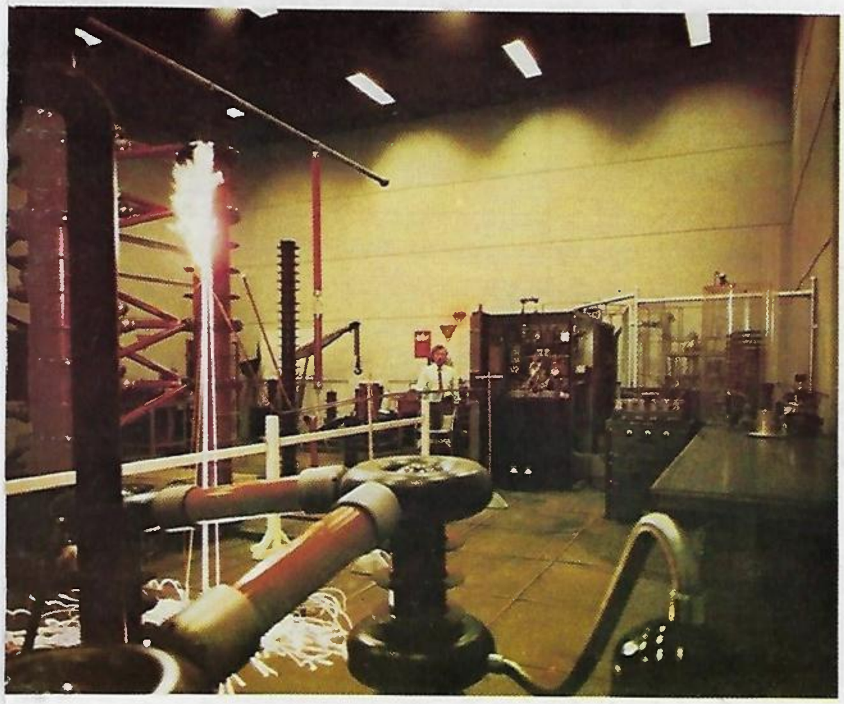
THE

Telecommunication Journal OF AUSTRALIA



THIS ISSUE INCLUDES

10C TRUNK EXCHANGE SYSTEM

COMMON CONTROL PRINCIPLES

STD IN AUSTRALIA

NEW CORDLESS SWITCHBOARDS

TV TELEPHONE STANDARDS

Vol. 23, No. 2

JUNE, 1973

A New Look for the Journal.

This issue commences a new format for the Telecommunication Journal and the Editors hope that you like it. The aims of the new format are set out in Volume No. 22 Issue 1, and suggestions for improvement are welcome.

TYPE FACE

The large type face was chosen for ease of reading, but the smaller type face used in the last main article in this issue may be equally acceptable to most readers. The Editors would like your views on this.

LENGTH OF ARTICLES

Brevity and clarity are essential if the Journal is to be useful to a wide range of readers. Preferably, articles should be less than 5,000 words. Short articles of one or two pages are especially welcome.

AIM OF JOURNAL

The Journal is intended to inform readers on the fundamental principles and applications of telecommunications technology in Australia. The utility of the Journal is enhanced if authors present the underlying principles and key points of their subject in a way that can be understood by the maximum number of readers. In the more specialised and theoretical articles complex material should be presented so that it does not obscure material which can be understood by the general reader. Use of appendices or a smaller type face for some material will help to achieve this.

We are apt to over-specialise at the expense of our understanding of the broader scene of telecommunications. The Journal can serve a useful purpose by publishing articles on the fundamental principles of telecommunications specifically for the general reader, and it is hoped to include such articles in future issues.

AUTHORS

Most articles in the past have been written by engineers, but we will be pleased to publish contributions by anyone working on Australian telecommunications. Intending authors should obtain a copy of "Notes for Authors and Editors" (issued in January 1973) from one of the Editors or State Representatives, and study them before commencing an article.

THE TELECOMMUNICATION JOURNAL

OF AUSTRALIA

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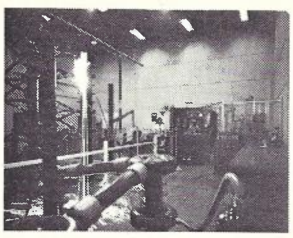

COVER
Electrical Discharge Testing.

The Telecommunication Journal of Australia

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

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An Introduction to the 10C Trunk Exchange System.

B. J. McKINLEY, B.A., M.I.E. (Aust.)

In April 1968 the APO sought from manufacturers through the world, a trunk exchange capable of handling the large quality of trunk traffic expected in the Sydney network commencing in the early 1970's. Following an evaluation of the offers received an exchange consisting of 10C equipment to be supplied by Standard Telephones and Cables Pty. Ltd. was selected.

The 10C system is an electronic trunk system which has a maximum capacity of 64,000 lines. This article surveys the functions of the major parts of the system and outlines the means by which these parts interact to process traffic.

INTRODUCTION

The ARM system was adopted as the standard APO trunk equipment in 1959, but the first exchange was not installed at Haymarket in Sydney until 1967. The maximum size of a single ARM exchange is 4000 inlets and 4000 outlets, and it is possible to increase the size by "twinning" to 8000 inlets and 8000 outlets.

It became obvious toward the middle 1960s that if the trunk growth continued to increase at the rate then current, and if, for economic reasons, all the trunk traffic in the larger cities was to continue to be handled through a minimum number of switching points, then trunk exchanges of greater capacity than ARM could provide, would be needed at the major trunk centres in the 1970s.

Following the preparation of a specification, quotations were sought from telephone manufacturing companies, on a world wide basis, for the supply of a trunk exchange for Pitt, Sydney, which could accommodate up to 50,000 lines (inlets/outlets). Tenders for this equipment closed in January 1969.

After a detailed evaluation of tenders which considered not only the equipment itself, but took into account associated economic factors such as operating staff, building requirements, air conditioning, power, loading of trunk lines, etc., based on the best information and assessments then available, the decision was taken in September 1969 to purchase a 12,000 line, 10C trunk exchange from Standard Telephones and Cables Pty. Ltd. (STC) to be installed in the Pitt St. building in Sydney. The equipment for this exchange was to be manufactured by Bell Telephone Manufacturing Company (BTMC) of Antwerp an associated company with STC in the International Telephone & Telegraphs group (ITT). About this time, the APO decided to use the 10C system as an alternative to the ARM system as dictated by economic considerations of the particular switching centres.

Subsequently, two further contracts for trunk exchanges were let to STC namely, 8000 lines for Lonsdale (Melbourne) and 8000 lines for Waymouth (Adelaide). The Pitt exchange will be commissioned in two stages with the STD section scheduled for November 1973 and the Manual assistance section about 18 months later. Following the decision to purchase 10C equipment, the ability of a processor controlled exchange to provide a more sophisticated manual assistance position was realised. At the time when the detailed specification of all the facilities to be included in these positions was finalised, it was not possible for the contractor to complete design, manufacture and installation of the manual assistance equipment at the date by which the STD facility was required at Pitt. It was therefore decided to press ahead with the STD exchange at Pitt, and to introduce the manual assistance facility after the completion of the Waymouth exchange which would be the prototype installation for the combined STD and manual assistance centre. Currently, Waymouth and Lonsdale are scheduled for commissioning in 1974/75.

FUNCTIONS PERFORMED BY THE IOC EQUIPMENT

The 10C equipment will be used in the network in a similar manner to ARM exchanges. The 10C system switches on a 4 wire basis and can grow to a maximum of 32,000 inlets and 32,000 outlets. It will be used for transit switching of trunk traffic, as well as an interconnecting point between the two and four wire networks. It will have a rate determining function, and will return metering information to dependent exchanges, when required, in a similar manner to the ARM exchanges.

Integrated manual assistance positions will be provided, similar in some respects to the AFG positions associated with ARM exchanges. From the design and operational viewpoints the 10C positions are significantly more advanced than the AFG equipment.

One important feature of the 10C equipment which is not currently included in the ARM equipment used in Australia is the Centralised Interception Service. The L. M. Ericsson ARF local switching system used for terminal exchanges has the capability of marking subscribers so that calls terminating on ARF exchange equipment will be re-routed to a centralised point which will be the 10C trunk exchange, where specialised handling of the call can be arranged.

10C EQUIPMENT — GENERAL

Hardware

From a hardware viewpoint, a 10C trunk exchange consists essentially of:

Telephone Switching Section

This Section basically consists of:

(i) junctors which are the interface between the exchange and the external trunks and junctions;

(ii) the switching matrix which is a five wire, six stage reed relay selector.

Telephone Periphery

The telephone periphery equipment is the interface between the processors and the conventional exchange items (junctors and switching matrix).

The Central Processor System

The processor system consists of:

(i) the central processor unit (CPU) which gathers information from the periphery, performs logical operations on this information, and, based on the conclusions, issues orders to the periphery for driving the junctors or the switching matrix;

(ii) the memory (a ferrite core system) in which the exchange program, translation tables and variable data are stored.

Computer Periphery

The computer peripherals consist of magnetic tape and disc drives, paper tape readers, and teleprinters, which are items of equipment normally associated with computer installations. Paper tape punches and line printers may also be associated with this computer.

Bus System

The bus system interlinks the computer and all peripheral equipment and is the means by which information necessary for the operation of the exchange is conveyed between the various items of equipment.

Software

Software is the instructions and data stored in memory which controls the operation of the exchange. The operational program can be sub-divided into a number of interconnected software packages:

Signalling Package

This package controls the reception of, and responses to, both line and information signalling, including time supervision for the various functions. It communicates (links) with other packages as required for this purpose.

Marker/Driver Package

This package controls the operation of the switching matrix, and collects information from other packages to generate final driving orders to the telephone periphery. Thus, other packages which require some operation in the telephone switching section are linked to this package.

Man-machine Package

All inputs (and outputs) from the computer periphery to the CPU are controlled by this package. All decisions by other packages to give teletype outputs, for example, are referred to this package. It also checks incoming messages for correct format before further processing.

Manual Assistance Package

The operation of all manual assistance positions and associated monitors and supervisors positions are controlled in this package. It will, for example, treat key operations, light lamps and display relevant information and refer action necessary for decisions taken to other packages such as Man-machine or Marker/Driver.

Intercept Package

This package controls the interception facilities provided by the exchange, and, in conjunction with the Manual Assistance package, controls the manual positions associated with this service. As before, it is linked to other packages as necessary.

On-line Test Package

The tests which are continuously run on the exchange are contained in and controlled by this package, e.g. CPU Console test. The tests done are of varying priority, some being done very early in each processor cycle of 10 ms and others towards the end. Thus, in those cycles where the work load is high, the execution of some of these test programs will be delayed until the processor has time available.

Test Equipment Package

This package contains the programs for controlling exchange test equipment such as the Traffic Route Tester and Automatic Call Sender. Again, this package is linked to others as necessary.

Take-over and Recovery Package

In the event of a fault developing in the system, particularly in the processor (CPU, memory, controllers, etc.), decisions must be in-built which enable the equipment to prevent calls being lost (take-over) and to recover from the fault situation. This package contains the programs necessary to control these functions. Such actions can involve reconfiguration of memory block allocations, program re-loading, etc.

On Demand Package

This package contains those programs which are not normally required for the correct operation of the exchange and therefore are not being continuously executed.

The programs are stored on paper tape and read into a reserved area of memory 'on-demand' via a medium speed paper tape reader. This reserved area will be much less than the sum of the on-demand programs, thus giving more economical usage of memory. The package contains such programs as detailed diagnostic tests, traffic dispersion and occupancy, etc.

PHILOSOPHY OF STORED PROGRAM CONTROL (SPC)

Before considering each of the above areas in greater detail it is of value to consider the basic philosophy of processor controlled exchanges. Processors are machines which are capable of performing both arithmetical and logical type calculations. A telephone exchange consists of items of equipment which perform logical operations based on informa-

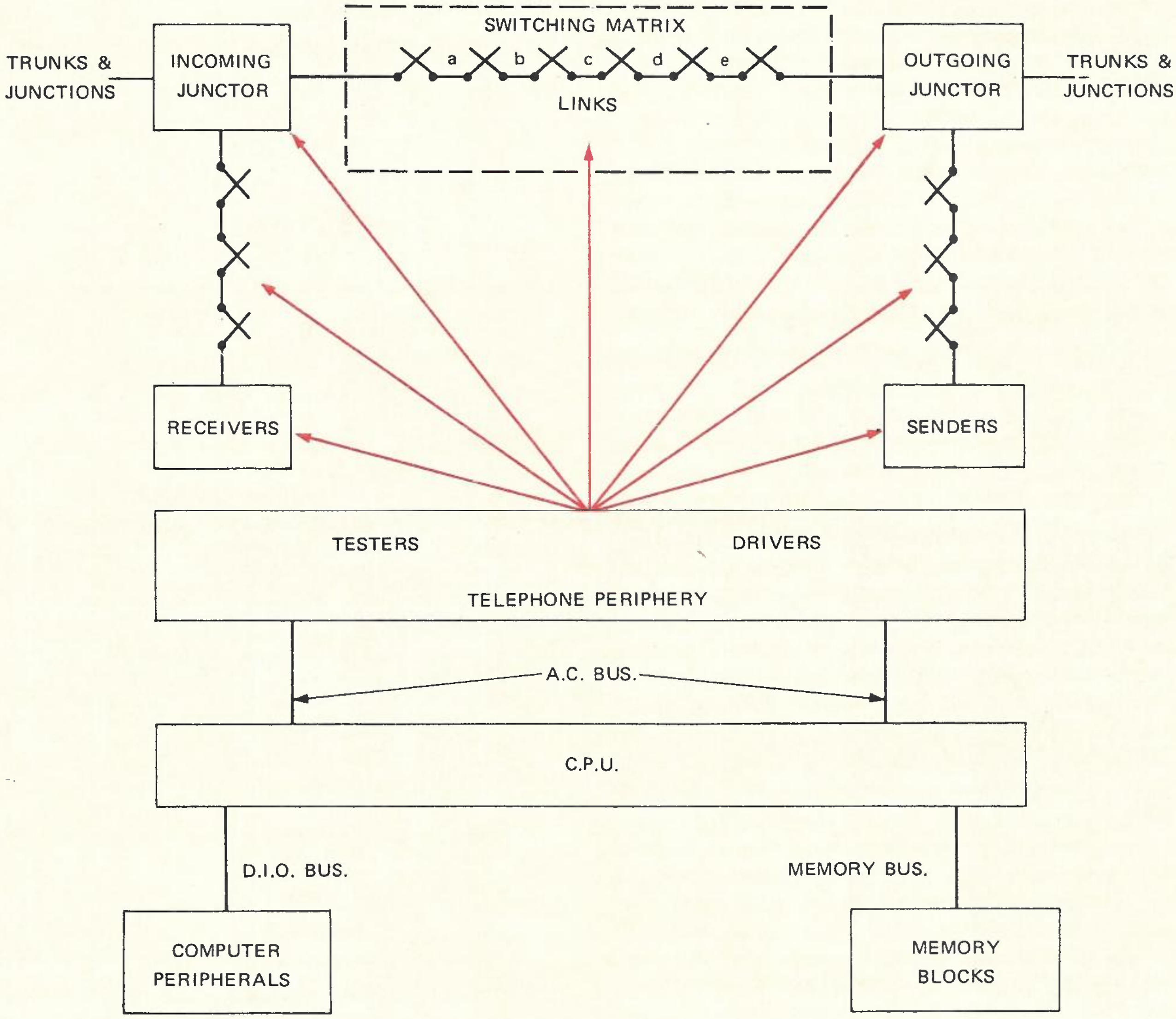


Fig. 1 — Major Divisions of a 10C Exchange

tion received from external sources. In conventional electromechanical exchanges, these logical operations are generally performed by relays. The intelligence in electromechanical systems can be widely dispersed as in step-by-step systems, or concentrated in blocks as in common control systems such as the ARF system. Greater concentration of control generally leads to economic advantages and the possibility of more sophisticated facilities. The extent to which common equipment can control individual items is a function, amongst other factors, of the speed of operation of the control equipment. As processors can perform logical operations in microseconds, they are able to directly control more equipment than common control systems using relays, where the logical operations occupy tens of milli-seconds. Advantage has been taken of this speed of operation of processors in electronic exchanges, to extend centralised control not only to the selector stages, as in electromechanical systems, but also to individual trunk and junction terminations.

The core of this centralised control is the CPU operating under SPC conditions, i.e. the sum of the software packages listed above. This software is arranged so that it is continuously running in the CPU in a cyclic fashion. The individual programs which make up the different packages are arranged in order of priority, and the processor executes these programs, covering all functions required in the exchange, at a fixed multiple of the basic cyclic rate.

IOC EQUIPMENT — DESCRIPTION AND OPERATION

Following this brief description of the basic philosophy, we shall now explore, in a little more detail the functions and the interrelationships of the various components of a Metaconta 10C electronic exchange. Fig. 1 outlines the major divisions of a 10C exchange.

Telephone Switching Section

Junctors (Trunk or Junction Line Terminations)

Junctors in the Metaconta 10C system consist of some 7 to 10 relays plus solid state detectors, transmission bridge, etc. These components produce variations to conditions on test points, provide metering reversals, holding for switching matrix crosspoints and coupling to signalling senders and receivers.

Collection of Information on Scanning

The junctors are controlled by the processor through test points and drive points. A test point will change potential, when conditions change on the external circuit to which it is connected. Fig. 2 indicates the basic elements of a test point.

At intervals of 100 milli-seconds, the processor inspects the state of this test point via the bus sysem and the peripheral equipment to determine any change. This is known as scanning.

It is important to note that the processor controls all actions in the exchange. The junctors, for example, do not send advice to the processor about a change of state. Instead, during its routine operations, the processor interrogates the test points in groups of 32 via the telephone periphery and later, requests the results to be returned to it. In this manner the processor knows the source of all information it receives.

Depending on the state of the component controlling the test point, a different condition (logic 0 or 1) is returned to the processor. The software signalling package compares this information with information from the previous scan stored within the processor's memory, and enables the processor to deduce what is happening on the particular circuit and take appropriate action.

Orders for Action or Driving

After the processor determines what action is necessary in the telephone exchange equipment (i.e. in the junctors or the switching matric), it calls on

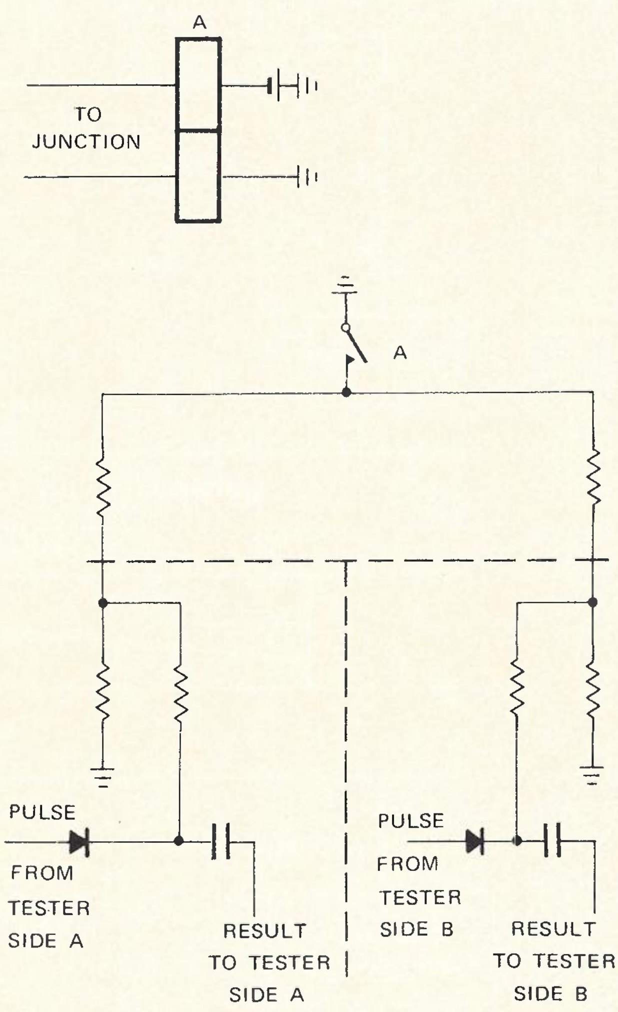


Fig. 2 — Basic Elements of a Test Point

the marker-driver package to transmit an instruction to the particular equipment items, which causes the required action. In most instances, this results in a relay operation in the device concerned, which locks and is released only when so instructed by a subsequent order from the processor.

Fig. 3 shows, for comparison, a 10C junctor card and an ARM relay set both of which are used to connect an incoming four wire physical circuit to the respective exchanges where the exchange initiates multimetering signals. The difference in the absolute size and the logic in each of the equipment items is readily apparent. What must be appreciated, is that the logic contained in the ARM termination has been removed from the 10C termination and resides in the program of the processor.

The Switching Stage

The switching stage in the 10C trunk exchange consists of a six stage reed relay matrix. The crosspoints themselves consist of five reed elements (four for the transmission path and one for the holding wire) surrounded by a single coil which operates the five reed inserts.

A basic building module consists of 16 reed crosspoints assembled into a 4 inlet, 4 outlet configuration. These can then be used either directly as a 4 x 4 unit or extended to 4 x 8, 8 x 8 or 8 x 16 to form the particular switching stage.

Fig. 4 shows an 8 x 8 reed crosspoint matrix. It is plugged into the rack via the connections on the left hand side of the card and consequently can be readily replaced.

The exchange itself at the maximum size of 32,000 inlets and 32,000 outlets, has a minimum number of 16 paths between any inlet and any outlet. The connections between the various stages comprising the exchange, are arranged in an orderly manner, to ensure that, from a knowledge of the exchange numbers of the calling inlet and a selected outlet, the 16 possible paths can be determined out of the 64,000 paths (C links) through the maximum size exchange.

The switching process is initiated by the processor selecting an outlet in the required route via the translation tables, following which it calculates the location of the C links (the link at the centre of the exchange between the two middle switching stages) from which the inlet and outlet are accessible. After tentative selection of one free C link, it calculates the address of the crosspoints forming the one possible path between each end of the C link, and the inlet and outlet. The processor then examines the condition of the crosspoints which is stored in the common data memory blocks. If all crosspoints on this path are not free it selects a second C link and tries again. When a free path is found, the processor sends appropriate instructions, via the

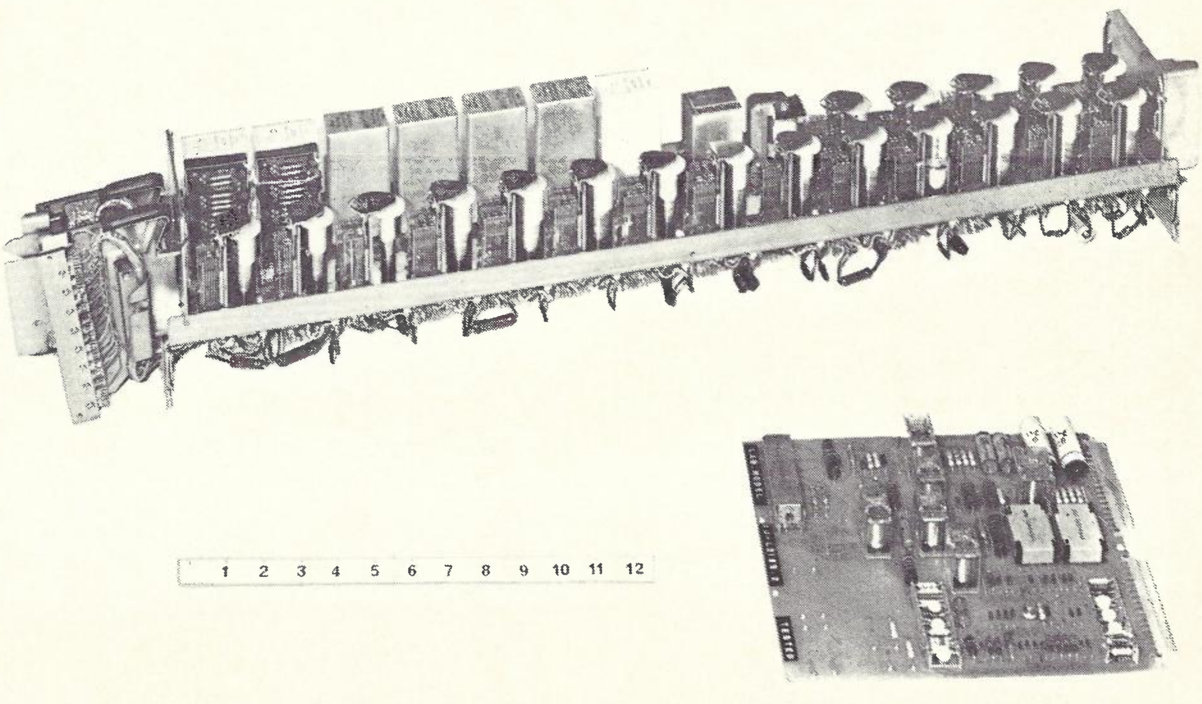


Fig. 3 — 10C Junction Card and ARM Relay Set

periphery, to operate the selected crosspoints and establish the required path between inlet and outlet.

Telephone Periphery

The time intervals in which the processor operates is in the order of microseconds, while the components in the telephone switching section operate in tens of milli-second intervals. The equipment known as the telephone periphery is the interface between these two different time environments. The bus system carrying data to and from the processor is connected to registers in the peripheral devices. These registers store the data in bistable elements which operate in microsecond intervals. The output of the register is steered through a series of diodes which produce a single active output for each different combination stored in the register. This output is used to initiate the particular function required. That section of the register in a particular unit which receives information from the address section of the bus is continually changing as orders are transmitted to the different peripheral units connected to the bus. The data section of the register however will only change when the address digits received correspond to the address of the peripheral unit which, after decoding, opens the gates for the data section of that register to accept data. Thus, after receipt of an order for a particular device connected to a peripheral unit, the order will remain in the register, and consequently on the device, until the processor next addresses the peripheral unit and changes the information in the register.

Thus the output of the peripheral unit towards

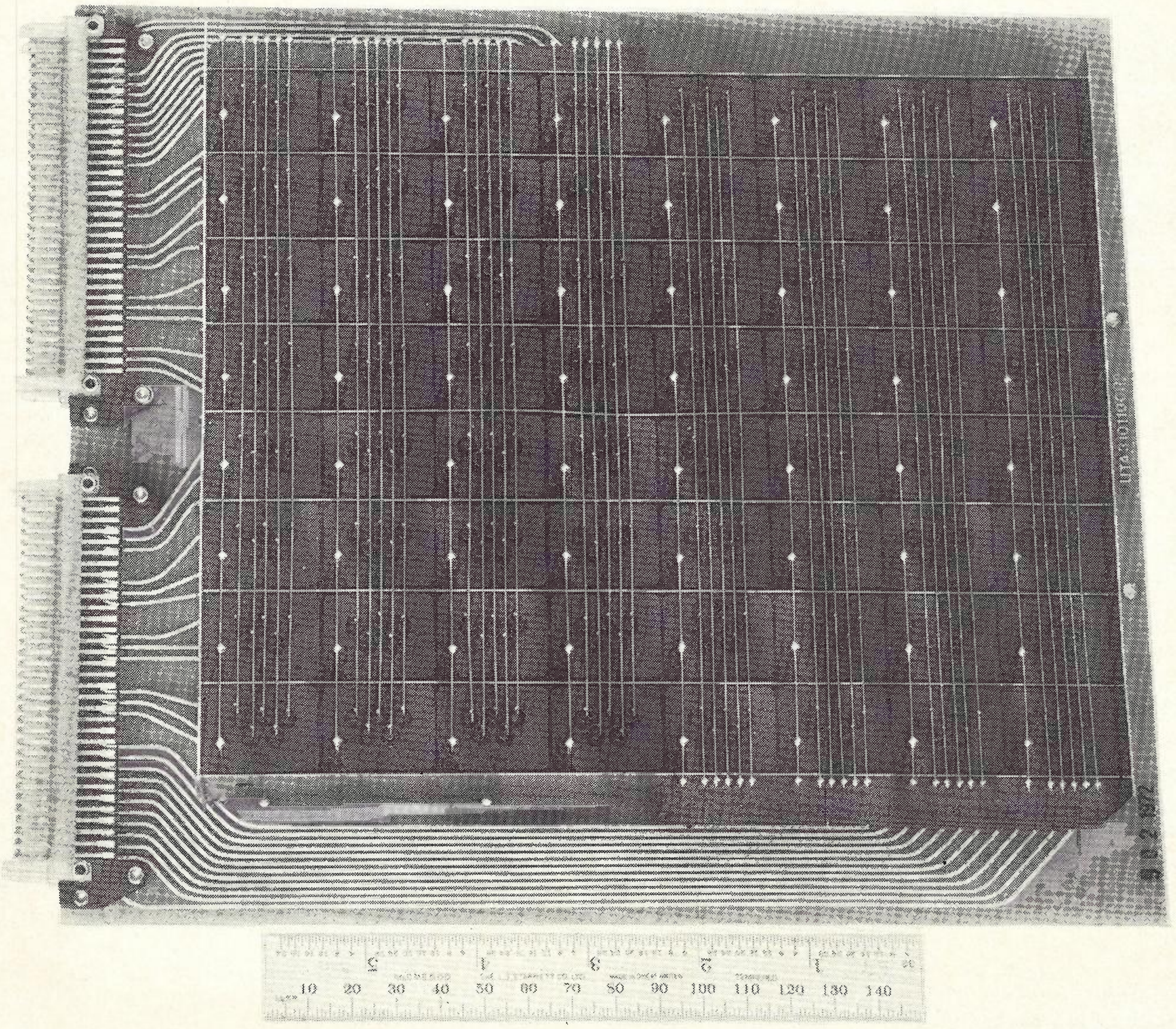


Fig. 4 — 8 x 8 Reed Crosspoint Matrix

the telephone switching part of the exchange will persist for a period after the input has been set at microsecond speeds. The period this condition remains on the output, being dependent on the intervals between which the processor addresses the particular peripheral unit, can thus be controlled and made to match or exceed the operating time of the components in the devices.

The telephone peripheral equipment can be divided into two major categories, testers and the drivers:

Testers

Testers are the units through which the processor determines what is happening in the telephone switching part of the exchange. The tester, which is addressed by the processor over the address bus system, admits into its peripheral register the data transmitted on the data bus.

This data is decoded and one active output results. This active output is connected to 32 test points of some particular group of peripheral devices. Depending on the state of these test points, pulses are returned on 32 leads to the peripheral register. Thus, the information stored in the 32 bits of the peripheral register, indicate whether each of the 32 devices interrogated are operated or released.

The processor will address the peripheral register again after an interval greater than eight microseconds (the functioning time of the tester) and read out the 32 bit word stored in it, which indicates the condition of the test points.

There are two separate bus systems from the processors to the testers and, in fact, to all peripheral equipment. The peripheral equipment itself is duplicated up to the actual test point of the individual device. This arrangement increases the security of the equipment, with complete duplication of the tester and the bus system back to the processors. Thus, in the event of a fault occurring in one of these areas, the second processor can take over control. The system is secure against one fault in the bus or peripheral equipment. However, one fault in the actual peripheral device (individual junctor) can result in that junctor being unusable.

During periods when there is no effective traffic to a peripheral unit such as a tester, the processor conducts 'on-line' tests to assure itself that the unit can function correctly. These tests consist of sending words in which all bits are "O" and, alternatively, all bits are "1". Each of these words, when received correctly in a peripheral unit which is functioning satisfactorily, will cause a particular test point to be activated.

By interrogating this test point the processor can deduce whether the peripheral unit is functioning correctly. If a satisfactory result is not obtained, the processor can initiate a procedure which will ensure that it no longer handles traffic to that particular unit. It also advises the maintenance staff via a teleprinter of the situation so that corrective action may be taken.

Drivers

The driver is the peripheral unit through which the processor causes action to be taken in the telephone exchange.

The driver is addressed by the processor in a similar manner to the tester, and the selected driver accepts data into its register. When this order is decoded one of the circuit elements in one of the peripheral devices served by the driver is caused to operate or release.

Like the testers, the drivers have an all "0", all "1" test for continued satisfactory operation.

Test of Effectiveness of Order

There is no test to confirm operation of the circuit element in the individual device following each drive instruction. However, after an instruction to set a particular connection through the exchange, a continuity test is applied on the speech wires between the incoming and outgoing junctors which confirms that the connection is established. There is no test, for example, to confirm that, following an order, the answer supervisory signal has been transmitted by a junctor.

THE PROCESSOR SYSTEM

Central Processor Unit (CPU)

The processor used in the 10C trunk exchange is known as the ITT 3200. The processor is a machine which makes logical decisions and carries out arithmetical calculations under the control of a program stored in its memory. The data on which the processor operates, is obtained from the telephone switching part of the exchange, from the computer peripherals, or extracted from memory. Following the operations made on this data, the processor issues appropriate orders to the equipment it controls.

Memory

The core memory is a series of ferrite cores arranged in words of 32 bits and in blocks of 16K words ($K = 1024 = 2^{10}$). In the 10C trunk exchange, the memory is divided into three categories:

(a) the private memory, of which there is one copy per processor with access restricted to that processor. The private memory contains the program packages which control the operations of the CPU.

(b) the translation memory, which is duplicated, is accessible to all processors and contains all the information about the particular trunk groups, the individual circuits of the trunk groups on the switchblock, the charging information peculiar to the particular exchange, number length analysis, and other trunk network information.

(c) data memory is a non-duplicated memory, accessible to all processors and containing a temporary record of the particular connections established in the exchange at any stage in a call. This information is continually changing as the CPU proceeds to set up and break down the required connections through the exchange.

Information is loaded into and extracted from memory by the CPU in 0.85 microseconds. This interval is the factor which, in the main, limits the number of operations the CPU can perform in a given period, and is the most significant factor in limiting the number of calls which can be handled by the CPU. The ITT 3200 processor can handle up to 215,000 calls per hour. The limit is also affected by the complexity of the calls. For example, control of a call being switched by a manual assistance operator will occupy the CPU for a much longer period, than a relatively simple STD call. It is expected at this stage that six processors will be required to serve a 64,000 line exchange. For security, one more processor, than is necessary for traffic reasons, is provided as safeguard against processor failure.

Program

The program is a list of instructions stored in memory which controls the operation of the CPU. The CPU operates on a cycle of:

(i) extract an instruction from store;

(ii) obtain the data from the location specified in the instruction;

(iii) operate on the data as specified in the instruction;

(iv) direct the processed data to the location specified in the instruction. (This could be returned to store or sent to the peripheral equipment as an order for action.)

The instructions which can be executed by a CPU are determined by the logical processes which have been built into the equipment. (These logical processes are determined by the detailed circuitry which constitute the CPU.) Not all CPU's can carry out the same logical processes, hence some are more suitable for particular applications than others. The ITT 3200, for example has been designed to efficiently undertake the logical operations required to perform communications switching while other CPU's have been designed for functions such as scientific calculations.

COMPUTER PERIPHERALS

The following items of hardware which are normally associated with computers are used in 10C exchanges to permit communications between the machine and operators.

Magnetic Tape Drives

Tape drives are used for two purposes:

Reload of Program

There are various indications that an error has occurred in the private program. In an operating exchange it is not likely that the error is due to a logic fault in the program itself. Rather it is more likely to be transient, or a failure in hardware. The error is indicated for example by the CPU receiving a non-existent instruction, or by detection of incorrect parity in an instruction word.

If the processor suspects an error in its private program it requests a re-load of the program from its dedicated magnetic tape drive. During the reload process, tests are performed at various stages to ensure the processor is operating correctly. These tests constitute a series of tasks which the CPU must be able to successfully complete as a check on its "sanity", before it is permitted to again handle traffic.

Recording of Data

There are four tape drives which record information from which traffic statistics for the exchange can be derived, and details of manual assistance traffic used to debit the appropriate charge to the calling subscribers.

This information is recorded on two tapes simultaneously, while the remaining two are in the standby condition and will be immediately taken into service at failure of one of the active drives, or at a scheduled changeover time.

Teletypes

These are used for various purposes by exchange staff to communicate with the processor to modify operation, obtain statistical information, request the execution of an "on demand" program, receive fault reports, etc.

Disc Drives

Disc drives are a much less expensive form of mass storage than ferrite core, and have a much faster access time than magnetic tape. These units are used to store infrequently used information such as number-to-name translation tables, details associated with subscribers interception service and details of manually assisted calls during the 15 minutes after the call is completed and before the call record is written onto magnetic tape.

Paper Tape Readers

These are used to read "on-demand" (O/D) programs into the processor store. These programs are special purpose, seldom used programs which for economy of ferrite core store are held off line on paper tape, and must be loaded by exchange staff when the particular function is required to be performed. O/D programs are used for detailed diagnosis of fault conditions, to provide service observation facilities, etc.

BUS SYSTEM

There are several bus systems used in a 10C exchange. A bus is a number of wires on which data pulses are transmitted between the various items of equipment constituting the processing system, or between this system and the telephone periphery.

As time delays on buses slow down the speed of the computer, it is desirable to keep the buses as physically short as possible — a bus introduces a propagation delay of about five nano-seconds per metre to the data pulses used. A further constraint on bus lengths is imposed by the distortion and 'skew' of pulses relative to each other as they pass along the buses.

DC Memory Bus

The bus system interconnecting the CPU to its memory blocks is designed to be as short as possible, because the propagation time in this area has a significant influence on the speed of the CPU and hence on the number of calls which can be handled by the CPU. The maximum length of the memory bus is 30 metres, but restrictions placed on the bus configuration by the number of loads (16) and the maximum distance from the CPU to any load (15 metres) can prevent this figure being realised.

Direct Input/Output (DIO) Bus

This bus connects the CPU's with the computer periphery controllers, and experiences similar limitations to the memory bus. As the traffic on this bus is not as intense as that on the memory bus, it is not so critical to minimise its length.

AC Bus

The bus sysem which connects the CPU with the telephone switching section of the exchange is known as the AC bus, and can be up to 300 metres long. This consists of 150 metres from the CPU to a bus repeater, and 150 metres from the repeater to the actual peripheral unit. The increased length is realised at the expense of increased holding time on the bus for any one signal, and by the inclusion of senders and receivers in each bus to amplify the signals which also contribute to an increased holding time for each signal.

The AC bus consists of a bundle of twisted pairs, one pair for each bit transmitted. There are 16 pairs to transmit, address and control information from the CPU to peripheral equipment, three to transmit control information from the peripheral equipment, and 32 to convey data in each direction under the control of the processor.

Signalling on AC Bus

Pulses on the pairs of the bus system experience propagation delays which are a function of the characteristics of the pair itself, and the associated senders and receivers included in the bus.

To overcome this differential propagation time, a pulse is transmitted on one of the control pairs after the signals have been sent on the data pairs. This pulse opens an electronic gate to the register in the peripheral equipment and allows the input to the register to be read simultaneously, and at a time which takes full account of the delays and distortion introduced by the bus.

Signal transmissions on the AC bus uses a compelled sequence technique. The signals are applied by the processor which waits for a signal, the condition code, to be returned to indicate that the transmitted signals have been received. Such a technique enables the occupation time of the bus to be limited to the minimum required for transmission of the necessary information. Thus the occupation time needed to signal to the most distant equipment does not necessarily determine the time which must be allowed to signal to equipment close to the CPU.

Thus the CPU on receipt of the condition code signal from the periphery knows whether the data has been received satisfactorily, and if not, it is given an indication by the condition code of the condition in the peripheral unit which affects its operation and the CPU can take appropriate action.

CONCLUSION

The telephone switching hardware of the 10C system, as is common with all processor controlled systems, is relatively simple compared to the electromechanical system. The logic, in the case of the processor controlled systems resides in the program or software and the operation of the exchange requires effective interaction between the software and hardware of the systems. Within limits this program may be readily altered to enable different facilities to be provided from the same configuration of hardware.

As this article is being written, the operational programs are being tested in a model of the Pitt exchange which has been built at BTM factory in Antwerp. This operational program has already been tested by a simulation process in which a processor which is programmed to resemble an exchange is connected to the bus system of normal exchange processors, to ensure as far as possible that all necessary logical operations can be performed.

The test performed on the model, known as system test, will test the interaction between hardware and software as far as is possible in a model. Both of these test procedures are being undertaken to ensure that, under traffic conditions at commissioning, the exchange will function with a minimum of interruption.

B. J. McKINLEY joined the Department as a Cadet Engineer in Sydney in 1947. After advancement to Engineer, he was engaged in several different areas in the N.S.W. Administration, the most extensive period being in the installation of telephone exchanges in the Northern region of the State.

In 1958 he was promoted as Class 3 Engineer to the Telephone Equipment Section at Headquarters and subsequently headed the Systems Design Sub-section which was chiefly concerned with the design activities involved in the introduction of the crossbar systems into the network.

Mr. McKinley is currently the Assistant Superintending Engineer, Design, in the Telephone Switching Equipment Branch at Headquarters.

Change of Director, Western Australia

RETIREMENT OF MR. J. H. WHITE

On 25th January 1973, Mr. J.H.White, M.I.E. Aust., retired from the position of Director, Posts and Telegraphs, Western Australia, thus concluding a notable career which began in Perth as a Junior Mechanic in 1925.

Mr. White commenced his Engineering career as a Cadet Engineer in Adelaide in 1928. In 1945, he served as Divisional Engineer, Newcastle, N.S.W., and in 1952 as Supervising Engineer, General Works Section, N.S.W.

In 1955, Mr. White was appointed Assistant Director (Engineering) Western Australia and during his term of office up to 1965, the Western Australian administration embarked on many major Engineering projects including the Perth—Bunbury Coaxial Cable, reconstruction of the East—West aerial trunk route, the initial development of major trunk systems in the North—West of the state, and the establishment of major television installations throughout the state.

Mr. White was appointed Director, Posts and Telegraphs, Western Australia in February 1966 and has maintained his active interest in the major Engineering projects undertaken in that state up to the time of his retirement.

The Telecommunications Society of Australia is indebted to Mr. White. He was Foundation Chairman of the Western Australian Branch of the Society when it was created in 1960, a position he occupied for six years and in which he contributed significantly to the development of the Society's activities.

All those who have had the privilege of working with Mr. White have appreciated the quiet, courteous but firm manner of his personality. They have come to respect him as a man of thoroughness in his work and loyalty to his staff.

On behalf of all members, the Council of Control wish Mr. and Mrs. White a happy retirement.

MR. H. G. SHAW

Mr. H.G. Shaw has succeeded Mr. J.H. White as Director of Posts and Telegraphs, Western Australia. Mr. Shaw, who is 54, has been Assistant Director (Postal Services) in New South Wales since 1956. He is a graduate of the University of Sydney and of the Australian Administrative Staff College.

After a brief teaching career in independent schools he joined the Commonwealth Service in 1950 as an Education Officer in the Commonwealth Office of Education. In 1954 he was appointed to Post Office Headquarters in Melbourne as a Legislation and Research officer. He was promoted as the first Superintendent of Postal Planning in Sydney in 1955 and appointed to the position of Assistant Director (Postal Services) in the following year. From 1941 to 1946 he served in the Second A.I.F. in Australia and New Guinea where he was adjutant of a native infantry battalion. Mr. Shaw, who is married with two adult sons, took up duty in Perth in early February. He has maintained his interest in a number of Post Office activities, including the Postal Institute.

New Cordless Switchboards

M. J. MURNANE, A.R.M.I.T., Grad. I.E. Aust.

Two new 2-wire cordless private manual branch exchange switchboards having capacity of four exchange lines and ten extensions (4+10), and five exchange lines and sixteen extensions (5+16), have been introduced. Each unit is housed in the same size compact, modern cabinet, and includes some new facilities and supervision techniques. Installation is simplified.

INTRODUCTION

At present, the requirement for small cordless switchboard PMBX's is satisfied by imported four wire extension units having two exchange lines and six extensions (2+6) and three exchange lines and twelve extensions (3+12). These were first introduced in 1964 as an interim replacement for the ageing 2+4 and 3+9 units many of which have been in service for about 40 years.

In the early 1960's, customer surveys showed that for local conditions, a higher exchange line to extension ratio was desirable; for example, four exchange lines and ten extensions and five exchange lines and sixteen extensions. A schedule was issued in 1965 calling for the development of modern cordless PMBX's having increased supervisory limits and more suitable exchange line to extension ratios as well as several other modern operational features. In 1967, a development and supply contract was placed with Standard Telephones and Cables Pty. Ltd., Sydney. Development by STC and the APO since then has resulted in the new PMBX's now being delivered as additions to the range of standard customer facilities.

The PMBX's are in two sizes, four exchange lines and ten extensions (4+10) (Fig. 1) and five exchange lines and sixteen extensions (5+16) (Fig. 2). Each unit is mounted in the same size case having a modern appearance, the only features to distinguish the 2 units being the number and layout of the miniature keys. Lamp signalling is used.

FACILITIES PROVIDED

The switchboards use "exchange ended" connect circuits. As well as simplifying the operation of the switchboard, incoming exchange calls cannot be "blocked" by having all connect circuits committed to local extension to extension calls. For extension to extension calls, two separate connecting circuits are provided for the 4+10 and three for the 5+16. With the general greater importance of exchange line calls, this number of local connect circuits is adequate.

By the extensive use of solid state components, all the required facilities have been included in a reasonable size unit, and two wire (plus earth for recall) extension reticulation is used. This has installation advantages, particularly when replacing the early 2+4 and 3+9 units with larger capacity units, as existing telephones and cabling can be retained and no additional apparatus is required when external extensions are required.

The 50V dc and 50 Hz ring for the switchboard are derived from the external 240V ac mains power supply.

The main features of the two wire cordless PMBX switchboards are:

General

- New miniature key
- Modern appearance
- More suitable capacities (higher ratio of exchange lines to extensions)
- Simplified installation
- Circuit modules "plug in"
- Operator's telephone included
- Dust cover (similar to typewriter cover)

Operational

- Operator's headset may be fitted instead of handset
- Follow-on-call trap on incoming exchange calls
- Automatic holding of exchange calls
- "Waiting Answer" lamp on extension to extension calls
- Call "splitting"
- Night service

Electrical

- "Exchange ended" connect circuits
- Exchange to extension limit — 1500 ohms
- Two wire extensions (3 wire if recall required)
- Extension test facilities for test desk
- Exchange lines not required to be polarized
- On mains failure no exchange to extension calls lost
- Tie lines appear as extensions
- External extensions require no additional apparatus
- Balanced battery feed to extensions

PHYSICAL DESIGN

The same basic case is used for the 4+10 and 5+16 units, with the case cover in two parts. The lower section is of brown ABS that clips onto the aluminium base plate. The upper section is of grey ABS and is secured to the key frame by two moulded glass reinforced polycarbonate screws. The key frame is of glass reinforced polycarbonate and is basically the same for the 4+10 and 5+16; different inserts are used in the mould at the time of manufacture to provide for the different key layouts. A brown ABS escutcheon clips to the key frame and carries the key designations and lamp cap strips. The lettering of the designations blends with that used on the standard DMS dial fitted to the switchboard. The escutcheon carries a directory card printed on both sides and folded in two before fitting under a clear cover. This form of directory may be used up to four times and the line spacings suit standard typewriters.

The switchboard has a built-in operator's telephone and the standard handset cord is directly terminated with quick-connect connectors. A brown tinted cradle is provided where the handset may be placed when not in use. If an operator's headset is required, a conversion kit is available. A locally developed miniature lever key is used. The key levers are fitted with small wedge-shaped ABS covers with colours that complement the overall design of the PMBX.

The lamp jacks are of a new design and clip into the key frame. No lamp extractor tool is required and lamps may be changed from the front of the switchboard.

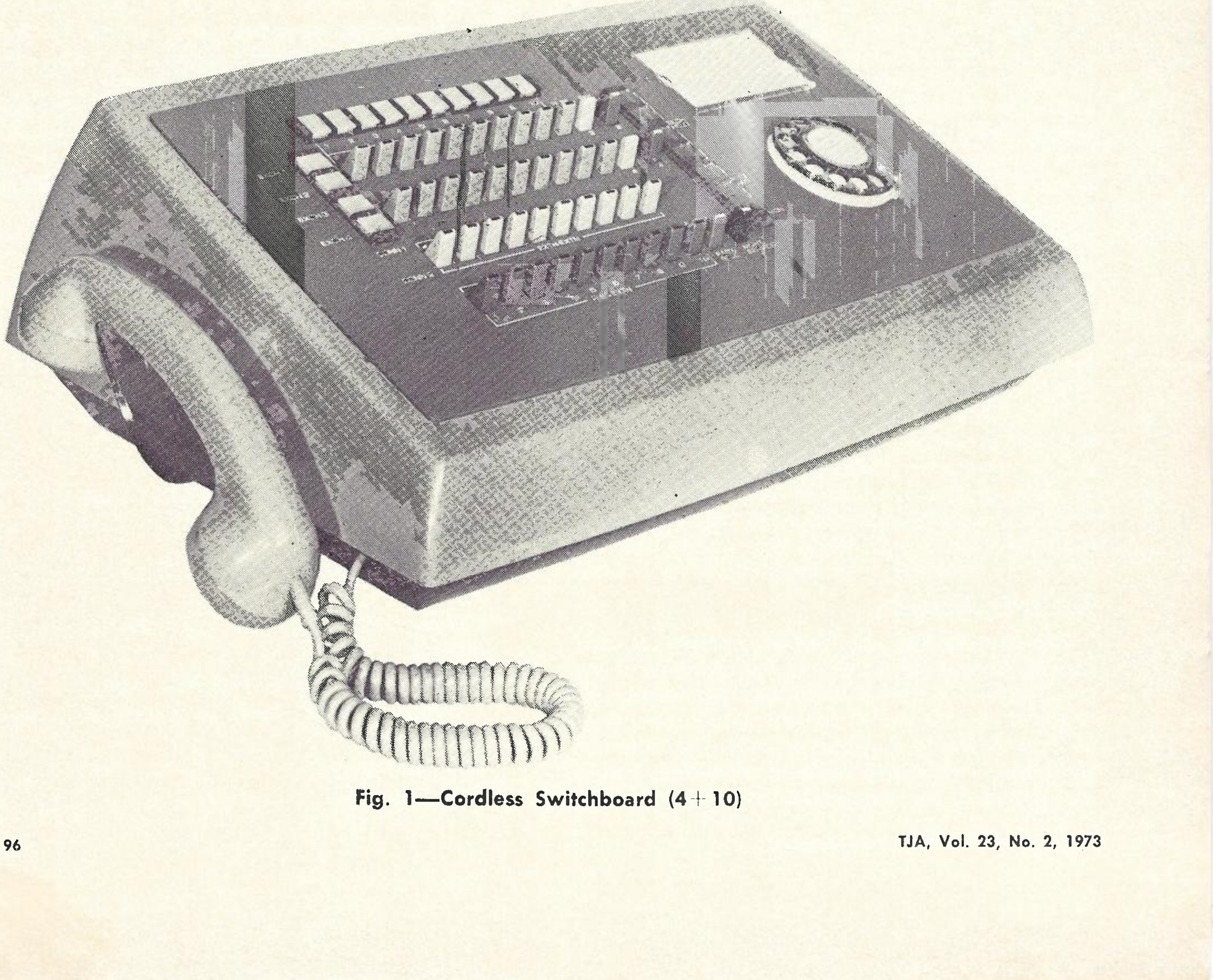


Fig. 1—Cordless Switchboard (4+10)

Under the cover of the switchboard there is a small panel with quick-connect program links (see Fig. 3). These links are removed with the aid of a special tool that is housed on one of the plastic feet of the PMBX. The panel provides strapping facilities for:

- Bar Exch Line Recall — Used when exchange lines are extensions of a PABX.
- Bar PABX Recall — Disconnects recall function from inbuilt operator's telephone.
- Test Link — Connects selected extension direct through to exchange line No. 1.
- Tie Lines — Provide for correct functioning of auxiliary tie line apparatus.

The key panel is hinged to the base plate and opens up to approximately 105 . By unclipping a small detent on the right hand side hinge the panel can further open to approximately 180° (see Fig. 4) and two small plastic supports keep the key levers clear of any table surface. Each interchangeable exchange line circuit is housed in a separate plug-in module. Individual plug-in circuit modules are also provided for the operator's telephone, miscellaneous alarms, and two modules for the local connecting circuits. The provision of a spare "cross wired" module receptacle allows transfer of modules to identify possible faulty units.

ELECTRICAL DESIGN

New, more sensitive and more reliable supervisory circuits, using small toroidal magnetic cores with windings in series with each side of the extension line, have been introduced. The windings form part of the feed-back circuit of a single transistor oscillator operating at about 120 kHz. The

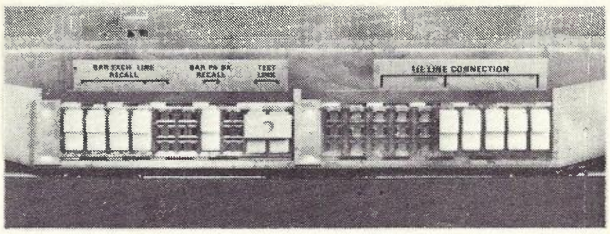


Fig. 3—Quick Connect Program Links

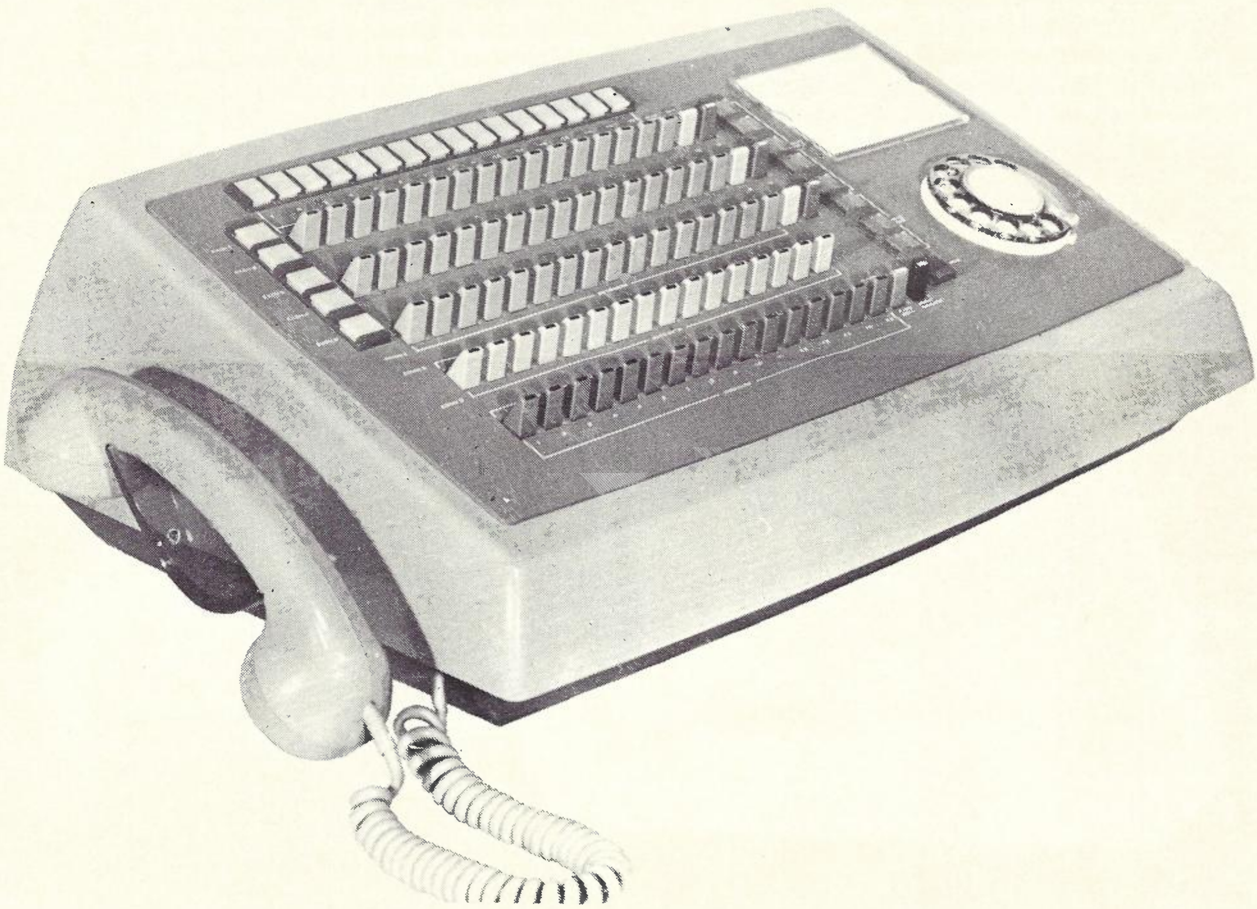


Fig. 2—Cordless Switchboard (5 + 16)

output of the oscillator is coupled to a transistor controlled relay via two intervening transistor stages with the necessary time guards. Additional windings in series with the extension line form a filter to eliminate radiation from the oscillator to line. For the loop supervisory circuit, direct current flow to an extension loop saturates the core, the oscillator ceases to operate, and the loop detector relay releases. Similar circuitry is provided for the recall detector, but in this case, the operating oscillator depends on the balance of the direct current through the line windings of the toroid. Unbalanced currents from the operation of the earthing recall button at the extension telephone cause the recall detector to operate, and the exchange call lamp for that exchange line to glow.

If mains power fails, exchange calls in progress are maintained but extension to extension and inter-switchboard calls fail, and the internal ac buzzer of the switchboard is automatically switched across the first exchange line to signal any incoming calls on this line.

For an incoming exchange call both the call lamp and the internal buzzer follow the ring cadence. A separate hold lamp is provided for each exchange line and any call can be automatically held until manually released by a non-locking key, individual to each exchange line. This key also provides a facility for testing any extension from the exchange as operation of this key gives a direct connection through the switchboard to any selected extension.

For extension to extension calls, "waiting answer" lamps for each connect circuit glow until the called extension has answered.

The operator's telephone can be directly connected to each exchange line by individual keys. Individual keys are also provided to connect the operator to each extension. This forms part of the "splitting" facility where an operator can offer an extension an incoming exchange call without being overheard by the caller.

When the operator is recalled to an exchange to extension connection, battery feed to the operator's telephone is derived from the switchboard power supply. This eliminates the severe transmission degradation that occurs if the exchange battery feed has to be shared between a high loop resistance extension and the relatively low resistance operator's telephone.

On operation of the night service key, direct connections are provided between exchange lines and selected extensions.

INSTALLATION

A new method of installation simplifies maintenance and reduces installation costs. It is based on extending the normal distribution cable directly into the switchboard so eliminating the relatively expensive cord and connector used on present switchboards. Terminating at the switchboard is by

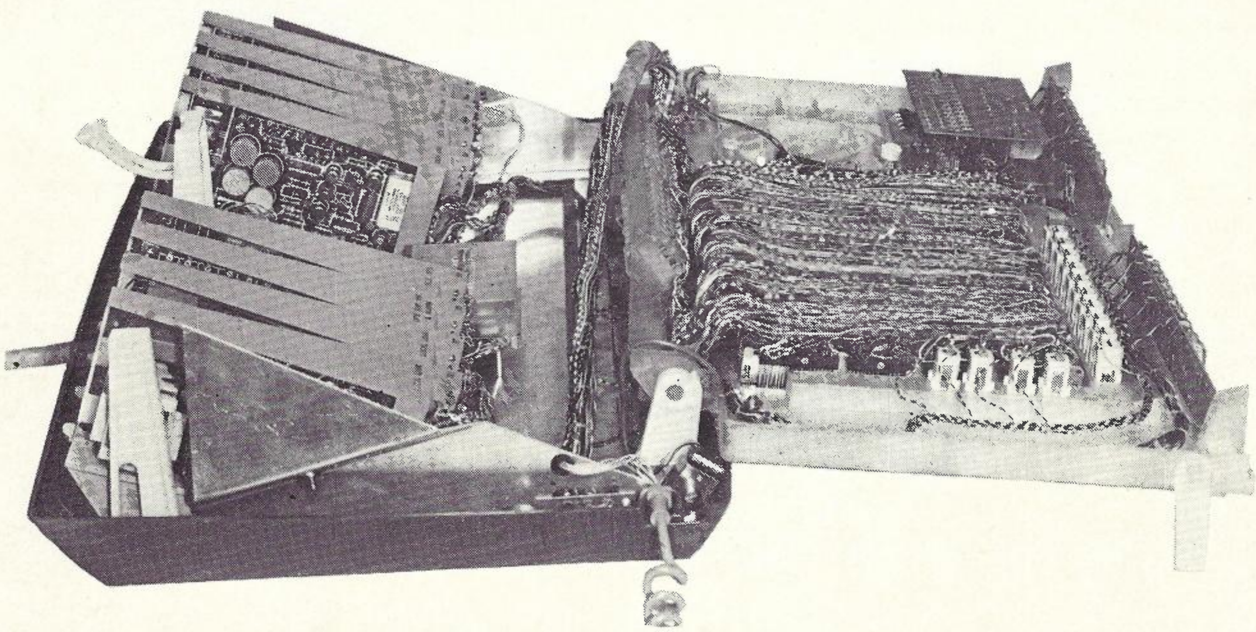


Fig. 4—Key Panel Hinged Open (4 + 10)

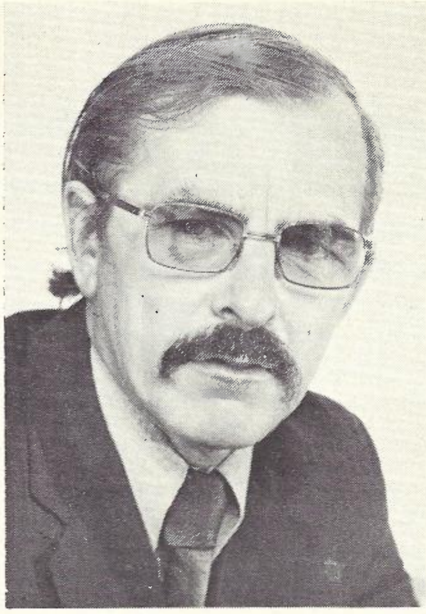
means of quick-connect connectors of a new type, better suited to crimping to standard solid conductors. When the switchboard is installed in "island" locations, a newly developed floor block is used to prevent cable damage at this point. The block is also suitable for wall mounting.

To further simplify installation, standard factory pre-formed and pre-terminated cable lengths are available, but to limit the number of different lengths held in store, cables are supplied with quick-connect terminations at each end. On installation, the cable length is cut as required and the remaining length held for use on subsequent installations. A new sheath colour (APO "teakwood") is being introduced and to further assist in the rapid identification of cable conductors a new conductor colour code identifies both A and B sides of each pair by means of a variation in spacing of a colour band marking.

CONCLUSION

The two new switchboards are expected to satisfy a long standing requirement for modern units, with a capacity between the existing cordless switchboards and the much larger, floor pattern, switchboards.

M.J. MURNANE, joined the P.M.G.'s Department in 1951 as a Technician-in-Training and qualified as Engineer in 1959. After four years at Postal Workshops, Melbourne, he was promoted as Engineer Class 2, Subscribers' Equipment Design Section at Headquarters. He is at present Engineer Class 3 in the Terminal Equipment Design Section and is associated with the introduction of the new cordless P.M.B.X.'s. and a number of other projects.



Staff Changes for the Telecommunication Journal

Previous issues of this Journal listed on page 2 Headquarters Representatives as well as State Representatives. These Headquarters' Representatives are not required now as their duties have been taken over by the Board of Editors.

We welcome Norman Cameron and Don Burns to the Board of Editors. Norman is the Editor for the Telephone Subscribers' Equipment Branch and Don for the Telegraphs and Data Equipment Branch. Each Editor at Headquarters represents his Branch or Sub-Division as follows:—

W. R. Dedrick	Telephone Switching Equipment
D. A. Gray	Research
R. A. Clark	Lines
G. H. Woolfall	Planning
R. W. E. Harnath	Long Line & Telepower Equipment
J. B. Collins	Network Performance & Operations
N. A. Cameron	Telephone Subscribers' Equipment
P. H. Richards	Radio
D. Burns	Telegraphs & Data Equipment
J. W. Pollard	Indexing Editor

There are some changes in the state representatives. Arthur Morton replaces Reg Treloar (retired) as a Victorian representative and Fred Scott replaces Charles Anderson (retired) as a Queensland representative. In N.S.W. John Liiv and Harry Freeman replace Charles Job, who passed away last year, and Michael Power.

A Case of Compromise —
The Choice of TV Phone Picture Standards

J. L. HULLETT, B.E., Ph.D.

The choice of picture standards for a subscriber reticulated TV phone service involves a balance of economic, technical and human-factor parameters. In this paper an attempt is made to identify these and to indicate the basis on which a design choice can be made.

Editorial Note: This paper was originally published in the Proceedings of the IREE, June 1972, and is reprinted by kind permission of the Institution.

INTRODUCTION

If one regards the ideal telecommunication medium as the one which supports the illusion of direct human sensory contact then the television telephone brings us closer to that ideal than ever before. It achieves this by offering a visual as well as an aural link for two-way person to person contact. A fully reticulated TV phone service however can only become a reality when technical feasibility allows the functional end of the medium to fall within limits imposed by cost and transmission capability.

This problem is compounded by three factors; firstly, if a viable substitute for real person to person communication is to be achieved, a large signal bandwidth is required to accommodate the visual signals generated; secondly, the bandwidth must be so limited that initially the signals are capable of transmission over normal telephone pair cables; thirdly, unlike television broadcasting where one channel serves many viewers, the TV phone network must be able to accommodate many simultaneous subscriber to subscriber connections. The importance of the video signal bandwidth to the establishment of the service is therefore evident.

In this paper we examine the choice of TV phone picture standards and the relationship between these standards and the signal bandwidth. Since cost dictates that conventional line scanning techniques be used in both TV phone picture production and display it must be obvious that standards selection will involve an adaptation of conventional television practice. However because the functional end of the new medium is so different to entertainment television and the influence of economics so great this adaptation must of necessity be quite broad.

What we have written is in essence an information paper. Our aim is to promote an understanding of the new TV phone facility to be used experimentally in Australia. This we hope can be achieved by an exposition of the design fundamentals.

TV PHONE TERMINAL

TV phone subscriber equipment comprises four separate functional components: a video unit with picture monitor, camera and loudspeaker; an audio unit consisting of a normal telephone set and a panel of mode selection switches; a power supply unit, which also houses the transmission equalising circuits, and a control unit housing the microphone and normal picture controls, i.e., brightness, contrast, etc.

Mode selection switches allow the user to choose between three operating modes. These provide for a two-way audio and video operation, a one-way video with two-way audio operation, or two-way audio only operation. There is in addition a self-view mode to be used prior to a call if any positioning or picture adjustment is necessary.

Fig. 1 shows photographs of three current terminals.

DESIGN FUNDAMENTALS

Geometric and Environmental Aspects

Because of the cost, initial applications of the TV phone service will be commercial. The most common location of the TV phone terminal will be the desk.

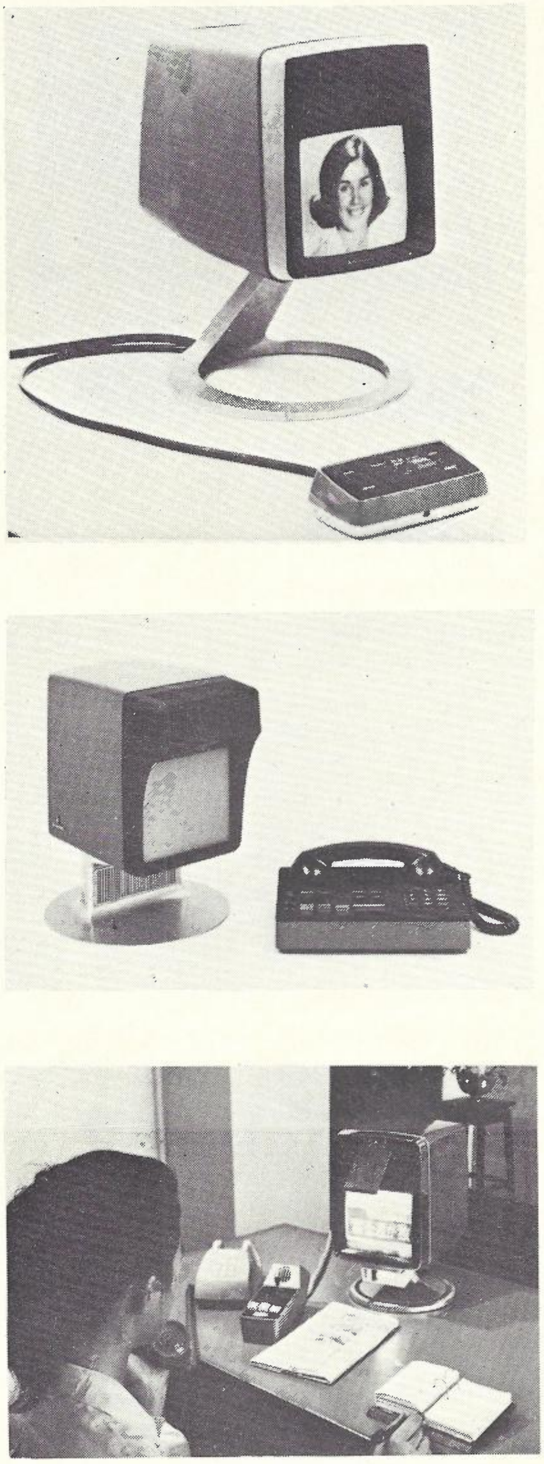


Fig. 1 — Current TV Phone Terminals.

(a) Bell Picturephone. (By courtesy of the Bell Telephone Laboratories.)

(b) Siemens. (By courtesy of the Siemens Industries Ltd.)

(c) Fujitsu. (By courtesy of the Fujitsu Ltd.)

Top executives may of course require an alternative wall installed video unit.

For desk top usage a TV phone set is most conveniently placed one metre from the user (Ref. 1). This leaves sufficient working space on the desk in front of the terminal, places the set within easy reach for off-table graphics use and ensures that the user can be picked up on camera without perspective distortion. With a 1 m user-to-terminal separation, lens depth-of-focus does not become critical for the lens has only to cover a narrow angle field and, in addition, sensitive camera tubes such as the silicon tube (Ref. 2) can always be used at small apertures.

Having determined the viewing distance, the geometric parameters which remain are the screen format and size. Good screen utilisation would be obtained if the subject's face filled the screen. This however permits him no lateral movement without falling-off the screen. A large horizontally-preferred aspect would solve this problem particularly as his vertical movement is slight but we would then have poor screen utilisation. Both conditions are shown in Fig. 2 together with the compromise aspect ratio, r, of 1 : 1.1.

The screen height is normally considered jointly with the viewing distance and a viewing ratio (i.e., the ratio of viewing distance to picture height) of eight is considered maximum. Higher ratios would damage the illusion of direct contact with the far end subscriber for in such instances the angular subtense of his head would be equivalent to that in actual face to face conversations where the separation is more than 3 m. With a viewing ratio of eight and a viewing distance of 1 m the screen height is 12.75 cm.

An important human factor aspect of the video unit design and one which is affected by the design geometry, is the positioning of the camera relative to the picture monitor. In TV phone conversation the subject looks at the person displayed in the monitor and not at the camera. Hence if the camera is placed at the side of the monitor the subject appears at the far end to be looking away to the side. This is far more objectionable than if he appears to be looking up or down as a consequence of the camera being respectively below or above the picture monitor. Since in face to face conversation it is most normal for each person to look slightly downwards, all TV phone terminals currently available place the camera in a position above the monitor. The angle involved is small (5°) and the effect is not objectionable (see Fig. 3).

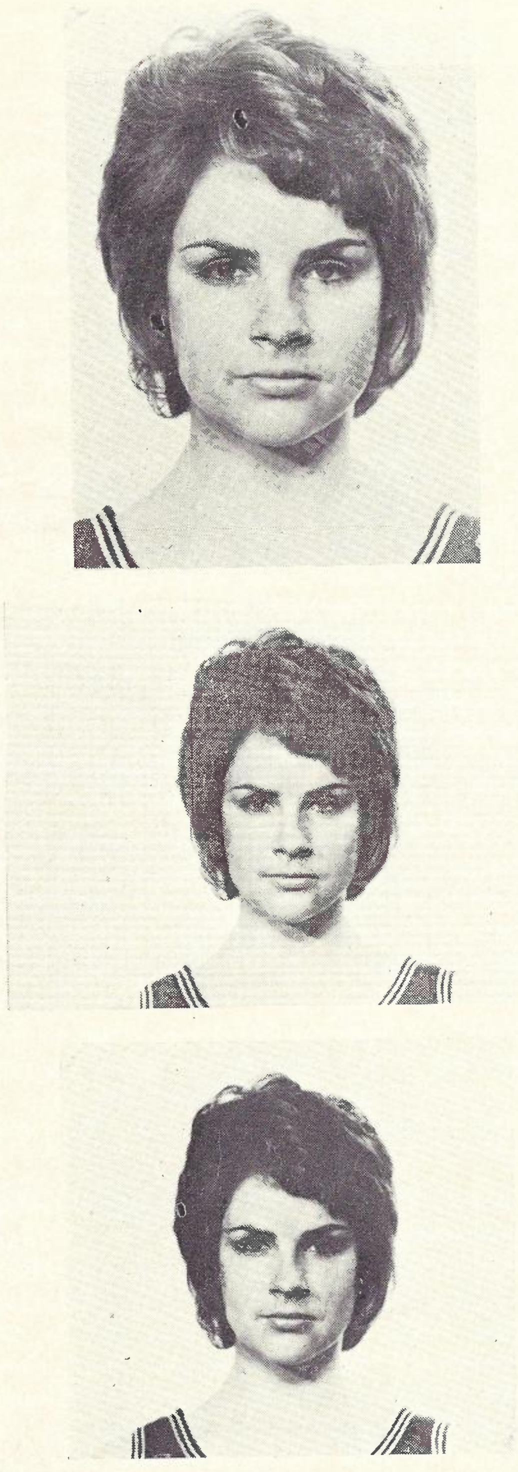


Fig. 2 — Screen Format.

(a) 3:4 Vertically Preferred Aspect Ratio showing Good Screen Utilisation but poor Movement Range.

(b) 4:3 Horizontally Preferred Aspect Ratio showing poor Screen Utilisation.

(c) 1:1.1 Compromise Aspect Ratio.

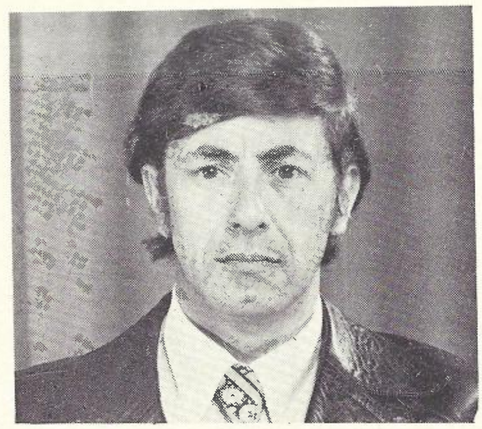


Fig. 3 — Effect of Mounting Camera 5° Above the Subjects' Line of Sight.

Scanning Standards

Cost still determines that television pictures will be produced and displayed using CRT tubes and line by line scanning. With such constraints television systems have been designed so as to match three properties of vision: motion perception governs the picture rate, flicker the field rate and visual acuity the size of the picture element. The signal as generated provides for the maximum contingency conditions of these parameters at all times even though this is not required by a human viewer (Ref. 3). Certainly the advent of flat screen solid state arrays within this decade will produce dramatic changes in the mode of picture presentation. However until then TV phone standards will mirror the earlier development accompanying the introduction of entertainment television.

The acuity of the human eye is such that at normal television luminances, in the range 10 to 340 cd/m^2 (3 to 100 ft L), two picture elements which subtend 1′ of arc can be resolved (Ref. 4). Thus if the TV phone system was to provide full resolution it must reproduce a chessboard pattern with 1.1 × 440 horizontal squares and 440 vertical squares over the (1.1 × 12.75) cm × (12.75) cm screen. The signal bandwidth, which is proportional to the total number of resolution elements, would as a result be high and in fact comparable to that used in normal entertainment television.

For meaningful reproduction of "head and shoulders" type of picture material however, it is not necessary to have a system whose resolution matches that of the viewer. Quality grading tests with systems varying resolution have shown that acceptable picture quality can be maintained with only (175 × 1.1) × (175) elements with each subtending an angle of 2.5′. Fig. 4 is a graph, derived from CCITT drawing No. 3755 (Ref. 5), showing

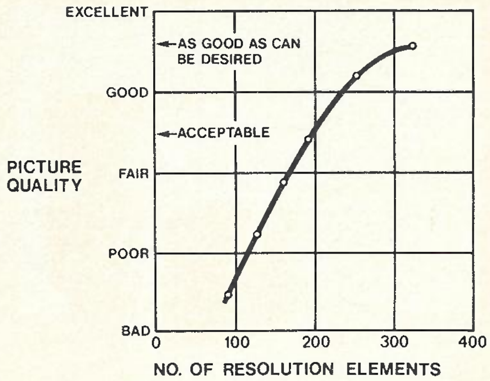


Fig. 4 — Picture Quality versus Resolution.

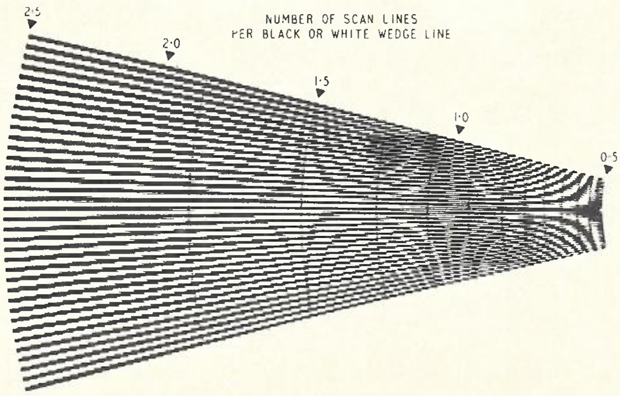


Fig. 5 — A Long-Exposure Photograph of a Picture-Tube Reproduction of a Resolution Wedge. (Reprinted from Electronic Technology, February, 1962.)

ratings from "excellent" through to "bad" for systems with various balance horizontal/vertical resolutions.

To produce 175 vertical resolution elements by means of a horizontal line scanning system more than 175 active scanning lines (i.e., those lines not in the vertical blanking interval) are required. The ratio of the number of resolvable black and white lines to the number of scanning lines is termed the Kell factor, k, usually taken as 0.7 (Ref. 6). Fig. 5 is a photograph which shows the effect of a scanning process on resolution. When such a resolution wedge is viewed on a picture monitor there is marked Moire pattern flickering. Nevertheless it may be appreciated from the photograph that below 1.43 scan lines per wedge line the definition is unreliable.

Moire pattern interference can be removed, albeit at the expense of resolution, by a proper vertical defocusing of both the camera and monitor scanning spots (Ref. 7). It is not current practice to do this however, for we are accustomed to the interference effect and prefer the artificial sharpness afforded by fine line scanning.

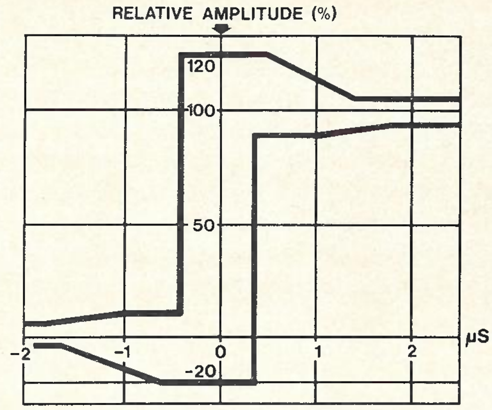


Fig. 6 — Preferred Video Unit-Step Response.

The normal objective measure of the number of horizontal resolution elements that can be resolved by a television system is the number of half cycles at the highest video frequency along the active portion of the line (Ref. 4). The highest frequency for TV phone systems is the so-called "slot" bandwidth, B, taken as the frequency 20-25 dB below the pass-band. Since this bandwidth is necessarily limited, the designer, in order to achieve the crispest contours, aims for the sharpest filter roll-off that is consistent with a limited overshoot and transient. A typical subjectively preferred unit step response is shown in Fig. 6.

In order to obtain an exact balance of horizontal and vertical resolution one would have to be more fastidious about the specification of horizontal resolving power. This would entail standardising the filter roll-off characteristic and examining subjectively the relationship between detail contrast and visibility (Ref. 6). This is because blurring and ringing, which are the impairments associated with the filter design, are quite different from the effects of the scanning structure on vertical definition.

Motion and Flicker Perception

For the reproduction of movement associated with face to face communication a picture repetition rate of 12.5 to 15 Hz would probably be adequate (Ref. 3). At this rate however a 4 : 1 field interlace would be required to avoid flicker and this introduces an annoying line crawling effect. To avoid line crawl we are limited to a 2 : 1 field interlace so that it is flicker rather than movement perception which determines the picture rate.

The threshold field repetition rate (f_r) at which flicker is just perceptible depends on many factors such as the image luminance, the spatial variation of luminance over the image, the angular subtense at the eye of the flickering area and the level of ambient illumination. When these conditions are held constant the threshold flicker frequency is known to vary with the logarithm of image luminance (L) which is the Ferry-Porter law (Ref. 4).

$$f_r = 12.57 (\log_{10} L) + C \quad Hz$$

where C is a constant.

Under typical TV phone viewing conditions, where the ambient illumination may vary from some 64 to 340 cd/m^2 (20 to 100 ft L), a 60 Hz field rate flicker will not appear while at 50 Hz it does (in this context we note that for the Australian television service which employs a 50 Hz field rate flicker does not normally present a problem because of the low ambient light levels encountered).

For Australia, where the power mains frequency is 50 Hz, the choice of the field rate will depend on whether the flicker at 50 Hz would be more annoying than mains interference on a 60 Hz field picture. Such interference may be due either to magnetic coupling or to the light modulation from fluorescent tubes. The former effect may be removed by shielding. This question of choice, although now unresolved, is being investigated.

STANDARDS SPECIFICATION

Implementational constraints on the camera and picture monitor determine k_h, the fraction of a scanning line containing active picture elements and on k_v, the fraction of active scanning lines in a picture. Typically $k_h \simeq 0.85$ and $k_v \simeq 0.91$.

For a picture rate of f Hz, with a 2 : 1 field interlace, a system reproducing n vertical picture elements would have a line period T_s, where

$$T_s = \frac{k_v k}{f\, n}$$

Then for nr horizontal resolution elements we have

$$\frac{nr}{k_h} = 2\, BT$$

whence

$$B = \frac{f\, n^2\, r}{2\, k\, k_h\, k_v}$$

If k = 0.7, n = 175 and r = 1.1, the bandwidth, B, for a 25 Hz picture rate is 780 kHz and 950 kHz for a 30 Hz picture rate. The scanning frequencies, $1/T_s$, are 7 kHz for the 25 Hz system and 8.25 kHz for the 30 Hz system.

Fig. 7 — TV Phone Graphics Application. (By courtesy of the Bell Telephone Laboratories.)

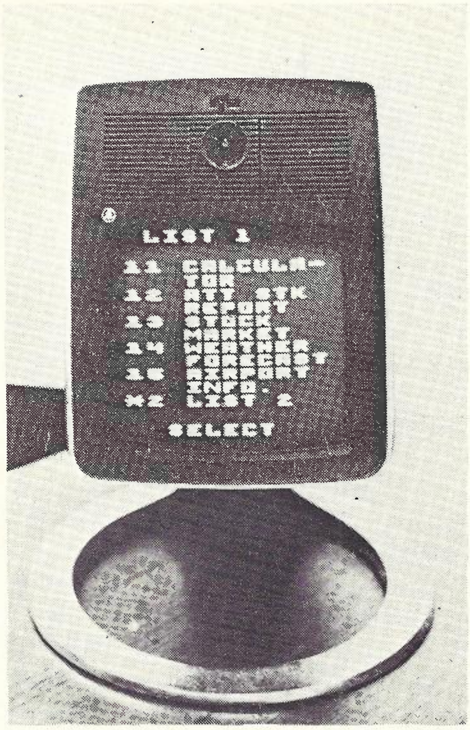


Fig. 8 — TV Phone Computer Interrogation. (By courtesy of the Bell Telephone Laboratories.)

Transmission System Constraints

It is evident that in the introductory phase of TV phone service some existing analog transmission systems will be used for long distance relaying. TV phone systems whose bandwidths are those calculated above would fit most easily into the 1.2 MHz mastergroup transmission hierarchy. On such links vestigial sideband modulation of the video signals would be used with a small vestigial sideband of 0.2 MHz with a 1 MHz base-bandwidth. For a 25 Hz picture system the additional bandwidth would go to improve resolution.

Because of the likely mixed allocation of telephone and TV phone channels on wide-band systems, there is some advantage to be gained by adjusting the line scanning rate to 8 kHz (Ref. 8). The resolution unbalance caused by such an adjustment is small. In this way the inter-modulation products of the picture signals can fall into gaps between the telephone channels and, in addition, the mutual interference of the picture signals is minimised because the second order video carrier intermodulation interference falls between main picture spectral lines. Disadvantages such as the effects of non-random phase crosstalk between channels could reduce these advantages somewhat.

If the constraints on scanning frequency are adopted the TV phone system would be designed about a bandwidth of 1 MHz and a scanning rate of 8 kHz. The number of scanning lines per picture would then be constrained because of interlace to be an odd integer whose value is such that the picture rate is as close as possible to either 25 or 30 Hz, depending on the system requirements. This leads to the following scanning parameters the first group of which is in accord with the Australian experimental standards specification.

TABLE 1 — PICTURE STANDARDS

Bandwidth	1 MHz	1 MHz
Horizontal Scanning frequency	8 kHz	8 kHz
Picture frequency	25.078 Hz	29.9625 Hz
Lines per picture	319	267
Fields per picture	2 interlaced	2 interlaced
Aspect ratio	1.1	1.1

THE FUTURE

The TV phone design which we have discussed in this paper has as its end the satisfactory portrayal of a "head and shoulders" picture of a subscriber. The standards above were chosen in support of this end. However it is to be expected that once a TV phone service is introduced and a wide-band video facility is available on each desk top, a wider application will be sought for the medium and its associated channel.

At present the TV phone can be used to relay pictures of line drawings and the like (Fig. 7) but here the low resolution and small screen size are inhibiting. Certainly a full A4 size page of typescript cannot be accommodated and, when used for computer interrogation (Fig. 8), the current TV phone models accommodate and display only 400 characters.

Graphics information however is basically stationary and does not require a high picture rate. Hence one may expect in future to be given a choice of either a fast or a slow scan system. Other apparatus such as facsimile, electrowriters and the like would also be used for relaying graphics material in conjunction with the normal TV phone picture by making use of the unused channel capacity available during the picture blanking intervals.

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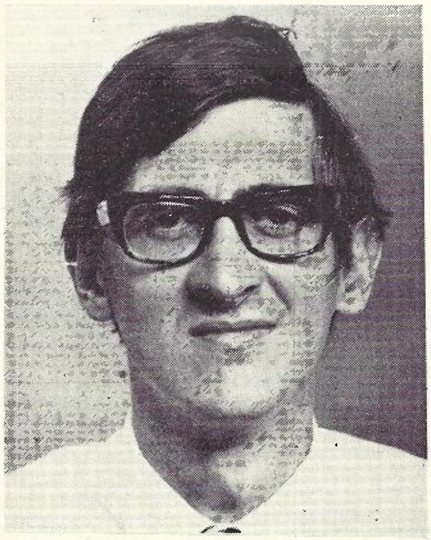


Technical News Item

45TH ANZAAS CONGRESS

The first ANZAAS Congress was held in Sydney in 1888. Since that time, the Congresses have had two major aims; firstly to bring together scientists of all types and occupations so that they may interchange information and ideas, and secondly to make the public aware of what science is, what scientists do, and of the applications and implications of scientific discoveries to their own everyday affairs and those of the nation.

The 45th ANZAAS Congress is to be held in Perth, 13th-17th August, 1973, and will have as its theme Science, Development and the Environment – a theme peculiarly apt for Australia, New Zealand and Papua New Guinea at the present time.

The Congress programme will be executed under 25 specialist section headings ranging from Physics through Physiology to Sociology, but in addition the 45th Congress will feature the following major Congress Symposia:—

- **The Scientist, The Bureaucrat and Environmental Responsibility.** What is the role of the scientist when environmental protection becomes a bureaucracy?
- **Education and Environment.** Is education failing to respond to the lessons of the environmental revolution?
- **Social Problems of Development and Change.** Has the pace of social change ceased to keep up with that of technological and environmental development? What can we do about this?
- **Economic Growth: Magnificent Obsession?** Development in Australia begs the questions – development for whom? development for what? Or, are we just obsessed by economic growth for its own sake?
- **Limits To Growth in Australia.** What are the criteria for optimising the population of Australia?
- **Whither Urban Australia?** Planning, Public Policy and Participation in the Future. What are the real problems of urban Australia? Do we make elitist policies? How should the citizen participate in urban decision making?
- **The Australian Aboriginal: The Widening Gap.** Assimilation, acculturation, alienation; what are their implications?
- **The Clash of Value Systems.** What are the implications for science as a sub-culture in a multi-value society?
- **Science and Manpower Policy in a Developing and Changing Economy.** Is there such a thing as a science policy? How do we program the output and training of scientists and technologists?
- **The Implications Of Nuclear Explosives.** Nuclear explosives and biological hazards, nuclear pollution, international relations and the responsibility of scientists.
- **Western Australia: Is It Too Late to Secede?** Better off alone?
- **Resource Management And Planning: Ideals and Reality.** Can we plan and manage our resources ecologically? Do we—for Australian resources?

All general Congress inquiries should be addressed to:—

Mrs. Dulcie Stretton,
ANZAAS Congress Executive Officer,
University of Western Australia,
NEDLANDS, W.A. 6009.
Telephone: 80-3838.

The 1972 International Switching Symposium at Boston, USA

F. J. W. SYMONS, B.E., D.I.C.

This paper reviews the more interesting and significant aspects of the June, 1972, International Switching Symposium at Boston, USA. It gives a summary of the major system and network developments in nine countries, as reported at the Symposium, and it describes the major distinguishable universal trends affecting switching systems and networks.

INTRODUCTION

The International Switching Symposium in Boston (ISS72) from June 5-9, 1972, was the latest in a series of symposia held to review the progress of the latest developments in switching systems and techniques. These symposia constitute an important forum for the interchange of information between those engaged in the development of forward looking systems, their potential users, and those who have recently adopted equipment utilising the latest technology. They represent a most important event to all those who are concerned with research and development relating to switching equipment for telecommunications purposes.

This paper is intended to give a review of the more interesting or significant aspects of ISS 72, and to give a brief summary of the distinguishable world trends in telecommunications switching systems and networks. The paper will concentrate on telephone public switching systems, and will not cover PABX applications or the various forms of data switching. The paper does not attempt to give equal treatment to all countries or systems.

KEYNOTE SESSION

The Symposium opened with a keynote session at which a senior officer from the telephone administrations of Japan, The United Kingdom, France, Germany and Sweden reviewed recent developments and future plans for switching systems and networks in his own country.

All administrations predict that the rapid growth of the demand for a wide variety of telecommunication services will continue at least for the next twenty years. The administrations are all turning to modern electronic stored program control or processor controlled switching systems to provide the means by which the new services and switching tasks can be performed. A large percentage of the administrations are looking to all-digital integrated service networks to enable them to provide the wide range of services required, and many have initiated development in this direction. Most of the administrations realise that the new powerful systems and large fully automatic networks will bring with them a new set of problems concerning the overall operation, management and maintenance of the network. Several developments have been started of regional administrative and maintenance centres. Most administrations also realise that the rapid growth of the demands on the network mean that the network and especially the switching systems must be very flexible as well as powerful, and that they must be able to cope in a simple manner with rapid changes.

Many more administrations are now getting together with manufacturers, not just to purchase equipment, but to carry out joint planning, designing and development of a modern network with modern advanced switching systems. The importance of carrying out field trials of new systems well in advance of their widespread application is now widely acknowledged, as well as the fact that these are best carried out jointly by administrations and industry.

OTHER PAPERS

For the remainder of ISS 72, another 83 papers were presented by manufacturers, administrations, operating companies and Universities on a wide variety of aspects of switching systems and networks. About two-thirds of the papers were presented by manufacturers, and several papers were submitted jointly by administrations and manufacturers, notably those from Japan.

Compared with previous symposia there were many more papers on switching systems and on the introduction of new systems into existing networks. There were very few papers on subsystems, components, devices and techniques, whereas the ISS of several years ago contained many more papers on these subjects. This change in emphasis reflects the change in the major problems facing administrations and manufacturers. Around 1960 most of the problems in the design and development of switching systems were to find components and techniques which could meet the requirements of the system. Now the problems are to design the system which can take the most advantage technically and economically of the available integrated circuit technology, to decide on what overall system is required, and to decide how best to introduce the new systems into the existing network in order that the superior performance of the new systems can be sufficiently exploited from its introduction.

BOSTON HIGHLIGHTS

There were four systems which I believe rated as Boston Highlights, and these are described briefly below.

The No. 4. ESS

At Boston the first public description in any detail of the Bell No. 4 ESS (Electronic Switching System) was given in the paper by H. E. Vaughan. This exchange is a PCM (Pulse Code Modulation) switching exchange for the trunk network, and is still in the final stages of development. It makes extensive use of integrated circuits. It will provide all the features of the present trunk system and in addition common channel signalling, and some network management functions. The exchange is expected to provide for 70,000 terminations, and will use the 1A processor which is about three times more powerful than the processors being used in the existing No. 1 ESS (see later section on ATT). There are very few PCM trunk lines in the USA at the moment, but there is a very large number of PCM junction circuits. All inlets to the exchange will have to be converted to the new D2 PCM standard format before being switched. The No. 4 ESS is expected to be in service by 1975. It is claimed to be economic even in a fully analogue environment where all channels will have to be converted to PCM. Almost all of the exchange is duplicated, and the switching network is completely duplicated. The most interesting thing is the reason for duplication. The duplication is not for reasons of hardware reliability or exchange security, but for operational convenience. While one half of the exchange is carrying traffic, the other half will be used to add, re-arrange and test circuits, and to add extensions of the switch. This is probably the first exchange to include duplication for these reasons.

The IFS-1 System

The Swiss telephone network has been 100% automatic since 1959, and the Swiss telephone administration is in the unique situation where their network is under very little pressure. The Swiss telephone administration, in conjunction with three manufacturers, Hasler, Siemens-Albis, and Standard Telephon und Radio (ITT), are developing the next generation Swiss switching system IFS-1, based on the 32 channel or 2.048 Mb/s PCM standard. The system is intended for widespread introduction beginning in the very late 1970s. This is a very bold step by the Swiss PTT to develop a comprehensive uniform digital network to provide a variety of services. It incorporates a large amount of remote control, and uses a series of switching network planes where each subscriber and/or call has access to three planes not only for switching but also for control. The network is divided into four fields, the peripheral field, the concentration field, the switching network, and the processor field. In the security arrangements, all control channels, which use the 64 kb/s of one PCM channel, are switched across the switching network. No direct control links are provided. The Swiss PTT is including as standard items digital subscribers concentrators as well as space division concentrators, and is contemplating digital subscribers distribution and subscribers equipment where each subscriber has access to a 128 kb/s data stream for a variety of services.

The C1-EAX Exchange

The C1-EAX is a small processor controlled exchange developed by GTE Automatic Electric (Canada). It provides a wide range of modern local services, except Centrex, and has been in production since 1970. By May, 1972, there were 37 installations in service totalling 40,000 lines, and a total of over 60 orders had been obtained. From early 1973 the maximum size will be 4,800 lines. GTE have made a deliberate effort to develop a versatile control system economical at small sizes. Amongst other things they have adopted the following features:

(i) no program maps for networks and devices;
(ii) no hardware interrupts (except perhaps clock pulses for timing);
(iii) no large electrically alterable memory;
(iv) software assisted maintenance;
(v) a simple processor with only 10 instructions.

The most interesting aspect, and one which GTE are very proud of, is the fact that all the call processing and maintenance programs total just over 8000 instructions, and were developed in 10 man years. In addition the support software, assemblers and real time simulators total only 5000 instructions, and were developed in 2.5 man years. These small program sizes and small software development times contrast strongly with several other approaches, and there may be several valuable lessons to learn from this experience of GTE.

Line Connectors

In a paper from Stromberg-Carlson Corporation, the use of line connectors was advocated. This line connector caters for up to 200 subscribers lines and is connected to the local exchange over PCM transmission links. It can be used with either existing electro-mechanical exchanges or with future digital exchanges. It is proposed as the first step towards the integration of the existing telephone networks, designed for voice frequency transmission, into an integrated all-purpose digital network suitable for both voice and data transmission. The line connector is claimed to present a unique opportunity to improve total system performance and at the same time achieve significant economies. The line connector is proposed mainly for new subscriber lines, and for the economic extension of existing local exchanges. The telephones connected to the line connector will use tone dialling and tone ringing. Intra-line connector calls will be switched across the line connector without trombone trunking. The line connector has been designed to work with the 32 channel 2Mb/s CCITT PCM standard, rather than with a 24 channel system, as it is claimed to have economic advantages. It is expected to make extensive use of modern integrated circuit technology. The most interesting aspect about the line connector is that it is not being proposed by research and/or development people. The use of the line connector is being advocated from the point of view of an operating company, which expects it to bring lower costs in many operating activities such as running costs, servicing, maintenance, subscriber line fault finding, installation, and general administration effort, as well as in capital expenditure.

DEVELOPMENTS IN VARIOUS COUNTRIES

A short description will be given below of the main developments in several countries, as presented at ISS 72.

Japan

Well over half of the telephone lines in Japan are currently connected to crossbar exchanges of various types. The crossbar family of exchanges has been extended to provide facilities such as abbreviated dialling, call waiting, automatic interception, and automatic charge information service. Other advanced facilities are currently being developed.

The large development effort of NTTPC (the Japanese telecommunications administration) in co-operation with four manufacturers, Nippon Electric Company (NEC), Oki Electrical Industry Company, Hitachi and Fujitsu, over the last eight years has culminated in the development of an electronic switching system using processor control of miniature mechanically latching crossbar switches. The production model family is called the D10 system. The history of the development of the D10 system through the various models of DEX-1, DEX-2 and DEX-21 is well described in the special issue of the Review of the Electrical Communication Laboratory, Volume 19, Number 3, March 1971. A trial DEX-2 local exchange of 3000 lines operated at Ushigome in Tokyo from December 1969 until February 1972. It has now been taken out of service, and is being used for training purposes. DEX-2 was expensive compared with the equivalent crossbar C400 exchange, and the system was modified to produce the cost reduced version called DEX-21. A DEX-21 trial office of 2000 lines was cutover in Kasumigaseki, Tokyo, in December 1971. The main changes from DEX-2 to DEX-21 were to change the memory module organisation and to use special integrated circuits instead of general purpose integrated circuits for the control, together with larger printed circuit boards, resulting in a reduction of the wiring to one third. The first two DEX-21 production exchanges were planned for cutover in June 1972, at Ginza, Tokyo (NEC), Senba, Osaka (Fujitsu), followed later in 1972 by Yodobashi, Tokyo (Oki), and Hirokji, Nagoya (Hitachi). Many installations are planned for 1973.

All the effort of the NTTPC and the four manufacturers is currently going into "broadbanding" the D10 system to be economical over a wide range of exchange sizes and services, using the basic building blocks in different configurations. The metropolital terminal DEX-21 exchange is intended to cover the range of 4,000-40,000 lines, and up to 70,000 calls per hour, or 4,000 erlangs. It occupies about one third the floor space of the crossbar counterpart C400.

The D10 family of exchanges provides for remotely controlled outposted switching stages. In some applications these will grow to the stage where they will have their own local control processors, and in other smaller applications they will remain remotely controlled. The D10 family will be used both to replace step by step exchanges and to extend crossbar exchanges. NTTPC have no immediate plans for PCM switching although there is a large amount of PCM transmission used on junction routes. They are waiting until the D10 system is fully developed, and there is a larger percentage of PCM lines.

Canada

In Canada the most interesting developments are taking place in the Bell Canada network which has over 6 million telephones, revenue of over 1000 million dollars, and a staff of 40,000. Bell Canada is a public company 98% public owned and 2% owned by the American Telephone and Telegraph Co., USA. At least 96% of the shares are held by Canadian people and companies. Bell

Canada 100% owns the manufacturing company Northern Electric Company Ltd., which has sales of nearly 600 million dollars and more than 21,000 staff. The Northern Electric Company manufactures a wide range of electronic and telecommunication equipment, and has significant export markets. Northern Electric Company has a controlling interest of 60% in the public company, Microsystems International, Ltd., Canada, which manufactures semiconductor devices. Bell Northern Research (BNR) is the Research and Development wing of the Bell Canada family, and is owned 51% by Bell Canada (the operating company) and 49% by Northern Electric Company (the manufacturing company), and is the largest industrial research and development organisation in Canada. BNR has annual operating expenses of 36 million dollars and a staff of 1800.

Over the last 10 to 15 years, the capability and operations of BNR, especially in the switching field, have deliberately been built up from relatively small beginnings to a level where they are now a significant group of world standing. BNR have developed the SP-1 switching system, incorporating processor control of miniature crossbar switches. The SP-1 local exchange covers the range of 2,000-20,000 lines, and up to 36,000 average busy hour calls. A field trial exchange with 800 lines was cutover in Ottawa in November 1969. The trial exchange has recently been withdrawn from service.

The first SP-1 installation was cutover in Aylmer, Quebec, in November 1971, and is currently serving 6500 lines. The second SP-1 local exchange was cutover in Calgary, Alberta, in June 1972, and at least three more were planned for later in 1972. At least 12 exchanges will be cutover in 1973, and more than 20 in 1974. BNR are currently developing a centrex exchange, a trunk or four-wire exchange, and a combined local and trunk exchange. These exchanges all use the basic SP-1 modules, and model exchanges already exist in the laboratory. The trunk exchange has a capacity of about 8000 terminations and about 40,000 average busy hour calls. The first installation will be at Thunder Bay, Canada, in early 1974. The first combined local and trunk exchange will be cutover late in 1974. The operating company Bell Canada has been very pleased with the operating experience gained so far with the SP-1 system, and they are finding that they are obtaining gains of all kinds from the system, compared with crossbar.

15% of Canadian trunk telephone lines are expected to be digital by 1975, rising to 90% in 1990. BNR have developed a special coaxial cable and transmission system, called the LD-4 system, for long-haul digital transmission up to 4000 miles. With repeaters every 6000ft, a 12-tube cable can provide more than 20,000 two-way voice circuits using a 273 Mb/s bit stream. The system was due to be field tested in 1972 and 1973, and installation is planned for 1975. Twenty-four channel PCM is curently economical for junction routes of 10 miles, and BNR expect this to fall to less than 7 miles in metropolitan areas over the next few years. BNR expect digital switching to be applied first in the trunk network, in conjunction with the LD-4 system. BNR are planning the field trial of a digital transit switch in the late 1970s.

The United States of America

In the USA, the telephone situation is dominated by ATT, but there are also very interesting developments in the "independent" companies.

American Telephone and Telegraph Co. (ATT)

The No. 1 ESS was the first commercial processor controlled telephone exchange, and it is used for large local exchanges. Since 1965 and up to June 1972, 250 exchanges had been installed, with a total of 4,000,000 lines and an average of 16,000 lines. By the end of 1972, another 100 exchanges had been installed. The largest exchange cutover was of 43,000 lines. During 1971, 160 exchange years of operation were accumulated, and the total "down time", affecting new calls only, was 50 hours. This is about 12 hours per exchange in 40 years, compared with the objective of two hours. Bell are confident that the objective can soon be met. One improvement being introduced is the reduction of the recovery time from a complete system failure from 3 minutes to 30 seconds. This alone will reduce the 12 hours in 40 years to 8 hours. Hardware is no problem. Considerable effort is now being put into improving operation procedures and approaches so that lower levels of skill are sufficient. By continual refinement the system call capacity in Peak Busy Hour Calls (PBHC) has been steadily increased from 25,000 in 1966 to 45,000 in 1971. With the addition of a signal processor the capacity has been increased from 64,000 in 1968 to between 83,000 and 95,000 (depending on the type of signals and facilities) in 1971.

The No. 2 ESS is intended for medium size local exchanges. The first exchange was installed in late 1970, and by the end of 1972 there were about six exchanges installed, over the range of 1500 to 6000 lines.

The TSPS (Traffic Service Position System) is a processor controlled installation for operator assistance. By June 1972, 48 TSPS systems had been installed, with a total of 3500 operator consoles serving 8.5 million lines and 0.25 million public telephones, and handling 2.5 million trunk calls per day. Another 12 systems were installed by the end of 1972. The TSPS system is proving to be very economical, especially to the operating companies, and a considerably improved customer service has also been achieved.

The AIS (Automatic Interception System) is a procesor controlled installation for various automatic interception services. Five of these systems have been placed in service to serve three million lines. They make use of a time division multiplex (TDM) switch, with phrases stored on a drum for voice announcements. An operator comes in only if a subscriber is not satisfied. Bell expect a savings in operators of at least 5 to 1.

It is interesting to note that the Bell network has a distribution of exchange sizes similar to that of the A.P.O. In the Bell network, half of the buildings contain exchanges of less than 2000 lines, and only 5% of the total number of lines. Bell are now looking at ways of handling this situation including such things as extending No. 2 ESS to be economical at 1000 lines, designing a new small exchange, and remote control.

Stromberg-Carlson Corporation

Stromberg-Carlson have developed the ESC-1, an electronic switching system with distributed control, and it is now in full production, following a field trial in Hinckley, Ohio, during 1970. The system caters for the range of 4000-15,000 subscriber lines and uses gold plated reed relays. One of the basic objectives of the system was to find a system design with a flexible common control economical down to sizes of 4000 lines or less. Stromberg-Carlson maintain that the system as well as being economical at 4000 lines suffers no significant control cost penalty at 15,000 lines. The ESC-1 system includes a range of customer facilities, including PBX number hunting and PBX night service. Calling party directory number and equipment number/directory number translation are provided, and a maximum of 225 different classes of service of originating and terminating numbers are catered for. The registers are organised in groups of 20. Up to 60 registers can be served by one electronic "register common", and up to four register commons can be served by the number and code translator.

North Electric Company

North Electric Company (NE) have taken the Swedish L.M. Ericsson AKE13 system and are implementing it with modern electronics for trunk exchanges. There are no major system design changes, and the code bar switch is being retained for the switching matrix, which NE will soon be manufacturing. As well as including electronics, NE are incorporating other manufacturing, installation and testing improvements such as automating and/or streamlining many procedures. An "omniboard" printed circuit board is being used, mounting a maximum of 96 integrated circuit packages. A single memory card contains 4K words and two complete 32K memory systems are contained in one shelf. Exclusive use is being made of plugs and sockets at the top of racks, and a grid interconnection scheme is used across the top of the racks. With this method 600 cables can be laid each day, compared with 60 using previous techniques. Some of the design techniques have been automated so that prototype or production cards can be produced from punched paper tape containing wiring and component placing information. The basic input to this scheme is the logic diagram of the board circuitry in coded form. The basic software is the same as the AKE13 system, but NE is developing a software test system based on a PDP11 mini-computer to expedite the software production and testing. NE are adding a few features not already incorporated into the AKE 13 system. These include network management features such as the control of dynamic overload.

The Datran Network

A very interesting development in the USA, both technically and in its relationship with other organisations involved in the telecommunications business, is the Datran network. Detailed information on this network has only recently become available. The Datran system is planned to be a USA-wide all-digital switched network, which will initially serve subscriber terminals in 35 metropolitan terminals. The system is expected to provide service by 1975 or 1976. The system is planned to have a two level hierarchy of district exchanges and fully interconnected regional exchanges. All exchanges will be computer controlled, and a special local distribution cable system will be utilised. High capacity digital microwave transmission systems will be used to interconnect the switching centres. The network is obviously aimed at the business community, and will be available only to those customers with the special local distribution cable system. Four types of services will be offered: 150b/s, 4.8kb/s, 9.6kb/s, and 14.4kb/s. Two important design objectives are

(a) a maximum connect time of three seconds during the busy hour,

(b) a maximum delay in answering requests for service (equivalent to dial tone) of three seconds.

Sweden

An interesting development took place in Sweden a few years ago. Because of project complexity and the relatively limited availability of specialised engineering personnel it was decided to combine the design and development teams of the Swedish administration and L.M. Ericsson in the form of the jointly owned company called Ellemtel. This company has been in operation since the middle of 1970, and is engaged in a number of development and design projects including new public and private switching systems. The new systems will be manufactured by both the administration and L.M. Ericsson. As the key personnel of Ellemtel have been drawn from the administration and L.M. Ericsson, the new company incorporates a valuable combination of design and development knowledge and experience from operation and administration.

Apart from a small electronic PABX (up to 800 lines) being developed by Ellemtel, the only Swedish systems described at ISS 72 were the L.M. Ericsson AKE system and the administration's A210 exchange, both processor controlled. Both of these have been described in several papers, mostly since 1966.

The United Kingdom

At the moment the BPO seem to be basing their plans for the early and middle 1970s on the TXE2 for small local exchanges, and on the TXE4 and crossbar for other applications. For the late 1970s and the 1980s, the BPO are looking to a processor controlled system with a large proportion of digital switching and transmission. They expect digital switching and transmission will first be applied in the Group Switching Centres (GSC) of the trunk network. There are 370 GSCs in the UK. About 300 TXE2 exchanges using reed relays and electronic control have been installed. This system has a capacity of up to 4000 lines, and 360 erlangs, and is being used mostly to replace Strowger exchanges. The BPO has ordered at least 20 TXE4 exchanges for installation during 1974-76. This exchange is planned to cater for large local exchanges up to 30,000 or 40,000 lines, and up to 5000 erlangs. It uses reed relays and electronic control. The TX4 system is still going through the final stages of development.

The Research Department of the BPO are designing equipment for two field trials incorporating processor control, digital switching and remote control.

Four papers were presented at Boston by the Plessey Company, describing a modular telephone switching system which they are developing with emphasis in the papers on the multi-processor control system called system 250.

Belgium

The major switching development in Belgium is the ITT 10C processor controlled switching system using reed relay matrices. The 10C system is now comparatively well known in the APO, mainly on account of several contracts for trunk exchanges, and so little will be said about 10C in this paper.

France

Since 1957 the French administration, through its research and development unit called CNET, have been carrying out many studies, using laboratory models and prototypes and conducting field trials employing a wide range of methods of transmission, control, switching matrices and technology. These activities have now converged with the development of two electronic switching systems known as E10 and E12, both using processor control, digital switching and remote control.

The E10 system is the production version of the PLATON (Prototype Lannionais d'Autocommutateur Temporel a Organisation Numerique) equipment installed in Brittany. The E10 system is intended for lower density areas and makes extensive use of PCM transmission and switching. It includes tandem exchanges, local exchanges and remotely controlled concentrators, typically for 512 subscribers. All exchanges have a maximum capacity of 50,000 calls per hour, and make use of the basic E10 module catering for a maximum of 1800 incoming PCM channels and 1800 outgoing PCM channels. Many of the administrative functions are performed on an area basis at a processing centre (CTI) which makes use of a single commercial computer. Two CTI versions are being developed, one for 50,000 subscribers, and one for 200,000 subscribers. The first local exchange was cutover at Perros-Guirec in January 1970, and it now has 1500 subscribers. Since then, a tandem exchange, another local exchange, several concentrators and the processing centre have been added. Several existing electromechanical exchanges have also been connected to the tandem-exchange and to the processing centre. In general, less problems have been encountered than with crossbar installations in similar situations.

The Lannion network has been extended by the addition of equipment in two new areas (Guingamp in May 1972 and Paimpol in June 1972). Three new areas will be added in 1974 (Rostrenen, Loudeac and Lamballe) and a transit exchange (800/800) will be installed at Saint-Brieuc in 1974. Two new regional networks will be installed around Le Mans (1973-1975) and Rouen (1973-1975), and an urban network totalling 6000 subscribers will be installed at Poitiers in 1973.

The E10 system has been completely designed and developed by CNET, with all the equipment being manufactured by Societe Lannionnaise d'Electronique (SLE), a subsidiary of CIT, specially formed, mostly for the purpose of making the E10 system. CIT is the French firm Compagnie Industrielle des Telecommunications. By the middle of 1972, there were about 10,000 lines of E10 equipment in service in five centres. By 1975, CNET expect that 100,000 lines of E10 will be installed per annum.

The E12 system is still being developed and is intended for the larger metropolitan networks, and has a basic maximum capacity of 150,000 calls per hour. E12 system includes tandem exchanges, local exchanges, remotely controlled concentrators and regional administrative processing centres, and is based on PCM switching and transmission. The "concentrators" are expected to grow up to 4000 or 5000 lines and both space division and time division models are being designed.

One of the biggest problems in the Paris network is the replacement of rotary exchanges, many of which are 40 years old. These are currently being replaced by crossbar, and they will be replaced by the E12 system, starting about 1976. There is a high percentage of transit traffic in the Paris network. The average distance between exchanges in Paris is about 5km, and PCM transmission systems will be installed between E12 exchanges, and from E12 to crossbar exchanges.

One of the most significant factors in planning the Paris network is the difficulty and high cost of providing suitable exchange locations and buildings. This makes the smaller space requirements of electronic equipment, and the use of remote control even more attractive than it is in other applications. By 1985, it is expected that new equipment installed in France will be 50% crossbar and 50% electronic (E10 and E12).

The E12 system uses the larger CTI centre designed for areas serving up to 200,000 subscribers. This centre will be used for such things as centralised maintenance, charging, traffic and load observation, administration of subscribers' categories. Whereas in the CTI operating at Lannion little data reduction is done at the switching centres, in the larger system for E12 much more data preprocessing will be done at the switching centres and only condensed data wil be sent to the CTI. The first field installation of E12 equipment is planned for 1974, and the first large local exchange is planned for 1976.

Holland

Four papers were presented at Boston on the PRX205 system developed by Philips Telecommunications Industries, Holland. This is a local exchange using reed relays for the switch block and duplicated synchronous computers for control. The exchange is primarily aimed at the range of 100-1000 erlangs, and for up to 20,000 lines. A laboratory model has been operational since the middle of 1971, and a 1000 line field trial was planned to be cutover in late 1972 or early 1973. Philips have put considerable effort into building a "system, hardware and software factory" so that much of the work involved in designing, dimensioning, programming, building and testing exchanges can be automated.

The most recent development in the PRX205 system is the finalising of the approach to be taken to the exchanges which have more than 20,000 lines or handle more than 1000 erlangs. In essence the larger exchanges consist of several exchanges combined together so that each control unit controls its own switching network as a self-contained exchange in the same configuration as a smaller exchange with one control unit.

Data messages are sent between the various control units over a special high speed internal parallel data link. In this way Philips maintain that the overall loss due to the multi-control unit configuration is kept down to 10%. For mostly practical reasons the number of units will be restricted to four or five, but this will allow a maximum traffic of between 5000 and 6000 erlangs to be handled.

At the moment the PRX205 system uses 16 bit 2-microsecond computers. It is interesting to note that they are developing, in addition to the multi-control unit configuration, a more powerful computer with reduced cycle time and longer word-length, with upwards software compatibility. With the same multi-control unit concept, the number of computers needed in a large exchange will be reduced.

Germany

In Germany the Deutsche Bundespost and several German manufacturers are developing the twin processor controlled switching (EWS) system with switching matrices employing sealed precious metal contacts. Siemens and the other companies have been testing a very comprehensive EWS prototype system in the laboratories for about two years. It includes two twin processors, together with at least one of every item of equipment of the EWS system, with a total of about 200 lines. A large number of tests and considerable test traffic have been handled, but no public traffic. All modes of working are being tested thoroughly. The processors are often used as four independent machines so that different types of tests can be carried out simultaneously.

Three field trials of local exchanges are planned to carry public traffic in 1973 and 1974. The first will be of 1000 lines in Munich, followed by 1000 lines at Stuttgart and 1000 lines at Darmstadt. The three exchanges will be interconnected by common channel signalling links. During 1973, a trial regional service centre will be commissioned in conjunction with the three trial switching centres. This service centre is planned to be able to cater for an area serving about 250,000 subscribers, and will eventually be used to automate a wide range of technical and administrative tasks. Widespread introduction of the EWS system is planned for 1975.

The German national telephone network consists of a hierarchy of four levels of exchanges, called Terminal Exchange, Junction Exchange, Main Exchange and Central Exchange. The distances between Terminal exchanges and Junction exchanges range from 4-14 km. The average distance between Junction exchanges and Main exchanges is 45 km, and the average distance between Main exchanges and Central exchanges is 150 km. Siemens have always been developing the EWS system as a solution to the total problems of the telephone network, and not just as a switching machine. The philosophy of introduction has always played a large part in the definition and design of the system. Siemens have probably thought through the full implications involved in introducing a processor controlled switching system into the network more than any other establishment in the world. They are also the furtherest advanced in identifying and understanding the potential of new switching systems in the network, and the interactions between networks and system design.

The EWS system includes a processor unit together with interface equipment to switching networks. The switching networks can either be adjacent to the processors or at a distance. The remote switching network can operate as a completely independent exchange as far as traffic and trunking are concerned, and it can also have junctions to the exchange adjacent to the processors.

There are three basic types of subscribers line concentrators: large — with up to 64 junctions and 512 subs: medium — with up to 16 junctions and 144 subs: and small — with up to 4 junctions and 20 subs. All these concentrators can be connected either to the exchange adjacent to the processors or to the remote exchange. The two smaller concentrators can also stand in the street in special cabinets. In many cases the large concentrator will be used in rented rooms, taking power from the public electricity supply, and having local standby batteries.

A fourth type of subscribers line concentrator is identical to the large concentrator as far as the network is concerned. The fourth concentrator will be used for extensions of existing exchanges, where exchange buildings are available, and where the exchange will eventually grow to have its own local processor. Local processors will probably be provided at several thousand lines. The three ruggedised concentrators are seen as final (or long term) solutions.

Initially, one control centre will be installed in each major urban centre, and this will be used to control remote switching stages and/or concentrators so that advanced facilities can be made available very quickly to all customers who want them. As the number of EWS lines grows, the area controlled from each centre will decrease.

EWS exchanges will be installed in the trunk network as an overlay network. All EWS local (and tandem) exchanges will be connected only to the new trunk network whether or not all levels of the hierarchy are available in the EWS system. A start will be made in areas with the most subscribers, and a full mesh of EWS trunk exchanges will be installed first in the heavy traffic areas. With this approach it is expected that a large percentage of the trunk lines will be connected to EWS exchanges within a few years. Traffic will stay in the new network as long as possible, and the cost of interworking relay sets will be minimised. Large savings will be made by the elimination of trunk relay sets due to the use of common channel signalling.

Siemens are developing PCM switching stages as an integral part of the EWS system using the same processors as the space switching stages. These PCM switching stages can also be adjacent to the processors or remote. It is probable that PCM switching stages will be added to some of the field trial sites. By 1975 the Bundespost will be installing about 1000 2 Mb/s PCM systems per annum, mostly in junction routes in the large towns. Siemens see tandem exchanges as the first application of digital switching, followed by local exchanges and then trunk exchanges.

CONCLUSIONS

There are several clearly distinguishable universal trends concerned with telecommunications switching and these are described briefly below.

Modern Switching Systems and Networks

To meet the demands of the future most administrations have turned to stored program control (SPC) switching systems, of both space division and digital time division types, and many administrations are looking forward to all-digital integrated service networks to enable them to provide the wide range of services required. On the one hand the modern electronic SPC switching systems, and especially digital systems, provide a means by which the new services and new switching tasks can be performed, and enable many operational and maintenance procedures to be automated. On the other hand, they bring with them new problems of a large modern automatic network, including many maintenance and operational problems.

Many countries are developing or using regional administrative centres to carry-out, to greater or lesser extents, a wide range of activities such as charging, maintenance, traffic and loading observation, network management, and various other administrative tasks.

There is now universal recognition of the importance of operational, maintenance, testing, and extension aspects being an integral part of the design of systems from the beginning, and of the importance of making systems simple and easy to use. There is also almost universal recognition that economies are available from SPC systems in all these areas if the new systems are applied properly.

System Flexibility and Administrative Flexibility

The rapid growth of the demands on a network mean that the network and especially the switching systems must be very flexible and must be able to cope in a simple manner with rapid changes. Many administrations recognise that just as there is a need for flexible switching systems in order to meet the new demands, there is a greater need for organisational and administrative flexibility in the telecommunications authorities so that the necessary total flexibility can be achieved in a complex changing administrative and technological environment.

New Cost Structures

There are also very significant changes in the cost structure of the development and application of switching systems. In the past, the production or manufacturing cost of the switching system was paramount. Now, and in the future, the production cost will be a much smaller percentage of the total cost of a system, as the percentages of both the development costs and the operation costs have increased. Administrations are now directly contributing much more effort to the overall design, detailed specification, and detailed design of new systems, this effort is an increasingly significant cost to an administration. Although the costs for the field maintenance of the physical equipment of the new systems have definitely fallen, the overall administrative costs have increased with the size, complexity and power of the new systems, and the frequent changes required of the system. In short, administrations are faced with a new cost structure where the actual production cost of the system is a decreasing percentage of their total cost of deploying that system in the network.

Technical Expertise in Administrations

In the future, administrations will need a high level of technical expertise so that they can give the necessary lead to the manufacturers in the definition of new systems and their mode of application in the network. Administrations and manufacturers will still have their own basic complementary roles, but in addition they will have to know much more about one anothers business emphases. Administrations will have to know much more in depth and breadth about systems, techniques and technologies and their potential and impact on the network. The deep knowledge and understanding of new systems and techniques is required by the administrations so that they are able to take full advantage of new systems, and not waste or dissipate their potential advantages. The manufacturers will have to know more about networks, planning processes, and operation and maintenance aspects. Total solutions will be needed in the future even more than at present.

Joint Design, Development, and Trials

In many countries field trials of new systems are being carried out by administrations in conjunction with manufacturers. In several countries there has been close co-operation between the administration and a number of manufacturers in the design and development of switching systems. This trend seems to be increasing with more countries adopting the approach of joint planning, design, and development of the network with modern advanced systems.

Rapidly Arising Demands

One key factor which is seriously affecting nearly all administrations is the rapidity with which some kinds of demands arise, contrasted with the traditionally long lead time of several years required to place a system in service once the need for it has been identified. The problems of balancing effort and investment aimed at short-term, medium-term and long-term demands have become greater.

Maturing Technology

The technology of modern integrated circuits has now matured to the stage where all the foreseen requirements of telecommunications systems can be met. In addition the essential technology required for future telecommunications systems, especially processor controlled digital switching systems, is no longer specialised to public telecommunications, but is basically the same for a wide range of applications including military communication networks and equipment, civil aviation ground and air systems, commercial office equipment, betting systems, and a variety of other systems for commercial and consumer markets. The same basic manufacturing resources and capabilities can be used for all these applications with resulting reduction of overheads and risks.

Telephone Facilities and Data Networks

One of the important problems of the near future is the technical, economic, and operational reconciliation of the telephone network and the various possible types of data networks. Most administrations seem to believe that it is essential to consider future telephony and future data requirements together, if very uneconomical solutions are to be avoided. The demand for telephony seems to be very strong and stable, and data service requirements are difficult to predict very far in advance. Because of the rapid rate of change of data requirements most administrations believe that it will be necessary to carry out continuous reviews, including dynamic planning and flexible implementation, of the future needs and of ways to meet them.

The role of PABX's in the future network also seems to be occupying the minds of many administrations, as it has a large effect on the type of local exchange required, especially where advanced subscriber facilities are being considered.

F.J.W. SYMONS is Engineer, Class 5, in-charge of the Network Studies Section in the APO Research Laboratories. For further biographical data see the February 1972, issue of the Journal.

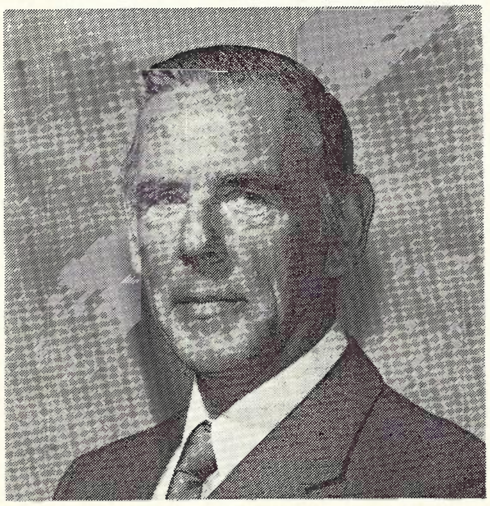
Retirement of Mr. G. A. Simpson.

Mr. Simpson retired from the APO on 19th June, 1973, after having completed 48 years with that Department.

Mr. Simpson joined the Australian Post Office as a Junior Mechanic-in-Training in 1924. He was promoted as a Draftsman in 1937 and as an Engineer in 1939. From 1939 until 1971, Mr. Simpson held many important positions in the Department, the two most senior during this period being the Superintendent of Buildings Branch and the Superintending Engineer, Support Services Branch. As the Superintendent, Buildings Branch, a position he occupied for 14 years, he was responsible for all sites, buildings and properties requirements for the Department, as well as for the installation and maintenance of all mail handling equipment and this included the first automatic letter transfer system in the Commonwealth which was installed at the Sydney GPO. He was also a member of the Steering Committee for the design of the new Sydney Mail Exchange building at Redfern.

During World War II, Mr. Simpson occupied a position of Defence Production Engineer and in this role was responsible for the production and acceptance testing of Army signalling equipment in N.S.W. As Executive Engineer, Support Services Branch, he was again responsible for the co-ordination of all sites, buildings and properties requirements as well as controlling one of the largest Workshops in the Commonwealth, this included responsibility for the State motor vehicle fleet, all mechanical aids and the Training Schools.

In January, 1972, Mr. Simpson occupied the position of Assistant Director, Engineering, New South Wales, and was responsible to the Director for the management of the Division.



Mr. Simpson has been actively associated with the Australian Postal Institute over many years, becoming a Divisional Councillor in 1966, and has also occupied the position of Ministerial Nominee on the N.S.W. Divisional Council of the Australian Postal Institute. From 1968 to 1970 he was Chairman of the Library and Cultural Committee.

Gordon Simpson will be missed. He was highly esteemed by all his colleagues not only for his ability as an engineer and administrator, but also for his friendliness and genuine concern for the interest and welfares of other people. The Society appreciates the assistance he rendered to the N.S.W. Division and wishes him a long and happy retirement.

A Communications System for the Moomba Natural Gas Pipeline (Part 1)

A. MONTGOMERY, B. Tech. and B. G. HAMMOND, B. Sc., M.I.E., Aust.

This article describes a communications system developed for the operation of a natural gas pipeline in South Australia. Apart from the interest of the unusual features of the system described, the article is relevant in view of current proposals for further major pipeline projects in Australia.

Part 1 of the article sets out the role of the Australian Post Office in establishing the communications system, and describes the external plant; Part 2, to be published in the next issue of the Journal, describes the internal plant and various aspects of the overall system installation.

INTRODUCTION

Natural gas was first discovered in commercial quantity at Gidgealpa, in South Australia, by Delhi Australian Petroleum Ltd. and Santos Ltd. in January, 1963. Successful drillings at Moomba in 1966, Daralinga, 1967, and Toolachie, 1968, proved the existence of sufficient reserves to make natural gas a marketable proposition. The Moomba gas field is about 500 miles north of Adelaide.

In April, 1967 the Natural Gas Pipeline Authority of South Australia (NGPA or the Authority) was created by an Act of the South Australian Parliament to be responsible for the construction of a pipeline and the transport of natural gas to Adelaide. Construction of the pipeline was completed in July, 1969. The gas from various well heads in the area is gathered at the treatment plant in Moomba, where it is cleaned, de-watered and fed through a metering station to the inlet of the pipeline down which it travels at approximately 20 miles per hour to Adelaide; the length of the pipeline is 486 miles. The pipe is 22 inches in diameter with a general wall thickness of 0.312 inches and an operating pressure of 1000 pounds per square inch. The pipeline is at present delivering 130,000,000 cubic feet of gas per day to the Adelaide consumers — equivalent to 8,500 tons of Leigh Creek coal. The capacity of the pipeline allows the initial demand for gas to be met without intermediate pumping. As the demand increases, up to seven compressor stations will be added along the pipeline at approximately 60-mile intervals from Moomba, in order to maintain the pressure at the Adelaide receiving terminal. One compressor station has already been installed in the pipeline 219 miles south of Moomba and work has started on a second, 101 miles south of Moomba.

A pipeline operation (or despatch) centre was set up in Adelaide by the Authority. This required the establishment of a computer-controlled system of telemetry, supervisory and data logging equipment to measure flow, density, differential pressure, specific gravity and calorific value of the gas entering and travelling down the pipeline and to monitor and control the valves and pumping machinery in the compressor stations. An extensive and reliable communication system was required to interconnect the Control Centre and the remote station telemetry systems, and also to provide mobile communications for maintenance staff. This paper discusses some of the problems encountered in establishing this unusual communication system over some 350 miles of desert from Moomba to Peterborough and then extending it to Adelaide over normal Post Office facilities.

ROLE OF THE APO

In 1968 the NGPA approached the Australian Post Office (APO) with a request for assistance in the provision of communications for their pipeline. After some discussion with the Authority, the APO undertook to act as consultant to the Authority and be responsible for the engineering management of the complete pipeline communications system while the Authority would enter into any contracts involved and fund the work. The communications system was to consist of a privately-owned radio system north of Peterborough and leased Departmental circuits south of Peterborough.

The responsibilities of the APO for the project engineering and management of the communication system were set out in a formal agreement in the following terms:

"The Department undertakes:

- To prepare a spacification and all necessary plans (with such particulars as may be necessary to enable the Authority to call tenders and to enter into a contract for the due execution thereof) for this communication system after consultation with the Authority and to alter the same if necessary to meet the wishes of the Authority.

- To advise the Authority regarding the calling of tenders for the provision of the specified communications system.
- To confer with tenderers and deal with queries concerning the requirements of the specification.
- To examine tenders and make recommendation to the Authority concerning the acceptance of the preferred tender.
- To supervise the installation of the communication system and the erection of buildings being part thereof by means of such continual supervision or periodical inspections as may appear to be necessary.
- To keep the Authority advised on the progress of the project, to certify progress payments according to the terms of the intended contract, to make recommendations on the need to enforce penalty clauses, and to assist in adjusting all accounts between the Authority and the contractor.
- To carry out acceptance tests on behalf of the Authority.
- To advise the Authority as to the time it should issue the Notice of Acceptance and the Final Certificate of Completion in accordance with the terms of the contract to be entered into between the Authority and the successful tenderer."

A condition of the agreement was that it "shall in no way prevent the Department from exercising its full powers under the Posts and Telegraph Act".

TECHNICAL REQUIREMENTS

When the agreement was finalised, APO and NGPA representatives met to determine the scope of the project. Basically an integrated communications system was required to provide point-to-point and mobile coverage along the Moomba to Adelaide pipeline as detailed below:

(i) The system would provide point-to-point communications:

- North of Peterborough. To each compressor station site and to the Inlet Meter Station at Moomba. This section of the route lent itself to solution by a radio relay system which was to be fully duplicated with an initial capacity of eight telephone circuits but capable of extension to 12 telephone circuits. These telephone circuits were to provide control and voice facilities for the mobile radio bases, control and supervision of the compressor stations, end-to-end speech circuits, and one end-to-end telegraph circuit.
- South of Peterborough. The telephone circuits were to be provided by the APO to extend the facilities on the radio system from Peterborough to Adelaide, connect the Despatch Office to the five Sales measuring stations, two mobile base stations, and one compressor station.

(ii) The system would provide mobile radio coverage along the full length of the pipeline, including the spur into Angaston. Control equipment for the mobile radio bases was to be installed in the Despatch Office in Adelaide and be duplicated at the Pipeline Maintenance Depot at Peterborough.

Fig. 1 indicates these basic requirements.

The circuits required by the NGPA were as follows:

Facility A — Supervisory, Control, and Telemetry.

This circuit was to consist of one 3kHz circuit with drops on a four-wire basis at Moomba, the compressor stations, and at Peterborough. Since the compressor stations would not be established until after the communications system had been installed, the equipment for each compressor station site therefore had to be installed with this circuit dropped out and demodulated. The circuit had to be capable of extension to the compressor control building at a future date. Data from the telemetry and supervisory control computers at the above-mentioned locations would be transmitted to and from the central computer at the Control Centre on this circuit.

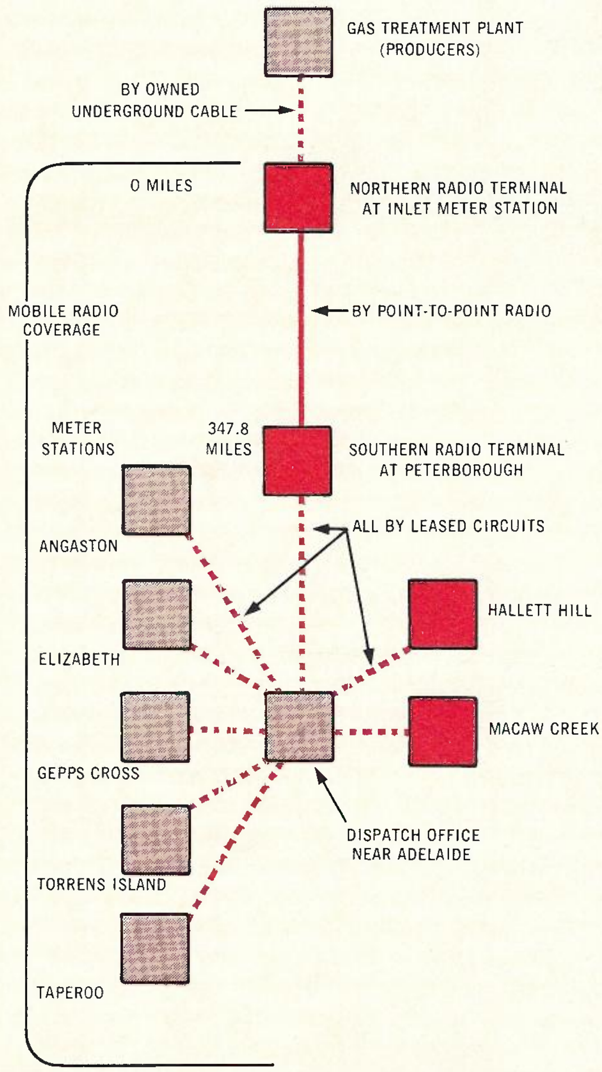


Fig. 1 — Basic Communications Requirements.

Facility B — Mobile Voice.

A complete mobile radio system was required including mobile base stations, interconnecting voice and control circuits, and mobile control consoles. A dual frequency simplex system was envisaged enabling vehicles to communicate directly with one another. The interconnecting voice circuit had to be a four-wire circuit providing a means of communication between sites and from the various sites to Adelaide. At each compressor station site a monitoring loudspeaker with volume control and switch and a press-to-talk handset was required. This was to be mounted outside the radio building in a weatherproof box. This external facility on the mobile system had to be readily extendable to the compressor buildings when constructed at a later date.

Facility C — Mobile Control.

Two mobile control consoles, one at the Despatch Centre and one at Peterborough, were required so that the Authority could operate and control traffic on the mobile system. The consoles had to provide the following facilities:

- Operation of the transmitter at any base station by the despatchers.
- A monitoring loudspeaker with volume control and a press-to-talk handset for the operator. The loudspeaker was to be cut-off when the handset was lifted from its hook.
- Supervisory alarm indications from any base station for the operator.

Facility D — Voice; Moomba to Adelaide.

The gas producers required one private voice circuit from the Gas Treatment Plant in Moomba to their office in Adelaide. Signalling by means of a bell and push button at each end was to be provided. A standard type telephone unit at each end was also required.

Facility E — Voice; Peterborough to Adelaide.

The Authority required one private voice circuit from their Maintenance Depot in Peterborough to their Control Centre in Adelaide. Signalling requirements were to be identical to those in Facility D.

Facility F — Teletype; Moomba to Adelaide.

A 75-baud teletype circuit was required extending from the producer's Gas Treatment Plant in Moomba to the Authority's Control Centre in Adelaide. This circuit was to be extended to the producer's office in Adelaide.

The teletype machine would not form part of the communications contract.

Facility G — Cable Extension; Moomba.

The northern terminal of the radio relay system was to be adjacent to the NGPA Inlet Meter Station at Moomba. Facilities D and F were to be extended to the producer's Gas Treatment Plant Control Room some 500 feet away. There was also a possibility that Facilities A and B might be extended at a later date. The radio terminal equipment would demodulate all signals and the necessary facilities would be extended by means of a buried cable.

Before preparing the specification, the route of the proposed radio relay system was inspected by APO and NGPA representatives. This route inspection made it obvious that the greatest problem to be encountered on the project would be logistics. No road existed along the route of the pipeline and the graded track which was used during construction of the line was in poor condition. This track was extremely rough and dusty for the first 120 miles north of Peterborough, and was almost pure 'bull-dust', 18 inches deep for the next 100 miles, with the final 120 miles consisting of fine sand. Raw materials for making concrete, i.e., sand and aggregate, were not available and suitable water was, in general, many miles from the pipeline. The track was cut by several creeks of which approximately eight were quite large with steep sides. The Authority had no plans to reconstruct this track prior to the installation of the communications system.

Following the route inspection, a specification was prepared and tenders called. Following examination of the tenders by the APO project team, the NGPA entered into a contract with STC for the design, fabrication, installation, and testing of the complete communications system.

The contractor was to be responsible for the overall design of the system, including the route survey and selection of sites subject to approval by the APO. This phase of the work was carried out and the route finalised in April, 1970. Fig. 2 shows the route and sites selected. The sites are named in terms of their distance from Moomba, i.e., MP42 is 42 miles from Moomba along the gas pipeline route.

The communications system comprises:

External Plant

- The power plant.
- The supporting structures and aerial systems.
- The equipment shelter.

Internal Plant

- The carrier systems.
- The mobile radio system.
- The point-to-point radio relay system.
- The supervisory system.

Fig. 3 gives a schematic of the overall system.

A brief description of the external plant follows. The internal plant will be described in Part 2 of the article, to be published in the next issue of the Journal.

Since many of the sub-systems listed above are standard systems whose design and operation are familiar to the majority of the readers of this Journal

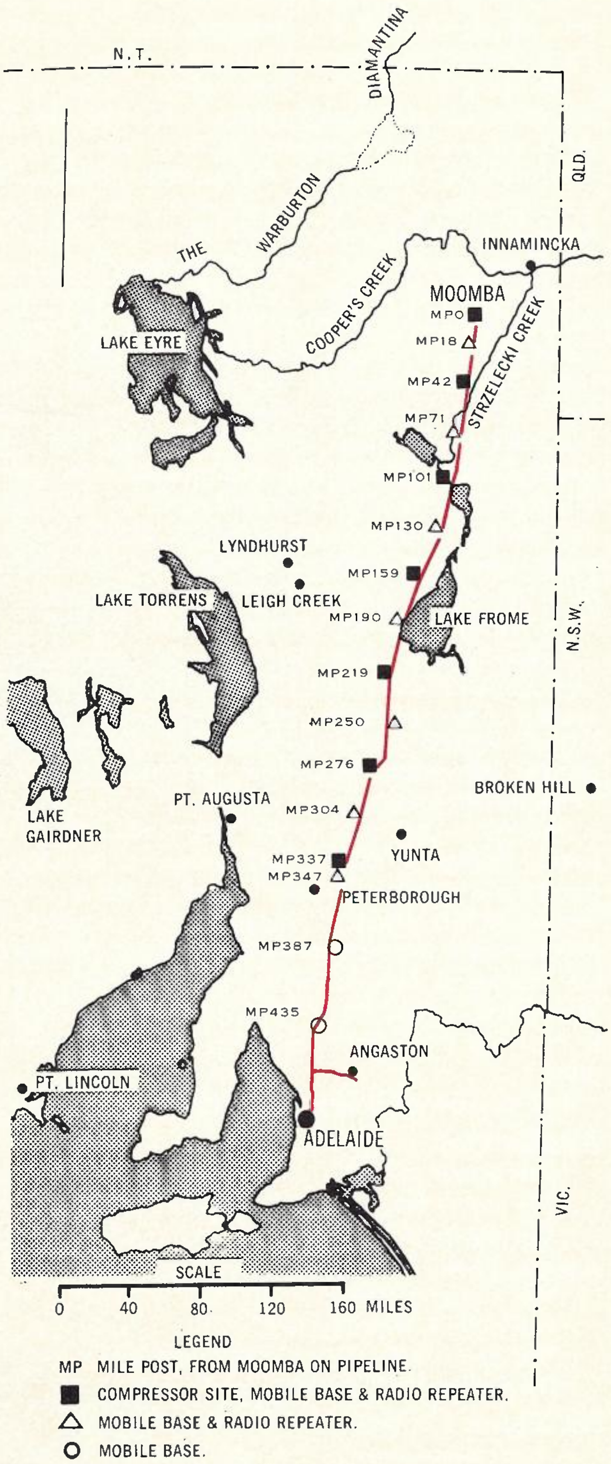


Fig. 2 — Pipe Line Route Showing Radio Repeater Stations.

they will not be described in detail. Where unique concepts have been incorporated in the system these will be described fully.

THE POWER PLANT

Commercial power on the route from Peterborough to Moomba is available only at Peterborough. At Moomba, 240V ac power is provided by the gas producers, but at all other sites the power plant was provided as part of the contract.

Northern Repeater Stations

At the remote sites the power plant consists of:

- Two banks of Exide EPP33, 500 ampere hour cells, each bank consisting of 22 cells (24V nominal).
- Two diesel engine-driven dc generators each having a rating of 4 kilowatts for continuous operation with a 2kVA alternator on the same shaft.
- One power control cubicle with duplicate controls; one set of controls for each diesel generator.

The lead acid storage battery system uses the Exide EPP33, pasted plate cell identical to those provided for the Adelaide-Perth microwave radio relay system and fully described in the special issue of the Journal on that system (Vol. 21, No. 1).

A description of the diesel generator set and control cubicle is contained in Appendix 1.

Terminal Stations

Moomba and Peterborough have 240-volt ac power available to them. At these sites the battery installation is float charged by a rectifier. A diesel generator set is provided and supplies the load when the ac supply to the rectifier is broken or drops below acceptable limits.

South of Peterborough

For the mobile base stations south of Peterborough, ac power in the form of a SWER line is available. The power installation at these sites consists of one only 240-volt ac single phase battery charger, voltage regulated and filtered with a dc output rating of 15 amps float charging a 12-volt battery. This battery consists of 6 cells of 200 ampere-hour rating.

A trailer-mounted diesel generator identical to those installed at repeater stations was supplied as part of the contract and is stationed at Peterborough. This unit is fully self-contained with in-built controls and fuel tank to be used in emergencies to charge the batteries at any site when both duty and protection units fail together. The trailer-mounted diesel is simply 'plugged-in' to a special point mounted at the back of the control cubicle at the radio sites.

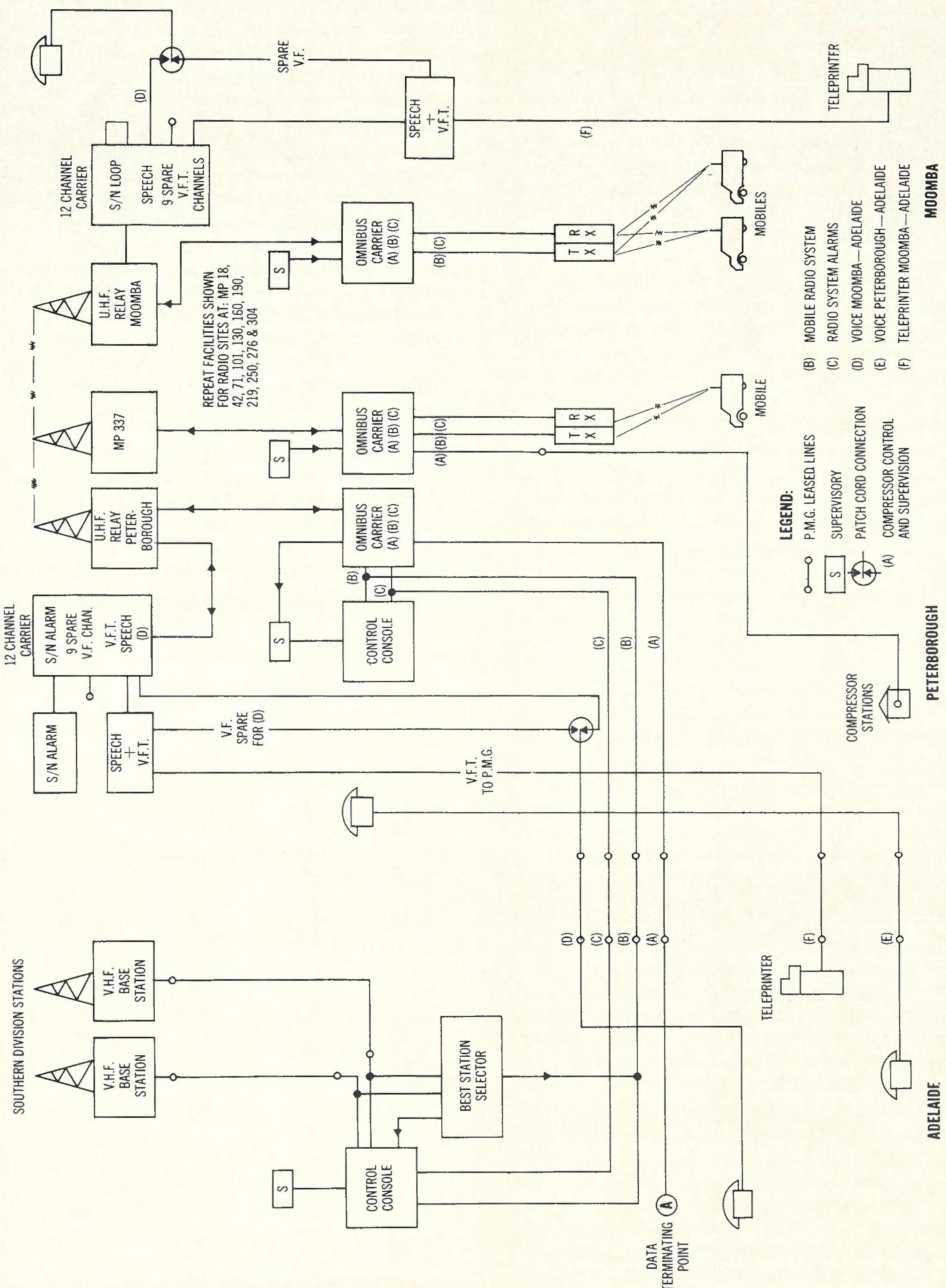


Fig. 3 — Simplified Schematic of Overall System.

THE SUPPORTING STRUCTURES AND AERIAL SYSTEMS

Supporting Structures

The antenna supporting structures for the radio repeater sites north of Peterborough are Harbos guyed masts manufactured and erected by B. Hardinge and Sons, Victoria, sub-contracting to STC. The masts vary in height from 100 feet to 350 feet and are of triangular cross-section measuring 39 inches on each of the three sides. The leg members are of tubular steel. The mast is designed to withstand steady or gusty winds of 100 miles per hour with head loadings four times that represented by the antenna system. An internal ladder runs the entire height of the mast. The mast was erected to the required height by bolting 10-foot sections on top of each other. The guys are attached to the mast at 50-foot intervals.

Although none of the masts fall into the obstruction category as defined by the Department of Civil Aviation (DCA), all the structures are painted and lighted to the DCA specifications for obstructions.

Because of the difficulty in transporting concrete and/or concreting materials to the remote sites guy anchor plates and pre-cast concrete bases were used. The guy anchors in the sandy areas consisted of large pre-cast concrete pipes, filled with sand and fitted with end caps. Each of these guy anchors have a dead weight of approximately six tons and can, in theory, be completely uncovered without detriment to the guy or mast.

At the sites south of Peterborough the supporting structures are self-supporting towers. These towers were designed, manufactured and erected by B. Hardinge and Sons. Two only were required, one of 100 feet and one of 150 feet. Once again, these towers are painted and lighted to DCA specifications.

Aerial Systems

The UHF radio relay aerial is illustrated in Fig. 4. Each aerial assembly consists of four 12 dB gain aerials stacked in a vertical configuration on an aluminium tube. The design is such that the total gain is at least 19 dBi. The aerial feed is a low loss (0.25 dB per 100 feet) foam dielectric feeder, 0.875 inches in diameter which is fixed to the mast at 3-foot intervals.

The VHF mobile radio aerial system consists of two yagi aerials, each of 10 dBi gain, mounted on opposite sides of the mast and oriented along the path of the pipeline route. These aerials are mounted for vertical polarisation. A single low loss feeder (identical to that on the UHF system) connects the transmitter/receiver diplexer unit in the station to an aerial power splitter which is permanently fixed to the mast at the aerial level. Each yagi is connected to the splitter and receives the ratio of power which has been predetermined and pre-set at the splitter. Generally, the power to the aerials receives a 50/50 split but this is adjustable over the range 30/70. The splitter is a passive device.

Equipment Shelters

The equipment shelters for the stations north of Peterborough are similar in design and appearance to those used on the Adelaide-Perth system. The sub-contractor for the supply and erection of shelters was again B. Hardinge and Sons of Victoria. The overall dimensions of the outer shelter is 14 feet in width by 28 feet in length. The internal dust and weather-proofed shelter is 9 feet in width by 17 feet 6 inches in length divided into two rooms. Fig. 5 illustrates the general layout of the shelters.

The water tank on the north-east corner of the shelter is of 200-gallon capacity. A walkway of expanded 3/16 boiler plate is provided between the front door entrance and the diesel area. Removeable panels allow access to the diesel area for major maintenance.

The shelters utilize the pier and beam foundation technique for the outer shelter whilst the inner shelter rests on pre-cast concrete beams. The piers

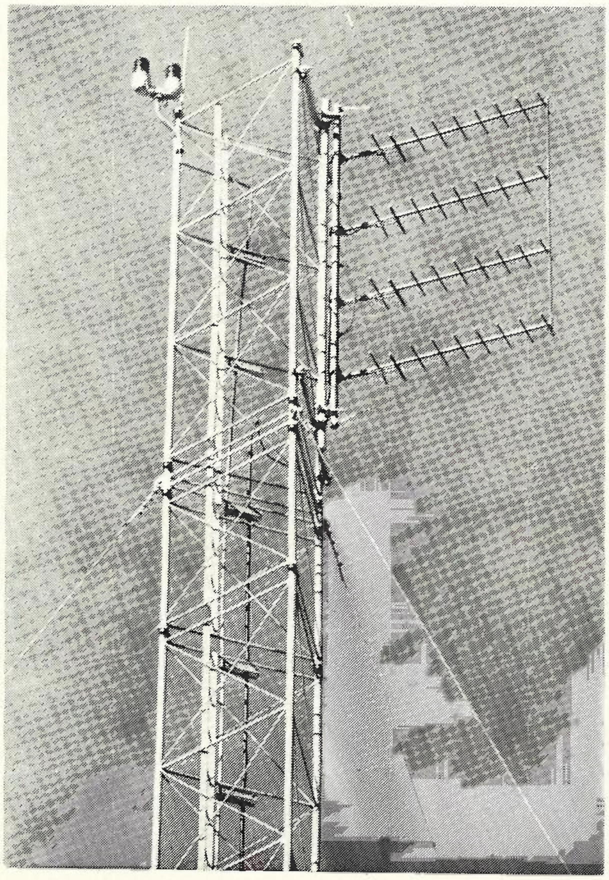


Fig. 4 — UHF Aerial Assembly.

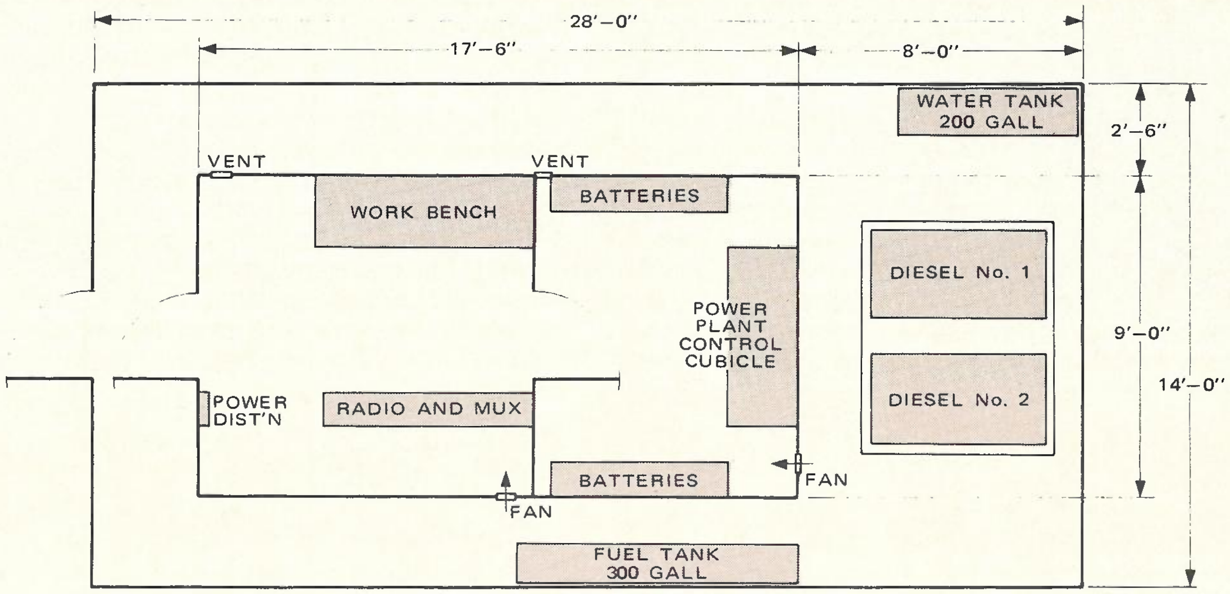


Fig. 5 — Layout of Equipment Shelters.

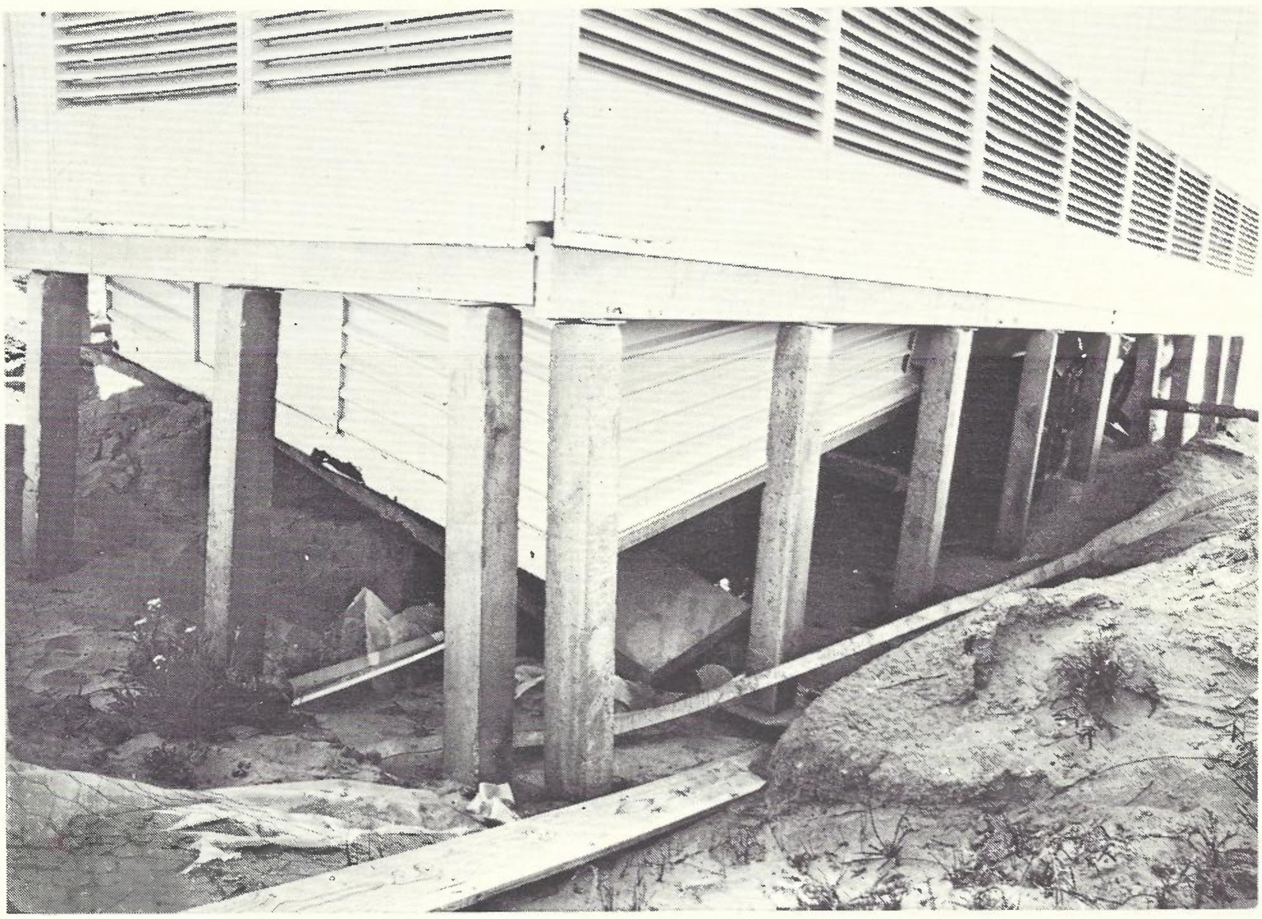


Fig. 6 — Sand Erosion at Site MP18.

consist of 5-inch by 5-inch by 4 feet long pre-cast concrete posts, each resting on a 12-inch square by 3/16 steel plate. A ½-inch threaded bolt is embedded in the top of the pier, which is at ground level. Fixed to each pier is the steel beam, which is fabricated of 10 BG material formed into a box section 7 inches high by 1¾ inches in width. The effectiveness of this type of foundation is clearly illustrated in Fig. 6. In this situation the inner shelter collapsed into a large hole caused by sand erosion. The inner shelter came to rest against the outer shelter. Although a number of piers in the foundation were uncovered, the outer shelter remained intact.

The beams for the inner shelter are 11 feet 4 inches in length and protrude by 2 feet 4 inches into the space between the inner and outer shelters on the northern side. There are five such beams which also form the foundation for the grille walkway which rests on the protrusions. The shelters are complete with small work bench, lighting (dc and ac), power points and vinyl tiled floors.

The two mobile base stations south of Peterborough, having a power dissipation under 50 watts, did not warrant the thermal considerations of the larger stations. Shelters, 6 feet by 8 feet clad with aluminium, painted white, have been used at these sites.

APPENDIX 1

The diesel generator set and the control cubicle were manufactured and installed by Dunlite Electrical Co. Pty. Ltd., of South Australia, sub-contracting to STC. The diesel generator set consists of an air-cooled diesel engine directly coupled to a single bearing generator.

The engine is a Lister model SR2, twin cylinder, air cooled diesel engine continuously rated at 10 BHP when running at 1500 RPM.

The generator is a Dunlite 24 Volt, 4kW dc brushless generator provided with:—

(a) built-on air cooled rectifiers

(b) a 2kVA ac output at 220/240 volts.

The diesel generator set is basically identical to that employed on the Adelaide-Perth system for non-mains repeater stations and the description in the Journal (Vol. 21, No. 1) applies.

The mobile base station equipment is designed for 12 volts dc operation. The power supply for the mobile is obtained from a 6 cell 12 volt battery again made up of EPP33 cells. A 24 volt to 12 volt dc to dc solid state convertor is installed in the control cubicle. It has a regulated and filtered output to keep the 6 cells of the mobile station battery on float charge at all times.

The station power storage system, therefore, consists of 30 Exide EPP33 cells of 2 volt nominal rating. These are divided into two batteries of 12 cells and one of 6 cells. Six cells of one of the 12 cell batteries are nominated for periodic interchange with the mobile system battery at approximately three monthly intervals. This exchange ensures that the mobile equipment battery will be boost charged, thus stirring its electrolyte.

A 300 gallon fuel storage tank is provided at all the repeater sites. Gravity feeding of fuel to the diesel engine was preferred to fuel pump feeding on this project. Fuel pumping requires a return circulation of the excess fuel pumped to the tank. This return keeps the fuel in the storage tank continuously stirred, causing any solid matter, such as dust particles, to be suspended in the fuel and eventually find its way to the engine. With gravity feed there is no stirring of the fuel within the tank, except at the periodic refuelling occasion, and this ensures the cleanest possible condition for fuel storage and usage. Low level and empty fuel alarms are provided and these are remotely supervised at Peterborough and Adelaide.

The control cubicle houses all the automatic control equipment necessary for the control and protection of the generating equipment. This equipment includes the generator regulator, alarm relays, sensing devices, fuses, etc., inside the cubicle and meters, switches and indicator lamps on the hinged door of the cubicle. All alarm relays and sensing devices are of the plug-in type which simplifies replacement and maintenance in the cubicle. A brief description of the operational facilities provided is as follows:

The station batteries are normally charged by one generating set with both batteries connected to the load. Additional facilities are provided to enable one battery to be connected to the load whilst the second battery is being boost charged. Change-over switches, manually operated, are provided to select the various generator or battery duties.

Voltage sensing relays are provided to sense the battery voltage. The Extra Low Voltage sensor is set to provide an alarm when the battery voltage, on normal station load, falls to 23.7 volts. This relatively high level for an extra low voltage alarm was chosen in order to give maintenance staff time to reach the site over the extremely poor access tracks before radio equipment failure occurs due to low voltage. Since the extra low voltage alarm can (in theory) only occur after the diesels have been called upon to start and have both failed to do so or a fuse is blown in the charging circuit, immediate attention is necessary at the site. The 23.7 volt setting gives an immediate indication of either of these occurrences after the low volt sensor has initiated the charging cycle. The Low Voltage sensor is set to initiate the starting of the duty generator when the battery voltage falls to 23.8 volts on load. The high voltage sensor is set to respond to a battery voltage of 31.8 volts. At this voltage it initiates a changeover from essentially constant current generation to essentially constant voltage generation controlled by a timer which can be set for any desired run-on period up to 310 minutes. The timer is presently set for a run-on period of 240 minutes. The run-on facility is provided to keep the engine running for the pre-set time to provide a 'gassing' charge. The Extra High Voltage sensor is set at 34.0 volts and initiates generator close down action (which must be manually reset at the site) should the battery voltage reach this level. This, of course, is a fault condition and an alarm is extended accordingly.

When the duty generator is called upon to start by the low voltage sensor, and fails to do so after the standard three attempt sequence, it is electrically locked out of service. The control system then commands the protection diesel to start and sends an alarm to the control centres. If the protection diesel fails to start after the three attempts sequence it too is locked out and an urgent alarm extended. In such an eventuality, which may occur for some minor reason (e.g. heavy oil on a very cold morning), the Despatcher can reset the starting sequence by operating the 'Test Carrier' key on his console. If both diesels fail to start a second time then he should initiate a call-out of the maintenance technician.

A. MONTGOMERY joined the Postmaster-General's Department as a Trainee Engineer in 1965. After completing the degree of Bachelor of Technology (Electronic) at the University of Adelaide in 1965, he was employed as an Engineer Class 1 in the Radio Communication Installation Sub-Section from 1966 to 1967 where he was engaged in the installation and commissioning of radio relay systems.

In 1968, he was transferred to the Radio Communication Maintenance area as Engineer, Class 2, where he was involved in the various activities associated with the operation and maintenance of radio systems throughout the State. At the beginning of 1970, he returned to the Radio Communication Installation Sub-Section as the project engineer for the Moomba Communications' Project.

B. G. HAMMOND joined the Postmaster-General's Department as a Cadet Engineer in 1950. Graduating as an Engineer in 1954 he was involved in the early development of 160 MHz and 900 MHz radio bearers.

With the advent of television in South Australia in the late 1950's he received special training in television and was involved in the installation of the National Television Service transmitters. As Divisional Engineer Broadcast Transmitters in 1961 and later as Divisional Engineer Television he was in charge of the development of broadcasting and television services in South Australia.

From 1966 Mr. Hammond was Divisional Engineer, Radio Communication Installation and has been involved in the rapid development of broadband radio bearers in South Australia and the management of the Moomba communications' project. He is currently Supervising Engineer, Building Engineering Services, in Adelaide.

Mr. Hammond is a Member of The Institution of Engineers, Australia, an Associate Member of the Institution of Radio and Electronic Engineers' Australia and a past chairman of the Adelaide Division of this Institution.

STD in Australia, 1960-1980

I. H. MAGGS, B.E. (Hons.), M.I.E.E.

Subscriber Trunk Dialling (STD) has been an integral part of the Australian telecommunications scene for over a decade and in 1971/72 57% of the total trunk calls completed in Australia were subscriber dialled. Today the automatic trunk network is handling more than 150,000,000 STD calls per annum compared to 1,000,000 STD calls ten years ago. Furthermore, a continued rapid expansion of the STD system is foreseen up to 1980 when subscribers are expected to be dialling their own National STD calls at the rate of about 600,000,000 per annum.

It is within this setting of rapid change to our telecommunications network structure, high growth rates and changing subscriber call patterns that the role of STD in Australia will be discussed in this article. The main objectives of the paper are to describe the introduction of STD into the Australian telephone network over the past ten years, what the Post Office is aiming to achieve with STD, the position that STD has arrived at in 1972 and finally, what further changes STD will bring by 1980 to the subscriber and to the APO.

THE NEED FOR STD

The STD service as it is known today could be viewed in a number of different perspectives. It could be seen as a typical business example of straight-forward economic management, as an improved service to the customer, or as an example of increased productivity. Each of these views of STD would depend on the background or interest of the viewer. I would suggest that STD represents all these aspects in addition to many more. However, while agreeing with these descriptions, I am of the opinion that one basic reason can be isolated as the main contributing reason for the advent of STD, not only in Australia but in all national communication networks throughout the world. The basic reason may be stated as: 'If the continuing growth of trunk calls is met with an equal growth in manual operators to handle these calls, then the telecommunications industry would inevitably employ a literal army of operators, even assuming they were available within the community.

Fig. 1 indicates the forecast range of growth of total trunk calls in Australia up to the year 2000. This long-term prediction is in accord with overseas growth patterns and conservatively assumes that the overall annual growth rate will change from today's average of 13.5% p.a. to about 5% by the year 2000.

However, even based on this conservative growth forecast, it can be seen that the costs (salaries, accommodation, amenities and overheads) of main-

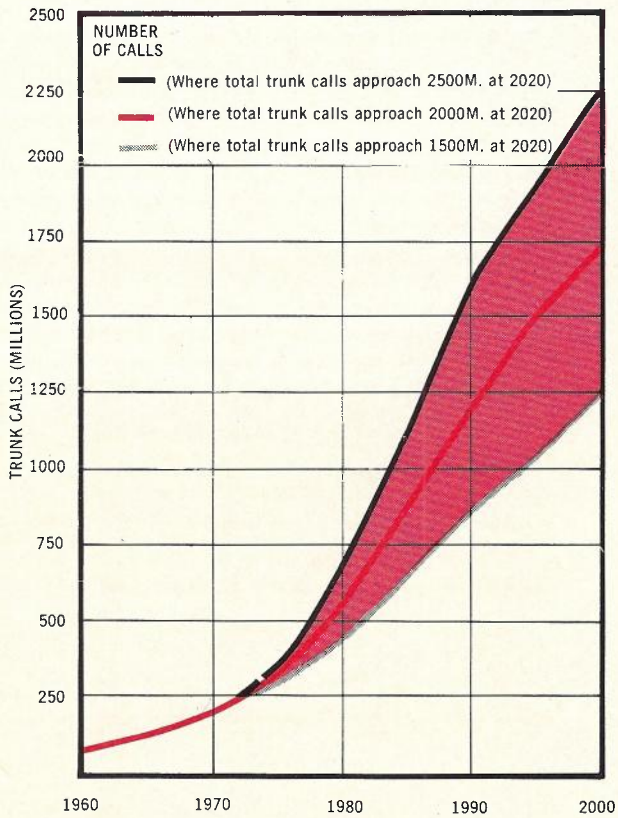


Fig. 1: Trunk Call Growth to 2000.

taining full operator working could reasonably be expected to grow to fantastic levels within several decades. Therefore, to continue on this path would be completely unrealistic and totally uneconomic. For example, at 1980, the total trunk operator salary bill to handle an expected 670,000,000 trunk calls on a fully manual basis, would be in excess of $150,000,000. Furthermore, the estimated annual operator salary bill by 1990 to handle an expected 1,250,000,000 trunk calls p.a. manually would probably exceed $400,000,000,

Obviously, therefore, considerable incentive exists to mechanise the trunk service for economic reasons without even having to fully evaluate the practicability or otherwise of recruiting, employing and accommodating such a large labour force. The basic problem of continuously escalating labour costs has created a general pattern of telephone development and mechanisation throughout the world telecommunications industry. However, because of different network and labour costs in the various countries, the timing of the mechanisation pattern will be different in each country.

The pattern of development I refer to is that most networks will, at some time or other, pass through three major mechanisation developmental stages. These stages and their timing relate to the gradual mechanisation of telephone networks for the basic economic reasons indicated earlier.

The three major developmental stages may be identified as:

- The mechanisation of *local* networks.
- The mechanisation of *national* networks.
- The mechanisation of *international* networks.

The present position of the Australian network is that the first stage, commenced in 1912, is nearly completed (92% local automatic network), the second stage started in 1956 is progressing well (57% STD in 1972), and the timing of the third and final stage is currently under consideration.

To complete the background into the need for STD it is also necessary to consider the substantial customer benefits that result from mechanising the long-distance telephone service. Briefly, these benefits may be stated as:

- Faster and more convenient service to the subscribers.
- Cheaper service to the subscribers overall as they are only required to pay for the actual duration of the call. (The manual service has a three-minute minimum charge.)
- The possibility, in the future, of increasing the concession rates available to subscribers in off-peak periods without the corresponding penalty of having to augment off-peak manual operating staff.

In summary, the need to mechanise the trunk calling service is two-sided. Firstly, it is economic from a business viewpoint and, secondly, it meets the continuing demands made by the subscribers for a more convenient, faster and cheaper telecommunications service.

INTRODUCTION OF STD

The Australian national trunk switching network of the 1940s and 1950s was based on the Siemens 2VF signalling and switching system. This system was adopted because it was one of the few available that had been designed specifically for use over long distances using carrier derived voice circuits. However, although the use of this system allowed an effective single trunk operator controlled network to be constructed, it was not considered to be technically or operationally satisfactory for direct use by subscribers. Because of these limitations in the existing 2VF trunk switching network, it was necessary in the early 1960s for the APO to commence to plan, specify, design, purchase and install the automatic trunk switching network required to cater for the needs of a full national STD service.

STD actually commenced in Australia on a very limited basis in 1956 with the introduction of subscriber trunk dialling facilities on the St. Mary's-Sydney trunk route, as it was then, a distance of about 28 miles. After this original trial, point-to-point STD facilities were provided at strategic locations in all States to minimise the growth pressure on existing manual trunk switching facilities while awaiting the commissioning of the new national STD network. The provision of STD facilities on a point-to-point basis continued steadily, and by 1967 about 100 individual STD routes were in operation throughout Australia (Ref. 2.)

Planning for the new subscriber dialling trunk network, which commenced in 1960, culminated in 1967 when the first stage of the new national automatic subscriber dialled trunk network was placed in service with the cutover and interconnection of five major four-wire ARM-20 crossbar trunk exchanges at Sydney, Canberra, Newcastle, Geelong and Launceston. (Refs. 3 and 4.)

In the following five years from 1967 to 1972 a further 30 major four-wire ARM-20 crossbar trunk switching exchanges were placed in service, representing a total capital investment, at 1972, of about $40m. The interconnection of these exchanges, in accordance with the principles laid down in the 'Community Telephone Plan', provided a national trunk switching network which allows subscribers connected to the network at any location to reach destinations connected to the network at any other location in Australia by dialling a total of 9 digits. (Ref. 1.)

STD PENETRATION IN AUSTRALIA

From about 1960, when STD accounted for 1% of all trunk calls, to 1967, STD penetration was limited to a rate commensurate with the actual provision of point-to-point STD facilities in the network. If this limitation is not fully understood it is possible that an incorrect inference regarding STD usage could be drawn when noting the slow growth of STD penetration in this early period. Actually the reverse was true; in the early years STD usage was extremely high. Wherever STD facilities were provided it was not unusual to see a large stimulus in trunk calls and a high usage of the 'self-dial' trunk service. Therefore, the gradual increase in STD calls in the early years, as shown in Fig. 2, reflects the limited STD facilities available to the subscribers rather than low usage of STD by the subscribers.

In 1964, following an intensive study, the APO set a target of 66% of all trunk calls to be subscriber dialled by 1975. The basic policy issue underlining this target aimed at maintaining the number of trunk calls handled manually at a constant level and thus preventing any significant increase in the number of telephonists employed in the trunk network. The 1975 target therefore represented the mechanisation of the trunk call growth expected within the Commonwealth in the ten years from 1965 to 1975. To realise 66% STD penetration by 1975 it was essential that a fully interlinked nationwide automatic subscriber dialled trunk network be established as quickly as possible. This network concept was necessary to allow as many subscribers as possible to reach the maximum number of destinations.

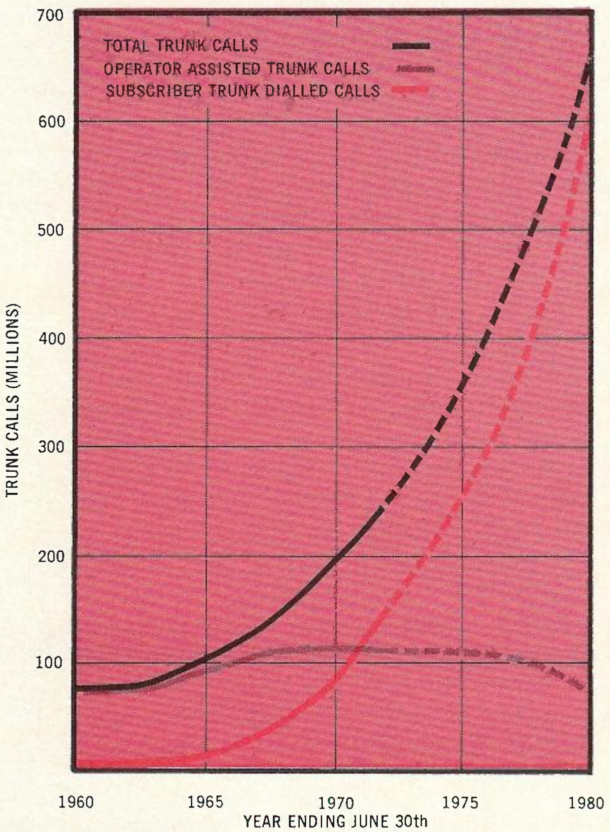


Fig. 2: STD Manual and Total Trunk Calls, 1960-1980.

As indicated previously this new national automatic STD network was commissioned in 1967. By 1971, four years after commissioning, the national STD network had grown to such an extent that it was handling almost as many trunk calls per annum (110 million) as the existing 2VF manual network, meaning that STD had reached 50% penetration. Furthermore, in the four years, from 1971 to 1975, the number of STD calls per annum are forecast to more than double, to about 240 million per annum, when it is expected that the 1975 target of 66% STD will be reached. The 1972 statistics indicated that 2.5 million subscribers were connected to the STD network and could reach three million subscribers located in most cities and towns throughout Australia. The subscribers actually dialled 57% of the total trunk calls made in the financial year ending 30th June, 1972.

To assist in the future planning and development of the national STD network, extensive studies have recently been carried out to determine a 1980 STD target for Australia. The results of these studies are important in determining the future role of the manual service and the growth of STD in Australia and, of course, the necessary funds, switching and transmission equipment and accommodation needed to provide an efficient STD service. The study indicated that a level of 90% STD penetration should be capable of achievement by 1980. This means that in the five years from 1975 to 1980, STD calls are again expected to more than double to reach a total of 600 million STD calls per annum by 1980 (see Fig. 2).

This rapid growth of STD calls, from 110 million per annum in 1971 to 600 million per annum by 1980, represents an equivalent 'average annual growth rate' of about 21%. However, it must be recognised that the actual STD growth rate in the early years will be considerably higher than that recorded at the end of the period. In the very early years of STD 100% per annum growth rates were achieved. This high initial growth rate has slowed to about 30% p.a. at present, and is expected to reduce gradually to about 20% p.a. by the mid-1970s, tapering to about 15% p.a. by 1980. When considering these high STD growth rates it is essential to fully understand that they are predicted to occur within the framework of an overall national trunk growth rate of 13 % p.a. up to 1980.

The progress of STD penetration (percentage of subscriber dialled trunk calls to total trunk calls) since 1960, together with the expected rate of advancement of STD up to 1980, is graphically illustrated in Fig. 3.

STD USAGE

Before discussing the role of STD usage in relation to the rate of STD penetration in the network it is appropriate to clearly define what we mean by STD usage. In this paper 'STD usage' is defined as the ratio of the number of trunk calls which are dialled by the subscribers compared to the total possible number of trunk calls that they could have dialled. Although it may be possible for a subscriber to dial, for example, 90 % of his required trunk calls via the STD system he quite often only dials a certain percentage of all those which are actually possible. The reasons why this occurs are many and varied. Some of the reasons relate to a lack of knowledge of the required area code, some people require a record of their call and some even forget or are not aware that the call can be made via the STD system.

Statistics on STD usage have been recorded as a result of customer surveys held at different times over the years. In the early years when STD access was restricted to a small percentage of subscribers and destinations, a high national level of STD usage, in the order of 85 % was achieved. In the country areas STD usage exceeded 90 % because STD was given to small pockets of subscribers (allowing extensive customer education) and in general the STD access was provided to their capital city, with easy to remember access codes, e.g., 02, 03, etc. This meant that the actual usage of the STD facility was exceedingly high as the service found a ready market in these situations.

However, the opposite picture is exhibited as regards STD usage in metropolitan networks where large numbers of subscribers were given access to STD in a short period. In addition, the STD network expanded rapidly in the 1967-1970 period and possibly the growth in the range of STD destinations outstripped the subscribers' knowledge.

Fig. 4 shows that during 1970-71, when the number of subscribers on the STD grid reached more than 80 %, following a three-year period of rapid increase in the number of subscribers with originating and terminating access to STD, STD usage reached a low point of 78 %. However, it is now rising steadily as the subscribers become more

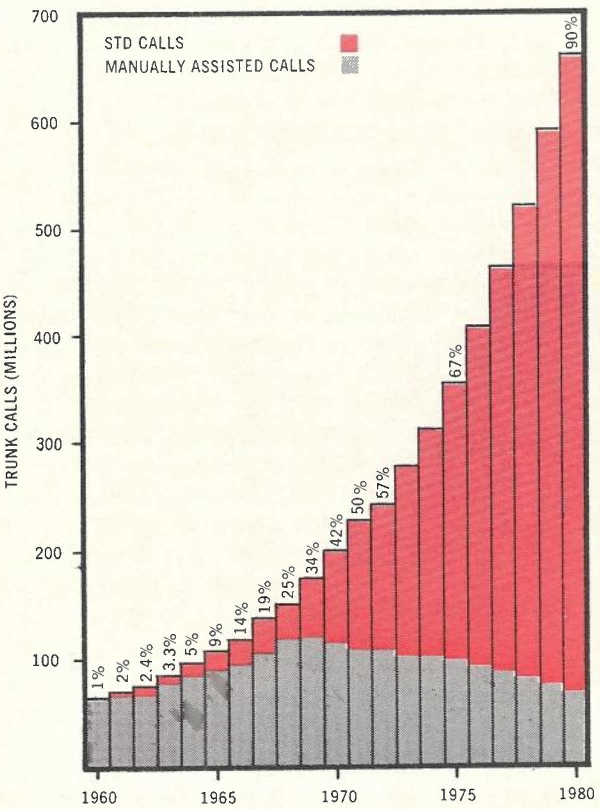


Fig. 3: STD Penetration, 1960-1980.

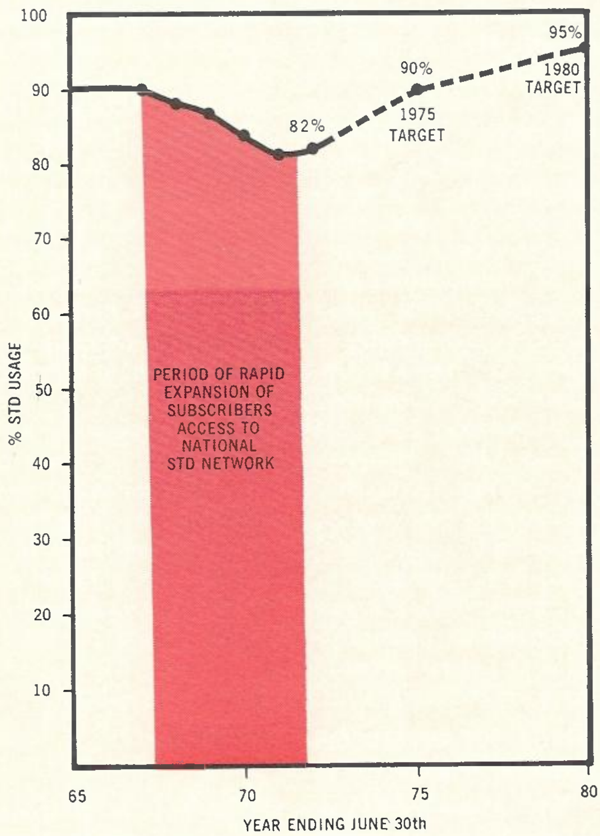


Fig. 4: STD Usage, 1960-1980.

aware of STD and they increase their knowledge of the expanded range of STD destinations. The continued upward movement of STD usage will obviously depend on the type of publicity and marketing concepts that the Post Office develop to educate the subscriber of the lower cost, greater convenience, accuracy and speed of the modern STD system as compared with the manual trunk system.

During 1969-70 a survey was undertaken to try to determine some of the reasons for low STD usage that was calculated for that year. As a result of the survey the following facts emerged concerning 22% of calls handled via the manual system that could have been completed via the STD network (i.e., STD usage estimated at 78%).

- 6% of trunk calls required the services of an operator.
- 4% of trunk calls came from non-STD public telephones.
- 12% of calls did not require any special facility but came from subscribers who were either not prepared to use STD or were not aware it was available.

The area of real concern is the 12% of calls made by subscribers who were either unwilling to use STD or were unaware of its availability. Some resistance to a 'do it yourself' telephone system is an inevitable normal human reaction but it is hoped that this reaction will be overcome in time. The Department will have to concentrate its marketing capabilities in this area to ensure that the percentage of manual calls that could be self-dialled are minimised. In addition, STD public telephones should assist in shifting 4% of calls from the manual system on to the STD network. The remaining 6% of calls requiring an operator such as reverse charge, priority, fixed time, etc., will have to be individually evaluated to determine the long-range Post Office policy in this area. If these calls are to be handled by an operator then perhaps the charge will need to be adjusted so that it is more appropriate to the actual cost.

In the long term, STD usage will obviously approach 100%. However, before 100% is reached the national telecommunications system will need to undergo many changes. Bearing this long-term objective in mind, the Post Office has set itself two important milestones. Firstly, it has set a target of achieving 90% STD usage by 1975 and, secondly, it expects to increase this to 95% usage by 1980. As STD usage reached 84% at June, 1972, both these objectives should be readily attainable.

THE EFFECT OF STD ON SUBSCRIBER CALLING HABITS

Prior to the introduction of STD facilities, all trunk calls required the assistance of an operator for their connection between the two interested parties. However, when STD facilities were provided in the telephone network it became possible for certain subscribers to dial their own national trunk calls. Although there are considerable monetary savings available to the subscribers if they dial their own trunk calls, it is still necessary to both educate and convince them that STD is in their own interest. The education process includes learning the meaning and use of 'area codes' and recognising the need to accurately dial 9 digits in lieu of the three (011) that had previously been necessary to establish a long-distance trunk call.

Therefore, it could be reasoned that it would be difficult to achieve a very high acceptance of STD in the initial years. The reason behind this thought is the normal human reaction to changing existing habits. To change from one well-established system to another undoubtedly requires considerable effort, remembering that the trunk system with which the existing customers are well acquainted has been in operation for over 50 years. Therefore, the introduction of STD and the demands it makes on the subscriber, involving him in new calling habits and procedures, could quite reasonably be expected to have a fairly slow acceptance in the initial years. In general, this philosophy has been proven correct whenever widespread STD facilities have been offered to large groups of subscribers. The apparent exception has been where selected STD facilities have been given to limited groups of subscribers, such as the provision of STD from a country town to a capital city. In these instances initial acceptance of the STD has usually been very good.

The gradual acceptance, of the total STD system by the subscriber, can be seen in the graph in Fig. 5. In this graph the subscriber's gradual change from having all calls connected manually in 1960 to a slow, tentative start towards self-dialling is clearly shown. From 1961 to 1967 there is a gradual increase in the number of STD calls per service. From 1968 to 1971 the change from the old system to the new system can be observed to quicken until in 1971 about 40 STD calls and 41 manual calls were recorded as the average number from each telephone service in the network. At that time subscribers were completing about half their trunk calls by STD and the other half by the manual system; the 50% STD milestone had been reached.

What further change in subscriber dialling habits can be expected over the next seven years to 1980? Obviously what one may think will happen is open to considerable conjecture. However, in comparison to the early years of STD, where access and destinations were limited and the subscriber was thinking manual , we are now in a new era where 85% of subscribers have STD access and can reach 95% of their destinations. Therefore, today s people are actually thinking 'STD' rather than 'manual' whenever they are motivated to make a long-distance call. When they pick up the telephone to make a long-distance call they will probably ask themselves, "Can this call be completed by the STD network, which is basically cheaper, quicker and more convenient than the existing operator network?" If this is a correct interpretation of the way the subscriber approaches the use of his telecommunications network in the mid-1970s then I think we can look forward to an even more rapid change in subscribers' habits up to 1980.

Based on our past experience, together with considerable knowledge of STD usage patterns in overseas countries, it is possible to forecast that the subscribers will continue to expand their use of the STD system. Fig. 5 shows the number of STD and manual trunk calls that are expected to be made per telephone service up to 1980. The graph indicates that the number of STD calls per service is expected to continue to increase from about 48 calls per service in 1972 to about 125 by 1980. In the same period manual calls per telephone service are forecast to drop from 37 at present to about 15. Although Fig. 6 illustrates the National pattern, it should be realised that there exists a marked difference in trunk call habits between metropolitan and country telephone services. For example, in 1972 the number of trunk calls made by the average country telephone service totalled 162, compared to 48 for the average metropolitan service.

THE EFFECT OF STD ON THE MANUAL TRUNK SERVICE

The number of telephonists, including supervisory staff, and the associated switchboards needed to handle the demand for trunk calls in the early 1960s totalled approximately 4,000 and 1,700 respectively. Although STD was initiated in 1956, its rate of penetration into the telephone network was not sufficient to prevent the continued steady growth of telephonists and switchboards. The number of manually connected trunk calls continued to grow and finally peaked at a total of 114 million in 1969/70. At the time of this peak the number of telephonists employed to handle trunk calls was approximately 6,000.

In the following year the growth in STD equalled the total growth of the trunk system. As a result, the number of manually connected trunk calls over

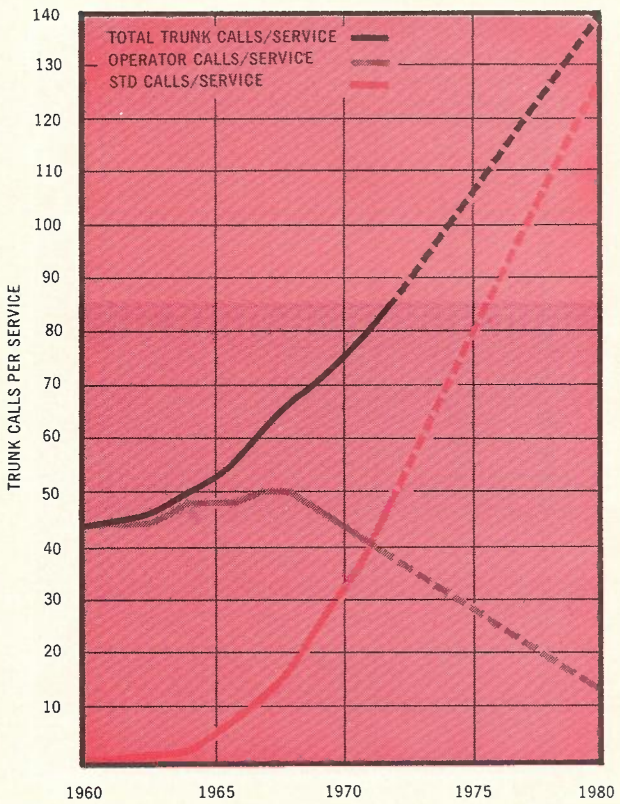


Fig. 5: Trunk Calls per Telephone Service — National.

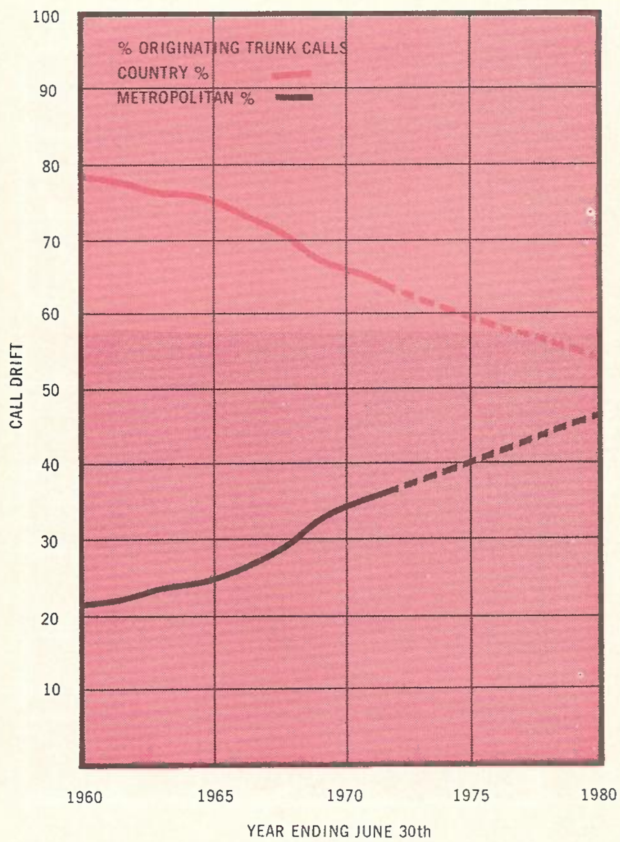


Fig. 6: Percentage of Trunk Calls Originated in Metropolitan and Country Areas.

the period, 1969 to 1971, remained constant at about 114 million p.a. However, in 1971/72 the number of manually connected trunk calls decreased 6% below the 1970/71 level. The steady rise in manually connected trunk calls from 1960/61 to the peak in 1969/70, and then the decline, is shown graphically in Fig. 2. An explanation of this latest change and its long-term effect is obviously required. However, it would be helpful if it could be determined whether this phenomena has occurred in any other countries in similar circumstances. Indeed, when we study the call patterns in overseas countries we note very similar trends at or around the 50% STD stage of development. The rapid growth of STD and the associated decline of manual calls in West Germany, the United Kingdom and Sweden are shown in Figs. 7, 8 and 9. If Australia follows the general pattern observed overseas, we can expect further regular annual decreases in the number of manually connected trunk calls from now through to 1980.

It is possible to conjecture after studying the West German, United Kingdom and Swedish trunk call growth patterns, that the decrease in manual calls in Australia may either be gradual or fairly rapid. Obviously the rate of decrease will depend on many factors. One of the factors would relate to any future change in the relativity between the cost to the subscriber of an STD call compared to a manually connected call. In addition, the convenience and speed of STD are similar to what customers have become accustomed in the local network, and these features will undoubtedly continue to be strong attractions. As the subscriber dials more of his own trunk calls so his knowledge and experience of the system will increase. He will then tend to concentrate more and more on the STD system and therefore decrease the number of calls that he places through an operator. In this regard our policies and objectives are aimed at ensuring that by 1980 more than 95% of the almost five million subscribers expected at that date will be equipped with full STD dialling facilities.

Studies have indicated that by 1980 we could reasonably expect the total number of manually handled trunk calls to decrease by about 30% from the 1968/69 peak level of 114 million p.a. to less than 70 million p.a. Furthermore, if we assume that the efficiency of the trunk operators will increase above the current 20,000 trunk calls per year handled by an average operator, to about 25,000 calls per operator per year by 1980, then the total number of trunk telephonists and switchboards needed by 1980 should reduce considerably. How-

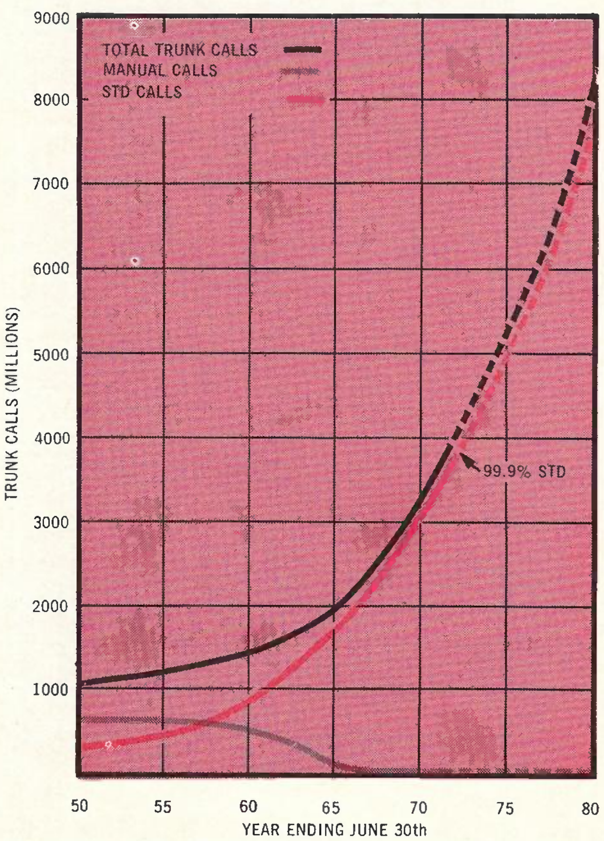


Fig. 7: Growth of Trunk Calls in West Germany.

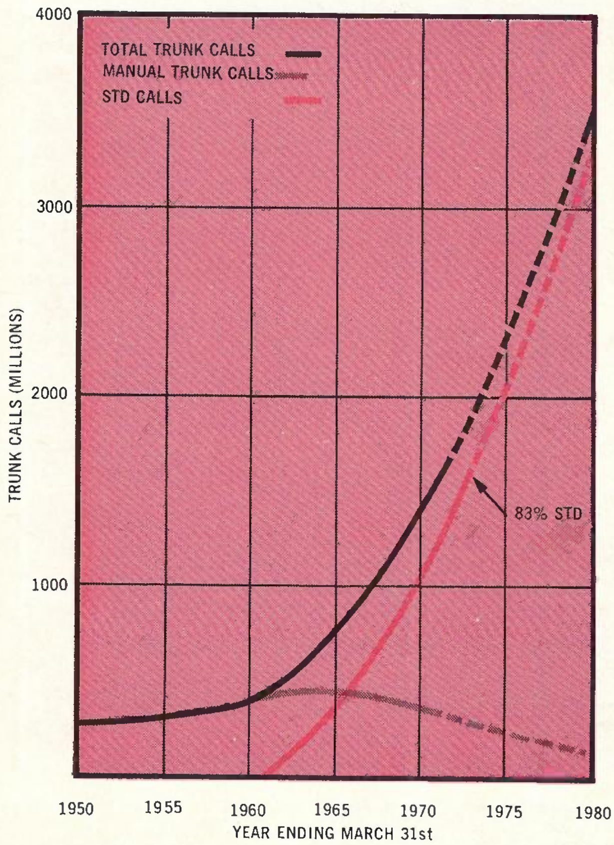


Fig. 8: Growth of Trunk Calls in United Kingdom.

ever, other manual services indirectly related to the connection of trunk calls, such as information, pricing and enquiry, are expected to continue their growth in accord with customer requirements. Possibly the expected decrease in the number of operators directly associated with the manual trunk system will mean maintaining a fairly constant number of operators over the next 10 years but with a shifting emphasis on the particular role that they will be required to perform.

HOLD TIMES OF STD CALLS

The duration of STD calls, which are originated at different locations and at different times throughout Australia, vary considerably. However, the main factors influencing the duration of the average STD call could be summarised as to whether:

- the call is effective;
- the call is not effective;
- the call is originated in the country;
- the call is originated in the city;
- the call is originated in the morning;
- the call is originated in the evening.

All of these factors influence the average duration of STD calls in one way or another. At present the average length of an effective STD call (the amount of conversation time) is estimated to be 3.5 minutes (210 seconds). However, there are large numbers of calls initiated by subscribers which do not mature into normal conversations. Examples of these calls are those where the subscriber dials only a few digits and then abandons the call, or where the call matures but busy tone or non-answered ring tone is the result. The average length of these ineffective STD calls is currently estimated to be about 0.5 of a minute (30 seconds) but there are wide variations from this average value.

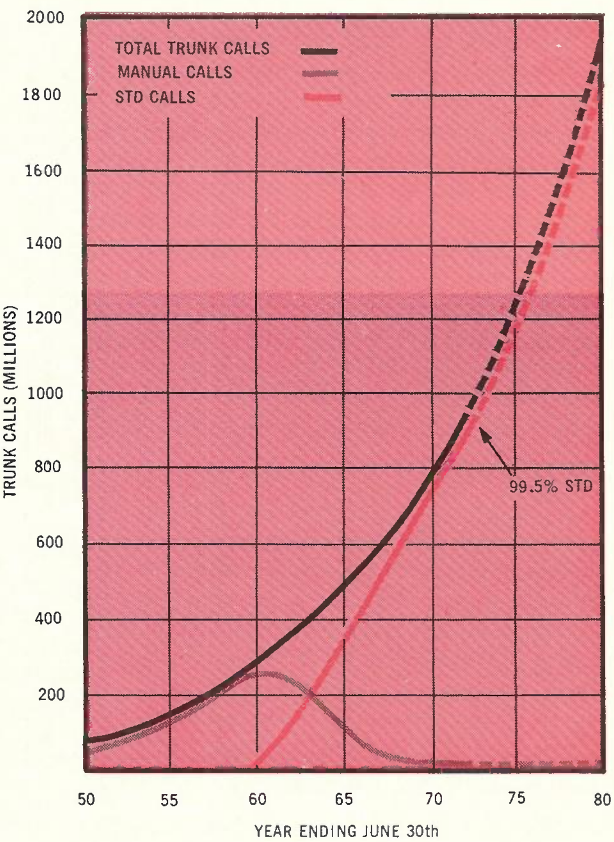


Fig. 9: Growth of Trunk Calls in Sweden.

Studies have indicated that the conversation time of STD calls originated in metropolitan areas is generally some 20% longer than those originated in country areas. The rationale behind these observations may be that metropolitan originated trunk calls are predominantly business oriented and perhaps require a longer period to complete the information transfer. It has been noted that the average country subscriber makes twice as many trunk calls as the average metropolitan subscriber and possibily has learnt to keep his trunk calls as short as possible. Further studies will be needed to probe the deeper underlying reasons that create the real differences in conversation times between these two distinct areas. Observations have also shown that trunk calls originated in the evening tend to be of longer duration than those originated in the morning. This is probably due to the cheaper rate available on calls placed after 6 p.m. which influences the duration of evening social calls.

It is thought that the average conversation time of STD calls has increased slowly over the years. It is difficult to be precise in this regard because of the rapid expansion of STD into different parts of the network. For example, in the early 1960s STD was provided on a point-to-point basis which meant that either social or business traffic was usually predominant on a particular STD route. It is only now, after STD has been provided on a nation-wide basis and exceeds 50%, that there is a true mix of all types of calls. Therefore, it will be important to observe what happens to the average conversation time of STD calls between now and 1980. Based on overseas experience it is expected that the average STD conversation time will increase slowly as the subscribers become more accustomed to the service and lengthen their conversational periods.

THE CHANGING ORIGIN OF TRUNK CALLS

In the early 1960s about 80% of all trunk calls were originated in the country. The remaining 20% originated from the six largest metropolitan cities. However, over the past 10 years a marked change in this dispersion pattern has occurred. There has been a steady decrease in the percentage of trunk calls originated in country areas and a steady increase in the percentage of trunk calls originated in the cities. Today, the percentage of trunk calls originated by city subscribers has more than doubled so that it now accounts for about 42 % of all calls. Which means only 58 % of all trunk calls are now originated from country areas, compared to 80 % in the early 1960s.

There have been many reasons advanced for this changing pattern, including:

- the movement of people from the country to the capital cities;
- the decline of some rural commodity prices on the world market;
- the increase in the size and efficiency of farms, resulting in a decreased number of rural workers.

Although all these physical items must be contributing to the change in the originating trunk call pattern to some degree, I consider that the main underlying reason for the change is due to the role that STD has undertaken in day-to-day business management. On this premise it could be expected that there will be a continuing shift in the origin of trunk calls away from the country to the metropolitan areas so long as our cities continue to expand and remain the main commercial centres. The changing pattern may only be arrested if there is a major combined Government and industry move towards decentralisation in the late 1970s.

The changing pattern of trunk call origins means that the calls initiated in city areas are growing at a considerably faster rate than the national average. This fact can be observed over the past 10 years where the number of trunk calls originated in metropolitan areas has actually been growing at about 16 % per annum compared to the overall national average growth of about 13 % per annum. Also the number of trunk calls per metropolitan telephone service is increasing considerably faster (about 10 % per annum) than the overall national average of 7 % per annum.

The gradual change in the percentage of originating calls made from metropolitan and country areas over the previous 10 years is shown on the graph in Fig. 6. This graph shows the percentage of trunk calls originated in both the country and metropolitan areas from 1960 to 1972 and extrapolates them to 1980 to give an indication of the long-term trends.

STD IN OVERSEAS COUNTRIES

Subscriber Trunk Dialling was initiated about 25 years ago in some of today's most advanced telecommunications countries, notably West Germany and America. In others, such as the United Kingdom and Sweden, the first 1 % STD was registered about 1960. Figs. 7, 8 and 9 show the growth of STD calls and the decline of manual calls in West Germany, United Kingdom and Sweden.

The STD penetration results currently being achieved overseas are considerably in excess of the level that we have reached in Australia. A comparison of overseas STD penetration results from some of the more advanced telecommunication countries compared to the Australian achievement at June, 1972, is made in Table 1.

TABLE 1: STD IN OVERSEAS COUNTRIES AND AUSTRALIA — 1972

Country	STD Penetration
West Germany	99.9 %
Sweden	99.5 %
Japan	90 %
United Kingdom	84 %
United States of America	75 %
Australia	57 %

In countries that have reached almost 100 % national subscriber trunk dialling it is interesting to note that their future policy is to make only a minimum manual service available to the customer and price this 'personal' service considerably higher than an equivalent STD call. For example, Sweden place a surcharge on manual trunk calls and in West Germany a trunk call placed via an operator is charged at approximately three times the cost of the equivalent STD call.

Current studies indicate that STD penetration must continually increase to prevent expansion in the number of manual operators employed on the direct handling of trunk calls. As stated earlier, the current APO target is 66 % STD by 1975, following on reasonably quickly to 90 % STD by 1980. Undoubtedly a target very close to 99 % STD will need to be the objective by 1990. In the long term, considering the increasing cost of operators and the scarcity of labour in general, it is not beyond the realms of possibility that we in Australia could see the manual service either withdrawn or as an alternative, priced more closely in line with the actual costs of providing a 'personal' service.

CONCLUSION

Although the 50 % STD penetration stage has been passed STD is still basically a new and novel feature for many subscribers. From 1960 to the present, it has been a dominant pressure in the development of the telecommunications network. In this period a new nationwide automatic subscriber trunk dialling network has been created. In this paper I have attempted to cover the history and progress of STD in Australia from its beginning to the present. I have also discussed in detail the effects of STD on subscriber call habits as well as levels of STD penetration expected to be achieved by 1975 and by 1980.

However, when we look beyond 1980 it can be foreseen that STD will account for something greater than 90% of all trunk calls and the service will undoubtedly be treated in much the same manner as subscribers currently treat local automatic telephone calls. From now on, new generations of subscribers will enter their business and social spheres in an environment where STD is part of their normal way of life. In particular, business and industry will continue to increase their use of the facility because of the speed and convenience of automatic direct dialling. These thoughts, conditioned by what has already happened in overseas countries, must inevitably lead to the long-term view that 100% STD is inevitable. The questions remaining, therefore, are when, how and at what rate will 100% STD be achieved. We observe that other countries have reached 99% STD in 1972 after passing through the 50% STD milestone some time between 10 and 20 years ago. Based on the longer 20-year time scale, perhaps 99% STD could be envisaged in Australia by 1990, remembering that 50% STD was realised in Australia in 1970.

The final thought on the future of STD in Australia could be a reminder that 50% STD at 1970 meant handling 100 million STD calls, 90% STD at 1980 will mean catering for 600 million STD calls and 99% STD at 1990 could see the development of a network capable of handling in excess of 1,000 million STD calls per annum.

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I.H. MAGGS joined the Postmaster-General's Department in Sydney as a Cadet Engineer in 1954. After graduating from the University of New South Wales in 1957 he was appointed Engineer Class 1 with the Country Installation Section in N.S.W. From 1960 to 1963, as an Engineer Class 2, he was actively engaged in the installation of telephone switching and carrier transmission equipment in N.S.W. in 1964 he was promoted to Engineer Class 3, Metropolitan Network Planning, Telephone Switching and Facilities Branch, Headquarters, and was engaged on the formation of forward switching and numbering plans related to the development of metropolitan telephone networks.

In 1967 he was transferred to the Trunk Network Administration position in Headquarters Planning and was associated with the detailed planning of the new national automatic trunk switching network. In 1972 he was promoted to Engineer Class 5 in charge of the National Trunk Network Planning Section and is currently associated with the planned development of the National Trunk Switching Network, including the introduction of 10C electronic trunk exchanges. Mr. Maggs has been closely associated with the production of the National STD Newsletter since its original publication and is also a member of the Institute of Electrical Engineers.

Detection of Electrical Discharges from Transmitter Antennae

E. J. BONDARENKO, A.R.M.I.T., F.R.A.S.

The APO has recently experienced problems of electrical discharges at one of its high power transmitter installations. This article outlines the discharge problems and describes a system for detecting those discharges, based on the detection of ultra-violet radiation.

INTRODUCTION

The extension of radio broadcast transmission to high power levels has aggravated the problems caused by electrical 'corona' discharges from transmitting antennae by increasing the likelihood of the occurrence of discharges and by raising the power dissipated by them. Although electrical discharges and the properties of gaseous electrical conductors have been investigated for nearly a century (mostly under d.c. and power frequency conditions however), the complexity of corona discharges is such that no analytical expression which generalizes the conditions that must be satisfied for this discharge to occur is yet available. In view of this it has not been possible to predict the likelihood of occurrence of radio frequency (r.f.) 'corona' discharges from antennae which are required to operate in a wide range of field environments, nor to suggest universally applicable methods of preventing their occurrence.

The APO has recently experienced problems of electrical discharges at the Radio Australia installation in the Northern Territory. This installation is unique in many of its technological features and its high power level, and represents significant advances over previous high frequency (h.f.) technology in Australia, and in some cases in the world. These aspects combined with the severity of the environment of the site have given rise to some particular difficulties that have had to be overcome. This paper describes the corona problem in that installation and a method adopted to overcome it.

OUTLINES OF THE INSTALLATION AND THE CORONA PROBLEM

The installation is located in the tropics at Cox Peninsula near Darwin and consists of three transmitters, five vertically polarized bi-plane log-periodic antennae and a water cooled 500 kW two conductor stainless steel dissipative line. At present the main function of the station is to re-transmit programmes originating in the studios of Radio Australia in Melbourne and transmitted from the Radio Australia 100 kW installation at Shepparton, Victoria. The broadcasts are radiated to South-East Asia, East Asia and the Indian Sub-Continent by three antennae directed 301° true north and two 340° true north from a datum point located 130° 37'30" east and 12° 24'48" south.

The transmitters used are computer-controlled Collins Radio Company type 821A-2. These transmitters are auto-tunable from 3.95 to 26.5 MHz and have a nominal power output of 250 kW each into a balanced 300 ohm load. The antennae are vertically polarized bi-plane log-periodics designed and constructed by Complimenti Elettronici, Italy, and supplied and installed by RCA Pty. Ltd. (Aust.).

In anticipation of possible future use of higher power transmitters the design of these antennae was based on parameters which would enable the antennae to operate at 500kW, 100% modulation.

The design of this type of antenna for the h.f. band capable of radiating even 250 kW required a considerable number of unique features whose behaviour in the severe field environment was difficult to forsee.

One of the problems experienced by the antennae was caused by an electrical 'corona' discharge from the radiating dipoles which occurred at irregular intervals even when the transmitters were operated well below their rated power.

These 'corona' discharges, which are sometimes referred to as 'plumes' or 'flares', have the appearance of a long slender arc with a luminous core up to two metres in length, with one end terminating at a dipole and the other diffusing in air. The power dissipated in these discharges has not been determined but may be several kilowatts and as a consequence they can damage the antennae by melting the discharging elements. A 'corona' discharge generated in the laboratory by a 10kW transmitter operating at 13.56 MHz is shown in Fig. 1. These discharges can be seen and, when modulated by the transmitted programme, heard over a distance of several kilometres under favourable conditions.

Consequently an investigation was undertaken to determine the cause of those discharges and to find means of preventing their occurrence. The initial results of this investigation suggested certain modifications to the antennae which proved successful in considerably reducing the incidence and the intensity of those discharges, but which have not eliminated them completely. Corona discharges also occasionally occur from transmission lines.

Subsequent findings (see Ref. 1) have isolated what is believed to be the main cause of those discharges; however considerable time may elapse before means are devised and implemented to eliminate the occurence of those discharges completely. The quickest solution to the problem then, and one that did not interfere with the scheduled operation of the station, appeared to lie in the detection and extinction of discharges before they caused any damage.

DETECTION SYSTEM

Prior to the installation of the detection system to be described, the station staff relied on a discharge detection system provided by a 160 MHz mobile receiver in which the squelch was triggered by noise radiated from the corona discharge. The receiver did not respond on all occasions and in addition this system could not readily be adapted to indicate from which particular antenna the discharge was taking place. Thus even when the station staff were aware of a discharge, its location had to be visually determined.

However, owing to the location of both the transmitters' control room and the antennae, and also the distance involved, a considerable time elapsed before this could be done. Furthermore the discharges were not always readily visible in the daytime and as a result the discharges occasionally persisted long enough to damage the antennae.

Previous experience with short range detection of indoor r.f. arcs with ultra-violet (u.v.) radiation sensors (Ref. 2, 3) suggested that the detection of the antenna discharges could be accomplished with similar devices. A similar suggestion was

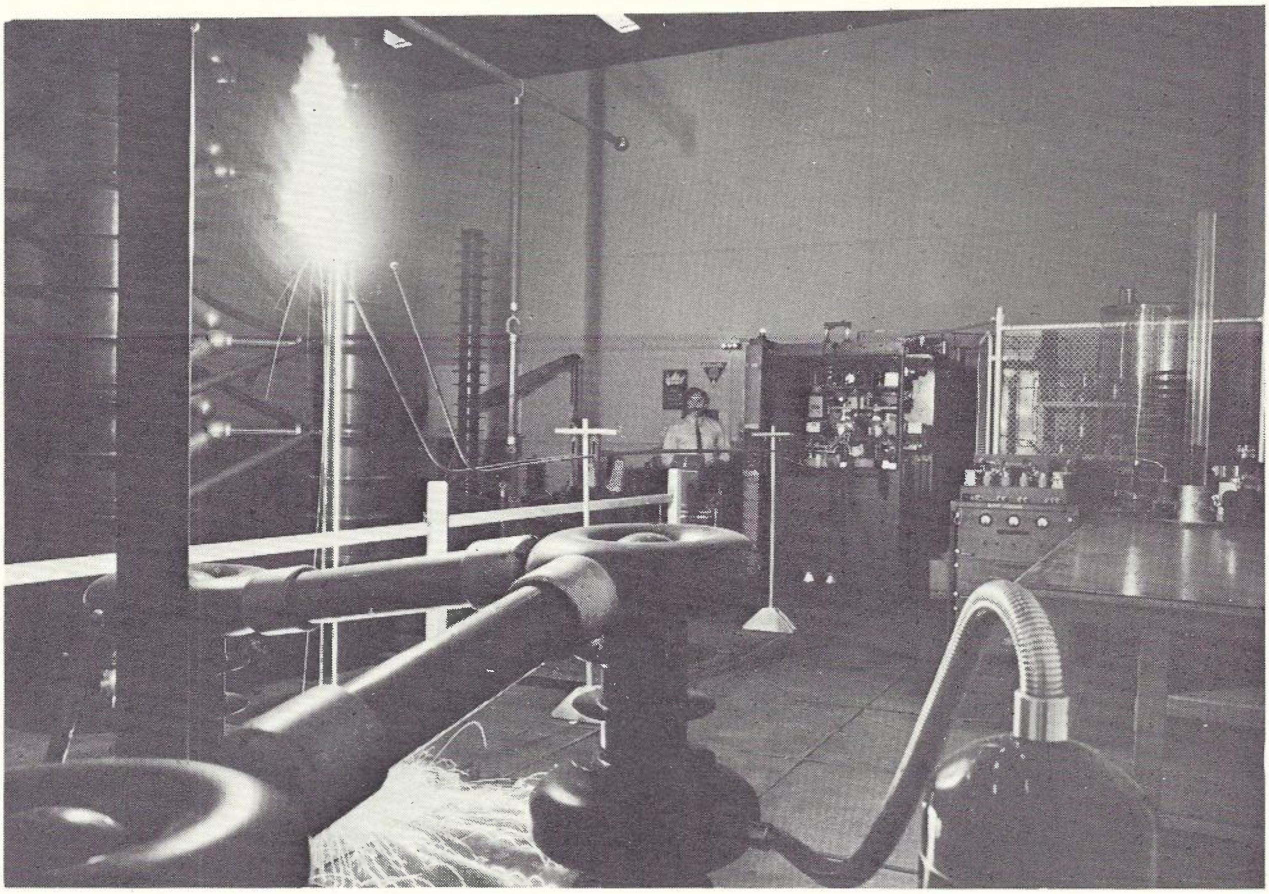

Fig. 1 — R. F. Discharge Generated in the Laboratory by a 10 kW Transmitter.

made independently by the Station Manager (Ref. 3).

At the same time various other methods were considered and advice was sought from a number of overseas broadcasting establishments. (Ref. 3). Some of the methods considered included detection of noise and harmonic radiation, unbalanced harmonic currents in the transmission lines, utilization of the 'Luxembourg effect', rectifying properties of corona discharges and the detection of audio and ultra-sonic sound and infra-red radiation emitted by the discharges. Amongst those some were considered to be feasible but not as attractive as the u.v. detection method in regard to reliability, simplicity and speed of implementation.

The first u.v. detection system installed used only two u.v. radiation sensors located in a position (see Fig. 2) from which the five antennae and most of the transmission lines were in their view. One of the detectors was arranged to observe discharges from antennae 1, 2 and 3 and the other from 3, 4 and 5. This arrangement and a complimentary mode of antennae use enabled the system to indicate from which particular antenna the discharge was taking place. Although this system achieved its purpose of relieving the station staff from the task of searching for the discharges, and by providing a quick and reliable method of identifying the discharge location permitted almost risk-free operation of the station at full power, the system had a number of undesirable features. Some of these were as follows:

- The system was not 'fail-safe'.
- Not all locations from which discharges could occur were covered by the two sensors (sections of transmission lines).
- Owing to the large distances and angles from which the discharges had to be detected (250 m nearest and 500 m furthest, total angle of view c. 140°), it was thought that the sensitivity of the detectors could be impaired by dense fog or heavy rain.
- Flexibility of antenna use was impaired.
- Owing to the location of the detectors, precautions had to be taken when using arc welding equipment in the workshop area if false triggering of the detectors was to be avoided.

Some of these shortcomings of this first stage detection system were eliminated by increasing the number of detectors to eleven. The location of those detectors is shown in Fig. 2. Detectors 1 to 5 are arranged to respond to discharges only from the respectively numbered antennae; detector number

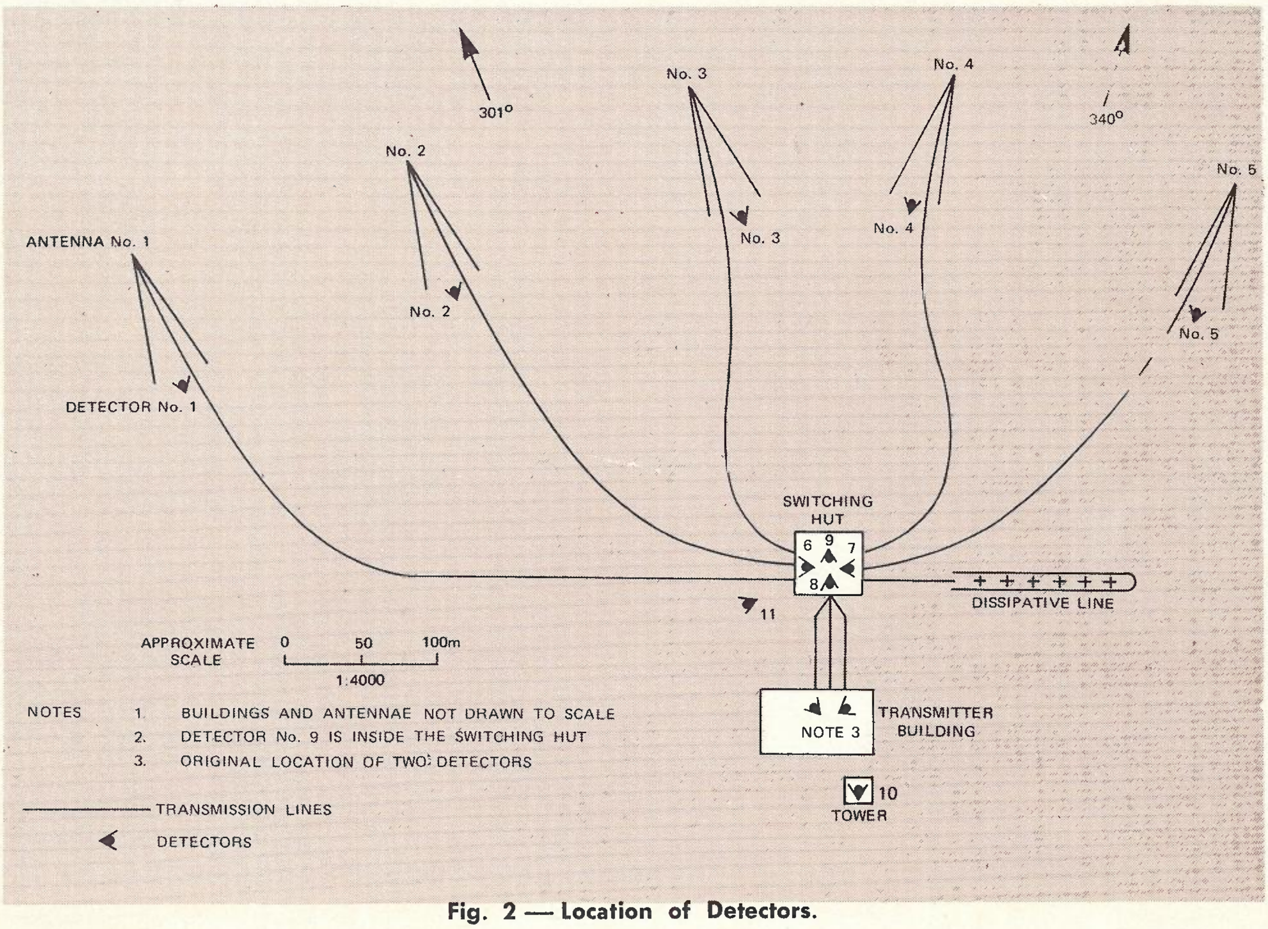

Fig. 2 — Location of Detectors.

6 to discharges from antennae 1, 2 and 3 and from transmission lines to those antenae; detector number 7 is a counterpart of number 6 for antennae 4 and 5 with the addition that it will also detect a discharge from the dissipative line; the location of number 8 allows it to see discharges from transmission lines between the transmitters and the aerial switching hut only; and number 9 to see discharges in the switching hut itself.

Detector No. 10 which is located approximately 20m above ground on a microwave antenna tower, views the whole installation and number 11 overlooks the workshops area without having a direct view of any antenna or transmission line. The signal from detectors 6 and 7 is suppressed by signals from detectors 1 to 5 and that from detector 10 by signals from detectors 1 to 8.

A signal from number 11 can be used to suppress signals from detectors 6, 8 and 10, all of which can see some parts of the workshop area. With this deployment of detectors the system is able to:

- indicate the discharging antenna;
- indicate a discharge from any part of the transmission lines or the dissipative line, although in this case the system at present is not capable of isolating the individual line;
- indicate a discharge inside the switching hut;
- in case of failure of any of the detectors associated with antenna the occurrence of a discharge is indicated by detectors 6 or 7;
- in the event that any of the antenna detectors and also detectors 6 or 7 fail, a discharge from any of the antennae or any part of the dissipative or transmission lines is indicated by detector 10;
- false alarms due to arc welding in the workshops area can be avoided.

The option of using the signal from detector No. 11 to suppress the signals from detectors No's 6, 8 and 10 can result in delaying a discharge indicating signal when the discharge occurs on certain sections of transmission lines.

This problem can be considered a theoretical one only since the need to use this facility will be infrequent; and the time delay will be short compared to the time required for the discharge to cause damage to the transmission lines. Furthermore, discharges from the transmission lines are relatively infrequent.

Thus the additional detectors and the mode of their use eliminated all the shortcomings of the first stage detection system with the exception of the 'fail-safe' facility. The use of detectors 6 and 7 as a back-up system for detectors 1 to 5 and also of detector 10 for detectors 1 to 5 and 6 to 8 is considered however to compensate quite adequately for the present lack of this facility.

Detection System Operation

In use the detection system functions as follows:

Antenna Discharges

If the discharge occurs from one of the antennae, the appropriate detector is triggered by the u.v. radiation from the developing discharge. The signal from the detector then activates an aural and visual alarm, the latter also indicating the discharging antenna on an installation layout display panel.

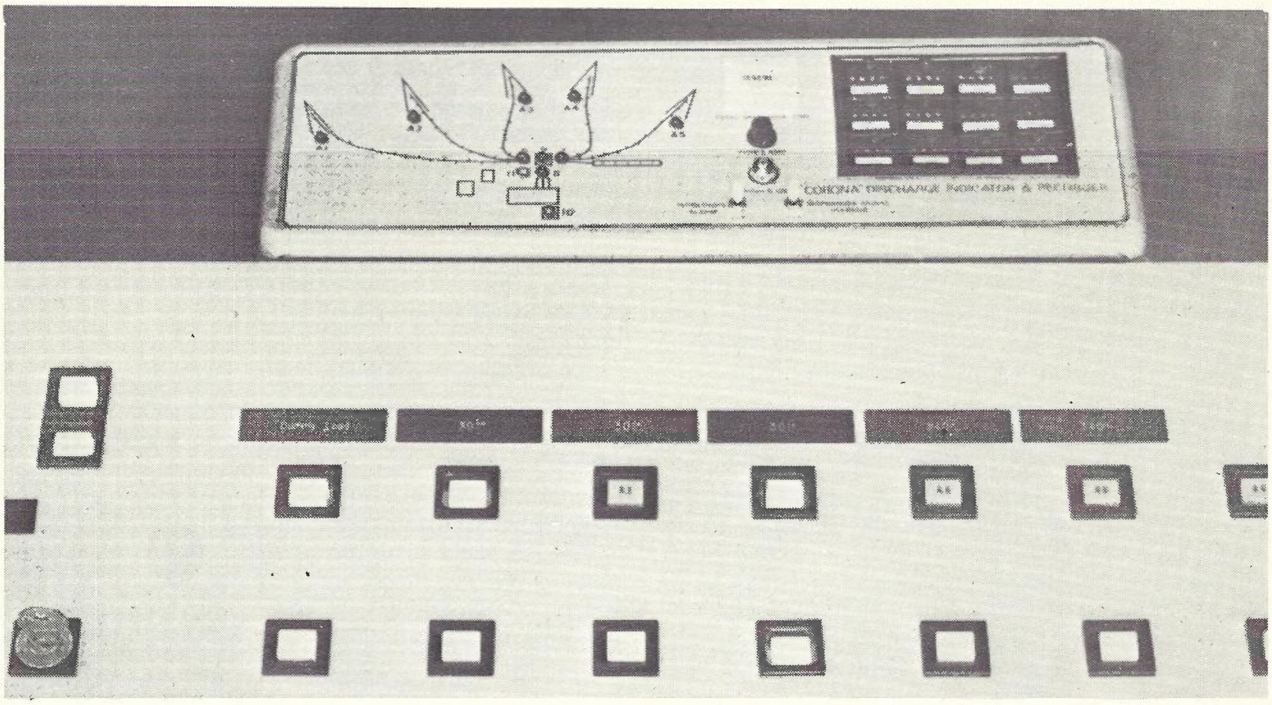

Fig. 3 — Corona Discharge Location Display Unit and Part of Transmitters-Antennae Switching Matrix.

This panel is next to the transmitters-antennae switching control and display matrix. Both are shown in Fig. 3.

If the system is used in the manual transmitter dekey mode, the operator after noting the antenna and transmitter involved operates an appropriate key which initiates an immediate removal of r.f. drive to the transmitter feeding power to the discharging antenna. Power is automatically re-applied by computer action within 100 milliseconds.

In this case the time elapsed between the appearance of the discharge and its extinction is determined by the operator, which in general need not be longer than a few seconds. The r.f. power off-on cycle is not governed by the operator and is too short to cause objectionable, if at all perceptible, interruption to the programme.

The occurrence of the discharge is automatically registered by the appropriate discharge counter in the detection system and dekeying the transmitter results in an automatic entry in the transmitter control computer print-out log showing the time of occurrence, antenna and transmitter involved, frequency and power level of transmission and other relevant data.

In its automatic mode of use, which is in the process of being implemented, the system will detect and extinguish the discharge without intervention from the operator. In this mode the detection-extinction time will be governed by the speed of the detection system logic circuits, which at present use electromechanical relays.

The relay switching time under the least favourable combination of conditions will be in the vicinity of 100 ms. The programme interruption time and other events will remain unaltered. In case the discharge is re-established immediately after the power interruption cycle, an event which has not occurred yet with a discharge from an antenna dipole, the power interruption cycle wil be automatically repeated twice more if necessary. Then the power will remain switched off until new instructions are fed into the transmitter control computer. Simultaneous discharges from more than one antenna have to be extinguished sequentially, either in the manual or automatic mode of use.

Transmission Line Discharges

In case a discharge occurs from an antennae transmission line, the dissipative line, or from an antenna if one or more of the antennae detectors fail to operate, the event will be indicated by a signal from detectors number 6 or 7. In this case if more than one transmitter is involved the system in its present state will not be capable of indicating which transmitter must be dekeyed either in the manual or automatic mode of use, and the appropriate transmitters, depending on whether they are connected to the lines and antennae supervised by detectors 6 or 7, will be dekeyed sequentially.

Signals from detectors 8, 9 or 10 will call for sequential dekeying of all transmitters in use.

Dekeying Incorrect Transmitter

The inability of the present system to always correlate a discharge with the appropriate transmitter is of little practical significance. The sequential dekeying will increase the time the discharge is allowed to persist by only a few seconds in manual operation, and by a few milliseconds in automatic mode, both of which are insignificant compared to the time the discharges require (matter of minutes) to cause any significant damage.

Furthermore, as mentioned previously, discharges from locations other than the antennae are infrequent. This, combined with the 1 in 3 chance of dekeying the wrong transmitter leads to a prediction that under normal conditions the event of dekeying the wrong transmitter is not likely to occur more than a dozen times in a year, and past performance of the detectors indicate that contributions by detector failures can be neglected in arriving at the above prediction. Nevertheless, means are available to enable the system to indicate the appropriate transmitter under all circumstances and they may be incorporated, with a 'fail-safe' and automatic detector test facility, into the system if the discharge problems are not resolved in the near future.

Regardless of whether the discharge initiation process and other factors governing the r.f. electrical discharges are understood to the extent that means will become available to prevent their occurrence under all severities of operating environment, the need for some sort of a discharge detection system in high power transmitter installations is likely to remain. As an example, this need may arise because the increased cost or operational constraints of a discharge-free system under all contingencies, e.g. lightning strikes (Ref. 4), fault conditions, misuse, or any other infrequent event, may not be considered warranted.

Detecting U.V. Radiation

Methods for detecting ultra-violet radiation are simple, sensitive and reliable. In view of this and the need for discharge detectors in transmitter installations, it is surprising that this method has apparently not been utilised by broadcasting establishments experiencing antennae discharge problems. The basic principle of operation of the detection system described relies on the initiation of an electrical discharge between two electrodes in a gas tube by photoelectrons emitted from one of the electrodes when irradiated with u.v. radiation. The dominant line spectra in the ultra-violet region emitted by a r.f. discharge from a copper electrode are shown in Fig. 4 together with the u.v. radiation spectra from the sun at the earth's surface. Superimposed on this is the relative sensitivity curve of the u.v. sensor used, and a transmission curve of a narrow band u.v. filter used in experiments with u.v. sensors whose response extended to include the sun's spectrum. The detection distance versus angle of view of a detector to a typical discharge

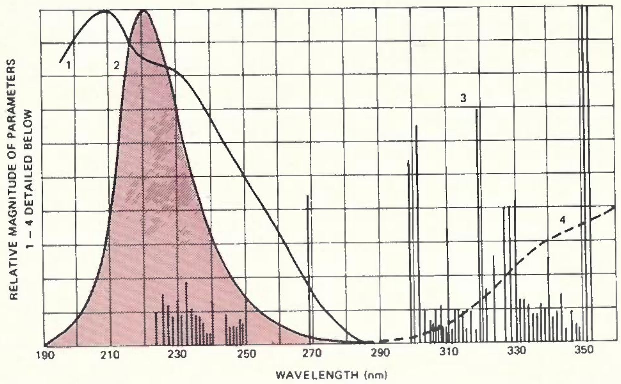

Fig. 4 — Relative Magnitude of Various Parameters in the Ultra Violet Spectrum.
Parameters:
1. **Transmission Characteristics of Filter.**
2. **Relative Response of Photocell.**
3. **Spectum (Predominant Lines) of Discharge from a Copper Electrode.**
4. **Sun Radiation at Earth's Surface.**

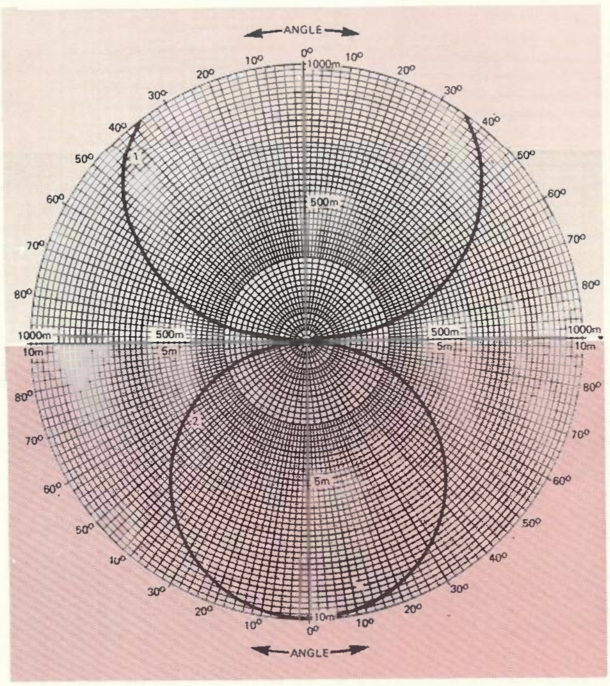

Fig. 5 — Sensitivity of a Typical Detector (Detection Distance).

is shown by the top curve of Fig. 5. The bottom curve shows the response to a specific type of flame (note change of distance scales). This curve is included to show the relative insensitivity of the system to bush fires which may occur in the vicinity of the installation. The sensitivity of the detectors may be altered most simply by varying the potential applied to the u.v. photo cell which also permits compensation for change of sensitivity with age.

The possible shift of relative response with age towards longer wavelengths and consequent overlap with the sun's spectrum can be compensated for by use of optical filters. Compensation has not however been required in the 18 months these detectors have been in use. False triggering by lightning activity is prevented by a simple response time delay circuit. A typical detector unit as used at Cox Peninsula is shown in Fig 6.

CONCLUSION

The corona discharge detection system developed for use at the Radio Australia Booster station in the Northern Territory is simple, flexible and reliable.

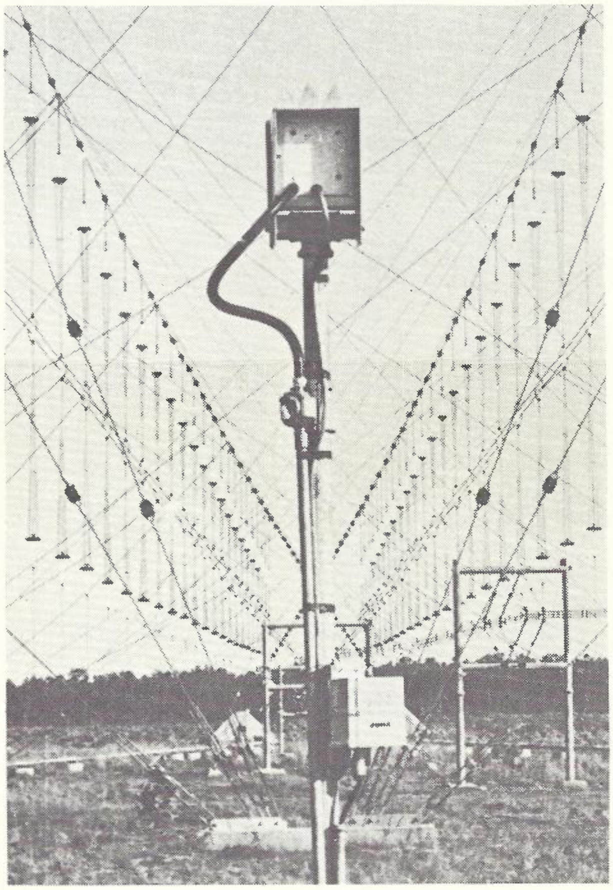

Fig. 6 — Typical Mounting and Location of an Antennae Discharge Detector.

On the basis of the almost total absence of corona caused damage since the installation of the u.v. detection system, the small cost of developing and installing the system has already been justified in terms of material cost, repair time, and reduced losses in transmission time.

Since corona problems, in one form or another, may continue to exist this detection method could find widespread use. A number of enquiries from overseas broadcasting establishments have already been received.

The system need not be confined to detecting potential damage causing discharges. It can be used in either fixed or portable form for preventive maintenance, for example early detection of faulty joints, leaky insulators, discharges from fences and other non-active structures, etc. around the installation.

The detection system will be described in more technical detail in a forthcoming APO Research Laboratories Report.

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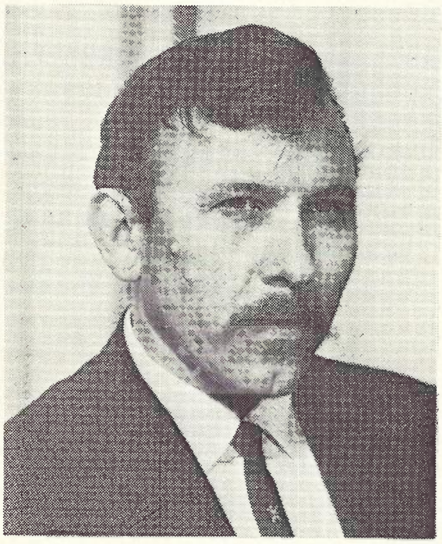


Maintenance and Performance of L. M. Ericsson Crossbar Switching Equipment in Australia (Part 2).

B. J. CARROLL, A.R.M.I.T.

Part 1 of this article in the previous issue of the Journal outlined the performance of ARF crossbar switching equipment used in capital city networks and the larger provincial centres. This second part outlines the performance of ARM switching equipment used at Secondary, Primary and Main Switching Centres in the trunk network. It also includes a brief review of the performances of ARK type exchanges in our rural networks.

THE ESTABLISHMENT OF THE ARM GRID

In 1963 when Subscriber Trunk Dialling was introduced, less than 5% of the total trunk calls were subscriber dialled as only 44,000 subscribers connected to 21 exchanges had access to the point to point STD network. By June 1972, 57% of all trunk calls were subscriber dialled, with STD facilities being available to 2.48 million subscribers connected to 1,682 exchanges. This progress has been made possible mainly by the introduction of crossbar switching equipment into the local and rural networks, and by the establishment of the 4-wire ARM trunk switching network. The development of high capacity broadband carrier systems using microwave radio and coaxial cable bearers also contributed greatly to the economic introduction of STD.

The first ARM exchanges were installed at Haymarket (Sydney), Newcastle and Canberra in N.S.W. in June 1967, and the initial eastern seaboard grid was commissioned in November of that year. Perth ARM, the last capital city ARM to be connected to the grid was cutover in July 1970.

At this point of time there are 36 ARM exchanges in service at Main and Secondary Switching Centres, with some 55,000 inlets and outlets in use. The development of the REG LP/H4 Minor Switching Centre has reduced the requirement for ARM type exchange to less than 50. The largest ARM exchange in service is the 11,000 line (equipped termination) Haymarket exchange in Sydney. This exchange, comprising two 8,000/8,000 line ARM units, switches between 8 and 10 million calls per month.

SUPERVISING THE OVERALL PERFORMANCE OF THE ARM GRID

Fig. 1 depicts the plan for supervising the overall performance of the STD network. The key features are:—

- The end to end performance is checked by service assessment of live traffic which, at present, is supplemented in the case of STD traffic by a programme of manual test calls. The APO is developing service assessment equipment to monitor traffic at the incoming relay sets (FIRs) at ARM exchanges.
- A programme of test calls generated by Traffic Route Testers (TRTs). This programme is organised by State Network Performance Analysis Centres to monitor the performance of main trunk routes.
- A programme of test calls generated by Automatic Exchange Testers (AETs) at ARM exchanges.
- The analysis of trouble reports from operators and customers.
- Traffic Study Reports issued by the Traffic Engineering Sections in our Planning & Programming Sub-Division.
- A device known as a Transmission Equivalent Statistical Analyser (TESA) has been developed to the prototype stage. This unit which can be used in conjunction with a TRT records the transmission level in the send and receive directions.

The targets set for the overall switching loss, including losses in the originating and terminating local networks, for STD calls are as follows:

(i) Switching loss 3%

(ii) Congestion loss 2%

The results from the service sampling and manual test call programmes for the year 1971/72 indicate that both switching and congestion loss exceed the targets for most capital cities, with congestion loss being as high as 5% in some cases. Traffic study reports indicate that the present high level of congestion is mainly due to the under-provision of switching plant and junctions in local networks. These figures are also reflected by the results of the traffic route testing (TRT) programmes arranged by the State Network Performance Analysis Centres.

SUPERVISING THE PERFORMANCE OF INDIVIDUAL ARM EXCHANGES

The methods and maintenance aids employed to supervise the performance of individual ARM exchanges and the traffic routes outgoing from them are depicted in Fig. 2. The main items employed are:

Standard Items Supplied by L.M. Ericsson

- The exchange alarm system.
- Service Alarms — indicate an abnormal number of disturbances in common plant items.
- Route Alarms — indicate faulty circuits on outgoing routes.
- The Centralograph. This unit which is a most valuable maintenance aid supervises the performance of the exchange with respect to technical defects from inlet to outlet. It provides a print out to indicate the main items of common plant used in the setting up of a call which experiences a disturbance, and indicates the link routes used through the switching stages.
- Statistical Meters — indicate calls, congestion and disturbances for markers, registers, etc.
- Automatic Exchange Testers (AETs) — used to generate test calls at incoming relay sets (FIRs) and outgoing relay sets (FURs). They have facilities to enable them to be used with any of the line and information signal systems employed by the APO.
- Tariff Testers — enable the tariff setting functions of route markers to be tested from line relay sets used on routes where tariff setting is performed at the ARM.
- Traffic Readings. The circuitry is designed to facilitate traffic supervision. The APO provides Erlang-hour meters to supervise its main routes. The time congestion feature is also used for outgoing routes.
- The Service Control Rack. This unit records exchange alarms, service alarms and route alarms and provides additional resettable meters which can be used to locate faults in markers etc.

Maintenance Aids Developed by the APO

Test FIRs

To enable the maintenance staff to supervise the performance of the exchange from the maintenance control room, a special Test FIR is wired in parallel to the 16th inlet of each register finder group. One FIR is provided for each register type (e.g. Reg-H1, H2 and EHY2), and the input jacks of these FIRs appear on the maintenance console. By key control of the "H" wire, test calls generated from an automatic exchange tester connected to Test FIR can be directed into any register group. (The APO uses only 60 out of the 64 inlets to the RS stage which leaves four spare inlets.)

Network Simulators

These units which were supplied by L.M.E. as installation test aids have been modified to include a Pulse Length Monitor (PLM) which tests the outpulsing performance of registers. They are connected to outlets from the exchange switching stage and can be set to simulate line and information signalling for any network. It is proposed to use these devices as maintenance aids, particularly for register testing. They will reduce the need to trace faulty calls into the network in the event of a register fault. They are used in conjunction with the test FIR described above. The Haymarket exchange in Sydney is equipped with 490 registers.

Automatic Transmission Test Units (ATTU)

The successful introduction of Subscriber Trunk Dialling (STD) is largely dependent on the transmission performance of the network. With operator dialled trunk networks the transmission quality of the circuit was checked by the operator before the call was established. However, with STD it is necessary to ensure that the transmision performance is maintained at a high standard, not only in the trunk network but also in local networks. At the time the APO installed its first ARM exchange, it had already developed a plan for transmission testing in its point to point STD network, and relay sets known as TCARs with facilities for two way transmission testing had been developed. To enable automatic transmission testing to be carried out on a go-no-go basis a device known as an Automatic Transmission Testing Unit (ATTU) has been developed. This unit can be fitted to an Automatic Exchange Tester (AET) and by connecting the AET to inlets (FIRs) at smaller ARM exchanges it will provide automatic transmission test facilities. For larger exchanges, an Automatic Transmission Routiner is being developed. This unit which interworks with test access circuitry designed by the APO is described in detail in an article by Mr. G. Foote in Vol. 23, Issue 1 of this Journal published in February 1973. This Automatic Routiner also works into the special TCAR relay sets at distant exchanges.

Tariff Testing

As the ARM exchange performs tariff setting functions for many routes incoming to it, it is essential that the tariff setting equipment be adequately tested and supervised. Modifications to simplify tariff testing and to obtain a Centralograph print out of meter rate setting irregularities (i.e. no tariff or more than one tariff set) as described in Ref. 3, have been developed. Special analyser strapping testers which gain access to route markers via the REG-VM selector, have been developed to facilitate a quick check of route and tariff settings. Although these units were designed mainly for use during installation they also have an application for maintenance work.

PLANT PERFORMANCE RESULTS

As the results from such indicators as service assessment, manual test calls and traffic route testing include losses attributable to the originating and terminating local networks, the performance criteria used for this article will be based on the average results obtained from:

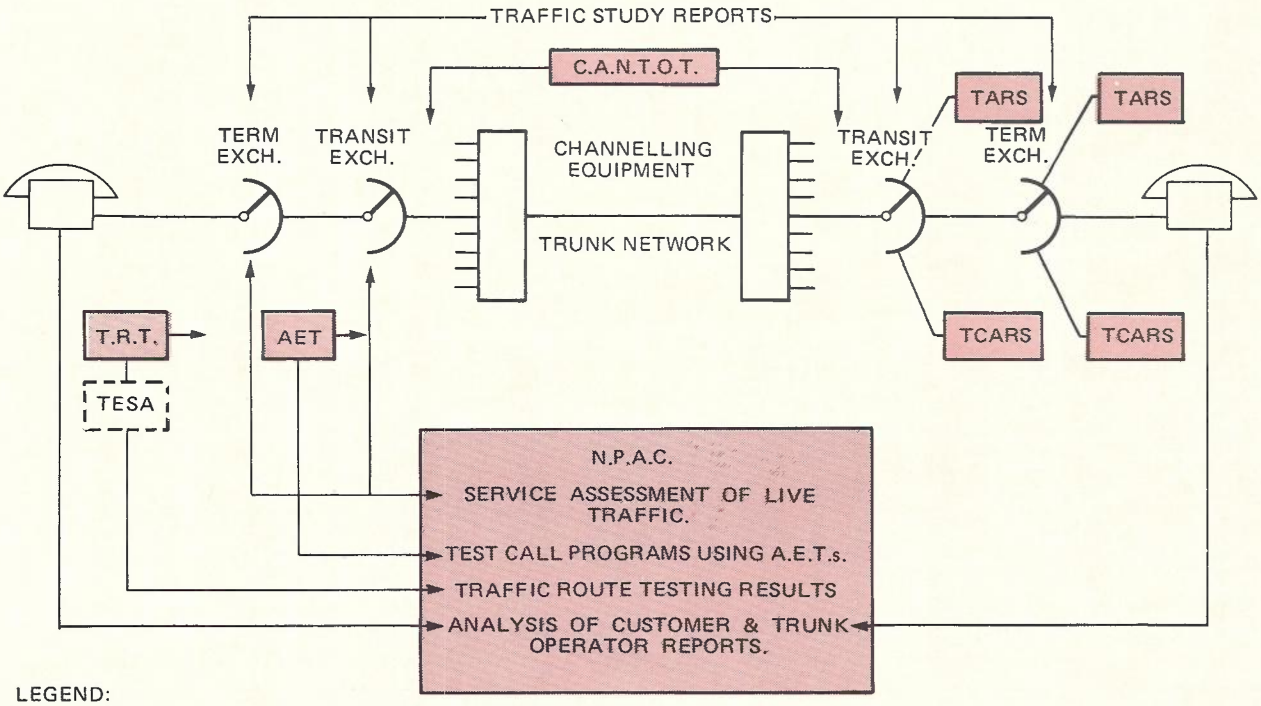
(i) Statistical meters connected to markers.
(ii) Special test call programmes.

These test calls which terminate on self answering relay sets connected to the outlets of the distant ARMs, are generated by Automatic Exchange Testers (AETs) connected to inlets (FIRs) at the originating ARM exchange.

Typical results from these indicators are as follows:

(i) Statistical Meters
 (a) Internal loss 0.16%
 (b) Average route congestion 0.95%
 (c) Average link congestion 0.01%
(ii) AET Test Call Programme Call Loss
 (a) All routes (includes congestion) 1.4%
 (b) Capital City ARM to Capital City ARM (excluding congestion) .... 0.5 %

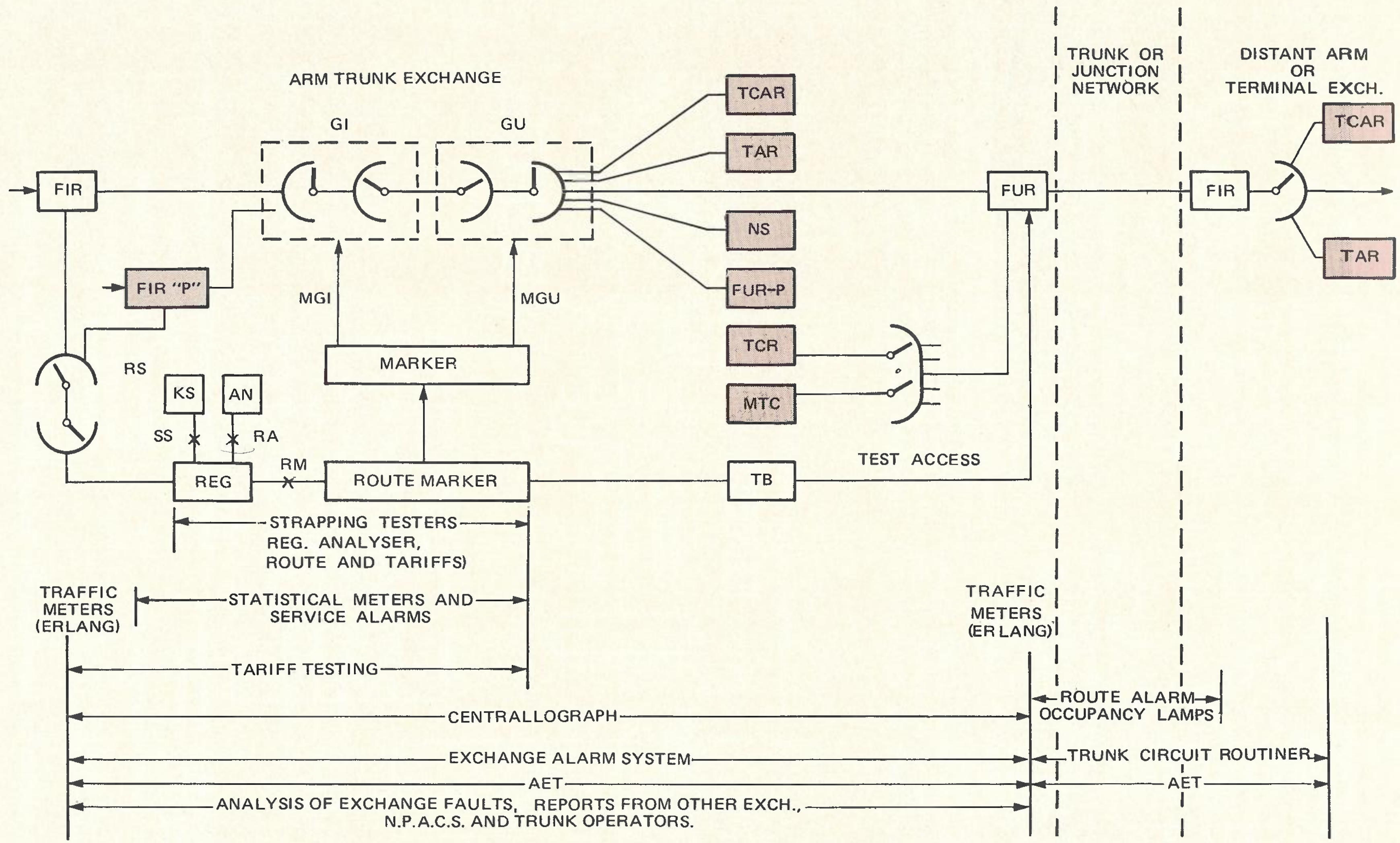
The internal loss in (i) (a) represents call failure due to plant switching defects within the originating ARM exchange. The call loss figure of 0.5% (switching loss) on inter-capital city routes includes loss at both ARM exchanges. These figures indicate that ARM exchanges in this country are providing a very good standard of switching performance. Experience to date indicates that the Multi-Frequency Signalling System and the L.M.E. Pulse



LEGEND:

C.A.N.T.O.T. = COMPUTER BASED PERFORMANCE INFORMATION SYSTEM FOR TELEPHONE CIRCUITS.
N.P.A.C. = NETWORK PERFORMANCE ANALYSIS CENTRE.
T.C.A.R.S. = TONE ANSWER RELAY SET FOR TRANSMISSION TESTING.
T.A.R.S. = TONE ANSWER RELAY SET FOR USE WITH T.R.T.
T.R.T. = TRAFFIC ROUTE TESTER.
A.E.T. = AUTOMATIC EXCHANGE TESTER.
T.E.S.A. = PROPOSED TRANSMISSION EQUIVALENT STATISTICAL ANALYSER.

Fig. 1 — Facilities for Supervising the Overall Performance of the STD Network



LEGEND:

A.E.T. = AUTOMATIC EXCHANGE TESTER.

T.C.A.R. = TONE ANSWER RELAY SET FOR TRANSMISSION TESTING.

T.A.R.S. = TONE ANSWER RELAY SET FOR USE WITH TRAFFIC ROUTE TESTERS.

N.S. = NETWORK SIMULATOR.

T.C.R. = TRUNK CIRCUIT ROUTINER.

M.T.C. = MANUAL TRUNK TEST CONSOLE.

FIR "P" = TEST F.I.R. FOR REGISTER.

FUR-"P" = TESTING. ETC: TEST ROUTE FOR TARIFF TESTING.

Fig. 2 — Facilities for Day-to-Day Supervision of Plant Performance, ARM Exchanges and Outgoing Circuits.

Signalling System (line signals) are very reliable and once correctly installed and tested, require very little maintenance attention.

ARM EXCHANGES — FAULT ANALYSIS

The average equipment fault incidence for ARM exchanges in Australia is in the order of 15 faults per hundred equipped terminations per year which is considerably higher than that recorded for ARF exchanges. As in the case of ARF exchanges, at least 30% of the faults are attributable to installation activity or equipment modifications. Table 1 sets out the incidence of and the mean time between faults for major items of plant.

TABLE 1 — FAULT LOCATION AND MEAN TIME BETWEEN FAULTS

Plant Item	Percentage of Total Faults	Mean Time Between Faults
Incoming line relay sets (FIR)	25%	8 years
Outgoing line relay sets (FUR)	17%	12 years
Registers (Reg)	12%	1.5 years
Route markers (VM)	20%	3 months
Markers (M)	2%	6 months
Selecting stages (GI/GU)	7%	6 months
Others (RS, SS, AN/SN, IDF, etc.)	17%	

Table 2 sets out the percentage of faults in ARM exchanges detected by standard maintenance aids. The Centralograph and test call programmes using Automatic Exchange Testers locate more than 50% of the total faults.

TABLE 2 — FAULT DETECTION, ARM EXCHANGES

Maintenance Aid	Percentage of Total Detected Faults
Centralograph	27%
Routine testing (AET's)	27.4%
Alarms	16%
Reports from distant exchanges	14%
Traffic route testing (TRT)	8.6%
Others	6.6%
NPAC, Subs, Telecommunications Division	0.4%

OPERATING COSTS — ARM EXCHANGES

Current operating costs for ARM equipment in Australia varies between five and eight man hours per equipped termination per year, depending on a number of factors, namely the size of the installation, the traffic carried, the hours of staffing, the availability of skilled staff, the role of the exchange as a training station, and the level of installation activity. The figure quoted includes that component of ARM maintenance known at Network Maintenance, which is defined as the work required to supervise the switching and transmission performance of the network as seen from the ARM and for the tracing and location of network faults.

PERFORMANCE OF ARK EQUIPMENT

One of the aims of the Community Telephone Plan was to provide telephone subscribers in country areas with a continuous automatic telephone service. To date, approximately 82% of the 1.2 million telephone subscribers in country areas are connected to Automatic telephone exchanges. Approximately 50% of these services are provided by crossbar equipment (285,000 lines of ARF and 221,000 lines of ARK are in operation). At June 1971 there were 600 ARK 511 type and 655 ARK 521 type exchanges in operation throughout the Commonwealth.

Field reports indicate that this equipment is extremely reliable and requires little maintenance attention. All ARK type exchanges are operated on an unattended basis. The limited available information suggests that the fault incidence for ARK equipment varies from two up to 40 faults per 1000 lines per year with the average being in the order of 15 to 20. On this basis a 200 line ARK exchange would require maintenance attention once every three months. This represents excellent service considering the amount of equipment involved for 1000 lines when it is distributed over a number of small ARKs and the wide range of climatic conditions under which these exchanges operate.

MAINTENANCE AIDS FOR ARK EXCHANGES

As these exchanges have a relatively low fault incidence and are unattended, the main maintenance aids are:

(i) Statistical Meters.
(ii) Portable TRTs.

In order to reduce the number of visits to ARK exchanges to a minimum, bearing in mind that some ARK exchanges can be located more than 100 miles away from the parent exchange, and to provide methods of supervising both the switching and transmission performance of these exchanges from the parent exchange (a nominated maintenance control station) the APO has developed the following aids:

The SNR-P

This unit enables test access to be gained to any subscriber's line in the exchange. The unit is a "go-no-go" device and transmits the result of the test to the remote testing station by the use of VF signals. The unit which operates over physical or derived circuits can be used by both Engineering and Telecommunications Division staff for the testing of subscribers' lines. The SNR-P is outlined in Fig. 3.

The Remote Call Repeater (RCR)

This unit which is described in part 1 of the article enables test calls to be generated from unattended exchanges under the control of a TRT located at a remote control centre. It is normally equipped with facilities to generate outgoing calls from 10 lines, but for larger exchanges the number of lines can be extended. Fig. 4 outlines the use of the Remote Call Repeater (RCR). When more detailed testing is required at the exchange a portable TRT can be connected directly into the RCR. It also incorporates features designed to facilitate semi-automatic transmission tests on circuits outgoing from these exchanges. All ARK exchanges will be equipped with TCAR relay sets to enable transmission testing to be carried out on circuits terminating at these exchanges.

Service Assessment

The APO provides service assessment facilities at the larger ARF and step type exchanges in order that the overall performance of the network and individual exchanges can be assessed from the customer's viewpoint. To achieve this, special circuits are required at the exchange to monitor live traffic. At present circuitry is under development to enable this facility to be extended to the larger ARK exchanges which are served by derived circuits. The system employed at present in Metropolitan areas requires a dc connection to the exchanges being monitored.

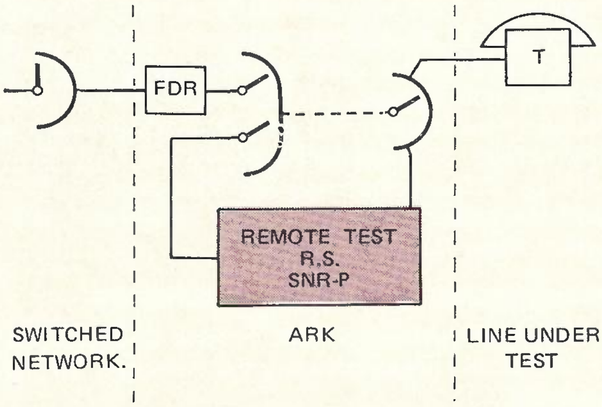


Fig. 3 — Remote Testing of ARK Subscribers' Lines

OPERATING COSTS ARK EXCHANGES

From Table 6 in part 1 of this article it will be noted that the labour usage rate of 1.3 manhours per telephone per year for crossbar exchanges in country areas is relatively high despite the fact that 44% of the equipment is of the ARK type which is very reliable (four visits per year for a typical 200 line unit). Factors which could contribute to these costs are the distance involved in some cases, the lack of test facilities for subscribers' lines and other routine maintenance practices in operation in various areas. Currently, a full-scale survey is being undertaken in order to determine more accurately the nature of the work load involved in these costs.

CONCLUSION

As in the case of the ARF equipment our experience over the past decade with ARK equipment and over the past six years with ARM equipment clearly confirms that crossbar plant correctly installed, and maintained by skilled staff will provide our subscribers with good quality service over a long period. Although we have not fully exploited the potential of this equipment with respect to operational economy, there is every indication that as the percentage of this modern plant in our network increases, we will achieve maintenance cost figures comparable with those recorded by overseas administrations with similar plant.

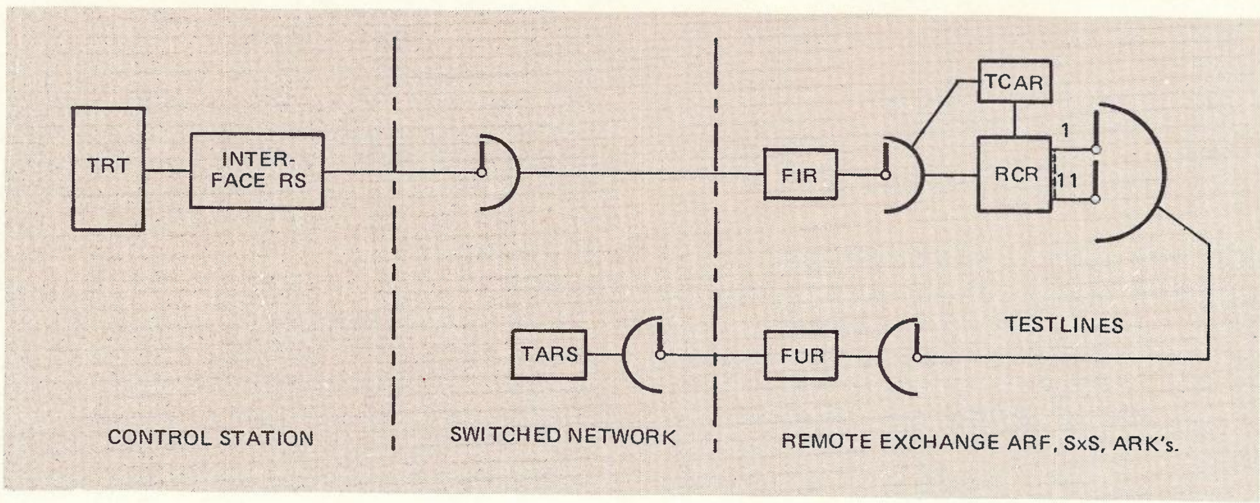


Fig. 4 — TRT Remote Call Repeater

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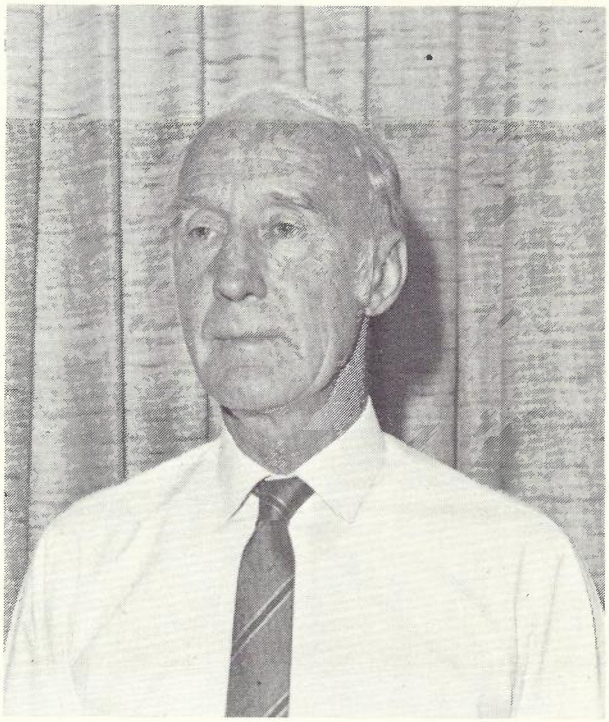
B. J. CARROLL is Senior Engineer, Operations and Study Section, Network Performance and Operations Branch APO Headquarters, See Vol. 19, No. 1, page 78 of this Journal.

Retirement of Mr. C. R. Anderson

Charles Anderson retired from the P.M.G.'s Department and from the position of Queensland Representative on the Board of Editors of the Telecommunication Journal of Australia on 19.1.73 after long and distinguished service in both areas. He joined the P.M.G.'s Department as a Telegraph Messenger in Portland, Victoria, on 6th June, 1922, transferred as a Junior Mechanic-in-Training in 1924, and progressed through the technical ranks. Studying assiduously he qualified as a Telecommunications Engineer in 1938 and is remembered mainly by his contribution to telephone equipment engineering, initially in Victoria and subsequently in Queensland. His particular speciality was Country Installations where he served the major period of his service in various ranks of Engineer. On retirement, his appointment was Engineer Class 5, Regional Operations Branch; but he left the Department from the position of Acting Assistant Director, Engineering.

Mr. Anderson served in the A.I.F. Signal Corps from 1941 to 1946 and for four years held the rank of Lieutenant Colonel. He successfully undertook Colombo Plan assignments in Ceylon and Malaya in the post-war period and was selected as Communications Liaison Officer for a number of Royal visits in recent years. He was honoured with the award of M.B.E. in the 1971 New Year Honours List. He was a Member of the Institution of Engineers, Australia.

Charles was a foundation member of the Telecommunication Society of Queensland formed in 1949 which later merged with similar Societies in other States to form the Telecommunication Society of Australia. His service as Journal sub-editor dates from 1949 and since then Charles has done much to encourage young writers and to assist them in the preparation of technical papers for publication in the Journal. He was awarded life membership of the Society in 1969.



Principles of Common Control in Crossbar Exchanges.

A. H. FREEMAN, M.I.E. Aust.

This article outlines the basic principles underlying the use of common control techniques in crossbar telephone exchanges. The switching and signalling principles of step by step type exchanges are first considered, and from this the common control concept as applied in particular to the ARF crossbar exchange system is developed. The nature of common control system traffic and common control system information signalling is also outlined. The article concludes with a brief review of the historical origins of common control systems.

Editorial Note: This article is a further chapter from a monograph on the principles of telephony to be published by the Telecommunication Society of Australia. The previous issue of this Journal contained the chapter dealing with principles of trunking and switching in automatic telephone exchanges. The article will be of interest to practically all readers of the Journal.

INTRODUCTION

An earlier article (Ref. 1) showed how switching units with the functions of pre-selection, group selection, or final selection can be constructed by using either mechanical switches with a large number of crosspoints, or crossbar switches or other devices with a limited number of crosspoints in a link trunked configuration. A crosspoint diagram of a relatively small exchange, in which all three types of selection were required, was also presented.

Larger exchanges are built up of a number of the above types of unit to provide the necessary interconnection of its terminations, together with a suitable means of controlling them to set up connections as ordered by the subscriber. These two parts are called the speech path network and the control equipment respectively, and both parts take quite different forms in step by step and crossbar networks.

In a step by step exchange or network, each selector function is performed in a single stage switch, and the necessary control equipment is permanently associated with each switch. This is illustrated in Fig. 1(a), which shows how a step by step exchange of 1000 lines could be constructed, if the requirement was limited to connecting these lines together, with no access to any other telephones.

Every subscriber's line is connected firstly to a uniselector, used for originating calls, and secondly to the bank contacts of a group of final selectors, used for terminating calls to all subscribers having the same hundreds digit in their number. When a call is originated, the uniselector belonging to the calling line searches for and switches to a free group selector. The first digit dialled (hundreds) steps the group selector wipers to the corresponding level, and the selector searches over that level to one of the free final selectors serving that hundreds group. The second (tens) digit steps the final selector to the "tens" level, while the third (units) digit steps it around to the position corresponding to the called subscribers line. Figs. 1(b) and 1(c) show progressively in less detail the configuration of the same exchange. The form shown in Fig. 1(c) is known as a trunking diagram and is used extensively to represent the main features of an exchange.

The trunking diagram of a 2000 line step by step exchange is shown in Fig. 2 and it can be seen that there are two stages of group selection. The first stage is operated by the 1000's digit and selects a free second selector of those serving the required 1000. Subsequent digits operate the second and final selectors as before. In large step by step exchanges and networks, each digit of the subscriber's number has to operate a separate selector stage and this characteristic is the reason for the designation "step by step".

In a crossbar system all the switching logic is external to the actual switches in common control devices, whose use is shared by many switches, and the dialled digits do not directly control switching stages. One result of this is that the switching configuration is usually not a direct representation of the numbering of the network. Fig. (3)(a) shows without any details of the control mechanism the speech path network of a 1000 line crossbar exchange located in a multi-exchange network.

There are two separately controlled link trunked stages. One is a combined pre-selector/final selector unit known as a subscribers (SL) stage which serves 1000 subscribers and can make two kinds of connection. On outgoing calls it connects the calling line to a group selector inlet using two partial stages as a pre-selector, while on incoming calls it connects a junction to the subscriber using all four partial stages. (For a larger exchange each 1000 subscribers has a separate SL unit). The other is a group selector (GV) stage, with two partial stages.

An outgoing call is connected via SLA and SLB preselection stages to a free group selector inlet where a "register" is temporarily connected to record the number dialled. After the full number of the called subscriber is dialled the register directs the group selector to select either a suitable outgoing junction or a link to the final selector. If a junction has been selected (because it is a call for another exchange) the next selector stage in the distant exchange or tandem can still request any or all digits of the called number from the register if necessary to control further switching. If it is a local call, a link to the SL stage is selected and only the three last digits are forwarded to the SL stage to allow it to switch to the called subscriber. The number of switching stages is independent of the number length since 3 or 4 digits may be used to switch the group selector on a local call, while on a tandem switched call several tandem stages may be positioned by the same number of digits.

A large exchange usually has two, or more group selector stages and Fig. 3(b) shows a 5000 line exchange, with an originating (1GV) stage and an incoming (GIV) stage.

It can be appreciated that in a crossbar system the speech path switches are almost devoid of switching logic and are basically "slaves" of the other parts of the exchange where the "intelligence" is concentrated in a relatively small number of devices. These devices, of which the most important are registers and markers, interwork on an exchange or network scale, so that to describe the control mechanism of a crossbar exchange or network requires a systems rather than a component oriented approach.

The rest of this article will therefore be devoted to consideration of the system design of crossbar signalling and control. In order to do so it will be necessary to make some unsupported statements about the properties of the various elements of the system which cannot be fully demonstrated until later when detailed descriptions of these elements will be given. However, without taking these liberties it is almost impossible to show how crossbar has evolved into its present form.

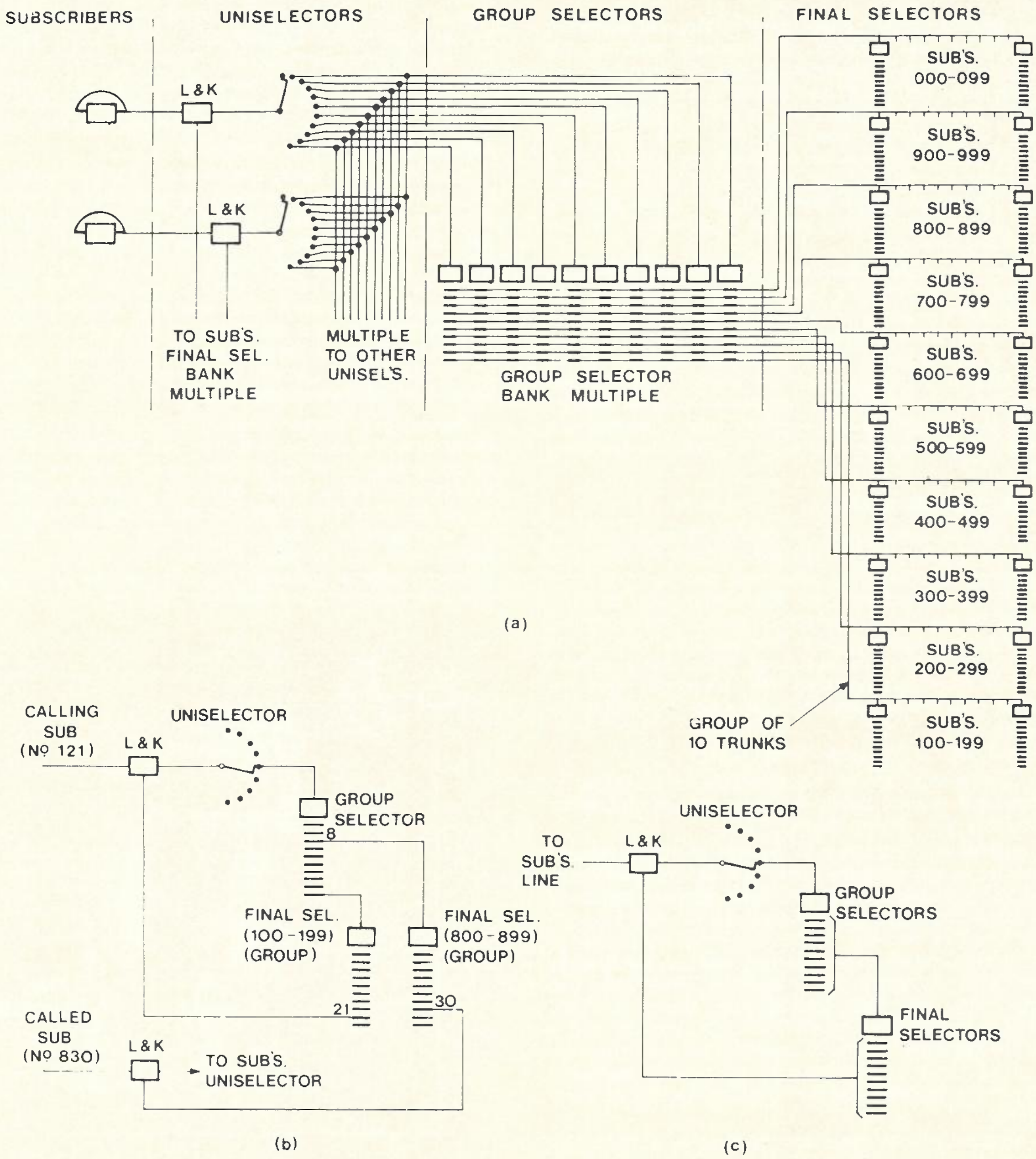


Fig. 1 — Principle of 1000 Line Exchange.

THE NEED FOR COMMON CONTROL

The first crossbar switch was invented in 1912 but proved to be ahead of its time, because the only trunking configurations known required one crossbar switch to be used as a single 100 (or 200) outlet selector by paralleling the inlets to the 10 verticals. In this form it was so much more expensive than a step by step group selector that its other advantages of reliability and easy maintenance were completely outweighed, except for a few obscure applications. Thus for 25 years the only applications of crossbar were in very small rural exchanges, which were so reliable that they could be installed in remote villages which might be snow bound for weeks in the winter, and for register finder circuits in a system based on mechanical switches, where it was chosen because of its high speed of operation.

In the late 1930s the possibility of crosspoint economy by the use of link trunking was realised, and for the first time it became conceivable that a crossbar exchange of large size could be built at a cost competitive with other systems, and with the inherent advantages of reliability and fast switching. At the same time, the complexity of the process of choosing an outlet and a path through a link trunking selector is much greater than that of single stage selection, and some form of common control was an essential complement to the use of link trunking.

The idea of common control is simply this: "Because the process of selecting a path through a selector and operating the necessary crosspoints can be completed in less than a second, while the path so set up will be used for a conversation lasting several minutes, a few sets of control equipment can be used to control the setting up of calls for a large number of selector inlets." Just how many controls are required and how they are associated with selector inlets is a traffic engineering problem.

CONTROL SYSTEM TRAFFIC

Every time a switch inlet is seized, it must seize a control, and hold it for the period needed to complete its switching process. This procedure can be described as a "call" to the control from the switch inlet, of duration equal to the time required to control the switching — this duration being called "service time." It is not difficult to see that if a group of inlets carry speech calls of average holding time "T" (seconds) and the associated controls require "t" (seconds) to switch the call, then

Control Traffic = Speech Traffic x(t/T)

This relationship is of considerable importance in control system design, being the most convenient means of estimating the control traffic.

The control circuits used to control switching stages are usually called markers, and one of the significant features of markers is that the total marker traffic of even a large exchange is extremely small. For example consider the 1st Selector (1GV) stage in an exchange with 5000 subscribers and a calling rate of .04 Erlangs per line. This is typical of a medium sized suburban exchange, and the 1GV speech path traffic is 200E. Assuming a call holding time (T) of 100 seconds, and a marker holding time (t) of 0.5 seconds, we get a marker traffic of 1E, and it is necessary to provide sufficient markers and a suitable marker coupling facility to carry this traffic.

One possibility is to have the markers in a full availability group, so that any inlet can use any marker as shown schematically in Fig. 4 (a). If not more than 1 call in 500 is allowed to fail because of all markers being busy 6 markers are necessary, so that the average traffic per marker is 1/6E, i.e. each marker is idle five sixths of the time. As a typical marker is a very large item of equipment which can cost several thousand dollars, this very light usage is a serious matter.

QUEUEING OF MARKERS

The only way to increase the traffic efficiency for such small quantities of traffic is by queueing. In a queueing or delay access system a call which arrives when there is no free device available to serve it is not rejected, but instead is allowed to wait in a "queue" until a serving device is available. In such a system no call need be lost provided a long enough queue can be accommodated and the queueing delays are acceptable. The design criterion for such a system is therefore not lost calls, but the distribution of waiting times for delayed calls. Usually only one or two points on the distribution are specified, and for markers the APO has specified that less than 1% of calls are delayed by one second or more in reaching a marker. Such delays are barely noticeable to the customer, so the resulting service impairment is unimportant.

Calculating the delay distribution in a queueing system is a far more complex traffic engineering problem than calculating the probability of loss in a lost calls system, and exact solutions are available only for a limited number of very simple cases. One such case is where there is only a single server (marker), with constant holding time for each call, and Fig. 5 gives the delay distribution for this case for a number of values of marker traffic. The time scale in this figure is in units of holding time, which is a standard procedure to normalise the representation.

Assuming a marker holding time of 0.5 seconds the delay criterion is that less than .01 of calls are delayed by more than 2 holding times and it can be seen that this is met with a traffic of 0.28E on the marker, which is greater than the traffic carried by each marker in the full availability no delay group of 6 markers discussed earlier and performance meeting the standard can be achieved with 4 markers. Fig. 4(b) shows schematically the arrangement for 4 markers and 320 inlets.

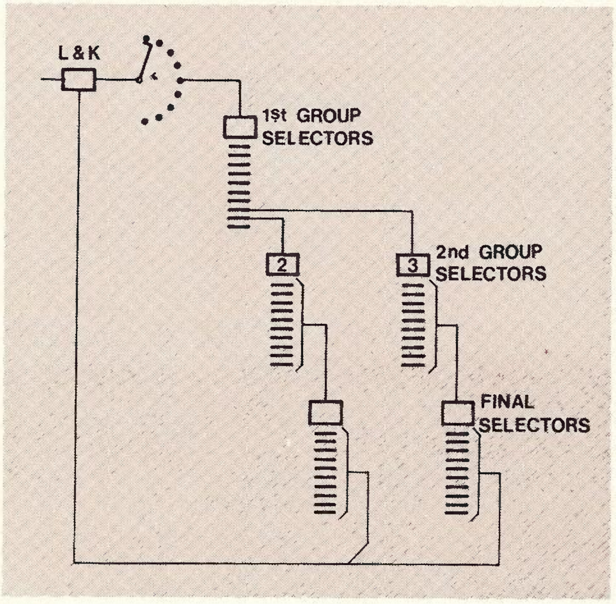


Fig. 2 — 2000 Line Step-by-Step Exchange.

Obviously, at the traffic levels, and for the operating times applicable to crossbar markers, delay access is a very powerful method of increasing marker loading; so powerful in fact that it permits markers to operate as independent units with satisfactory efficiency. This method of working means that the switching stage inlets are divided into blocks with each block being controlled by a single marker. The coupling arrangements between inlets and markers are much simpler for this configuration than when each inlet has access to a group of markers, and this configuration is used wherever possible. Typically, one marker will serve between 40 and 160 inlets depending on the traffic, and the marker holding time.

REGISTERS AS BUFFER STORES.

The use of delay access has a number of subsidiary requirements which tend to offset the economies. Firstly, the marker must receive routing information to control the switching and with delay access this must be available *at the precise time the marker is ready* — no earlier, or the information would be lost and as far as possible

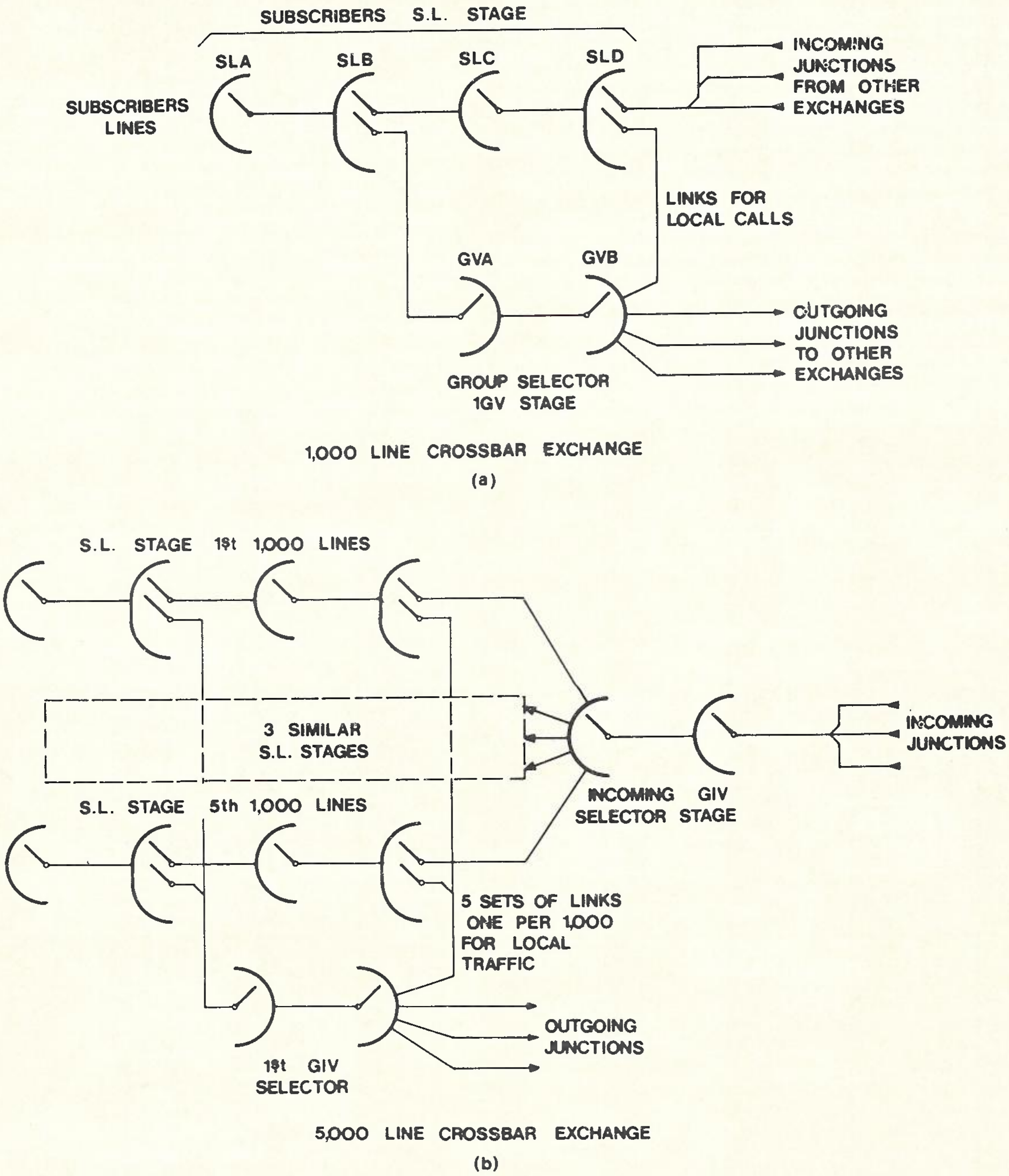


Fig. 3 — Crossbar Exchanges.

no later, or the marker holding time will be unnecessarily increased. Since the time at which the marker is connected is unpredictable this means that the marker has to ask for routing information when it is ready and two way information transfer between the marker and the source of information is essential. A corollary of this is that the source cannot be a subscribers dial and that a buffer store must be inserted between the subscriber and the markers. This buffer store is usually called a register, and is also a piece of common equipment. As the register must always have the necessary information to reply to any request from a marker, it must not start to set up the call until the full wanted number is stored, so that post dialling delay is inevitable and usually long enough to be noticeable. These various requirements and conditions are interdependent, so that there is in effect a package deal involved; marker costs can be reduced by using delay access, which permits increased loading and if desired less complex marker coupling arrangements, provided all the following conditions are accepted:

(i) Registers are provided to receive the subscriber's dialling and act as a buffer store.
(ii) A bothway information signalling system is provided between registers and markers.
(iii) The resulting post dialling delays are accepted.

In the crossbar system this package is the only method which produces a control system capable of competing economically with the other types of system.

CONTROL SYSTEM (INFORMATION) SIGNALLING

The choice of a signalling system between markers and registers is an important factor in producing a satisfactory crossbar system. The marker service time per call includes the time needed to signal between register and marker and therefore if the signalling time can be reduced, there is a corresponding reduction in marker traffic, and each marker can control more inlets. Assuming 100 seconds holding time per call, the speech path traffic which one marker can control for three different marker holding times is given in Table 1.

TABLE 1

Marker Holding Time	Traffic Per Marker	Corresponding Speech Path Traffic
1 Sec.	.15E	15E
0.5 Sec.	.28E	56E
0.33 Sec.	.38E	114E
0.25 Sec.	.48E	192E

It can be seen that halving the marker holding time allows a marker to control considerably more than twice as much speech path traffic, and that therefore there is an economic incentive to reduce marker holding time and a high speed signalling system between marker and register can be good sense economically apart from any other advantages.

Multifrequency Code (MFC) signalling as used in LME crossbar is an important element in reducing marker holding times sufficiently to allow them to be organised as single independent markers controlling a discrete part of the exchange.

This of course requires the exchange to be designed so that it is built up of appropriately sized modules and in the original form these modules were 1000 line subscriber (SL) stages, and group selectors of 2 partial

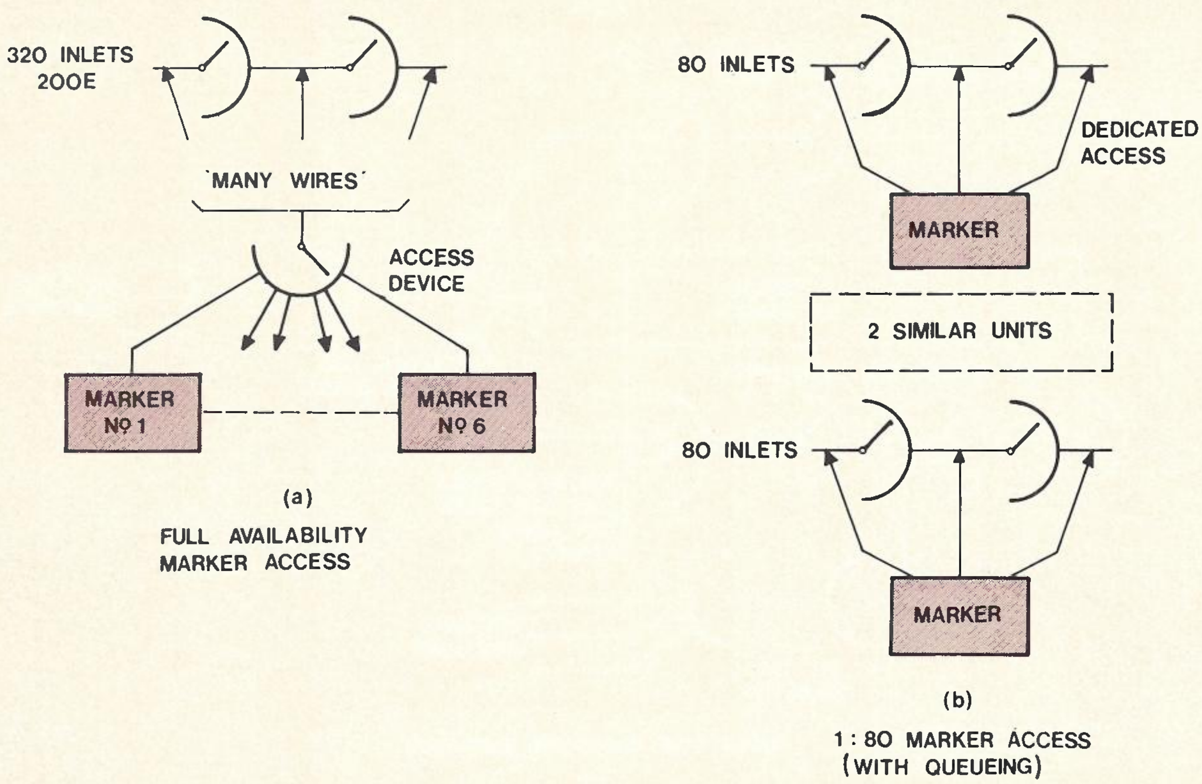
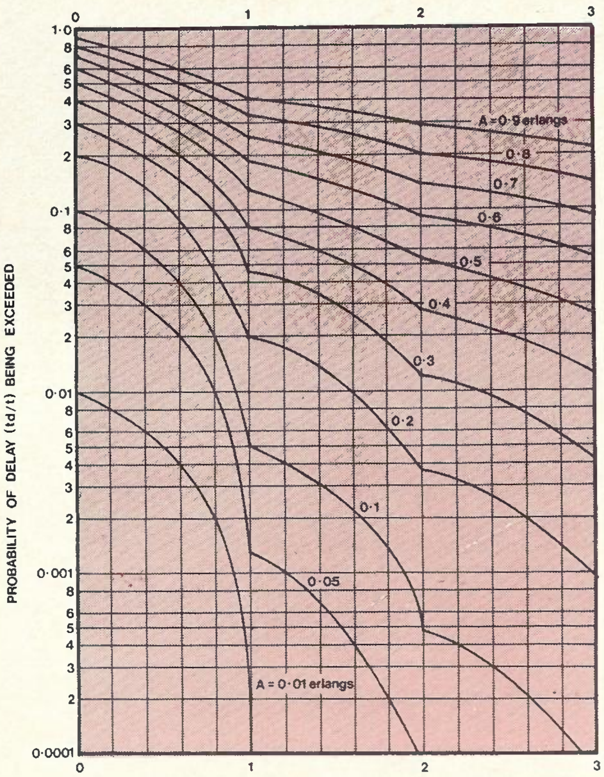


Fig. 4 — Marker Access.



DELAY (td/t)

DELAY CURVES FOR CONSTANT SERVICE TIME WITH ONE MARKER AND CALLS SERVICED IN RANDOM SEQUENCE

t MARKER HOLDING TIME
td DELAY DUE TO QUEUING
A MARKER TRAFFIC

Fig. 5 — Delay Distribution.

stages with 80 inlets and 400 outlets. Since then it has been possible to design a 3 partial stage group selector with single marker control, giving more efficient use of junctions. The limitations of single marker working prove too restrictive for trunk exchanges where the external circuits are more expensive and therefore the ARM trunk exchange has a configuration in which up to 20 markers may simultaneously control the one large block of switches over four partial stages, but this is the only significant use of multiple markers in LME crossbar.

The registers are both a buffer store and signalling conversion device, and for each call a register is held from the time the subscriber signals that he is about to call (by removing the handset) until the connection to the called number is complete, so that typical holding time is 15 seconds giving register traffic of the order of 15% of speech path traffic or 30 Erlangs for the 5000 line exchange being used as an example. Because the register traffic is much larger than marker traffic, reasonable efficiency can be obtained without queueing, and at the same time the holding time is so great that queueing could only give a great increase in efficiency if very long delays were permitted. For these reasons, access to registers is via "register finders" operating as a lost call system and with availabilities of about 20.

The signalling and switching sequence of a call in a crossbar network, and the devices that are involved are:

(1) Subscriber commences call (i.e. removes handset).
(2) Subscriber is connected to register (and receives dial tone).
(3) Subscriber dials into register.
(4) When register has stored a complete number it calls the first marker.
(5) Marker and register interchange signals, marker switches call through its stage, causing next marker to be called and then drops off.
(6) Second and subsequent markers repeat step 5. Last marker signals "connection complete" or "end of selection" to register.
(7) Register drops off.
(8) Called party's bell rings.
(9) Called party answers and conversation takes place.
(10) Call is metered.
(11) Call is cleared.

The signals involved in the above steps are grouped into two categories. "Line Signals" are those which must be received and acted on by equipment permanently associated with the speech path, and "Information signals" which are those which are received and acted on by markers or registers.

Line Signals include all signals above except those in steps 3, 5 and 6. Since they must be transmitted, identified and acted on by equipment permanently associated with the speech path, a fairly simple and economical system is desirable. Meeting these requirements is helped by the relatively low information transfer rate needed, and the small number of distinct signals that need to be recognised. Within a small network with physical junctions they are carried by DC signals over the speech pairs, while carrier systems are provided with low speed binary signalling channels for the same purpose. Signalling conversion and repetition relay sets are needed at various points in the system and these are called line relay sets. The signal "call marker" is also transmitted via the line signalling system and is classified as a line signal.

Information signals are present only at defined times at the beginning of a call, and the start of a sequence of information signals is announced by a line signal, i.e., "Subscriber calls" or "call marker". Because these signals are received, and (except the subscribers original dialling), sent by items of common equipment shared by many inlets, it is possible to use more exotic signalling systems. The structure of the exchange is such that the speech path which will later be used for conversation is available between the register and the marker, permitting a fast high-speed tone signalling system to be employed.

Fig. 6 shows the devices concerned with signalling and control added to the speech path trunking of Fig. 3. These devices are:

(1) The cord circuit (SR) relay set which is placed at the IGV inlet, and which handles most of the line signals to or from the two telephones in a call. The signalling currents are also used to provide power for the microphones in the two telephones.
(2) A supplementary switching stage known as a register finder (RS) associated with the SR relay set, which provides a connection to a register when required.
(3) Registers (Reg-L) reached via the RS stage.
(4) Markers (GVM) associated with the IGV and GIV selector stages, with one marker per 80 or 160 selector inlets.
(5) Markers (SLM) associated with the SL stage with one marker to each 1000 line group. This marker will connect a calling subscriber to an SR relay set

for outgoing traffic and an SLD inlet to the called subscriber on an incoming call.

(6) Line relays (LR/BR), one pair for each subscriber, whose main function is to recognise an outgoing call and provide a busy test.

(7) Junction relay sets (FIR and FUR) to provide an interface between the signalling conditions on the line and those within the exchange and to transfer signals across the interface.

DEVELOPMENT OF COMMON CONTROL SYSTEMS

Some readers may be intrigued that a control mechanism so devious and at the same time so powerful ever came into existence, and a short digression into history may be of interest.

The system naturally was not invented from scratch in the 1930s, when the need arose, but depended on earlier developments, going back almost to the beginning of automatic telephony. The first element to be developed was the buffer store, with two way signalling between the switch and the buffer store. In its first form the buffer store was not a common control unit but was the subscriber's calling device. It had 3, and later 4 slide switches on which the desired number was set up *before* the subscriber pressed a call button. The first selector then began stepping, sending back an impulse on one leg of the subscriber's line for each step. These impulses stepped a rotary switch until it was on the position marked on the calling device for the first digit. A "stop" signal was then sent to the selector on the other leg of the line, the selector searched and reached a free second selector and the same procedure was repeated. Fig. 7 shows the circuit principles involved.

The motives for this bizarre system were twofold. Firstly, this system did not require the switches to be in step with a dial and allowed the use of robust switches driven from a rotating shaft via clutches. It was claimed, and with justice, that this kind of switch could be made more robust than a ratchet and pawl drive switch. (The rotating drive shaft was driven from a single motor of about one horsepower to serve all switches in the exchange.) Secondly, since the telephone dial was already patented by the most successful competitor, some clearly different calling device was needed.

This system was able to compete with Strowger step by step equipment and was in service as early as 1906, while by 1910 it had inspired the development by Western Electric of the "Rotary" system. In this system a true register was provided, coupled to the line via a register coupler. The subscriber had an ordinary dial which set switches in the register that corresponded to the slide switches on the subscriber's calling device of the earliest system. The same type of two way signalling was used and it had now received the name of "revertive signalling". The Rotary system proved to be very satisfactory and was used extensively in France and

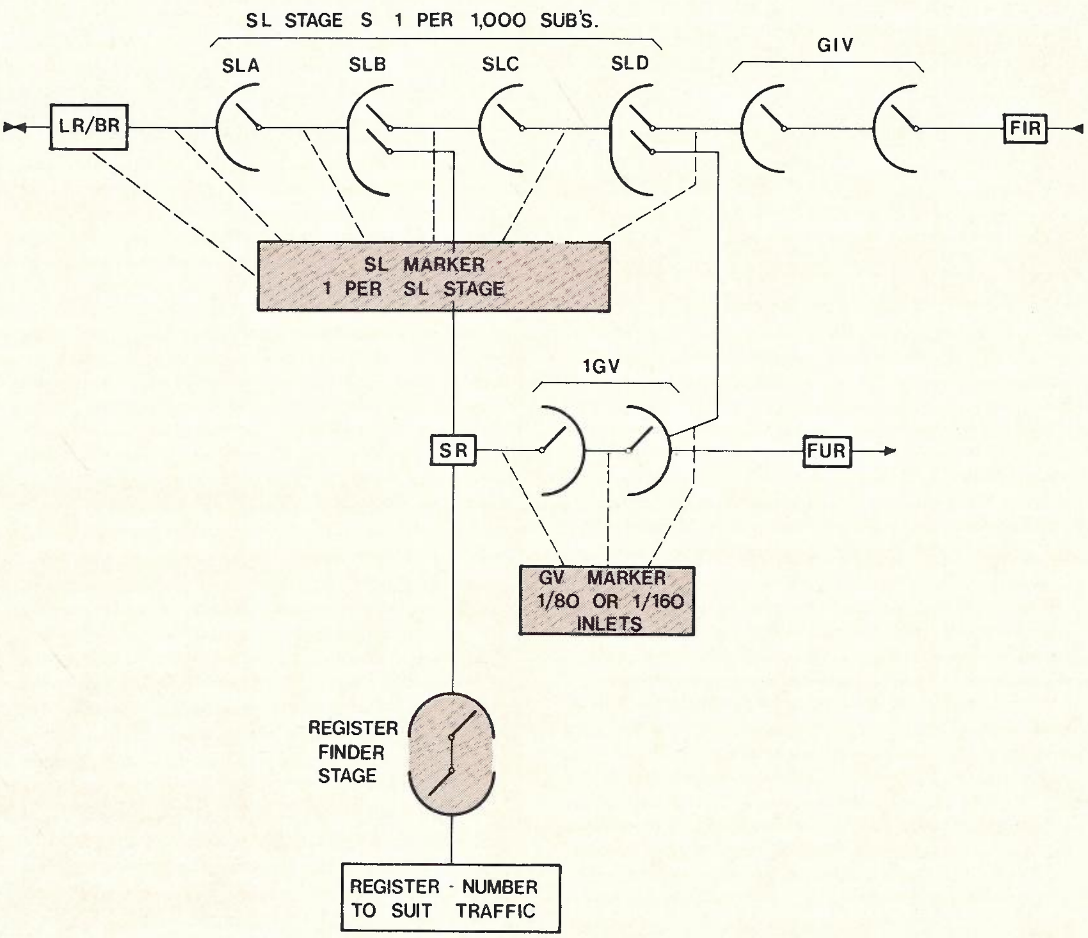


Fig. 6 — Control Equipment in ARF Exchanges.

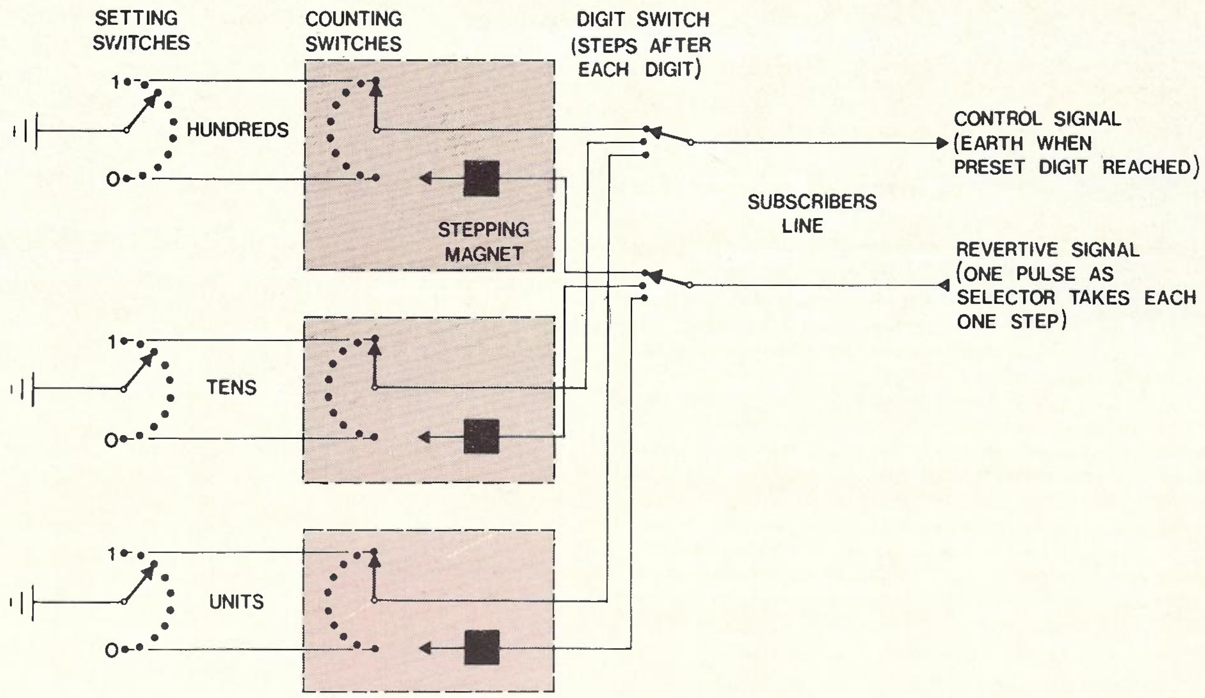


Fig. 7 — Principle of Revertive Signalling.

Belgium in particular, including the Paris telephone system. With further developments it continued to be manufactured until after 1950. Two other systems, the Western Electric Panel System and the LME 500 outlet switch system employed virtually the same technique and design details, but with different switch mechanisms and both were very widely used.

This line of development produced the register as a buffer store, and the idea of two way signalling as a means of ensuring that the signalling timing suited the switch. In fact, the switch controlled the timing and the register waited till the switch condescended to send back its revertive pulses. The selector switches used mechanical logic for most of their functions, and control circuits were simple and individual to each switch. As far as possible in these early systems any complex intelligence needed to create complex network configurations was concentrated in the register.

The use of common controls for switches was extensively pursued in the 1930s with the development of a variety of competing systems using simple switches (usually uniselectors) with relay logic replacing mechanical logic. Most of these systems failed to dislodge the established step by step and machine drive systems, one notable exception being the Siemens motor uniselector. However, in this period many common control configurations were tried, and it was realised that the machine drive systems using revertive signalling could use common controls for the switches on a delay access system to add new facilities, such as those needed for automatic trunk switching.

Thus it was that by the mid 1930s when link trunking was being developed for crossbar switches in Sweden all the necessary control techniques were already in existence in the 500 point switch system, and there was a large body of engineering experience to guide the designers in the direction they followed.

At that time the best that could be done in respect to register to marker signalling was a high speed dc signalling system about three times as fast as loop disconnect dialling. This was a reasonable compromise between speed and economy and for local networks the post dialling delay was acceptably short, indeed much less than any other system suitable for large cities. The system, known as ARF101 was one of the first successful crossbar systems for large networks, and many parts of the ARF 102 system used by the APO are almost unchanged from that design. The development of transistors and more economical tuned circuits made it possible by about 1955 to introduce MFC signalling with even higher signalling speed and the potential of providing numerous special facilities that could not be given with the simpler dc signalling scheme.

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A. H. Freeman, 'Principles of Trunking and Switching in Automatic Telephone Exchanges'; Telecomm. Journal of Aust., Feb. 1973, Vol. 23, No. 1, page 18.

A. H. FREEMAN is Supervising Engineer, Fundamental Planning, New South Wales. See Vol. 18, No. 3, page 287 of this Journal.

Answers to Examination Questions

Examination No. 6230, held 30th October 1971 and subsequent dates to gain part of the qualifications for eligibility for promotion as Telecommunications Technical Officer.

PART 1 — ELECTRICAL TECHNOLOGY

Note: Although these answers are representative of the type of answer anticipated by the examiners, they are not necessarily typical of those received from candidates. However, any alternative answer submitted would have been assessed on the method of approach to the problem and the practibility of the solution.

When alloting marks in this type of examination the following general features of the candidate's paper would also be taken into consideration:

- In numerical calculations, accuracy to three significant figures is expected. Candidates who worked to only two significant figures, or who worked to a pseudo accuracy of five or more significant figures could expect to lose marks.
- The candidate would be expected to express himself clearly and consisely in good English.

SECTION A

Question 1.

(a) A conductor carries a current of 10 A at right angles to a magnetic field having a density of 0.5 T. What is the force on the conductor in newtons per metre length?

(b) The current through a coil having an inductance 0.4 H is reduced from 4 A to 2 A in 0.04 s. What is the mean value of the e.m.f. induced in the coil?

(c) Express ampere-turns in terms of magnetic flux and reluctance.

(d) Define 'electronvolt'.

(e) Express in polar form the impedance represented by Z = (20 — j20) ohms.

(f) What is the frequency of an alternating voltage described by the expression e = 3 sin 12560 t volts?

(g) Give the relationship between line and phase voltages in a 3-phase star connected system.

(h) A triode has an amplification factor of 15 and an anode a.c. resistance of 15 kilohms. What is its mutual conductance?

(i) Under what circuit conditions would the decibel power gain and the decibel voltage gain of an amplifier be the same?

(j) The diode shown in Fig. 1 has a forward voltage drop of 0.7 V and offers infinite resistance in the reverse direction. Sketch the output voltage, Vo, if the generator signal is a sine wave with 3 V peak.

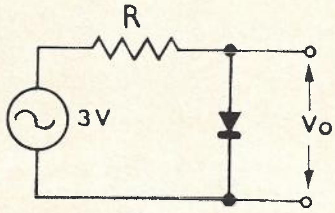


Fig. 1

Answer 1.

(a) $F = B.I.$, so $\dfrac{F}{l} = 0.5 \times 10 = 5\text{N/m}$

(b) $E = -L \dfrac{di}{dT}$ volts $= -0.4 \times \dfrac{(2-4)}{0.04} = 20\text{V}$

(c) Ampere-turns = Magnetic flux × reluctance.

(d) Work done when an electron is moved through a pd of 1 volt.

(e) $Z = (20^2 + 20^2)^{1/2} \tan^{-1}\left(\dfrac{-20}{20}\right)$

$= 28.3 \angle -45°$ ohms

(f) $f = \dfrac{\omega}{2\pi} = \dfrac{12.56 \times 10^3}{6.28}$

$= 2$ kHz

(g) $VL = \sqrt{3}\ VP$ or $VL = 1.73\ VP$

(h) $gm = \dfrac{\mu}{ra} = \dfrac{15}{15 \times 10^3} = 1000\,\mu$mhos or 1 mA/V.

(i) When input and out impedances are identical

(j) See Fig. 2.

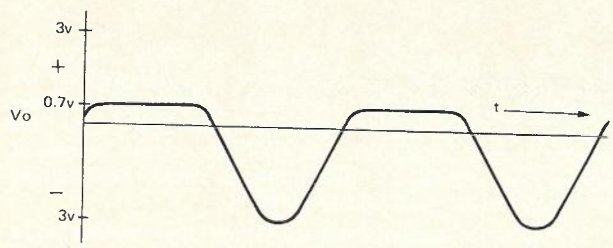
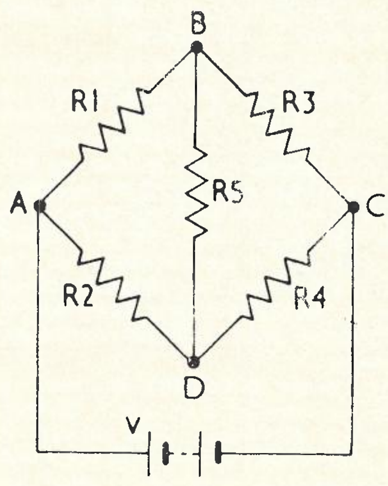


Fig. 2

Question 2.

From the given data, determine the value of the current flowing in R5 in the circuit shown in Fig. 3.



R1 = 10 ohms
R2 = 20 ohms
R3 = 40 ohms
R4 = 30 ohms
R5 = 25 ohms
V = 3 volts

Fig. 3

Answer 2.

Solution 1 — Kirchoff's Laws

Assume currents I1, I2 and I3 as shown in Fig. 4

then $I_{BC} = I_1 - I_3$

$I_{DC} = I_2 + I_3$

Taking mesh ABECA, then:

$3 = 50\,I_1 - 40\,I_3$ ......(i)

For mesh ABDA, $0 = 10\,I_1 + 25\,I_3 - 20\,I_2$ ......(ii)

For mesh BDCB, $0 = 25\,I_3 + 30\,(I_2 + I_3) - 40\,(I_1 - I_3)$

$= -40\,I_1 + 30\,I_2 + 95\,I_3$ ......(iii)

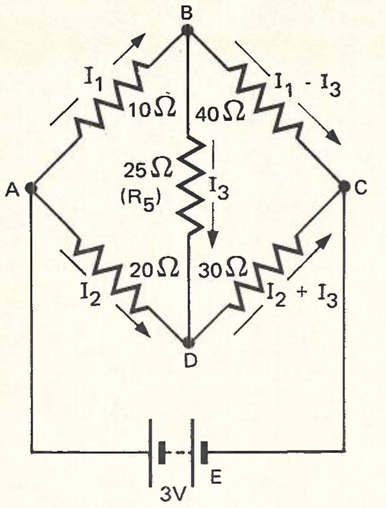


Fig. 4

Solve for I1 in terms of I3 by multiplying (ii) by 3 and (iii) by 2.

then $0 = 30\,I_1 - 60\,I_2 + 75\,I_3$

$0 = -80\,I_1 + 60\,I_2 + 190\,I_3$

Add $0 = -50\,I_1 + 265\,I_3$,

hence $I_1 = \dfrac{265}{50}\,I_3 = 5.30\,I_3$ ......(iv)

Substitute this value for I1 in (i),

$3 = 50 \times 5.30\,I_3 - 40\,I_3$

$3 = 225\,I_3$

hence $I_3 = \dfrac{3}{225} = 0.0133$ A or 13.3 mA

Solution 2 — Thevenin's Theorem

Remove R5, then pd A—B $= 3 \times \dfrac{10}{10 + 40} = 0.6\text{V}$

(see Fig. 5)

pd A—D $= 3 \times \dfrac{20}{20 + 30} = 1.2\text{V}$

Hence pd B—D $= 1.2 - 0.6$

$= 0.6\text{V}$ (B + ve to D)

Replace battery with its equivalent internal resistance. Since the circuit indicates that it is negligible, junction A—C can be shorted.

Resistance of BA/BC $= \dfrac{10 \times 40}{10 + 40} = 8$ ohms

Resistance of DA/DC $= \dfrac{20 \times 30}{20 + 30} = 12$ ohms

Resistance between B and D $= 8 + 12$

$= 20$ ohms

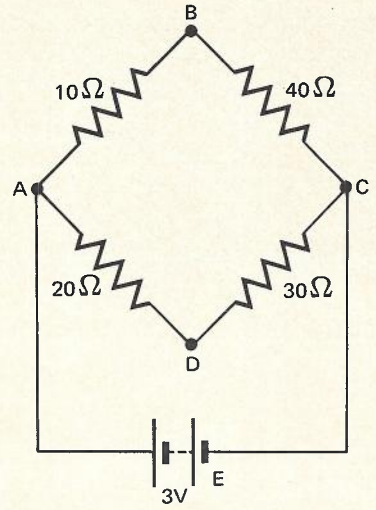


Fig. 5

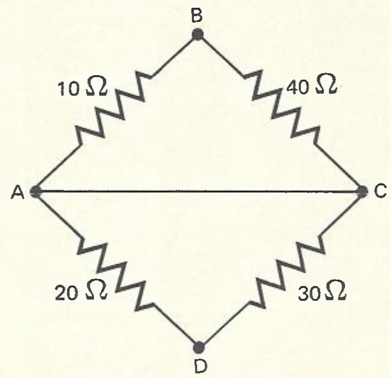


Fig. 6

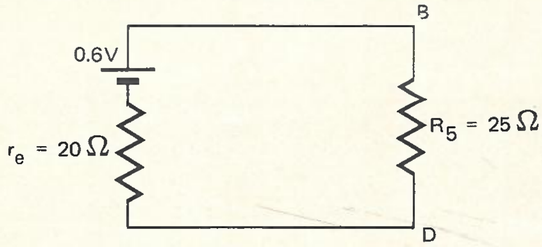


Fig. 7

The Thevenin equivalent of the network is now as shown in Fig. 7, hence current in R5 is

$I_{R5} = \dfrac{0.6}{20 + 25} = \dfrac{0.6}{45} = 0.0133\text{A}$ or 13.3 mA

Question 3.

A symmetrical alternating voltage had the following instantaneous values, in millivolts, measured at equal intervals of time over one half cycle.

0, 4. 8. 12, 12, 12, 0.

The voltage varied in a linear manner between successive intervals.

Sketch the wave-form over one half cycle and determine:

(a) the average value;

(b) the r.m.s. value; and

(c) the form factor.

Answer 3.

See Fig 8.

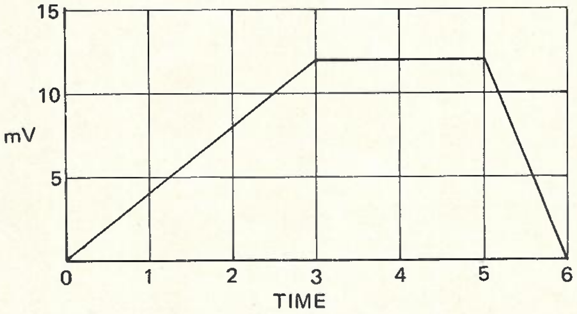


Fig. 8

From the values given, the mid-ordinate values will be 2, 6, 10, 12, 12, 6 mV.

(a) Average value

$$= \frac{e_1 + e_2 + \ldots\ldots e_n}{n}$$

$$= \frac{2 + 6 + 10 + 12 + 12 + 6}{6}$$

$$= \frac{48}{6} = 8\text{ mV}$$

(b) r.m.s. value

$$= \sqrt{\frac{e_1^2 + e_2^2 + \ldots\ldots e_n^2}{n}}$$

$$\sqrt{\frac{(2^2 + 6^2 + 10^2 + 12^2 + 12^2 + 6^2)}{6}}$$

$$= \sqrt{\frac{464}{6}}$$

$$= \sqrt{77.33}$$

$$= 8.80\text{ mV}$$

(c) Form factor

$$= \frac{\text{r.m.s. value}}{\text{average value}}$$

$$= \frac{8.8}{8} = 1.1$$

Question 4.

The characteristics of a junction transistor are given in the following table:

Collector voltage (V)	*Collector current (mA)*		
	Ib = 25μA	Ib = 50μA	Ib = 75μA
1.0	*1.7*	*3.3*	*5.0*
4.0	*1.9*	*3.7*	*5.6*
6.0	*2.1*	*4.0*	*6.0*

The transistor is used in a common-emitter stage with a collector load resistance of 600 ohms and a collector supply voltage of 6.0V. If the transistor operates with 50μA bias current, draw the load line and determine:

(a) the quiescent collector voltage,

(b) the total voltage swing at the collector for a sinusoidal input signal of 25μA peak, and

(c) the current amplification.

Answer 4.

The characteristics are plotted as shown in Fig. 9. The points for constructing the load line are determined as below and joined to provide the load line.

(i) When Ic = O, Vc = supply voltage = 6V (Point P)

(ii) When Vc = O, Ic $= \frac{6}{600} =$ 10mA (Point Q)

(a) With 50μA bias, Point D is the quiescent operating point, at which Vc = 3.76V.

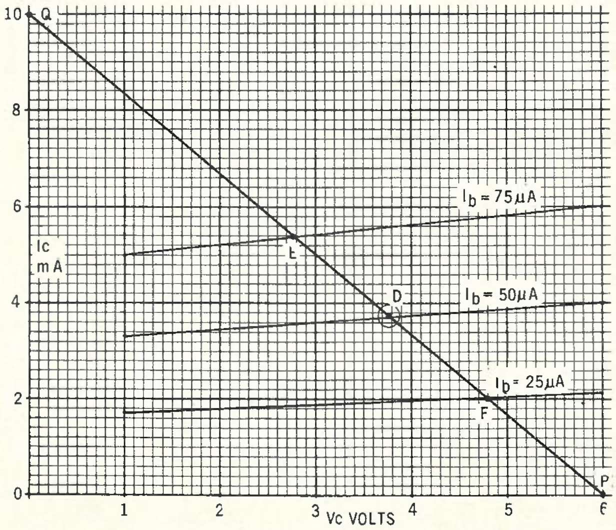


Fig. 9

(b) With 25μA peak signal, base current will vary between 75μA and 25μA, hence Vc will swing between points E & F,

= 4.76 — 2.78 = 2.0V

(c) Current amplification

$$= \frac{\Delta Ic}{\Delta Ib} = \frac{(5.35 - 2.0)}{50 \times 10^{-3}}$$

$$= \frac{3.35}{5} \times 10^2$$

$$= 67.0$$

SECTION B

Question 5.

(a) Two conductors made of the same metal have the same volume. One conductor is 10 metres long and has a resistance of 0.06 ohms. Find the resistance of the other conductor if it is 30 metres long.

(b) Two coils having resistances of 12 ohms and 16 ohms respectively are connected in parallel across a battery having an e.m.f. of 9V and internal resistance 1.4 ohms. Calculate the energy in joules dissipated in the 16 ohm coil in five minutes assuming the current remains constant for this period.

Answer 5.

(a) Resistance of 10m conductor = 0.06 ohms

The length of the second conductor is 3 times the first, and as the volume is the same, the area will be 1/3 of the first.

Resistance is proportional to $\frac{\text{length}}{\text{area}}$

Hence, the resistance of the 30 m conductor

$$= \frac{3}{1/3} \times 0.06 = 9 \times 0.06 = 0.540 \text{ ohms}$$

(b) Equivalent resistance of the 12 and 16 ohm branch

$$= \frac{12 \times 16}{12 + 16} = \frac{192}{28} = 6.86 \text{ ohms}$$

$$\text{Circuit Current} = \frac{9}{6.86 + 1.40} = \frac{9}{8.26} = 1.09\text{A.}$$

$$\text{P.d across 16 ohm} = 9 - (1.4 \times 1.09) = 9 - 1.51 = 7.45\text{V}$$

$$\text{Energy} = \frac{(7.45)^2 \times 5 \times 60}{16} \text{ joules} = 1060 \text{ joules.}$$

Question 6.

Determine an equivalent series circuit for the circuit shown in Fig. 10 and calculate the value of the supply voltage V, if the p.d. across R3 is 2V, and R1 = 200 ohms, R2 = 90 ohms, R3 = 10 ohms, XL = 90.5 ohms and XC = 88.5 ohms.

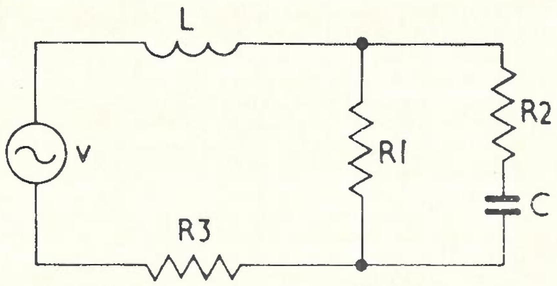


Fig. 10

Answer 6.

Step 1: Combine the parallel group into a single impedance, ZS.

$$\text{Then ZS} = \frac{ZX \times ZR}{ZX + ZR}$$

$$\text{where ZX} = R2 - jXc = 90 - j88.5 = \sqrt{90^2 + 88.5^2}\,\angle \tan^{-1}\left(\frac{88.5}{90}\right) = 126\,\angle{-44.6^\circ}$$

$$\text{and ZR} = R1 + j0 = 200 + j0 = 200\,\angle 0^\circ$$

$$\text{Hence ZX + ZR} = 290 - j88.5 = \sqrt{290^2 + 88.5^2}\,\tan^{-1}\left(\frac{88.5}{290}\right) = 303\,\angle{-17.0^\circ}$$

Step 2.

$$\text{ZS} = \frac{(126\,\angle{-44.5^\circ})\;(200\,\angle 0^\circ)}{303\,-\angle 17.0^\circ}$$

$$= \frac{126 \times 200}{300} \times \angle(17^\circ - 44.5^\circ)$$

$$= 83.3\;{-27.5^\circ} = (73.7 - j43.3)$$

$$= [83.3 \cos(-27.5^\circ)] + [j\,83.3 \sin(-27.5^\circ)]$$

$$= (73.7 - j38.5) \text{ ohms.}$$

Step 3. Hence equivalent series circuit,

$$\text{ZT} = \text{ZL} + \text{ZS} + \text{ZR3}$$

$$= (0 + j90.5) + (73.7 - j38.5) + (10 + j0)$$

$$= 83.7 + j52.0 = 96.2\,\angle 29.5^\circ$$

$$= \sqrt{83.7^2 + 52^2}\,\tan^{-1}\frac{52.0}{83.7}$$

$$= 98.6\,\angle 31.9^\circ$$

Thus the equivalent series circuit is an 83.7 ohm resistance in series with 52.0 ohm inductive reactance.

$$\text{I} = \frac{\text{VR3}}{\text{ZR3}} = \frac{2\,\angle 0^\circ}{10} = 0.2\,\angle 0^\circ \text{ A}$$

$$\text{V} = \text{IZT} = 0.2\,\angle 0^\circ \times 96.2\,\angle 29.5^\circ = 0.2 \times 96.2\,\angle 31.9^\circ = 19.2\,\angle 31.9^\circ \text{ V}$$

Question 7.

(a) Write brief notes comparing Leclanche dry cells and mercury cells with respect to:
(i) terminal voltage;
(ii) size; and
(iii) shelf life.

(b) Define ampere-hour efficiency of an accumulator and give an approximate value for a lead-acid cell.

Answer 7.

(a) Terminal Voltage: The Leclanche dry cell has an e.m.f. of about 1.5V when new, but due to polarisation, this e.m.f. falls fairly rapidly if the cell is in continuous use. However, depolarising action continues when the load is disconnected from the cell and the e.m.f. tends to recover its normal value. Hence its main application is for intermittent usage.
The mercury cell maintains its terminal voltage practically constant at about 1.2 to 1.3V for a relatively long time due to the absence of polarisation.
Size: The capacity of the Leclanche dry cell falls off rapidly as the size is reduced. On the other hand the mercury cell has a high ratio of output energy to mass and can be made very much smaller than the Leclanche cell for an equivalent capacity.
Shelf Life: Local action in the Leclanche cell limits its shelf life to about 2 years: local action in the mercury cell is negligible and it can be stored for a relatively long period without appreciable loss of capacity.

(b) Ampere-hour efficiency of an accumulator is the ratio of the number of ampere hours obtainable during discharge to that required to restore it to its original condition.
The value for a lead-acid cell is about 90%.

Question 8.

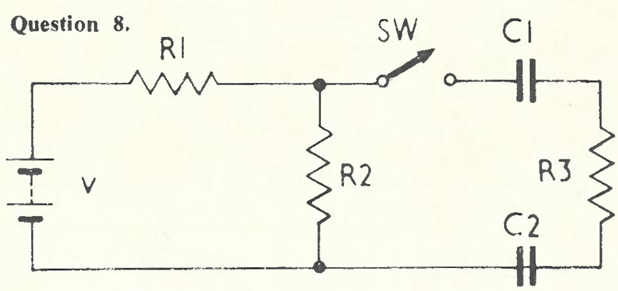


Fig. 11

In the circuit shown in Fig. 11, capacitors C1 and C2 are fully discharged and then switch SW is closed. Calculate the voltage across R3:

(a) at the instant of switch closure; and

(b) 50 ms after the switch has been closed

$(V = Vf + (Vi - Vf)\ e^{-t/cr})$

Given that V = 250 volts, R1 = 100 kilohms, R2 = 300 kilohms, R3 = 50 kilohms, C1 = 2μF and C2 = 2μF.

Answer 8.

(a) The first step in the solution consists in simplifying the circuits to the left and right of the switch.

On the R.H.S., the capacitors can be combined to give a single equivalent capacitance of 1μF, and the L.H.S. can be simplified to an equivalent circuit by the use of Thevenin's theorem. Then:

$$RTH = \frac{100 \times 300}{100 + 300} = \frac{30{,}000}{400} = 75k\Omega$$

$$\text{and } VTH = \frac{300}{100 + 300} \times \frac{250}{1} = 187.5V$$

The single loop equivalent circuit is now as shown in Fig. 12.

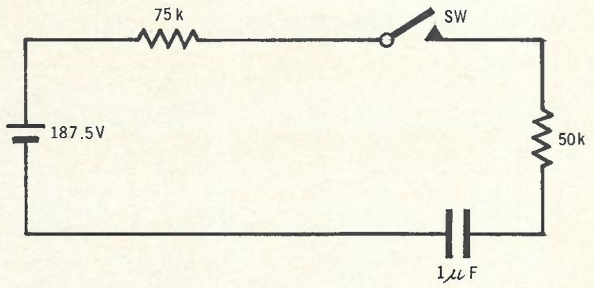


Fig. 12

At the instant SW is closed.

$$I = \frac{187.5}{75 + 50} = \frac{187.5}{125} = 1.50$$

Hence initial voltage across R3,

$$Vi = 1.5 \times 10^{-10} \times 50 \times 10^{3} = 75V.$$

(b) The voltage across R3 after 50 ms is found by usin, the formula given in the question:

$$V = Vt + (Vi - Vf)\ e^{-t/cr}$$
$$= 75 \times 0.670V$$

where Vf = voltage across resistance R, after an infinite time

Vi = initial voltage

RC = the product of total series resistance and capacitance.

$$\text{Now } RC = (75 \times 10^{3} + 50 \times 10^{3}) \times 1 \times 10^{-6}$$
$$RC = 125 \times 10^{3} \times 10^{-6} = 0.125$$
$$\text{but } Vf = 0,$$
$$V = 0 + (75 - 0)e^{-\frac{0.05}{0.125}}$$
$$= 75e^{-0.4}$$
$$= 75 \times 0.670V$$
$$= 50.3V$$

Question 9.

The armature of an eight pole d.c. generator is wound with 320 conductors. The magnetic flux and speed are such that the average e.m.f. generated in each conductor is 1.8 V, and each conductor is capable of carrying a full-load current of 20A. Calculate the terminal voltage on no-load, the output current on full-load, and the total power generated on full-load when the armature is:

(a) lap connected; and

(b) wave connected.

Answer 9.

(a) With the armature lap connected the number of parallel paths is 8; then, number of conductors per path = 320/8 = 40

No-load voltage = 1.8 × 40 = 72V

Also full load current = 20 × 8 = 160A

Total power on full load = EI = 72 × 160 = 11.5 kW

(b) With the armature wave connected, parallel paths = 2

then conductors per path = 320/2 = 160

No-load voltage = 1.8 × 160 = 288V

Full load current = 20 × 2 = 40A

Total power full load = 40 × 288 = 11.5 kW

Question 10.

An 'ideal' full-wave bridge rectifier is fed from a 50-Hz sinusoidal a.c. supply. A 250μF capacitor is connected across the output.

(a) If the p.d. across the capacitor is 24V, calculate the r.m.s. value of the supply voltage.

(b) A load is now connected across the capacitor and draws a load current of 100mA. Calculate the voltage fluctuation across the capacitor and sketch the input waveform to the rectifier bridge and the corresponding output voltage waveform across the capacitor. What output voltage would be indicated by a d.c. voltmeter connected across the output?

Answer 10.

(a) With no load connected, the voltage across the capacitor would be the peak value of the supply voltage, hence

$$\text{r.m.s. value} = 24 \times \frac{1}{\sqrt{2}} = 16.9V$$

(b) Between successive peaks of supply voltage the load current will be supplied by the capacitor, i.e. for a period of approximately one half the period of the wave, the voltage will then vary by an amount given by:

$$\Delta v = \frac{\Delta q}{c} = \frac{100 \times 10^{-3} \times 1/(2 \times 50)}{250 \times 10^{-6}}$$
$$= \frac{10^{-3}}{2.5 \times 10^{-4}} = 4V$$

Hence the output voltage will fluctuate between 24V and 20V.

If a dc voltmeter were connected across the load it would read the average voltage and hence would indicate a voltage of (24 + 20)/2 = 22V.

Question 11.

(a) The specification for a particular ammeter gives the calibration error as ± 3% of full scale current. Which end of the scale gives the greater measuring accuracy? Illustrate your answer with appropriate calculations.

(b) A multi-range dc voltmeter with a sensitivity of 20 kilohms per volt is used to measure the pd across terminals A and B of the circuit shown in Fig. 13. Neglecting calibration error, what values of voltage would the meter indicate on the ranges 50, 15, and 5 volts respectively, if R1 = 400 kilohms, R2 = 400 kilohms and V = 24 volts?

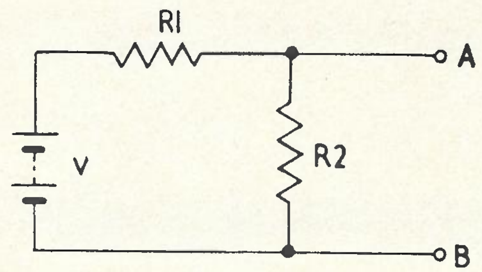


Fig. 13

Answer 11.

(a) Greater accuracy is obtained at the upper end of the scale since the method of specifying calibration error permits wider departure from true readings at the lower end of the scale.
For example: consider an ammeter having a full scale deflection of 100mA and the percentage error given in the question; when a current of 100mA flows in the meter, it will read between 97μA and 103μA, or an error of $\pm$ 3%. On the other hand, for a current of 10mA, the meter would read between 7mA and 13mA and the percentage error could therefore be up to 30% at this value of current.

(b) By inspection it will be seen that the Thevenin equivalent circuit presented to the voltmeter at terminals AB is as shown in Fig. 14.

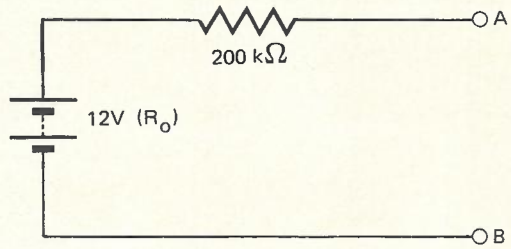


Fig. 14

$$\text{meter reading 50V range} = \frac{50 \times 20\text{k}}{(50 \times 20\text{k}) + 200\text{k}} \times 12$$

$$= \frac{10^3 \times 12}{1.2 \times 10^3} = 10.0\text{V}$$

$$\text{meter reading 15V range} = \frac{15 \times 20\text{k}}{(15 \times 20\text{k}) + 200\text{k}} \times 12$$

$$= \frac{3 \times 10^2 \times 12}{5 \times 10^2} = 7.20\text{V}$$

$$\text{meter reading 5V range} = \frac{5 \times 20\text{k}}{(5 \times 20) + 200\text{k}} \times 12$$

$$= \frac{10^2 \times 12}{3 \times 10^2} = 4.00\text{V}$$

Question 12.

An amplifier has an input resistance of 20 kilohms, an output resistance of 100 ohms, and an open circuit voltage gain of 80. A signal of e.m.f. 4 mV and source resistance 50 ohms is connected to the input of the amplifier and a resistance of 100 kilohms is connected across the output:

(a) calculate the voltage across the load resistance;

(b) calculate the turns ratios of ideal loss free transformers necessary to impedance match the input and output of the amplifier; and

(c) calculate the voltage across the load when the input and output are matched as in (b).

Answer 12.

(a) Under unmatched conditions the equivalent circuit can be drawn as shown in Fig. 15. Then it will be seen that the output resistance of the amplifier, 100 ohms, is much less than the 100 kilohm load and can be neglected, hence Vout = $80V_{in}$.

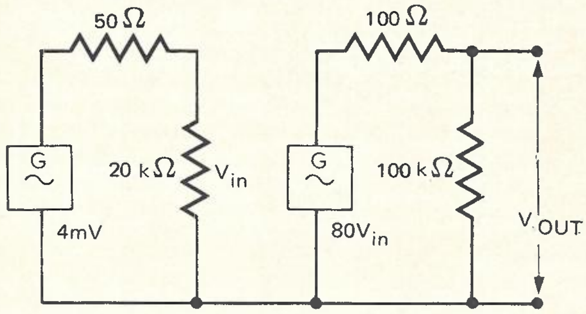


Fig. 15

Similarly, the 50 ohm source resistance is much less than the 20 kilohm input resistance and it can be neglected, hence Vin = 4mV

Vout = 80 $\times$ 4 = 320 mV

(b) Input transformer turns ratio $\frac{NS}{NP} = \sqrt{\frac{ZS}{ZP}}$

$$= \sqrt{\frac{20 \times 10^3}{50}} = 20$$

Output transformer turns ratio $\frac{NS}{NP} = \sqrt{\frac{ZS}{ZP}}$

$$= \sqrt{\frac{100 \times 10^3}{100}} = 31.6$$

(c) With the transformers in circuit, the source voltage appearing across the primary of the input transformer (50 ohm reflected from secondary side)

$$= 4 \times \frac{50}{50 + 50} = 2\text{mV}$$

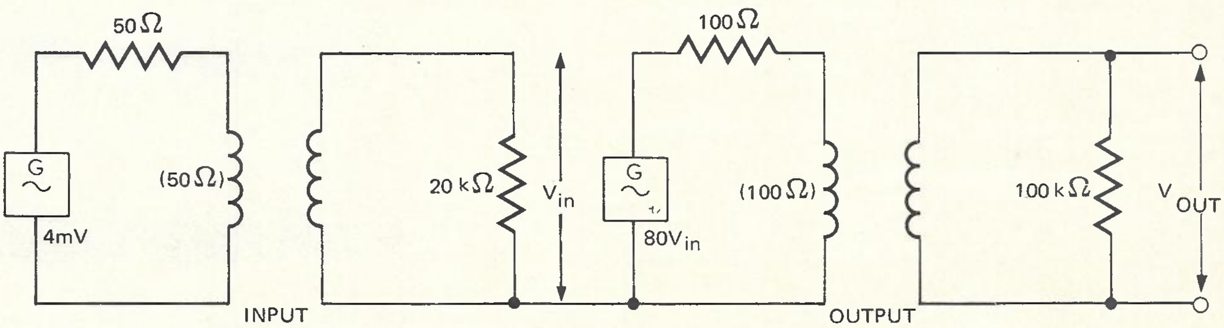


Fig. 16

Vin = 2 × 20 (1:20 turns ratio)
= 40mV

Voltage across primary of output transformer (100 ohm reflected from secondary side)

$$= 80 \text{ Vin} \times \frac{100}{100 + 100}$$

$$= 80 \times 40 \times 0.5 \times 10^{-3}$$
$$= 1.60 \text{ V.}$$

$$\text{Vout} = 1.6 \times 31.6 \text{ (1:31.6 turns ratio)}$$
$$= 50.6\text{V}$$

Question 13.

A signal generator is connected to the input of an amplifier via a single section symmetrical 'T' pad. The pad has a characteristic resistance of 600 ohms; the resistance of each series arm of the pad is 490 ohms and the resistance of the shunt arm is 121 ohms. Calculate:

(a) the limit values for the signal source resistance at the input to the amplifier if the output resistance of the signal generator is not known;

(b) the loss, in decibels, introduced by the pad if the output resistance of the signal generator and the input resistance of the amplifier are both 600 ohms.

Answer 13.

(a) The value of generator source resistance, Rs, is unknown hence its value may lie anywhere between zero and infinity. When RS is zero ohms, the padded source resistance RPS is given by:

RPS = 490 + (121 in parallel with 490)

$$= 490 + \frac{1.21 \times 10^2 \times 4.90 \times 10^2}{6.11 \times 10^2}$$

$$= 490 \times 97.1$$
$$= 587 \text{ ohms.}$$

When Rs is infinity, i.e. open circuit,

$$\text{RPS} = 490 + 121$$
$$= 611 \text{ ohms.}$$

So the padded source resistance will lie between 587 and 611 ohms.

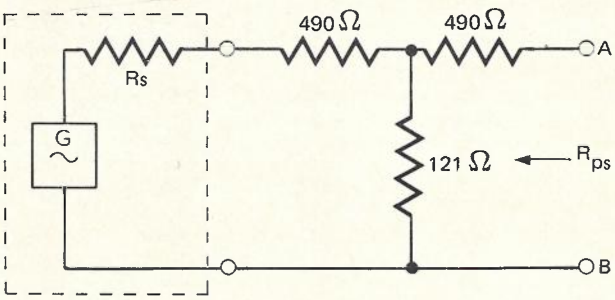


Fig. 17

(b) Thevenin resistance at AB = Ro = 600 ohms (see Fig. 18)

and Thevenin resistance voltage

$$\text{at AB} = \frac{121}{121 + 490 + 600} \times \text{VG}$$

$$= \frac{121}{1211} \text{VG}$$

$$= 0.1 \text{ VG}$$

Now with 600 ohm load connected across AB. (see Fig. 19).

$$\text{VAB} = \frac{600}{600 + 600} \times 0.1\text{VG} = 0.05\text{VG}$$

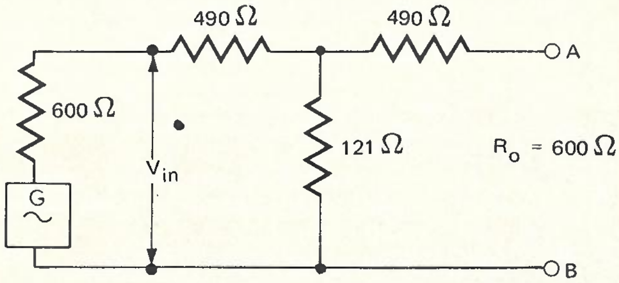


Fig. 18

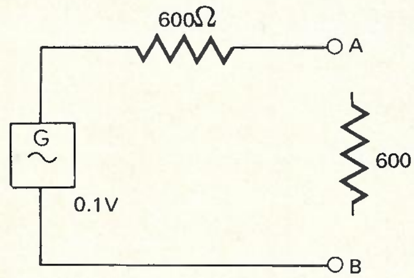


Fig. 19

Also the input resistance of the generator = 600Ω

$$\text{input voltage, Vin} = \frac{600}{600 + 600} \times \text{VG} = 0.5\text{VG}$$

$$\text{Attenuation} = 20 \log_{10} \frac{\text{Vin}}{\text{VAB}} = 20 \log_{10} \frac{0.5}{0.05}$$

$$= 20 \log_{10} 10$$
$$= 20_{dB}$$

Question 14.

(a) Convert the binary number 111101 into its decimal equivalent.

(b) Add the binary numbers 1011 and 11011.

(c) Draw a block logic diagram to illustrate the Boolean equation, $C = A\bar{B} + \bar{A}B$.

(d) Construct the truth table for the logic system shown in your answer to (c).

Answer 14.

(a) $(111101)_2$ =

$$1 \times 2^0 = 1$$
$$+ 0 \times 2^1 = 0$$
$$+ 1 \times 2^2 = 4$$
$$+ 1 \times 2^3 = 8$$
$$+ 1 \times 2^4 = 16$$
$$+ 1 \times 2^5 = 32$$

63

$(111101)_2 = (63)_{10}$

(b)

```
   1011
+ 11011
-------
 100110
```

(c) See Fig. 20.

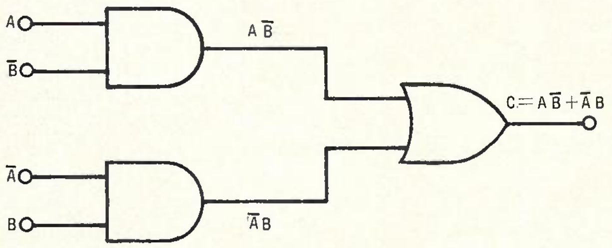


Fig. 20

(d)

A	B	$\bar{A}$	$\bar{B}$	$A\bar{B}$	$\bar{A}B$	$C = A\bar{B} + \bar{A}B$
0	0	1	1	0	0	0
1	0	0	1	1	0	0
0	1	1	0	0	1	1
1	1	0	0	0	0	0

Technical News Item

METRIC CONVERSION OF AUSTRALIAN POST OFFICE ENGINEERING ACTIVITIES

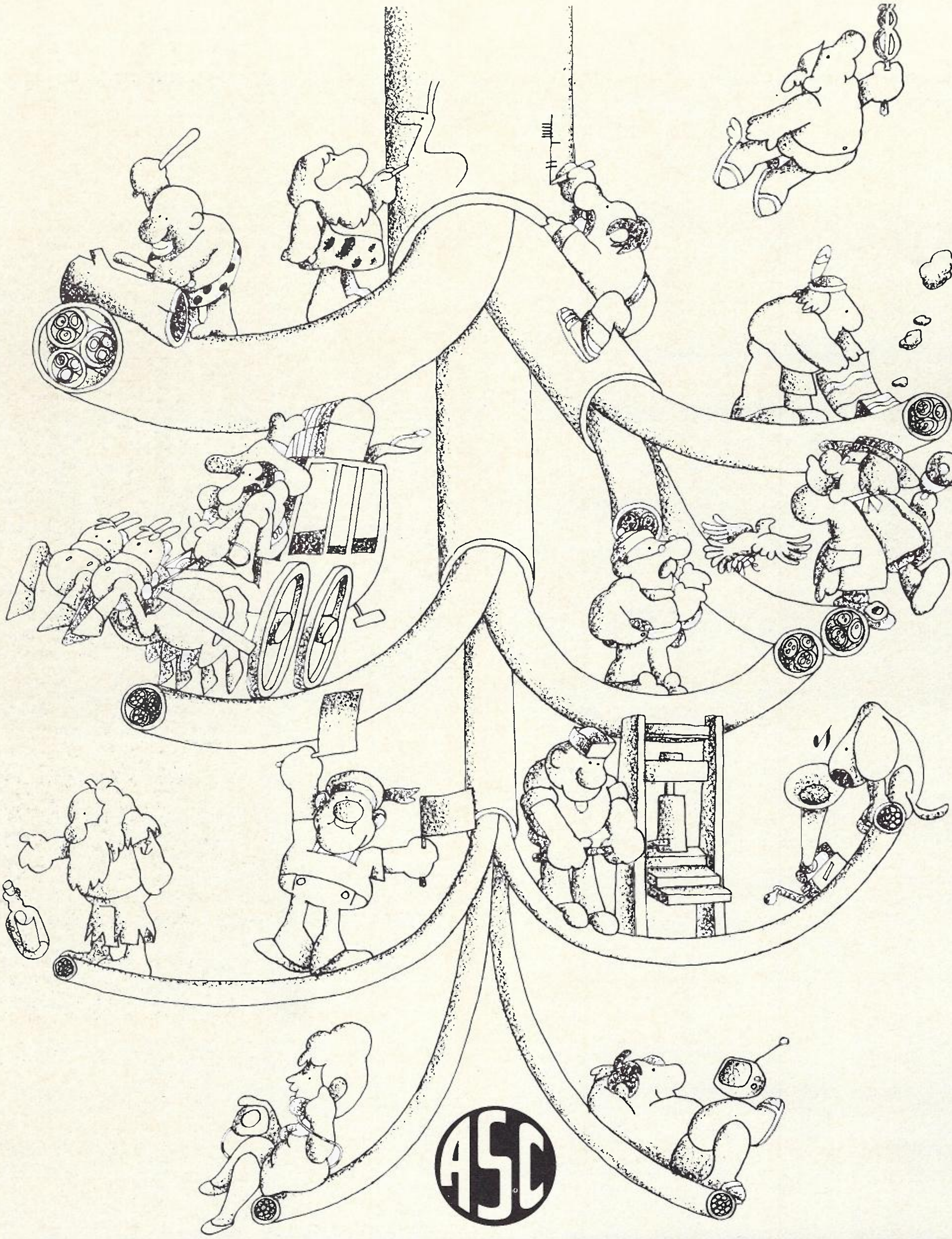
In January 1970 the Commonwealth Government announced that the metric system of weights and measures was to be adopted by Australia. This decision has a significant affect on the Australian Post Office's engineering activities and the following broad principles will be followed in the progressive introduction of metrication in the A.P.O.:—

- Existing plant and material designs in Imperial measures will not be redesigned simply to convert to metric; when a redesign is necessary for other reasons it will be in metric.
- As far as possible the metric values chosen in a redesign will be the most convenient and logical numerical values and not just a rounded off conversion of existing Imperial values.
- The metric equivalent will replace the Imperial measures in field operations and in equipment designs pending on redesign.

There is already a significant use of the metric system e.g. metric designs are used for all crossbar equipment, the new stored programme controlled exchange equipment and a substantial proportion of radio, long line equipment and automotive plant. The following summarises the present position, and action in hand to extend metrication to all aspects of plant and equipment design and general operations:—

- All new internal plant items have been designed in metric units as from 1st July 1972.
- Plastic insulated wire to be delivered in the financial year 1972/73 will be dimensioned in metric gauges, as will also the larger sizes of plastic insulated internal cable. The smaller sizes of internal cable will be purchased in metric gauges in the financial year 1973/74.
- Machines purchased for Workshops are suited to metric working and no conversion is required.
- External plant field operations will be converted as from 1st July 1973, whilst material design has been metric from 1st July 1972. External cable gauges will remain unchanged (use of different wire diameters will be considered when new cables are being designed) and the gauge will now be referred to as the nominal diameter of the wire in millimetres (e.g. 10lb./mile copper becomes 0.64 mm). Standard drum lengths will, however, be converted to convenient metric lengths (e.g. to 500m.). A major problem is the conversion of the very large number of existing cable and conduit drawings, estimated at 100,000 for the Commonwealth and the task of full conversion is expected to extend over a number of years. Conversion of drawings is being done at a number of levels ranging from the use of both metric and Imperial dimensions on one sheet (Level 1) to a totally metric dimensioned drawing with a preferred metric scale on international metric size drawing sheets (Level 4).
- New Engineering Instructions are being prepared in metric with the Imperial equivalent in parenthesis. From 1st July 1973, they will be in metric only.
- New specifications will be issued in metric units provided metric supplies are available without cost penalty.
- The A.P.O. Research Laboratories have used the metric system in all reports and papers since 1st January 1972. All new laboratory equipment and machine shop purchases are specified in metric units, and designs of equipment that are likely to be supplied for more than two or three years are metric.
- Training courses are being revised to include SI units. In addition a special half-day course has been organised for the training of linemen and courses are being held over a two month period leading up to 1st July 1973.
- A series of A.P.O. Metric Notes is being produced to promulgate both general and detailed information on metrication. These notes are being widely distributed in the Department in a similar manner to Engineering Instructions.
- Stores operations will be in metric from 1st July 1973. The major requirement is that material items have metric units for issue transactions.

Inherent in the change to the metric system of weights and measures is the unique opportunity to rationalise the provisioning of material items by standardization and/or the elimination of redundant sizes or types, and by so doing to offset, at quite an early stage, some of the initial real costs involved in metric conversion.



For better lines of communication

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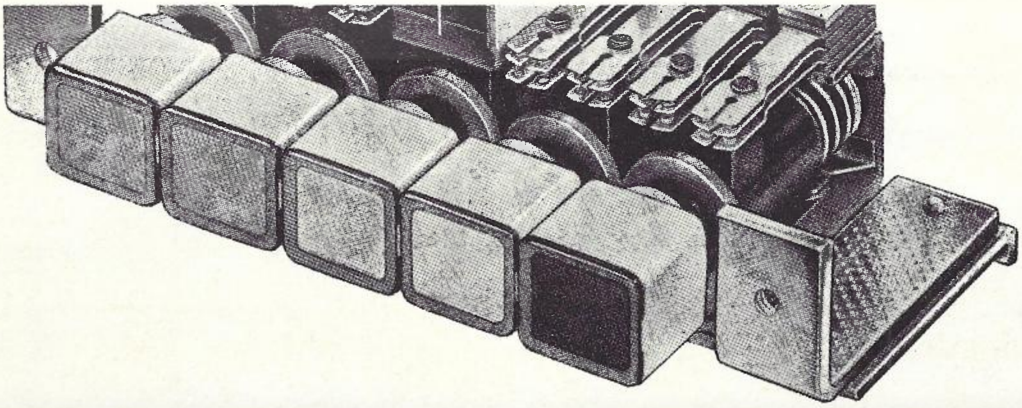
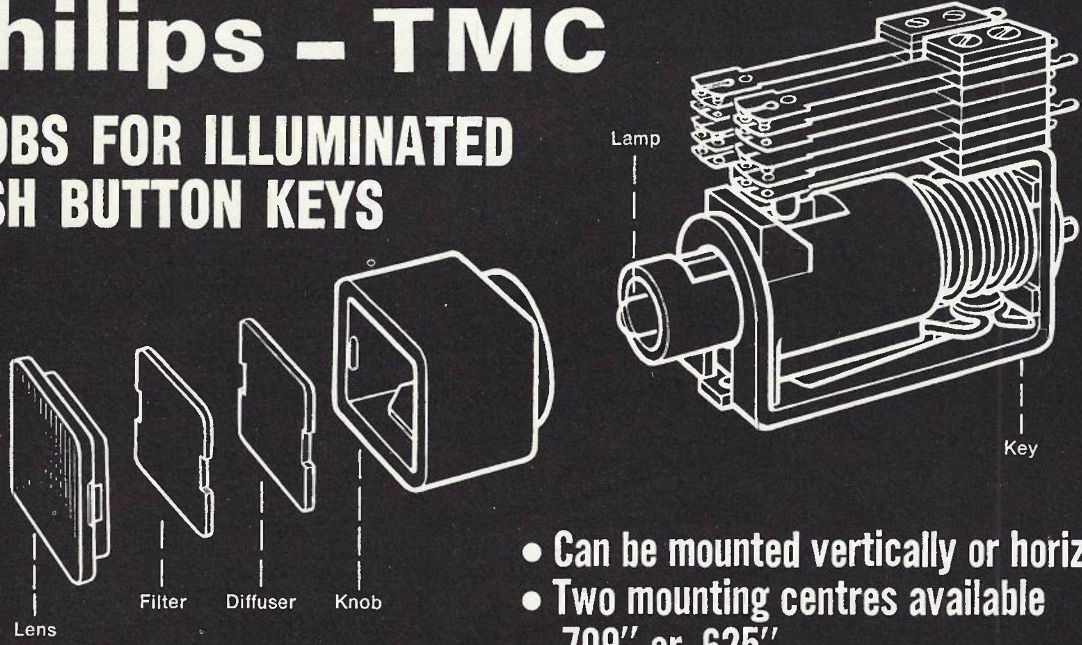


Philips - TMC

KNOBS FOR ILLUMINATED PUSH BUTTON KEYS



- **Can be mounted vertically or horizontally**
- **Two mounting centres available .709" or .625"**

Philips-TMC Knobs (Lamp Caps) for Illuminated Push Button Keys are available in a wide colour range and can be mounted vertically or horizontally. This means now that as well as extremely versatile key mounting arrangements you have added flexibility of layout with a choice of coloured knobs. To change lens colour you simply change the filter without changing the whole assembly, keeping costs to a minimum. Filter colours are white, yellow, amber, red, blue, green and black.

Lenses are clear, press clip type with extra large engraving face.

Philips-TMC Push Button Knobs for .709 or .625 mounting centres are available in ivory or black.

The exploded view above illustrates the whole **Philips-TMC** Push Button Knob assembly. The lens system consists of three pieces, a translucent diffuser, a filter and transparent lens. Only the filter requires removal for an easy colour change.

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SOUTH AUSTRALIA: A. J. Ferguson (Adel.) Pty. Ltd., 123 Wright Street, Adelaide, 5000. Telephone: 51 6895

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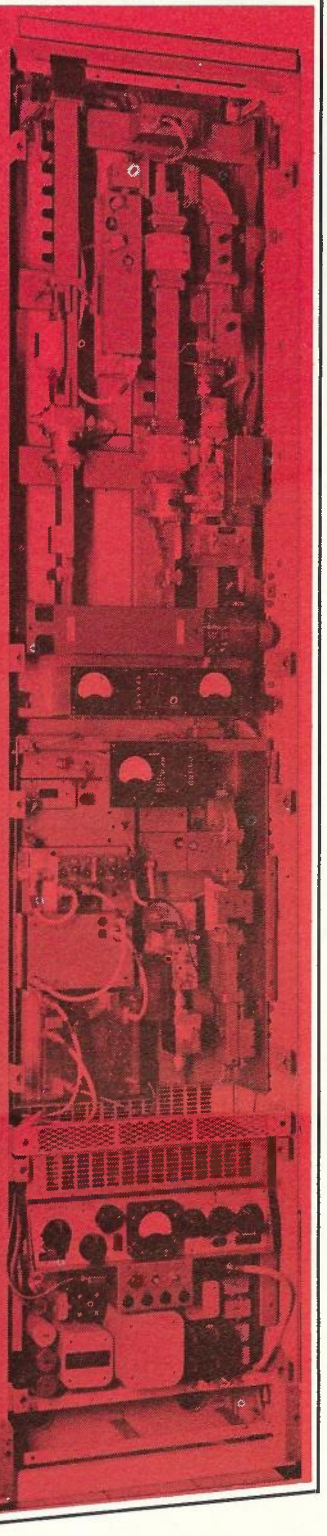
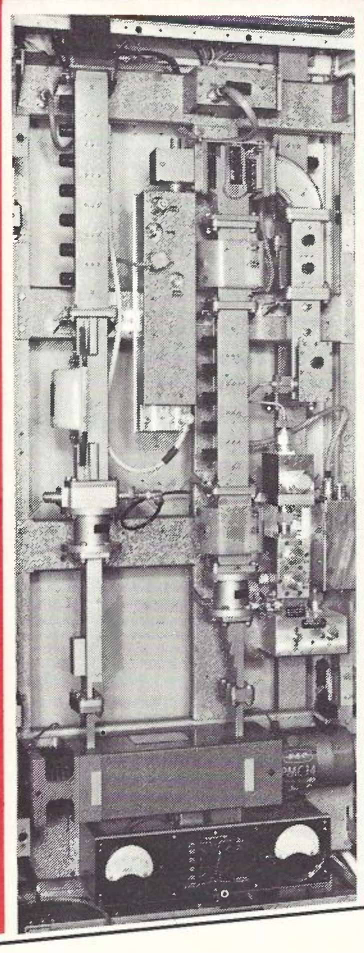


Take a new look at our 6.1GHz Microwave system — we often do



Behind the success of GEC 6.1GHz radio systems is a policy of continuous systematic improvement to a proven system. Modifications are introduced not for the sake of change but because they represent a significant advance on previous practice. In this way, GEC builds on the success of its 6.1GHz system. One recent example of this kind of studied innovation was the introduction of phase-locked oscillators which have significantly reduced oscillator noise.

Our system-planning engineers will be pleased to show you some of the other ways in which we have improved on the proven and established 6.1GHz system, which has a capacity of 1800 speech circuits, or one colour television channel and its associated sound channels – all in accord with CCIR recommendations.

The 6.1GHz system includes frequency division multiplex, supervisory and control, I F and baseband switching, narrowband auxiliary radio for serviceband, and antenna systems.

G.E.C.

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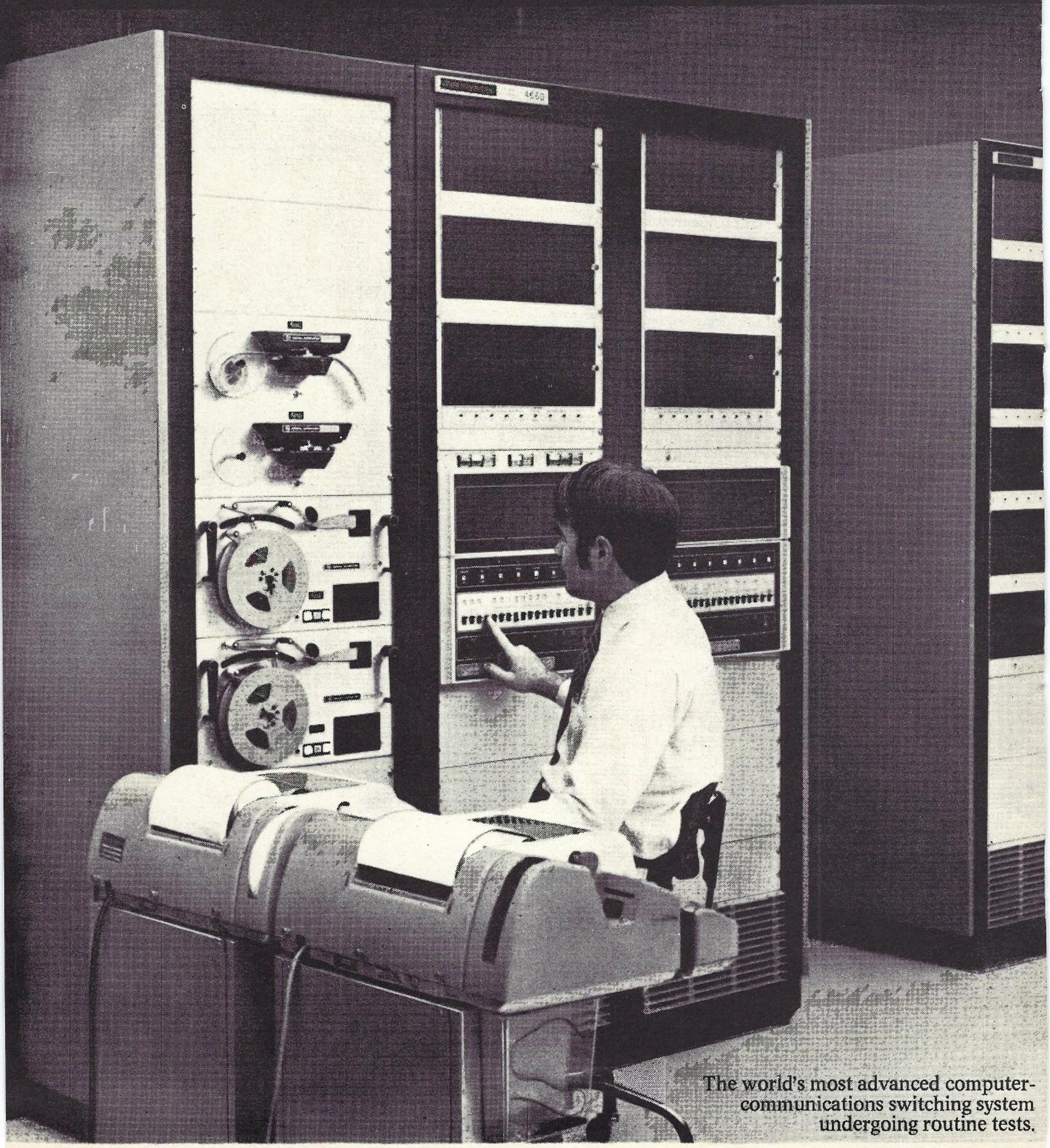
Today's telex exchange-SPC; electronic; solid state



The world's most advanced computer-communications switching system undergoing routine tests.

Plessey System 4660

Not so much an exchange as a computer that can take all the requirements of a telex network in its stride. There are no crosspoints in the conventional sense – the signal path is routed through the computer core memory.

Here are some of the things it can do: if an addressed line is busy it can hold the message until it is cleared; it can send a message to a required number of addresses in one operation; it can store messages until low tariff periods commence; it can select alternative/optional routes. . .

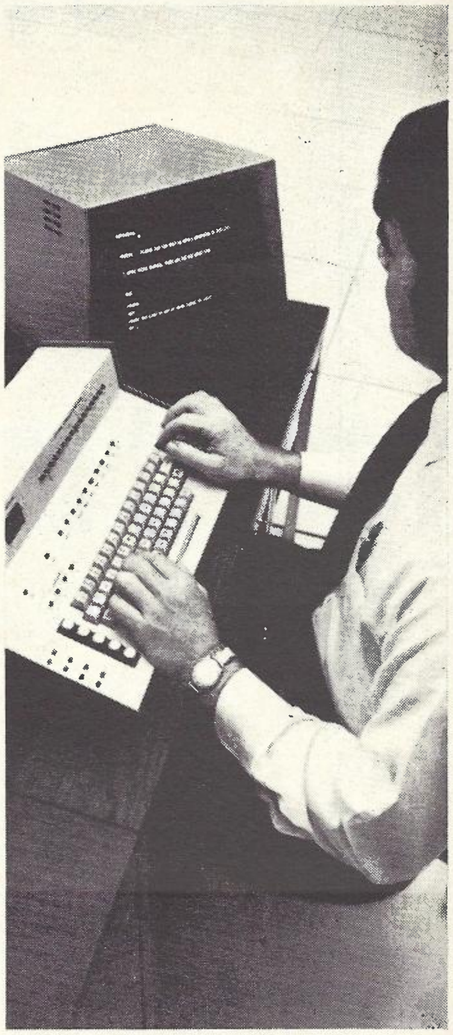
These are merely some of the sophisticated extras System 4660 can offer, but they indicate the advanced technology of its design. The terminal equipment, for example, includes operator consoles with c.r.t. display, print-out or magnetic cassette.

Sizes: systems can range from 50 to 32,000 lines, based on three computer sizes.

Features include: *High traffic capability • Modular design • CCITT compatibility • Economy and low cost • Speed and code conversion • Ease of maintenance • Automatic message accounting • Self diagnosis and fault indication • Space saving • Solid state reliability • Flexibility and speed of installation.*

There is a full spares and after sales service.

For further information about System 4660 please write or telephone: Plessey Telecommunications, Edge Lane, Liverpool, England L7 9NW.
Telephone: Liverpool (051) 228 4830. Telex: 62267.



Cordless Switchboard Operator position handling assistance call with CRT Visual Display.

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90322/V4717

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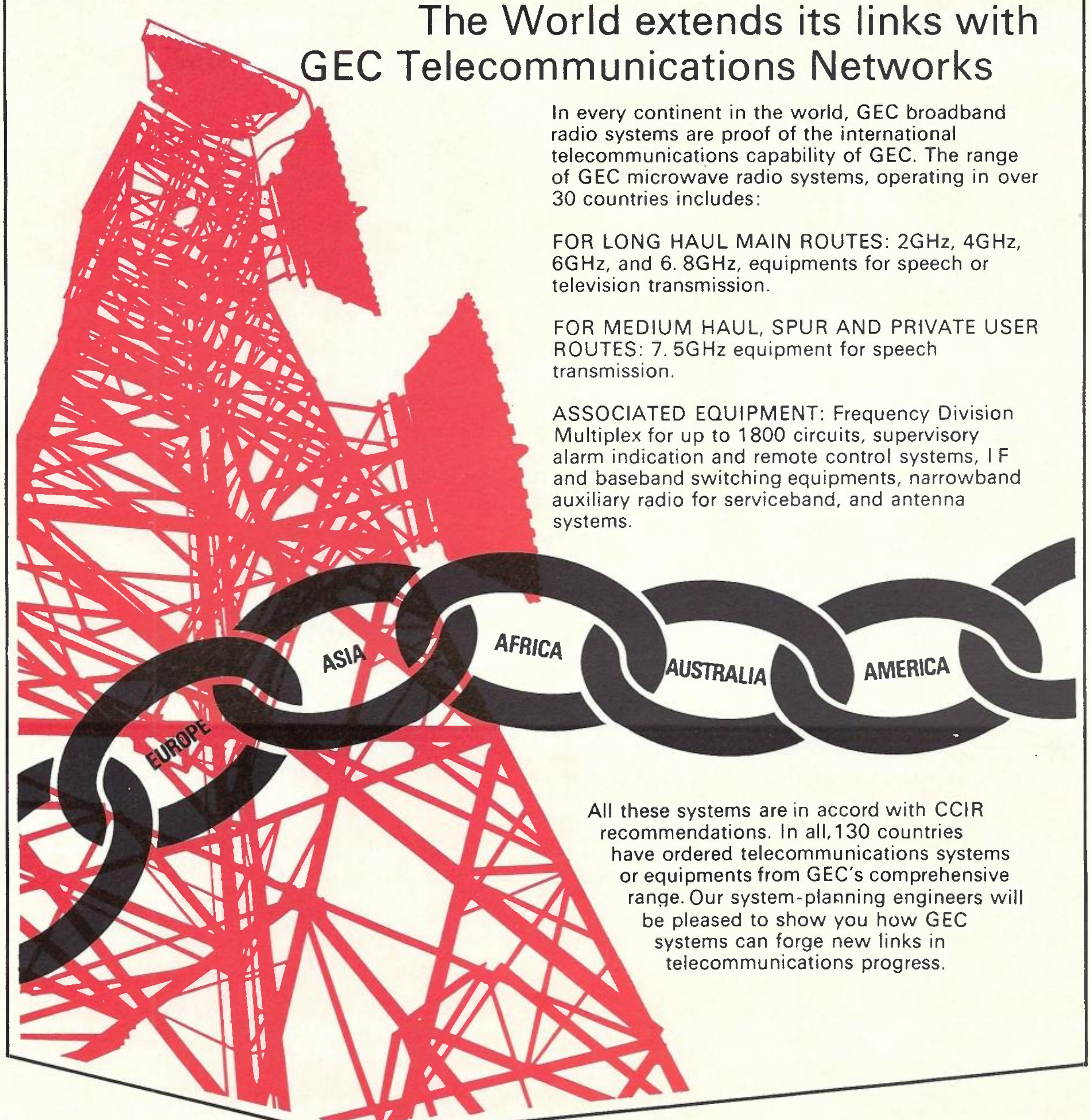

In every continent in the world, GEC broadband radio systems are proof of the international telecommunications capability of GEC. The range of GEC microwave radio systems, operating in over 30 countries includes:

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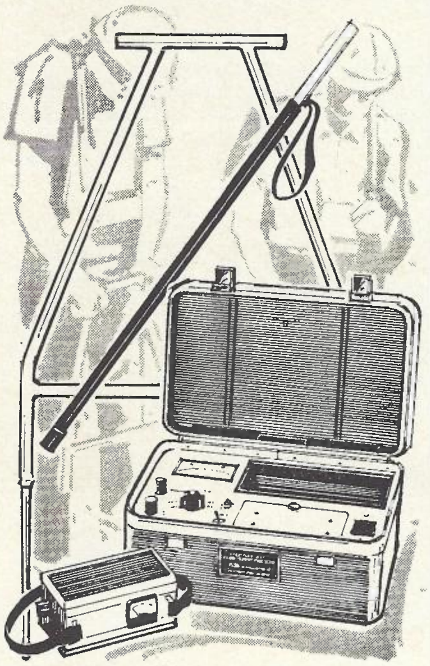
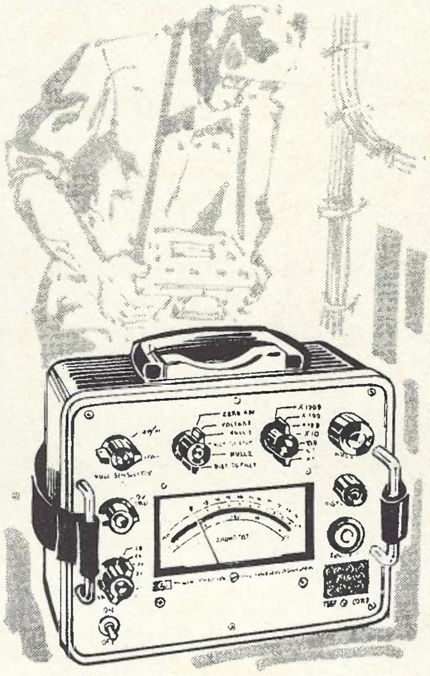
Fast and accurate location of cable faults is all important when lines of communication are threatened. The HEWLETT-PACKARD team of portable cable fault locators will quickly pinpoint the trouble and save you valuable time and labour.

CABLE FAULT LOCATOR MODEL 4904A



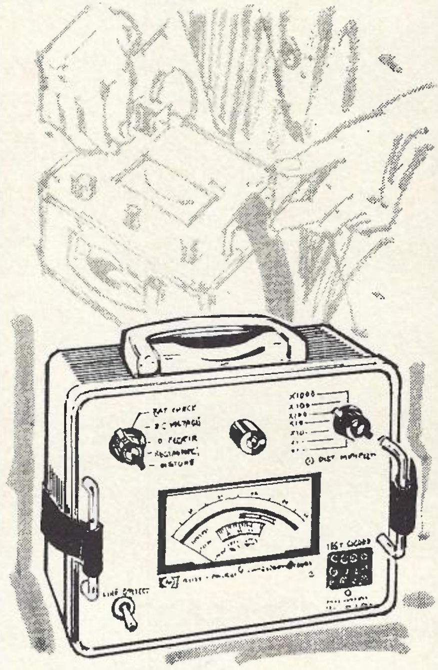
APPLICATION:
Locates grounds, shorts, crosses and splits in buried, underground or aerial cables — determines precise path and depth of buried cables.
ACCURACY:
Pinpoints faults to precise digging location.
OPERATION:
Ground cable — battery-powered pulse transmitter and receiver with search wand. Variations in pulse tone indicate cable path and faults.
Aerial cable — same principle but with tone pick up by pole mounted or hand held search coil.

CONDUCTOR FAULT LOCATOR MODEL 4912F



APPLICATION:
Solves high resistance fault problems. Locates wet PIC shorts, crosses and grounds as easily as solid faults.
ACCURACY:
Faults located to better than plus or minus 1% of total length.
OPERATION:
Six logical steps work up to an exact read-off of distance from fault on meter. Front panel functions are colour keyed to minimize error and simplify operation. A built-in test and scale checking circuit is provided.

OPEN FAULT LOCATOR MODEL 4910F



APPLICATION:
Direct reading distance to open faults in pair communications cable.
ACCURACY:
Better than plus or minus 1% location accuracy.
OPERATION:
Four logical steps are taken to provide the final result with direct readout in feet (or metres if preferred). Control panel is laid out for ease of use and minimum error.

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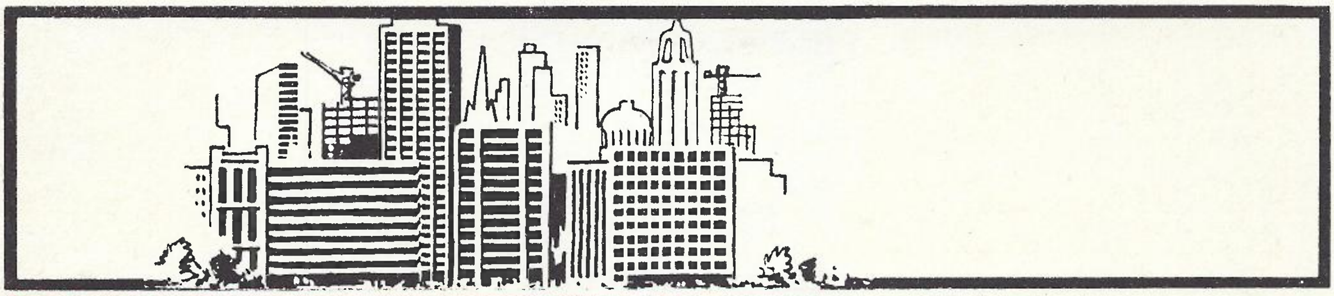

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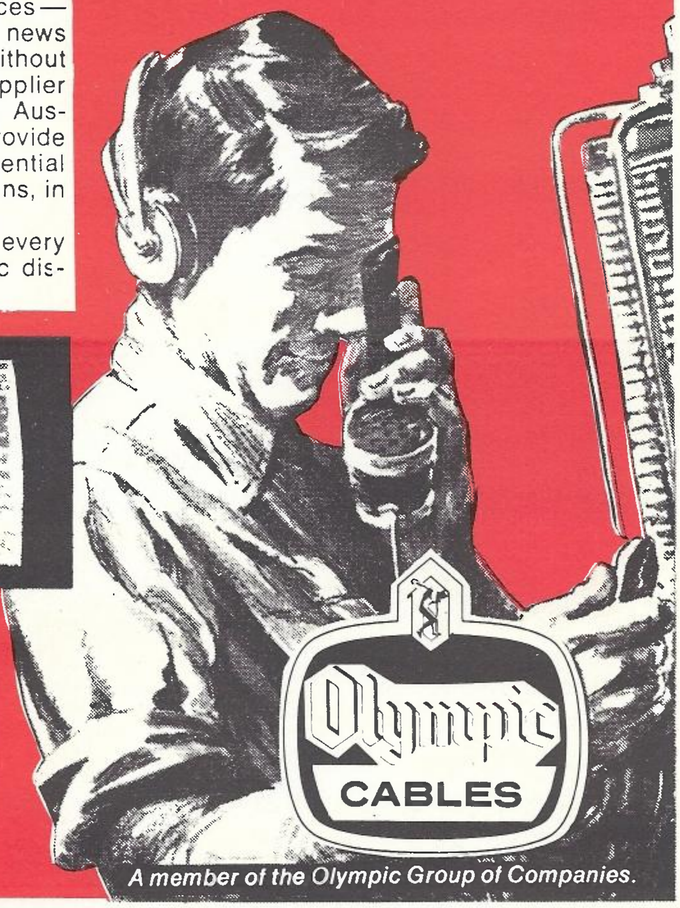

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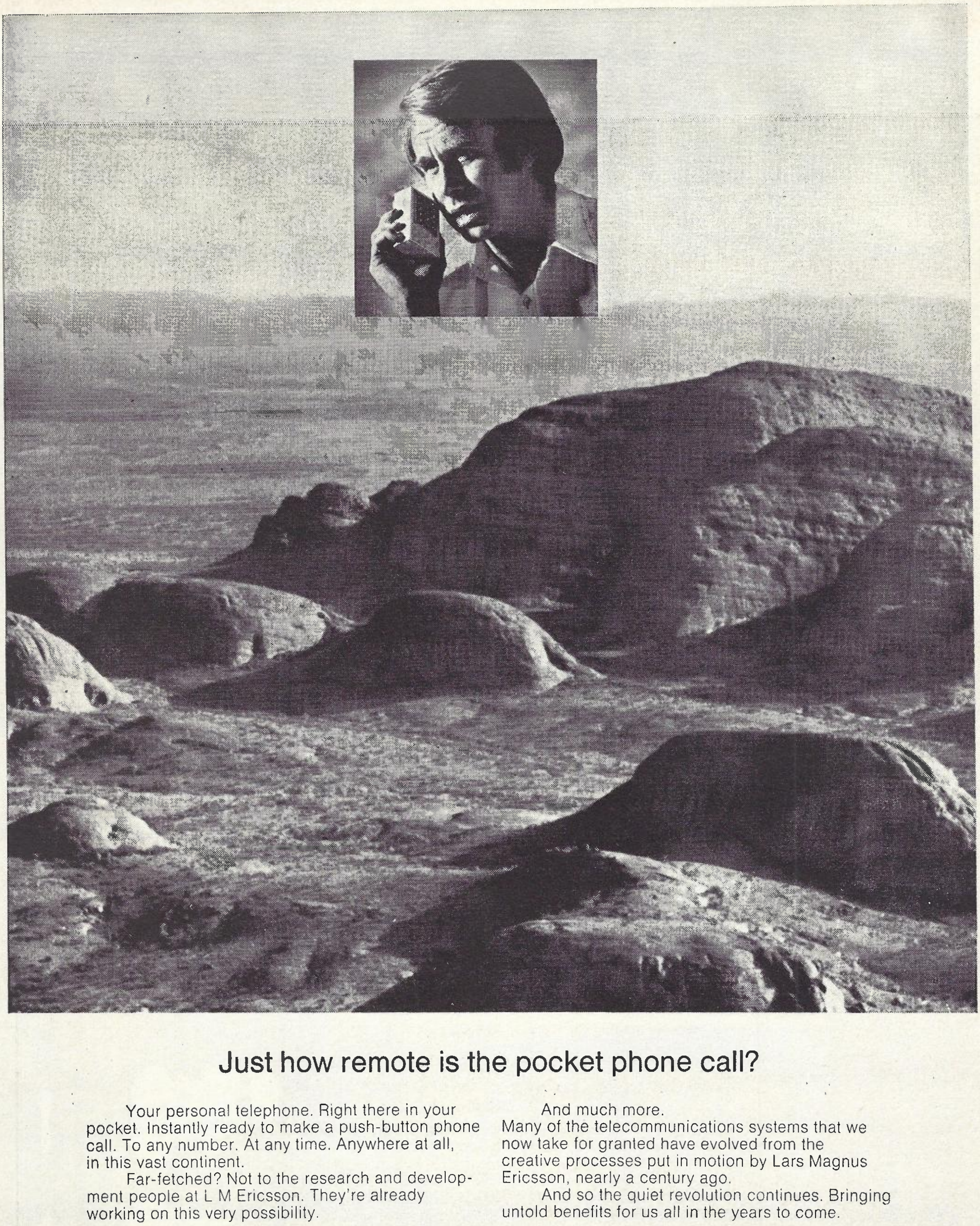

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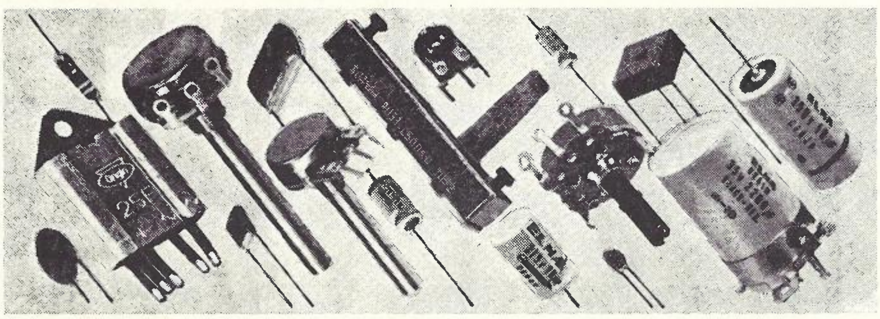

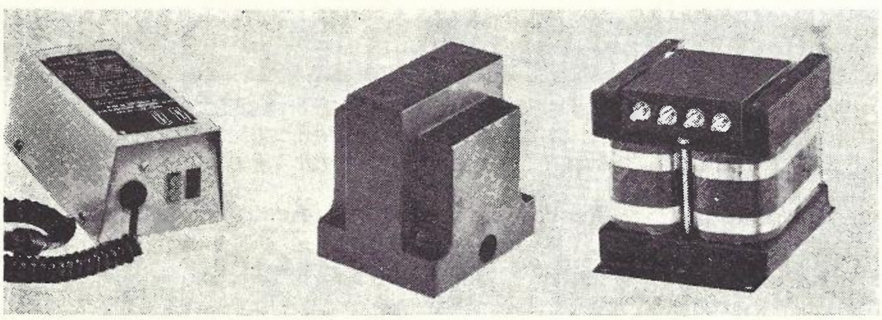

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The Telecommunication Journal of Australia

ABSTRACTS: Vol. 23, No. 2.

BONDARENKO, E. J.: 'Detection of Electrical Discharges from Transmitter Antennae'; Telecomm. Journal of Aust., June, 1973, page 136.

The APO has recently experienced problems of electrical discharges at one of the high power transmitter installations. This article outlines the discharge problems and describes a system installed for detecting those discharges. The system is based on detection of ultra-violet radiation.

CARROLL, B. J.: 'Maintenance and Performance of L. M. Ericsson Crossbar Switching Equipment in Australia (Part 2); Telecomm. Journal of Aust., June 1973, page 143.

Part 1 of this article in the previous issue of the Journal outlined the performance of ARF crossbar switching equipment used in capital city networks and the larger provincial centres. This second part outlines the performance of ARM switching equipment used at Secondary, Primary and Main Switching Centres in the trunk network. It also includes a brief review of the performance of ARK type exchanges in our rural networks.

FREEMAN, A. H.: 'Principles of Common Control in Crossbar Exchanges'; Telecomm. Journal of Aust., June 1973, page 150.

This article outlines the basic principles underlying the use of common control techniques in crossbar telephone exchanges. The switching and signalling concepts of step by step type exchanges are first considered, and from this the common control concept as applied in particular to the ARF crossbar exchange system is developed. Common control system traffic and common control system information signalling is also outlined. The article concludes with a brief review of the historical origins of common control systems.

HULLETT, J. L.: 'A Case of Compromise — The Choice of TV Phone Picture Standards'; Telecomm. Journal of Aust., June 1973, page 100.

The choice of picture standards for a subscriber reticulated TV phone service involves a balance of economic, technical and human-factor parameters. In this paper an attempt is made to identify these and to indicate the basis on which a design choice can be made.

MAGGS, I. H.: 'STD in Australia, 1960-1980'; Telecomm. Journal of Aust., June 1973, page 136.

The main objectives of the paper are to describe the introduction of STD into the Australian telephone network over the past ten years, what the Post Office is aiming to achieve with STD, the position that STD has arrived at in 1972 and, finally, what further changes STD will bring by 1980 to the subscriber and to the APO.

McKINLEY, B. J.: 'An Introduction to the 10C Trunk Exchange System'; Telecomm. Journal of Aust., June 1973, page 85.

In April 1968 the APO sought from manufacturers throughout the world, a trunk exchange capable of handling the large quantity of trunk traffic expected in the Sydney network commencing in the early 1970s. Following an evaluation of the offers received, an exchange consisting of 10C equipment to be supplied by Standard Telephones and Cables Pty. Ltd. was selected.

The 10C system is an electronic trunk system which has a maximum capacity of 64,000 lines. This article surveys the functions of the major parts of the system and outlines the means by which these parts interact to process traffic.

MONTGOMERY, A. and HAMMOND, B. G.: 'A Communications System for the Moomba Natural Gas Pipe Line (Part 1)'; Telecomm. Journal of Aust., June 1973, page 117.

This article describes a communications system developed for the operation of a natural gas pipeline in South Australia. Apart from the interest of the unusual features of the system described, the article is relevant in view of current proposals for further major pipeline projects in Australia.

Part 1 of the article sets out the role of the Australian Post Office in establishing the communications system, and describes the external plant used; Part 2, to be published in the next issue of the Journal, describes the internal plant and various aspects of the overall system installation.

MURNANE, M. J.: 'New Cordless Switchboards'; Telecomm. Journal of Aust., June 1973, page 95.

Two new 2-wire cordless private manual branch exchange switchboards having capacity of four exchange lines and ten extensions (4+10), and five exchange lines and sixteen extensions (5+16), have been introduced. Each unit is housed in the same size compact, modern cabinet, and includes some new facilities and supervision techniques. Installation is simplified.

SYMONS, F. J. W.: 'The 1972 International Switching Symposium at Boston, USA'; Telecomm. Journal of Aust., June 1973, page 107.

This paper reviews the more interesting and significant aspects of the June, 1972, International Switching Symposium at Boston, USA. It gives a summary of the major system and network developments in nine countries as reported at the Symposium, and it describes the major distinguishable universal trends affecting switching systems and networks.

THE TELECOMMUNICATION JOURNAL
OF AUSTRALIA

VOL. 23, No. 2, JUNE 1973

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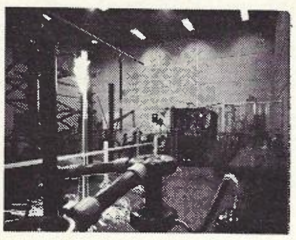

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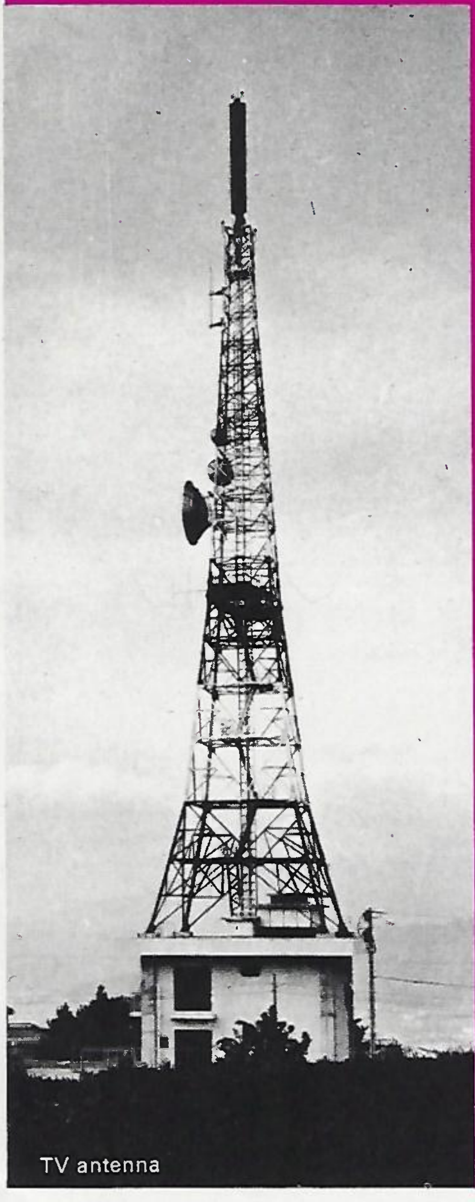
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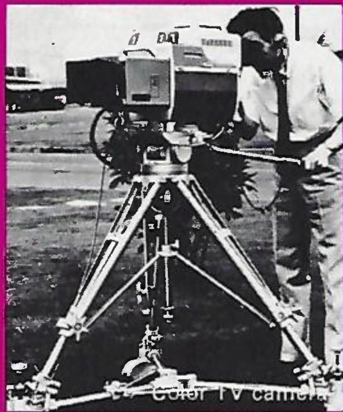
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