plant planning and specification;
- produce detailed work orders specifying the changes to be made to junction route sizes.

KETT, R. W.: 'Design Principles of a New Telephone Apparatus Measuring System — Part 2'; Telecomm. Journal of Aust., Vol. 28, No. 1, 1978, page 56.

The examination of problems associated with the quality assurance purposes is continued, leading to the enunciation of design principles for a new telephone measurement of telephone apparatus for transmission apparatus measuring system for use by Telecom Australia.

LINDENMAYER, G.: 'Cable Television'; Telecomm. Journal of Aust., Vol. 28, No. 1, 1978, page 38.

The technique of feeding television signals to a number of receivers via a cable reticulation system, common in some other countries, is little used in Australia. Cable Television Systems have a place in meeting certain special needs, such as in areas of poor off-air reception or where there is a call for additional programmes. Some of these applications and the technology they employ are described here.

MORE, J. and BEVERIDGE, R. C.: 'Queued Access System for Information Positions (QAS 1)'; Telecomm. Journal of Aust., Vol. 28, No. 1, 1978, page 84.

The Queued Access System is a crossbar queueing system for information services and is currently in use at the Brisbane Directory Assistance Centre. The system configuration allows for flexible trunking arrangements to suit the demands of various services, and can expand from a single marker-group system of typically 40 inlets and 24 operators to 5 marker-groups. The equipment can be placed in ordinary commercial buildings, allowing Information Centres to be located remote from an exchange building. Plug-in cabling ensures minimum installation time and maintenance features assist fault tracing. This article discusses the features and operation of the system.

ROBERTS, G. J. A.: 'The Brisbane Terminating Trunk Tandem Exchange'; Telecomm. Journal of Aust., Vol. 28, No. 1, 1978, page 64.

This article outlines the background for the need to develop a temporary trunk switching tandem exchange in the Brisbane Trunk Network. It describes the unique design of the Terminating Trunk Tandem (TTT) using two switching disciplines, the resulting necessary equipment modificactions, and finally the installation of the Brisbane TTT.

SMYTH, J. D.: 'Metaconta 10C SPC Exchanges — An Operating Approach'; Telecomm. Journal of Aust., Vol. 28, No. 1, 1978, page 25.

A new technology means a change in demands on the staff who are required to operate and supervise the equipment which uses it. New capabilities may also mean new problems. The introduction of Stored Program Controlled (SPC) switching with the Metaconta 10C Trunk exchange brought such changes; an operation viewpoint is given of the work involved in introducing this type of exchange to the Australian network.

THUAN, N. K.: 'Integrated Power Suites (IPS) for Telephone Exchanges'; Telecomm. Journal of Aust., Vol. 28, No. 1, 1978, page 72.

Integrated Power Suites, a local name for the well known multiple rectifier-battery float system, are the standard d.c. power supply for Telecom Australia telephone exchanges. This paper sets out general information necessary for the understanding of the power system, its performance features and its limitations.

THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

Volume 28 No. 1, 1978

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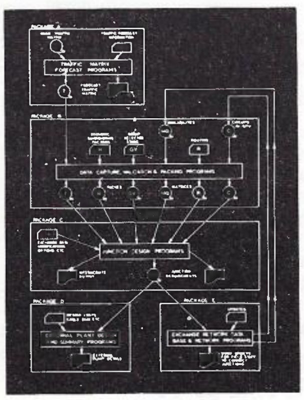

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