Common Channel Signalling

G. L. Crew: 630 7591

Common Channel Signalling

During 1967 and 1968, the International Telegraph and Telephone Consultative Committee (CCITT) specified a new telephone signalling system to be known as Signalling System No. 6. It will provide high speed, high capacity signalling between telephone exchanges employing computer based, stored programme control techniques.

Although designed principally for international use the system may have direct application in the national network and as a result the Australian Post Office, represented by a member of the Research Laboratories, in association with the Overseas Telecommunications Commission (Australia), OTC (Aust), played a part in the design and specification of the system.

Although System No. 6 may or may not be employed directly in the Australian networks it is quite certain that, as larger and larger groups of trunk channels and exchange junctions are introduced and as stored programme controlled exchanges take on a significant role in the network, common channel signalling, of which System No. 6 is representative, will become an important factor in increasing the efficiency of the network and at the same time reducing its capital cost.

The CCITT, during the Plenary Period 1969/72, will conduct a field trial of the System No. 6 which will test the international aspects of its operation. In conjunction with OTC (Aust) the Switching Group of the Research Laboratories is preparing to conduct national field trials of the System No. 6 by establishing suitable stored programme control exchanges in Melbourne and Sydney coupled together by a group of trunk channels and an appropriate signalling link. Not only will the trial evaluate the value of System No. 6 to the Australian network but it will provide an insight into many aspects of common channel signalling and will be of great assistance in the future as this form of signalling is introduced.

Telephone signalling consists of those messages, passed over the interconnecting circuits, used in setting up, supervising and clearing down of calls.

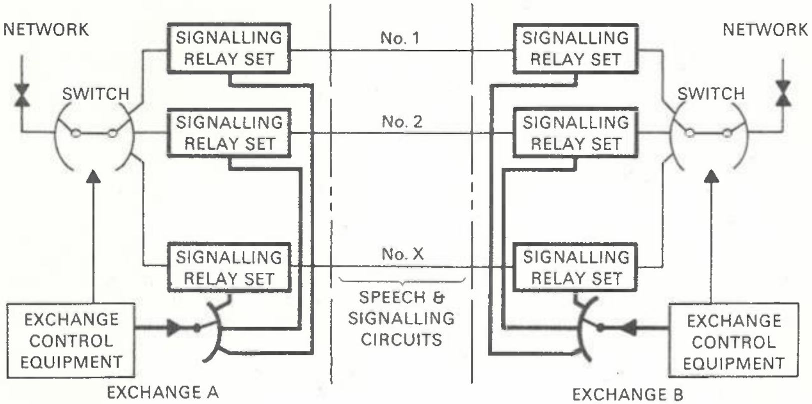


Fig. 1 Conventional signalling system

In the case of manual operators this may be a request from one operator to another to 'please connect me to a circuit to Sydney'. In an automatic network the signal may consist of a train of impulses on the line, produced by a dial, to indicate the way in which the equipment is to proceed with the setting up of the call. Many other signals are used but they all have one point in common; they are all directly related for their transmission to the speech path to which they refer. i.e. the voice request is conveyed over the speech path and the dialling impulses consist of periodic changes in the electrical condition of the wires forming the speech path.

As the network has grown more complex so the task of controlling these signals has grown more expensive. The point has now been reached where the control equipment provided on Subscriber Trunk Dialling routes can cost over $500 per trunk channel.

Common Channel Signalling offers an attractive alternative in that signalling is removed entirely from the individual channel and all signalling for the circuits in a group is passed between the switching exchanges over a single common channel.

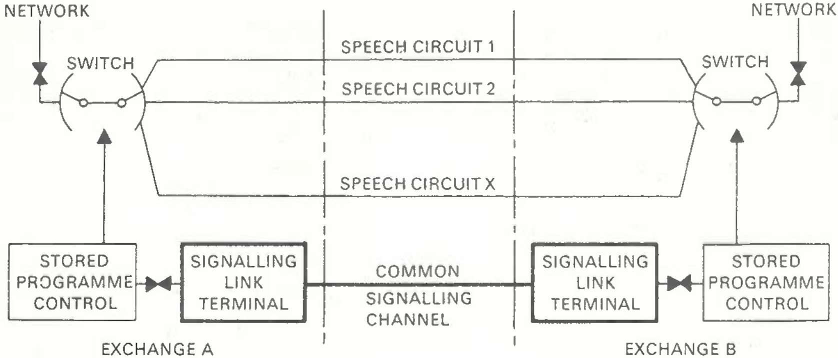


Fig. 2 Common channel signalling system

The requirements for such a system are twofold. Firstly, a signalling channel is required that will have a capacity to handle all the necessary signals for the given group of voice channels at an acceptable error rate and secondly, the means is required to manipulate and marshal the signals for this group of voice channels.

The CCITT System No. 6 specifies a bothway data link operating at 2400 bits per second as the common signalling channel. Messages consist of 28 bits and, allowing for control units there will be about eighty signal units per second in either direction. Each unit must be labelled to indicate to which voice channel it refers: 11 bits out of the 28 are allocated for this purpose. Depending on the characteristics of the telephone traffic on the voice channels up to 2048 (2^{11}) voice channels can be catered for by one link.

The CCITT System No. 6 has been designed on the assumption of electronic, computer type, processor controlled exchanges although the details are not specified in any way by the System specification.

Research Laboratories No. 6 Exchange

The field trial is primarily being conducted to investigate aspects of common channel signalling and in particular CCITT Signalling System No. 6. A secondary, but very important aim, is to study and use the techniques of stored programme control of exchanges using electronic processors (computers). To meet these requirements the exchange will consist of a specially purchased processor (BTMX) which will be linked by suitable interfaces to the switching matrix and associated line relay sets, etc., and to the signalling link terminal equipment. The switching matrix used will be a standard APO item consisting of 100 lines of ARM (trunk exchange) equipment and marker, modified for processor control. The signalling terminal has been designed and is being built within the Laboratories and has been designed to employ integrated circuit logic components.

Switching Matrix, etc.

The switching matrix is capable of connecting any inlet to any outlet under control of the marker. As the design of such hardware is not an integral part of the project suitable standard items have been used.

One of the advantages of stores programme control of telephone exchanges is that the signalling relay sets on circuits into and from the existing network which can't use common channel signalling can be greatly simplified. The logic functions associated with signalling can be performed within the processor rather than

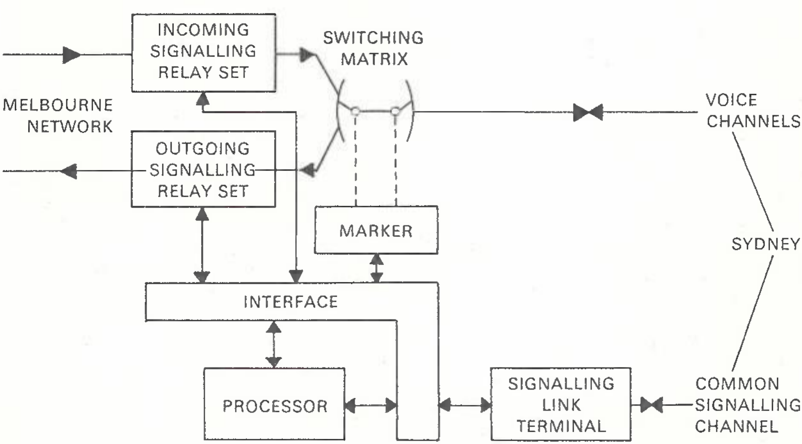


Fig. 3 System No. 6 Exchange — simplified block diagram

on relays within the relay set. As an example, a relay set which would normally require 30 relays, has been designed to use 6 relays.

As a separate exercise in the replacement of electro-mechanical devices with electronics, electronic versions of some of these relay sets are being designed by the Crossbar Development Division.

Processor The processor is a high speed electronic computer capable of performing up to 500,000 operations per second. It is basically a general purpose computer modified, in design, to operate in a real time, telephony environment. A processor has been purchased and can be seen on display CG9. 'Exchange Control Processor'.

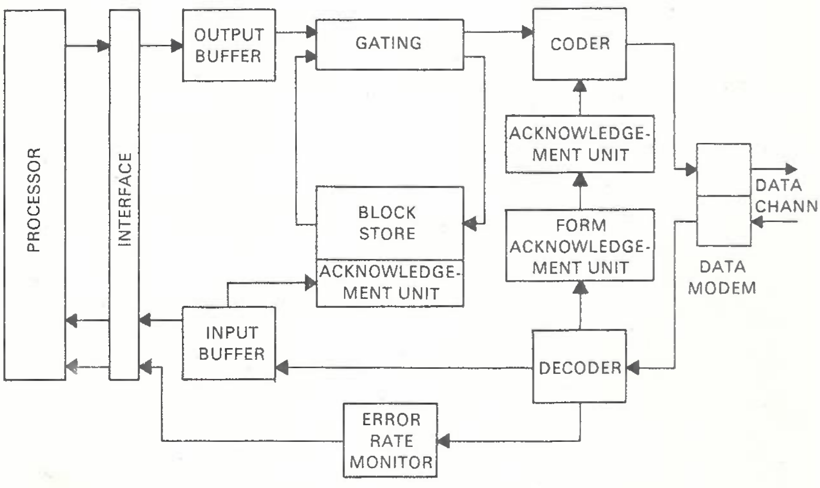


Fig. 4 Signalling Link Terminal — simplified block diagram

Signalling Link Terminal

The Signalling Link Terminal receives messages into the Output Buffer from the processor as 20 bit units. Each unit consists of one telephone signal relating to a particular voice channel. The unit is passed through the coder, which adds an 8 bit error checking code, to the data modem and on to the data channel.

Units are transmitted in a similar manner from the other end and are received via the data modem into the decoder. The decoder checks the unit and the 8 bit check code to see if an error has occurred in its transmission. If no error has occurred the unit is passed to the processor via the input buffer.

The stream of units being transmitted is broken into 12 unit blocks, the last unit in each block being a special acknowledgement unit injected by the signalling terminal. It identifies the block being transmitted and acknowledges the correct reception of the eleven units in the last block to be received.

The Block Store temporarily stores units being transmitted until the appropriate acknowledgement unit is returned from the distant end. If the acknowledgement unit indicates that a unit has been received correctly by the far end it is discarded. If it has been received in error it is retransmitted and, of course, stored again in the Block Store.

National Field Trial

Preparation for the national field trial is well under way. The processor has been installed in the Laboratories, the switch and marker equipment are being installed and the signalling link terminal equipment is fully designed and partially prototype constructed and tested. The remaining major task is the programming of the processors. In the light of overseas experience the effort required here is commensurate with the effort required on the hardware. Programming is under way and it is expected that trials using test traffic will commence in the latter part of 1970.

Instrumental Chemical Analysis

D. Waters: 630 7997

Atomic Absorption Spectrophotometry

This recently developed instrument, which utilises the absorption of atomic radiation, is a most efficient analytical tool for determination of low concentrations of metallic elements.

When the presence of a metal to be determined in the material has been established, it needs only to be brought into solution before proceeding with its estimation; as most other elements present will not cause interference.

A determination is carried out in the following manner. The radiation from a hollow cathode lamp emitting only the spectral lines of the metal is directed over a burner into the monochromator unit of the instrument, which is set at the selected resonant wave length. The entrant light beam is focused on a photomultiplier, the current produced is amplified and registers on a meter. With the lamp radiating and the burner correctly adjusted and burning the appropriate gaseous mixture, the recording meter is set to read 100% transmission when a control solution, free of the metal under test, is drawn into the burner as a fine spray. The solution containing the metal is next drawn into the burner, and the change in transmission is read. A calibration curve is prepared from the results obtained with standard solutions, thus enabling any subsequent concentrations of this metal to be readily ascertained.

Much time is saved in repetitive determinations such as the estimation of iron in battery acid and topping-up water.

The metals copper, zinc and iron which are being determined in a normal supply water, can be readily measured in concentrations of less than 1 part per million.

The Gas Chromatograph

This instrument is used to analyse and separate organic substances that can be vaporised without decomposition.

The basic elements of this instrument are an absorption column containing an inert absorbent, a detecting device, and a potentiometric chart recorder.

Before commencing an examination of any substance, an inert carrier gas such as helium,nitrogen, and argon, is passed through the instrument at a carefully maintained pressure. Both the absorption column and the detector compartment are maintained at a constant temperature. The operating temperature is dependent upon the nature of the substance under investigation.

When the instrument has attained a state of operating stability, the sample is introduced into the carrier gas stream and vaporised before entering the absorption column. The different molecular species in the sample are differentially absorbed by the column material while being carried through by the carrier gas. After the elapse of a retention time, which is specific for each component and the particular column used, the components individually produce a signal on entering the detector. Either a catherometer based on thermal conduction, or the more sensitive hydrogen flame ionisation detector is used in this instrument. The signal obtained is traced by the recorder and from the resulting chromatogram the concentration of each component can be determined.

The identity of each component is readily effected by using this instrument in conjunction with an infra-red spectrophotometer.

Samples of a Departmental solvent formulation are presently being checked.

Automatic Titration

Soluble phosphates are added to laundry powders to enhance their cleansing power.

Due to the large quantity of these powders used, and the need to evaluate the numerous products available, automatic titration is frequently employed for the phosphate determinations.

In these determinations the organic matter is charred to a residue of carbon and inorganic salts by controlled heating. The residue is then heated with dilute acid which converts the phosphates to phosphoric acid, leaving the carbon in suspension. The pH of the solution is adjusted to 4.3 with sodium hydroxide which converts the free phosphoric acid into sodium dihydrogen phosphate. By titration with standard sodium hydroxide to pH 8.8 this compound is converted to disodium hydrogen phosphate. Despite the presence of the suspended carbon, which precludes the use of visual indicators, the phosphate concentration can be readily ascertained.

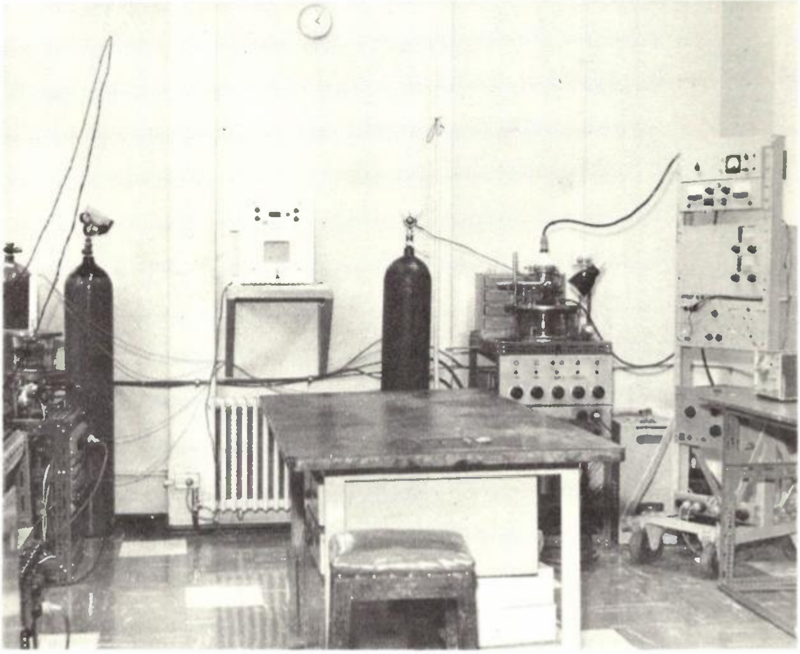
Semiconductor Thin Film Facility

Dr. N. Teede: 630 7945

Semiconductor Thin Film Facility

Few technological developments in this century have had as large an impact on the electronics industry as the development of the transistor in 1949. Continuing research in the field of semiconductor materials over the succeeding ten years gave rise to a very diverse range of sophisticated devices. Materials research, coupled with the development of semiconductor technology, made feasible the integrated circuit in the early 1960s. The compactness, reliability, long lifetime and comparatively low cost offered by integrated circuits, ensure their prolific use in the 1970s especially in the field of computational and communications equipment.

It is for the purpose of assessment and development of new semiconductor phenomena in terms of communications application potential that a semiconductor research group functions within these research laboratories.



Besides providing a central pool of knowledge of recent advances in semiconductor development, the work of this group extends into the areas of materials research in compound semiconductors, and prototype device development using these materials. To facilitate the fulfilment of these functions a range of vacuum and diagnostic facilities have been established.

Vacuum Facilities

Four high vacuum systems are provided to allow the preparation of a large number of materials in a clean environment. These systems include facilities for vacuum evaporation of semiconductor and metal films, vacuum melting and annealling, plasma sputtering of dielectric and insulating materials, and electron beam zone refining and recrystallization. This range of vacuum facilities is necessitated by the diverse characteristics of the different materials under heat treatment.

Diagnostic Facilities

As the electronic properties of semiconductors are strongly dependent on crystalline structure and purity, both electrical and physical diagnostics are employed to assess the interaction of these parameters.

Use is made of a quadrupole mass spectrometer to assess the effect on electrical properties of occluded dopant impurities in evaporated or heat treated semiconductor films. The structural and compositional characteristics of the semiconductors after the various heat treating processes, are assessed by electron or X-ray diffraction, X-ray fluorescence, and atomic absorption spectrophotometry. These facilities are all available in various parts of these laboratories.

Materials Research

Most of the materials research has been concerned with the achievement of bulk crystal electrical properties of the compound semiconductor, indium antimonide, in thin layer form. The basis of this research is that in many semiconductor devices the electrical conduction in thin layers determines the performance of the device. The preparatory procedure involves the evaporation of the compound InSb from a heated source, through a metal mask defining a convenient measurement geometry, onto a glass or quartz substrate. Subsequent recrystallization is achieved by moving a molten zone created by a scanning electron beam, through the length of the film. The physics of the semiconduction mechanism is being studied as a function of structural defects, impurity concentration, and surface properties, in order to determine the parameters which are important in limiting the electrical properties in thin layers.

In conjunction with the device developmental work, the evaporation processes and film characterization have been undertaken for many metals and oxides of metals such as those of indium, silicon, tantalum and aluminium.

Device Development

In the development of devices, this group restricts its activity to the prototype development of devices which cannot be purchased from commercial manufacturers. Several examples of devices which have been fabricated and tested are optical detectors for laser beam demodulation, magnetoresistors for microwave power measurement and a magnetoresistance microphone. The development of a microwave field effect transistor is currently being undertaken. Due to the small sizes of these devices integrated circuit photo etching techniques are being used in their fabrication.

Graphical Symbols for Logic Diagrams

N. McLeod: 630 7804

Graphical Symbols for Logic Diagrams

The Research Laboratories have been studying the various logic symbols standards being used. This was initiated by the increased use of Integrated Circuits, and the need for a more suitable set of symbols for the complex logic systems which are now feasible. The Research Laboratories Symbols Committee have produced a proposal for submission to the Australian Standards Association for adoption as an Australian Standard. In preparing this document discussions have been held with other Commonwealth Departments, in particular the Weapons Research Establishment, in an attempt to reach agreement. Any differences that exist between the documents of these various Departments is in text and layout, rather than in content.

The resulting proposal follows the basic philosophy of Mil-Std-806B-U.S.A., but expanded and modified where appropriate.

The following are extracts from the Research Laboratories proposal with some comments added.

Definitions

BASIC LOGIC DIAGRAM. A logic diagram that depicts logic functions with no reference to physical implementations. It consists primarily of logic symbols and is used to depict all logic relationships as simply and understandably as possible. Non-logic functions are not normally shown.

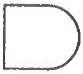
DETAILED LOGIC DIAGRAM. A diagram that depicts all logic functions and also shows non-logic functions, socket locations, pin numbers, test points, and other elements necessary to describe the physical aspects of the system. The detailed logic diagram is used primarily to facilitate the diagnosis and localisation of system mal-functions. It is also used to verify the physical consistency of the logic and to prepare fabrication instructions. The symbols are generally connected by lines that represent signal paths.

TABLE OF COMBINATIONS. For purposes of this document, tables of combinations describe the input/output conditions of the basic logic functions, using H (HIGH) for more positive and L (LOW) for less positive.

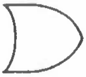
The specification refers to the two levels as H and L in truth tables (tables of combinations), rather than 1 and 0. The use of H and L as defined in the extract above, removes some of the confusion that may arise from the use of 1 and 0.

Logic Symbols

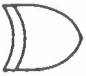
AND. The symbol shown shall be used to represent the AND function. The AND output is Active if and only if all the inputs are Active.



OR. The symbol shown shall be used to represent the INCLUSIVE OR function. The OR output is Active if and only if one or more of the inputs is Active.



EXCLUSIVE OR. The symbol shown shall be used to represent the EXCLUSIVE OR function. The EXCLUSIVE OR output is Active if one and only one input is Active.

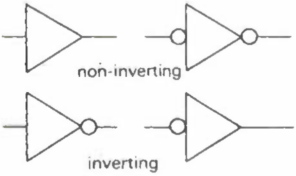


The above extracts show the symbols for the AND, OR and EXCLUSIVE OR gates. It should be noted that all these gates are defined in terms of active and in-active. A basic principle of these symbols is the use of active and in-active (instead of 1 and 0), and whether the active conditions is a high or low is specified by the use of a 'State Indicator' as defined in the following extract.

STATE INDICATOR. A small circle may be placed at the inputs or outputs of a logic symbol. This small circle shall never be drawn by itself on a diagram.

> *A small circle(s) at the input(s) to any element (logical or non-logical) indicates that the relatively low (L) (or low going) input signal activates the function. Conversely, the absence of a small circle indicates that the relatively high (H) (or high going) input signal activates the function.*
>
> *A small circle at the symbol output indicates that the output terminal of the activated function is relatively low (L).*

Hence the basic shape is defined in terms of actives. The 'State Indicator' indicates whether an active is a high or a low.



<u>AMPLIFIER</u>. The symbols shown shall be used to represent a Signal Amplifier. The amplifier may have one or more stages and may or may not produce gain or inversion. Level changes and inverters (NOT gates), pulse amplifiers, emitter followers, cathode followers, relay drivers, lamp drivers, and shift register drivers are examples of devices for which this symbol is applicable.

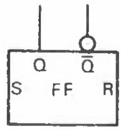
<u>FLIP-FLOP</u>. The flip-flop is a device which stores a single bit of information. It can have complementary outputs, Q and $\bar{Q}$, and a number of possible inputs — depending on the type of flip-flop.

The flip-flop is 'set' when the Q and $\bar{Q}$ outputs are active and the flip-flop is 'reset' when the Q and $\bar{Q}$ outputs are inactive.

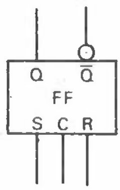
> ***Symbol:*** *The basic symbol for flip-flop is as shown. The aspect ratio of the symbol shall be 1.8 : 1. The symbol may be rotated 90° in either direction, to suit the layout of the diagram.*
>
> *All flip-flop symbols shall be realised by adding inputs and outputs to the basic symbol. The outputs of a flip-flop, Q and $\bar{Q}$, will always be adjacent and on a long side of the symbol. Inputs which set the flip-flop shall be placed in proximity to the Q output, and inputs which reset the flip-flop shall be placed in proximity to the $\bar{Q}$ output. State indicators shall be used as required on a flip-flop symbol.*

An important point to note with the above definition is that the outputs Q and $\bar{Q}$ are complementary. That is, if Q is high, $\bar{Q}$ must be low; or if Q is low, $\bar{Q}$ must be high. Further, these outputs indicate whether the flip-flop is set or reset by their being active or inactive respectively. Since both Q and $\bar{Q}$ are active (or inactive) at the same time, and the two outputs are electrically complementary, the flip-flop symbol must always have a state indicator on one of the two outputs, Q or $\bar{Q}$.

<u>UNCLOCKED INPUTS</u>. Inputs whose action is independent of any clock input. As shown the 'S' input shall be on the short side in proximity to the 'Q' output, and the 'R' input shall be on the short side in proximity to the '$\bar{Q}$' output. The symbols 'PR' (Preset) and 'CR' (Clear) may be used instead of 'S' and 'R' respectively where appropriate.



<u>CLOCKED INPUTS</u>. Inputs that can only influence the state of the flip-flop when activated by a clock input. As shown the three 'S' (set), 'C' (clock), and 'R' (reset) will always appear on the opposite side of the flip-flop to Q and $\bar{Q}$. C will appear between S and R, and as defined under 'Flip-flop Symbol', S will be in proximity to Q, R to $\bar{Q}$.



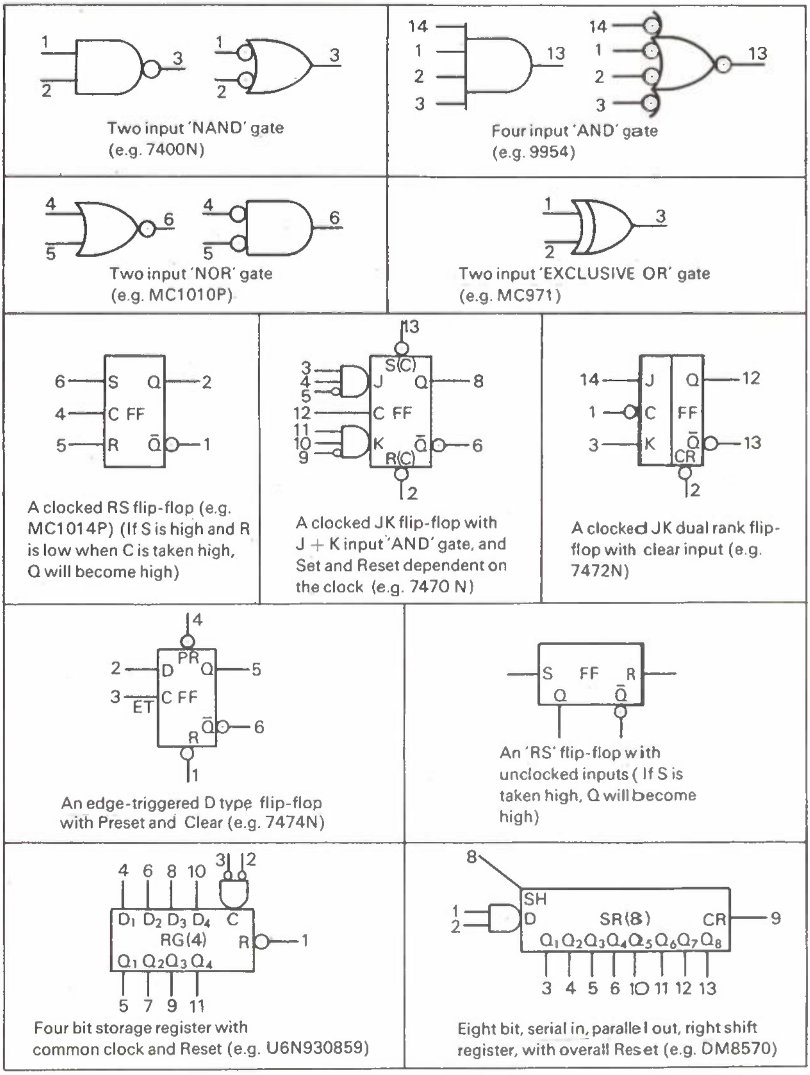


Fig. 1 Some examples of the use of these symbols.

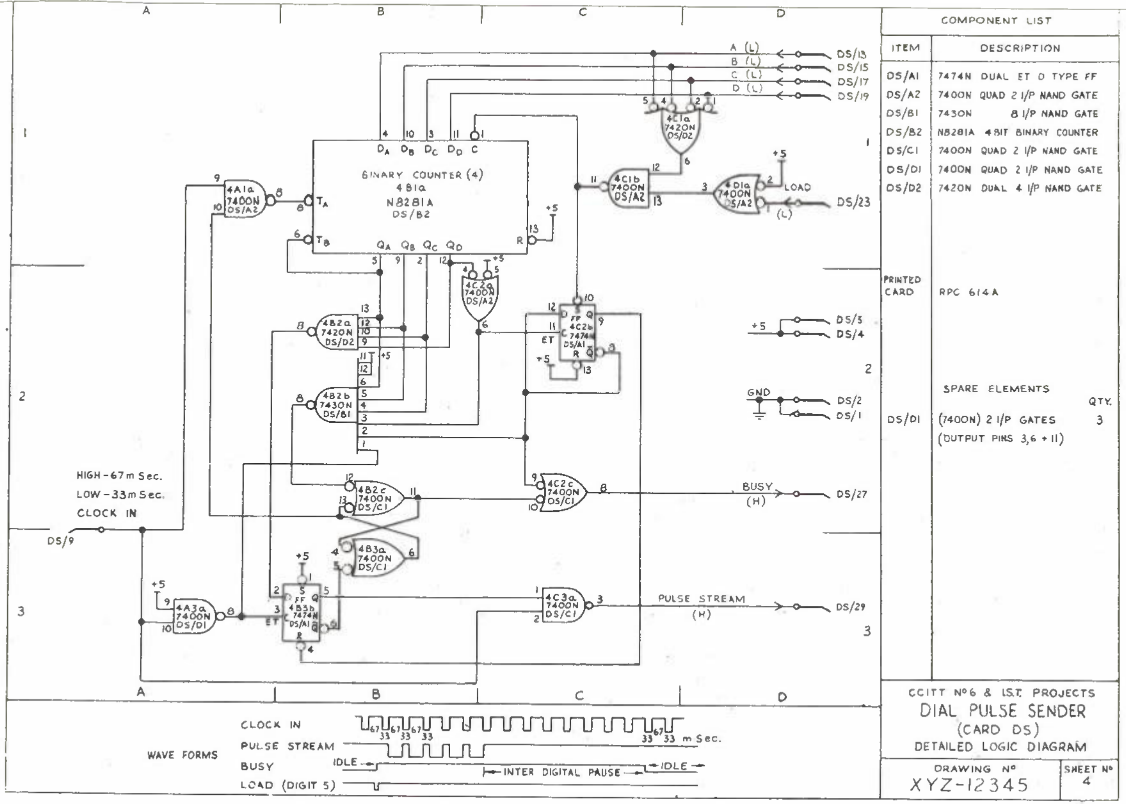


Fig. 2 An example of the use of these symbols on a detailed logic diagram.

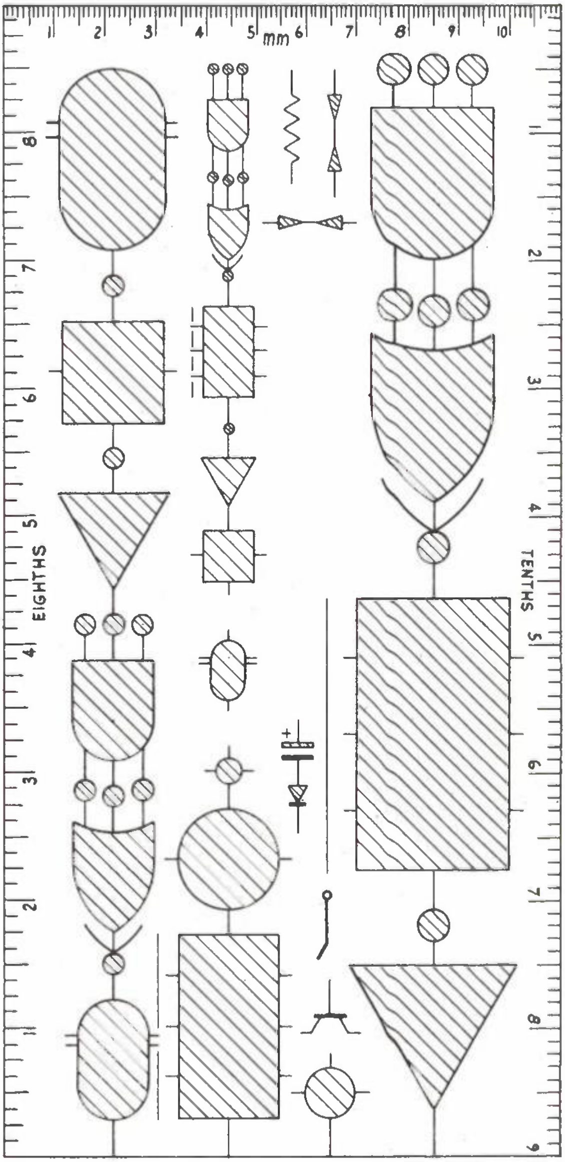


Fig. 3 Template suitable for use with these symbols (shown reduced).

AUSTRALIAN POST OFFICE
RESEARCH LABORATORIES

Communication by Radio to Remote Areas of Australia

D. Snowden: 630 7927

Communication by Radio to Remote Areas of Australia

For some years the Post Office has been working towards the achievement of a completely automatic telephone system in Australia. One major difficulty has been to give this service to a large number of subscribers in country areas who have erected their own single wire earth return lines. These lines give performances ranging from satisfactory to very poor when connected to the old magneto-type exchanges but are quite unsuitable for automatic services.

It is now the Department's policy that all new subscribers' lines must be suitable for automatic working. Physical lines ('metallic circuits') must be properly constructed, consisting of two conductors adequately insulated from each other and from the ground. Lines of this type are expensive and the cost of long ones often exceeds the Department's contribution by a substantial amount which the subscriber must pay.

An alternative means of subscribers' line provision is the radio telephone system. Exchange-subscriber links have been in limited use for some time and now satellites are being considered as a means of giving service to subscribers who are too far from an exchange to be served by either a physical line or a radio system.

'Conventional' Radio Telephone System

These systems replace the telephone lines between subscribers and their exchanges. They offer excellent performance but their operating ranges are limited to about 40—50 miles under favourable propagation conditions. Economically, they have been attractive only as alternatives to very long lines and consequently the use of radio for subscribers' telephone circuits has been limited.

In the Radio Systems Division, we are attempting to develop a cheap and reliable radio telephone system which will make the use of radio more attractive economically than in the past. Systems in use at present employ analogue frequency modulation of the carrier and use transmitter powers ranging from one to twenty-five watts. The system being developed here codes analogue signals into digital signals for transmission. Theoretically, the transmitter output power requirement of the digitally-modulated system is only one-tenth of the power requirement of the conventional FM system. In reducing the transmitter output power, significant reductions of initial and operating costs are expected.

The major disadvantage of the digitally-modulated system is that it must be given a wider RF channel than the FM system if interference with other analogue-modulated systems is to be avoided. However, the digitally-modulated system's greater immunity to noise and interfering signals should enable the frequency spacing between physically adjacent **digitally**-modulated systems to be considerably less than the spacing between analogue and digital systems. Work will begin soon to determine the minimum frequency spacing between digitally-modulated channels.

Satellite Radio Telephone System

In contrast to 'conventional' exchange-subscriber radio telephone links, subscribers to a satellite system will be linked directly through the satellite repeater. The Laboratories are examining the possibility of providing telephone services (and perhaps sound and television broadcasting too) to people living in very remote areas of Australia.

The major advantage of a satellite system is that it can be used by earth stations located **anywhere** in the area covered by the satellite's antenna. Thus, if a satellite is positioned to cover the whole of Australia, communications can be established to any point of the continent by the use of a suitable earth station.

A future satellite system serving individual subscribers in Australia would probably provide a total of about 100 satellite channels to serve about 1,000 subscribers. Control stations will automatically assign channels to users as required and will also enable connections to be made between conventional telephone subscribers and those in the satellite network.

A careful study of the problem indicates that digital modulation of single channel carriers is the most suitable modulation method. Preparations are being made to conduct a series of experiments using a satellite to show us how closely the satellite channels can be spaced in frequency and also to give us information on the transmitter powers required in the system.

Speech Level Meter

A. Gibbs: 630 7316

AUSTRALIAN POST OFFICE RESEARCH LABORATORIES

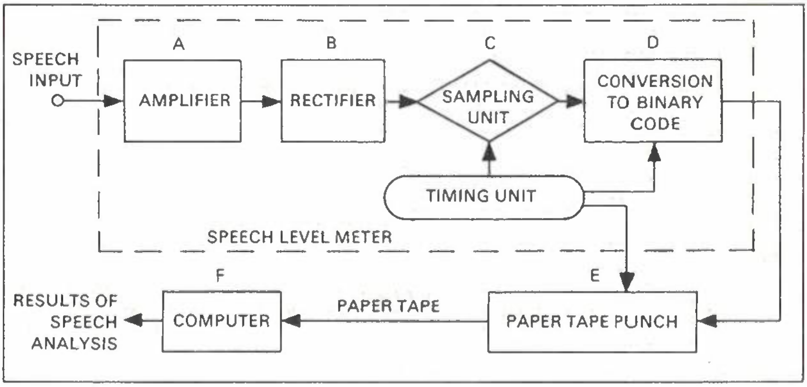
Speech Level Meter

To help in the efficient design of telephone equipment it is useful to know the characteristics of speech produced by telephone subscribers. This information is of particular use in the design of carrier equipment where a large number of telephone channels are combined into one broad band channel.

Most useful is statistical information measured at the most busy time (for telephone traffic) of the day. The main interests are the average power levels of speech signals, their level distribution and their activity factor (the fraction of time speech is present).

Method of Operation

The basic operation may be understood by reference to the following diagram and description.



The speech signal is amplified and then full-wave rectified (B). The instantaneous voltage level at the output of the rectifier is sampled three times a second. The sampled level is then converted to a binary code suitable for feeding a paper tape punch.

The paper tapes are then processed to give the required information on speech signals, viz. activity factor, average power level while the circuit is active, variance of power level and ultimately the distribution of speech power levels in multichannel links.

Soft Magnetic Iron Testing

D. McKelvie: 630 7985

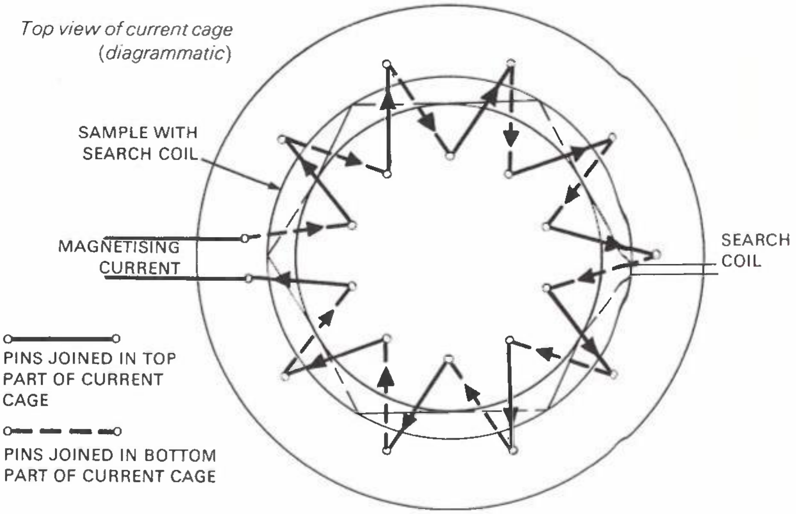
Soft Magnetic Iron Testing

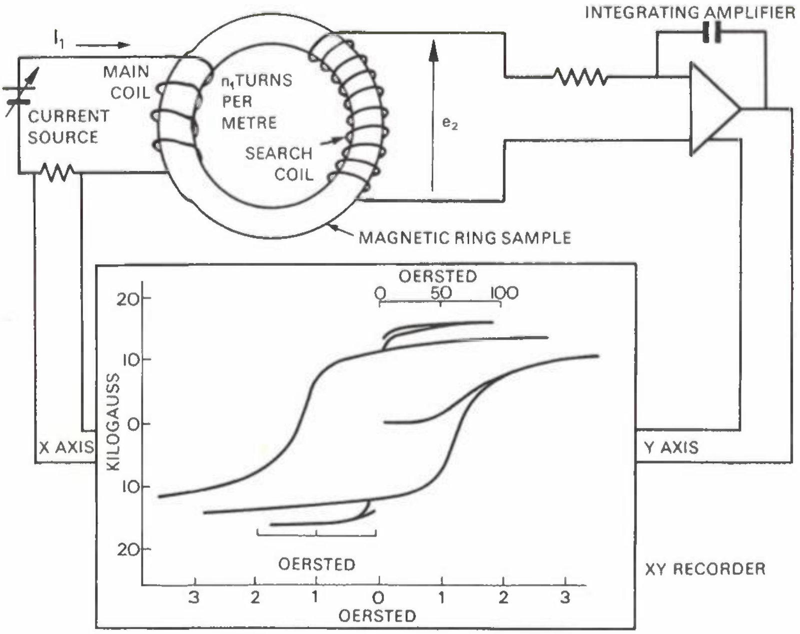
Soft magnetic iron used in the manufacture of modern telecommunication equipment must have magnetic parameters which lie within narrow limits or exceed minimum values. It is also important that the magnetic properties of the iron are stable over a long period so that the equipment (relays, cross-bar switches, etc.) does not have to be designed to allow for a gradual decrease in efficiency or alternatively be adjusted at intervals during its life.

For this reason, before the iron is released to the equipment manufacturers, the Department tests samples from each batch of bar, rod, or sheet material. The tests include an artificial ageing treatment to assess the change in magnetic properties which can be expected over 20 years.

These tests are at present being carried out by the Research Laboratories and are performed as follows:

Top view of current cage (diagrammatic)





$X = H = kn_1\ I_1$

$Y = B = K\ e_2 dt$

WHERE H IS THE MAGNETIC FIELD VECTOR

AND B IS THE MAGNETIC INDUCTION VECTOR

VALUES OF H CAN BE READ FROM THE RECORDING ACCURATE TO $\pm$0.01 OERSTED

VALUES OF B CAN BE READ FROM THE RECORDING ACCURATE TO $\pm$100 GAUSS

B-H Curve Tracer: Principles of operation (*block diagram*)

Sample Preparation

Rods and bars are formed into rings 200 mm in outer diameter and washers, 36 mm O.D. are punched from the plate material and annealed. The linear dimensions of each sample are measured and a search coil is wound on by hand, the number of turns depending on the cross-sectional area of the sample.

Current Cage

The sample is placed into a 'current cage' which is a demountable coil, which when closed, places 246 (large rings) or 36 (washers) turns around the sample.

Demagnetising

The sample is next demagnetised by applying an alternating magnetic field of slowly decreasing amplitude.

B-H Curve-tracing

The sample is then automatically cycled from zero flux to saturation and then around the hysteresis loop at an almost constant rate of change of flux. The time for a complete cycle is 90 seconds to avoid the effects of magnetic viscosity.

A voltage proportional to the magnetising current (and magnetising force) is fed to the recorder X axis. The voltage produced in the search coil by the changing flux density is integrated and the resulting voltage, which is proportional to B, is applied to the recorder Y axis.

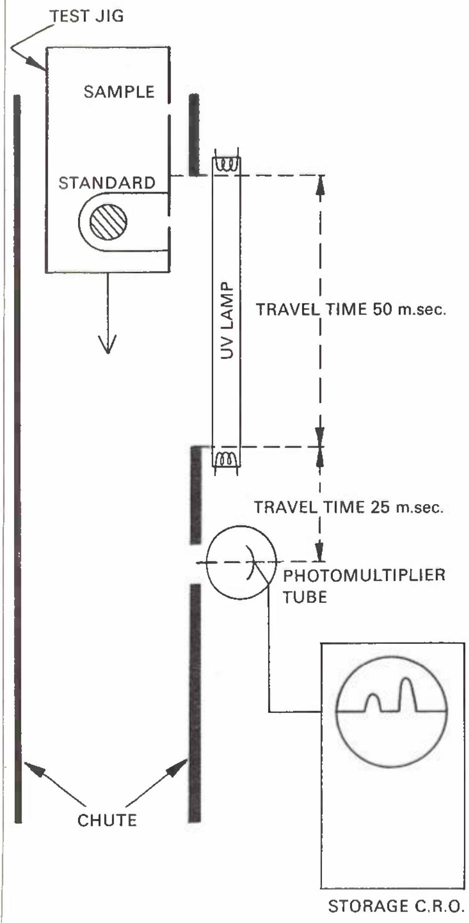
Luminescent Tape Testing

N. Sadler: 630 7987

Assessment

The two output pulses from the photomultiplier are displayed on a storage cathode ray oscilloscope and the ratio of the two pulse heights is used as a measure of the quality of the tape with respect to its luminescent properties.

Principle of operation



The Adaptive Echo Canceller

H. Bruggemann: 630 7954
L. Mackechnie: 630 7957

The Adaptive Echo Canceller

With the advent of communication satellites and the rapid growth of international telephone traffic, there is a renewed interest in the problem of echoes generated at hybrids which interconnect 2-wire and 4-wire links. It has been found that these echoes have a disturbing effect on conversations over such links, if the echo delay time is excessive. The operation of the conventional switched echo suppressor is quite simple; it senses the presence or absence of speech on the incoming path of the 4-wire circuit and uses this information to introduce attenuation on the outgoing path. However, due to the presence of two such echo suppressors, a number of difficulties arise which impede the natural flow of conversation, especially during double talking over links with long delays, and hence interest in other methods of echo suppression has arisen.

The Project

The aim of the current project is to investigate a method of echo cancellation based upon the generation of a signal equal in magnitude and opposite in sign to the unwanted echo and the addition of this signal to the outgoing path of the hybrid. Basically, the two functions necessary to achieve cancellation in this way are:

1) Sensing of the transhybrid response using a suitable test signal.
2) Simulation of the transhybrid responses encountered in practice. (This simulation is to be controlled by the above sensor, *see Fig. 1*.)

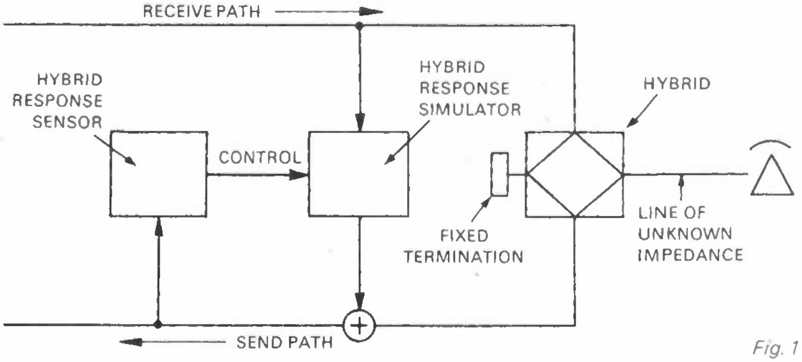


Fig. 1

The Display The project has progressed to the stage where the hardware associated with phase one has been completed and is on display.

Fig. 2 is a block schematic of the salient functioning components of the system. Prior to a conversation an iterative control strategy, operative during a short burst of PRN, sets the tap settings of the transversal filter such that it simulates the transhybrid response. Thereafter, the tap settings are held until a new control sequence is initiated.

Referring to *Fig. 2* we have:

$x(t)$ = incoming signal

$y(t)$ = outgoing signal

$E(t)$ = unwanted echo signal

n = tap number ($n = 0 \ldots\ldots 40$)

τ = Nyguist interval = 150μs.

$[\phi_{XX}(n\tau)]$ is an n X n element matrix representing the autocorrelation function of $x(t)$.

$[\phi_{XY}(n\tau)]$ is an n element column matrix representing the cross-correlation function of $x(t)$ and $E(t)$.

$[h_D(n\tau)]$ is an n element column matrix representing the impulse response of the transversal filter.

$[h_O(n\tau)]$ is an n element column matrix representing the impulse response of the cancelled hybrid.

A control algorithm which ensures the convergence of $[h_O(n\tau)]$ to zero by an iterative adjustment of tap settings and using a general signal $x(t)$ may be described as follows:

$$\left[h_D(n\tau)\right]_{i+1} = \left[h_D(n\tau)\right]_i + \left[\Phi_{XX}(n\tau)\right]_i^{-1} \left[\Phi_{XY}(n\tau)\right]_i$$

where i denotes the ith iteration,

where $\left[\Phi_{XX}(n\tau)\right]_i^{-1}$ is the inverse matrix of $\left[\Phi_{XX}(n\tau)\right]_i$

The hardware complexity associated with such a matrix inversion makes its implemention cumbersome and expensive.

A substantial simplification is achieved by letting $x(t)$ be a filtered PRN sequence. $[\Phi_{XX}(n\tau)]$ then becomes a diagonal matrix whose element values are $\Phi_{XX}(o)$ (which is constant for a given level of $x(t)$). The inverse of this matrix is also a diagonal matrix whose element values are $\frac{1}{\Phi_{XX}(o)}$.

Consequently, the control algorithm simplifies to:

$$\left[h_D(n\tau)\right]_{i+1} = \left[h_D(n\tau)\right]_i + \left[h_o(n\tau)\right]_i$$

$$\left[h_D(n\tau)\right]_{i+1} = \left[h_D(n\tau)\right]_i + \frac{1}{\Phi_{XX}(o)} \left[\Phi_{XY}(n\tau)\right]_i$$

The canceller on display operates according to this strategy. A level detector is used to terminate the control process when the echo signal falls below a predetermined threshold.

Using simulated delays of 640 ms, it has been possible to achieve a degree of cancellation which renders the echo unobjectionable, although still perceptible. It has been found that the degree of echo cancellation is dependent largely upon the type of PRN filtering employed. Times taken for the cancellation ratio to reach its final value have been of the order of 300 ms for typical responses.

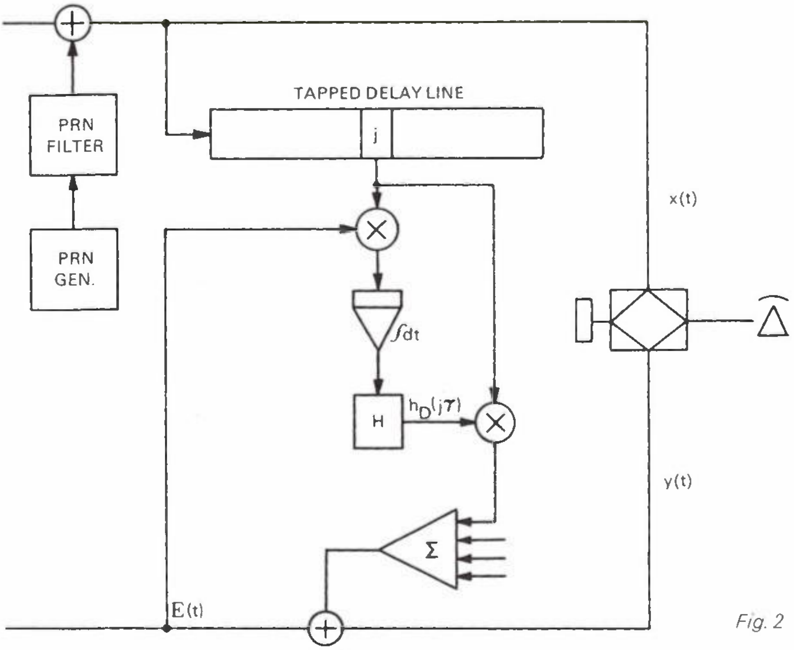


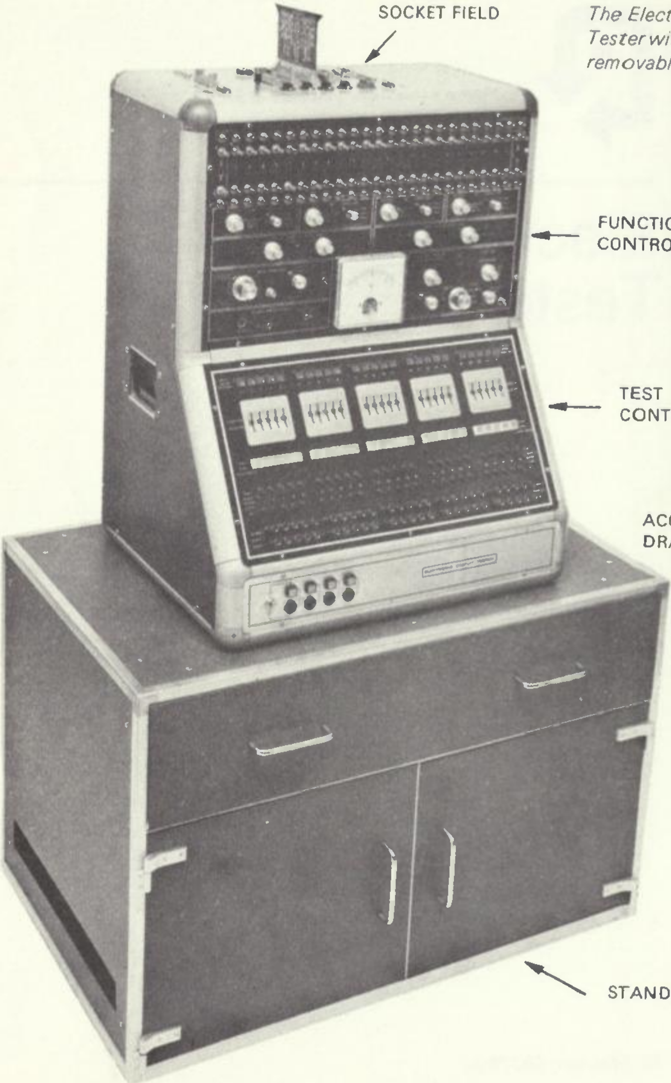
Fig. 2

In the current project, the response simulator (2) is in fact a transversal filter and the error sensing (1) utilizes a correlation technique.

The development of the prototype of such a canceller is proceeding according to two phases. The first phase involves the injection of a filtered pseudo-random-noise (PRN) test sequence to sense the transhybrid response and to equalize the link prior to a conversation. This state of cancellation is then held until the end of the conversation, or until the echo level necessitates another equalizing burst of PRN (perhaps during a speech gap). In the second phase of development, it is intended to implement a control strategy whereby the speech signal itself becomes the sensing signal and the cancellation continuously adapts to the time variant state of mismatch at the hybrid. Computer simulations indicate that a stepped control technique may be suitable.

Electronic Circuit Tester

N. McLeod: 630 7804

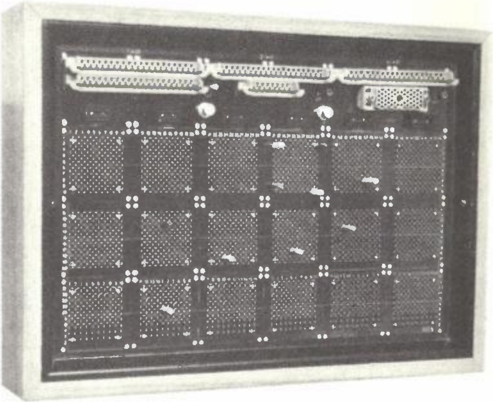


The Electronic Circuit Tester with removable stand/trolley

When designing and prototyping equipment, there is a need for a simple means of testing the modules used in a system. In the past this has been done by making special testing equipment for each particular case, or testing the modules in the system. This is inefficient due to the expense of the test equipment, and the time taken in debugging the completed system. With increased use of complex Integrated Circuits, a general purpose tester becomes still more necessary.

The Electronic Circuit Tester has twenty-five lines, that is, modules with up to 25 pins may be controlled and monitored. Each of these lines may have one of ten independent functions connected to it via ten position 'thumb-wheel' switches — as used in a valve tester.

The 25 lines, with selected functions, pass through a field of terminal posts, where discrete components may be added to simulate serial and parallel loads, etc. The lines are then connected to a range of sockets wired in parallel, to take integrated circuits, printed circuit cards, relays, and external cable connection.



The Programme Matrix Board

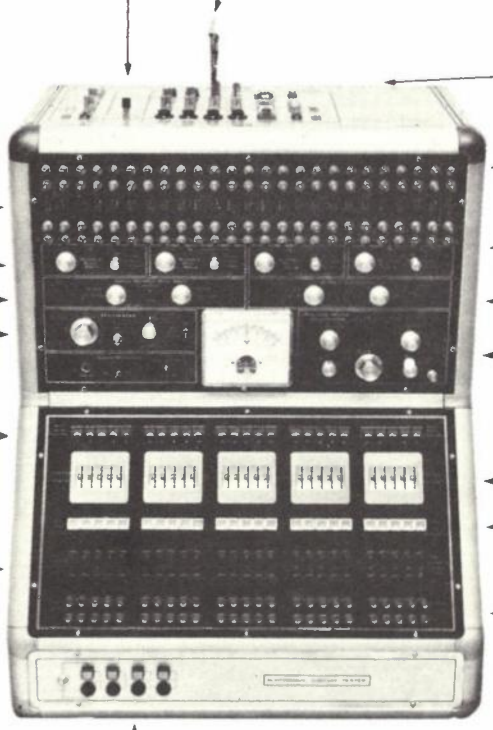
A major accessory is a 30 by 60 point programme matrix board. Twenty-five of the 30 lines are connected to the Electronic Circuit Tester, the remaining five being available for other functions. The 60 lines are connected to a range of connectors. Shorting pins are inserted in the cross-points of the board, to interconnect these sockets, and select lines to be connected to the Electronic Circuit Tester, as appropriate.

Applications include

Breadboarding of discrete component circuits using terminal field.
Testing of Integrated Circuits. Simple circuits at rates of 50 packages per hour.
Prototyping and testing of printed circuit boards during construction of systems.
Testing a complete system.
Breadboarding of logic circuits with four I.C. packages with Programme Matrix Board.
Training in Logic Circuits.

Features include

Four Independent Supply Rails.
Input bounce-free keys for manual simulation of pulse trains.
Output level GO/NO GO Indicators.
Square-wave Generator.
Multi-Range Voltmeter.
Control and Monitoring of up to 25 lines.
Circuit Isolation Switch.
Terminal Field for Additional Components.
Programme Matrix Board for Expanding to 60 lines.
Suitable for Automatic Control (with some modification).



CIRCUIT ISOLATION SWITCH
CIRCUIT UNDER TEST
SLIDER
ITCHES IN
RIES WITH
ACH LINE
PLY RAIL,
GE LEVEL
CURRENT
LIMIT
ONTROLS.
JNCTIONS
1, 2, 3 & 4
UT DRIVE
LEVEL
ONTROLS.
NCTION 6
TIMETER,
SELECTOR
NSITIVITY
AMPS TO
CATE LINE
CTED FOR
LTIMETER
OUTPUT,
O/NO GO
MONITOR
LAMPS.
NCTION 7
TEST SOCKET FIELD
TERMINAL FIELD
FOR ADDITION
OF EXTRA
COMPONENTS
LEVEL
CONTROLS FOR
OUTPUT
GO/NO GO
MONITORS
FUNCTION 7
SQUARE-WAVE
GENERATOR
CONTROLS
FUNCTION 8
FUNCTION
SELECTORS
INPUT DRIVE
PUSH-BUTTON
KEYS.
FUNCTION 6
TERMINALS
FOR EXTERNAL
CONNECTION.
FUNCTION 9
POWER SWITCH, FUSES & INDICATORS

Research Laboratories' Computer Centre

B. Warren: 630 7336

Introduction

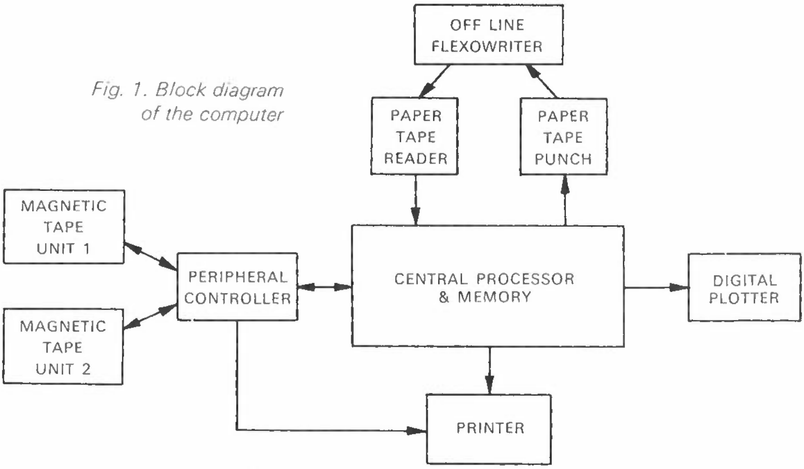
The Research Laboratories are equipped with a C.D.C. 160-A digital computer, which allows users relatively quick access to a computing service of medium capacity. This installation meets three basic needs. It provides a general purpose computing service for small engineering or scientific problems, permits testing of algorithms or programs which are to be run on larger computers, and serves as control for other hardware during experiments.

The central processor and paper tape peripheral equipment were obtained in 1963, and the printer and magnetic tape units were added soon afterwards. An auxiliary memory unit was purchased during 1968.

Details of the Research Laboratories' Installation

The system installed in the Laboratories consists of a central processor and two memory banks, an auxiliary memory unit with two additional banks, a paper tape reader and punch, a peripheral controller and two magnetic tape units, a line printer and a digital plotter. Each memory bank contains 4096 12-bit words with a cycle time of 6.4 microseconds. Table 1 lists the characteristics of the various peripheral units and Fig. 1 shows their relationship.

Fig. 1. Block diagram of the computer



PAPER TAPE READER ..	350	CHARACTERS/SEC.
PAPER TAPE PUNCH ..	110	CHARACTERS/SEC.
LINE PRINTER	150	LINES/MINUTE
DIGITAL PLOTTER	1	IN./SEC.
MAGNETIC TAPES (2) ..	41,600	CHARACTERS/SEC.

Table 1. Characteristics of Peripheral Devices

The printer and magnetic tape units may be used off-line, i.e., information stored on magnetic tape may be listed on the printer whilst the computer is engaged on other work (not requiring the printer).

The staff of the Computer Centre consists of two programmers, a computer operator, two paper tape punch operators and a clerical assistant. The programming staff assist users with their programs, write general purpose library programs and develop and maintain software.

When a program is received, it is recorded in a register before being sent to the computer room. After a program has been run, the output is checked by a programmer; if it contains minor errors which can easily be located, these are corrected and the program is re-run.

Programming

The symbolic assembly language is OSAS-AX. Apart from its use in writing computer software, this language is generally used only for reading paper tape or magnetic tape which has been written in a non-standard format.

Two versions of FORTRAN are available, one being C.D.C. 160-A FORTRAN and the other, a locally developed variant, is termed APO Research FORTRAN. Both versions employ an interpretive system. That is, the compiler does not produce machine language object code, but rather a code closely related to the corresponding FORTRAN statement. This code is then read into memory and interpreted at object time by a machine language program called 'the interpreter'.

APO Research FORTRAN is the language in which most programs are written. The compiler for this language was written by officers of the Department.

It is faster than the original compiler and produces more efficient object code. Further, it contains additional debugging facilities. For example, when an element of an array is referenced, the subscript is first checked to ensure that it does not lie outside the range specified by the DIMENSION statement.

APO Research FORTRAN is oriented towards the use of paper tape. In particular, the length of a line of coding is not restricted to 72 or 80 characters as in card oriented versions of FORTRAN; the end of a line (which may be of any length) is indicated by a carriage return character. The use of paper tape generally has the disadvantage that the entire program must be repunched to correct errors. However, an edit program enables the computer to correct programs by inserting, replacing or deleting specified lines of coding.

Program Testing

In a scientific and engineering environment, much of the programming effort is in the development of short lived programs. Therefore, a large percentage of computer time is used for program testing.

The operation of the Computer Centre is on an 'Open Shop' basis. In general, programming is carried out by the engineer originating the problem, rather than by a full-time programmer. However, the programming staff of the Computer Centre are always available to offer advice and assistance.

Some recent programs which have been submitted by computer users concern simulation of a PABX, and the effect of a filter on a specific wave form. A program which approximates a function by a sum of Laguerre functions has been tested on this computer for later running on a larger machine.

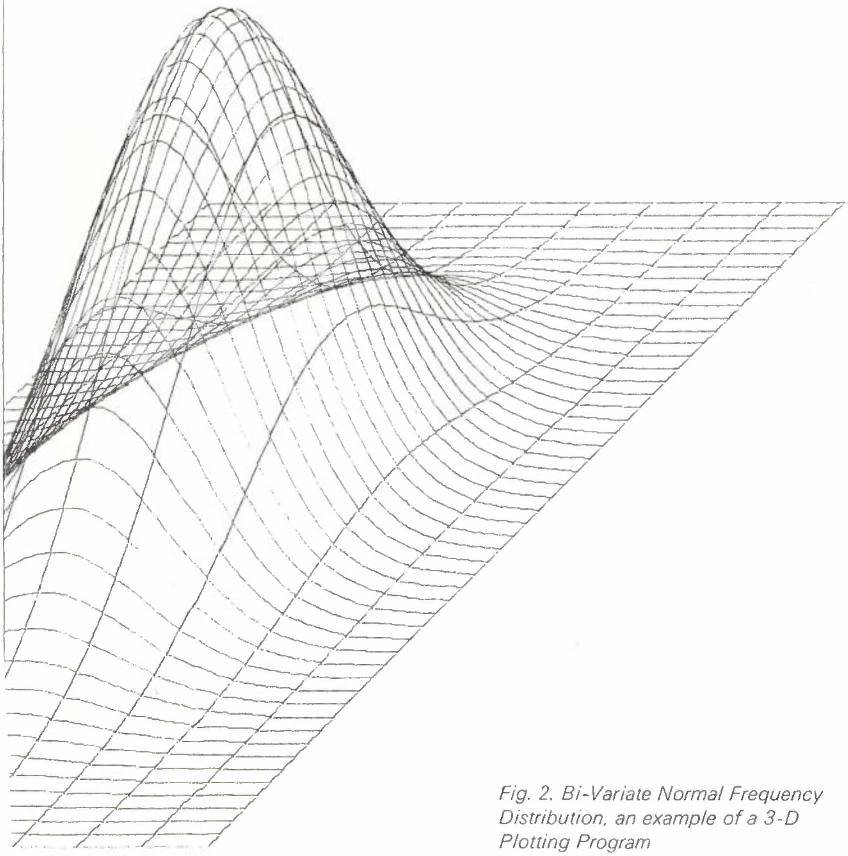


Fig. 2. Bi-Variate Normal Frequency Distribution, an example of a 3-D Plotting Program

Library Programs

A comprehensive library of standard programs is available to users. The library contains programs to perform statistical analyses, mathematical manipulations (such as the solution of equations and complex arithmetic) and general utility programs. Some of the more interesting library programs are described below.

The execution of OSAS programs can be traced by a program which provides diagnostic messages. The contents of selected locations, the special registers and other information can be printed at selected points during the execution. The program to be tested is run under the control of the diagnostic program.

An analog or hybrid computer can be simulated on the digital computer by means of a library program. Data supplied to the program specifies the type of analog units and the configuration in which they are connected. Analog units available include integrators, summers, multipliers, comparators, extrema detectors and function generators. The output of each unit is evaluated at small discrete intervals of time and the results may be displayed on the printer or the plotter. It is intended, when staff become available to pursue further investigations into the local potential of hybrid computation facilities.

A subroutine is available to plot contours in three dimensions. The surface to be plotted is specified by the (x,y,z) co-ordinates of a sufficiently large number of points. Fig. 2. shows a bi-variate normal distribution plotted by this subroutine.

On-Line Control

Experiments have been conducted by the Switching Group of the Laboratories with a model telephone exchange which can be controlled by a computer. In the early stages of this work, the exchange was connected to the C.D.C. 160-A computer. A program in the computer analyses the digits as the subscriber dials, then directs the switching equipment to connect the call as required. Various subroutines are available to connect the ring tone, determine when the called party answers, detect excessive dialling time and perform other functions.

In these studies, the C.D.C. computer was used to control a very simple crossbar switching network which could interconnect 6 telephone subscribers. Normal telephone service was provided by this simple network. Control was carried out in a real time mode using programs specially written in machine language. A high speed parallel data link, developed in the Switching Group was used to link the computer to the switching network (then separated by a quarter of a mile).

Computer Communications via Satellite

The Research Laboratories' Computer has been used in a computer-to-computer link via the Applied Technology Satellite ATS-1. The experiment was carried out jointly with the National Aeronautics and Space Administration (NASA) and the Department of Supply, with the assistance of Control Data (Aust) Pty. Ltd. who supplied the computer at the distant end. This 'distant' computer was also located in Melbourne, on St Kilda Road. The transmission path then included the satellite ground station at Cooby Creek, near Toowoomba (Queensland) and the satellite ATS-1. The two computers were linked to the tracking station by land-lines. The transmission path was of approximately 50,000 miles and the speed of transmission was 1,200 bits per second.

A program enables one computer to interrogate its companion automatically and request it to perform a prespecified task. Subroutines in both computers enable data to be transferred and either stored on magnetic tape or printed on the line printer. Subroutines are also available to subdivide the data into blocks and to transmit a test pattern to determine the errors introduced during the transmission.

Air-Conditioning

To ensure reliable operation of the computer, it is essential that the room temperature and humidity be controlled. This is performed by an air-conditioning unit with a capacity of more than 120,000 BTU/hour. Full stand-by facilities are provided, the air-conditioning equipment being duplicated so that a second unit can be switched on if the main unit fails.

Propagation Measuring Equipment, Records & Analysis

R. Harvey: 630 7924

Introduction

In the era 1910-1920, mathematical physicists solved the basic problems of calculating the strength of signals received from a radio transmitter, for most types of path and equipment locations of practical importance. However, these solutions, for idealised cases, yield only the undisturbed field, and do not describe the considerable signal variations which occur from time to time in many situations. Much research has been done on the explanation and prediction of these variations ('fading') but there are a number of practical situations in which, at present, fading can only be defined (to an accuracy adequate for engineering needs) by direct field measurements.

The two Radio Propagation Divisions are particularly concerned with these fading phenomena as they affect microwave equipments operating at frequencies of 2 GHz and above. Here their particular interest is with the 'optical' paths of 20-100 miles employed in broadband bearer systems, for multichannel telephony or television relays. For such 'tropospheric' paths, fading is due to variations in the meteorological structure of the lower atmosphere ; other causes are rarely of practical importance.

Signal level variations occur on all optical microwave paths. System manufacturers hence normally offer equipment yielding channels of satisfactory performance despite quite marked fading. In 'temperate-zone' weather conditions, 'average' inland paths (not exceeding 35 miles and over terrain of normal roughness) rarely show fading exceeding this inbuilt allowance. In assessing propagation factors when engineering systems on such paths, the system designer then needs only to check that path 'fade performance' should fall within this safe range ; he needs no exact definition of fade statistics.

However, for paths of unusual configuration (e.g. long and over-water, with repeater heights differing markedly etc.) or in regions subject to unusual meteorological conditions, fading may be markedly more severe. To afford a firm basis for engineering design in such circumstances, fade performance must then be defined statistically by field measurements.

This exhibit displays equipment employed for such measurements, the types of record obtained, and some of the analyses made from these records. To date, 'narrow-band' equipment, such as that displayed, is employed for most field measurements, which therefore define only the single-frequency performance of the path. For paths carrying systems yielding 600-960 phone channels, or a TV relay, these measurements normally give adequate definition of path performance. However, as telephone channel capacities rise to 1,800, and even 2,700, per radio-system, there is an increasing risk that many fade conditions will also cause marked signal distortion.

Current work is hence directed towards 'broadband' measurement techniques which will provide definition both of amplitude variations of the received signal and of transient variations in path phase-linearity during fading. These changing phase-shifts, in extreme cases associated with significant variations of signal amplitude across the modulation band, can degrade system performance in several ways. Transient increases in intermodulation noise on high-capacity systems are one result of particular concern.

Other improvements in test techniques being pursued include the use of digital (magnetic tape) recording on site, offering direct computer-processing of field records, and provision of low power-drain radio equipment of increased reliability. These latter units are being developed in the Radio Equipment Division of the Research Laboratories.

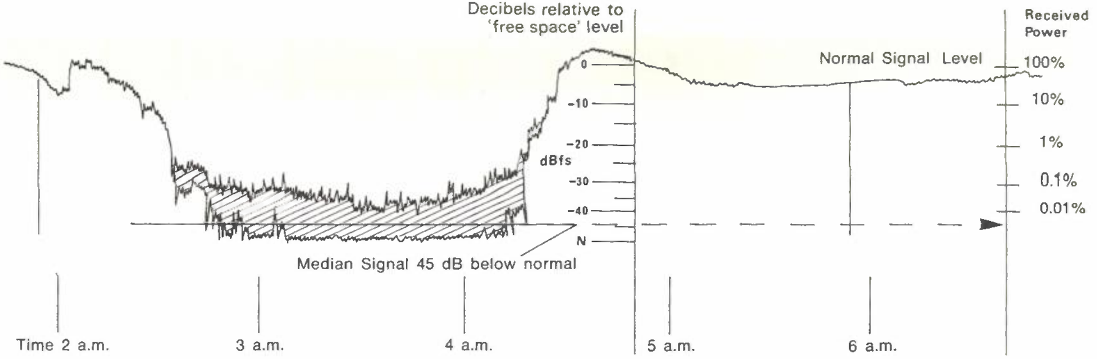
Equipment is also being produced for propagation measurements at 36 GHz. These units, which will probe both basic fading and path bandwidth, are on display in the Microwave Techniques Division.

General Factors

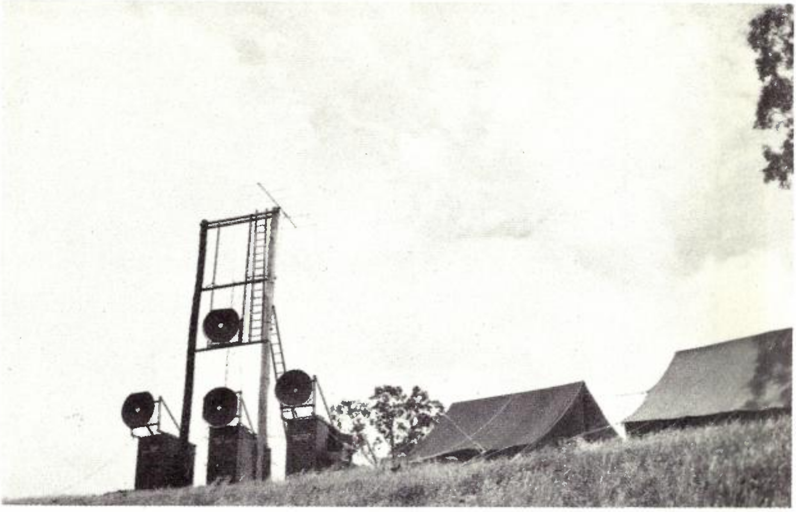
From consideration of the physical properties of possible paths in a region, and of the meteorological conditions likely to apply to them, it is possible to predict that certain paths have a high risk of serious fading. A substantial majority of paths so selected for test have revealed problems requiring remedial measures. In these measurements, it is desirable to relate the fading to meteorological data measured on site and derived from Meteorological Bureau reports. With some insight into the particular phenomena involved, specific proposals can be advanced for mitigating the effects, which solutions are then verified by measurements. Recent examples of high risk paths that show the value of testing are:

1) **East-West System** (Ivy Tanks, S.A. area). This area was assessed, from regional factors only, as offering considerable propagation hazards. Median signal levels, on occasions, were depressed as to be capable of seriously embarrassing the intended system. (See record section reproduced.) Following a study by the Propagation Research Division, relating this propagation problem to the meteorological and physical characteristics of the area, the system was re-routed nearer the coast. Later measurements confirmed the anticipated benefits of this move.
2) **Townsville-Mt Isa System** (Julia Creek, Qld area). Adverse propagation conditions were predicted here from topographical factors and regional meteorological records. Serious depressions of the median signal level have been observed on the test path and an investigation is currently being being made to define possible remedies.

Propagation-measuring equipment is required to operate unattended and in remote locations. It requires considerable stability and reliability in performance, so that it provides an accurate record of propagation variations on the path and this record is not contaminated by equipment malfunctions. Earlier types of microwave-link equipment did not in themselves offer adequate level stability for use in such precision measurements. Being F. M. systems, they achieved satisfactory overall performance without taking any special measures to stabilise I.F. gain. To achieve reasonable accuracy in microwave propagation investigations it was therefore necessary to develop special measuring equipment. As well as these improvements in performance, this equipment includes features, and ancillary units, to facilitate the overall calibration of transmitter and receiver installations so that absolute values of path attenuation can be determined.



Ivy Tanks depressed median condition (West Path, no tree cover)



9.2 GHz, Mt Gray (Goulburn, N.S.W.) December1949

Equipment Displayed

The two types of Propagation Measuring Equipment displayed show an evolutionary trend. The first type is an all valve equipment which requires a 230 volt supply and relies on thermostatic control of the ambient temperature within its case to maintain level and frequency stability. The second and more modern unit is a solid-state, low power-drain equipment. It is crystal-controlled and designed to operate over a wide range of temperature without local ambient control.

To improve the fade range recordable, both types of equipment employ narrowband post-I.F. detection in the receiver, with 1 kHz square-wave modulation of the transmitter carrier.

In the valve equipment the detected 1 kHz signal operates the I.F. amplifier AGC and is also recorded on strip chart as the receiver output (signal strength) record. This approach requires high level stability of the I.F. amplifier over a wide range of input levels.

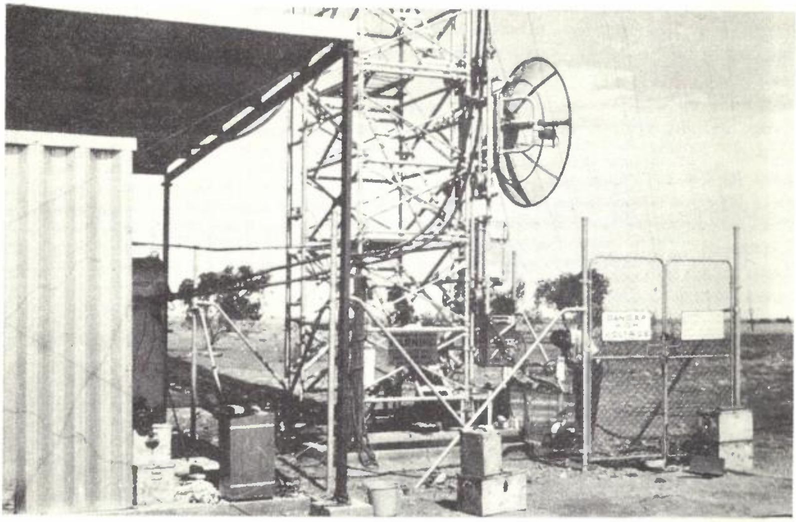
The solid-state equipment overcomes some of the problems associated with achieving adequate level stability in an I.F. strip by using a servo loop. Here the I.F. amplifier is a constant gain unit, and variations in the detected 1 kHz output control a servomotor which adjusts an I.F. input attenuator to maintain constant detector output. The chart recorder pen is fixed to the I.F. input attenuator and thus records instantaneous attenuator position, and therefore signal level. An improved 'Mark II' version of this solid-state equipment is at present under development in the Radio Equipment Division of the Research Laboratories, and is on display there.

Calibration of Measuring Installations

The overall calibration of such a transmitter-receiver pair, in the field, enables the received signal levels to be related to the theoretic 'free-space' level which should be received under fade-free conditions. Transmitter power is measured and transmitter power-monitor calibrated against the same R.F. power meter. Transmitter and receiver feeder losses are determined, and the gains of the test aerials (usually 6 ft dia. paraboloids) are evaluated by switched comparison with a gain-standard horn aerial. The receiver is regularly calibrated with a signal generator. The transmitter power values are related back to the signal generator readings by using the R.F.-power bridge as a 'transfer standard'. Thus, as all measurements are related to the signal generator, the 'path loss' is determined as a difference reading on the signal generator piston attenuator, which becomes the basic standard of path loss measurement.

Height-Gain Measurements

Height-gain records show the variation in signal strength with change in antenna height (generally under fade-free conditions). The receiving antenna is mounted on a wheeled carriage which traverses the height of the receiving mast, and pulses from a height indicator are marked automatically on the received signal records. To check mast twist and irregularities, actuators (motor driven jack-screws) are used to align the antenna in azimuth and elevation. If the mast is not 'true', then by scanning the antenna continuously whilst moving vertically, the height-gain pattern appears as the envelope maximum of the scanning cycles.



4.037 GHz, St Elmo Station (Julia Creek, Qld) June 1969 Height-Gain Measurements

The height-gain generally depicts only the interference pattern between the direct and ground reflected rays, and enables the ground reflection coefficient and mean refractive index gradient to be derived. An example of height-gain patterns taken over a 24 hour period is displayed, showing changes in position of the minima (due to refractive-index gradient changes) and changes in maximum to minimum signal level, caused possibly by reflections from atmospheric layers adding to ground reflections.

Fading Measurements

Measurements on test paths are usually conducted for a period of fifteen months to enable seasonal trends and the 'worst month' to be defined. Statistics derived from the recordings are then used by the Department's Central Office Radio Section in the design of the final system.
The normal, fixed antenna-height recordings (of field-strength versus time) are taken continuously. Separate

receivers are used to record, on a multiple channel recorder, field strength levels for different fixed antenna heights and different frequencies.

It is necessary to inspect the records carefully to eliminate those parts where the variations recorded are due to equipment faults, changes in transmitter power, or other extraneous causes. ('Fading' recorded has, on occasions, proved due to slight water leakage into feeders — even to ladybirds multiplying within a waveguide!) This visual inspection uses the transmitter power monitor record and accumulated past history to validate the receiver record. After being checked and appropriately marked, the record can then be scanned to note the fade-types and suggest possible mechanisms. These fading mechanisms are described in the display and may be due to:

1) Interference between 2 rays or many rays.
2) Loss of signal due to 'earth bulge' (subrefraction), duct cutoff (radio hole) or rain attenuation.
3) Signal enhancement due to duct propagation. (This effect is not of direct concern itself, but sounds a warning—duct enhancements may easily become duct depressions.)

The analysis machine shown is used to derive statistics from the validated receiver chart recordings. An interrupter, operated from the chart spooling drive, pulses the counters via a switch which is adjusted manually as the signal falls below set levels. The counters thus record the proportion of time the signal level is below the chosen analysis levels. Calculation of the statistics of percentage time below each level is made in six hour time blocks. These statistics can be presented in various formats, of which three different examples are displayed. In the **Fade Period** comparison, the plots contrast the severity, frequency of occurrence, and duration of fade episodes between summer and winter periods on the same path. The **Cumulative Distribution** plots shown are annual summaries of these statistics and are used in designing the working system. These distributions can also show the benefits of switched diversity reception, data then being obtained by analysing diversity recordings on the machine simultaneously.

The lower left part, or 'tail', of the curve describes the serious fading, which occurs for a very small percentage of the time. Thus errors in measurement have a large effect here and considerable care is taken to minimise the possibility that the few fade episodes which define this 'tail' do not include low signals due to transient equipment faults.

To show seasonal and year to year effects, the same data can be plotted month by month to produce the **Monthly Distributions** shown.

Television Ghosts

J. H. Reen: 630 7921

Television Ghosts

This exhibit demonstrates a wave propagation phenomenon sometimes observed by TV viewers, and also of possible utility in offering guidance on local radio propagation conditions. The effect is demonstrated because of its general interest; it is not currently under investigation in the Research Laboratories.

'Ghost' images are occasionally seen on domestic TV receivers, a shadowy replica of the main image being visible to the right of it. 'Ghosts' may appear positive, with their black and white tone values following those of the parent picture, or as negative images.

Their tone scale is then the reverse of the parent image, and they closely resemble a photographic negative.

Ghosts occur when the receiver aerial accepts both the wanted signal, direct from the transmitting aerial, and also a delayed signal reflected from some large object such as a hill, a massive building, a gasometer etc. The separation on the screen between main image and ghost increases with the time delay between their signals, and hence with the extra distance the echo signal travels compared to the direct signal.

When the radio waves of the direct and echo signals add to produce the composite signal input at the receiver aerial terminals, they show the normal phenomena of wave interference.

The sum signal submitted to the receiver thus varies significantly with both the relative amplitude and phase of these VHF signals. If in phase, an RF carrier section corresponding to a black element in the delayed picture will add to the direct signal received at that instant, to increase resultant carrier level, i.e. to render a grey image blacker at that point. The ghost is thus positive. On the contrary, if ghost signal carrier is in antiphase with the direct signal, a section of the ghost carrier corresponding to a black element of any line will subtract from the carrier value then existing in the direct signal, so producing a picture element on the screen lighter than it would otherwise be, i.e. producing a negative ghost.

In most cases the ghost signal is much weaker than the direct, and the picture synchronisation remains under the control of the synchronising pulses of the main signal. However, the synchronising pulses of the ghost signal may now appear on the screen, to darken the left-hand edge of the picture (when the ghost is positive) or to lighten shades there if the ghost is negative. With very strong ghosts (as sometimes noted with a non-directional, or poorly oriented, aerial), the receiver may synchronise to the ghost signal, and the weaker direct signal now provides the ghost, on the left of the 'main' picture. With near equality of echo and direct signals, picture 'tearing' and alternation of synchronisation from direct to ghost pulses may be observed.

The total radio system of transmitter, receiver, and echoing object constitutes quite a sensitive interferometer and slight changes of aerial position (say of about 2 ft) will change the phase relationships between direct and echo waves sufficiently to change ghost type. This effect can be seen by moving the aerial of the demonstration receiver.

Changes in propagation conditions, in particular the day-to-night variation of atmospheric refractive index and (more particularly) of vertical refractive-index gradients, can produce similar changes. By varying the phase angle between direct and ghost signals, weather variations can thus cause ghost type to alter.

In one home receiver, regular changes of this type have been noted.

Signalling System for PCM Transmission

D. Mattiske: 630 6343

Signalling System for PCM Transmission

With recent development of semi-conductors and integrated circuits, PCM systems have been developed to a stage where they offer the possibility of digital transmission on an economic basis between exchanges where the distance is between ten and fifteen miles.

The transmission advantages of PCM are well known but PCM systems can be designed at little extra cost to provide means of line signalling whereby more than one signalling lead can be extended in each direction and with an appropriate signalling scheme, greatly reduce the cost of the signalling relay sets.

Such a signalling scheme has been developed by Research personnel which utilises two signalling leads in each direction.This has been designated the T5 or 'Double E and M signalling' scheme.

The following table lists the codes of the T5 Signalling Scheme:

Forward Signals	FUR FIR	M1 E1	M2 E2
Circuit Idle		0	1
Seize Forward		1	1
Decadic Pulsing		0	1 (67 mS break pulses)
Clear Forward		0	1

Backward Signals	FIR FUR	M1 E1	M2 E2
Circuit Idle		0	1
Seizure Acknowledge		1	1
Call mfc receiver		1	0 (150 mS pulse)
Answer		1	0
Meter		1	1 (150 mS pulse)
Clear-Back		1	1
Release Guard		1	0
Forced Release		0	0
Blocking		0	0

The system is a tone on idle systems and failure of the system causes a blocking condition. Because 2 signalling leads enable the state of a call to be described in steady state conditions of the signalling leads, simplification of the signalling relay sets compared to their pulse signalling equivalents can be achieved with consequent reduction in costs.

Measurement of Radio Refractive Index of the Air

G. Jenkinson: 630 7922

The engineering of microwave radio systems, such as those used in the Department's broadband communications network, requires a knowledge of the propagation conditions which apply to the system concerned. The Research Laboratories have for many years maintained teams working full time on radio propagation studies, usually concentrating on specific paths which pose particular problems.

Over the years many unexplained phenomena have been encountered in the course of propagation path testing in Australia. Because of this, and bearing in mind the expansion of this Department's microwave network, a research programme aimed at elucidating the fundamental mechanisms controlling radio propagation is under way. This programme, which involves a meteorologist of the Bureau of Meteorology, is primarily a study of the correlation between radio propagation and weather conditions.

Microwave radio propagation through the troposphere is controlled by the radio refractive index of the air. There is generally a gradual decrease of refractive index with increase of height (i.e. a roughly constant refractive index gradient). This gradient will bend the path of a horizontal radio ray slightly downwards towards the earth, under normal conditions.

Frequently, however, weather conditions can produce layers of air with abnormal refractive index gradients. These layers are vitally important in radio propagation studies as they produce abnormal bending of the radio waves. Sometimes this causes enhanced received signal levels but more often signals are reduced in level with periods of fading which can persist for some hours. In unfavourable circumstances the signal can be entirely lost.

The refractive index of the air can be measured in a number of ways — for example by measuring separately the air temperature, pressure and humidity, and from these calculating the refractive index. The most accurate method, however, is to measure refractive index directly using a refractometer.

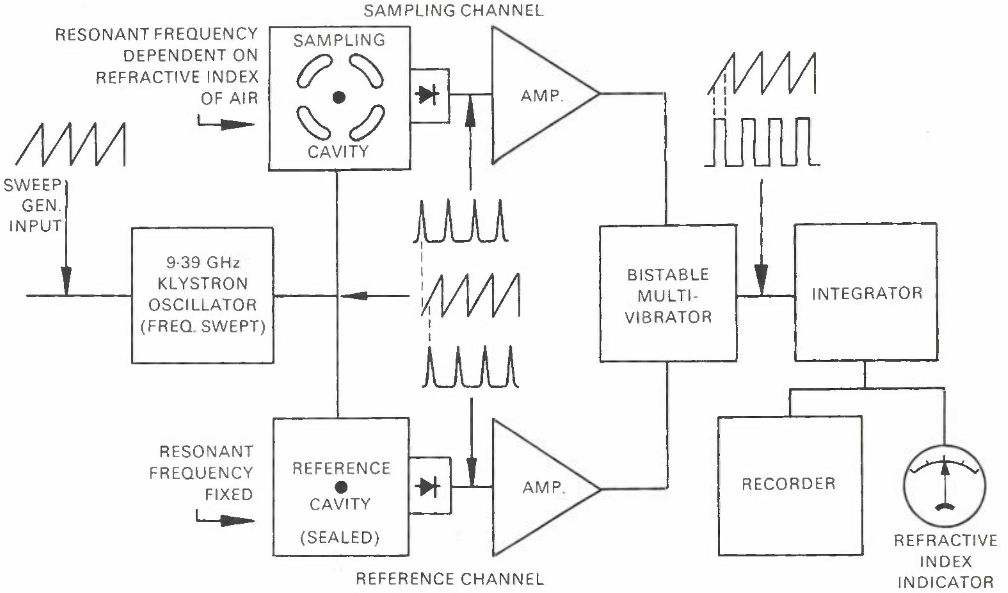


Fig. 1. Birnbaum type microwave refractometer

The instrument on display is a Birnbaum type microwave refractometer, which directly and continuously measures the air's dielectric constant. Since the refractive index is equal to the square root of dielectric constant, it thus directly measures refractive index. The sampling head of the refractometer is a microwave resonant cavity with slots to allow through-flow of air. The actual resonant frequency of this cavity varies with refractive index. The remainder of the instrument measures the resonant frequency continuously and gives a proportional output signal. A block diagram is shown in Fig. 1.

The equipment has been designed for mounting in a light aircraft to allow variations of refractive index with height and distance to be measured. It has been flown, on a number of occasions, over Bass Strait and also on the Nullarbor Plain, South Australia. On other occasions it has been fitted to a trolley moving up and down a 250 ft mast, on the Nullarbor Plain and at Julia Creek, North Queensland. Reports describing some results of these investigations have been published.

Electronic Signalling Equipment

D. Mattiske: 630 6343

Electronic Signalling Equipment

The development of electronic exchanges has been possible by the great advances made in semiconductors and stored program controlled processors. The large families of integrated circuits, Medium Scale Integration, and even Large Scale Integration has enabled logic functions normally performed by relay circuits to be now produced with purely electronic components at competitive prices and with very large improvements in reliability.

The IST exchange, developed in these Laboratories, aims to demonstrate its ability to interwork with the existing network and consequently needs dial pulse receivers and senders, tone signal senders and receivers which can send and accept the information from the existing network and yet be compatible with the electronic equipment with which it must interwork.

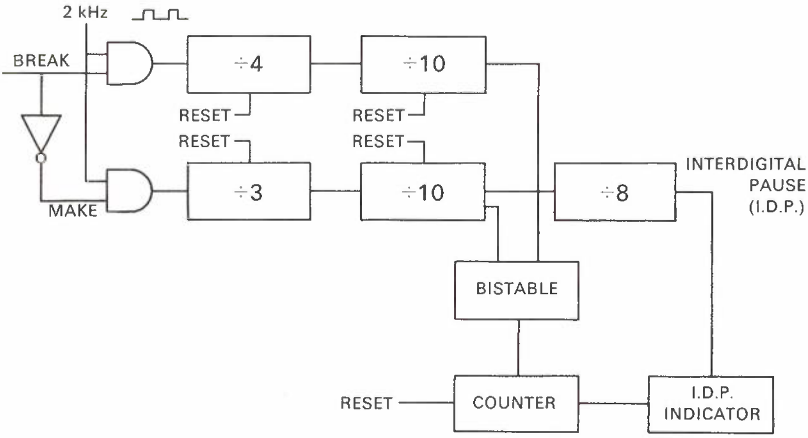
Because the processor uses binary notation, the signals received from the network must be converted to binary signals and signals from the processor for the network must be converted from binary signals to decadic pulses or 2 out of 6 m.f.c. tones.

Dial Pulse Receiver

This device has been designed to be used both in the IST exchange and the CCITT No. 6 Field Trial. In the former, samples of the line condition will be received, whereas in the latter case continuous line signals will be monitored. In each case, however, it is possible that the dial pulses may be distorted by considerable quantities of 'noise' caused by relay contact bounce and interference. The equipment had to be built to be at least as tolerant of this noise as its relay circuit equivalent.

The circuit developed uses binary logic and times the duration of the pulses by using a 2 kHz reference signal. Because of the variation of dial speeds and their wide make/break ratio tolerances, a genuine break was recognised by a persistent break condition for at least 20 mS. A make condition was recognised by a persistent make condition for at least 15 mS.

To differentiate between successive impulse trains, an Interdigital Pause Timer was also required. This recog-



Dial pulse receiver

nises 120 mS of the make condition after a dial pulse train as a true Interdigital Pause.

The action of the Dial Pulse Receiver is to regenerate the impulse train by a bistable device shown in the above diagram. Using the 2kHz reference frequency, a series of counters time the make and break periods, and change the state of the bistable device after 20 mS of the break period has been timed and after 15 mS of the make period has been timed.

If noise occurs during a make period, it may be of sufficient duration to increase the count of the break period counter. However each time the make counter reaches a total of 30, (i.e. 15 mS) it resets the count in the break counter, thereby discounting the false counts caused by noise. A similar action occurs during a break period when the make counter is reset every break counter total of 40 (i.e. 20 mS). This action produces an impressive noise rejection action.

Dial Pulse Sender

Two separate circuits are used to produce the required train of decadic impulses.

The Dial Pulse Generator produces a continuous 10 Hz signal, 67 mS on and 33 mS off, from the same accurate 2 kHz signal used in the Dial Pulse Receiver.

The signal, which simulates the ideal dial pulse, provides the timing reference for a number of dial pulse senders.

Under processor control the binary representation of the digit to be sent is loaded into a store in the dial pulse sender, which produces the required number of dial pulses, and times an interdigital pause of 800 mS. The operation of this circuit is based on a five stage binary counter, which is nominally capable of being in one of 32 states. However, only 19 states are used, which are given the arbitrary values of −10 to zero to +8. The circuit normally rests on the value of +8. If the digit n ($10 \leqslant n \leqslant 0$) is to be sent, the binary representation of n is stored in the sender, which adopts the value of −n. At the same instant the output condition called Busy is automatically activated.

The sender then commences counting the pulses from the Dial Pulse Generator, and presenting these pulses to the pulse stream output.

This continues until the counter has reached the value of zero, by which time n pulses have been sent. Hence the sending of pulses is terminated, but the counter continues to count the 10 Hz pulses until the value of +8 is reached. At this stage the circuit steps counting pulses, locking on this value of +8, and removing the output Busy condition. The circuit rests in this condition until the next load instruction is received, and the above sequence repeated.

As with the Dial pulse Receiver, the Dial pulse generator and senders are made up solely of Digital Integrated circuits, and have an accuracy, with respect to time, which depends on the accuracy of the 2 kHz source.

Code Sender (KS)

Signalling between crossbar exchanges is achieved by transmitting 2 out of 6 tones in one direction and acknowledging this signal with another 2 out of 6 tones sent in the opposite direction. However in crossbar exchanges relay sets are used to convert each of the 15 possible signals to their 2 out of 6 combination of tones.

In the processor controlled IST exchange, it is necessary to convert the binary signal from the processor to the 2 out of 6 tone signal when signalling to a crossbar exchange. The converse is also necessary when signals from a crossbar exchange must be converted into a binary signal for the processor.

These functions have been achieved using integrated circuit logic mounted on printed circuit cards. The functions performed are:

Tone Receiver

(1) Check presence of exactly 2 tones, allowing for propagation delays.
(2) Convert 2 out of 6 signals to 1 out of 15.
(3) Convert 1 out of 15 signals to binary.

Tone Sender

(1) Convert binary to 1 out of 15 signals.
(2) Convert 1 out of 15 signals to 2 out of 6.
(3) Send 2 out of 6 tones.

The Tone Receivers have conventional receiving equipment with a small buffer associated with each receiver to interface with the logic circuits.

The Tone Senders utilise a novel 'analogue switch' capable of switching the tones on and off. This device takes the form of an AND gate, one input of which is the tone to be sent and the other a controlling on/off signal. This device eliminates the need for relay contacts and enables one tone supply to be used for several Tone Senders.

Transmission Media

J. Reen: 630 7921

If the average phone user ever thinks of his 'phone-line', or speculates on the channels his trunk call follows, he probably pictures under-street cables, or a pole route beside a country road. For his connection to the exchange, and on to the regional trunk centre, his cable picture is probably correct.

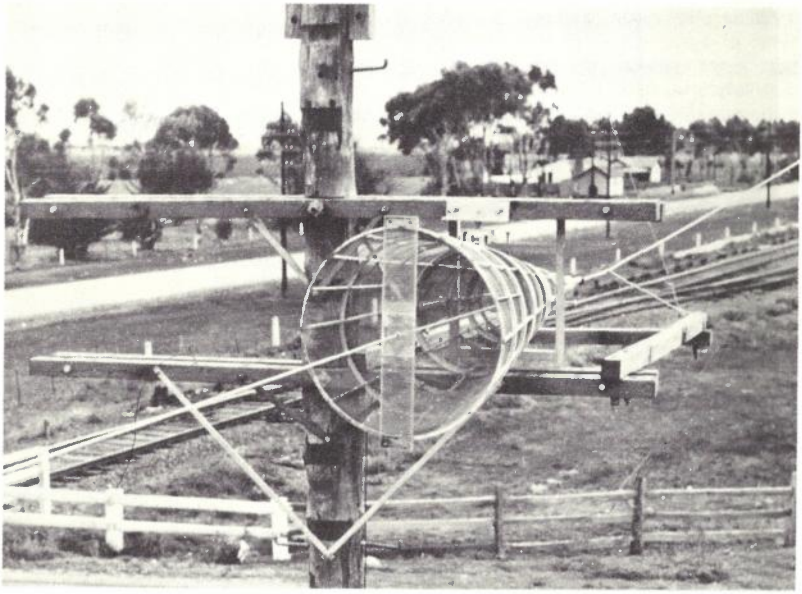
Balanced-pair 'transmission media', realised as underground cables or in open-wire construction, still supply most local connections and must remain predominant in this section of our telephone system for many years. However, in the Department's trunk network, the use of micro-wave radio and coaxial cable systems has increased so rapidly since their introduction in 1959 that, in combination, they now provide about one-half of the total channel mileage of the APO trunk system.

To meet the growth in traffic demand, which experience has shown is an exponential function of time, new systems with potential capacity much greater than heretofore available must be developed and introduced into plant use. Thus active research has been started into millimeter wave and optical systems. In addition, for the provision of services to isolated areas, the potential of domestic satellite systems is being investigated.

Modern telecommunications systems use a variety of transmission media to connect the 'sender' and the 'receiver'. It is logical, and beneficial, to view these transmission media as members of a common family comprising two distinct categories. One category uses some physical guidance structure and the other depends on propagation through free space. Many concepts, phenomena, and parameters, are of general relevance over the full field, although perhaps initially studied as part of the specialist technology of a narrower sub-field, or developed independently in allied sub-fields without full appreciation of their essential identity.

Within the Transmission Media Group are the three Divisions directly concerned with transmission media as such:

The Transmission Lines and Radio Propagation Divisions are not responsible for the overall design of specific new plant systems. This engineering design work is performed outside the Laboratories, by the appropriate specialist design groups in the Long Line Equipment, Lines and Radio Sections of the Department (in Central Office or in the State Administrations depending on system size). Our transmission measurements, for current media applications, are made to define the properties of new cables in general, or of that small fraction of microwave paths which are considered likely to offer propagation hazards because of their unusual geometry or meteorology. Also, both Lines and Radio Propagation Divisions are frequently called on as expert consultants, by system designers who anticipate transmission problems in a specific project.



Surface Wave Transmission Line-launcher

Line Transmission
Path Evaluation (of radio paths)
Propagation Research (for radio waves),

and two Divisions associated because of their historical relevance to the needs and technology of these Divisions:

Computation Research
Satellite Research.

In total, these Divisions cover the full range of electric-wave transmission media the Department now employs, or is likely to employ, in the foreseeable future. The first three Divisions are concerned only with the media themselves, and not with the associated electronic equipment required in media exploitation. The Satellite Research Division, however, is engaged both with the medium and with the specialised radio equipment required in Satellite Earth Stations.

The Group studies theoretic aspects of media performance and makes field and laboratory measurements of transmission parameters. In nearly all of these measurements, the solutions derived have a wider relevance than is implied by the initial statement of the problem and results can often be generalised, and combined with the results of more fundamental investigations, so that the maximum contribution possible can be made towards increasing world knowledge of transmission phenomena.

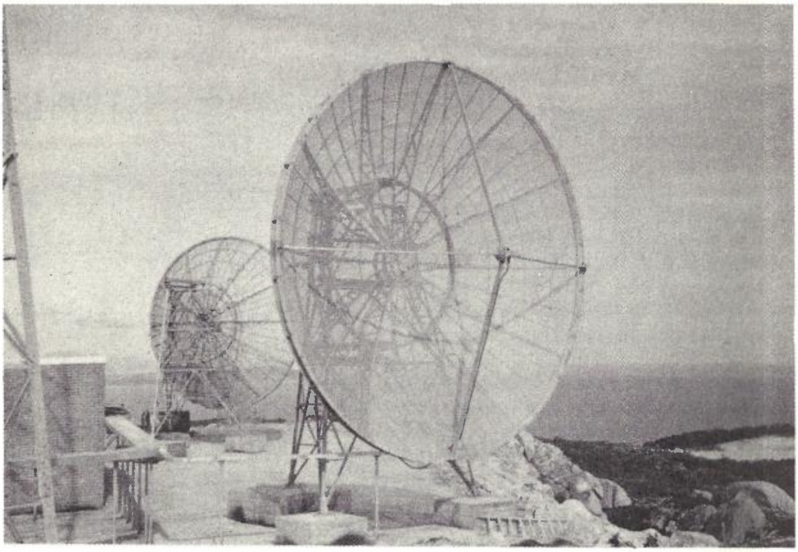
Transmission Media Divisions also engage in theoretic studies and practical investigations against the probable needs of the future, particularly in regard to the media appropriate to systems of very high capacity. These studies are aimed to assess the potential in the Australian Post Office network of proposed new guided-wave systems and new fields of radio spectrum exploitation. Our geography, meteorology and population distribution differ significantly from those of many countries researching advanced techniques in telecommunications. New systems developed in Europe, for example, are hence not necessarily technically, or economically, viable in Australian environments. Conversely, local conditions may well warrant a form of media exploitation not appropriate to European needs.

Current, and recently completed, investigations of the various Divisions will outline the nature of their studies more exactly. Exhibits on this floor also display specific facets of their work.

The Transmission Lines Division now concentrates its efforts on the problems associated with guided transmission media for systems of high channel-capacity. A recent project here was the investigation of the behaviour of coaxial cables at frequencies up to and beyond 60 MHz (such cables are currently employed with frequencies up to 12 MHz only). A surprising outcome of this study was the discovery that a minor regular periodicity in the cable, apparently arising from slight deformations produced incidentally in manufacture, produced phase-coherent return echoes which integrated to a detectable effect in the overall frequency response of the cable. Despite this phenomenon, it appears that such cables could be employed with frequencies up to 60 MHz, with some additional precautions during installation and jointing. Associated with these studies, the 'carrier-burst' technique of cable testing was developed. Now described in the literature, it offers substantial benefits over earlier 'D.C. pulse' testing methods. It is demonstrated in a display item at Block T. A theoretic investigation of transmission waveguides is now in progress, aimed to define, inter alia, any areas of that new technology in which local experimental studies should be made.

The Path Evaluation Division is responsible for the investigations of radio propagation required on particular paths. The works programme of this Division is designed to produce results of direct application to the radio system engineering effort of the Engineering Works Division, and hence comes in the category of applied research.

Recent projects included 2 GHz propagation measurements on five paths on the Nullarbor Plain, for the East-West microwave system now being installed. These confirmed that it was desirable to move the planned route closer to the sea in one area (near the Head of the Bight) and also defined the best path



Mt Tanner (Flinders Is) Systems Installation, employing 28 ft aerial solution resulting from propagation measurements

geometry on a route section extending some 120 miles west of Eucla. Current tests involve two long overwater paths running north and south from King Island, components of a new broadband-bearer route between Tasmania and the Australian mainland (see the Transmitter Power Telemetering Display).

By contrast, the Propagation Research Division is concerned with the more fundamental aspects of radio propagation. Propagation research is sometimes considered a highly specialised and academic subject remote from the realities of radio and often used as an exercise in abstruse mathematics. Propagation is in fact a subject of wide interest, intensely practical in many of its aspects and basic to the whole of radio.

The Propagation Research Division has addressed itself particularly to the investigation of the correlation between meteorological and radio propagation phenomena. Co-operation with the Bureau of Meteorology has been established through a Meteorologist Class 3, who has been assigned for work in this programme. The Division is also engaged in antenna research, for which a model range on the roof of a city building, and a field site, have been established. Following recent studies on the Nullarbor Plain near Ivy Tanks (Head of Bight area), probing the radio-meteorological mechanisms responsible for bad 'median depression' fading of signals there (see Inner Foyer display panels), this Division is now engaged in studies near Julia Creek in Central Queensland. From topographical considerations, later reinforced by a study of meteorological conditions, adverse propagation conditions were predicted along this section of the route of the new Townsville-Mt Isa system. Test results confirm these predictions, and recent meteorological data suggest that strongly subrefractive conditions may occur in this region. These conditions probably result from moist maritime air (from the Gulf of Carpentaria or the Coral Sea) overrunning dry Continental air. The Transmission Media studies mentioned earlier, into broadband media appropriate to systems of new high channel capacity, are part of an overall program of the Advanced Techniques Section. Other Divisions, in the Communications Electronics Group, are currently producing specialised equipment for these transmission studies. In particular, millimetre wave (36 GHz) propagation measuring equipment is in an advanced state of development (see display at Block T). Its field use will also offer a trial of a novel method of probing medium bandwidth, devised in the Pulse Techniques Division.

The Satellite Research Division was set up specifically to participate in the Applied Technology Satellite (ATS) programme run by the US National Aeronautics and Space Administration (NASA) and its two staff members are outposted to NASA establishments. One is in the ATS Project Office at Goddard Space Flight Center, near Washington, DC, USA, and the other is at the Cooby Creek Station, near Toowoomba, Queensland. They are employed as systems engineers, responsible for parts of the NASA programme of ATS experiments and also concerned with Australian-sponsored experiments using the ATS facilities. In addition, these engineers report regularly on items concerning general satellite communications

ATS Earth Station, Cooby Creek, Queensland

technology developments which are of interest and value to the APO and OTC.

Planning and equipment provision is now proceeding to implement a major programme of experiments in the first half of 1970. This programme was evolved during a system study into the problems of providing telecommunication services to remote areas by satellite means. The study concluded that a satellite service to telephone subscribers might be based on a particular system configuration which was developed as a part of the study. However, because the system concept proposed differs in significant respects from other known proposals, there are several aspects for which engineering data is not available. These were identified and the experimental programme has, as a major objective, the provision of this data for future more refined systems study and design. The programme is based on the use of the microwave transponder in ATS-1 to supply the space segment and the use of the Cooby Creek facilities to simulate a multi-channel station such as would be required to connect a group of subscribers by satellite into the telephone network. The Research Laboratories are constructing an experimental prototype subscribers' outstation and will conduct the experiments and analyse the results. This experimental programme is a co-operative venture, with contributions from all three Sections of the Laboratories under a project leader drawn from the Transmission Media Group of Advanced Techniques. The display illustrating the project is located in Block 'C'.

Apart from these ATS experiments, there are several other activities in the satellite communication field, generally of a consultative nature. An instance of this was the development of criteria to allow resolution of specific Australian problems of co-ordination between space and terrestrial systems, which share common frequency bands, so that mutual interference can be kept down to tolerable levels. The work on this subject suggested that antenna radiation patterns which included a deep null in specific controlled directions would be very desirable, and a research contract is now in force with the University of Sydney to assess this idea. Preliminary results, using radio interferometric techniques, show considerable promise and are expected to be applicable not only to the problem which inspired the investigation, but also to the allied problems of controlling overshoot interference and path intermodulation in terrestrial radio relay systems.

The Computation Research Division is responsible for the Research Computer Centre, which is set up to provide a service to users throughout the Research Laboratories and to others outside. The service is particularly intended for scientific and engineering computation work and for feasibility studies on new or unfamiliar computational methods, rather than for large volume routine data processing. The Division is also responsible for investigations into computational methods using digital, analog, and combined digital/analog ('hybrid') techniques. Both hardware and soft-ware aspects are to be considered. The Division itself is at present inactive, due to staff movements, but operation of the Computer Centre continues. Established originally at 10 Lonsdale Street, the Centre is to move to 31 Flinders Lane just before the 1969 'Open Days'.

As is apparent, the activities of the Transmission Media Group fall into two major categories. Firstly, specialised studies and measurements are made to solve current plant transmission problems. Secondly, a broad program of studies is pursued to evaluate, in Australian environments, the potential of the broadband media required for the very high capacity systems of the near future.

Over the Advanced Techniques Section, there is an increasing trend towards the integration of individual effort into major project teams. The broadband media studies exemplify this trend, which is extended further in the operations of the satellite Special Project Team. Here members are drawn from all three Sections of the Research Laboratories.

Australia has entered a period of dramatic growth, in many fields. Inevitably, as further remote areas are opened up, and an ever-increasing variety of information must be transmitted, an enormous growth in the quantity and versatility of our telecommunication channels is required.

In the Transmission Media field, the predictable future offers formidable challenges. It is also certain that novel problems, as yet unspecifiable, must appear as new forms of media exploitation are developed. Solution of these problems will demand both the specialist skills of the fundamental theoretician and further expansion of the strategy of broad-front attack by expert teams.

Data Transmission

A. Gibbs; 630 7316

Data Transmission

The need to transmit data over the telephone network is increasing rapidly and it is expected that data traffic will equal the quantity of voice communication in the near future. Typical schemes which use data transmission are time-shared computers, inter-office business machines, inter-office banking transactions, airline reservation networks and the like.

The digital data from these systems is usually not suitable for direct transmission over the telephone network which has a limited bandwidth and does not transmit the very low frequency components of the digital data. To overcome this difficulty the digital data frequency spectrum is shifted up by modulation for transmission over the network and is then demodulated at the receiver to retrieve the original digital data. To permit transmission in both directions over the network it is common to have both a modulator and demodulator in the one unit which is then called a modem (a combination of modulator/demodulator). Typical modulation techniques used are frequency modulation, vestigial sideband amplitude modulation and phase modulation. The display shows a frequency modulation modem operating at 1200 bits/second and a phase modulation modem operating at 40,800 bits/second. The low speed modem is the type that is supplied by the APO for the DATEL service.

Signals transmitted over the telephone network are susceptible to added interference and distortion which can cause errors in the received data. The diplay using the DATEL shows how these phenomena, simulated in the laboratory by a noise generator and an artificial line, are being studied with the aim of minimizing their effect on the modems' operation. This is accomplished by transmitting a 'pseudo-random' data sequence between the modems and counting the errors in transmission by comparing the received sequence with the original sequence. By varying the noise level and line distortion, information is obtained on how these parameters affect the error rate. Results indicate that errors are most likely when an added noise peak exceeds the signal level and effectively overrides the data contained in the signal. Several of the important waveforms, viz., received signal and eye patterns are shown in the 1200 bits/second display.

Data transmission at a rate of 1200 bits/second requires the use of one voice channel which means that existing switching facilities can be used for its distribution. However, transmission at speeds of 40,800 bits/second or 48,000 bits/second requires a bandwidth of 12 voice channels, and thus special switching facilities are required for its distribution. The Research Laboratories are currently investigating the provision of a switched high speed data facility, and the high speed data display shows a 'mock up' of a typical switched network.

It is envisaged that this will consist of junction cable from the subscribers premises to the local exchange, cable carrier to the trunk exchange and broad-band bearers for inter-city and inter-state links. It is proposed that switching will be performed in the band 60-108 kHz, and the performance of standard crossbar switches, reed relay and wideband semiconductor switching matrices is being investigated.

Reed Relay Tester

I. Dew: 630 6614

Reed Relay Tester

The present generation of automatic telephone exchanges in Australia employ either step by step switching or cross-bar switching. It is anticipated that the next generation of telephone exchanges will employ electronic processor control of the signal routing and that the actual speech path connections will be made by electro-mechanical switches under the control of the processor. There are several types of switches which could be used, but most current systems overseas use reed relays.

Accordingly, a program was developed to test reed relays in order to gain knowledge of the reliability to be expected under a variety of operating conditions. The reed relay tester developed in accordance with this program is capable of simultaneously testing a maximum of 300 reed inserts. Each test block may contain 100 reed inserts and a different test condition may be employed in each block.

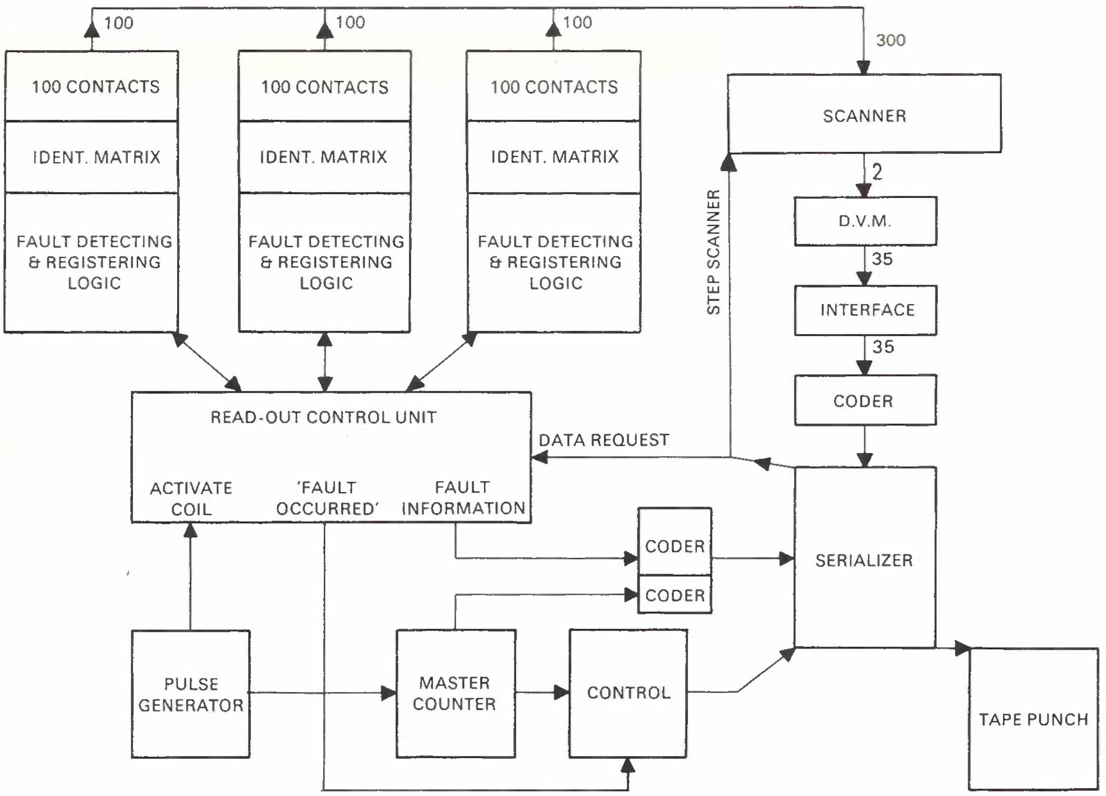
Reed Relay Test Method

The block diagram illustrates the method employed to test up to 300 reed relay inserts at a time.

Each reed insert is operated 12.5 times per second and is checked each time it is operated and released and if faulty, lamps display the position number of the faulty reed. Periodically the numbers of faulty reeds are punched out on paper tape.

At preset intervals the reed inserts are held closed and their contact resistance is measured using a digital voltmeter. The results of measurement are serialized and punched out on paper tape.

The information thus gathered is subsequently analyzed by a computer, enabling the comparative performance of each type of reed insert to be assessed.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100 CONTACTS
IDENT. MATRIX
FAULT DETECTING & REGISTERING LOGIC
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FAULT DETECTING & REGISTERING LOGIC
SCANNER
2
D.V.M.
35
INTERFACE
35
CODER
STEP SCANNER
DATA REQUEST
READ-OUT CONTROL UNIT
ACTIVATE COIL
'FAULT OCCURRED'
FAULT INFORMATION
CODER
CODER
SERIALIZER
PULSE GENERATOR
MASTER COUNTER
CONTROL
TAPE PUNCH