ARE 11 System Appreciation

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Telecom Australia is about to embark on a major modernisation programme to provide new facilities in the crossbar exchange network. Studies of these updating proposals for the crossbar network revealed an economic application for the ARE 11 exchange system in providing these new facilities in existing exchanges. On 1 March, 1976, the ARE 11 exchange system was accepted for use in the Australian network with an application in new exchanges and for the upgrading of existing ARF exchanges.

This paper, the first of a series, describes the system features, the advantages of the system compared with ARF and its application to the Australian network.

INTRODUCTION

L. M. Ericsson have developed an upgraded crossbar exchange switching system known as the ARE 11 exchange system that incorporates the crossbar switching stages of the ARF 102 exchange system and a new processor controlled common equipment sub-system (ANA 301). The development of the ARE 11 exchange system was the outcome of a design for an electronic register known as the ROM 30 which employed time division multiplex techniques. (ROM 30 was later re-designated ANA 30.) It was realised that the ROM 30 technique did not go far enough in control of common equipment functions, and the development of a processor controlled system was commenced in 1970. The system (ARE 11) which can control most of the common equipment functions in an exchange has been under examination for application in the Australian telecommunications network since late in 1971. As a result of the early studies of the system application in the network a contract was let in June 1973 for two trial exchanges at Elsternwick in Victoria and Salisbury in South Australia and for a model exchange in the Telephone Switching Design Laboratories of Headquarters.

The ARE 11 system incorporating the ANA 301 subsystem could be applied for both new exchange applications and for updating existing ARF exchanges. Elsternwick was selected as a new exchange installation of 4000 lines and Salisbury as an existing ARF exchange of 10,000 lines to be updated by replacement of the existing common equipment by the ANA 301 subsystem. Experience with the model exchange and the trial installations has confirmed the technical viability of the system.

Economic evaluation studies into the application of the system into the Australian network were finalised late in 1975, and on 1 March 1976 the system was accepted by Telecom Australia for use in the network as an alternative to the standard ARF exchange system.

SYSTEM FEATURES OF AN ARE 11 EXCHANGE

The ARE 11 exchange system consists of a common control system part (ANA 301 subsystem) with processors for the control of traffic and maintenance functions and a crossbar switch for the switching system part.

In the design of the system a balance has been achieved between the utilisation and complexity of the ANA 301 control system and the retention of the ARF basic switching functions utilising current electro mechanical technology. As a consequence, there has been little change to line relay sets and to some of the marker identification equipment.

The ANA 301 subsystem uses stored program control (SPC) technology for the analysis and logical control functions and replaces those parts of the existing ARF system where advantages can be achieved by centralisation of the control logic and analysis. These are for example the register functions, subscribers categories, PBX selection and GV route analysis and selection. Also, the inherent flexibility of an SPC system offers a simplified and more economical method of providing new subscribers and network facilities. This can be accomplished by alterations and/or additions of programme packages and functional units. The structure of the ANA 301 subsystem enables existing ARF ex-

changes to be modernised to provide some of the new network and subscribers facilities which are available with modern full SPC exchanges.

New improved operational and maintenance facilities are also offered. New techniques are required as the operation of the exchange is supervised by an operations and maintenance processor which can simplify the identification of exchange malfunctions and assist in fault diagnostics. The system also offers the potential for remote control of the exchange from a centralised location.

EXCHANGE STRUCTURE

The common control system of an ARE 11 exchange is capable of being expanded from performing only the basic register functions to controlling all the registers and all GV and SL switching stages. The options available and their grouping into levels of control for ARE 11 in the Australian network are discussed later.

An ARE 11 exchange has three groupings of equipment:

(i) The crossbar switching equipment.
(ii) The interface equipment.
(iii) The processor equipment.

Parts (ii) and (iii) form the ANA 301 common control subsystem and are shown in Fig. 1.

The interface equipment is required to enable the speed and operating voltages of the processor equipment to be matched to that of the crossbar electromechanical exchange. The equipment units consist generally of plug-in integrated circuit boards that are directly controlled by the processor.

The processor part consists of up to six traffic control processors (TCP), a single operations and maintenance processor (OMP) and the central data stores.

Interworking between the processor and other devices is by means of a processor bus system using balanced pairs. A bus system connects the processors to a multiplex switching device (MUX) on each of the interface racks to which the processor has access. This is indicated in Fig. 2.
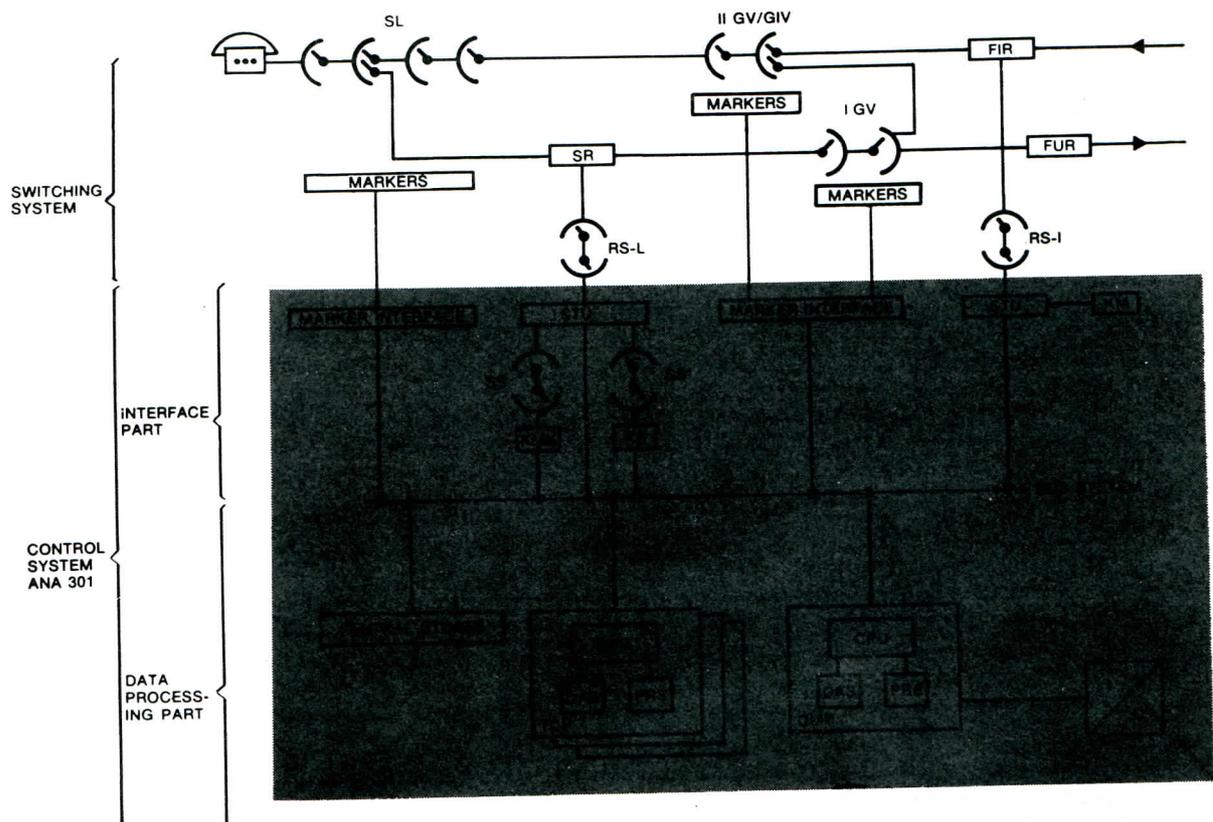

Fig. 1 — ARE 11 Survey Block Diagram.

FACILITIES AVAILABLE IN ARE 11 EXCHANGES
Exchange and Network Facilities

Operations and Maintenance

The ARE 11 exchange system provides improved equipment reliability and advanced operating features which will reduce the operations and maintenance costs. The system offers the potential for fault diagnostic work to be carried out remotely to the same degree as if on site, and thus the exchange can be maintained as an SPC exchange rather than crossbar. A new maintenance strategy will be required which will be different from that currently employed in the network.

Reduced operational and maintenance costs are expected to be achieved from the following features:

- Improved equipment reliability.
- The remote supervision aspects.
- Subscribers, exchange and network dependent data is held in data stores which enable remote alteration. For example alterations to subscribers category information, route analysis, the blocking and enabling of subscribers lines, etc.

GV Stage-Improved Capability

A number of the disadvantages of the present GV stage equipment are overcome by the introduction of ANA 301 control of the GV stage. The most significant amongst these include:

- Increased address capacity for the marker equipment to 256 addresses for a processor group in an exchange.
- Greater flexibility in allocating availability. A 2/160 stage can have route availabilities of from 5 to 80 in steps of 5. A similar arrangement also applies for the 1/80 GV stage which can have route availabilities of from 10 to 80 in steps of 10.
- Simplified extension of the 2/160 three stage GV availability to 1600 without the need for significant marker re-arrangements.

PBX Facilities

An extremely simple method of PBX connection has been devised with a single wire jumper wire only required to the PBX equipment. Current ARF 102 number restrictions are removed and PBX lines can be freely distributed through a 10,000 line group.

Metering Equipment

Current standard metering facilities are used but the system has potential for the introduction of electronic metering facilities and this is currently being investigated for possible introduction by about 1980.

New Signalling Schemes

Introduction of changes to the signalling schemes will generally only require amendments to program packages. However the provision of new program packages and new hardware for other alternative signalling schemes if these are required in the future is expected to be very much cheaper with ARE 11 because of the SPC techniques used. Common channel signalling could be one such scheme.

New Subscribers Facilities

An ARE 11 exchange can provide all the subscribers service facilities offered from an ARF exchange, together with the currently approved new network facilities of calling line identification (CLI) for international subscriber dialling (ISD) with automatic message accounting (AMA), revised trunk access barring capability, centralised interception and for voice frequency push button telephones.

The system could also be adapted to provide additional facilities if required in the future. Some of these facilities are:

- Abbreviated dialling — A subscriber need only dial a short code number to call regularly called numbers in either national or international networks.
- Hot line — The connection is established to a specified number from a designated telephone simply by raising the handset.
- Extra subscribers categories — Additional categories are available over and above those proposed for modified ARF exchanges.
- Follow me — Calls to a subscriber can be temporarily re-directed to another number.
- Cenpex — A group of subscribers connected to the exchange may be given additional facilities that are available in a PABX, e.g. short numbers, transfer and enquiry, etc.

SYSTEM DESCRIPTION OF THE ANA 301 SUB-SYSTEM

The ANA 301 subsystem is divided into two main parts as indicated in Fig. 1:

- A data processing part.
- An interface part.

The data processing part can be sub-divided into three sections; the traffic control processor, operations and maintenance processor and the central stores.

The processors in the ANA 301 system are the APN 110 type and have the same structure when used for either the traffic control application or as an operations and maintenance processor. Only the programs differ between the processors.

A processor consists of a central processing unit (CPU), a programme store (PRS) and a data store

(DAS). Both these stores consist of semi-conductor memories mounted on plug-in printed circuit boards. The PRS which stores the more permanent traffic programmes and operations and maintenance programmes is a read only memory. The DAS however is a read/write random access memory which stores temporary data applicable to individual calls. The CPU consists of a number of functional units internally linked together for the execution of the operations included in the programme instructions.

A maximum of six Traffic Control Processors (TCPs) and one Operations and Maintenance Processor (OMP) are combined to form a processor group.

Each TCP can serve 60 signal transfer units (STUs) which are interface units replacing the registers of an ARF exchange. A full processor group can serve 360 STUs which could serve up to a maximum of 40,000 subscribers, depending on the traffic capacity of the exchange. In very large exchanges with higher traffic requirements a maximum of four processor groups can interwork by means of an external communications buffer (ECB). Processor groups can then share the tasks of handling the traffic.

An operations and maintenance processor (OMP) is required for each processor group. The OMP supervises the operation of the TCPs, provides input/output facilities for communicating with the system and supervises the other units forming part of the ANA 301 system and provides for fault printouts and transmission of alarms. These input/output devices can include teleprinters, a visual display unit, a tape reader and data modems. In the case of a processor fault the OMP will transfer control of the corresponding equipment to another TCP within the processor group. Statistical traffic and switching data can be obtained for operational analysis and as an aid in fault tracing in the exchange.
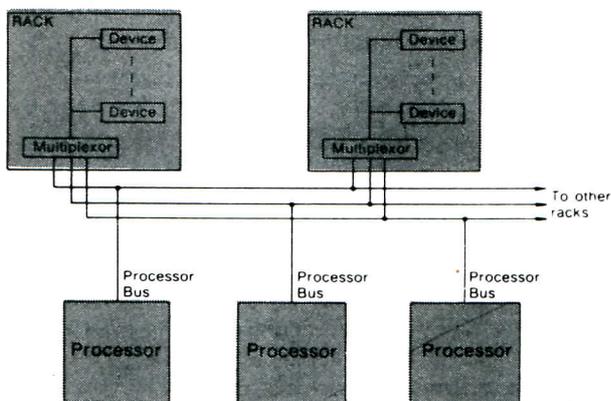

Fig. 2 — Connections between Processors and Device Racks.

Central Data Stores

The central store for the exchange and subscribers data are common to a processor group and consist of the subscribers category store (SCS), translation store (TRS) and the abbreviated dialling store (ADS). These stores contain alterable control information and have some logic functions which simplify the addressing requirements of the central processor. The SCS contains the category information for all subscribers as well as data for PBX subscribers. For economic reasons, the SCS is divided into a number of parts, which reduce the overall memory requirement for an exchange. One part contains the small number of common category combinations for all subscribers while the other parts contain the extended range of category and temporary categories required by a small number of the total subscribers.

The TRS contains the network data for the exchange. It is used for translation of the B number to the routing and charging information needed to establish the call.

Information concerning PBX equipment is shared between the SCS and TRS. The data required for connecting and testing of PBX lines is stored in SCS. However, the translation data to enable the PBX directory number (now not necessarily a double digit) to be replaced by the selected auxiliary number (now allocated from anywhere in a 10,000 line group) is stored in TRS.

The ADS is provided when required and contains special subscribers data for abbreviated dialling purposes. This store is used to translate a one or two digit number into a complete B number either national or international. A subscriber may have up to 100 abbreviated numbers. Also included are facilities for hot line where the ADS translates the A number with a category to a complete B number.

Interface Equipment

The interface equipment is needed to match the slower speed, higher voltage switching part to the higher speed, lower voltage data processor part as indicated in Fig. 1. The separate items of equipment providing these functions are shown in Fig. 4 and generally consist of plug in printed circuit boards which are directly controlled by the processor.

Levels of Control

The ANA 301 processor subsystem is modular in structure and consists of a number of autonomous functional units which allows various options of control in an exchange. Of the many options available, these have been grouped together to form four levels of control for use in the Australian network. These levels have been selected using both facility requirements and economic considerations.

TABLE 1 — FACILITIES AVAILABLE AT EACH LEVEL OF CONTROL.

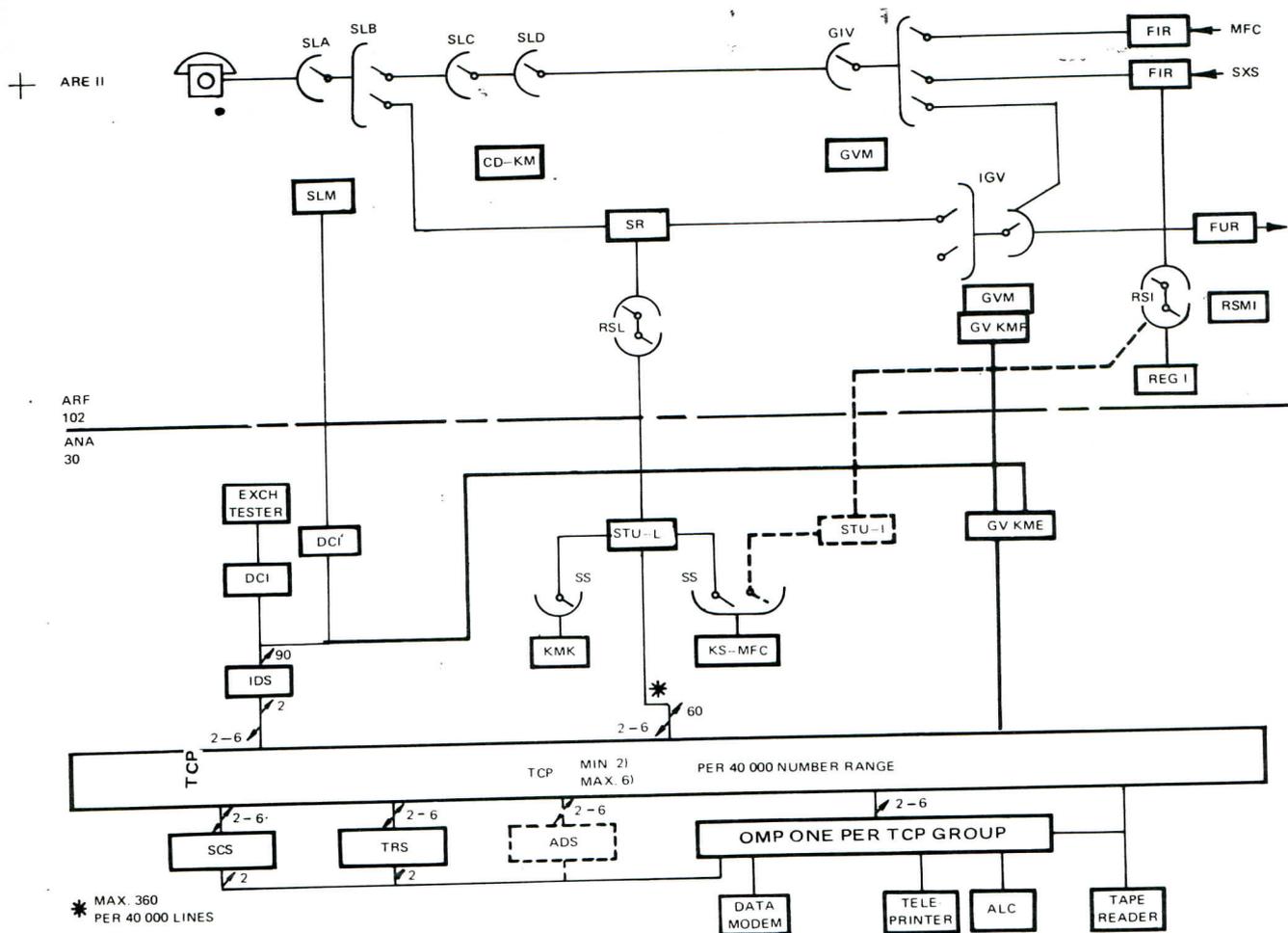| Facilities Provided	ANA 301 Processor Control		
	Level 1 & 2 (Register Replacement)	Level 3 (Register and 1GV)	Level 4 (Registers, 1GV, GIV & SL)
Calling Line Identification	X	X	X
VF Push Button Telephone capability	X	X	X
Increased Subscriber Classifications (Originating & Terminating)	X	X	X
Abbreviated Dialling Capability	X	X	X
Network Analysis Determined by Processor	X	X	X
Remote Alteration of Subscriber Categories	X	X	X
New MFC Signals Available	X	X	X
Centralised Interception for Terminating Calls	X	X	X
Remote Supervision of ANA-301 Equipment	X	X	X
Improved Facilities for 1GV Stage		X	X
— Increased number of route addresses			
— Increased range of outlets per route			
— Deletion of GV strapping fields			
— Remote control of traffic routing			
— Increased statistical data			
Improved Facilities for GIV Stage			X
Improved PBX Facilities			X

Fig. 3 — Level of Control; No. 1, No. 2 and No. 3.

The modular structure of the ANA 301 subsystem makes the system particularly suitable for converting existing exchanges. Functional control of the individual parts of the exchange can be transferred to ANA 301 control independent of the other operations of the exchange during the conversion process. The technical aspects of these conversion techniques have been investigated at the model exchange and at Salisbury crossbar exchange in South Australia. The levels of control that have been selected as appropriate for use in the Australian network are listed below together with the facilities provided at each level. Table 1 summarises the facilities available at each level of control.

Level No. 1 — Replacement of Local Register Functions

At the levels of control No. 1, the ANA 301 subsystem provides for the replacement of the local register functions of either the Reg LM or Reg LP.

The incoming register equipment (Reg I's or a proportion of Reg LP for step by step decadic traffic with the associated SS and KS) are retained. Conventional MFC signalling is retained internally in the exchange between ANA 301 subsystem and the other common controlled equipment items. The following additional facilities can be provided with Level 1 control compared with an existing ARF crossbar exchange.

- Calling line identification required to provide AMA for ISD.
- Increased originating and terminating classifications.
- Ability to introduce VF push button telephones by addition of code receivers and coupling stage.
- Ability to remotely alter subscribers categories.
- Ability to introduce abbreviated dialling.
- Ability to provide centralised interception of terminating calls.

- Remote supervision and control of ANA 301 equipment.
- Introduction of new signalling arrangements to enable the new network facilities to be provided.
- Number length and TOTE analysis performed in ANA 301 equipment and requirement is eliminated from 1GV in former Reg LM exchanges.

ANA 301 equipment to be provided for a level 1 control exchange is indicated on Fig. 3 by the black outline.

Level No. 2 — Replacement of Local and Incoming Register Functions

At this level of control ANA 301 subsystem provides for the replacement of the incoming register functions for decadic traffic in addition to the local register functions. Depending on the type of line relay set equipment, the incoming register function will be provided by using STUL's where Reg LP (loop signalling to the register) incoming junction relay sets are proposed or by STUI's where Reg I (single wire signalling to register) incoming junction relay sets are provided. No additional facilities other than those available from Level 1 are available.

Additional items of equipment for Level 2 control where Reg I equipment is replaced is shown in Fig. 3 in the red dashed outline.

Level No. 3 — Direct Control of the 1GV Stage

At this level of control the ANA 301 subsystem is extended to provide control of the 1GV stage.

Direct control of the 1GV stage enables a number of enhanced facilities to be provided which overcome many of the present limitations. MFC signalling is no longer required for 1GV stage control which is now exercised by the GV KME, IDS and a new GV KMR relay set.

Levels of control No. 1 or 2 can be extended to provide 1GV control and the additional equipment required is indicated in Fig. 3 by the red outline.

The additional facilities available at this level arise from the improved capability of the GV stage. These improvements include the ability for remote alterations to the routing and analysis; additional address capacity, improved route availability, allocation and flexibility; and the ability to increase the availability to 1600 without the need for significant GV marker changes.

Level No. 4 — Full Control

At this level ANA 301 control is extended to the GIV and SL stages and thus controls all the common equipment functions in the exchange. For the incoming MFC traffic an interface relay set (RAR) is provided for connection between the MFC junction relay sets and an STU I (M) via an RSI stage. A code

receiver is permanently associated with the STU I for MFC signalling. The need for intra-exchange MFC signalling is removed and a common group of STUI's can serve both MFC and decadic traffic.

Direct control of the GIV and SL stage in an ARE 11 exchange provides the following additional facilities to those above; improved PBX facilities, elimination of the need for MFC signalling internally within the exchange (thus provides savings in common equipment items through reduced holding times of common plant) and the capability for the exchange to become a terminating analysis point which could remove the need for distant end analysis for special requirements in the network.

Changes to the ANA 301 System for use in the Australian Network

A number of changes are proposed to the exchange system offered for use in the Australian network and to that installed at the trial exchanges, and these have been adopted for general use in all subsequent installations. These amendments have been as a result of experience with the trial exchanges and because of the need for adaptation to meet Australian network requirements.

- ### SS Stage

  The SS stage for the ARE 11 exchange system is a design incorporating a miniature relay system with electronic control. The system provides for 120 STUs to be connected to 15 devices. These could be either code senders (KS) or code receivers (KMK) for push button telephones or both. However, no grading facilities were provided.

  An examination of the existing ARF SS (20/12) currently used in Reg LM exchanges was made and it was found economically attractive to design an additional interface to the STUs to enable the ARF SS to be used in an ARE 11 exchange in lieu of the ARE SS (120/15) and this has now been adopted as standard. This arrangement will be particularly appropriate to enable re-use of the SS (20/12) equipment recovered where existing Reg LM exchanges in the network are upgraded with ANA 301. Separate groups of this SS (20/12) equipment will be provided for KS and KMK when appropriate.

- ### Operations and Maintenance System

  The basic operations and maintenance system in the ANA 301 monitored the ANA 301 equipment and did not effectively supervise the performance of the ARF type equipment in the ARE 11 exchange. Consequently, a significant amendment to the system has been specified and a comprehensive maintenance system evolved which encompasses the operational supervision of the whole exchange and enhances the facilities
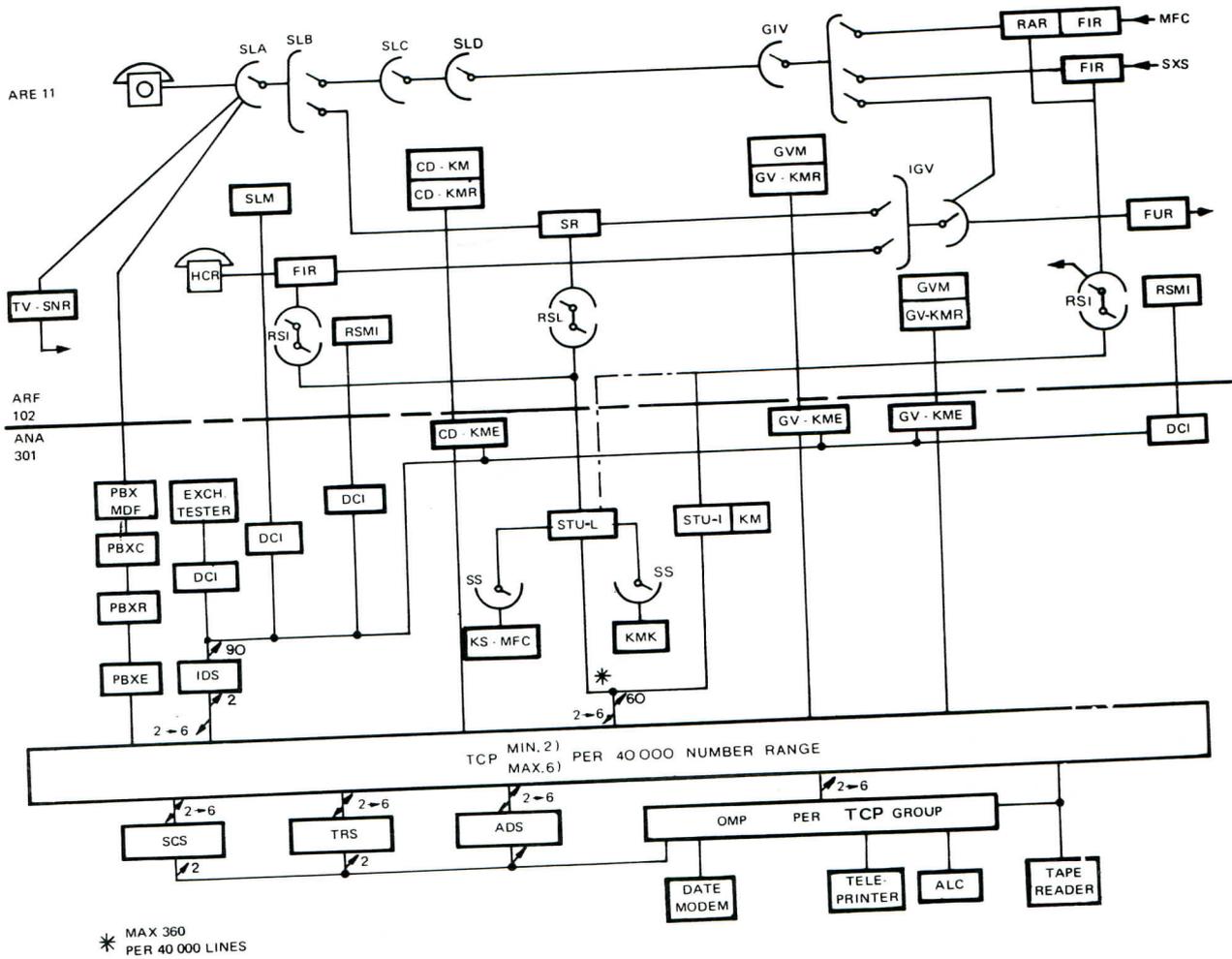
Fig. 4 — Level of Control; No. 4.

available from the ANA 301 system to interwork with a remote exchange maintenance centre.

- *Interception and Terminating Classification*

This facility is available at level 4 control. At other levels of control this facility was not initially available other than by the provision of the TV equipment proposed for ARF exchanges. However, the facility can now be provided by the installation of a CD KME relay set in conjunction with the CD marker. Access to the processor and category store thus enables terminating classifications to be determined. Provision of interception in the future is simplified as the TV equipment proposed in ARF exchanges is no longer required.

- *GV Stage Control*

The capacity of a processor group is presently limited to the control of a single 1GV stage and

single GIV stage. Existing exchanges in the network which are expected to be converted to ARE 11 have more complex arrangements of switching stages than this, and it is proposed to modify the exchange programs to enable a number of 1GV switching stages and/or GIV switching stages in the same exchange to be controlled by the ANA 301 equipment. The number of switching stages to be controlled is still under consideration but a maximum of 16 controlled by a processor group is being investigated. Also, the 256 routes at present available for the GV stages under the control of the one processor group will be increased to a maximum of 512.

APPLICATION OF ARE 11 IN THE AUSTRALIAN NETWORK

The ARE 11 exchange system has been adopted for use in the Australian network as an alternative
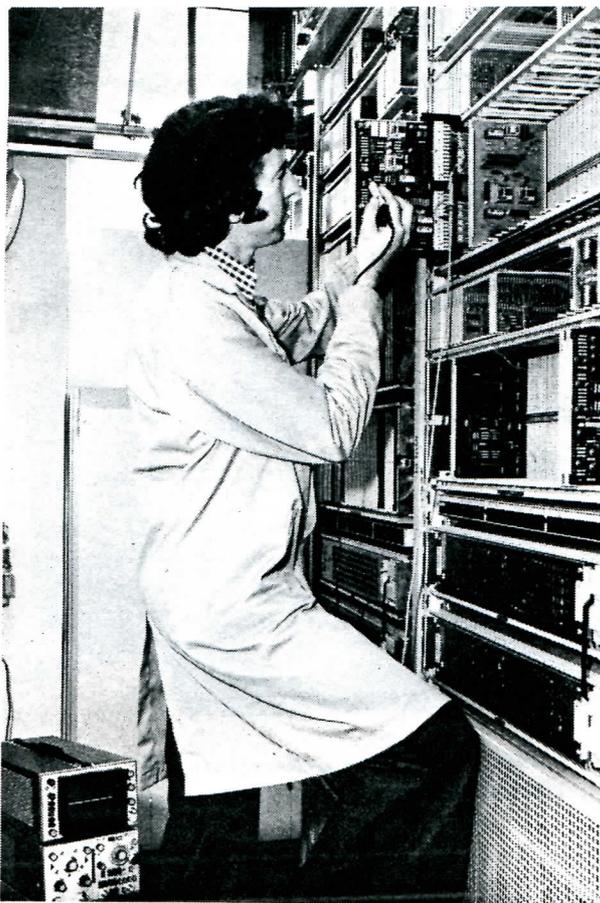
Fig. 5 — Typical example of ANA 301 Equipment Rack. Equipment shelves and printed circuit boards for a Signal Transfer Unit rack at the Elsternwick, Victoria, installation are shown.

to ARF 102 where this is economically justified. Studies of the economic application of ARE 11 have indicated that this system could be employed in urban networks for new exchanges and for the implementation of the proposed crossbar exchange modernisation programme. The modernisation programme provides for the modification of crossbar exchange equipment (in the main to registers) to enable provision of calling line identification, extended range of trunk access barring facilities, centralised interception and for the connection of VF push button telephone receiver equipment. The main role foreseen for ARE-11 in the Australian network is in this upgrading of the existing exchanges and subsequent growth.

In urban networks ARE 11 is expected to be used in new exchange installations and for initial installations in new switch rooms at existing exchanges, commencing in 1978. In new urban exchange installations Level 4 control would be recom-

mended to obtain the economic and facility benefits of this level of control. In country locations however, the existing electromechanical (Reg LP) would be retained for new terminal exchanges and at minor switching centres. At this time, there would appear to be significant operational penalties in the isolated use of ARE 11 equipment in the country areas.

Existing Switch Room Installations

The application of ARE 11 in an existing switch room depends on the type of equipment installed.

The evaluation of the modernisation proposals for the existing Reg LM equipment in the network indicated that rather than modify this equipment it could be economically replaced with either ANA 301 or Reg LP equipment. Reg LM in country exchanges would normally be replaced with Reg LP equipment rather than ARE 11. It is not expected that the Reg I equipment at a Reg LM exchange converted to ARE 11 would be replaced.

The requirement for Reg I equipment is not expanding in the network and the modifications required to the Reg I to provide the new facilities are not expected at this time to be sufficiently extensive to warrant recovery to avoid the modifications required.

The costs for modifying Reg LP exchange equipment are not as high as that for Reg LM equipment but at selected urban Reg LP exchanges it is expected to be economically attractive to replace the registers, rather than modify them, provided that the equipment can be re-used for growth in other exchanges. The recovery for re-use of this equipment in urban areas is expected to curtail purchases of Reg LP equipment for future growth needs in urban or country exchanges of the network. Replacement of Reg LP equipment with ANA-301 equipment will prove particularly attractive at those locations where a high growth rate is expected and where both types of registers (Reg LM and Reg LP) have been installed because of the lower incremental cost of ANA-301 equipment compared with Reg LP.

At exchanges providing first stage crossbar facilities for Step-by-Step equipment (SRB exchanges) it is also expected that the registers would be replaced where appropriate. The additional facilities of the ARE 11 system would not however be available to the step by step subscribers without the ability to identify the A subscribers number.

In replacement exchanges a minimum of Level 3 control is being recommended. Level 3 control provides the enhanced facilities for the originating GV stages which offer significant potential network savings. These savings, particularly in large exchanges in the metropolitan networks would
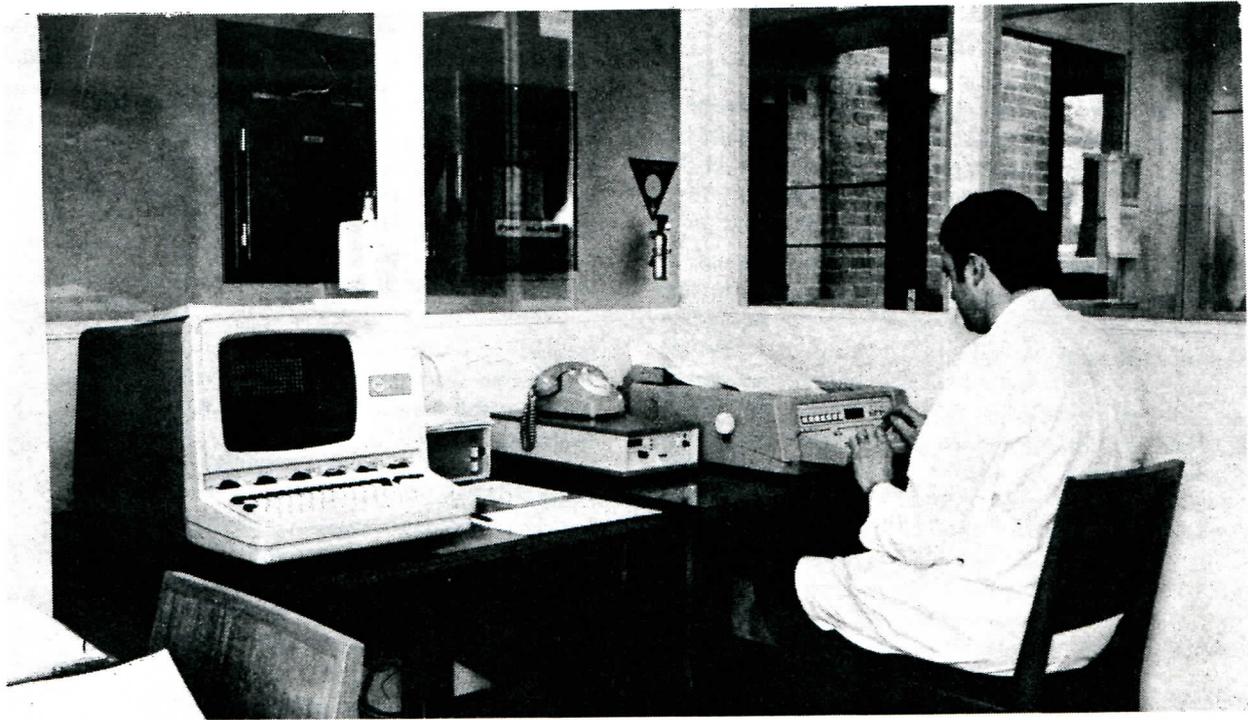
Fig. 6 — Man-Machine Communications at the Simulated Remote Operations Centre at Elsternwick Exchange, Victoria.

compensate for the additional marginal cost of this level compared with Level 1 or 2. Level 3 also provides additional operational benefits and the operational complexity in the network would be reduced if only two levels (3 and 4) were employed in the network.

Level 4 control in a replacement installation offers significant benefits, particularly in large busy exchanges, however there are considerably more costs involved because of the need to provide processor access to all incoming junction circuits (both MFC and decadic). These high initial costs are expected to limit the number of conversions possible at this level in the early years of the modernisation programme even though these may be economically attractive. Therefore, it is being recommended that extensions for growth should be at Level 4 control in a replacement ARE 11 exchange rather than Level 3. This approach ensures that the ultimate conversion to Level 4 is not prejudiced at some future time because the cost of the original replacement installation from Level 3 to Level 4 control is not increased and, in addition, the Level 4 facilities are available to subscribers terminating on the exchange extensions. These extensions at Level 4 are expected to cost about the same as those at Level 3 control.

In conjunction with the installation of ARE 11 in the network it is also proposed to equip the exchanges with the capability for VF push button telephones. In this way, a significant penetration of these facilities in the network can be achieved by the end of the modernisation programme thus reducing requirements for the more expensive decadic type of push button telephone currently being introduced into the network.

ARE 11 in Country Networks

ARE 11 is not generally economically or operationally attractive for use in the country at this time. However, studies are in hand for providing AMA facilities for STD and if the provision of the facility is adopted an option being considered in the country network is the provision of the AMA facilities in minor switching centres. ARE 11 may have an economic application in providing this facility together with other facilities required in the modernisation programme in these locations. Also, if ARE 11 were provided at a minor switching centre, the advanced facilities provided for subscribers at the centre could be more economically extended to the subscribers connected to the small country exchanges (ARKs, etc.) in the minor switching centre.

CONCLUSION

The introduction of the ARE 11 exchange system will have a significant impact in the Australian network. Although the system utilizes crossbar switching stages, both the common equipment and the installation, operational and maintenance techniques will embody many of the concepts of a full SPC type exchange system and this is a significant departure from present practices.

The adoption of ARE 11 will firstly enable cost savings to be achieved in providing new exchanges and in exchange extensions compared with providing the updated design of the current standard ARF 102 system. Secondly, it will provide benefits in operations and maintenance aspects through the greater equipment reliability and in the ability to introduce new maintenance concepts, including the remote alteration of exchange and subscribers data; and thirdly it will simplify the subsequent provision of additional facilities in these exchanges.

ARE 11 will have its main application in the upgrading of the existing crossbar exchange network as a consequence of the crossbar modernisation programme and the consequent growth in the converted exchanges. The use of ARE 11 for new exchanges will be limited because the SPC local exchange system, which will be introduced in the early 1980's as an alternative system, provides even greater economies in these applications than can ARE 11.

Currently an order has been placed by Telecom Australia for ANA 301 equipment to upgrade 13 exchanges in all States of Australia to enable the recovery of about 1500 Reg LM and 200 Reg LP. These exchanges are expected to be cutover in 1978. The modernisation proposals for the network are expected to be completed by 1982. By 1985 the penetration of ARE 11 into the network is estimated to be approximately 3.4m lines of the estimated total of 7m lines in the network at that time.

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