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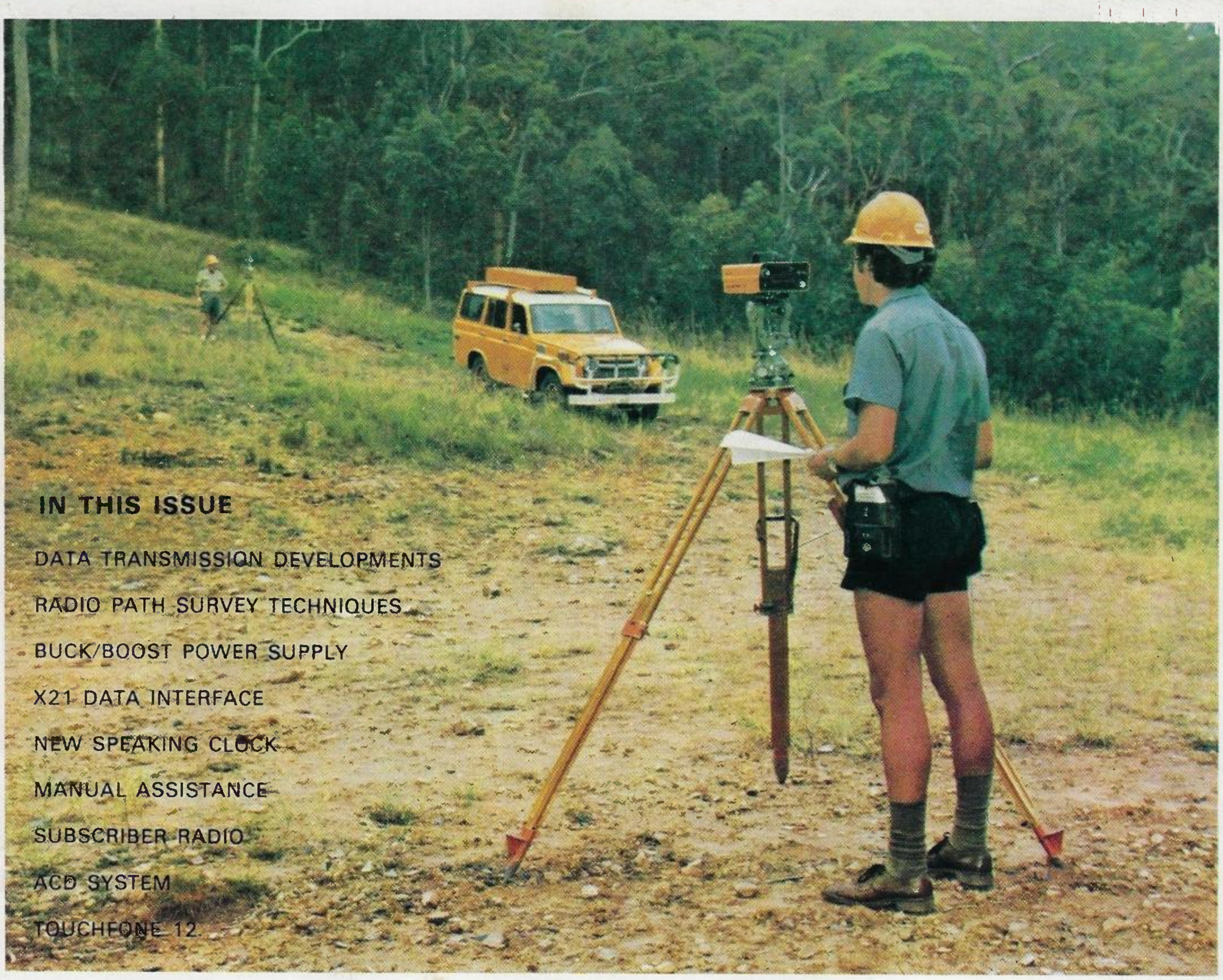

29/3

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COVER

RADIO — SYSTEM SITE SURVEY

The Telecommunication Journal of Australia

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OVERSEAS APPLICATIONS

The General Secretary, Telecommunication Society of Australia,
Box 4050, G.P.O., Melbourne, Victoria, Australia, 3001.

Radio-Relay System Path Survey Techniques — Part 2, Survey Methods

N. L. WAIN, A.R.M.I.T.

This second and concluding part of a study of radio-relay system survey methods outlines the techniques commonly employed to obtain the path parameters necessary for reliable design of transmission performance and cost estimation of proposed systems.

Common survey practices are covered together with some of the more economic and novel methods used for small capacity and single channel systems.

INTRODUCTION

Part 1 of this article gave a brief outline of the relationship between environment and propagation characteristics encountered on line-of-sight radio-relay systems. The dependence of the system performance on the ray-line clearance of the system paths was emphasised and led to the need for a survey of each path to establish accurately the necessary tower and antenna heights for the system to achieve the desired performance.

The clearance criteria outlined in Part 1 are not usually applied to small capacity and subscriber radio systems operating in the VHF and UHF bands because the larger Fresnel radii would require very high antennas on a typical system and consequently increase the cost of antenna support structures beyond the economical limit for such a system. The propagation performance at the lower frequencies is less susceptible to anomalous tropospheric behaviour than it is in the SHF bands, so reducing the incidence and magnitude of fading at these frequencies. Also the noise performance criteria for small capacity and subscriber systems are less stringent than those stipulated for broadband systems thus making it practicable to design paths with low ray-line clearance. A further constraint is that these systems often have the radio equipment co-sited with subscriber or switching equipment at locations not ideally situated from a radio point of view. In such circumstances the paths may be severely obstructed by the intervening terrain in which case the system design is optimised for economy and noise performance from a map study, field inspection and propagation measurements, eliminating the need for an expensive detailed survey.

The survey techniques to be described include the normal survey practices employed by Telecom for the design of long-haul broadband radio-relay systems together with some of the more economic and novel methods used by system designers for predicting path performance of small capacity and single channel systems.

OBJECTIVES OF THE SURVEY

The survey provides information upon which accurate estimates of system performance and overall costs can be made.

The principal parameters obtained from a survey include:

- The co-ordinates of the station mark (with respect to the Australian Geodetic Datum, AGD), identified by a peg indicating the position of the proposed tower or mast.
- The site RL (reduced level), i.e. the elevation of the station mark with respect to the Australian Height Datum (AHD).
- The relative elevation of topographic features along the path.
- Path length and distance to significant features along the path.
- The true bearing of the ray line and its angular separation from significant features in the vicinity of the path.
- The height and density of vegetation below the ray line.
- The extent and slope of likely reflection areas below the ray line.
- An estimate of access road construction and power supply costs.

The information obtained from the survey is collated by the Surveying Authority and is used to prepare the following documents:

- Route plan
- Path profile drawings
- Near-end detail plan and profile drawings
- Site information drawings
- Site contour drawings

Examples of these drawings may be found in Reference 1.

The Surveying Authority is the organisation carrying out the survey aspects in accordance with Specification 1214 (Reference 1) and in most cases is the Drafting and Survey Section in the State Administration of Telecom. However, when specialised work is required, for instance photogrametry, the work is contracted to a competent authority equipped with the necessary expertise and facilities to conduct the survey. Close liaison between the design engineer and the Surveying Authority is essential to monitor progress and advise of additional work as the survey information is analysed.

COMMON SURVEY INSTRUMENTS

Some of the more conventional instruments used to survey radio paths include:

- Heliograph, a device using a mirror system to reflect the sun's rays in a continuous beam on a desired bearing and so serve as a reference for a distant observer.
- Theodolite, an instrument for the accurate measurement of horizontal and vertical angles by means of a telescope capable of rotation in the vertical and horizontal planes. Circularly graduated plates are used to measure the amount of rotatory motion when the telescope is sighted on successive targets.
- Tellurometer, an electronic instrument used to measure the length of survey lines for distances up to 60 km by the phase shift in a SHF transmission propagated from one end of the path to the other and back. Accuracy is of the order, 1:100 000. A photograph of these three instruments is shown in **Fig. 8.**
- Spirit Level, a tripod mounted telescope levelled in the horizontal plane by means of adjusting screws and spirit bubble and able to be rotated in the horizontal plane.
- Levelling Staff, a telescopic arrangement of graduated rods calibrated in units of length and used in conjunction with a spirit level or Theodolite for levelling measurements. A photograph of a spirit level and staff is shown in **Fig. 9**.
- Survey Barometer, a sensitive atmospheric pressure measuring instrument operating on the Aneroid principle used to indicate the difference in altitude of a point with respect to a known datum.
- Geodimeter, an electronic distance measuring system (EDM) in which the phase shift of a modulated light beam transmitted over the path to a prism reflector and back to the sender is interpreted in terms of path length. This instrument gives a direct read-out of path length in metres and is able to resolve distances up to 1.5 km. accuracy is of the order 1:200 000. The geodimeter is used in levelling traverses and is shown in **Fig. 10.**

SURVEY METHODS FOR BROADBAND SYSTEMS

The field survey of a broadband route can be subdivided into three phases:

- field reconnaissance
- detailed traverse
- site and road survey

An outline of these functions follows.

FIELD RECONNAISSANCE

The first requirement of the survey is to establish that a workable route can be provided using the sites selected in the map and feasibility study.

This involves a field reconnaissance of the route in which each path is roughly profiled using barometric levelling and/or limited theodolite traversing depending on the roughness of the terrain. It is during this phase that Civil Engineering advice on road cost estimates is required and the basic route of access roads is determined.

Fig. 8 — Theodolite, Heliograph and Tellurometer

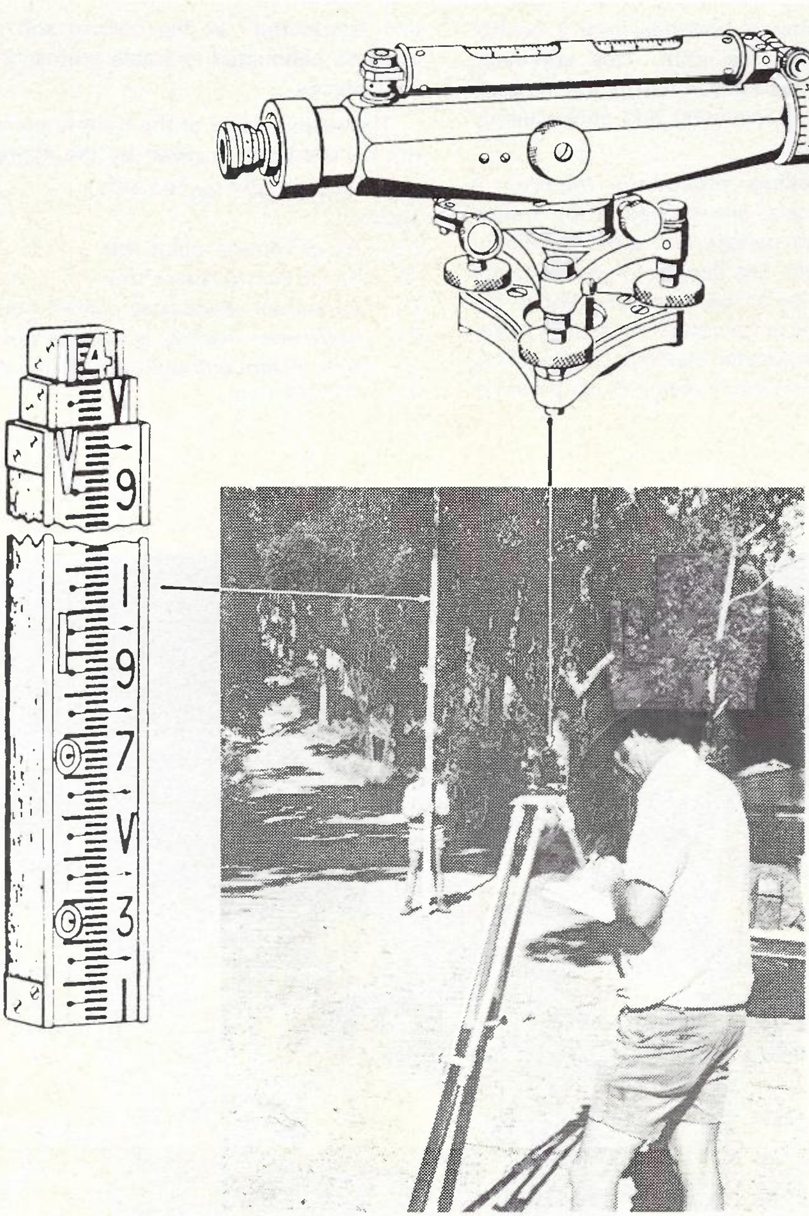

Fig. 9 — Spirit Level and Staff

Reconnaissance techniques have varied over the years, depending on the type of terrain and the accuracy of map information used for the original route selection.

On paths with sites that are intervisible, clearance above the significant terrain features along the path may be established by barometric or theodolite levelling depending on the accessibility to the relevant features.

In undulating, timbered country the significant features can be difficult to locate and considerable time and resources can be expended in their evaluation particularly in remote areas where detailed map information is unavailable. Surveying in this type of country normally requires Radio Lines Group support for the erection of portable guyed observation towers (up to 40m) at the sites and obstructing ridges.

Barometric Levelling

A preliminary path profile can be determined using barometric levelling techniques and involves driving from one end of the line to the other in a suitable vehicle taking barometric readings at significant points, as required, for comparison with simultaneous readings from a control barometer at one end of the path. This approach, however, can introduce difficulties in navigation in rough country and can be time consuming and consequently give unsatisfactory results.

The barometric levelling procedure requires a minimum of two barometers, one located at the station site (control) and the other transported to the significant (remote) points on the path. The barometric readings are affected by the temperature of the air column above the barometer and therefore a temperature correction factor must be applied to the barometer readings. The levelling procedure requires simultaneous readings of pressure and temperature at the control and remote sites and must be conducted in stable atmospheric conditions for best results.

The relative level of the remote points with respect to the control point is given by the expression

$$h2 = h1 + 67.42T \log (P1/P2)$$

where

h2 - RL of remote point (m)
h1 - RL of control point (m)
P1 - barometer reading at control point (mb)
P2 - barometer reading at remote point (mb)
T - mean of temperatures at remote and control points $(T1 + T2)/2$ (°C)

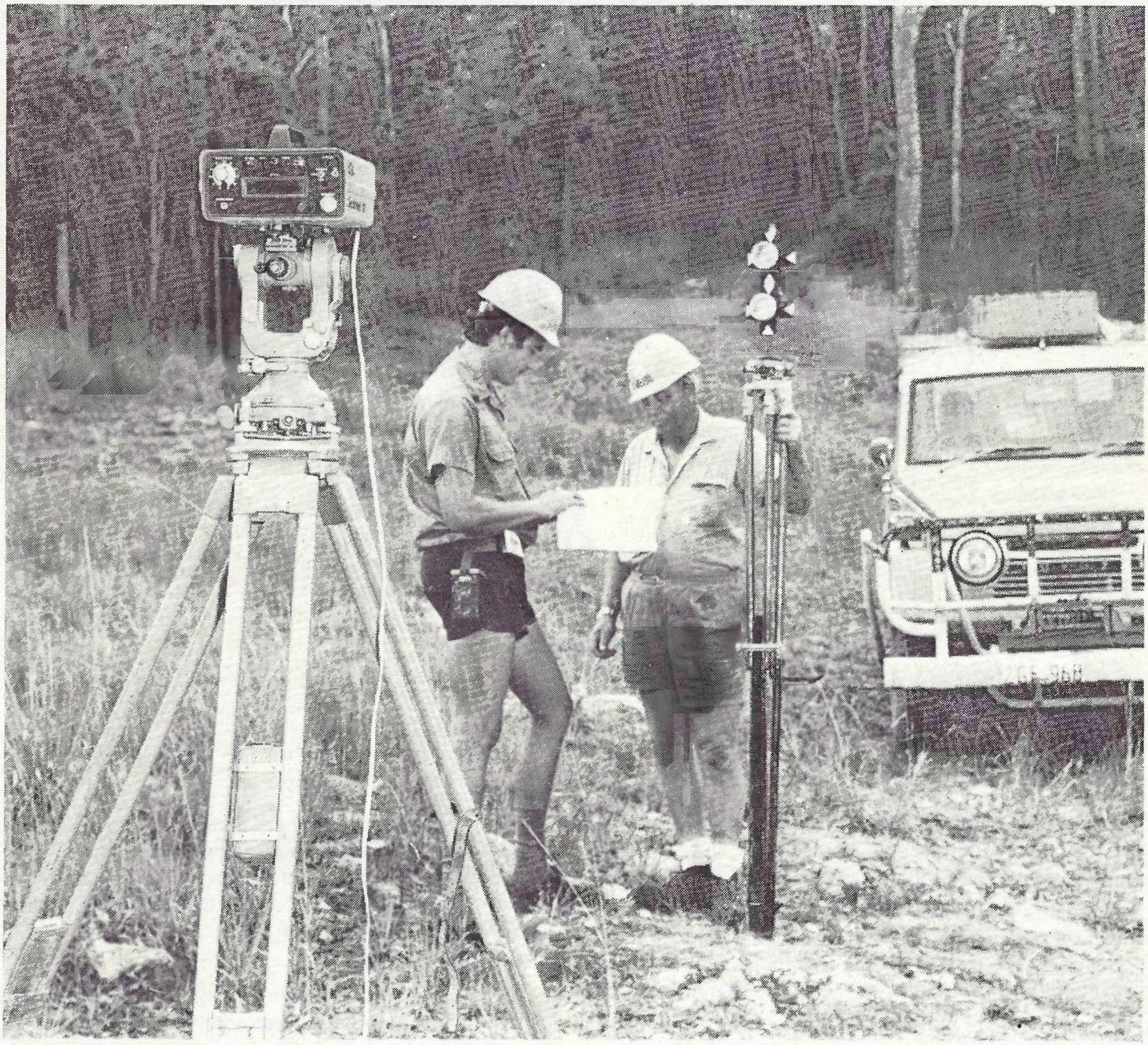

Fig. 10 — Geodimeter (Mounted on theodolite) and target

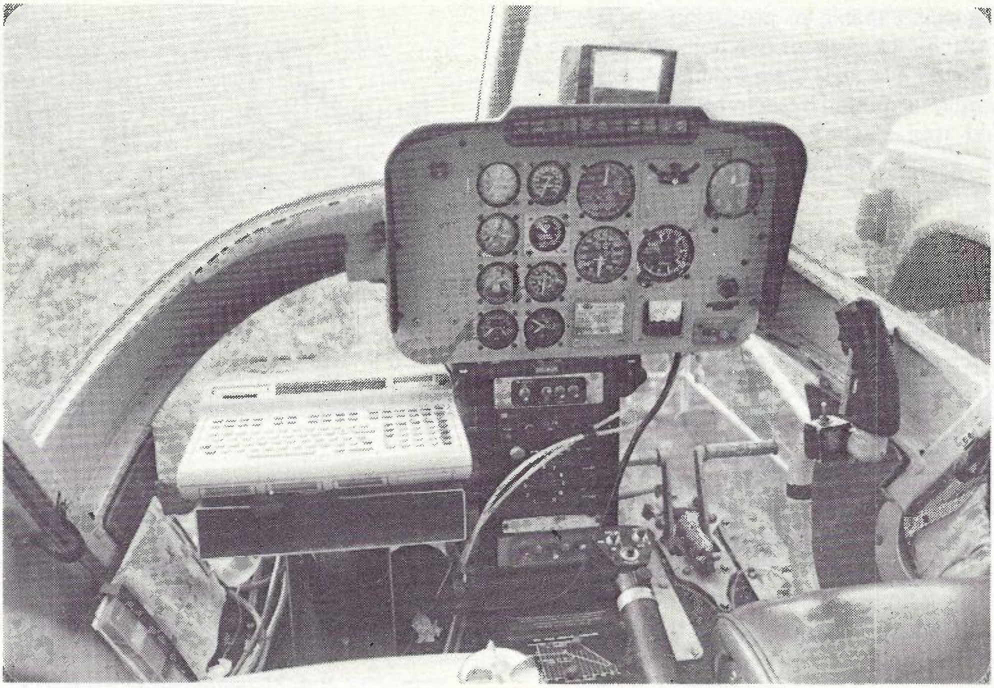

Fig. 11 — Radar Profiler Helicopter Installation

Radar Profiling

The Queensland Radio Section have developed an airborne path profiling facility which greatly improves the accuracy and time taken to conduct the reconnaissance and is capable of producing a continuous path profile to an accuracy of ± 3m, sufficient for the firm selection of the route.

The method employs a small helicopter to fly along the line at relatively low altitude (100m) carrying sensitive radar and barometric altimeters to measure the position of the aircraft relative to the terrain and an isobaric reference level. The output of the altimeters is digitised and stored on tape within a computing calculator carried onboard. The aircraft is navigated down the line by use of automatic ranging equipment which provides the pilot with a left/right indication on the instrument panel enabling him to keep within 5m of the line. The auto-ranging equipment also provides information for computation of distance travelled along the line which is stored on the tape simultaneously with the altitude parameters. The cockpit arrangement of the calculator and navigation read-out is shown in **Fig. 11.**

On completion of the flight the tape information is processed by the computer and used to drive an X-Y recorder which plots the path profile. The profile indicates the location of the significant features which will determine path clearance, and barometric levelling procedures are then conducted using the helicopter to transport the 'mobile' barometer to the remote points. The results of the levelling process are used to correct the profile data and allow the profile to be re-plotted for preliminary system design and costing estimates. A typical profile is reproduced in **Fig. 12.**

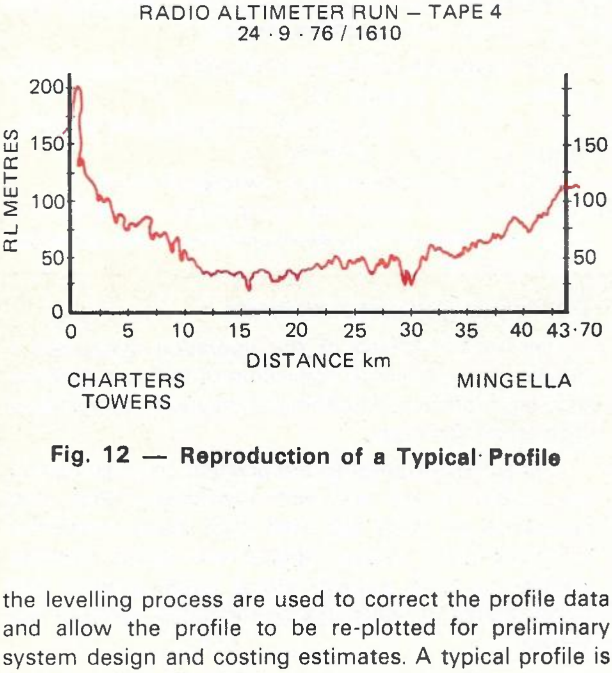

Fig. 12 — Reproduction of a Typical Profile

The helicopter flies at about 180 km/h down the line at an altitude sufficient to give a line-of-sight path to the auto-ranging transponder from any point along the line, typically 100m or so above the tree tops on an undulating path.

This technique is capable of producing a reconnaissance profile at the rate of about one path per day and is considerably faster and less demanding on resources than the conventional ground based method, especially in undulating and tree covered terrain where accurately detailed maps are not available.

Laser Profiler

Another technique that has been considered for preliminary survey of radio paths is the Laser Terrain Profiler which employs a modulated laser carried in an aircraft to derive height above ground information. The aircraft is automatically controlled to fly along an isobaric surface about 2000m above sea level. The pilot navigates the aircraft by visual correlation of photomaps and conspicuous ground features. A 35mm film record is also taken of the terrain below the aircraft to indicate the exact track of the laser profile.

During a measurement run the continuous output of the profiler is registered on a multichannel strip chart recorder together with:

- a continuous timing marker (also recorded on the 35mm film)
- statoscope height, to show vertical deviation from a preselected barometric altitude (isobaric surface)
- vertical gyro, to indicate variations in aircraft roll which affects profiling accuracy.

The laser profiling technique is designed principally for the control of aerial mapping and has some inherent disadvantages for the rapid evaluation of radio-relay path profiles. These disadvantages include:

- visual navigation of the aircraft and continuity of the profile data is affected by cloud.
- pitch and roll of the aircraft increases the effective height of the laser readings.
- drift off course due to wind or navigation errors.
- specialised personnel and equipment are required to prepare profiles with consequent delay in the presentation of results.

DETAILED GROUND SURVEY

The second phase of the operation comprises a detailed ground survey consisting of the co-ordination of station marks and levelling of the paths by means of theodolite traverses.

The survey establishes the position and elevation of the station marks and path obstruction pegs with respect to the AGD and AHD from measurements of horizontal and vertical angles and slope distance relative to local trigonometrical (trig) stations and bench marks of which the co-ordinates and RL's are known.

Reciprocal Levelling

The accuracy of levelling observations over long distances is affected by earth curvature and atmospheric refraction of the optical sighting for which allowances must be made. These effects can be eliminated by using the reciprocal levelling technique in which theodolites, located at the reference point and the remote point, are aligned on each other and the vertical angles read simultaneously. The slope distance between the sites is also measured using a tellurometer and the values obtained are manipulated in a simultaneous equation to derive the RL of the remote site and eliminate the earth curvature and refraction terms as follows:

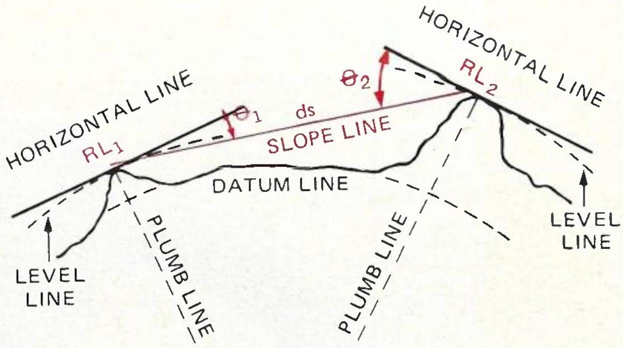

Fig. 13 — Reciprocal Levelling Geometry

$RL_2 = RL_1 + d \tan \phi_1 + (0.0785\ d^2/k)$
$RL_1 = RL_2 + d \tan \phi_2 + (0.0785\ d^2/k)$
subtracting
$RL_2 = RL_1 + d\ (\phi_1 - \phi_2)/2$

where RL_2 - reduced level of remote point (unknown)
RL_1 - reduced level of reference point (known)
d - slope distance in metres (tellurometer)
ϕ_1 - vertical angle at reference point
ϕ_2 - vertical angle at remote point
(angles of elevation are positive and angles of depression are negative)
$(0.0785\ d^2/k)$ is the earth curvature and retraction term.

Reciprocal levelling is capable of transferring levels to an accuracy of 0.5m over a distance of 50 km. A reciprocal levelling measurement is shown diagramatically in **Fig. 13**.

Co-ordination of Station Marks

The transfer of latitude and longitude and azimuth from a trig station to the station mark uses a theodolite and tellurometer to measure horizontal angles and slope distance. In cases where the outlook from the proposed station site is obscured by trees, a special tower needs to be erected for the surveyor to have an optical path to the reference object. The method requires the observation of a true bearing from the trig point to a reference object (usually another trig station) to provide a base for the measurement. The horizontal angle between this base line and the station mark (forward bearing) is then measured together with the slope distance. The mean of twelve successive measurements is used in a mathematical expression to give the latitude and longitude of the station mark and the reverse bearing to the trig station. The forward and reverse bearings may differ by up to 180° ± 10 minutes over 50 km at the higher latitudes due to grid convergence.

The slope distance may differ by a few metres from horizontal distance and for accurate assessment of site position the measurement may be corrected using the expression:

$d/d_s = r/(r + m)$
where d - horizontal distance (m)
d_s - slope distance (m)
r - earth's radius (6376×10^3 m)
m - mean altitude of the path in m
$m = RL_1 + (RL_2 - RL_1)/2$

Levelling Traverses

When the survey has established the site and midpath peg coordinates it is usually necessary to level 1 to 2 km either side of the midpath obstructions to establish the general topography of the terrain, also in cases where reflective areas are prevalent additional levelling will be required to determine the slope and roughness of the area.

The usual method used for path levelling is the stadia traverse and differs from the reciprocal method of fixing a point by bearing and distance in that the traverse is a series of measurements in which a forward point, fixed from an observation point becomes an observation point for the fixing of a new forward point. Such a traverse may follow a zigzag course with relatively short spans of 50-1000 m depending on the terrain and method of measurement.

The stadia traverse makes use of the tachemetry principle in which the distance between the observing theodolite and a distant staff is proportional to the staff graduation interval observed between two horizontal hairs called stadia hairs in the eyepiece of the theodolite. The stadia hairs are arranged in the optical system of the theodolite to give a ratio of distance to graduation interval of 100:1 as shown in **Fig. 14a.**

The horizontal distance to a forward point is given by the equation:

$d_h = d \cos \phi_v$
where d is given by:
$d = 100\,(h_T - h_B) \cos \phi_v$
and H_t - staff reading at the top stadia hair
h_B - staff reading at the bottom stadia hair
ϕ_v - vertical angle of the theodolite

The RL of the forward point is determined from the equation:

$RL_2 = RL_1 + h_1 + d \sin \phi_v - h_s$

where RL_1 - altitude of observation point.
h_i - height of theodolite
h_s - staff reading at the middle stadia hair

The geometry is depicted in **Fig. 14b.**

The horizontal angle to the forward point is also measured to control the plan position. In order to traverse as rapidly as possible three men are usually involved and include a chainman with plumb line at the backward station for a horizontal reference, a surveyor at the observation point and a chainman with a staff at the forward point.

With the advent of solid state techniques, battery powered electronic survey instruments are now quite common. The geodimeter is one such instrument which measures slope distance automatically and far more accurately than the tacheometer. The geodimeter is small enough to be mounted on top of the theodolite and is oriented towards a triagonal prism reflector at the forward point. Whereas the stadia traverse is limited to about 100m legs the geodimeter is capable of 500-1000m legs and allows a traverse to be made 5 to 10 times faster.

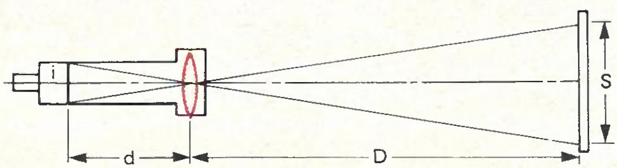

Fig. 14a — Simplified Diagram of Tacheometer Principle

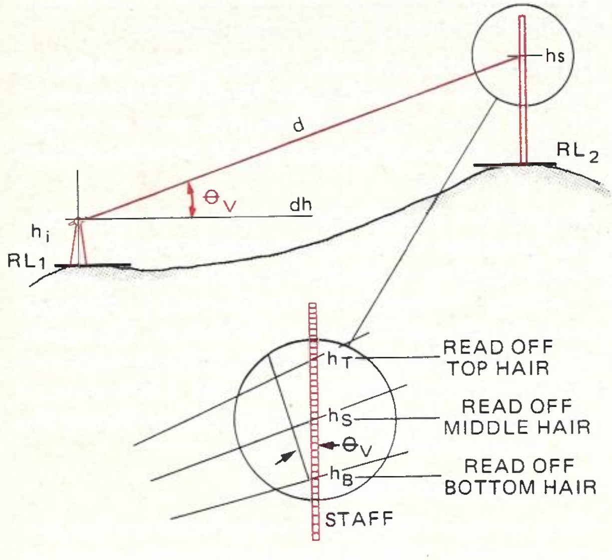

Fig. 14b — Geometry of a Stadia Traverse

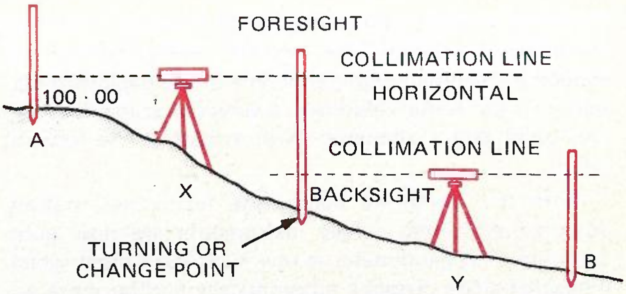

Fig. 15 — Spirit Levelling

Spirit levelling is also used to transfer levels from nearby bench marks. The instrument used for this measurement is either a dumpy level or an automatic level. The traverse requires the observer to take a backsite reading of a staff placed on a bench mark and then rotate the telescope to take a foresight reading on a staff at the forward point. The difference in the two readings being the fall between the backward and forward points. This process may be repeated many times to transfer a level over several kilometres. The principle is demonstrated in **Fig. 15.**

Photogrametry

The difficulties associated with a detailed ground survey of long-haul radio-relay systems in the more remote regions of Australia have led to the use of photogrametric techniques for the route selection and path profiling aspects of the system design.

The basic technique requires the interpretation of overlapping black and white aerial photographs by means of special stereoscopic instruments to produce accurate topographic strip maps of the route from which suitable paths may be selected and profiles prepared.

The main advantage of the photogrametric method of surveying is that it minimises the amount of field work required and allows most of the detailed study to be conducted in an office environment where computer analysis is more practicable.

Although it is a very accurate method of topographic survey, photogrametry requires comprehensive ground control, is expensive and requires close liaison between the system designer and the Surveying Authority. However, on such systems as the East-West, Townsville-Mt. Isa and Mt. Isa-Darwin, where photogrametry was used the cost estimates of the routes finally selected have shown significant savings when compared with the routes selected during the feasibility studies.

ROAD AND SITE SURVEYS

When the sites have been firmly selected the final survey work required is the detailed levelling and traverse for the road and site surveys. Road design of course is primarily concerned with gradients and water drainage and requires reasonably accurate levelling to within 100 mm.

The site survey requires the RL of features on or adjacent to the site to be measured relative to the station mark and the preparation of a site contour plan, or where the area is relatively flat, spot heights in grid form, to adequately show the site gradient.

Automatic levelling or stadia traverse techniques are usually employed for this purpose.

SPECIAL TECHNIQUES FOR SMALL CAPACITY SYSTEMS

Detailed surveys are not normally conducted for small capacity radio-relay systems because of the physical and economic constraints associated with the provisioning of such systems.

In most cases a map study is conducted to determine the approximate path geometry and is usually followed by a field visit to confirm the findings of the map study particularly where an obstruction is likely to affect propagation performance.

Small capacity system designers usually have no alternative but to use paths having some degree of obstruction and the common theoretical methods of predicting propagation performance in these circumstances may not give a sufficiently accurate estimate of noise performance on which to base a system design. To overcome this deficiency, a propagation survey is conducted to determine median path loss and the height gain characteristics of the path.

The survey technique may be best illustrated by outlining the procedure adopted by the NSW Radio Section for the survey of small capacity radio-relay systems. The survey makes use of two specially equipped four-wheel drive vehicles fitted with propagation measurement transceivers, telescopic masts and antennas for the VHF and UHF bands.

A measurement is conducted by positioning the vehicles at the respective terminals of the path to be tested and raising the antennas to the maximum height of the telescopic mast (20m). With the propagation equipment energised and stabilised the antennas are aligned in azimuth for maximum signal level as indicated by a RF level indicator at station A. Having aligned the system and obtained a satisfactory reference level a calibrated signal generator is substituted for the receiver and the level adjusted for the same reading on the indicator to give the absolute received signal level. This figure is used in conjunction with the calibrated values of transmitter power, feeder loss and antenna gain to determine the median path loss for that antenna height. The measurement is repeated for antenna height intervals of 15m, 10m and 5m above ground level to indicate the significance of signal level variations with height — sometimes referred to as the height-gain effect. Reciprocal measurements are also made at station B to verify the results.

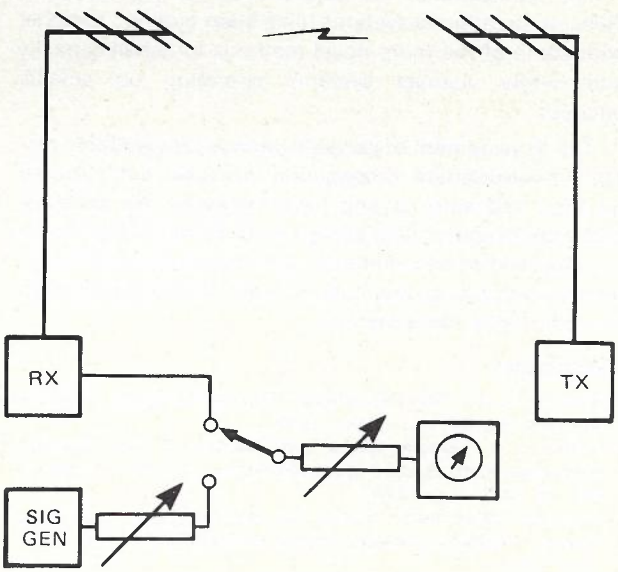

Fig. 16a — Propagation Measurement Block Diagram

Fig. 16b — NSW Survey Vehicle

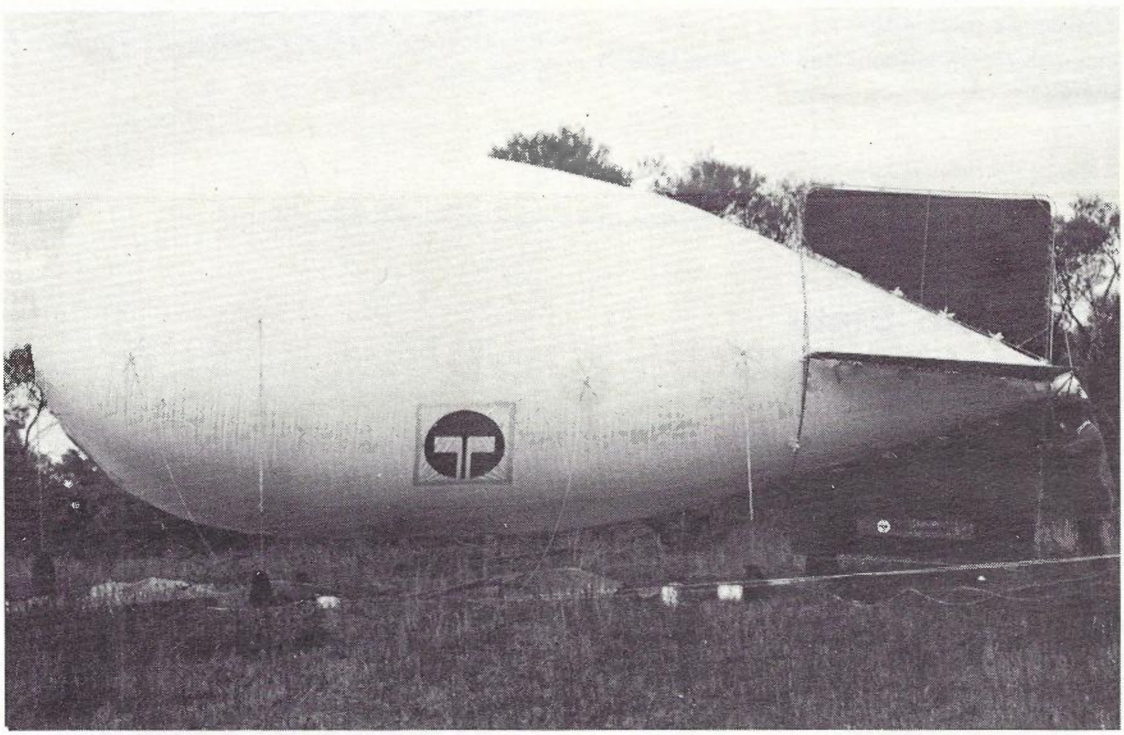

Fig. 17 — Balloon used in NSW Propagation Measurements

The performance of 24 or 60 channel systems may be affected by multipath delay distortion which cannot be identified by the measurement described above and it is now recommended that white noise tests be made in conjuction with the propagation survey to evaluate this aspect.

A simplified block schematic diagram of the propagation measurement technique is shown in **Fig. 16a**. A typical survey vehicle is depicted in **Fig. 16b.**

SURVEY TECHNIQUES FOR SINGLE CHANNEL SYSTEMS

The survey of single channel subscriber systems may also be accomplished by means of the mobile propagation measurement technique, however, with the advent of group concentrator systems in outback areas where several potential subscribers may be located within a 50 km radius of a proposed concentrator site, mobile measurements of field strength can be a long and expensive exercise.

A technique recently tried by NSW Radio Section to expedite the survey of subscriber concentrator systems in remote areas made use of a large, tethered balloon to carry an omnidirectional VHF transmitting antenna aloft from the proposed base station site. This provides a source signal for propagation measurements conducted at potential subscriber locations by means of an airborne receiving unit mounted in a small helicopter. The use of a helicopter enables the rapid evaluation of height-gain and median path losses for each station in the system and allows the geographical layout to be optimised for overall performance very quickly, reducing survey time and demand on resources considerably.

A photograph of the balloon used for these tests is shown in **Fig. 17.**

CONCLUSION

The effect of path topography on the performance of a radio-relay system is of such significance that a survey is required to provide information for the accurate design and provisioning of the system to acceptable standards.

The conventional techniques used for the survey of Telecom broadband systems have been outlined together with some of the more novel methods for small capacity and single channel systems operating on smaller budgets.

The development of portable devices for electronic distance measurement, propagation measurement, airborne profiling and auto-ranging have improved the accuracy and expedience of field survey work so much that many profiling and survey methods once disadvantaged by inherent inaccuracies and cost are now a viable proposition for radio-relay route survey.

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Neil Wain is Engineer Class 3 in Radiocommunications Construction Branch at Headquarters. See Vol. 29, No. 2, page 108.

New Telecom State Manager for Tasmania

Telecom's new State Manager for Tasmania will be Mr Ivan Le Fevre.

In announcing this, Telecom's Chief General Manager, Mr W. J. B. Pollock said that Mr Le Fevre will be the first Tasmanian-born person for over fifty years to manage the State's telecommunications. (Mr H. L. D'Emden was Deputy Postmaster-General for Tasmania from 1903-1923).

Mr Le Fevre succeeds Mr R. S. Colquhoun, MBE, who has retired after 41 years service including four years as Director, Posts and Telegraphs, Tasmania, and four years as Telecom State Manager.

For the past eight years Mr Le Fevre has been in charge of telecommunications engineering activities in the State during which Tasmania became the first Australian State to have a completely automatic telephone service.

He is a member of the Faculty of Engineering, University of Tasmania, Member of the Institution of Engineers, Australia, member of the Royal Institute of Public Administration and the Industrial Relations Society.

Aged 57, Mr Le Fevre is married with four children. He is a keen rose grower and an active member of the Royal Hobart Golf Club. For the past five years Mr Le Fevre has been Secretary of the Rose Society of Tasmania and for over twenty years a member of the Board of Management of Scots Church, Hobart.

Touchfone 12

A. A. RENDLE, B.A (Hons.)

Telecom Australia has released a tone signalling push button telephone, Touchfone 12, for use on exchange and PABX lines equipped with tone receivers. The paper gives a brief background on tone signalling in the subscribers' network, a description of the design of Touchfone 12, and a comment on future technology.

TOUCHFONE TYPES

Touchfone 12 is a tone signalling companion to the decadic pulsing Touchfone 10 (see Ref. 1). It can of course be used only on exchange or PABX lines equipped to receive tone signals. At present, these are a very small proportion of the network, but the conversion of exchange equipment, and the installation of new exchange equipment and PABX's, will rapidly increase the number of lines with VF tone capability. (A good summary of the future of the Australian network is contained in Ref. 2).

Many of the features, including the keyblock and mechanical arrangements, simply follow from Touchfone 10. The distinctive feature of the 12 button Touchfone 12 is that it produces tone signals for transmitting digits, instead of the simulated dial pulses of the 10 button Touchfone 10.

TONE SIGNALLING BACKGROUND

The pioneering work on tone signalling in the subscribers' network was done in the Bell System about 20 years ago (see Ref. 3). The basic aim was to devise a tone system which could be transmitted over an ordinary voice connection, and yet be immune to false signals from speech. The solution, as is now well known, was to transmit a distinct pair of tones for each digit. In principle, the system provides for 16 combinations of 8 different tones, but most ordinary telephones use only 12 buttons, and so need only 7 different tones. The system is often known as DTMF (Dual Tone Multi Frequency).

The Bell System coined the name "Touch Tone" for this new tone signalling system, and proceeded to develop their network to accept "Touch Tone" push button telephones. The rest of the world has been slow to follow the North American lead in tone signalling, and even now about 17 years later, the only other country with significant penetration of tone signalling is Japan. The Bell System tone frequencies and push button layout were later adopted by the CCITT, who really had little choice, in view of the penetration already achieved in N. America.

FREQUENCY CODE

Touchfone 12 uses the CCITT standard frequencies and button layout as follows:

	Columns (Hz) 1209	1336	1477	1633
Rows (Hz) 697	1	2	3	A
770	4	5	6	B
852	7	8	9	C
941	*	0	#	D

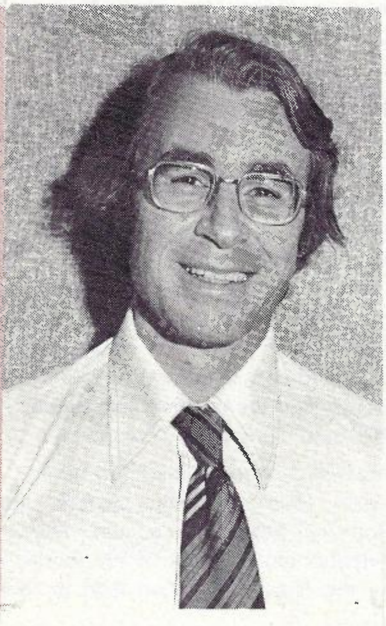
Each column and row has its own particular tone frequency. Any button then picks up the appropriate column and row tone pairs: for example, the tones for digit "1" are 697 Hz and 1209 Hz. In a telephone, only 3 columns are normally provided, allowing for 10 digits plus the * (star) and # (hatch) buttons. The fourth column (A, B, C, D) is available for data use.

WHY TONE SIGNALLING?

The main reason for introducing tone signalling was to speed up the transmission of digits to the local exchange. The tone pairs are transmitted only as long as the button is pressed, so a 7 digit number can be keyed in manually in about 2 seconds. The same number would take about 15 seconds to transmit using a rotary dial, or decadic push button telephone (Touchfone 10). A repertory dialler

Fig 1: Touchfone 12

TONY RENDLE joined STC (UK) as a graduate apprentice in 1958, after graduating in Mechanical Sciences at Cambridge University. He joined the PMG Research Laboratories in 1962, and moved to the subscriber equipment area in 1964. During his 15 years in customer equipment he has been particularly involved with the CT3 project, push button telephones, and electronic telephone transmitter developments. He is currently involved in moves to introduce a range of new generation telephone customer equipment.



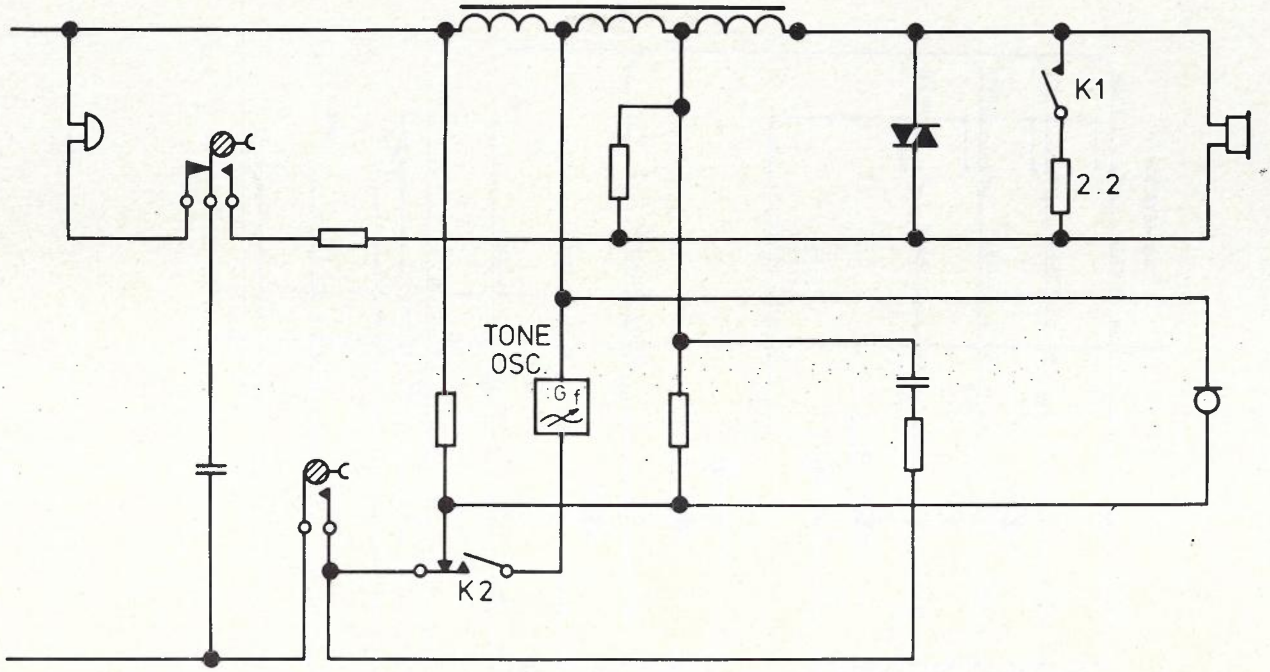


Fig 2: Simplified Touchfone 12 Circuit

is even faster: any 7 digit number can be transmitted in about 700 mS. The speed of tone signalling is a plus both for the customer and the administration: the call is connected faster; and common equipment holding time is reduced.

Another powerful attraction of tone signalling, which was foreseen from the beginning (see Ref. 3), is that signals can be transmitted "end-to-end" over an established voice connection. This opens the door to all sorts of possibilities; for example, in some areas of the USA you can conduct your banking via the telephone, identifying yourself and instructing the bank's computer with tone signals from the telephone. The computer responds using synthesised speech. Another area of application is remote control of equipment; heating or airconditioning (for example) could be controlled or monitored remotely. In Japan, train bookings are made via tone push button telephones.

DESIGN OF TOUCHFONE 12

As for Touchfone 10, Touchfone 12 had to be fully compatible with other 800 series telephones in all plans and configurations. The circuit (see **Fig. 2**) is recognisable as the normal 800 series telephone circuit. When not sending tones, it is in fact identical to the normal telephone. When a button is pressed, the tone oscillator replaces the transmitter, and the normal voltage dependent resistors, used for transmission regulation, are switched out of circuit. The tone oscillator (see **Fig. 3**), which uses a two transistor LC arrangement is relatively straightforward, although it was not easy to meet all the requirements of a difficult specification. The tone levels are regulated according to line length, to keep the levels as constant as possible at the local exchange. This is an aid to "end-to-end" data signalling, to keep the levels at the far end as high as possible, without overloading transmission equipment in the network. The oscillator output is injected into the transmitter circuit to utilise the step-up ratio of the hybrid transformer, and to minimise "clicks" when the buttons are pressed. The "clicks" are caused by discontinuities in the dc through the transformer, and the method of injection used here minimises the change in current when changeover from the speech to the tone sending mode occurs. A low resistance (2.2 ohms) is shunted across the receiver to reduce the tones to a pleasant level.

The question bound to be asked is "Why not use an IC?". The answer is that, for IC's currently on the market, the necessary peripheral circuitry would have raised the cost above the simple LC version, and the IC version would not have had any significant advantage in physical size.

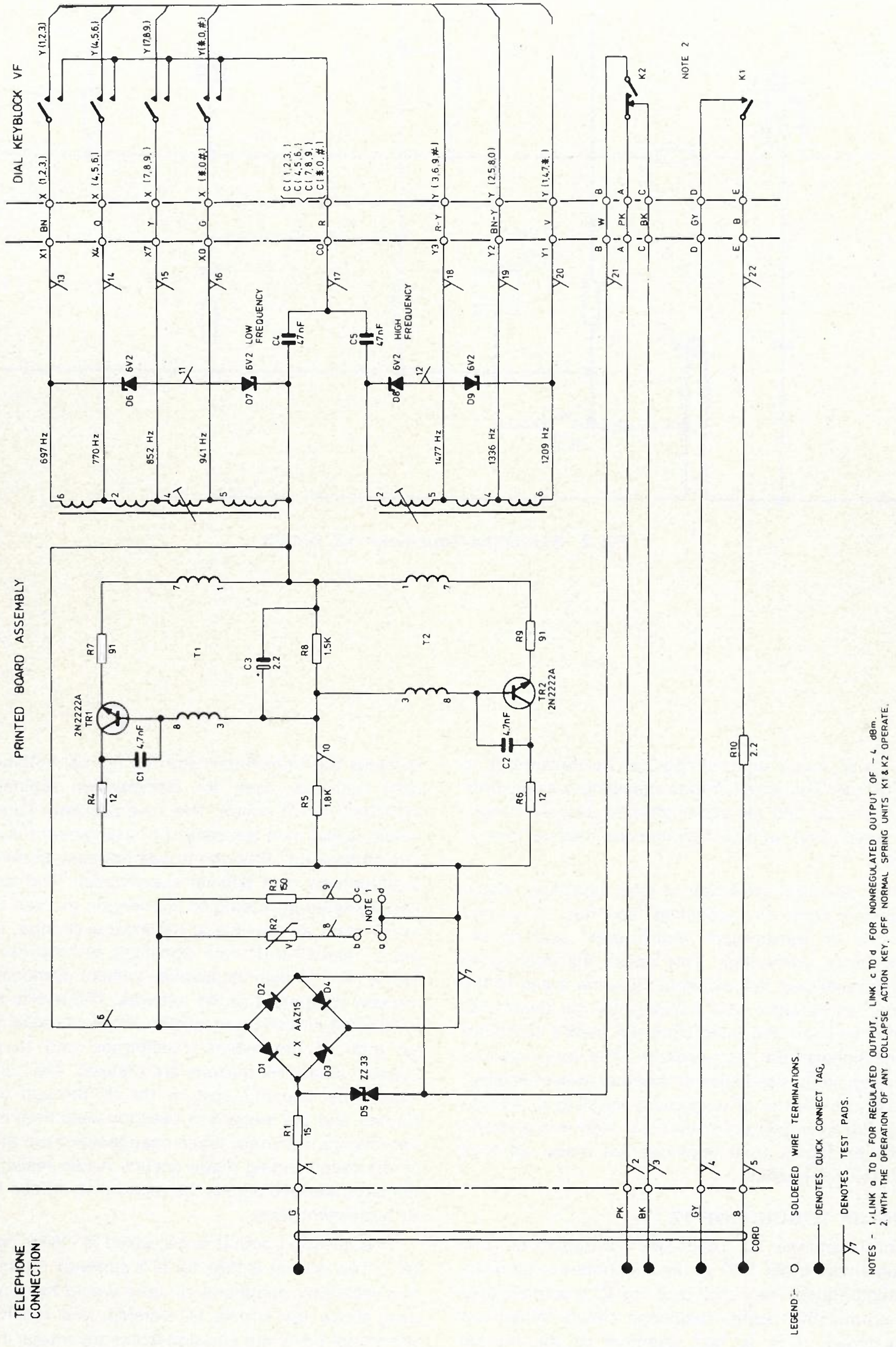


Fig 3: Tone Generator Circuit

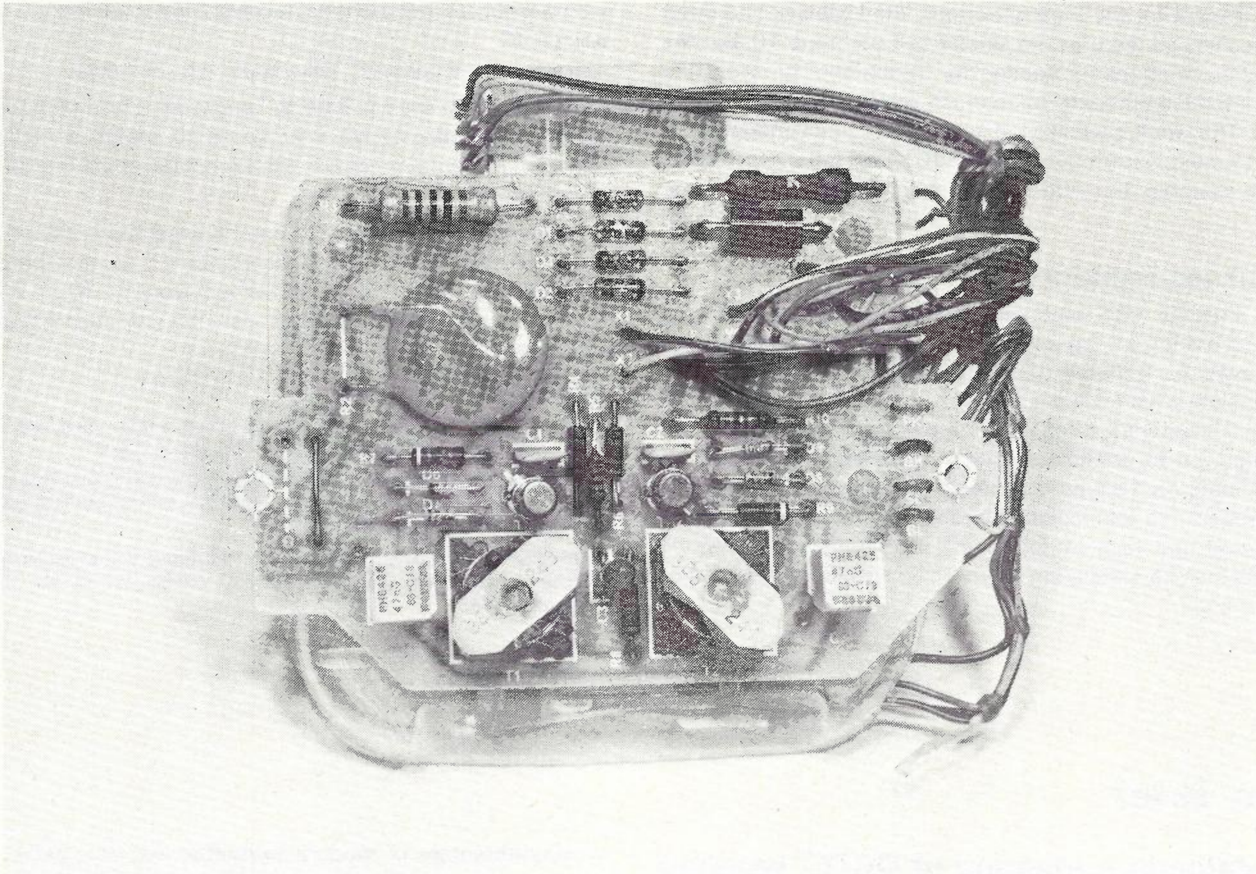


Fig 4: Push Button Assembly: Rear

Fig 5: Push Button Assembly: Front

Except for the 2 extra buttons, the keyblock and other mechanical features are similar to Touchfone 10, but the fewer components needed for Touchfone 12 allow the printed circuit board to be much smaller (see **Figs. 4 and 5**). The whole push button assembly is small enough to fit into most instruments in the 800 series family, including, for example, the Two Line Telephone, and the Wallfone.

FUTURE TECHNOLOGY

Present day technology still makes the cost of Touchfone 12 more than a rotary dial telephone. However, semiconductor developments are in the pipeline which will eventually produce VF tone push button telephones as cheap as a dial type. Work is already going on to produce a "one chip" telephone, which will include, on a single monolithic IC, all the active circuitry needed in a telephone; the tone generator, active hybrid circuit and tone ringer circuit. The complete telephone will than be reduced to a very small number of basic components:

- 3 transducers (microphone, receiver, and tone ringer)
- single IC
- simple, single contact, "calculator" type keyblock

The problem then will be to "package" these components in an imaginative way so as to create a really worthwhile improvement in the complete telephone instrument.

Another development that can be expected is the addition of memory to a tone generator IC, so that both redial of the last number, and a repertory of 10 or 20 numbers would be available as part of the single monolithic IC.

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In Brief

Melbourne meeting of CCITT working party on languages for stored program controlled telephone exchanges

From 1 to 11 October 1979, Telecom Australia hosted the International Telephony and Telegraphy Consultative Committee (CCITT)'s Working Party XI/3, whose charter is the development of international standards for the principal technical languages to be used in specifying, implementing, documenting and communicating with modern computer-controlled telephone exchanges. In the world of telecommunications, the development of these languages is just as significant as the development of FORTRAN, COBOL and ALGOL were for the computer world.

Between 50 and 60 delegates, including 10 Australians, took part in the Melbourne meeting of this international Working Party; it meets typically twice a year during a four year study period. The results of the Melbourne meeting will be assessed by a higher body (a full meeting of CCITT Study Group XI) in March - April 1980 in Geneva, and are then likely to be declared as new international standards (CCITT Recommendations) by CCITT's Plenary Assembly in November 1980.

The Working Party, in practice, spends most of its time divided into Sub Groups working in parallel sessions developing three different types of languages known as the SDL, CHILL and the MML.

SDL (the CCITT Specification and Description Language) is a graphical language, based upon state transition diagrams, which is intended to improve a telephone company's ability to specify its requirements to manufacturers of modern switching systems and to improve the manufacturers' ability to document the behaviour of the completed systems. The development and standardisation of the SDL is carried out in two Sub Groups, chaired by **Mr Eric Bierman** of Canada and **Mr Peter Gerrand** of Australia.

CHILL (the CCITT High Level Language) is an English-like programming language intended to be used in implementing both the operational and the support software for modern telecommunication switching systems. CHILL as a language has absorbed many features of earlier languages, such as PASCAL and PL/1, but has been optimised to suit telecommunication switching system applications. The Chairman of the High Level Language Sub Group is **Mr Nick Martellotto** of the USA; this Sub Group's special team of experts, called the CHILL Implementors' Forum, is chaired by **Mr Remi Bourgonjon** of the Netherlands. The Implementors' Forum met in Melbourne in the week 24 - 28 September before the main Working Party XI/3 meeting.

The **MML** (Man Machine Language) is the command-and-response type of computer language used for communication between the operators of a modern switching system and the system itself. The Sub Group developing the MML is chaired by **Mr Bo Rydbeck** of Sweden.

The Chairman of the whole Working Party XI/3 is **Mr Dennis Roche** of the UK. He was assisted during the meeting by CCITT Counsellor **Mr Maximo Betancourt,** of the CCITT Secretariat in Geneva. The ultimate Recommendations arising from the work of Working Party XI/3 will be published early in 1981 as separate volumes of the CCITT Golden Book.

Manual Assistance in Australia — Its Future Role

J. E. LOFTUS and C. W. A. JESSOP

The personal touch of the telephonist has been with us since the inception of the telephone service and will continue to play an important part in telecommunications in the years to come. This article outlines the future role of manual assistance services in Australia, and explains how modern technology can be used to benefit Telecom, telephonists, and the customer. A National Manual Assistance Plan is foreshadowed which will give direction to manual operations during the 1980's.

INTRODUCTION

Since the inception of the telephone service in Australia in 1880, its outstanding characteristics have been **growth**, the **application of technology**, and **personal service** — from telephonists. Projected advances in technology have been described in many other articles; this article will outline the future role of manual assistance, and explain how modern technology can be used to benefit Telecom, telephonists and the customer.

The term "Manual Assistance" is used throughout this article to incorporate the four main manual services of Trunk and International Assistance, Directory Assistance, and Service Assistance "1100", as opposed to the local manual service for non-automatic exchange working. These four will form the main bulk of Telecom's manual service in the years ahead. Other services of equal importance, such as "000" Emergency, Appointment and Reminder, and changed number redirection, will continue to offer customers a wide range of personalised service, but will only be dealt with briefly in this article.

It is the belief of the authors that personal service from Telecom telephonists will continue to play an important part in telecommunications in the years to come. The plans outlined in this article will ensure that a firm basis for this future development is established.

DEVELOPMENTS IN MANUAL SWITCHING TECHNIQUES

Originally the manual operator physically performed the switching operation at the switchboard. This was done by plugging a cord circuit into the appropriate sockets, and the telephone conversation would proceed via this connection, as shown in **Fig 1 (a)**.

The introduction of "cordless" boards such as the Siemens trunk and later the AFG boards associated with ARM trunk switching exchanges brought a change in concept. In this case the call was still switched via the switchboard, but under key control of the operator who no longer had to plug in a cord circuit **(Fig. 1(b)**.

Modern manual assistance systems (typified by the 10C system) have brought a further change in concept by splitting the control and switching functions. The operator still controls the connection of the call but the circuit is established at the switching centre, not via the operators' board **(Fig. 1(c)**. As the telephone conversation does not now go via the board, siting of manual operators' positions is **independent** of the location of the switching centre. This allows much greater flexibility in deciding where to site operating positions.

The basis of new manual assistance plans is derived from this feature. The question has now become "Where do we want to put the positions?", not "Where **must** the positions go?" Consequently, now is the time to rethink and revise our plans where necessary.

THE CORPORATE PLAN AND MANUAL ASSISTANCE

The major thrusts of the Corporate Plan are:

- quality of service
- efficiency
- staff relations and development
- technological improvement

and our future plans for manual assistance are matched to each of these thrusts as follows:

- Quality of Service:
  Existing standards will be at least maintained, and in many cases improved. Through-switching will be achieved with greater speed, and information (either Directory or Customer service records) will be available to the manual operator much more readily. Result — a more satisfied customer.
- Efficiency:
  Hand in glove with the improved speed of service will come greater efficiency of operation. Automation of

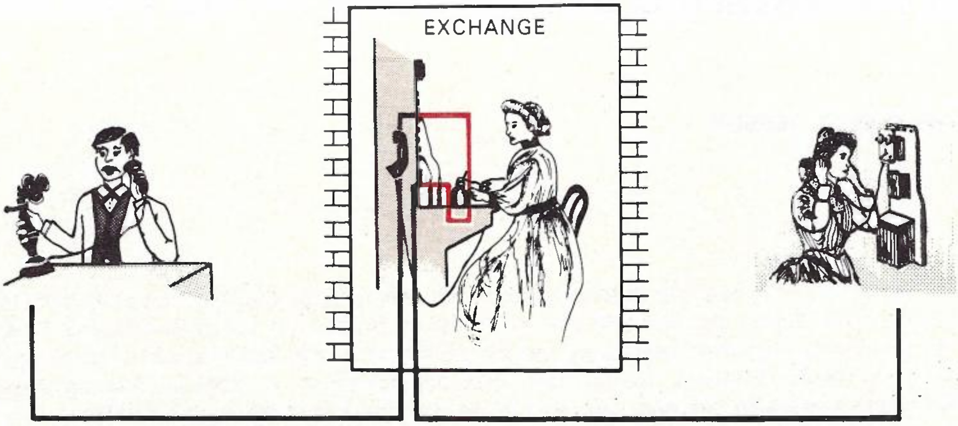


Fig. 1(a) — Telephone Conversation Switched via Switchboard and Cord Circuit.

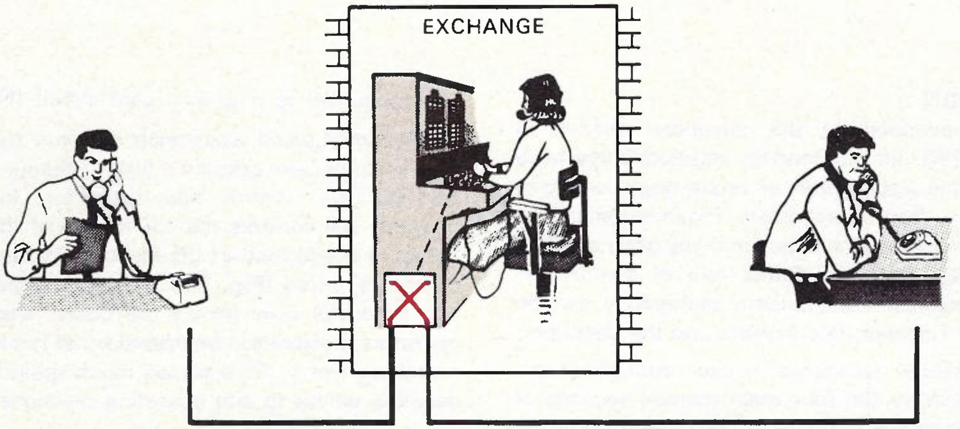


Fig. 1(b) — Telephone Conversation Switched via Switchboard under Key Control.

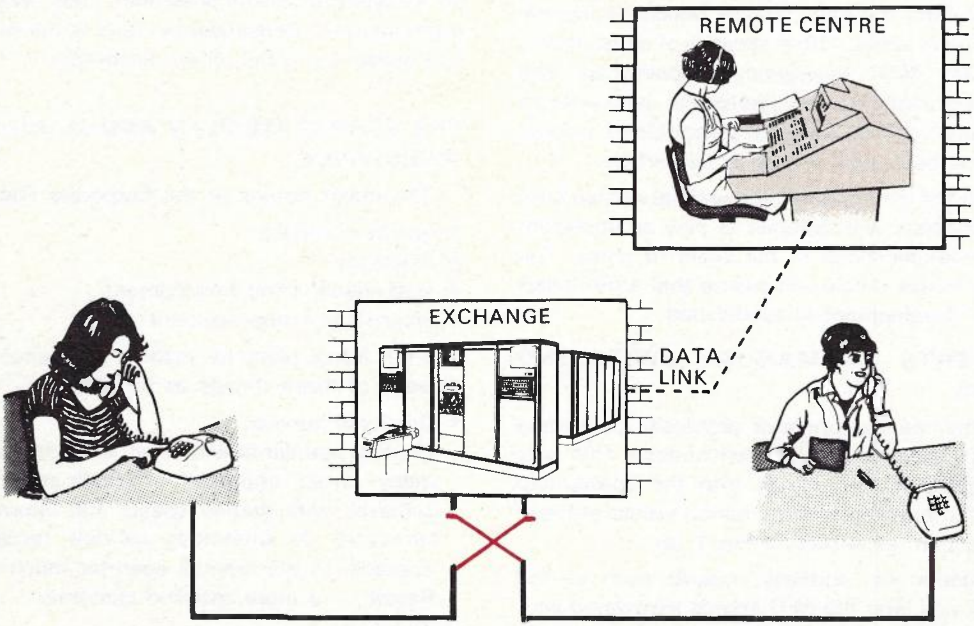


Fig. 1(c) — Telephone Conversation Switched via Exchange under Remote Control.

record handling (dockets or information) will allow the telephonist to spend proportionally more time concentrating on the customer.

- Staff Relations and Development:
  With the relative flexibility of location of positions, and the ability to vary the work-load at each centre, the opportunity exists to give greater consideration to human preferences for work location. The size and location of Manual Assistance Centres can (within reason) be chosen to provide work where it is required, i.e. take the job to the people not vice-versa.
- Technological Improvement:
  The above advances can be achieved through the marriage of technological improvement (modern manual assistance and automated information retrieval systems) with the skills of Telecom telephonists.

POLICIES

In May 1978 Telecom reviewed its manual assistance policies with a view towards minimising the impact of declining manual traffic on employment opportunities in country areas. The result of this review was the endorsement by the Chief General Manager in July 1978 of a revised policy for increased decentralised siting of manual assistance positions, and at this time, discussions with the staff association representing telephonist staff on methods of implementation were commenced. The new policies and principles relating to the future development of manual assistance centres are summarised as follows:

- The controlled introduction of modern manual assistance equipment with improved operating facilities.
  - — Modern manual assistance equipment with docketless operation and remote facilities is being provided wherever possible to allow improved service to customers and flexibility of operation.
  - — The introduction of Calling Line Identification (CLI) facilities will allow a calling number to be automatically identified and displayed on a telephonists operating position. This feature will assist in providing a speedy and efficient service to customers, and will enable a wider range of services to be offered in the future.
- The centralisation of manual assistance traffic and the decentralisation of manual assistance positions and staff:
  - — Manual assistance traffic is being centralised wherever possible in order to provide sufficient traffic volumes to allow efficient operation of manual assistance services. The centralisation of traffic also facilitates the use of advanced switching and operating systems.
  - — The technology of remote operation enables Telecom to adopt a policy of decentralised operation. In this way the reduction of employment opportunities in country areas can be minimised.

FUTURE DEVELOPMENT

Telephonists provide assistance for a wide range of customer needs, as shown in **Fig. 3.**

It is useful to consider the future in relation to 6 groups of services, and projections of likely changes in the size and distribution of each of these groups are shown in **Fig. 2**. The movement among the various services reflects significant achievement in meeting the needs and expectations of communities throughout Australia. These moves also portray a changing role for telephonists,

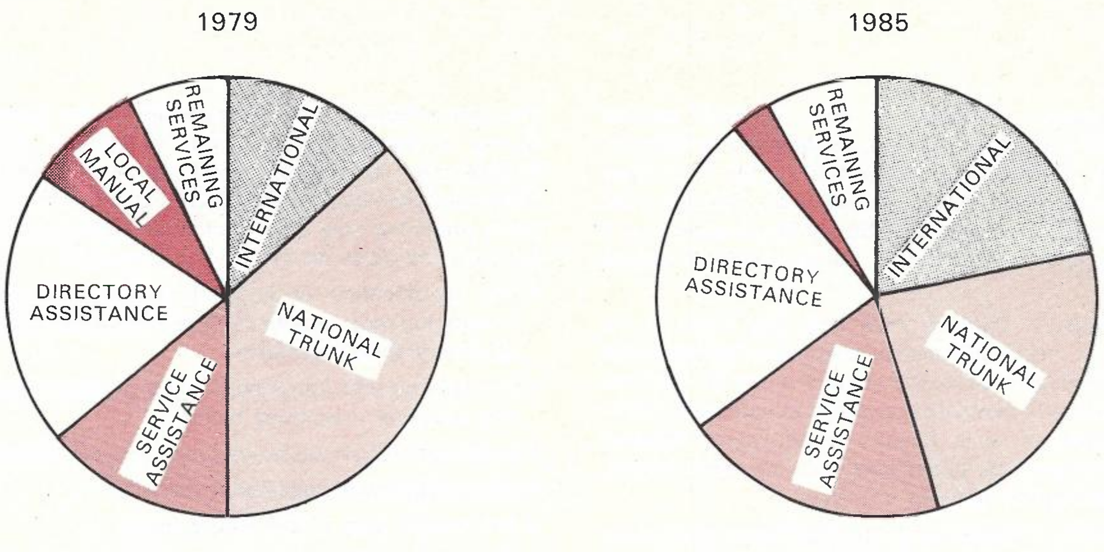


Fig. 2 — Projected Distribution of Manual Services — 1979 to 1985.

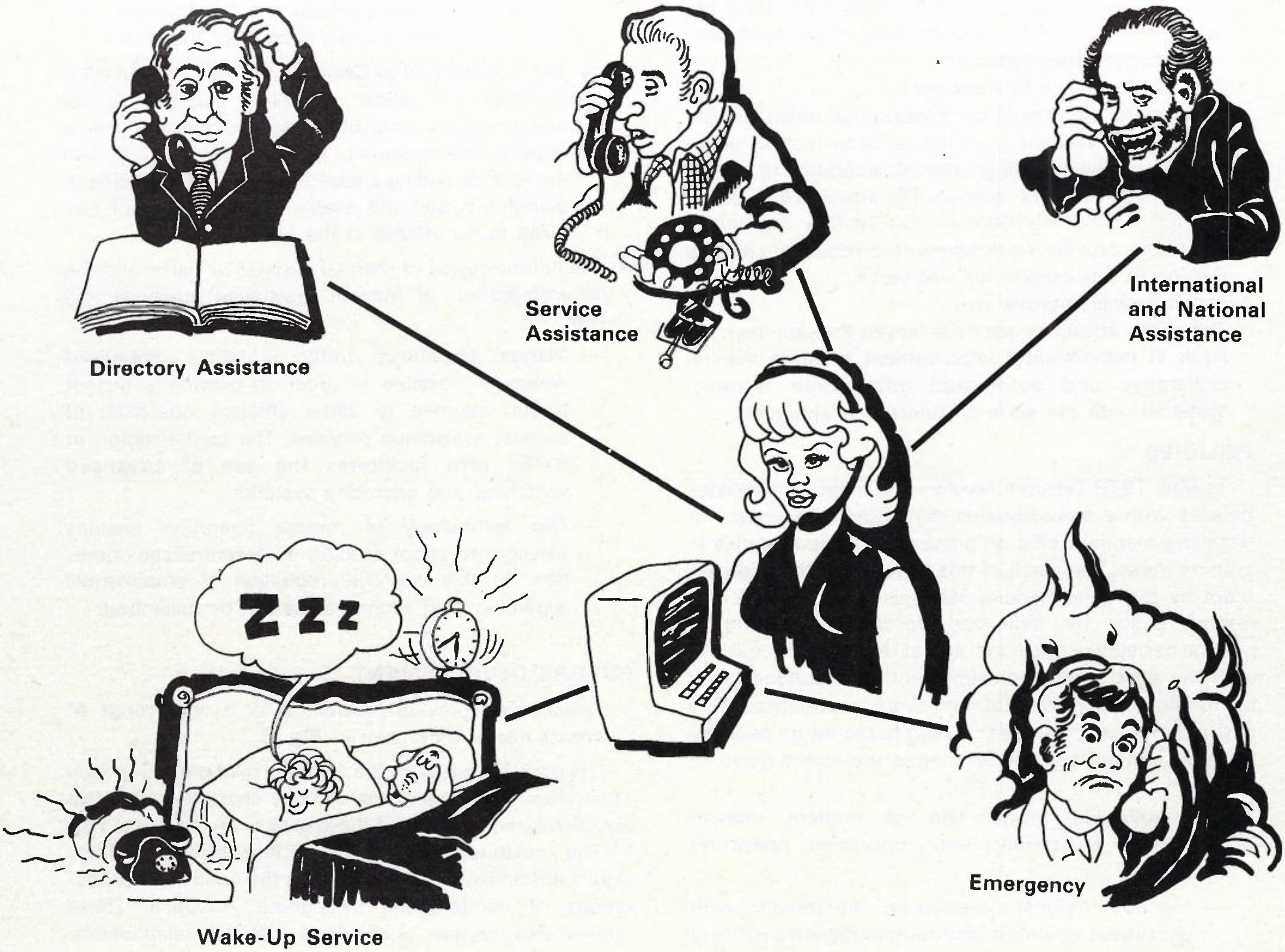


Fig. 3 — Telephonists Provide Assistance for a Wide Range of Customer Needs. Some typical services are shown here.

through greater emphasis on the "service" aspects (interaction with the customer), as opposed to the connection or switching of telephone traffic. The basic switching facility is already provided by STD for most customers and by the mid 1980's it is expected that a similar situation will pertain to the International service and ISD.

Consequently, changes must also take place in the overall level and distribution of telephonist employment. This is particularly so in the country areas as local exchanges are progressively converted to automatic working. However, it is in country areas where Telecom Australia's remoting philosophy will, to some extent, reduce the impact of these changes.

The optimum location and size of all future manual assistance centres is currently the subject of detailed investigation by inter-departmental working parties throughout Australia. Working parties in each State consisting of representatives from Customers Services, Engineering, Operations, Accounting and Supply, and Personnel and Industrial Relations Departments, are currently preparing long term manual assistance plans with particular attention to the following aspects:

- the identification of future locations and sizes for remote and non remote MAC's, and the possible level of decentralised operation;
- the existing and future staff levels at each MAC, and the effect on manpower plans;
- organisational structure with decentralised operation;
- consultation with telephonist staff, and
- the relative cost of alternative plans.

The studies have already revealed the importance and complexity of the many facets which must be considered in this multi-disciplinary exercise. A detailed national plan is expected to be completed by early 1980, and will have a time horizon to the year 1990.

The general direction in which these plans are likely to go is outlined in the following paragraphs.

LOCAL EXCHANGE AUTOMATIC CONVERSION PROGRAMME

Through representations received from country areas, it is clear that these communities strongly support the manual exchange conversion programme. It is also clear that retardation or abandonment of the programme would be strongly opposed as this would leave the communities affected with an inferior telephone service, characterised by lack of continuous service, poor transmission quality, and lack of access to STD. For these reasons, Telecom Australia intends to pursue the Conversion Programme with a view to completion by 1990. Target figures for the number of manual exchange services to remain at June 1980 and 1985 are shown for each State in Table 1.

State	1980 Target	1985 Target
New South Wales	28,300	10,000
Victoria	11,500	0
Queensland	22,000	5,000
South Australia	8,100	2,000
Western Australia	1,400	400
Tasmania	0	0
Australia	71,300	17,400

TABLE 1: Targets for Residual Manual Exchange Services

INTERNATIONAL ASSISTANCE

All International manual traffic is centralised to six mainland capital cities (including Canberra) and all operators are located in those cities at present. International manual calls are currently increasing by 20% per year, but are expected to be contained by the ISD service and the progressive introduction of Automatic Message Accounting for ISD calls (ISD-AMA). Preliminary estimates indicate that the growth of International manual assistance will continue until about 1983. Beyond 1983 growth will be minimal.

NATIONAL TRUNK ASSISTANCE

National manual trunk calls are rapidly reducing in number, and this trend is expected to continue until 1985. As this traffic continues to decline the number of centres switching manual trunk traffic is being reduced. Plans exist for almost all capital city manual trunk calls to be centralised to Metaconta 10C switching centres by about 1982. If additional 10C trunk exchanges were to be installed at Canberra, Newcastle, and Townsville, more than 90% of manual trunk traffic could be centralised to the 10C system.

SERVICE ASSISTANCE

Prior to June 1977, service assistance (Service Difficulty and Faults) calls were increasing at slightly less than the rate of growth of the telephone network. In the 12 months to June 1978 the number of service assistance calls declined by 5.8% from 21.4 to 20.2 million. This reduction is mainly attributed to the use of Recorded Voice Announcements that do not direct callers to MAC's unless it is essential to do so. Beyond 1980 very little growth in service assistance is expected.

Options for a new Service Assistance system are under consideration at present, and will include the facility to use remotely locatable positions.

DIRECTORY ASSISTANCE

Trials of an automated information retrieval system were recently conducted in Sydney, and have proved to be successful in practice. It is likely that future Directory assistance positions will also be remotely located from exchange centres, and telephonists may have access to number information through a computer information retrieval system.

The number of Directory assistance calls is currently increasing at about the same rate as telephone network growth. A similar rate is expected to 1982, after which less growth is expected.

REMAINING SERVICES

The services grouped under this heading encompass changed number redirection, wake up service, mobile radio, '000' emergency, and service advisors. The importance of these services, which currently employ approximately 6% of telephonist staff, is expected to increase with expansion in the range of services offered to customers. Greater emphasis on these services will also assist in providing employment opportunities for staff displaced by the decline in National trunk traffic.

OPTIONS FOR REMOTE OPERATION

The effect on country areas of changes in the volume and distribution of manual services can be offset to some extent with careful planning in the use of new switching technologies and remote operating positions. To achieve this objective, Telecom Australia intends to progressively increase the number of remotely located manual assistance positions.

As the siting of manual positions is basically independent of switching location, and to add clarity in discussion, the following terms have been adopted:

— Manual Assistance Switching Centre (MASC) — refers to the switching centre for the trunking of manual assistance traffic.

— Manual Assistance Centre (MAC) — refers to the location of telephonists for the handling of manual assistance traffic.

Some preliminary steps towards remote working have been taken in relation to Windsor exchange in Victoria, Nambour and Toowoomba exchanges in Queensland, and Murray Bridge in South Australia.

Changes in operations and the need for a centralised control of traffic will result in a change to the functions and responsibilities of telephonists, and more particularly, supervision. An in depth analysis of the supervisory structure and methods of working is being undertaken as part of the total review of Manual Assistance Plans. The outcome of this review is expected to be an improved and more flexible structure meeting the needs of the 1980's.

LIMITATIONS ON REMOTE OPERATION

Some technical and economic limitations exist with regard to Metaconta 10C remote centres, namely:

- Maximum distance of manual assistance centre from the switching centre is 800 km;
- Maximum number of remote centres is 16 per 10C exchange (24 positions each). Special action is needed if more than nine remote centres are required from a 10C exchange;
- Remote systems are provided in modules of 24 positions, comprising three groups of eight positions each. Remote centres may be installed with less than 24 positions. However, small MAC's will make less efficient use of the remote equipment.

CONCLUSIONS

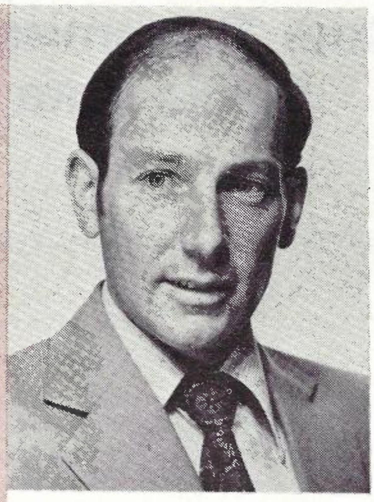
Manual Assistance services will continue to play an important part in the telephone service of the future. The type of service provided by telephonists will be increasingly one of assistance rather than a basic switching function, and to provide personalised service to the customer. As technology advances, there will be an even greater need for the human touch to be available.

The opportunity is presently with us to totally review our manual service, and produce new plans that are in keeping with the needs of the 1980's. This opportunity has come about through the application of modern technology to manual assistance systems and represents a milestone in the development of the manual assistance service. The new manual assistance systems will allow greater flexibility in the location of positions, enabling employment opportunities to be decentralised to a much greater extent than previous systems.

It should be appreciated that changes in demand for Telecom Services have been occurring for a number of years, and are essentially the cause of the planning review; not the result of it. These changes have not always been pleasant, particularly in terms of employment opportunities, and it is probable that the new National Manual Assistance Plan will not satisfy everyone. However, the new plan will make use of modern technology in a manner which attempts to benefit all parties; Telecom, telephonists, and the customer; not just one party.

The future always brings with it a challenge, and the area of manual assistance is no exception. New plans will allow greater flexibility of operation, and will ensure that future services not yet in operation can be introduced when required. The real challenge is to provide a service that gives satisfaction to all concerned.

J. E. LOFTUS is currently employed as a Service Officer with Telecom's Customer Services Department, Headquarters where he is responsible for policy formulation for the long term development of State manual assistance plans. His early experience was in the HQ Research Laboratories, Switching and Signalling Branch, and later in the Engineering Planning Division as a Senior Technical Officer associated with the integration of new items of switching and signalling equipment into the national trunk network.



C. W. A. JESSOP is an Engineer Class 5 in Headquarters Planning Division. He has been concerned with the planning of trunk switching and manual assistance for a number of years until recently taking up the position of Section Manager, Engineering Plans.

Prior to joining Headquarters in 1973 Tony was with the N.S.W. Administration involved with telephone switching planning for that State.

CORRECTION

CCIR and NSG Organisation

The article in Volume 29, No 2, on "Telecom Australia Preparation for WARC — 79" had an error in Table 1, which listed the names of the CCIR and National Study Group Chairmen, (Page 132).

Dr J. A. Saxton, Chairman of the Study Group on Propagation in Non-Ionised Media, is from the United Kingdom, not USA.

Data Transmission Developments and Public Data Networks

NGUYEN A. DUC, B.E. (Hons.), Ph.D., M.I.R.E.E. (Aust), M.I.E.E.E. (USA)

Traditionally, data transmission is conducted over the public switched telephone network and over private lines. In recent years, the increasing use of automatic data processing by commercial and government organisations coupled with the advent of less expensive computers and associated terminal equipment has considerably boosted the demand for faster and more reliable data communications facilities. This demand has grown at such a rate and to such an extent that new specialised public data networks are deemed economical and necessary in order to meet the special transmission requirements of computer users.

This paper considers the various developments in data transmission. Special reference is made to the development of data services in Australia which culminates in the planned introduction of the Telecom Australia Digital Data Network (DDN) in 1980. Overseas developments and trends are briefly mentioned. The typical service and operational features associated with a public data network are highlighted, and different types of networks are described with illustrations of some well-known (public and private) networks.

INTRODUCTION

With the development and rapid growth of the computing industry, a need has arisen for the efficient transmission of information in digital form. Optimum transmission of this digital information requires telecommunication facilities and services that are quite different from those presently used for voice and telegraph transmission. However, owing to the relatively limited data traffic volumes in the past, it has been more economical to make use of the ubiquitous analogue telephone network instead of constructing new separate digital facilities and introducing special data-oriented transmission services. Digital data is generally transmitted over a 300-3400 Hz voice band channel using voice frequency (VF) data modems. These devices modulate the input digital information into an appropriate analogue signal suitable for transmission over frequency-division-multiplexing (FDM) systems and demodulate the incoming received analogue signal into its corresponding digital format. In high data rate applications, a wide band channel is used (e.g. 60-108 kHz group band channel) in conjunction with an appropriate wide band modem.

In recent years, the demand for faster and more reliable data transmission facilities has grown considerably with the advent of less expensive computers and associated terminal equipment. This growth is coupled with the need for greater interconnection between computer systems in order to share resources and facilities (e.g. computing, processing, data bases . . .). Furthermore, industries and government departments are becoming increasingly dependent on data communication facilities.

Significant effort has been made by the telecommunication operating organisations in adapting the existing telephone network, which was originally designed for voice communications, to the transmission requirements of computer users. But as data traffic grows, the telephone network shortcomings become more evident and costly to overcome. There is thus a need to introduce new services designed to meet the specific needs of data communication users.

This paper begins with a concise overview of the development of data transmission facilities in Australia which culminates in the planned introduction of the Digital Data Network (DDN) in 1980. Overseas trends and developments in this field of data communications are also briefly mentioned. In a subsequent section the typical features associated with a public data network are discussed. These offer considerable benefits to both the data user and the operating organisation. The different types of data networks are described, and some well-known (public and private) networks which are in service or being introduced are illustrated. Special mention is made to the proposed Telecom Australia DDN, its offered services and operational aspects.

Transmission band	Recommendation	Date	Switched Application	Modulation Process	Scrambling	Equalization	Remarks
Voice band 300-3400 Hz	V21	1964	Yes	FSK 200/300 baud	-	-	Full Duplex ch.1 = f_1 = 980Hz, f_o = 1180Hz ch.2: f_1 = 1650Hz, f_o = 1850Hz
	V23	1964	Yes	FSK 600/1200 baud	-	-	600: f_1 = 1300 Hz, f_c = 1700Hz 1200: f_1 = 1300Hz, f_o = 2100 Hz
	V26	1968	No	4 phase: 2400 bit/s - 1200 baud	-	-	f_c = 1800 Hz
	V26 bis	1972	Yes	4 phase: 2400 bit/s - 1200 baud 2 phase: 1200 bit/s - 1200 baud	-	-	" "
	V27	1972	No	8 phase: 4800 bit/s - 1600 baud	Yes	Manual	" "
	V27 bis	1976	No	8 phase: 4800 bit/s - 1600 baud 4 phase: 2400 bit/s - 1200 baud	Yes	Automatic	" "
	V27 ter	1976	Yes	8 phase: 4800 bit/s - 1600 baud 4 phase: 2400 bit/s - 1200 baud	Yes	Automatic	" "
	V29	1976	No	QAM: 9600 bit/s - 2400 baud 7200 bit/s - 2400 baud 4800 bit/s - 2400 baud	Yes	Automatic	f_c = 1700 Hz
Group Band 60-108 kHz	V35	1968	No	VSB-AM/LF Suppressed Binary: 48kbit/s	Yes	-	f_c = 100 kHz f_{gp} = 104.08 kHz
	V36	1976	No	SSB-AM/PR Class 4 Shaped Binary: 48-56-64-72kbit/s	Yes	-	f_c = 100 kHz f_{gp} = 104.08 kHz

QAM: Quadrature Amplitude Modulation
VSB-AM: Vestigial Side Band - Amplitude Modulation
SSB-AM/PR: Single Side Band - Amplitude Modulation/Partial Response

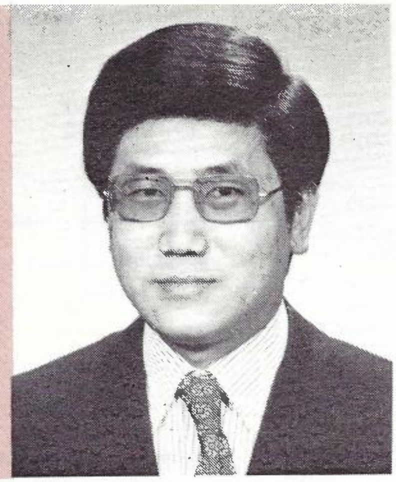
f_c = Carrier Frequency
f_{gp} = Group Pilot Frequency

Table 1 - Summary of CCITT Recommendations Related to Data Modems

NGUYEN QUANG DUC was born in Gia Dinh, Vietnam, on June 23, 1947. He came to Australia in 1964 on a Colombo Plan Scholarship sponsored by the Australian Government. He received the B.E. (Honours) and the Ph.D. degrees in Electrical Engineering from the University of Queensland, Brisbane in 1969 and 1973, respectively.

From 1969 to 1972, he was a Tutor in Electrical Engineering and in Pure Mathematics at the University of Queensland. He then joined the Telecom Australia Research Laboratories, Melbourne (then part of the Australian Post Office), working on various transmission aspects of digital line systems and digital data communications. He is presently engaged in the studies of data networks, integrated services digital networks, protocols and common-channel signalling. Between June 1976 and May 1977, he was a Visiting Associate Professor at the School of Computer and Information Science, Syracuse University, Syracuse, NY, USA.

Dr Duc is a member of the Institution of Radio and Electronics Engineers (Australia) and of the Institute of Electrical and Electronics Engineers (USA).



Present Data Transmission Facilities

The majority of present data communications take place over analogue VF channels of the public switched telephone network (PSTN) and private lines (PL) using voice band data modems. The commonly used VF data modulation techniques are:

- frequency-shift-keying (FSK) for user's data rates of 200, 300, 600 and 1200 bit/s,
- phase-shift-keying (PSK) for data rates of 2400 and 4800 bit/s and their sub-rates, and
- combined amplitude and phase-shift-keying or quadrature amplitude modulation (QAM) for data rate of 9600 bit/s and its sub-rates over private lines.

Owing to the bandwidth limitation of the channel, VF data modems become fairly complicated and expensive for data rates greater than 2400 bit/s, requiring some form of manual or automatic built-in equalisation. For data rates above 9600 bit/s, a wideband channel is required. For example, a group band channel (corresponding to 12 contiguous VF channels) is utilised to accommodate a 48 kbit/s stream using vestigial side band amplitude modulation (VSB-AM) of the low frequency (LF) suppressed binary data signal. For 48 kbit/s rate and above, single side band amplitude modulation (SSB-AM) of the partial response (PR) class 4 version of the binary data signal is adopted for group band data.

The data transmission techniques mentioned above are covered by various CCITT Recommendations (**Table 1**) and the modems using these techniques will be referred to as carrier-type data modems. Other data transmission techniques (viz. baseband) will be briefly mentioned in a later section.

In addition to the public switched telephone network and private lines, data is also transmitted over the private non-switched telegraph lines and the public switched telex network, but at lower rates of 75 baud and 50 baud, respectively. **Fig. 1** and **2** illustrate how data communication is conducted over the public switched telephone network and over private lines.

Growth of Data Services in Australia

In Australia as in most overseas countries, data transmission facilities were introduced in the early 1960's. Private lines and the public switched telephone network are used to provide the transmission medium. As data is transmitted over telecommunications circuits, these services are known as Datel services. Data modems are provided by Telecom Australia for both private non-switched and public switched line applications.

Since Datel services were first introduced in 1969, the number of data modems in operation over the public switched telephone network and private lines has in-

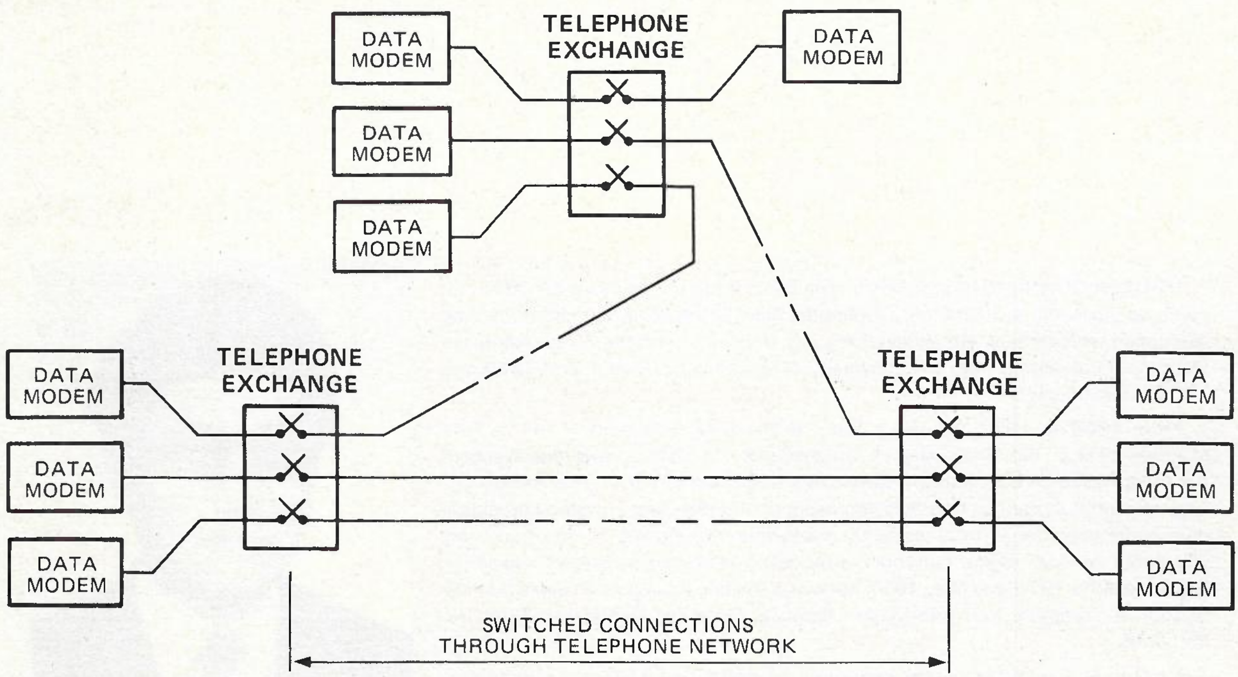


Fig. 1-Data Transmission over the Public Switched Telephone Network.

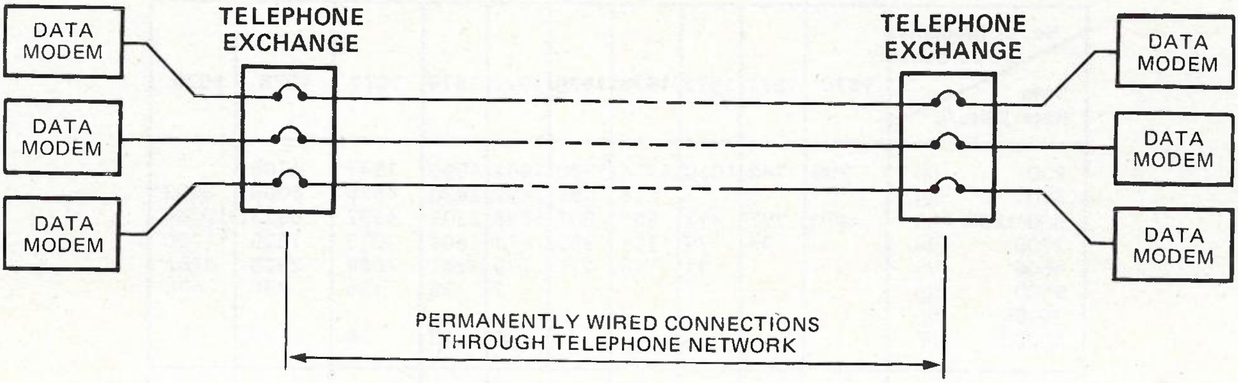


Fig. 2-Data Transmission over Private Lines.

creased considerably (**Fig. 3**). **Table 2** gives the distribution of these modems between 1970 and 1979 in terms of data rates (Ref. 1). Over the past seven years, this growth rate is in excess of 36% per annum, with the majority of data modems being used over private lines. This latter trend is becoming more and more dominant since the introduction of Datel services. **Table 3** shows the composition of data modems in service over the past nine years and also the figures for those expected to be in operation in 1980 and 1985. From this table, the percentage of modems connected to private lines has risen from 55% in 1971 to 76% in 1979 and is expected to reach 79% in 1985.

To meet this rapid growth of demand for data transmission facilities, in particular those over private lines, the introduction of a specialised network to carry only digital data information seems to be a desirable solution. Several such networks are already in operation or being developed overseas. In Australia, the Telecom Digital Data Network (DDN) is planned for introduction in 1980 (Ref. 2). In addition, the Australian Department of Defence has announced plans of its own network called DISCON (Digital Integrated Secure Communications Network) to be introduced in 1982 (Ref. 3).

Developments in Other Countries

Developments in data transmission follow a similar pattern in other countries with the exceptions of different rates of progress and different regulatory policies. Data transmission generally forms a relatively small, although vital part of a user's total data processing systems. Demand for the transmission facilities is therefore largely outside the control of telecommunication administrations and operating companies. It depends heavily on the development and marketing policies and plans of computer and associated terminal manufacturers. A plausible solution in meeting this fast growing but fluctuating

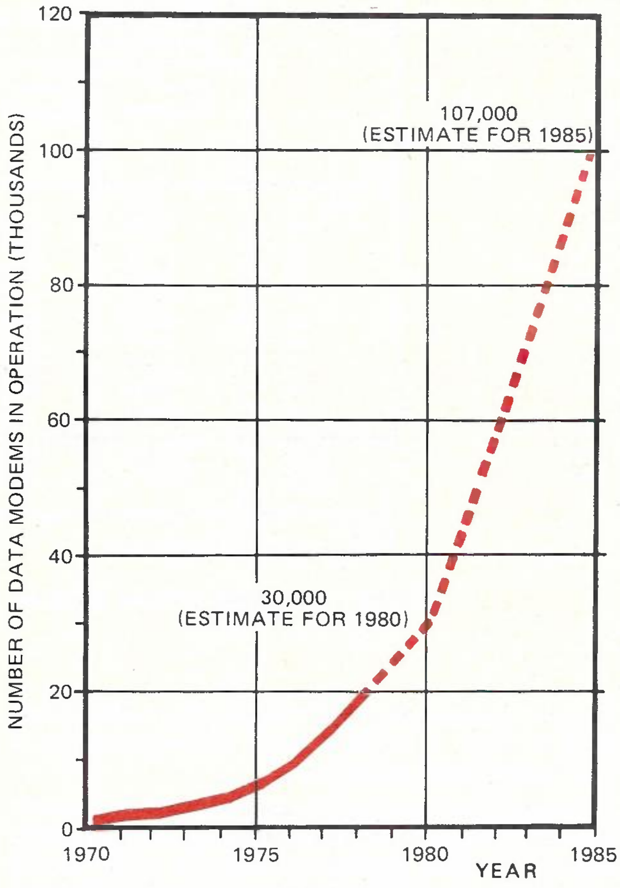


Fig. 3-Growth of Data Services in Australia.

Data Rate (Bits/s) \ No. of Modems at 30 June		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
200	(a)	295	745	1010	1474	1780	1942	1895	1847	1766	-
300	(e)	-	-	-	28	365	1452	2820	4495	6008	9503*
600/1200	(a)	270	397	417	557	801	1233	2307	4192	6923	10704
2400	(b)	-	46	79	254	369	611	804	1013	1326	1785
4800	(c)	-	-	21	143	411	773	1261	2088	2938	3782
9600	(g)	-	-	-	-	-	2	39	138	298	476
40800	(d)	-	-	2	2	2	-	-	-	-	-
48000	(f)	-	-	-	-	-	6	13	19	27	41
TOTAL		565	1188	1529	2458	3728	6019	9139	13792	19286	26291

(a) Introduced January 1969
(b) Introduced January 1971
(c) Introduced January 1972
(d) Introduced May 1972
(e) Introduced April 1973
(f) Introduced October 1974
(g) Introduced January 1976
*This number includes the 200 Bits/s data modems

Table 2 — Number of Data Modems in Operation in Australia (Ref. 1)

Year	In operation over public switched telephone network and private lines		In operation over private lines	
	No. of Modems	Annual Growth Rate	No. of Modems	Percentage of Private-line Modems to Total No. of Modems
June 70	565	-	-	-
71	1188	110%	651	55%
72	1529	29%	861	56%
73	2458	61%	1593	65%
74	3728	52%	2311	62%
75	6019	61%	4115	68%
76	9139	52%	6490	71%
77	13792	51%	10191	74%
78	19286	40%	14526	75%
79	26291	36%	20016	76%
1980	30000*	35%*	-	-
1985	107000*	30%*	85000*	79%*

* These figures are estimates.

Table 3 — Number of Data Modems in Operation over Private Lines in Australia

demand is to provide a data network with sufficient flexibility in order to adapt to users' requirements and to meet international standards.

In some overseas countries where telecommunication facilities are not provided by a single national administration but by several independent operating companies the situation is quite different. In particular, in the US and in Canada, commercial competition is very fierce and several highly-sophisticated data networks have been introduced in order to win a large share of the huge, ever-increasing demand for faster and more reliable data communication facilities.

In other countries, particularly in Europe, data networks are being developed or introduced in order to meet the national demands as well as to share resources via trans-national interconnections.

PUBLIC DATA NETWORKS

As discussed in the previous sections, dedicated networks for data communications are being introduced to overcome the shortcomings of the traditional transmission techniques and also to meet the fast growing demand for speedier and more reliable transfer of digital information. A data network, depending on its level of sophistication, may or may not make use of the available transmission facilities of the existing telephone and telegraph networks. But a common feature of specialized data networks is that they all bring about benefits to both the user and the operating organization alike.

Features of a Public Data Network

From the user's point of view, a public data network offers the following transmission features:

- Significantly low cost for data transmission

  This is the most significant impact of a data network. Two main operational aspects contribute to lower data transmission costs:
  - Low cost baseband data modems are used where possible instead of the expensive carrier-type data modems.
  - Low rate data streams are multiplexed together into higher bit rate aggregate signals (e.g. 64 kbit/s, 2048 kbit/s). It is therefore possible for the operating organization to maximize the number of usable data circuits within a given transmission bandwidth.

- High quality of transmission

  As the network is specifically designed to handle data users' special transmission requirements, robust digital techniques are used wherever possible in the users' loop termination and in the metropolitan and long-haul data links. In addition, its operating performance is constantly monitored and stand-by systems are brought in as the need arises. Very high network availability and error performance can therefore be achieved. In some sophisticated data networks, effective error detection and/or correction techniques are adopted to provide a virtually error-free communication within a time frame that the customer considers reasonable. The user's data transfer throughput is thus kept high.

- Wide range of data transmitting speeds.

  Asynchronous and synchronous data are catered for over a wide range of speeds. These can be as low as 50 baud for the former, and as high as 56 kbit/s or even higher.

- Full-duplex capabilities

  These are normally offered as standard facilities. Transmission of inquiry-response type traffic which is sensible to the reversal delays associated with half-duplex facilities can be effectively accommodated in a public data network.

- Transparency of transmission

  This means that the user's data content is not required to be modified in any way prior to entering the network, although some formatting procedure for control/signalling purposes may be carried out within the network data access units located at the user's premises. The network operation is therefore not apparent to the user.

In addition to providing the above user-oriented facilities, a dedicated data network features the following operational aspects:

- Efficient shared line usage

  In traditional data transmission facilities, a complete analogue channel (either voice band or wideband) is allocated to a data user whether the service is carried over private lines or the public switched telephone network. This usage can be very wasteful in terms of bandwidth as the user's data speed may be well below the maximum achievable data transfer rate. This drawback is readily overcome in a data network by bringing the low rate users' data streams together and multiplexing them into a single high aggregate rate digital stream for all metropolitan and long-distance links. The latter rate is usually chosen to be 64 kbit/s, the same rate at which speech is conveyed over a pulse code modulation (PCM) channel. This 64 kbit/s data stream can be then transmitted either as a digital signal over a voice time slot in a time-division-multiplexing (TDM) system or as an analogue signal over a group band channel in a frequency-division-multiplexing (FDM) system*. The second technique is adopted in basic data networks and in areas where PCM systems are not yet available.

- Low provisioning costs

  The rationalization of bandwidth utilization discussed above can avoid the time-consuming and costly process of line conditioning of individual metropolitan and long-distance data circuits. Further economy can be achieved by avoiding the use of analogue data modulation techniques (cf. Table 1) wherever possible, in particular in the local distribution areas. Baseband-derived techniques (e.g. Refs. 4-6) are adopted in order to provide reliable, inexpensive and simple communicating sets at the user's premises.

  Only distant subscribers would gain access to the network using the traditional analogue carrier-type data modems. Line conditioning normally associated with some of these transmission techniques is therefore kept to a minimum, and less provisioning manpower resources are tied up in this costly process. Consequently, the delays usually associated with the provision of new private-line data services are much reduced.

- Low maintenance costs through efficient network management

  In a data network, the operational and maintenance procedures are carried out from centralized network offices. In-service performance monitoring, loop-back testing, fault detection and isolation can be readily per-

* Note that the use of groupband circuits to carry 64 kbit/s aggregate data streams (of which 48 kbit/s are user's data) is efficient only for user's data rates less than 4.8 kbit/s. In comparison, the 12 individual VF circuits which make up a group can carry a total of 57.6 kbit/s (or 115.2 kbit/s) if each one of them operates at 4.8 kbit/s (or 9.6 kbit/s).

formed at these operational centres. High availability of network facilities and high error performance are thus ensured at all times.

In the local distribution area, as reliable and simple baseband data modems are provided at the customer's premises, they are easy to maintain. Furthermore, their performance can be remotely tested using loop-back facilities.

In summary, the introduction of a dedicated data network offers benefits to both the network user and the operating organization. The data customer can obtain a speedy service connection to a high quality, reliable data communication facility. The network operating organization gains on plant utilization and efficient bandwidth in many cases and saves on centralized operational and maintenance resources while offering reliable, private-line quality, pre-provisioned data services.

Different Types of Data Networks

Public data networks can be classified under four different categories depending on the method by which information is transferred from the sender to the addressee. These are:

- Non-switched network,
- Circuit-switched network,
- Message-switched network,
- Packet-switched network.

Although the last two types, message-switched and packet-switched networks belong to the same class of store-and-forward switched networks, the latter has such applications importance that it warrants a separate description.

Non-Switched Data Network

This type of network, also known as private-line or leased-line network is the most basic kind of data network. Its transmission facilities resemble very closely those presently provided in private-line data services. A data subscriber (or group of subscribers) can transfer information to a distant data subscriber (or group of subscribers) via a permanently-arranged connection within the network. However, instead of using the whole transmission channel as in the majority of present private-line applications, the user's data is multiplexed with other users' data in the same service area in such a way to produce a 64 kbit/s aggregate rate stream. This stream is then conveniently transmitted to the required distant data service area over FDM- or TDM-derived circuits which are pre-provisioned in a cross-connected fashion. Demultiplexing and cross-connecting to the appropriate channels of other multiplexers may be required before the final data service area is reached. At this location, the aggregate stream is demultiplexed, and the component data streams are delivered to their respective permanently-arranged destinations. Non-switched data networks are therefore simple in structure and operation, and their introduction requires minimal plant investment. Although this type of network offers facilities similar to those of leased-line services, the availability and error performance of the data circuits are much improved through centralized in-service monitoring.

Circuit-Switched Data Network

Such a network is an extension of the leased-line data network, in which connections between two data users are made via switches. Circuit switching may be carried out as follows:

- Space-division switching
- Time-division switching
- Any preferred combination of the above techniques.

With space-division switching or line switching, the aggregate data stream is demultiplexed at each switching node. On the other hand, with time-division switching, demultiplexing is not required at the switches.

In a circuit-switched data network, as in private-line network, a complete data circuit is used exclusively by two communicating parties during the whole period of information transfer. This allows any terminals operating at the same speed and using the same data communication interfaces or procedures (e.g. character-oriented or bit-oriented) to directly communicate without the need of specialized interface converters. For this reason, circuit-switched data networks are said to provide "transparent" data services.

Message-Switched Data Network

In this type of network, an individual message (a convenient unit of information from the user's point of view) is sent in its entirety from the sender to one or more destinations on the basis of address information it carries. At each intermediate switching node, the message is first stored on some form of mass storage and later forwarded to the next node on the path when an appropriate data circuit is available. Such a network is also known as message store-and-forward data network.

Message switching finds applications mainly in handling administrative messages within large organizations. However, it has a few major disadvantages for most data communication applications. The main difficulty is the inherent long delay between the source and the destination, making it unsuitable for interactive applications.

Packet-Switched Data Network

Packet switching is a relatively new store-and-forward data communication technique stemming from a refinement of message switching. The key difference between packet and message switching is that long messages are divided into shorter blocks called "packets" (e.g. of the order of 1024 or 2048 bits long). Each packet contains the source and destination address information to direct it across the network independent of other packets. The packets are dynamically routed through the network depending on the load in the switches at the nodes and in the transmission links joining the nodes. The total transmission delay through a packet-switched network can be thus kept to a minimum. In addition, error-free communication can be achieved through the use of error control techniques on a link-by-link basis.

From the user's point of view, a packet-switched network can behave like a circuit-switched network, while simultaneously offering a means in interconnecting data terminals operating at different speeds and computer systems from different manufacturers. This univer-

NETWORK	OPERATING ORGANIZATION	REMARKS
DATAROUTE	TCTS[a] (Canada)	World first nation-wide public data network, operational since February 1973 (Ref. 7)
DDS Digital Data System	ATT[b] (USA)	Operational since December 1974 (Ref. 8)
NRD	Italian PTT	Expected to be operational in 1979 (Ref. 9)
DDN Digital Data Network	Telecom Australia	Introduction planned for 1980 (Ref. 2)
DISCON Digital Integrated Secure Communications Network	Australian Dept. of Defence	Introduction planned for 1982 (Ref. 3)

a TCTS : Trans-Canada Telephone System
b ATT : American Telephone and Telegraph Corp.

Table 4a — Some Non-Switched Data Networks

NETWORK	OPERATING ORGANIZATION	REMARKS
DATRAN	Data Transmission Co. (U.S.A.)	World first public circuit-switched data network. Operational between December 1973 and September 1976 (Ref. 10)
NORDIC Nordic Public Data Network	Nordic PTT's (Denmark, Finland, Norway & Sweden)	Expected to be operational in 1979 (Ref. 11)
DDX-1 Dendenkosha Data Exchange Network	NTT[a] (Japan)	Experimental (1973) Circuit and packet-switched hybrid (Ref. 12)
DDX-2	NTT (Japan)	Under field trial tests (1976) (Ref. 13)
INFOSWITCH	CNCP[b] (Canada)	Operational since 1978. Circuit and packet-switched hybrid (Ref. 14)

a NTT : Nippon Telegraph and Telephone Corp.
b CNCP : Canadian National/Canadian Pacific Telecommunications

Table 4b — Some Circuit-Switched Data Networks

NETWORK	OPERATING ORGANIZATION	REMARKS
AUTODIN Automated Digital Network	U.S. Dept. of Defence	Operational
CUDN Common-User Data Network	Telecom Australia	Operational since January 1972 (Ref. 15)
MSDS Message-Switched Data System	TCTS (Canada)	Operational since 1968
ATECO	Swiss PTT	Operational since 1971
ONTYME	Tymnet, Inc. (U.S.A.)	Operational since July 1977 (Ref. 16)

Table 4c — Some Message-Switched Data Networks

sal access is carried out through the "interface processors" which incorporate the information from data terminals (whether they are character-oriented or bit-oriented) into the packets used in the network.

For a detailed discussion on various aspects of packet communication networks, the interested reader is directed to Ref. 23.

Remarks

Both circuit switching and packet switching networks satisfy the general requirements of data transmission for teleprocessing systems. Packet switching has the ability to allow communication between data terminals operating at different speeds and systems of different types. On the other hand, circuit switching offers "transparent" network services allowing a diversity of applications to be implemented by data users. While both packet- and circuit-switched networks offer high availability of data communication circuits, the quality of transmission in a packet network is very high by virtue of the use of link-by-link error control.

From the operating organization viewpoint, substantial investment may be required in the provision of computer-controlled buffered switches in packet networks. This could present a large initial investment cost in the early implementation stages for this type of network. The choice between circuit switching and packet switching for a data network depends fundamentally on the type of applications. But in general, packet switching is suitable for relatively short messages (e.g. inquiry-response communications, cashless transactions, credit verification . . .), while circuit switching is more effective for long messages (e.g. bulk data transmission, digital facsimile,. . .).

For illustration purposes, **Tables 4a-4d** list some well-known public and private data networks of the four types discussed above.

Telecom Australia Digital Data Network (DDN)

This network, planned for introduction in 1980, is initially a non-switched private-line data network (Ref. 2). Because of the high degree of urbanization in Australia, the major data teleprocessing systems are characterized by national and regional networks centred mainly on the two largest cities, Sydney and Melbourne, and the national capital, Canberra. Consequently, the data network will initially be a double-star configuration with the main nodes at Melbourne and Sydney **(Fig. 4)**.

The services offered on the DDN will be functionally similar to those presently provided on private lines. The following speeds will be catered for:

Asynchronous: 300 bit/s
Synchronous: 1200, 2400, 4800, 9600, 48000 bit/s.

The network will consist of terminal centres and main centres connected by links. Terminal data centres are connected to only one other centre. They contain multiplexers and customer loop terminations. On the other hand, main data centres are connected to two or more other centres. In addition to the facilities available in terminal centres, they also contain the necessary timing supplies, test facilities and cross-connect arrangements.

The data links connecting any two data centres will be operating initially at 64 kbit/s. In the metropolitan areas, these 64 kbit/s data streams will be derived using base-band data modems operating over physical cable pairs. For the inter-capital links, 64 kbit/s data streams will be derived using carrier-type data modems operating over 48 kHz FDM groupbands.

For further details on the network development of the DDN, the interested reader is directed to Ref. 2.

NETWORK	OPERATING ORGANIZATION	REMARKS
ARPANET Advanced Research Projects Agency Network	U.S. Dept. of Defence	World first packet-switched data network. Operational since 1970 (Ref. 17)
CTNE Compagnia Telefonica Nacional de Espana Network	Spanish PTT	Operational since 1973 (Ref. 18)
DDX-1 Dendenkosha Data Exchange Network	NTT (Japan)	Experimental (1973) Circuit and packet-switched hybrid (Ref. 12)
NPL National Physical Laboratory Network	NPL (U.K.)	Operational since 1973 (Ref. 18)
TELENET	Telenet Communications Corp. (U.S.A.)	World first public packet-switched data network. Operational since 1975.
DDX-2	NTT (Japan)	Under field trial tests (1976) (Ref. 13)
EPSS Experimental Packet-Switched Service	U.K. Post Office	Operational since 1977 (Ref. 19)
EIN European Informatics Network (or COST 11 project)	Nine EEC Countries	Operational since 1976 (Ref. 18)
DATAPAC	TCTS (Canada)	Operational since 1977 (Ref. 20)
TYMNET	Tymnet Inc. (U.S.A.)	Operational since 1976
INFOSWITCH	CNCP (Canada)	Operational since 1978. Circuit and packet-switching hybrid (Ref. 14)
EURONET	Nine EEC countries	Operational since 1978 (Ref. 21)
TRANSPAC	French PTT	Operational since 1979 (Ref. 22)

Table 4d — Some Packet-Switched Data Networks

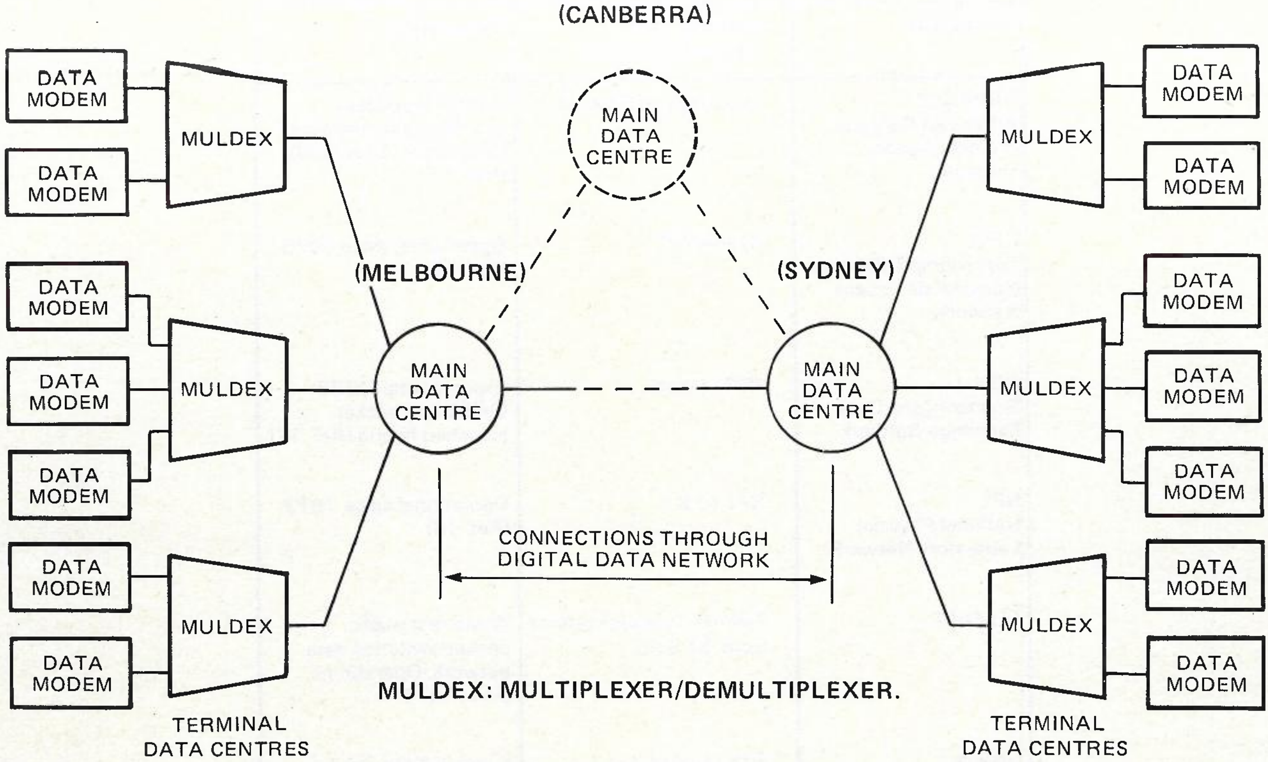


Fig. 4-Data Transmission over the Digital Data Network (Early Stage).

CONCLUDING REMARKS

A brief overview of data transmission developments has been outlined. The increasing use of data teleprocessing will continue to boost the demand for faster and more reliable data communication services. Despite some inherent limitations to carry data traffic, the public telephone network will continue to play its present role in providing omni-accessible data transmission facilities over analogue FDM-derived circuits. Special data user requirements will be readily served by new networks specifically designed to carry data traffic. These can be private-line, non-switched networks. They can also use circuit-switching or packet-switching techniques.

Although the above-mentioned data services demand is increasing steadily at a fairly fast pace, it is difficult to forecast precisely the level of demand far ahead to enable the timely introduction of specialized data networks. A plausible approach to meet both the present demand and the expected growth is the introduction of a basic data network. This network needs to have sufficient flexibility in its structure and operation in order to allow internationally accepted standards of switching and transmission techniques to be incorporated at a later stage.

ACKNOWLEDGEMENTS

The author wishes to thank Dr B. M. SMITH and Mr D. J. GANNON for their helpful comments on the manuscript. The material in this paper is adapted from a report (Ref. 24) prepared by the author while on temporary transfer to Transmission Network Design Branch, Engineering Department, Headquarters, Telecom Australia.

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Obituary

It is with regret that we record the death of two life members of the Society's Victoria Division in June of this year.

MR R. C. MELGAARD commenced his career in telecommunications in Victoria and then moved to Headquarters. During his career, Ron made valuable contributions to telecommunications, particularly in the fields of exchange power, customer equipment and general maintenance practices.

In 1965 he was appointed to the Australian Post Office Representative's Office in London where he spent 2 years in liaison with representatives of European telecommunications administrations, representing Australia at international meetings and keeping Australia in touch with trends in telecommunications in overseas administrations and manufacturing companies.

After returning from London, Ron played a significant role in the development of centralised maintenance practices in the customer equipment area and in founding the Five Year Engineering Operations Programme. In 1975 he returned to Victoria as Assistant Superintending Engineer, Regional Operations Branch. He later became the State Co-ordinator and here gave valuable assistance to the State Manager and all Departments in the Victorian Administration.

Ron served as Editor of the Telecommunication Journal from 1959 to 1965. He wrote a number of articles for the journal and took an active interest in the affairs of the Society right up until his untimely death.

MR C. J. GRIFFITHS, OBE, retired in March 1970 after a distinguished career which commenced in 1927. Clyde made significant contributions to the development of telecommunications both in Australia and internationally through his association with the International Telecommunications Union.

From engineer-in-charge of substation activities in Melbourne to First Assistant Director-General, Engineering Works, Clyde Griffiths demonstrated, in his quiet courteous manner, his talents as a leader and one who could quickly obtain significant results in handling complex national and international communication problems.

Early in his career as a senior engineer in Headquarters he played a prominent part in establishing the telephone cable manufacturing industry in Australia. Other significant landmarks were his close association with major trunk cable projects such as the Bass Strait submarine cable and the provision of telecommunication facilities for Woomera and Maralinga rocket ranges. In the international scene he played a leading role in the planning of COMPAC and SEACOM submarine cables and in 1965, the centenary year of ITU, he was Chairman of the Administrative Council, the main executive body of the Union.

Clyde was an active supporter of the Telecommunication Society of Australia as demonstrated by several important articles he wrote for the Telecommunication Journal, as Editor of the journal from 1944 to 1956, and as Chairman of the Council of Control from 1961 to 1962 and 1966 to 1968.

X.21: An Interface Between Data Terminals and Circuit Switched Data Networks

G. J. DICKSON B.E. Hons., M. Eng. Sc.

The subscriber signalling schemes used in switched data networks are generally more complex than the signalling used in telephony. This article discusses a signalling scheme recommended for circuit switched data networks and shows how graphical documentation techniques employing state transition diagrams can be used to give an improved description of the signalling scheme.

INTRODUCTION

The number of data services in Australia has been growing very rapidly and the demand for better services with new facilities has reached the point where the traditional approach of a data modem operating over an analogue circuit is no longer adequate.

Telecom Australia has announced plans to introduce a Digital Data Network (DDN) to provide leased circuit data services of higher quality with more facilities and more economically (Ref. 1). The DDN consists basically of high bit rate trunks between traffic centres upon which are assembled the lower bit rate signals from the individual subscribers. The services are provided on a long term leased basis.

Development beyond the immediate DDN will probably involve the introduction of an element of switching. Other countries have already introduced specialised switched public data networks providing a wide range of data communications facilities. Two forms of switching are used in these networks viz. circuit switching and packet switching (Ref. 2). Circuit switching of data is similar to the telephony case where a transparent connection is established for the duration of the call. Packet switching breaks the data stream into relatively small 'packets' which are transferred through the network using store and forward techniques and reassembled at the terminating end.

Everybody knows how to use a telephone ie. how to operate the interface between the instrument and the switching network to set up, maintain and clear down a call. In the data case the interface has to cope with some difficult requirements such as:

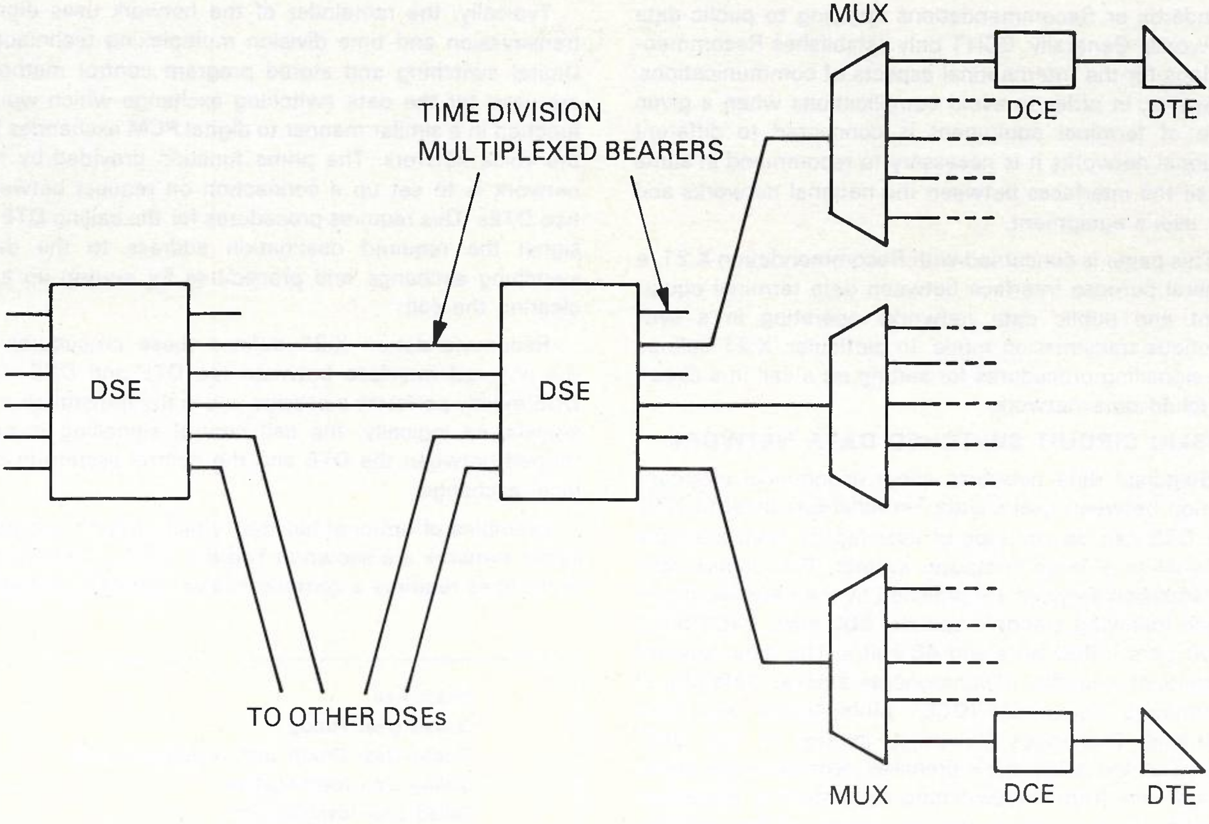
- fast call set up
- a wide range of facilities
- unreliable transmission
- variable delays
- the absence of a flexible human mind for controlling some of the processes

A set of rules or, in data jargon, protocols are required and they tend to be rather complex. Recommendation X.21 specifies a standard protocol devised by the International Telegraph and Telephone Consultative Committee (CCITT) to provide an interface for circuit switched data networks. The Switching and Signalling Branch of the Telecom Research Laboratories has been studying X.21 as part of its work to increase the knowledge of data networks. A graphical method, employing the CCITT Specification and Description Language (SDL), has been used to assist the understanding of X.21 and to provide less complex methods of representing protocols.

This article is not intended to provide in depth treatment of X.21 or of SDL but rather to illustrate how the two can be brought together to improve the representation and understanding of complex procedures.

INTERNATIONAL STANDARDS

The establishment of public data services in various countries, leads to the need to interconnect these services on an international basis and requires co-operation between network administrations. The CCITT has set up a special working group to determine the procedural



DSE-DATA SWITCHING EXCHANGE

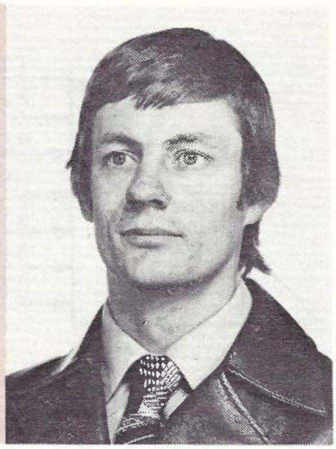
DCE-DATA CIRCUIT TERMINATING EQUIPMENT

DTE-DATA TERMINAL EQUIPMENT

MUX-DATA MULTIPLEXER/DEMULTIPLEXER

Fig. 1 — Possible Structure of Circuit-Switched Data Network

GARY DICKSON joined Telecom Australia as a cadet engineer in 1973 and graduated from the University of Queensland in 1975. After completing an M. Eng. Sc. in 1976 he worked for Construction Branch in Queensland. In 1977, he was promoted to Engineer Class 2 in Switching and Signalling Branch of the Research Laboratories where he is currently studying data switching techniques and protocols.



standards or Recommendations applying to public data networks. Generally, CCITT only establishes Recommendations for the International aspects of communications. However, in order to avoid complications when a given type of terminal equipment is connected to different national networks it is necessary to recommend in some detail the interfaces between the national networks and the user's equipment.

This paper is concerned with Recommendation X.21, a general purpose interface between data terminal equipment and public data networks operating in a synchronous transmission mode. In particular, X.21 defines the signalling procedures for setting up a call in a circuit switched data network.

PUBLIC CIRCUIT SWITCHED DATA NETWORK

Switched data networks allow economical interconnection between user's Data Terminal Equipment (DTE). The DTE can be any type of user facility from a simple terminal to a large computer system. Full duplex data transmission services are provided by the network at one of the following standard speeds; 600 bit/s, 2400 bit/s, 4800 bit/s, 9600 bit/s and 48 kbit/s. The data network consists of a number of components, such as Data Circuit terminating Equipment (DCE), Multiplexers, and Data Switching Exchanges (illustrated in **Fig. 1**). The DCE, located at the subscriber's premises, terminates the transmission line from the switching equipment or Multiplexer (MUX) and performs the conversion of the interface line signals to the transmission line codes. The DCE is provided by the common carrier (e.g. TELECOM) and, to the user, is equivalent to the modem in analogue networks.

Typically, the remainder of the network uses digital transmission and time division multiplexing techniques. Digital switching and stored program control methods are used for the data switching exchange which would function in a similar manner to digital PCM exchanges for the voice network. The prime function provided by the network is to set up a connection on request between two DTEs. This requires procedures for the calling DTE to signal the required destination address to the data switching exchange and procedures for setting up and clearing the call.

Recommendation X.21 defines these procedures at the physical interface between the DTE and DCE. The DCE mainly performs a passive role in the transmission of signals, so logically, the call control signalling is performed between the DTE and the control system in the local exchange.

Examples of optional facilities which may be provided by the network are shown in **Table 1.** Such a wide range of facilities requires a comprehensive signalling scheme.

Direct Call
Closed User Group
Closed User Group with outgoing access
Calling Line Identification
Called Line Identification
Abbreviated Address Calling
Multi-address Calling

Table 1: Optional User Facilities

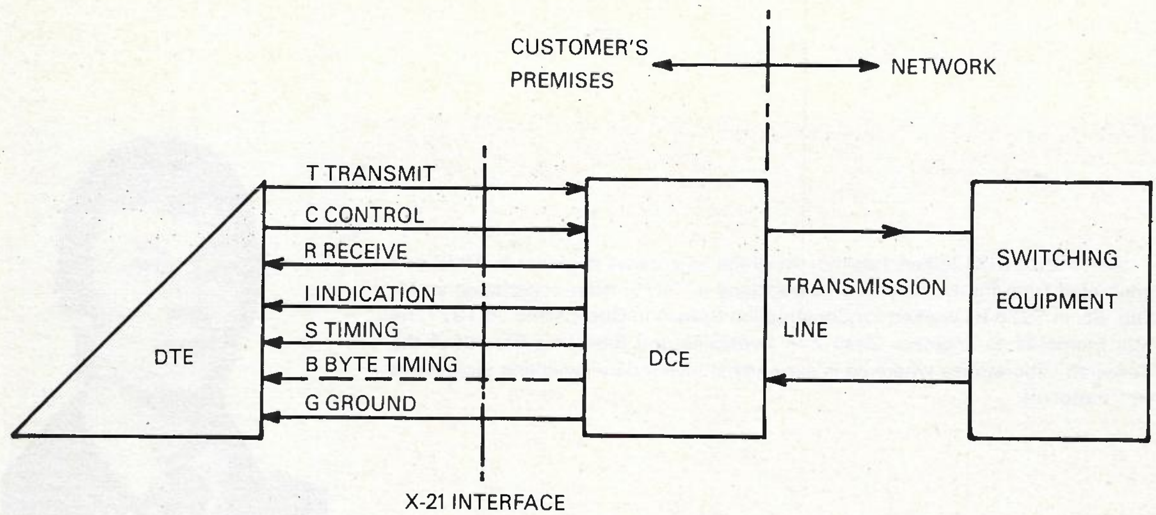


Fig. 2 — X.21 Interchange Circuits

THE X.21 INTERFACE

Physical and Electrical Characteristics

The X.21 interface between the DTE and DCE uses a minimum number of interchange circuits **(Fig. 2)** and provides full transparency (bit sequence independence) for the transfer of data.

Generally, the DTE transfers synchronous data to the DCE on the Transmit (T) circuit and incoming data is received on the R circuit. Circuit C is controlled by the DTE and is equivalent to the on-hook/off-hook signal in telephony. Circuit I is controlled by the network and indicates the period of transparent data transfer. Transmit and receive clocks are provided by the Signal element timing circuit (S), and the Byte timing circuit (B) is an optional circuit used for character alignment. The signal conditions on the C and I circuits refer to steady ON or OFF conditions (i.e. persisting for at least 16 contiguous bit intervals). Signals on the T and R circuits together with associated conditions on C and I may be identified as:

- line signals, i.e. steady binary 1s and 0s
- information signals i.e. signalling characters taken from the 8 bit International Alphabet No. 5 (IA 5) (similar to ASCII),
- data signals.

Interface Procedures

Two X.21 interfaces are normally involved in a successful call set up; one for the DTE originating the call and one for the destination DTE. An example of the possible sequence of signals for a successful call is shown in **Fig. 3.** The procedures followed at each interface can be described in four phases.

In the Quiescent phase, the DCE or DTE may send an appropriate line signal to indicate whether or not they are ready to enter the Call Control phase. If both are ready, this is equivalent to the "on-hook" condition in telephone networks.

The calling DTE signals CALL REQUEST line signal (equivalent to "off-hook") to enter the Call Control phase. The DTE waits for PROCEED TO SELECT (dial tone) before indicating the call destination and facilities required by means of information signals (dialling). The network may send, in response, appropriate CALL PROGRESS signals (ring, busy etc.). If the call is successful, the network signals INCOMING CALL (ring) to the destination. The called DTE would normally respond with CALL ACCEPTED (answer) and the network may provide optional CALLING LINE IDENTIFICATION information signals. A further exchange of signals leads to the Data Transfer phase.

During Data Transfer phase, a transparent connection is established between two DTEs. Data transmitted by one DTE on circuit T is delivered to the remote DTE on circuit R. The DTEs are free to use any format, code and synchronization procedure for the transfer of data.

Either DTE can, at any time during Call Control or Data Transfer phase, issue a CLEAR REQUEST line signal to enter clearing phase. This initiates a sequence that leads back to Quiescent phase.

A more detailed description of the call set up procedures can be found in Ref. 3.

Characteristics of X.21

The above description indicates that the basic characteristics of the X.21 call set up procedure are similar to the call set up procedure in telephony. The following additional features are provided:

- hand-shake protocol based on acknowledgements from the network
- parity checking of information signals to reduce the possibility of errors in call set up
- information signalling using IA5 to provide a wide signalling repertoire and allow a comprehensive range of facilities
- the full bandwidth of the data circuit is used for information signalling allowing rapid call set up (ie. in-band signalling).

However, X.21 seems to have a number of short-comings which stem from its early design and its telephony heritage. For example, the post-answer signalling arrangements appear to be inadequate. Facilities requiring post-answer signalling include:

- indication of charge accumulated during call
- indication that another call is waiting
- various conference facilities

Provision is made for the calling DTE to be advised of the charge incurred after a call has been completed, but this seems to be an add-on feature and is not well integrated with the rest of the protocol. There is also a proposal for network recall during Data Transfer phase to allow post-answer signalling. However, since information signalling is in-band, this will interrupt the transparency of the data transfer.

Another short-coming, for some applications, is that the call control procedures are based on electrical signalling (i.e. line and information signals on control and data circuits), rather than control messages (i.e. signalling messages on data circuits only).

SPECIFICATION AND IMPLEMENTATION ASPECTS

For a user's application program running on a computer system to interwork with an X.21 channel requires a hardware interface device and complex software for controlling it. Complex software is also required in the stored program controlled (SPC) data switching exchange. To design the software, a clear and accurate specification of the X.21 protocol is required. A very powerful technique is the use of Processing State Transition Diagrams based on the Specification and Description Language (SDL) recommended by CCITT for system documentation (Ref. 4). SDL uses graphical and pictorial methods to describe systems in a more accurate and formal manner than prose.

Specification and Description Language

When using SDL, it is more appropriate to specify a system with well defined boundaries rather than an interface as in Rec. X.21. This difference in viewpoint is overcome by choosing a system boundary such that only X.21 interface signals cross the boundary. For example, all those components which can affect the state of the DTE as perceived at the X.21 interface are contained inside the boundary shown in **Fig. 4** which will be referred to as the Data Terminal System.

The interface specification should be independent of the components and interfaces within the system, but they are identified here for the sake of clarity. For exam-

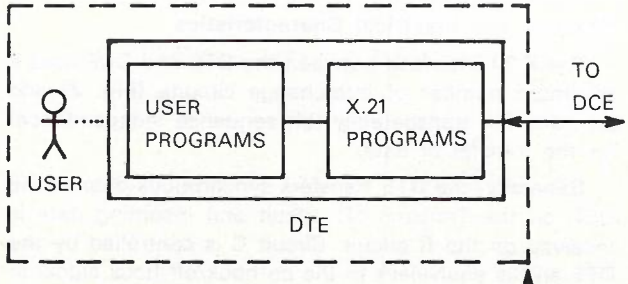


Fig. 4 — Data Terminal System

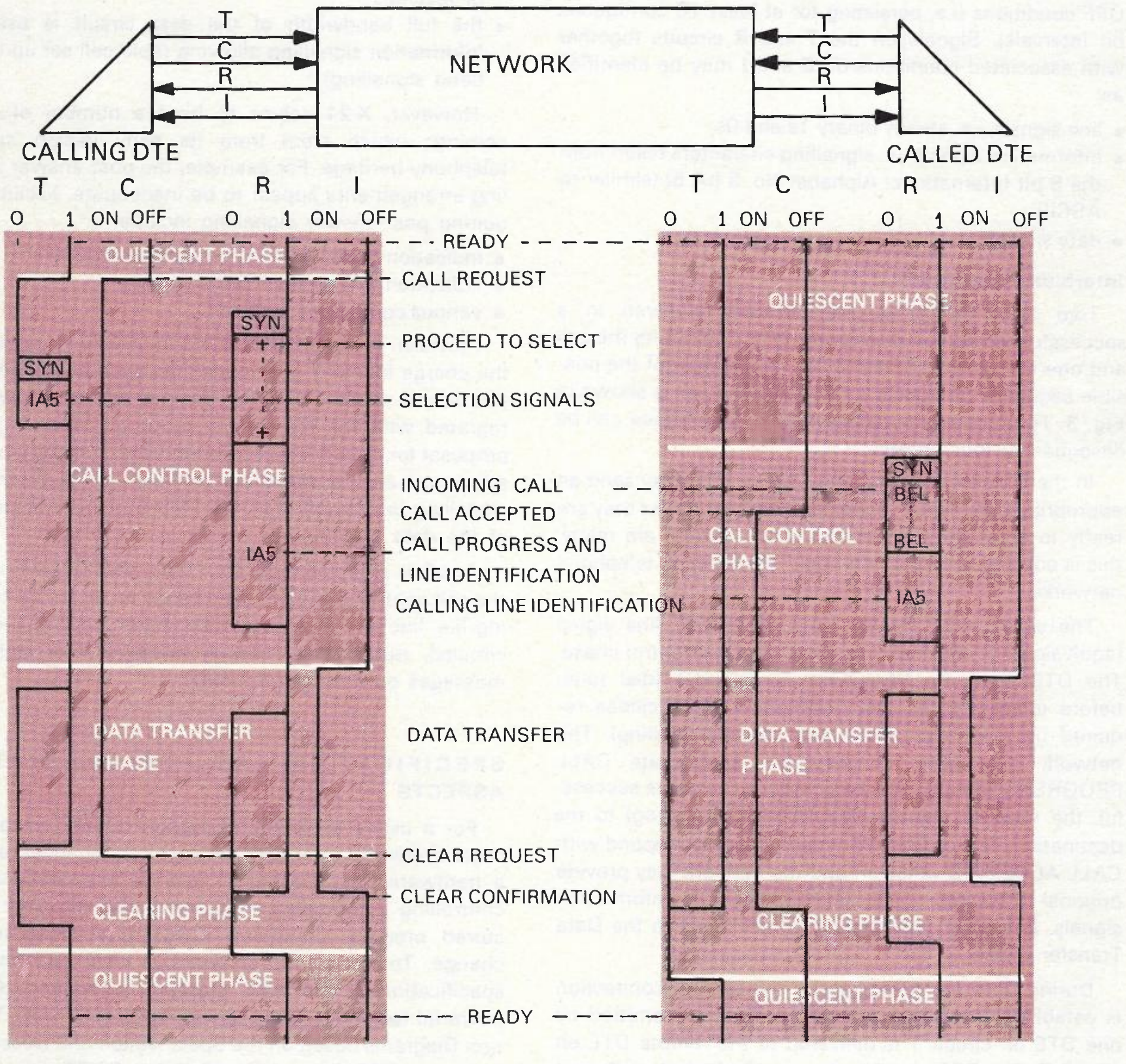


Fig. 3 — Example of a Successful Set-Up Sequence

ple, the Data Terminal system consists of equipment which implements the X.21 procedures and the user functions (application programs) possibly involving interaction with the user.

The behaviour of the system can be specified in terms of its behaviour in response to internal signals and to external signals which cross the X.21 interface. The external signals are simply the X.21 line and information signals that have already been identified. The internal signals represent the inputs or events within the system, which cause the system to take actions affecting the interface. The internal signals may be given meaningful "generic" names without prejudicing implementation of the system.

For example, the user may perform some manual action to initiate a call or, as another example, a remote data aquisition system might automatically initiate a call after collecting data for a certain period of time. These events are represented by an OFF-HOOK generic internal signal.

Processing State Transition Diagrams, employing the pictorial option of SDL, may be used to specify the Data Terminal system. A state is a condition in which a process is suspended awaiting an input signal, e.g. after sending a CALL REQUEST output signal, the Data Terminal System waits for a PROCEED TO SELECT input signal. A state is represented by the symbol shown in **Fig. 5.** The pictorial elements and the input symbols identifying the possible state transitions completely and unambiguously define the state. A transition from one state to another occurs in response to an input signal. The actions required to implement the protocol can be determined from the changes in the pictorial elements of the states, together with any task shown explicitly in the transition between the states.

To illustrate these concepts, **Fig. 6** shows a simplified part of the Processing State Transition Diagram for the Data Terminal system. Two possible transitions from the READY state are shown. The actions which occur if an OFF-HOOK signal is received are:

- a CALL REQUEST signal is sent on the T and C circuits
- timer t_1 is started
- the state changes to CALL REQUEST

References 4 and 5 show how these techniques can be systematically applied to specify complex systems in an easily understandable manner.

Machine Realisation

Systems described by SDL can be realised using software consisting of:

- A table of states and inputs.
- State transition routines performing the actions required to change state.

The state table has an entry for each possible input for each state. The entry is the start address of a state transition routine which performs the actions required and determines the next target state to be reached. The advantage of this technique is reduction of software complexity. Programs constructed in this manner are highly modular and any changes in design can be easily obtained by altering the state table.

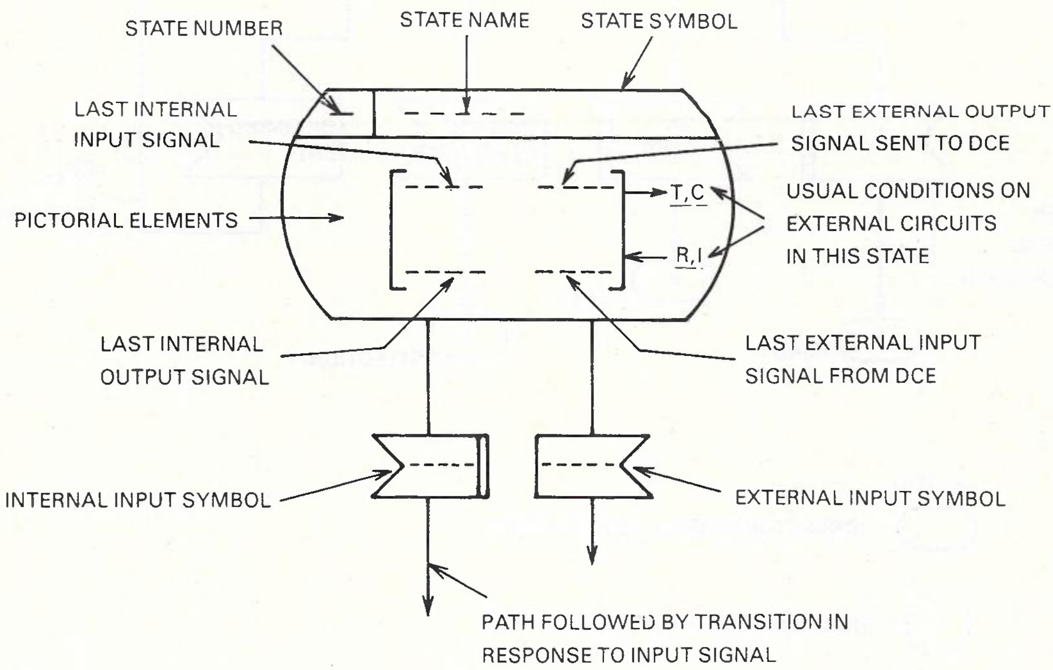


Fig. 5 — Explanation of State Symbol

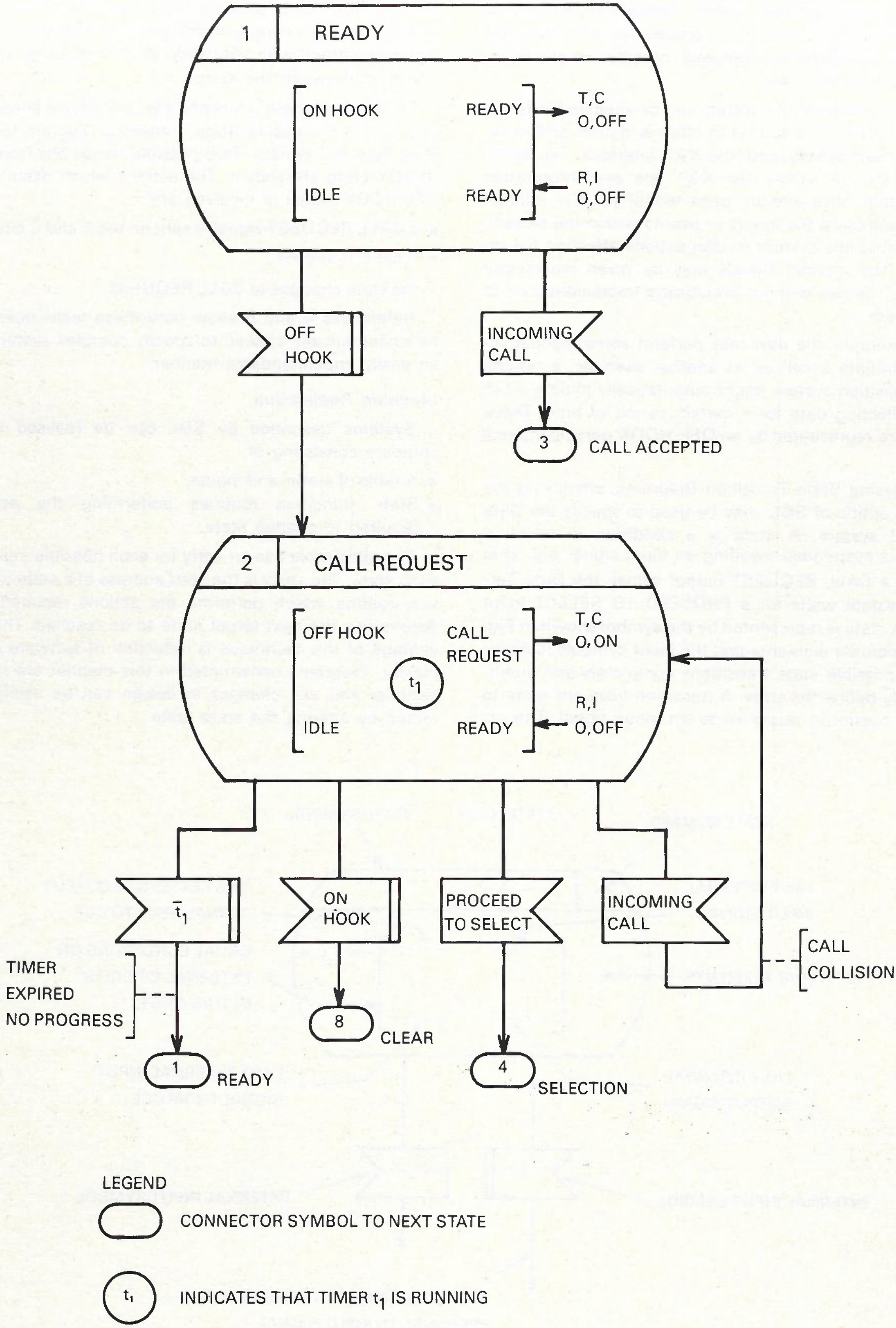


Fig. 6 — Example of Processing State Transition Diagram (Incomplete)

A model data terminal (DTE) has been constructed to investigate these techniques. The model is based on a Teletype connected to a Motorola 6800 microprocessor which controls an X.21 interface. An operator uses the Teletype to interactively set up a call and perform data transfer.

The microprocessor software consists of:

- State table and transition routines for eleven states.
- Programs for driving the Teletype and communicating with the operator.
- An operating system which scans software and hardware flags to detect signals. When a signal is found, the state table is looked up to determine the address of the appropriate state transition routine.

The entire program was written in assembly language and uses 1.5 kbytes of programmable read only memory for program storage. The use of SDL resulted in a modular program structure which is easy to implement, test and document.

CONCLUSION

X.21 is a workable protocol for call set up in circuit switched data networks but it appears to have a number of shortcomings:

- Post answer signalling facilities are inadequate.
- It uses electrical signalling based on telephony methods rather than control messages.

Circuit switching data networks using the X.21 interface are being installed in a number of countries. However, the growing general investment in packet switching using the X.25 interfacc and the possible future introduction of integrated services digital networks may mean that the use of X.21 signalling will be restricted to specialised networks.

The protocols for operating a telephone are taken for granted because a flexible and adaptable human mind is controlling the process and can take suitable action in the case of errors or failures. The protocols for data communication are complex because it is necessary to completely define the behaviour of a computer system in response to various unexpected conditions. Methods for applying SDL to the specification of data protocols have been demonstrated. When systematically applied, SDL results in more detailed and less ambiguous specification than can be achieved with prose. The advantages of this technique are such that it is being increasingly supported by new operating systems, high level languages and even automatic generation of code from state transition diagrams.

Work on these topics is continuing with the aim of producing specifications of the complex packet switching protocol, X.25.

ACKNOWLEDGEMENT

The author is indebted to Dr F. J. W. Symons who originally proposed the concepts used in choosing appropriate boundaries and the use of generic signals.

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Retirement of F. A. Waters

Frank Waters retired in July, 1979 as the Chief Operations Manager, Victoria, after a very successful career commencing as a Clerk in Tasmania in 1938. Frank became a cadet engineer in 1939 and in 1943 took up his first appointment as engineer at Bendigo. Later he moved to Melbourne and was involved in Traffic Engineering, followed by a period in Metro installation. In 1949 he took charge of a Metro Service Division covering the City and the Western part of the Metro Area.

He was promoted to Divisional Engineer in 1950, moving back to Bendigo in 1951 where he took charge of a division controlling an extensive area including Mildura and part of Ararat District. In 1961 he returned to Melbourne for a period in Headquarters prior to taking up an appointment as Supervising Engineer Internal Planning, Country, Victoria. 1972 saw Frank as the Superintending Engineer Planning and Programming, and with the introduction of the Commission in 1975 he became the first Chief Operations Manager in Victoria.

Frank will be remembered for his management expertise, his foresight in the Planning area and his technical judgement and friendly but determined approach as a leader.

In addition to his normal duties Frank played a leading role in the Professional Officers Association being a central councillor in the 1960s. He was very active in the Postal Institute being the first President of the Royal Mail Branch during 1964/65; Vice president 1965-66 and a Committee Man until 1968.

He took an active interest in the Telecommunications Society as a State editor of the journal during his period as Chief Operations Manager.

A Buck/Boost No-Break Telephone Power Supply

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

This article describes the principles and performance characteristics of a new solid state, fully regulated, buck/boost no-break power supply dedicated to the powering of 10C electronic trunk switching equipment at the Wellington Telecommunications Centre, Perth, WA. The new power plant was installed and commissioned in August 1978 and is the first buck/boost system placed into service by Telecom Australia.

INTRODUCTION

Wellington Telecommunications Centre is the largest telecommunication building in Perth, WA. It is designed to house a wide variety of telephone equipment providing local, trunk and telex switching and other communications facilities. The 10C Electronic Trunk Switching equipment at Wellington Exchange, unlike those 10C Trunk Exchanges which precede it (Pitt, Lonsdale, Waymouth, Bendigo and Woolloongabba), will be powered by a more sophisticated, advanced and regulated power system. This new power system is based on a buck/boost principle and has been selected for Wellington 10C Trunk Equipment after intensive design evaluation spreading over several years since 1972.

In Telecom Australia, dc power required to operate telephone exchanges is currently provided by a system of rectifiers and batteries connected in parallel in the form of an integrated power suite (IPS) (Reference 1). While the IPS can produce a well regulated output under ac mains operation, its performance under ac mains failure is critically determined by the performance of the batteries connected directly across its output circuit. The battery voltage on discharge is dependent in turn on the discharge current, the condition of the batteries and the duration of the discharge.

The buck/boost power system is, by contrast, a fully regulated system which can hold the exchange voltage at a constant level not only under ac mains operation (ac mains powered mode), but also under battery operation (battery powered mode). This is possible because the buck/boost system is used for adding (boosting) or subtracting (bucking) a dc voltage from the batteries.

The buck/boost power supply realises a shorter battery reserve without loss of power system reliability. It requires a high order of availability of the ac essential supply to the centre. This has been achieved in most large telecommunications centres where ac mains supply is supported by an automatic multi-set standby system.

COMPONENTS OF A BUCK/BOOST MODULE

The buck/boost power supply system is a full solid state design employing heavy current thyristors for power switching and controlling. The system is built up in modular form; each module is rated at 48V/1000A and consists of the following sub systems (components): load

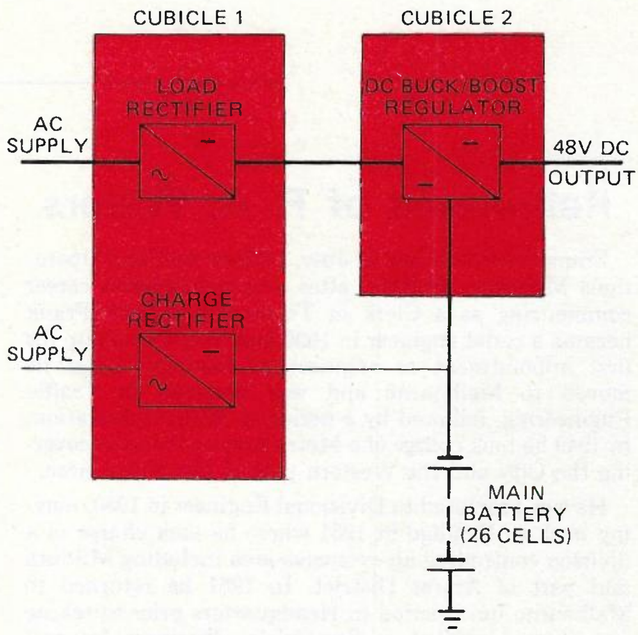


Fig. 1 — Components of a Buck/Boost Module

rectifier, charge rectifier, buck/boost regulator and main battery (**Figs. 1 & 2**).

- Load Rectifier (48V/1000A)

  This is the main rectifier which provides the energy necessary to operate telephone equipment in all normal operations except when the system is powered by the battery. This rectifier is essentially an unregulated rectifier operated at maximum efficiency.

- Charge Rectifier (56V/100A)

  The charge rectifier is smaller than the load rectifier; its rating is only 1/10 that of the load rectifier as it is not required to support the exchange load at all. It is used only to charge the main battery and is capable of floating the 26 cell lead acid main battery or automatically recharging this battery after any ac mains supply interruptions. Only simple filtering is provided for this rectifier. In any integrated buck/boost system where the design can be optimised, the charge rectifier is built as a part of the load rectifier to reduce floor space and costs.

- DC Buck/Boost Regulator (± 5V/1000A)

  The buck/boost regulator is a solid state dc regulator which can provide full regulation of the power supply output voltage in all operating conditions.

- Main Battery (26 x 2170 Ah)

  The cells used are Telecom Australia pure lead type for stationary applications. The battery is capable of discharging at high current, about 1200A to maintain the module rated output at 48V/1000A. The cells float in the optimum range of 2.17 to 2.20 volt/cell, and are automatically boost charged after ac mains interruptions. The capacity of the battery has been selected to provide 1 hour battery reserve within the operating limits of the buck/boost regulator at rated load.

In addition to these basic power sub systems, a smaller lead acid battery bank, consisting of 22 cells and having an extremely high rate of discharge, is used to improve the dynamic responses of the buck/boost supply. Normally, two banks of these smoothing batteries connected in parallel are provided for a 48V/3000A buck/boost system. The smoothing batteries are hard connected to the exchange dc busbar and maintained in a charged state by the buck/boost output

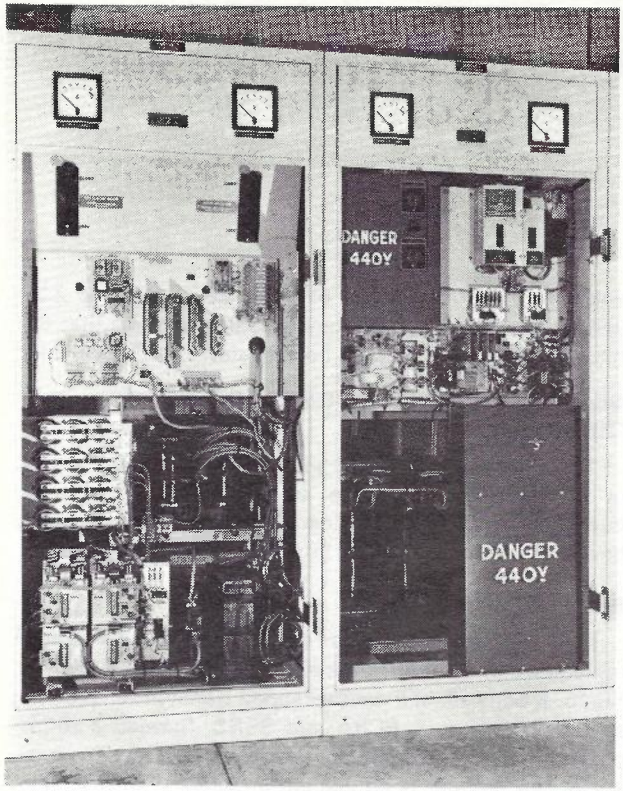


Fig. 2 — View of a 48V/1000A Buck/Boost Module

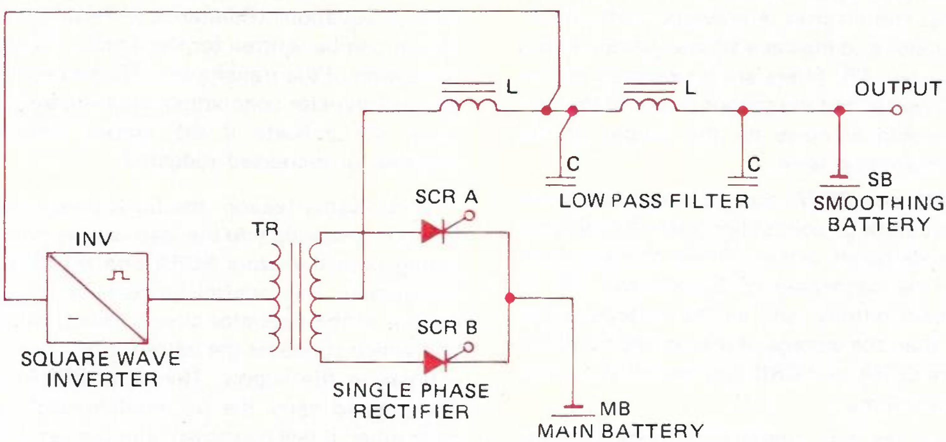


Fig. 3 — Buck/Boost Regulator Circuit — Battery Powered Mode

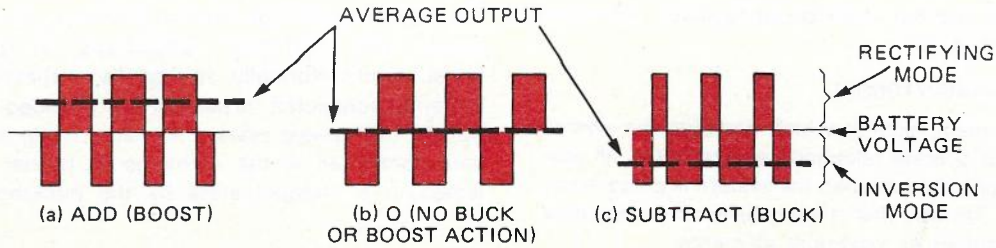


Fig. 4 — Combination of Single Phase Rectifier and Battery Voltage

voltage. The float voltage of these cells is set at 2.20 volt/cell to minimise maintenance; this requires that the buck/boost output voltage be adjusted to 48.5 volt dc.

SOLID STATE BUCK/BOOST REGULATOR CIRCUIT

This paper is concerned solely with the power circuit of the new power system, with emphasis on the dc buck/boost regulator. The control circuits and batteries have not been considered in detail in the present text.

Battery Powered Mode

Under battery powered mode, the dc buck/boost regulator can be represented schematically as shown in **Fig. 3.** It consists of a centre-tapped transformer TR, two switching elements, SCRA and SCRB, forming a single phase rectifier, and a square wave inverter, INV. The output of the rectifier is connected in series with the main battery, MB, and can be made to either add a voltage to (boost) or subtract a voltage from (buck) the battery voltage. This boost or buck action is dependent on whether the regulator is operated in the rectifying mode or inversion mode. The inverter is powered from the dc output of the regulator and injects a square wave into the primary of transformer, TR; filters are provided in the input circuit of the inverter and the output circuit of the rectifier to reduce electrical noise on the output of the regulator to an acceptable level.

Thyristors, SCRA and SCRB, can be controlled to remain in a blocking state or conducting state as required to achieve the buck/boost action. These thyristors are used to connect the secondary of transformer, TR, in series with the main battery, and as the voltage of the battery is greater than the voltage of the secondary of the transformer either SCRA or SCRB can be left in a conducting state at any time.

If the thyristors are left conducting longer on the positive portion of the cycle than the negative portion of the cycle, the resultant ac waveform contains a dc component which adds to the battery voltage **(Fig. 4a)**. On the contrary, if the thyristors are left conducting longer on the negative portion of the cycle than the positive portion of the cycle, a dc voltage will subtract from the battery voltage **(Fig. 4c)**. If the conducting period for both the positive portion and the negative portion of the cycle is the same, no adding or subtracting of voltage will occur **(Fig. 4b)**.

A thyristor will continue to conduct on a negative half cycle in this circuit provided that the opposite, forward biased thyristor is left in a blocking state. If the opposite, forward biased thyristor is now allowed to conduct, the transformer will commutate naturally the load from the conducting thyristor to this opposite, forward biased thyristor.

In other words, a buck/boost action in this circuit is controlled by the point at which a blocking forward biased thyristor is triggered into conduction. **Fig. 5** sums up qualitatively the mechanism of adding or subtracting a voltage to the battery voltage by this circuit.

For a more rigorous proof of the buck/boost action, voltage equations (Reference 2) relating to the input and output can be written for the circuit. Taking into account turns ratio of the transformer, TR, and various circuit conditions (thyristor conducting, blocking etc.), voltage equations will indicate if the output voltage is reduced (bucked) or increased (boosted).

If, for some reason, the buck/boost regulator fails to function, the supply to the load will be maintained by triggering both thyristors SCRA and SCRB into continuous conduction. This control function is independent of the control of the regulator circuit. This is the fall back position which connects the battery direct to the load without a break in the supply. Thyristors SCRA and SCRB are designed to carry the full module load independent of each other. It will be shown later the same fall back provision is provided for the circuit under an ac mains powered situation.

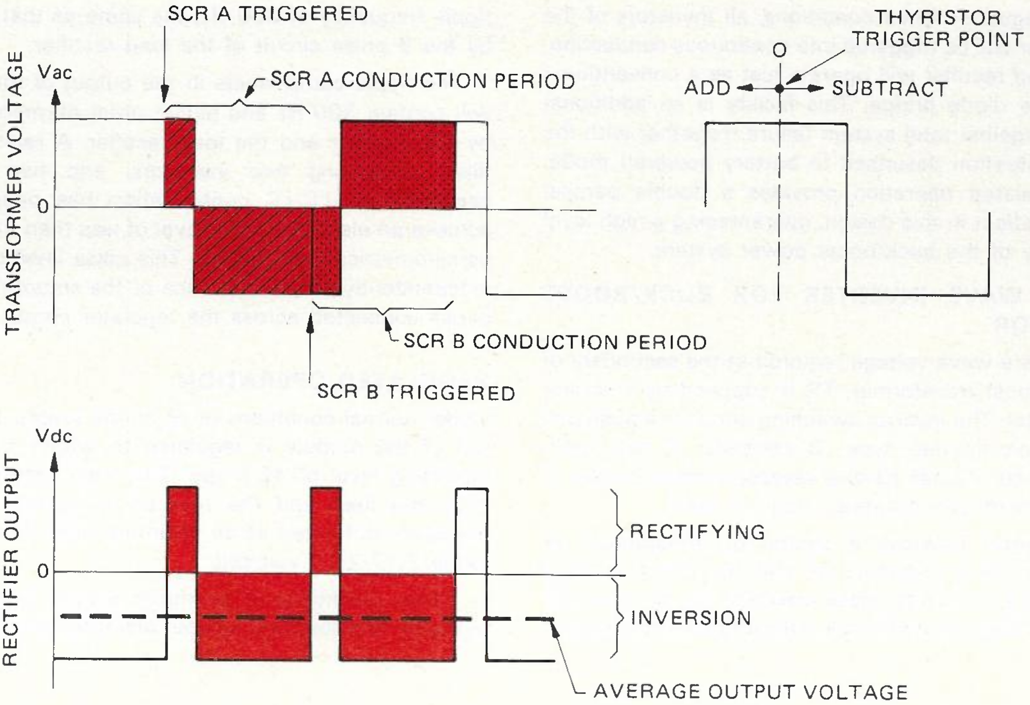


Fig. 5 — Mechanism of Buck/Boost Action

AC Mains Powered Mode

The buck/boost mechanism of the regulator can be extended to accept a suitably rectified ac supply to provide the required constant voltage output. The buck/boost regulator, in fact, can accept a number of dc inputs at the nominal value of 48 volt and supply a constant output voltage, when the input voltage varies from say 40 to 58 volts.

Fig. 6 is a schematic diagram of the load rectifier in which three dc sources derived from the rectified phases of the ac mains supply have been shown. The load rectifier is an unregulated three phase bridge rectifier with dual thyristor selectable negative outputs. The dual outputs such as those provided by thyristors SCRA 1 and 2, 3 and 4, 5 and 6 are equivalent to the dual negative outputs provided by thyristors SCRA and SCRB in the previous battery powered mode.

The load rectifier, therefore, performs two simultaneous functions: one as a three phase diode bridge circuit and the other as the single phase centre tapped rectifier shown in **Fig. 3.**

Buck/boost action occurs when the load rectifier output is combined with the voltage produced by the secondary of transformer TR. In normal operation, the thyristors of each negative output are switched as a group (either SCRAs or SCRBs). Natural commutations will occur between the three thyristors in each group depending on the instantaneous voltages of the three phase supply. The two groups of thyristors (i.e. SCRA 1, 2, 3 and SCRB 1, 2, 3) act in a similar manner to thyristors SCRA and SCRB in the battery powered mode.

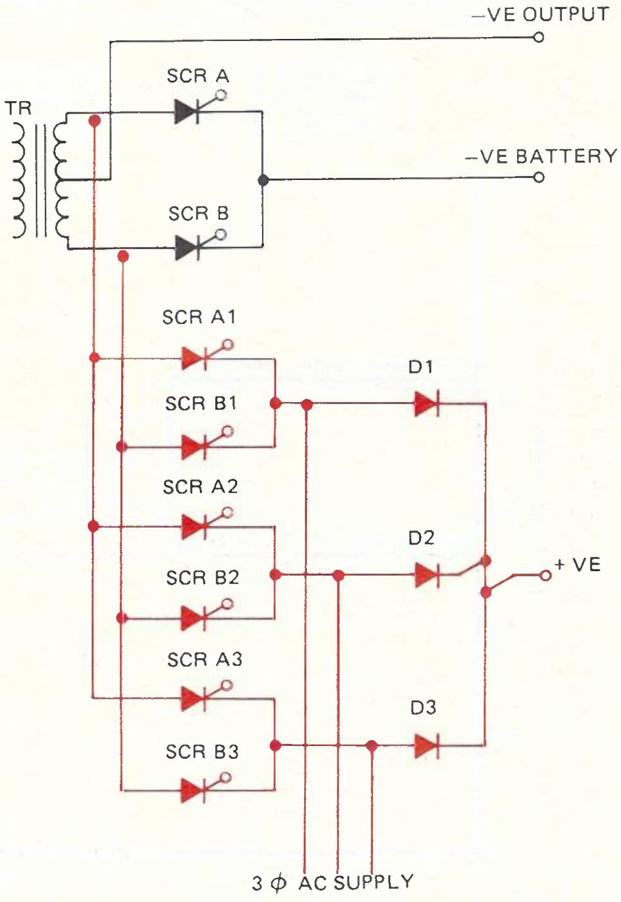
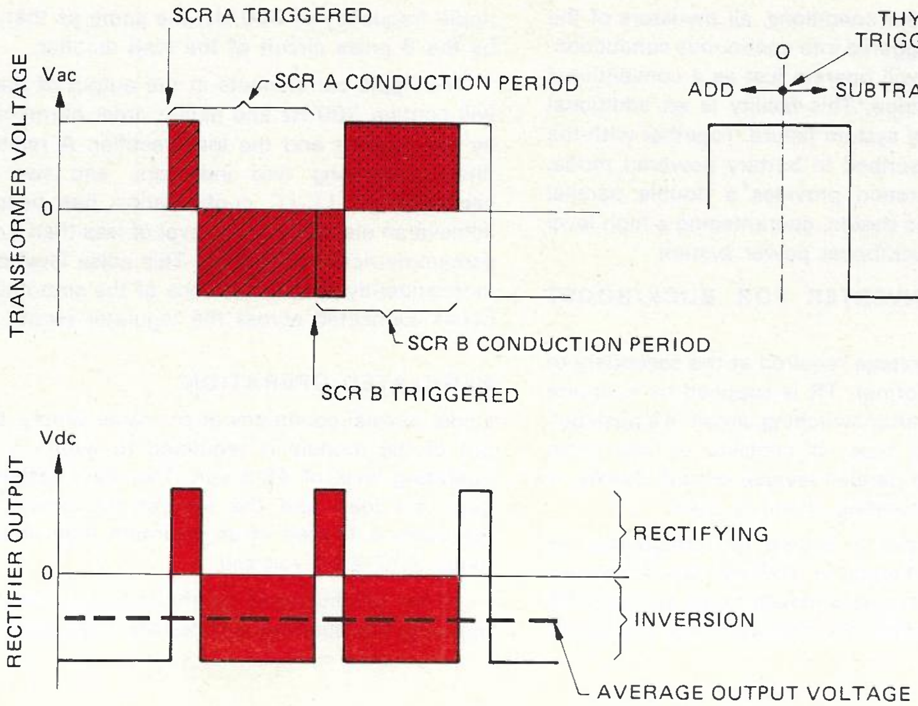


Fig. 6 — Schematic Diagram of the Load Rectifier



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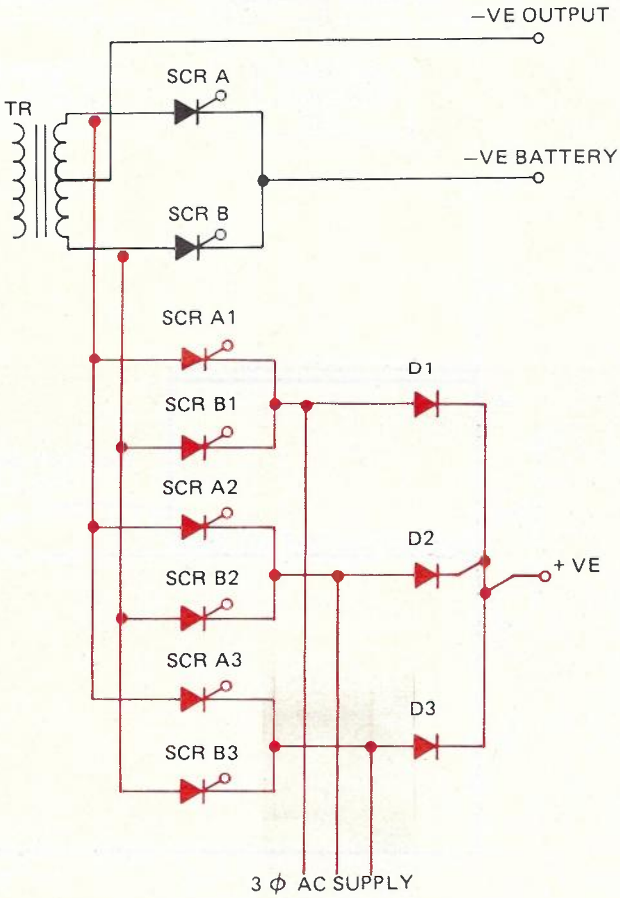

Fig. 6 — Schematic Diagram of the Load Rectifier

Under regulator failed conditions, all thyristors of the load rectifier will be triggered into continuous conduction, and the load rectifier will operate just as a conventional three phase diode bridge. This facility is an additional safeguard against total system failure. Together with the fall back situation described in battery powered mode, this unregulated operation provides a double parallel redundant effect in this design, guaranteeing a high level of reliability of the buck/boost power system.

SQUARE WAVE INVERTER FOR BUCK/BOOST REGULATOR

The square wave voltage required at the secondary of the buck/boost transformer, TR is supplied by a square wave inverter. The inverter switching circuit is a push pull auxiliary commutated type. It consists of two main thyristors with inverse parallel reverse current diodes. A series resonant commutating circuit is used.

The inverter provides a source of unregulated ac square wave of a frequency of 150 Hz. This frequency was chosen so that it is phase locked to the ac mains 50 Hz supply. This will enable the output to have the lowest ripple frequency of 300 Hz, the same as that generated by the 6 pulse circuit of the load rectifier.

The ripple components in the output of the regulator will contain 300 Hz and higher order harmonics caused by the inverter and the load rectifier. A relatively large filter comprising two inductors, and two banks of capacitors in LC-LC configuration has been used to achieve an electrical noise level of less than 1 mV (CCITT psophometrically weighted). This noise level is achieved independently of the existence of the smoothing battery banks connected across the regulator output.

REGULATED OPERATION

Under normal conditions of ac mains supply, the dc output of the module is regulated to within ± 1% of the operating level of 48.5 volt. The main battery, isolated from the load and the rest of the power circuit by thyristors is floated at an optimum float voltage in the range 2.17-2.20 volt/cell.

Under conditions of ac mains supply failure, the dc regulator will continue without any interruption to supply

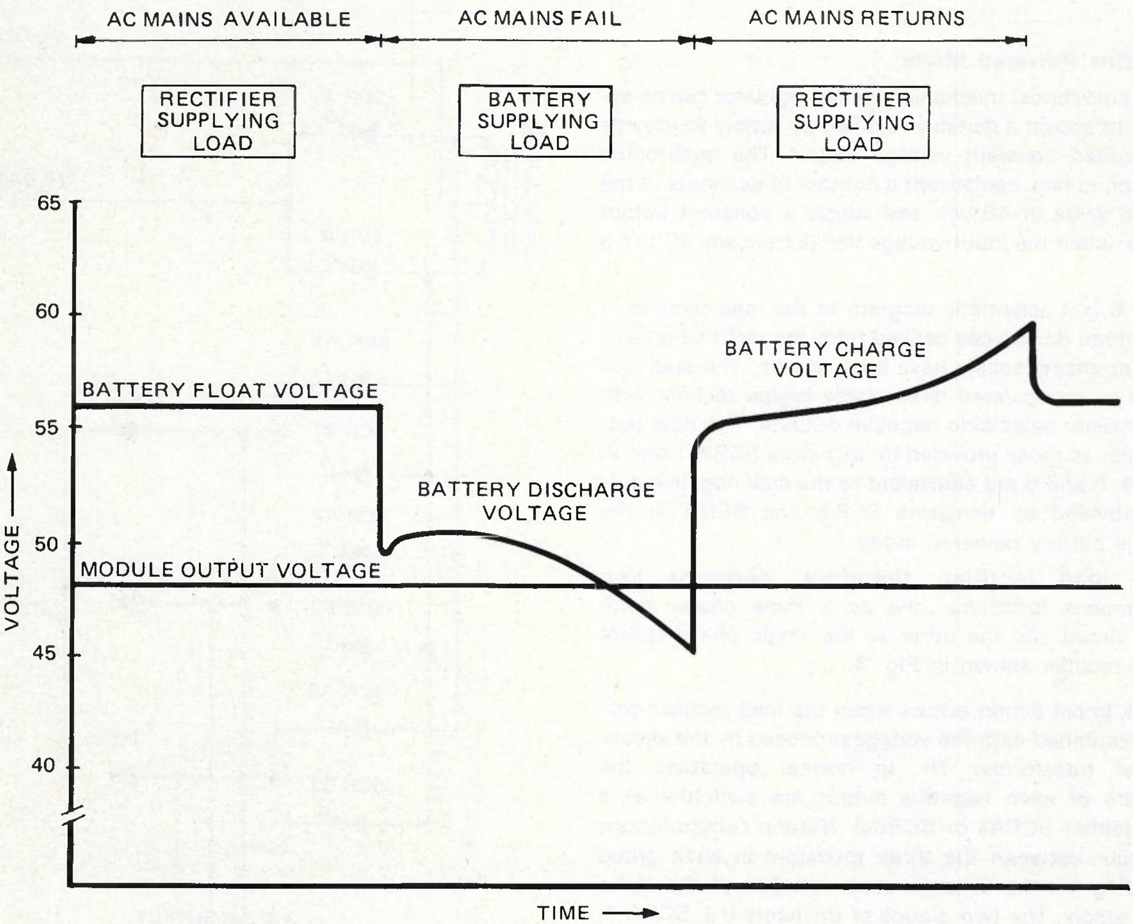

Fig. 7 — Complete Operating Cycle of the Buck/Boost Power Supply

the exchange with energy derived from the main battery. Under this mode of operation, the dc regulator again automatically compensates for the falling battery voltage and maintains the exchange at the constant 48.5 volt potential.

However, if ac supply failure is extended for example, by prolonged ac mains failure coupled to emergency standby supply failure, the buck/boost module will continue to operate for the duration of the battery reserve. Regulation will be lost at the point where the voltage of the battery falls to approximately 44 volt.

Simultaneous failure of ac mains supply and emergency standby supply is rare; the ac essential supply is usually restored quite quickly. Restoration of ac power will re-establish normal ac mains powered operation of the power module after a short delay of about 30 seconds. This time delay is provided to ensure reliable commutation from battery powered mode to ac mains powered mode, and also to enhance the stability of the power system during the transitional period.

Also, after ac mains has been restored, the battery will be boost charged automatically by the charge rectifier. When the end voltage of about 60 volt (2.30 volt/cell for 26 cell battery) is reached, the charge rectifier will revert to auto float operation and float the battery at 2.17-2.20 volt/cell (56.42 volt to 57.20 volt).

Fig. 7 depicts the regulated operation showing the constant output characteristic and variations of the battery voltage under various conditions. **Fig. 8**, on the other hand, shows the output voltage as a function of the load current; this is the load regulation curve of the buck/boost module under normal operation, ac mains powered or battery powered.

UNREGULATED OPERATION

If for some reason the regulator section of the buck/boost module fails or has been shut down, the module will continue to supply rated output power to the exchange, although the output voltage will no longer be closely regulated to within 48.5 V ± 1%. This is the unregulated mode of operation; if the regulators of the power suppy system fail, power necessary to drive the exchange will not be interrupted. The range of voltage supplied by the power module under unregulated operation has been designed to comply with the normal operating range of telephone equipment (47 volt to 52 volt).

This is in contrast with the practice in the conventional rectifier-battery system where failure of the rectifiers will result in the shutting down of the power system and the exchange must rely on batteries to continue its operation. This could cause exchange outage if the rectifiers of the power system are not reset in time.

In the unregulated mode of operation, all thyristors of the load rectifier are triggered into continuous conduction; the load rectifier operates therefore like a full wave three phase diode bridge. If the mains supply suffers failure while the power module is under unregulated operation, all thyristors in the battery circuit will be triggered on to connect the battery to the exchange without a break in the supply. The exchange could operate indefinitely in the unregulated mode until the fault in the regulator is fixed and the buck/boost module is returned to its normal regulated operation as described previously.

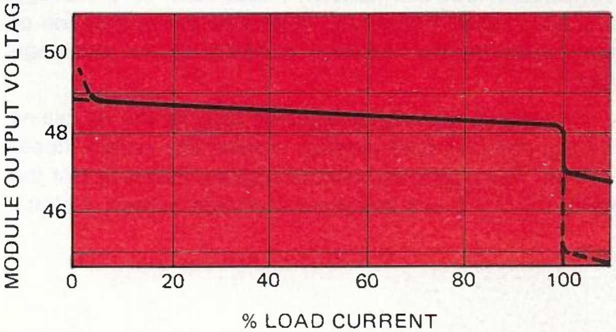

Fig. 8 — Normal Regulated Operation: Battery or Mains Supply

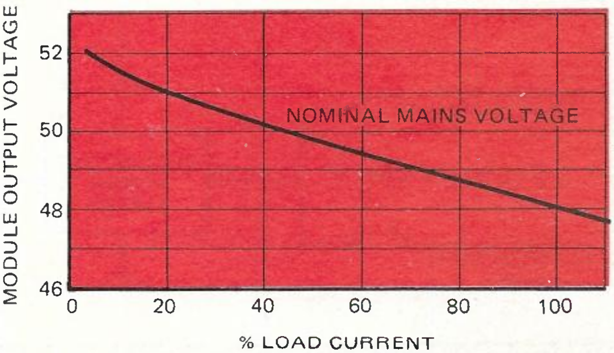

Fig. 9 — Regulator Failed Operation: Mains Supply

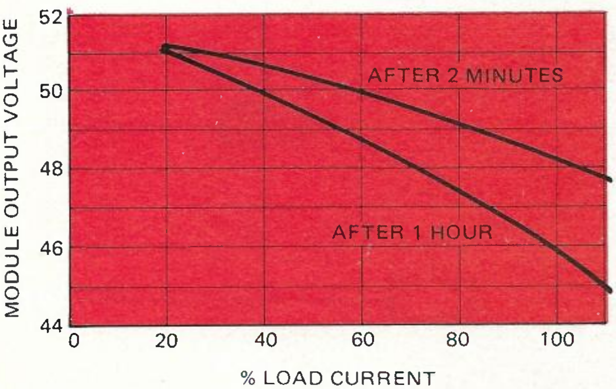

Fig. 10 — Regulator Failed Operation: Battery Supply

Figs. 9 and 10 illustrate the operating characteristics under the unregulated operation. It can be seen that the range of voltages shown in these operating characteristics are the normal design operating range of most telephone switching systems.

MAINS MONITOR AND LOAD MONITORS

The mains monitor and the load monitor play a very important function in the operation and control of the buck/boost power module. These are two voltage monitors which control and determine the connection of the battery to the regulator or direct to the exchange load.

The mains monitor senses the level of the ac mains supply and the load monitor senses the output (load) voltage. The mains monitor will initiate connection of the battery if there is a complete loss of ac power, a phase failure or a low mains condition. The mains monitor has a sub cycle response and transfers the triggering signals from the thyristors of the load rectifier to the thyristors of the battery; there is no break in the dc supply to the exchange equipment.

The load monitor senses the output voltage, shuts down the regulator and permanently connects the battery to the exchange load if the operating limits have been exceeded. Regulator shut-down occurs because it may be the cause of the low or high voltage disturbances. DC power supplied to the exchange load is now provided by either the unregulated load rectifier or battery depending on which source is at a higher level (unregulated operation). Manual intervention is necessary to restore the system to normal regulated operation. **Fig. 11** shows the mains and load monitors and some additional monitoring and control functions of the power system.

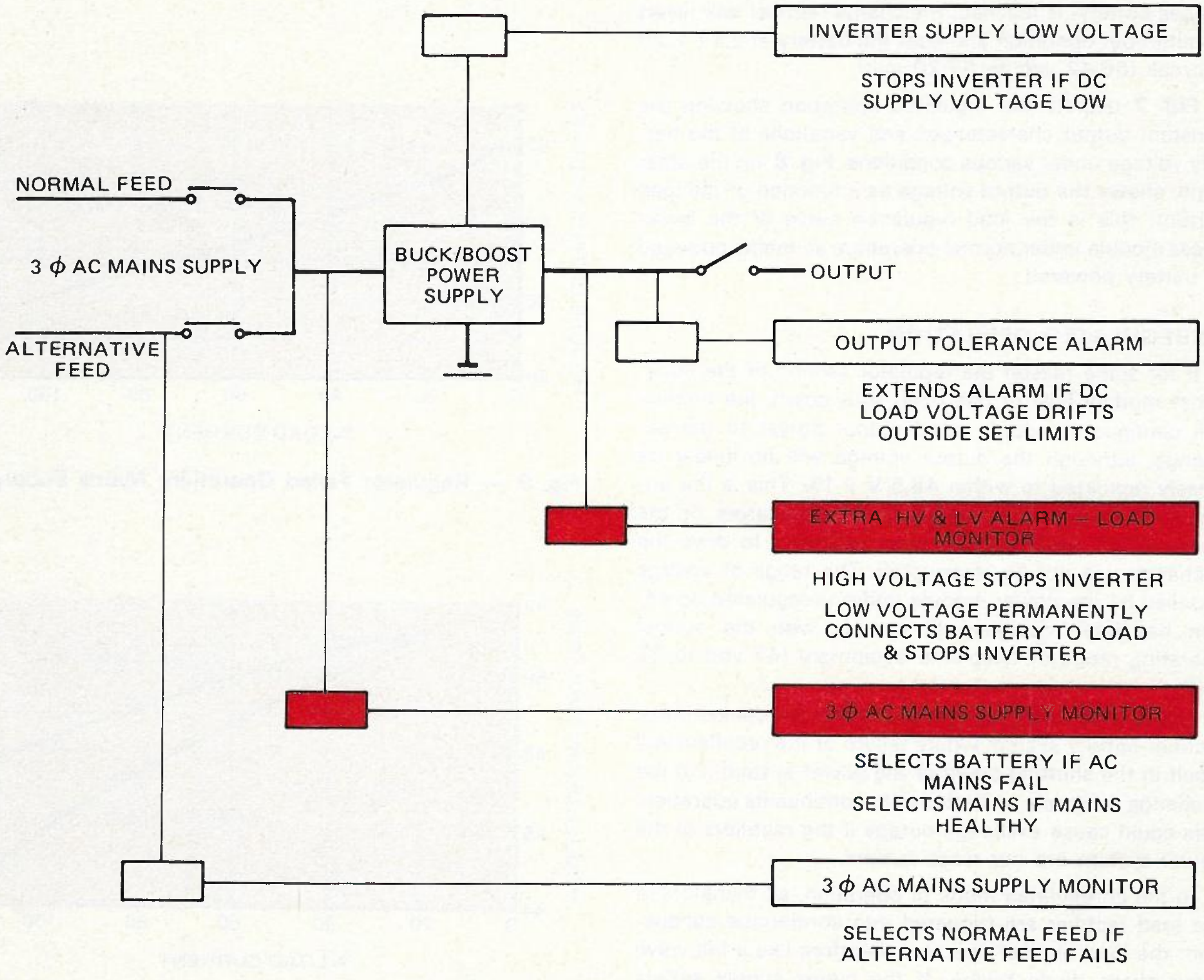

Fig. 11 — Mains and Load Voltage Monitors

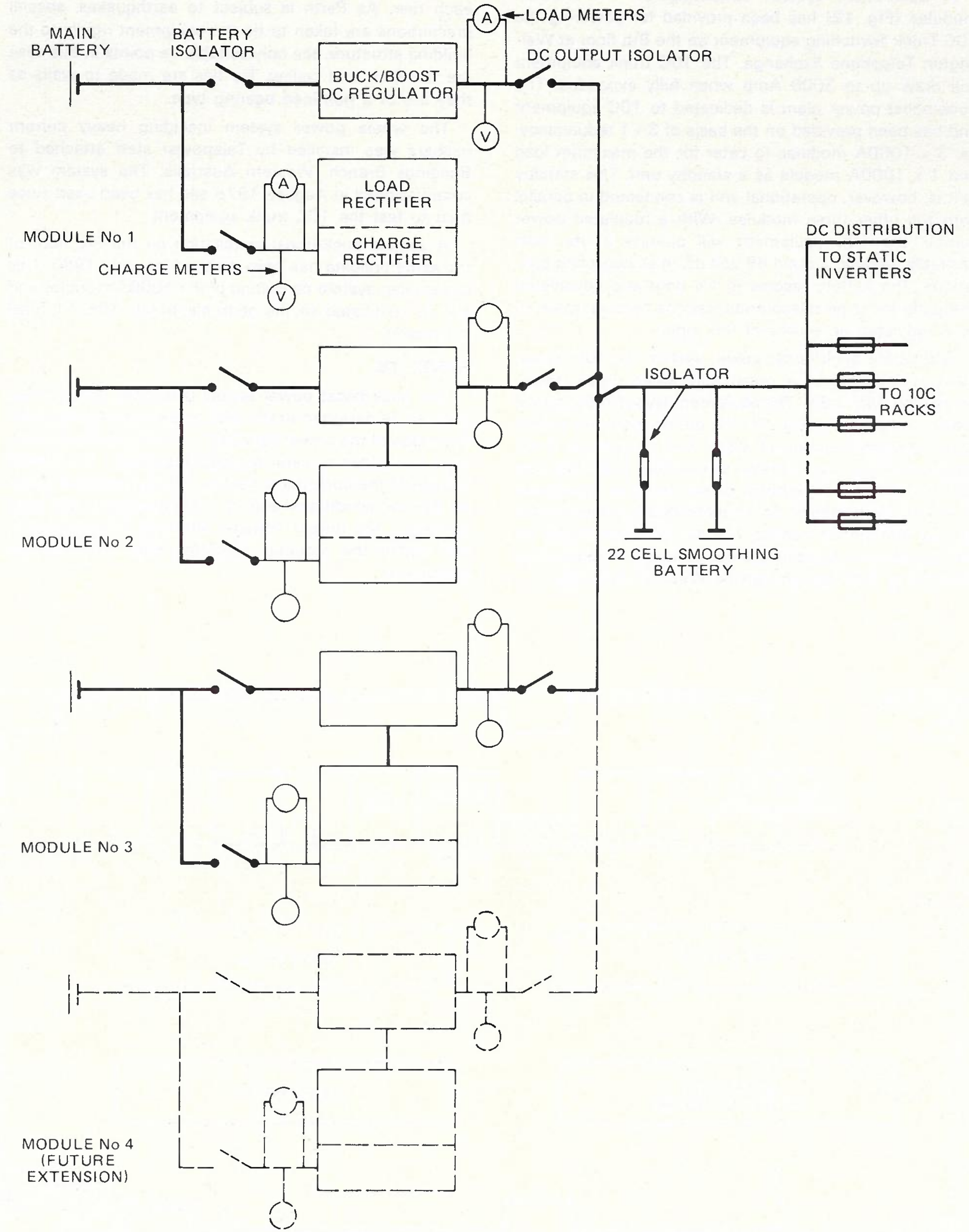

Fig. 12 — Wellington 10C Buck/Boost Power System

FIRST BUCK/BOOST POWER INSTALLATIONS

A buck/boost system consisting of 4 x 1000A modules **(Fig. 12)** has been provided for powering the 10C Trunk Switching equipment on the 8th floor at Wellington Telephone Exchange. The 10C trunk equipment will draw up to 3000 Amp when fully expanded. The buck/boost power plant is dedicated to 10C equipment and has been provided on the basis of 3+1 redundancy, i.e. 3 x 1000A modules to cater for the maximum load and 1 x 1000A module as a standby unit. This standby unit is, however, operational and is connected in parallel with the other three modules. With a regulated power source, the 10C equipment will operate at its most desirable voltage, around 48 volt dc, in all operating conditions. The battery reserve is 1½ hour and considered adequate for large telecommunications centres powered by a regulated dc source of this kind.

The whole buck/boost power system for 10C equipment is installed in a reasonably small power room, measuring 14m x 8m. The equipment layout in the power room is as shown in **Fig. 13.** The power room has a clear area between columns of $96m^2$ and equipment is arranged in three rows parallel to the 14m wall. One row contains the four buck/boost power modules, two banks of smoothing batteries, an ac switchboard cubicle and a dc fuse distribution cubicle. The ac switchboard and dc fuse distribution cubicles are not normally required to be provided in this fashion outside Western Australia.

The other two rows accommodate 4 x 26 cells of lead acid batteries (2170 Ah capacity), two battery banks in each row. As Perth is subject to earthquakes, special precautions are taken to tie the equipment rigidly to the building structure; the only suitable tie points in this case are the floor and ceiling. No ties are made to walls as they are of a non-load bearing type.

The whole power system including heavy current busbars was installed by Telepower staff attached to Buildings Branch, Western Australia. The system was commissioned in August, 1978 and has been used since then to test the 10C trunk equipment.

A second buck/boost installation on the 3rd floor of the same building has been planned for early 1980. This is a smaller system consisting of 2 x 1000A modules and will be dedicated to the semi-electronic ARE 11 local equipment.

BENEFITS

The buck/boost power supply is flexible, modularised and can be designed to suit exchange load requirements. Extension of the power capacity is easy and simple; extra units are added to cater for load escalation. The output voltage of the buck/boost system is fully regulated under all service conditions and in the emergency fall back operation, the output voltage, although unregulated, is still within the required operating limit of telephone equipment.

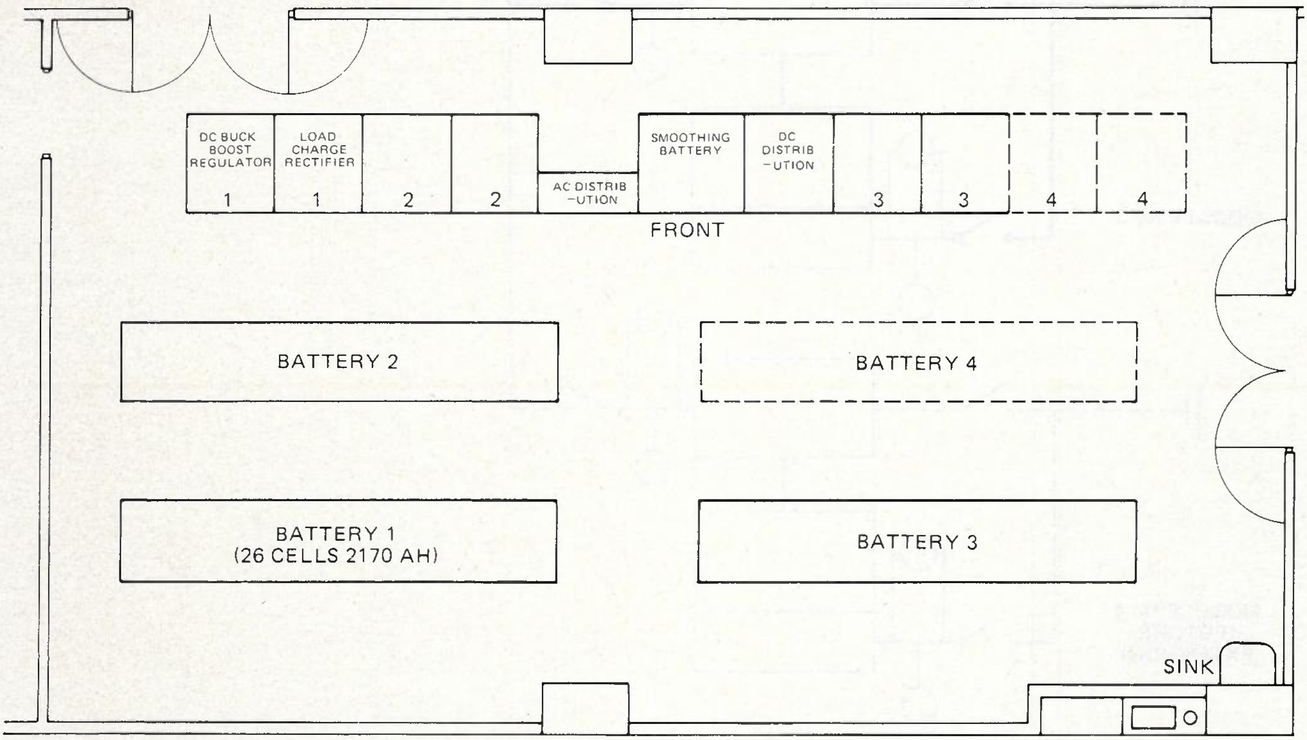

Fig. 13 — Layout of the Wellington 10C Buck/Boost Power System

Exchange equipment powered by a buck/boost power system will operate at its desirable nominal value of 48 volt and will not experience serious voltage swings during mains failure and restoration.

Battery savings are possible; with the buck/boost system, a shorter battery reserve can be used without loss of system reliability.

The lower operating level of the buck/boost power system is also a bonus to switching equipment in terms of energy savings. A substantial reduction in overall power consumption is possible. This means lower overall power costs and additional savings in operating costs for air treatment.

With the dwindling of the world's energy resources and the continuing escalation of energy costs, it is obviously desirable to introduce the innovative buck/boost power system concept into the national communications network as soon as feasible. The buck/boost power supply at Wellington Exchange will be the precursor of a whole new generation of exchange power systems in Australia.

ACKNOWLEDGEMENTS

The buck/boost power supply system is designed and manufactured in Australia by Standard Telephones and Cables (Australia) Pty. Ltd., Liverpool, New South Wales.

Thanks are due to Mr R. Cruise, Telecom Power Section, Headquarters, who has made a valuable contribution to this work.

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N. K. THUAN is a senior engineer of the Engineering Department, Telecom Australia, Headquarters, Melbourne. See Vol. 28, No. 1, page 81.

In Brief

Defence now Plugged into International Communications System

The Defence Department in Canberra can now draw on vast quantities of information stored in computer data banks throughout North America.

The Department has adopted OTC's new international communication system called MIDAS (Multimode International Data Acquisition Service) which will greatly reduce the cost and time involved in obtaining Defence related information from overseas. The Department of Defence is the first government department to introduce MIDAS.

In anticipation of the introduction of MIDAS, the Department carried out a pilot scheme aimed at evaluating the usefulness of the North American data bases as a Defence information resource. The pilot scheme was tested over a period of 12 months, and proved that MIDAS could be successfully introduced by Defence.

By means of a satellite link and the latest computer packet switching technology, the Department will be able to receive unclassified data, at a cost of about $25 an hour compared with $144 an hour under OTC's previous system which used the more expensive voice communication circuits. The time saved will be considerable because of the greater transmission speeds available under MIDAS.

The introduction of the new communications system marks the beginning of a new era of low-cost international data transmission.

The type of information available through MIDAS is concerned with report type literature and spans almost all fields of recorded knowledge.

Immediate online access to the wealth of information available will be invaluable to Defence planners, managers and researchers.

In operation, the MIDAS access route from within Australia utilises STD lines to Sydney, the OTC network from Sydney to North America (either by satellite link or, to a considerably lesser extent, the trans-Pacific cable) and then telecommunication networks to the host computers storing such information in North America.

To coincide with the introduction of MIDAS, and to take advantage of the lower costs, four additional access points are being installed by Defence in Canberra, Sydney, Melbourne and Salisbury, South Australia. They are expected to be operational in the near future, and will provide the major Defence centres in Australia with the new facility.

OTC also plans to expand MIDAS to other countries, including the United Kingdom, Europe and Japan. Defence authorities will be watching developments in this area with a view to expanding its North American MIDAS service to include these countries.

A Solid State Digital Speaking Clock

G. R. BARBOUR B Tech

The speaking clock service provided by Telecom Australia is the most popular recorded information service available to customers. Decreasing reliability and the increasing difficulty of maintaining the original electromechanical equipment in South Australia necessitated replacing the magnetic tape time announcer to provide for a continuing, reliable and economic service.

This article describes the Solid State Digital Speaking Clock developed and manufactured by the South Australian Engineering Department of Telecom Australia and installed in Adelaide. The design is based on dual minicomputers, for reliability, and uses an Adaptive Delta Modulation speech encoding scheme for digital storage of the vocabulary required. The equipment provides six different time zone announcements which, are being fed to several States of Australia.

BACKGROUND TO THIS DEVELOPMENT

Prior to the availability of an automatic time of day announcing service, time information was provided by an operator announcing the time every fifteen seconds during the busy parts of the day and on demand at other times.

In March 1960, the Speaking Clock Service was officially commenced in South Australia, the announcement being provided by a Siemens and Halske Magnetic Tape Time Announcer. Since then, with the growth of the country automatic telephone network, the service has been made available to an increasing number of regional centres and figures recorded for the 1977/78 year indicate 3,750,000 calls originated from the Adelaide metropolitan area and 587,000 from the country areas. Statistics for the whole of Australia indicate approximately 75 million calls each year, making the service easily the most popular recorded announcement facility provided by Telecom Australia.

The combination of continuous operation of this automatic time announcer for a period exceeding 150,000 hours and the growing difficulty in obtaining maintenance parts resulted in an increasing maintenance commitment to ensure continuity of the service. Providing alarm outputs under certain failure conditions was also difficult and since any loss of service generates immediate and unfavorable public reaction, investigations were begun towards finding a replacement. Enquiries through Telecom Australia's Research Laboratories and locally revealed that the only likely replacements were electromechanical in nature and would, therefore, be prone to similar problems after several years of continuous service.

The justification for developing a suitable replacement speaking clock with all the required features, under Telecom Australia's Research, Development and Innovation Programme (RDI), was then assessed. The RDI programme regulates the allocation of resources to work of this nature. On the strength of the facility specification listed below and the cost/benefit summary outlined later in this article, the project was approved.

Development work on the speaking clock began in the Microelectronic Systems Design Group in September 1976. The equipment was developed, constructed, 'debugged' and installed by March 1978 for connection to the telephone network. Initially, the original equipment was kept as a 'hot standby' in case of failure but in January 1979 was removed from standby status. Since that time the new equipment has demonstrated excellent reliability and is now providing time announcement feeds to several States of Australia. **(Fig. 1)**

The announcement generated is of the form: "At the third stroke, it will be one, ten and forty seconds." Three pips of 1kHz tone then follow, marking the eighth, ninth and tenth seconds of the period. Each pip is exactly one hundred cycles of a 1kHz sinewave and the beginning of the first cycle of each pip marks the time with an accuracy of better than one ten-thousandth of a second at the speaking clock equipment. Distribution of the announcement to the last local exchange before the customer's premises should introduce a delay of no more than one hundredth of a second.

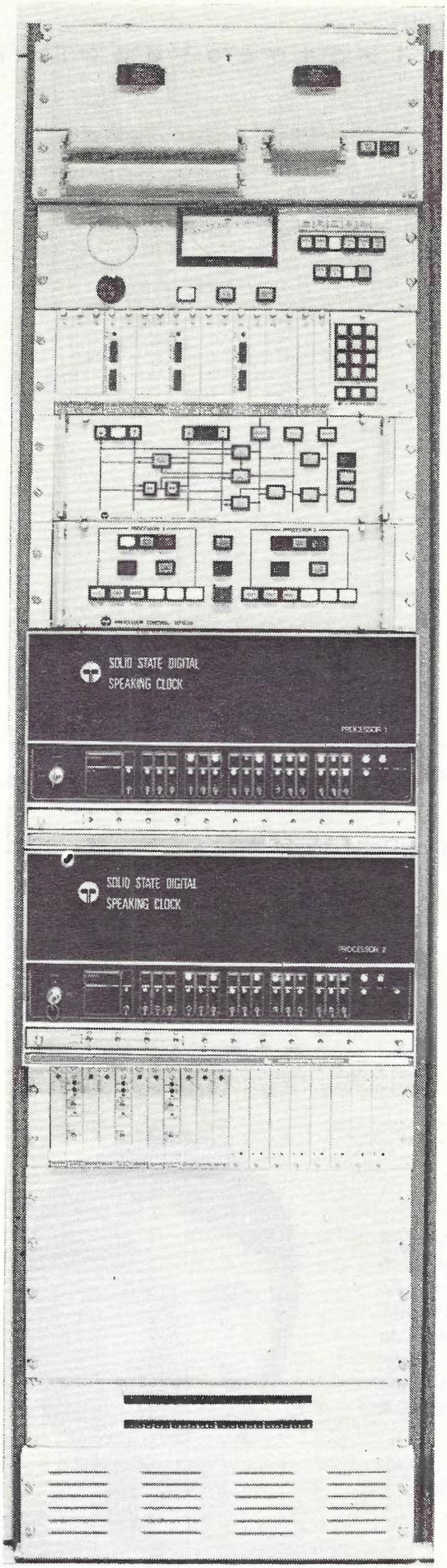


Fig. 1 — The Solid State Digital Speaking Clock

SPECIFICATIONS FOR A SPEAKING CLOCK

Ideally, a speaking clock should meet the following specifications for its major facilities:

- have speech output indistinguishable from 'live' speech:
- announce the time of day in a format easily comprehended in a single announcement;
- announce the time of day often enough to minimize the duration of customer access;
- provide a time reference of useful accuracy at the end of each announcement to define the actual time being announced.

The hardware used to implement a speaking clock should also satisfy the following criteria:

- have duplicated announcement generation equipment to provide maximum security in the event of equipment failure;
- have failure detection alarms and automatic changeover control to provide rapid recovery in the event of failure;
- have no moving parts. (These require regular maintenance and, after several years of continuous service, are the major cause of failure).

If it were also possible to provide multiple announcements for different time zones from a single set of equipment, this would offer substantial savings in capital cost and staff training in a country with multiple time zones such as apply in Australia.

A SOLID STATE DIGITAL SPEAKING CLOCK

To satisfy the above requirements, consideration was given to producing an announcing machine using electronic speech encoding techniques and a computer for storing the necessary vocabulary and reconstructing it as required for the final announcement. Initially, electronic speech synthesis was examined since this technique offered very low data storage requirements compared with direct speech encoding. For example, the standard coding rate for a 3kHz speech channel is 8000, eight bit samples per second, giving a bit transfer rate of 64,000 bits per second (BPS). By comparison, typical speech synthesisers have a bit transfer rate of between 200 and 1000 BPS. There would obviously be significant savings in memory size for the 38 word vocabulary (which lasts approximately twenty seconds), by using a speech synthesiser.

Aural assessment of the speech quality of several synthesisers from different manufacturers demonstrated their inability to produce sufficiently realistic sounding speech and it was judged that customer acceptance of such an announcement would be poor.

There are many other encoding schemes available for digitizing analogue waveforms and some of the more common ones in use for speech coding are PCM, with various companding laws, and Delta Modulation, with various adaption laws. In such encoding techniques the most important parameters are the bandwith and the ratio of signal to quantizing noise. Quantizing noise can

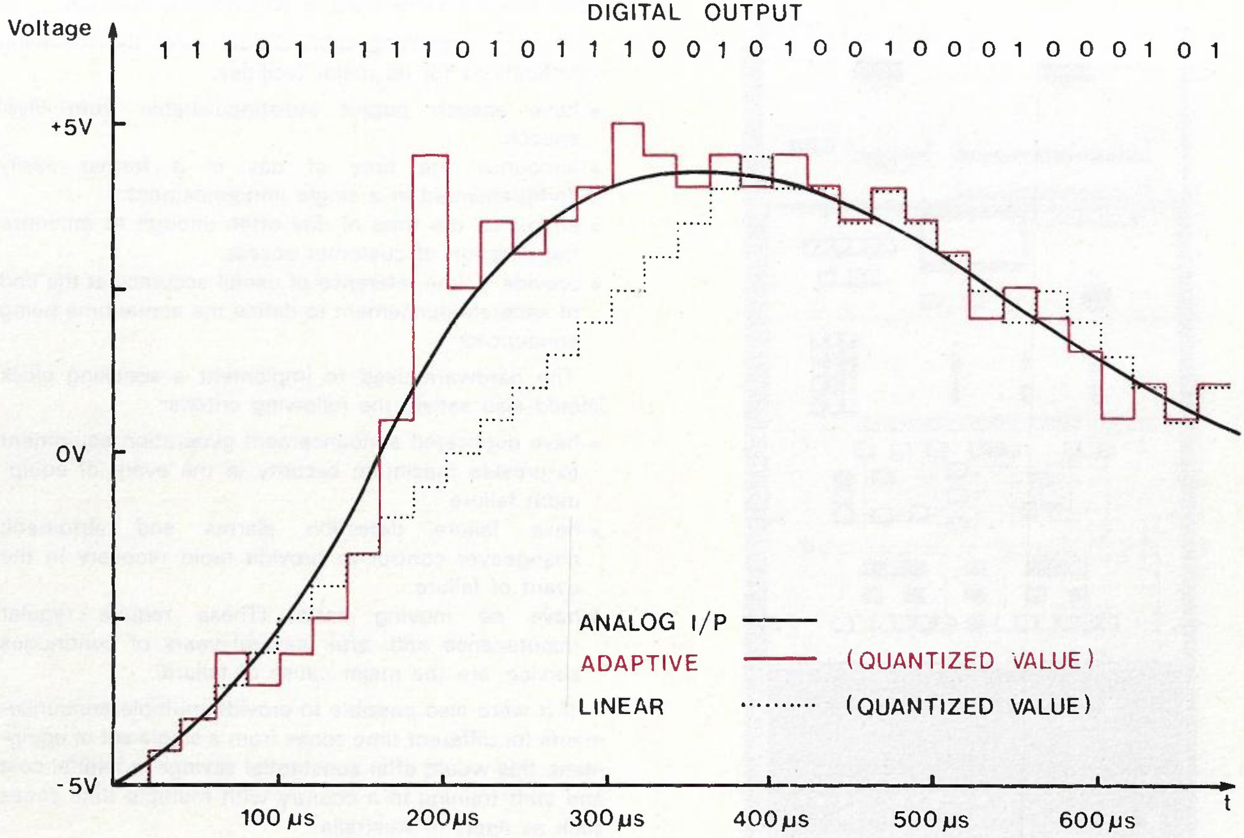
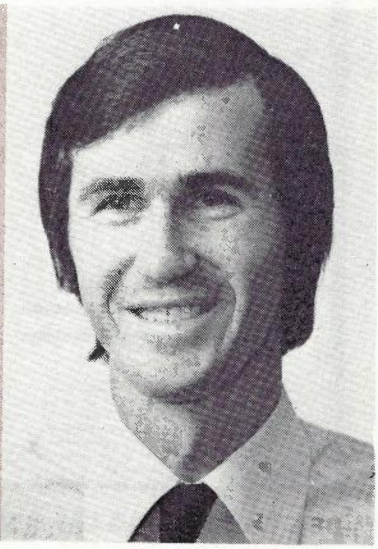


Fig. 2 — The Principle of Linear and Adaptive Delta Modulation

GEOFF BARBOUR graduated from the South Australian Institute of Technology with a Bachelor of Technology Degree in electronic engineering in 1972. His first appointment as Engineer was in Construction Branch where he spent two years involved with the construction and installation of country ARK exchanges and extension of ARF exchanges. In 1974, he transferred to Telegraphs and Data Section where he became responsible for several design projects for new equipment and facilities in that area. This culminated in the design and reprovisioning of the Solid State Digital Speaking Clock and the S A Time and Frequency Standard.

In 1978 he was appointed Engineer Class 2, responsible for directing the activities of the Microelectronic Systems Design Group in South Australia.



be described as the difference between the original signal and the reconstructed signal, caused by the finite step size of the encoder being unable to represent exactly the original input magnitude.

The signal to quantizing noise ratio improves with increasing bit transfer of the encoder and thus a compromise is required between a low transfer rate to minimise storage requirements and a high transfer rate to achieve acceptable output quality. A recording made by the IEEE has comparative examples of the quality of speech to be gained by different encoding schemes at different transfer rates (Reference 1). After many listening tests and examination of the hardware implementation costs, Adaptive Delta Modulation was finally chosen as the most desirable method.

ADAPTIVE DELTA MODULATION

Delta modulation is the technique of encoding an analogue wave form by taking one bit samples and determining the output by comparing the analogue signal with the previously quantized value. (see **Fig. 2**)

For Linear Delta Modulation, the step size is fixed and the quantized signal can only increase or decrease by one step size each sample period. Consequently, if an excessive rate of change of input signal is presented to the encoder, the quantized signal cannot follow the input and 'slope overload distortion' occurs. The step size can be increased to overcome this effect but this increases the quantizing noise.

Adaptive Delta Modulation (ADM) is the technique where the step size changes in response to the rate of change of the input signal. Various step size ratios are possible but the optimum for band limited speech is between 1.5 and two times the previous step size. (Reference 2).

For ease of hardware implementation, two times was used for this project and, briefly, the adaption rules are:

- each step size is twice the previous step size except that the first two after a change in direction are the same size:
- for a change in direction, the next step size is half the previous step size.

A prototype of the ADM circuit was constructed to allow evaluation of the actual implementation cost and to permit assessment of the quality achievable. The circuit is mainly digital, using analogue components only at the imput and output, and consequently repeatability of manufacture is excellent.

In the discrete ADM used, overload due to excessive input signal is detected as an over-range bit in the Arithmetic Logic Unit used to add or subtract the step size to the previously quantized value stored in the digital integrator. This over-range bit is used to reduce the step size until the overload condition disappears causing 'hard limiting' of the output instead of uncontrolled oscillation which would otherwise occur in digital ADM's.

Bandpass active filters were designed to restrict the speech signals to the bandwidth of voice frequency telephone channels, (that is 300Hz to 3,300Hz).

Testing was undertaken with a wide range of sampling rates and many different listeners. The minimum bit transfer rate consistent with quality essentially indistinguishable from the input was determined to be in the range of 45kBPS to 55kBPS, depending on the aural acuity of individual listeners. In this application, due to the defined format and repetition of the announcement, subjective quality does not need to be as great as for random speech or music. For other applications, intelligible speech over an ADM is possible with bit transfer rates as low as 16kBPS but the quality is not acceptable for commercial use.

Fig. 3 shows the main components of an ADM and it is interesting to note that to change such a circuit from modulation to demodulation, it is only necessary to operate the single switch shown to accept either analogue or digital input.

A bit transfer rate of 50kBPS was finally selected to make use of readily available oscillator components since the difference in quality from 45kBPS to 55kBPS was not very noticeable. Critical timing tests of the vocabulary required indicated a total duration of between 19 and 20 seconds, requiring a storage volume of approximately 970,000 bits or 61 thousand, 16 bit words. This left approximately 4000 words of memory for the programs so that a standard size memory of 65,536 words (commonly called 64k words) could be used.

IMPLEMENTATION

Since the new equipment must operate into the existing telephone network it was important to ensure that the output feeds would be compatible in signal level with the appropriate standards for transmission of speech and tones over the network. In addition, the announcement facility is distributed to several metropolitan and many country areas in order to minimise the effect on trunk routes of a high calling rate to the time announcement service. This meant that many output feeds were required and these were provided using analogue splitters with VF amplifiers to set the levels correctly.

A total of six time zone announcements were provided on the equipment to cater for the three major time zones across Australia as shown on **Fig. 4**: namely Eastern Standard Time, Central Standard Time and Western Standard Time. Two of the zones (1 and 3) implement Daylight Saving during the summer and so five different announcements must be generated during this period. The sixth time zone announcement (zone 5) is not used but can be programmed readily to produce any time offset for a special requirement.

Minicomputer

Data General Nova 2/10 minicomputers were selected as the base upon which to develop and implement the hardware and software necessary for the speaking clock. Two minicomputers were provided, each handling identical functions, to ensure the maximum reliability of output announcement in the event of failure of one unit. Basic requirements of the minicomputer were:

- ability to address 64k 16 bit words of memory;
- processor speed sufficient to handle the critical output routines where the six outputs must be serviced every 320 microseconds;
- full programmer's console with automatic program load and power fail/automatic restart facilities so the quick loading of programs and automatic recovery after power failure is possible.

The Data General minicomputer was chosen after examining several different brands of available minicomputers which offered the necessary facilities. It was cost competitive, compatible with equipment and software already available in the Microelectronic Systems Design Group in South Australia, minimised the need to retrain staff who would be working on the project, and experience had been gained with Data General minicomputers in earlier projects. This earlier experience had demonstrated that reliable performance over long periods of time could be expected.

Software

The software required to implement the speaking clock was divided into two main sections. One was the set of routines which formulate the required messages and then outputs them to the Adaptive Delta Demodulators. The other routines were those needed during the creation of the master vocabulary or for maintenance purposes. These are shown in **Fig. 5**.

Once every ten seconds an external interrupt causes the minicomputer to read in the 'Time of Day' from an external time reference and then the messages for each of the time zones are formulated by adding or subtracting the appropriate time offset from the reference time. Tables are built in the software which provide pointers to the start and end of each of the words necessary for each announcement. The pauses between each word are also stored in memory as multiples of ten milliseconds and are accessed by the output routine between each word.

When all the tables have been generated the output routine is entered. A pause of about two seconds is timed to allow a gap between the pip of the preceding ten-

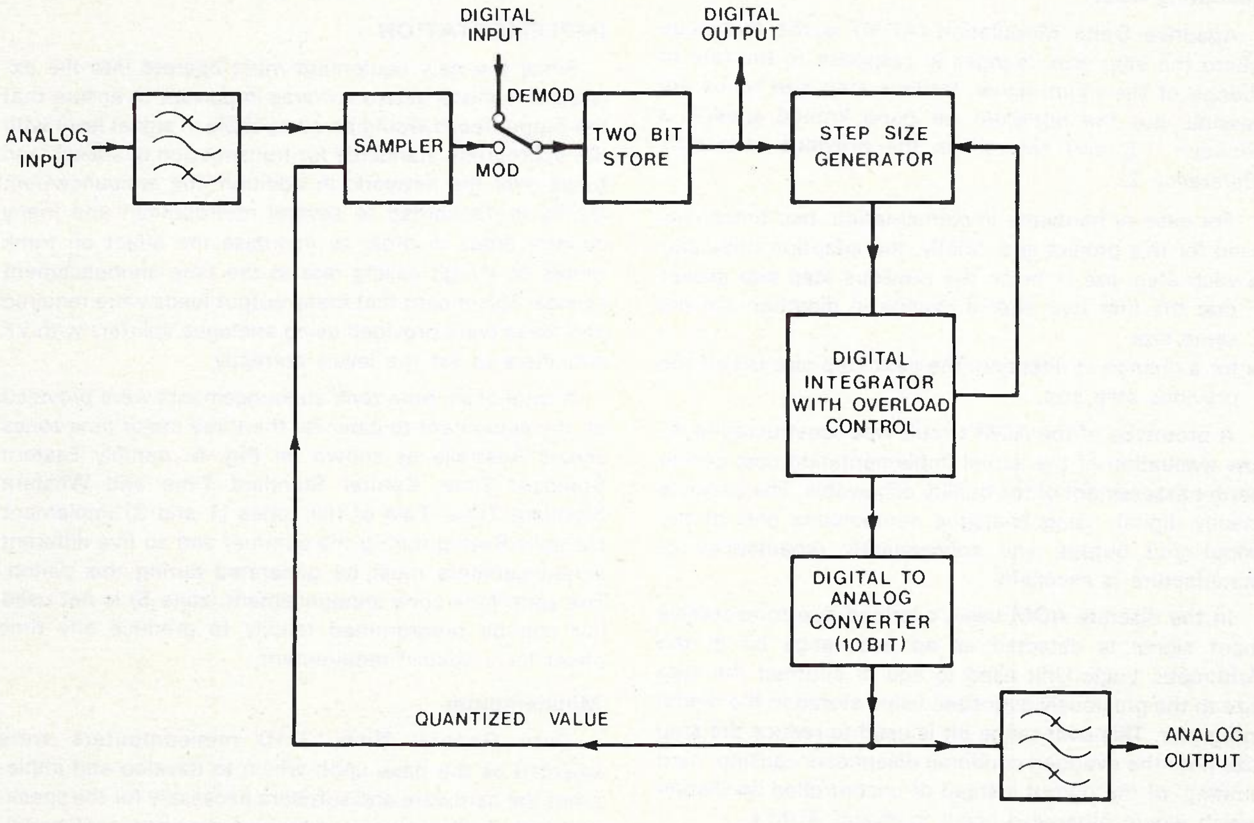


Fig. 3 — Block Diagram of the Adaptive Delta Modulator

second point and then the output routine begins to send data to each of the six demodulators, including pauses as necessary, to produce the final announcements. Phonetic correction is required for concatenated words such as "twenty-one", since the "twenty" used by itself is different in inflection from the word "twenty" used in "twenty-one". As this applies similarly for the words "thirty", "forty" and "fifty" each word must be stored twice.

When all of the words have been completed, the software enters an idle loop, waiting for the next ten second interrupt. During this period if control signals are received from the Processor Control Panel, the computer will begin to output a data transfer stream which is a complete image of its core memory. This facility allows the second minicomputer at the same site to rebuild its memory, allowing commissioning of a new system or recovery from memory mutilation.

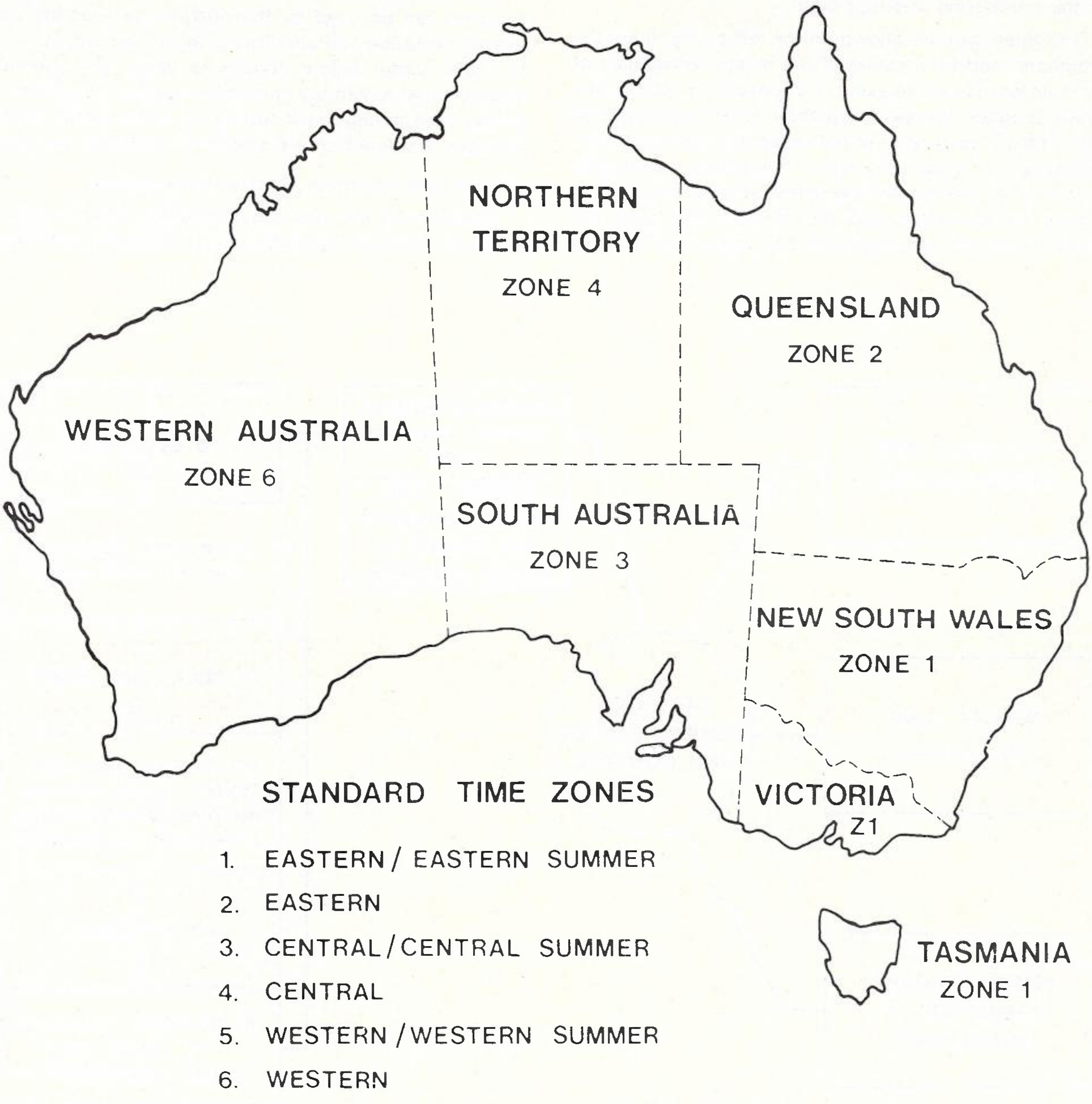


Fig. 4 — Standard and Daylight Saving Time Zones across Australia

Once the operator causes the computer to begin announcing, via commands from the operator's Visual Display Unit, the process will continue every ten seconds until either a power failure occurs or the operator halts the processor by inserting a key in the front panel to unlock the control keys and then pressing the 'stop' key. This ensures that accidental operation of the processor front panel controls will not cause failure of the speaking clock. In the event of a power failure, circuitry in the computer senses the loss of power and initiates a special routine which saves the environment of the program in the permanent memory and then implements an orderly shutdown. When power is restored the program's environment is restored and the output routine is restarted at the ten-second interrupt point.

The three routines shown on the left of **Fig. 5** are the programs used for creation of the master vocabulary or for maintenance in the event of erroneous operation. The 'Load' program allows an operator to encode and load into memory each word of the vocabulary from a master recording on magnetic tape. Interactive commands between the operator and the software allow one word at a time to be loaded into the memory and then the operator can edit the beginning and end of the word to remove all but the required information. This process is repeated for each of the 38 words and a table is created listing the start and end location of each word in memory, allowing the output routine to access later the required words when formulating a message.

The 'Memory Dump and Reload' program is used to transfer the edited form of each word from memory to an external device, such as a minicomputer development system with mass storage, or to load back into the speaking clock word images previously stored. This is necessary during editing of the words since the amount of memory used during editing of the master vocabulary is much greater than finally needed.

The 'Memory Content Examination and Manipulation' program can be used by the operator to examine any memory location and alter its contents if necessary. This is useful under failure conditions when the operator suspects that a memory mutilation may have occurred. It is also used during initial setting up of the pause values between words which are stored in a table in memory.

Alarms and Common Control Subsystems

Since one of the main requirements of the equipment is a high order of reliability, it was necessary to provide

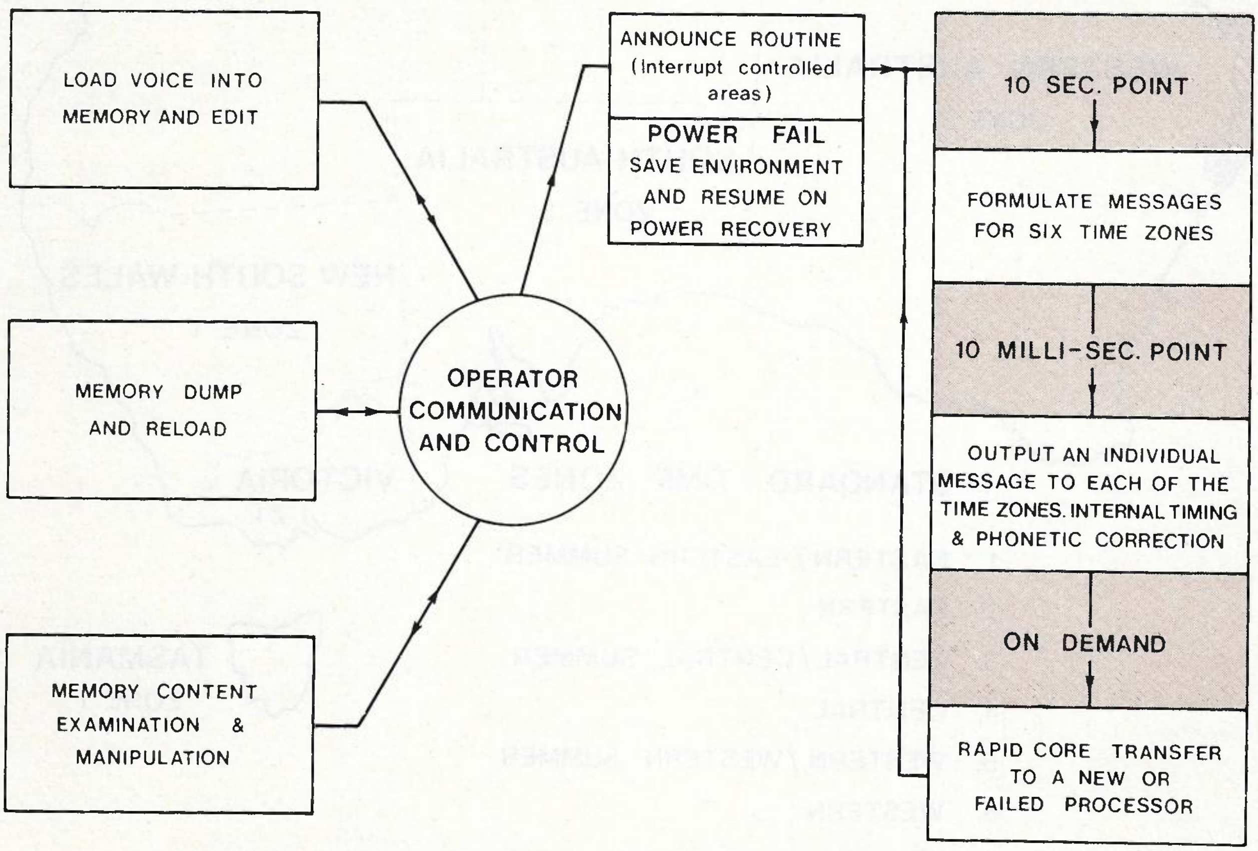


Fig. 5 — Overview of the Software Routines required for the Speaking Clock

extensive fault detection ability on all parts of the system. Continuous checking for integrity is done from the serial 'Time of Day' input through to Program Fail Alarms on the outputs of each minicomputer and on the final feeds to the network.

Checks are also made by the software on the integrity of the time input, the 'Daylight Saving' control lines and operation of the output interface circuits and demodulators. All fault indicators are fed to the Processor Control Card Frame where they are analysed to determine the mode of failure. Once a failure has been identified, action is taken where possible to restore operation. For example, if a Program Fail Alarm detects that one of the outputs of Processor 1 has failed and Processor 1 is the on-line machine, the outputs of Processor 2 are checked and, if valid, a changeover is initiated to make Processor 2 the on-line machine. An urgent alarm is also raised to bring the failure to the attention of maintenance personnel.

Many different modes of failure are possible and, consequently, it is not feasible to describe all of them adequately in this article. However, a great deal of effort was devoted to analysing failure modes and arranging for appropriate action in each case.

Front panel indicators and controls are provided to inform maintenance personnel of the status of the equipment and to allow operators to either force the equipment into specific states or to inhibit various operations. This facility is essential under maintenance conditions; for example, to inhibit changeover to the standby machine when that machine has been taken out of service for maintenance.

A second frame, the Interface Switching Control, is provided to control interconnection of the communication ports of the following devices.

- Processor 1 teletype port;
- Processor 2 teletype port;
- Visual Display Unit for operator access to the software;
- Modem for transfer of data to or from the processors.

Control circuitry for transferring data between processors when recovering from memory mutilation or when loading a new memory is also provided in this frame. All transfers are effected under block format with error checking so that if an error occurs during a transfer the sending processor is informed from the receiving end and, under operator control, the sending processor retransmits the last few blocks of data. This procedure allows secure data transfer but is not automatic; an operator is required to supervise the process. He must be on site in any case to initiate the transfer and to restart the processor at the completion of the transfer, and so this was not considered a deficiency.

The only other modules required are the Voice Frequency Amplifiers necessary to adjust the output levels for the feeds to the network, both local and interstate. Connection to customers is achieved via a Recorded An-

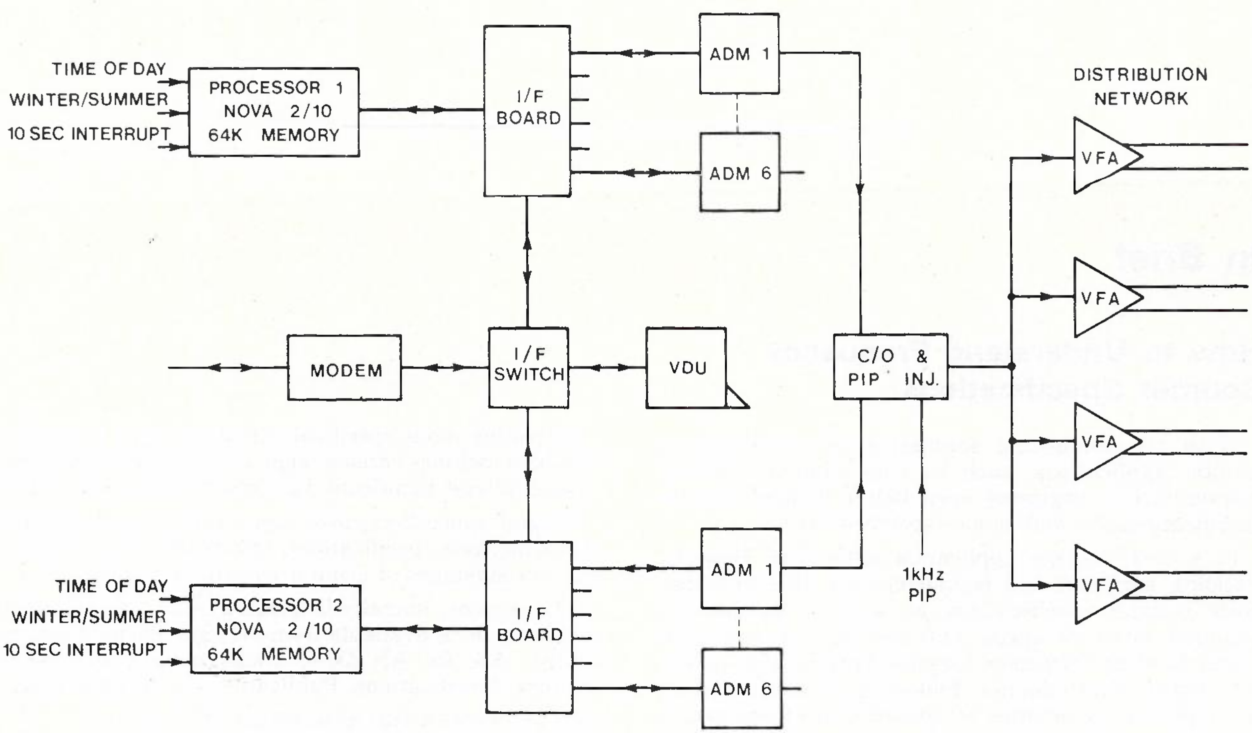


Fig. 6 — Block Diagram of the Speaking Clock Equipment

nouncement Distribution Amplifier which has a low impedance output to minimise interference between simultaneously connected lines.

Fig. 6 shows the interconnection of the various blocks required for the speaking clock.

COST/BENEFIT CONSIDERATIONS

An economic comparison between the only known commercial time announcer available at the time, which would have required significant extra development to provide similar facilities, and the actual development and production costs for the digital speaking clock indicate that it would have been about 20% cheaper to use the commercial equipment if only one site was to be equipped to serve the whole of Australia. If, however, two sites in Australia were to be equipped to back-up each other in the event of a failure of one site, there would be an economic advantage of some $20,000 (in present value terms) in adopting the digital speaking clock.

It is difficult to incorporate failure rates and maintenance charges for the two types of equipment in such a comparison due to the lack of accurate statistics of maintenance liability for electromechanical versus solid state equipment. Considerable weight was given to the anticipated reliability of a solid state speaking clock, particularly in view of the high failure rate and associated maintenance costs of the previous electromechanical machine and the immediate and unfavourable public reaction associated with any loss of service.

The decision was made that development of the digital speaking clock was justified, even for one site, in order to benefit in the longer term from the improved reliability. Excellent performance over the first seventeen months of operation has been achieved with only one fault causing a very short loss of output to customers. This and previous experience with other similar minicomputer equipment has ratified this decision.

CONCLUSIONS

Development and installation of the Solid State Digital Speaking Clock in Adelaide has provided a replacement for the failing electromechanical equipment previously providing Time of Day announcements over the telephone network.

Reliability of the equipment since March 1978 has been excellent, greatly reducing the maintenance requirement compared with the previous equipment and, due to the technology used, this should continue for many years.

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In Brief

How to Understand Frequency Counter Specifications

With the increasing sophistication of frequency counter applications, such as time domain stability measurements, engineers need better defined counter specifications, as well as new specifications.

In a new 34-page application note from Hewlett-Packard, engineers and technicians are able to review basic counter specifications as well as become acquainted with new specs. This new AN 200-4 entitled Understanding Frequency Counter Specifications starts with a general introduction. Following is a section detailing input characteristics of counters including range, sensitivity, signal operating range, dynamic range and trigger level considerations.

Operating mode specifications are covered in Section III which includes various range specifications and a discussion of least significant digit, resolution and accuracy.

Several appendices cover topics such as time interval averaging, rms specifications, effects of wideband noise and measurement of counter contributed noise.

The booklet, liberally illustrated, also includes many examples. It is available from Hewlett-Packard free of charge. Ask for AN 200-4, Understanding Frequency Counter Specifications, Publication No. 02-5952-7522.

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Concentrator Subscriber Radio Services

G. BANNISTER, A.R.M.I.T.

The concentrator subscriber radio system has been developed following the successful use of exclusive service (single channel) radio systems to connect rural and remote subscribers. Both the concentrator and exclusive services are economic alternatives to connection by cable.

Field trials for the concentrator system have been completed and the way is now clear for the installation of these systems on a larger scale.

This paper describes the concentrator and its application.

INTRODUCTION

Many potential telephone subscribers live or work beyond the reach of physical telephone lines, being isolated by sea, river or mountain range, or by flood or snow hazards. In addition, many subscribers, existing as well as potential, while not completely isolated, are well beyond the economic distance for connection by cable to their nearest exchange. In these circumstances radio may be used to provide service to the subscriber. At present there are approximately 500 subscriber radiotelephone services located throughout Australia.

Telecom Australia is required by the Telecommunications Act 1975 to "make its services available throughout Australia for all people who reasonably require those services" and to "have regard for the special needs for telecommunications services of Australian people who reside or carry on business outside the cities".

As part of meeting this obligation 100,000 manual subscribers are due for conversion to automatic service by 1990. Over a quarter of these are currently connected by Part Privately Erected line to distant manual exchanges, probably sharing the party line with other subscribers. Most of these lines will not meet the required standards for automatic service. It is expected that for over 6000 of these, radio will be the most economic method of connection.

SUBSCRIBER RADIO SYSTEMS

General

A subscriber radio system must meet the requirements of the subscriber, the network and spectrum regulations.

In the case of the subscriber, a highly reliable bearer is needed providing his telephone with all its normal features and abilities, and able to support any of the special facilities which would be available to him on a physical line. It must give signalling and transmission performance equal to a good suburban service, and give it whenever, and as often as, he reasonably wants it. It must ensure the normal privacy of his telephone conversation. And it must do all these things without inconveniencing him, and at the smallest possible rental.

The network needs a bearer which behaves like a high quality physical line when connected to any of our multitude of exchange types — magneto, common battery, step by step, crossbar, SPC. At the same time this bearer must be reasonably cheap and simple to install and maintain, without need for specialist staff in the field. It must have a long working life and a high recovery value. It must be reliable and inherently well protected against environmental extremes, and the possible maloperation or neglect of the subscriber or his private power supply, and, of course, it must stand up to the rigours of back-country transport. Because it is applying concentration, it must be able to readily accomodate changes in subscriber numbers and calling rates.

Like all radio systems subscriber radio services must occupy an acceptable frequency in an approved frequency band, if possible conforming to a geographical — frequency plan which permits repetitive safe use of the same minimal spectrum for all compatible requirements throughout Australia. It must conform to Post and Telecommunication requirements on bandwidth, transmitter power, etc., and it must be compatible with all the other radio equipment (HF and VHF fixed services, mobiles, sound and television broadcasts and others) which may be in the area and neither create nor suffer interference.

Exclusive Service Systems

Isolated subscribers are scattered throughout almost the whole habitable area of Australia, including some locations relatively close to major population centres.

These subscribers, because of their isolation, are connected with a radio system dedicated to their exclusive use, even if their calling rate is minimal. This type of service requires two frequencies, a transceiver, mast and an antenna at each terminal.

Concentrator Systems

Where there are a number of subscribers within a radius of about 50 km from a suitable central point (ie, within radio "line of sight") they can usually, without detriment, share radio channels and common equipment provided to accommodate their collective calling rate requirements.

The service area of a group of subscribers may centre conveniently on an existing exchange, or may be offset so as to require physical or radio junctions to connect the base station channels to the exchange.

The penalties for not concentrating the subscribers into groups can be heavy. Frequency spectrum is scarce and individual frequencies to and from each subscriber are normally not available within the required area. The volume of equipment, with its forest of directional aerials, requires expensive protection and support. Power drain is a problem and the simultaneous operation of many transceivers imposes problems in mutual interference. All these penalties are aggravated when the base station must be isolated from the exchange, particularly in an inhospitable environment.

In fact, many areas where subscribers most need radio, connections cannot be served without some form of group concentration system.

Prototype concentrator systems were first installed on the Furneaux group of islands in Bass Strait in 1974 followed by systems in Tasmania and at Issac River between Mackay and Rockhampton, Queensland. More modern equipment was installed at Longreach on a trial basis in 1977 and this has been followed by two systems near Darwin and two in the west of N.S.W. A further seven systems are programmed for installation within the next year.

Capacity

The concentrator system can be expanded up to eight channels in increments of one channel and up to one hundred subscribers in increments of one subscriber. A wide range of calling rates can therefore be handled. The minimum sized system, however, must have two channels to allow one group system subscriber to connect with another.

A typical system would have five channels serving twenty subscribers. If the calling rate should increase an additional channel may be brought into service by plugging in one module in the exchange equipment, installing an additional base station transceiver and plugging in a small module in each subscriber's equipment. New subscribers are also catered for on a plug-in basis in the exchange equipment.

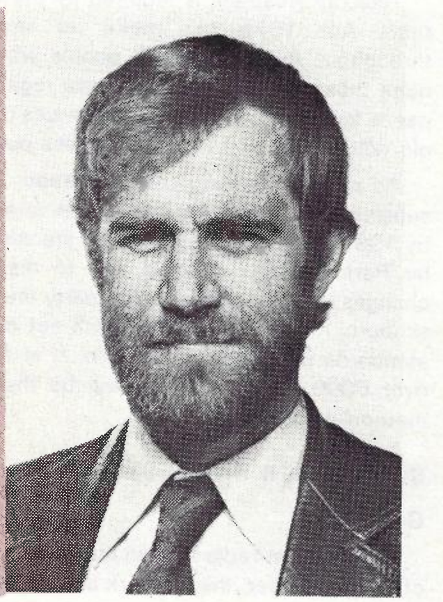
Service Area

Propagation in the VHF band can be extended beyond the radio horizon but given the constraints of spectrum conservation, available technology and the high quality of transmission required, in practice, subscriber systems are limited to the radio horizon. The horizon is, of course, dependent on the height of the antenna above ground.

GREIG BANNISTER joined the PMG's Department as a Technical Assistant in 1969. On graduating from the Royal Melbourne Institute of Technology with a Diploma of Communications Engineering he was appointed a Class 1 Engineer in the Radio Section, Headquarters in 1971.

He has been involved in system design and equipment evaluation of small capacity bearers, mobile and paging radio services. Over the last five years he has been concerned with all aspects of subscriber radiotelephone systems in the HF, VHF, and UHF bands.

He is currently a Class 2 Engineer in the Customer Section of the Headquarters Radiocommunications Construction Branch of Telecom Australia.



For example, if a radius of 40 km is to be achieved over flat terrain with a height of 10 metres at the subscriber's end, an effective height of 60 metres is required at the base station. High ground and existing towers are naturally taken advantage of wherever possible.

SYSTEM CONFIGURATION

The concentrator subscriber system connects subscribers over trunk radio links to an exchange using three main items of equipment, the exchange end equipment, the radio base station and subscriber end equipment. **Fig. 1** shows the basic system layout.

The exchange equipment needs to be located at an exchange. Its functions are to interface with the exchange and concentrate subscriber's lines onto the trunking links and their associated radio channels at the base station. If the selected base station site coincides with a carrier system terminal or repeater, or is near physical wire lines,

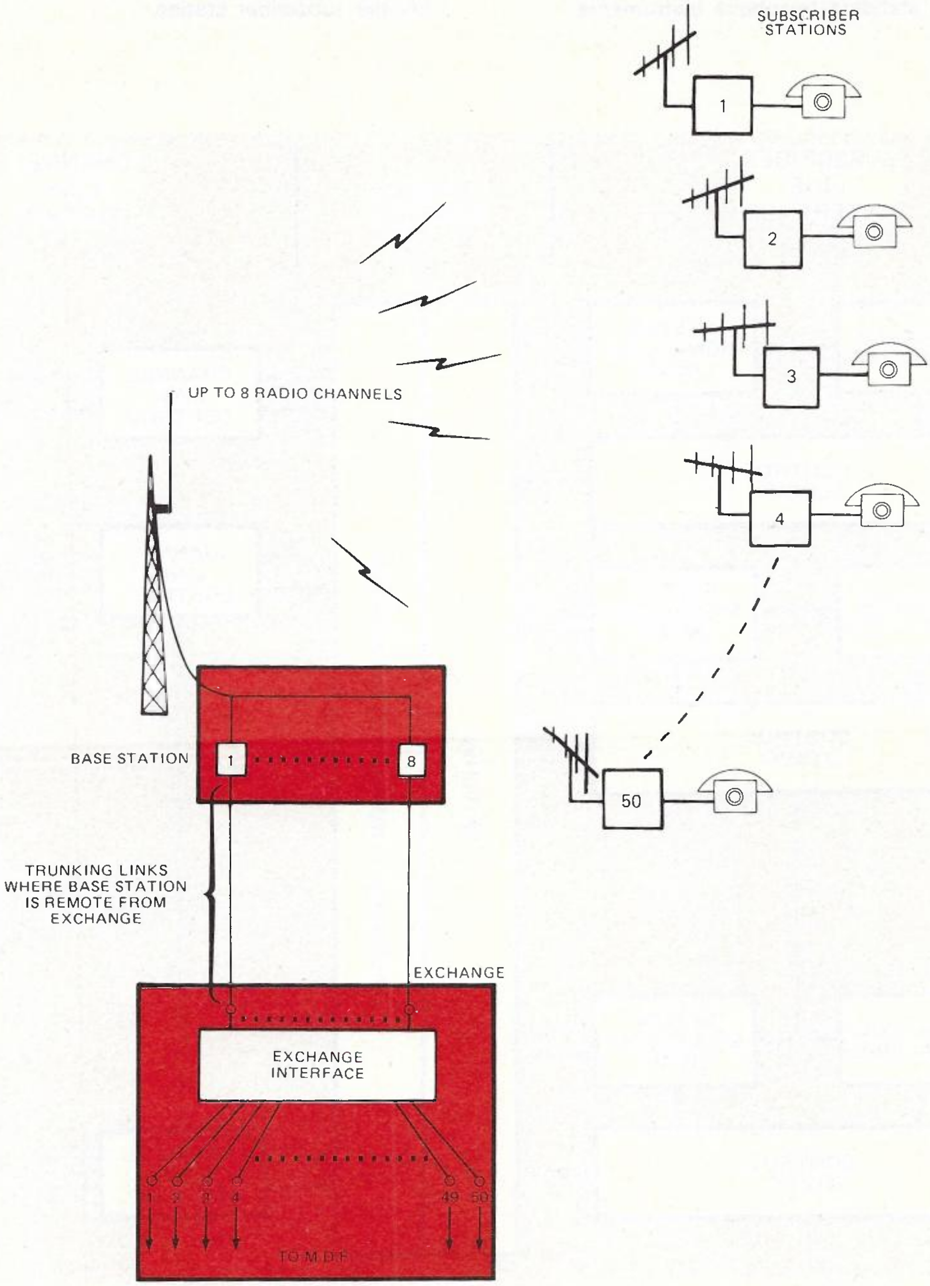


Fig. 1 — System Configuration

use is made of these facilities to provide trunking links. Where the base station is located remote from existing services trunking links will have to be installed.

Where possible the base station equipment is situated on high ground to augment propagation and increase the coverage area. The base stations' function is to frequency modulate a number of VHF carriers with the audio signals trunked from the exchange. Base station equipment may also be used to form the trunking links between base station and exchange.

The subscribers' equipment is capable of receiving and transmitting on any of the radio channels and interfaces with Telecom's standard telephone instruments.

SYSTEM COMPONENTS

A block diagram for each of the three main components of the system is given in **Fig. 2.**

Subscriber Equipment

The subscriber equipment is made up of signalling, logic, interface circuits and a VHF transceiver. The transmitter and receiver are similar to those used in VHF mobile services. The major difference is the ability of the two to change frequency automatically. The receiver, in the idle state, is continually scanning the channels assigned to the system searching for firstly an RF carrier and secondly the unique sequence of tones which identify the subscriber station.

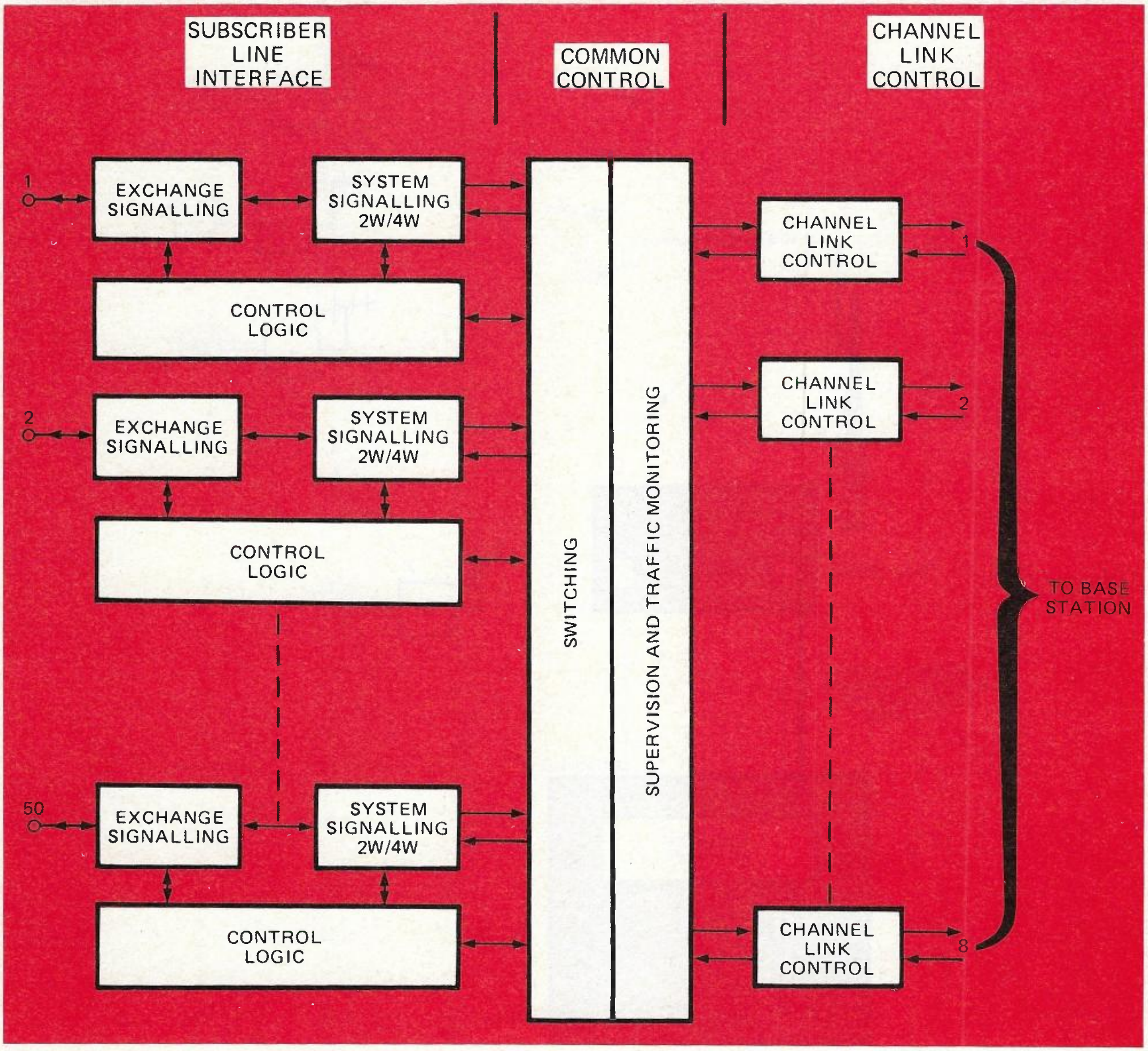
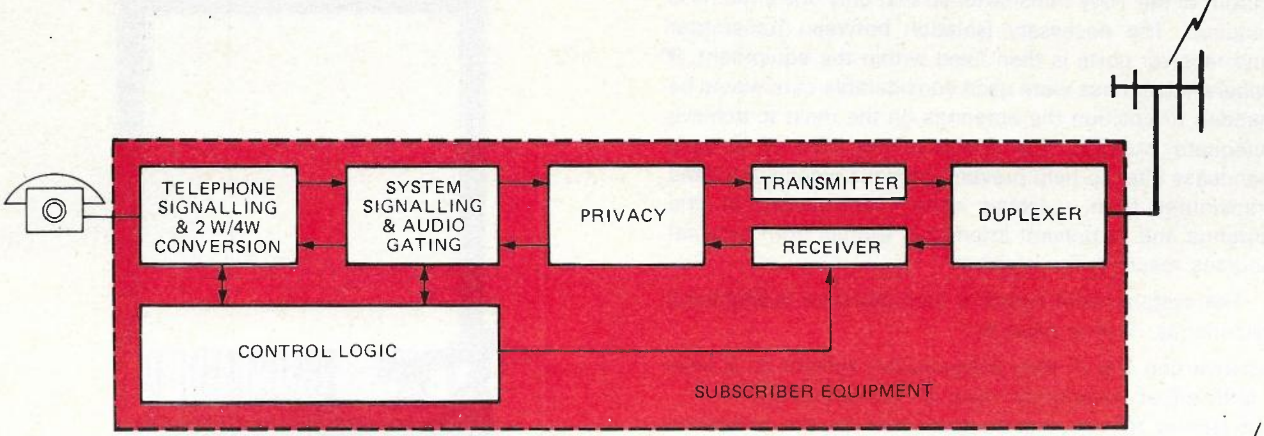
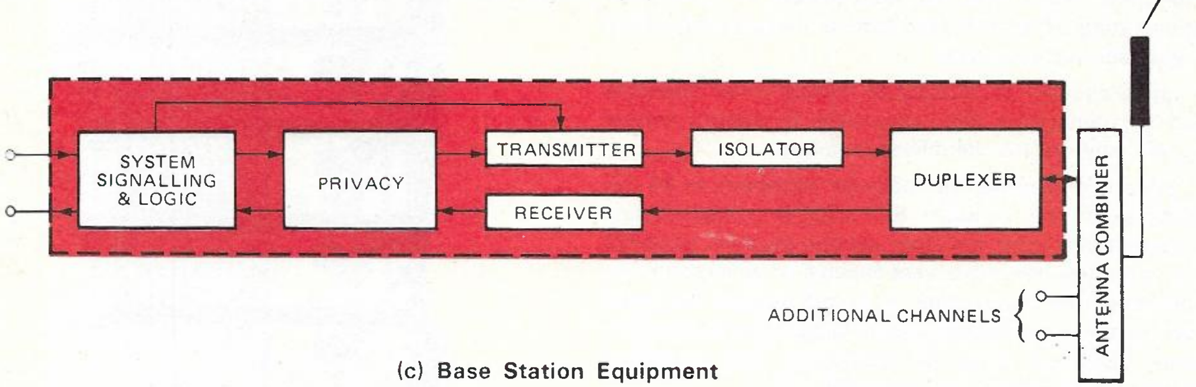


Fig. 2 — System Components — (a) Exchange Equipment



(b) **Subscriber Equipment**



(c) **Base Station Equipment**

Fig. 2 — System Components

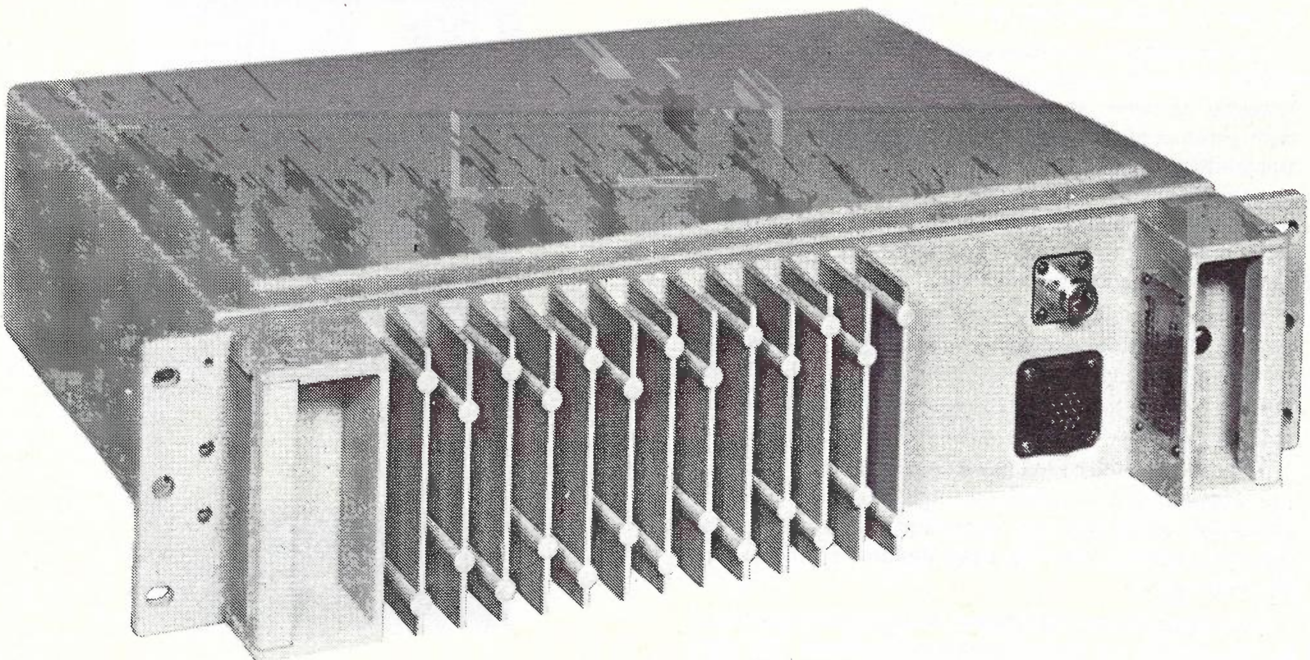


Fig. 3 — Subscriber Equipment

A duplexer combines the input of the receiver with the output of the 10W transmitter so that only one antenna is required. The necessary isolation between transmitter and receiver ports is then fixed within the equipment. If separate antennas were used considerable care would be needed to position the antennas on the mast to achieve adequate isolation. The duplexer may also serve as a bandpass filter to help prevent spurious signals from the transmitter from reaching either the receiver or the antenna and to prevent interfering signals from external sources reaching the receiver.

The system must interface with standard subscriber's telephones. This is done by:

- converting the 4 wire transmission system to 2 wire with either transformer type or active hybrids.
- detecting the DC signals generated by the telephone and converting them to voice frequency tones suitabie for transmission over the radio system.
- generating DC signals, feed current, meter pulses where required and busy tone.

Logic circuitry is required to control these functions and the generation and recognition of system control signals such as the identification tones.

Speech processing has become necessary in all unmultiplexed VHF Telecom R/T links to prevent casual eavesdropping with low cost general purpose receivers and some television receivers capable of tuning onto the radiotelephone frequencies. A simple method has been used to render the speech unintelligible when received on these consumer types of equipment. The subscriber equipment housing is shown in **Fig. 3.**

Base Station Equipment

Base station transceivers are fixed on one channel. One base station transceiver and associated equipment, is used for each channel of the system.

The base station duplexer performs the same functions as the subscriber station duplexer. An isolator is included, however, between the transmitter and duplexer to prevent external signals from cosited base stations or other transmitters on similar frequencies from reaching the transmitter. Without the isolator, it is possible that intermodulation products would be generated in the transmitter and be rebroadcast on a frequency likely to cause interference to concentrator or other cosited systems.

An antenna combiner allows the connection of more than one base station transceiver to a single antenna. The combiner provides isolation between the transceiver ports. The insertion loss between each transceiver port and the antenna is slightly greater than 3 dB.

Only enough logic circuitry is required in the base station equipment to respond to outgoing signals from the exchange equipment or incoming signals from the receiver output so that the base station transmitter may be switched on.

Each base station transceiver is housed in a steel container identical to the subscriber equipment. An eight channel base station is shown in **Fig. 4.**

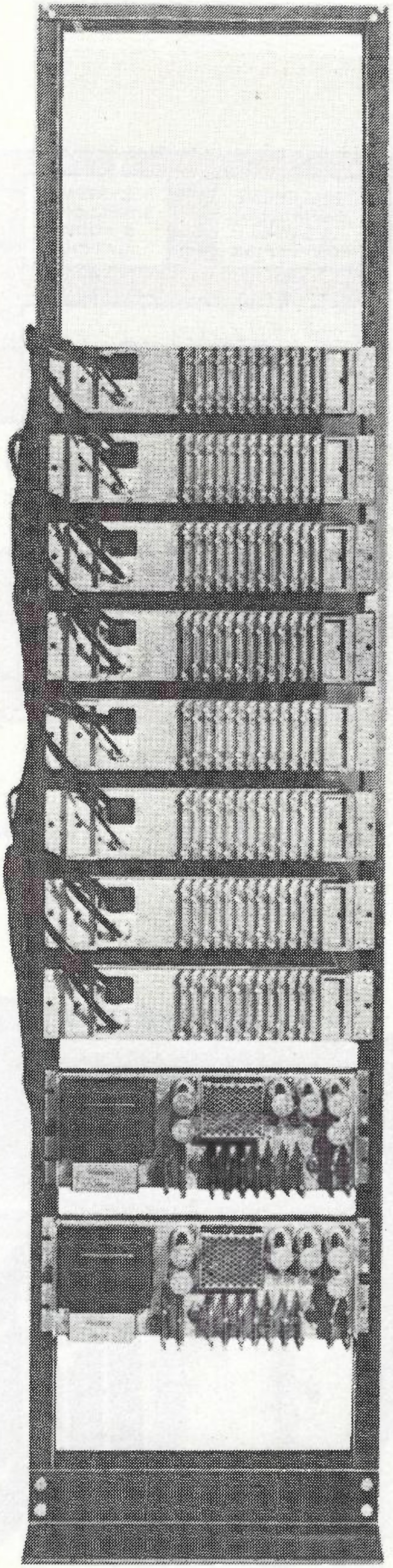


Fig. 4 — Base Station Equipment

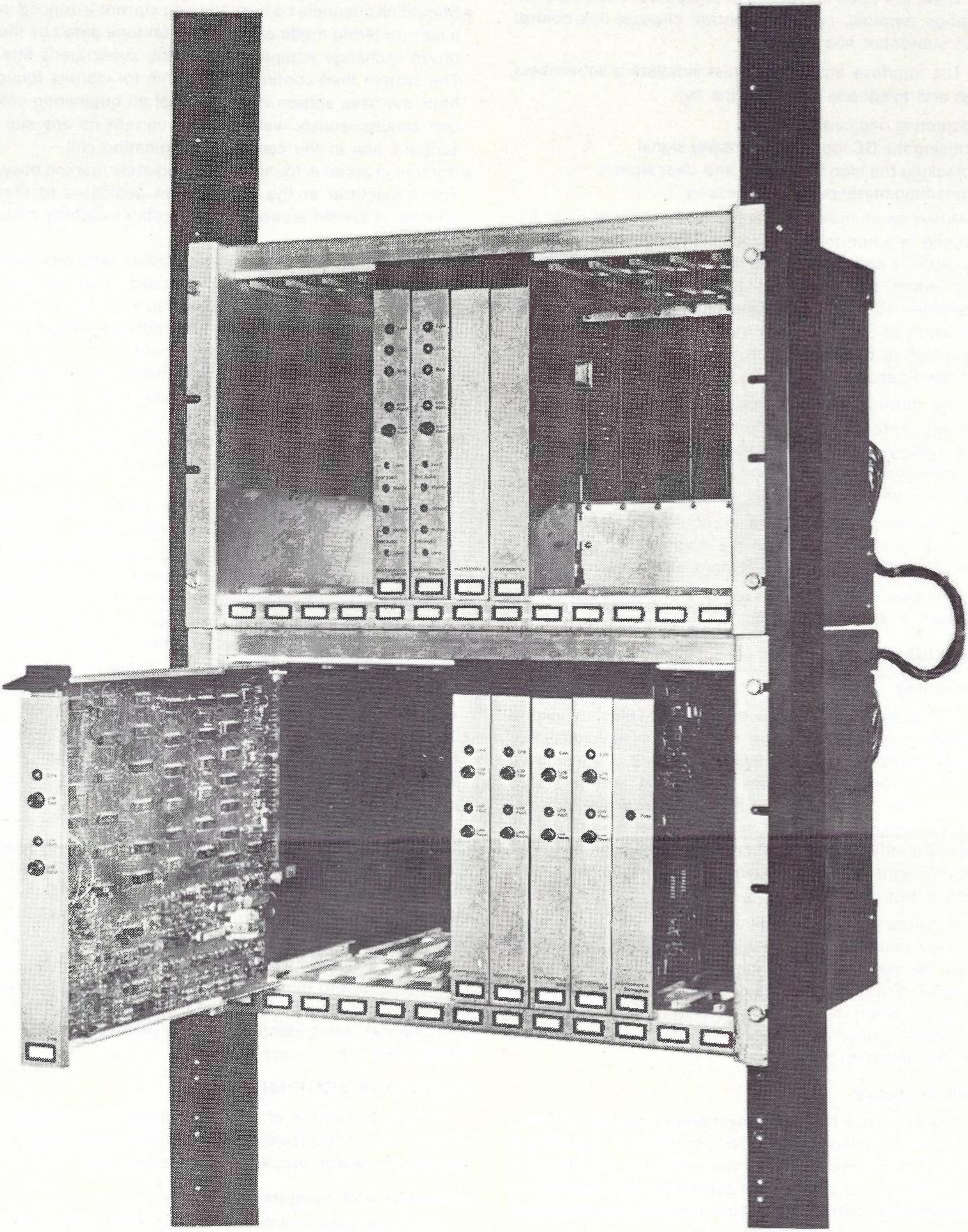


Fig. 5 — Exchange Equipment

Exchange Equipment

There are three categories of equipment within the exchange terminal, common control, channel link control and subscriber line interface.

The interface equipment must simulate a subscribers line and telephone. This is done by:

- detecting ring current
- closing the DC loop for the answer signal
- breaking the loop for dialling and clear signals
- detecting meter pulses if necessary

When no channels are available the system must trip the ring in a non-metering mode. The equipment release condition is also detected so that a system channel is not held when the subscriber line stages are no longer available. All these functions plus the generation and detection of identity tones must be done by equipment dedicated to each subscriber line. One plug-in module is provided per subscriber.

The common control equipment concentrates subscribers onto available channel link control modules. Supervisory and traffic monitoring circuits are provided. Outputs are available to indicate failed and successful calls and when all channels are busy.

One channel link module is required per channel. Its function is to interface with the 4-wire transmission link and control the base station transmitter.

Exchange equipment set up for 2 channels and 5 subscribers is shown in **Fig. 5.**

SYSTEM OPERATION

Signalling

The system currently purchased by Telecom uses a signalling code comprising four out of ten voice frequency tones sent sequentially. Each tone is transmitted for forty milliseconds. The number of unique codes available is almost 10,000 allowing large physical distances between systems before an identity is repeated. This is a safeguard against freak propagation conditions which might otherwise connect a subscriber from one system into another.

A non-continuous signalling scheme is used. This can be very reliable since signalling takes place before and after the conversation period, making use of the whole channel. Special signalling equipment, may be required however, when meter pulses need to be transmitted to a subscriber's private meter or STD public telephone during the conversation period.

Call Sequence

The sequence for the connection of a subscriber to exchange call is shown in **Fig. 6.** 'Handshake' signalling is used in this direction as in the exchange to subscriber case. Forward and backward signals are transmitted in a compelled sequence before the connection is established.

Referring to **Fig. 7** the sequence for connecting an exchange to subscriber call, is as follows:

- Ring current appears on the subscriber's pair at the exchange. This initiates a search in the group system exchange equipment for an available radio channel.
- Should all channels be busy the ring current is tripped in a non-metering mode and congestion tone gated by the group exchange equipment onto the subscriber's line. The system then continues its search for identity tones from the base station in the case of an originating call and simultaneously waits for ring current on any subscriber's line in the case of a terminating call.
- If a free channel is found it is immediately marked busy. The transmitter at the base station dedicated to that channel is turned on and the subscriber's identity code transmitted.
- On receiving an identity, all subscriber receivers stop scanning. Those subscriber stations that do not recognise the identity resume scanning. The station which recognises the identity transmits the same code backward to the exchange equipment.
- Providing the backward identity reaches the exchange equipment within a predetermined time, signalling tones are transmitted in sympathy with ring current. The subscriber's bell is not rung until the connection has been confirmed with both forward and backward identity tones.
- The tones representing ring current are decoded at the subscriber's station and ring current generated. This will continue indefinitely until the ring current at the exchange ceases for a time greater than the normal two seconds delay between ring-current bursts. If this is the case, the exchange equipment returns to idle as does the subscriber equipment on reception of a clear signal.
- If the subscriber lifts the handset a connect signal is transmitted to the exchange equipment where the line is looped. The conversation may then proceed.
- The connection is cleared when the radio system subscriber replaces the handset or if the calling subscriber replaces his handset and the equipment release signal is detected by the exchange. If, because of equipment failure, or exceptional propagation loss, the connection fails and one of the carriers is lost for more than five seconds, the system clears and returns to the idle condition.

The time allowed from the subscriber lifting the handset to the reception of dial tone or, in the case of a call in the exchange to subscriber direction, from receiving ring current to the subscribers' bell beginning to ring, is one second. Within that time the system must find a free channel, send identity tones in both directions and finally send the connect signal.

ANCILLARY EQUIPMENT

A large proportion of capital expenditure and approximately half of the faults associated with group systems are due to power supplies and external plant.

Antennas and Support Structures

The base station antenna system may consist of a large number of low gain antennas, each dedicated to a base station transceiver or a number of combiners which may couple all base stations onto one antenna. Given

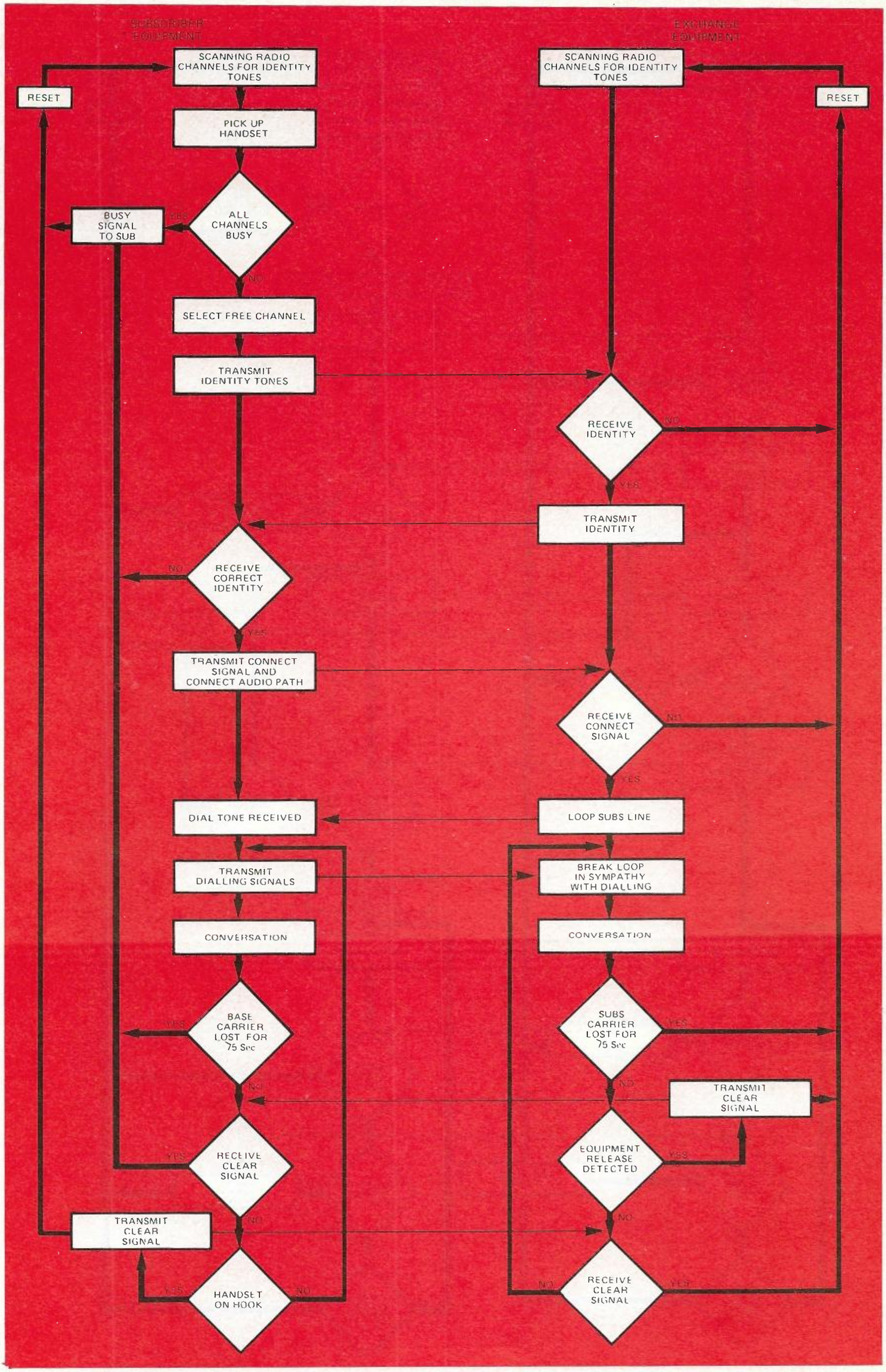


Fig. 6 — Call Sequence — Subscriber to Exchange

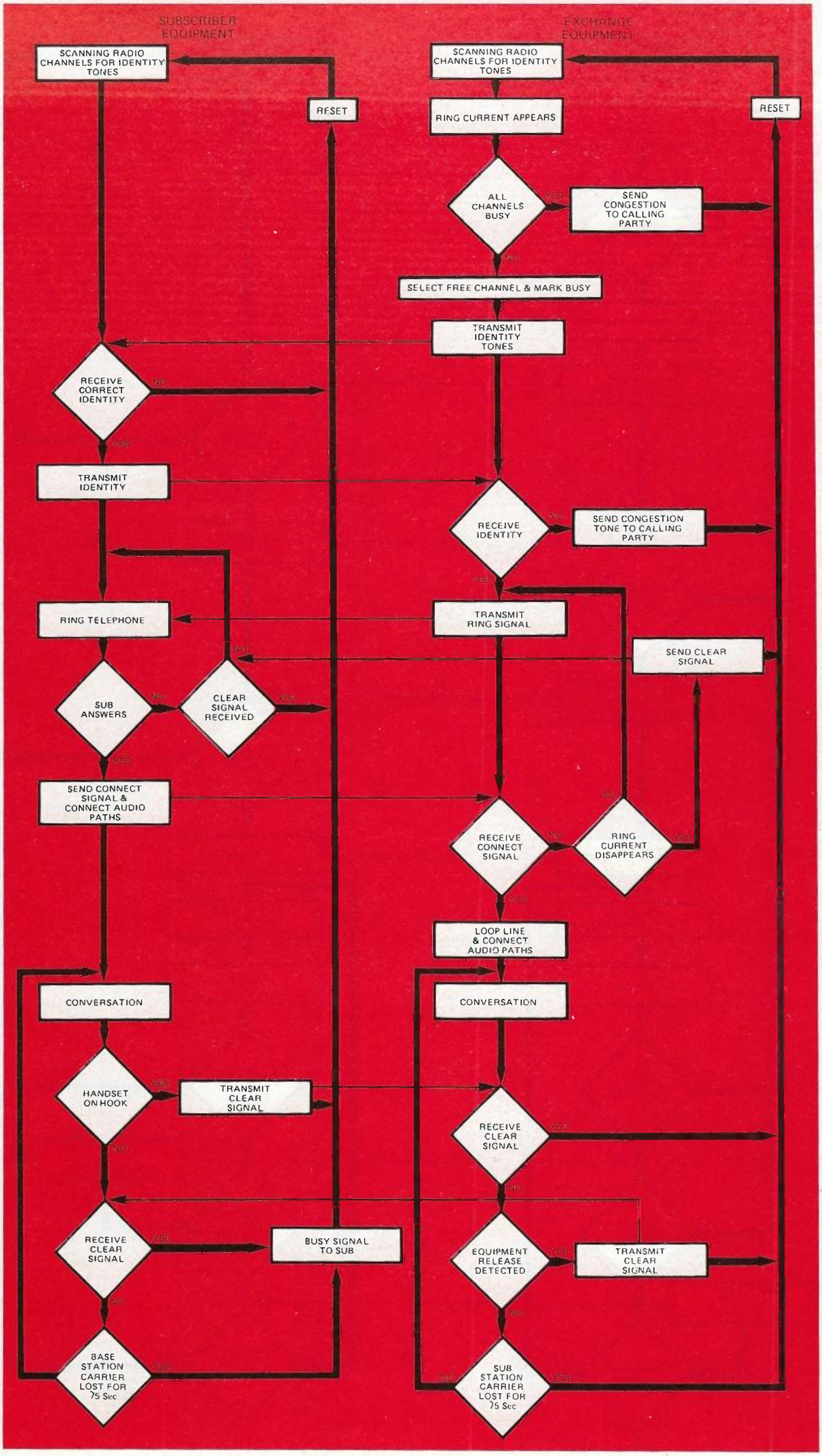


Fig. 7 — Call Sequence — Exchange to Subscriber

limited space for mounting antennas there is no system gain advantage of one scheme over the other. A large number of antennas, require a greater maintenance effort but more than one antenna is desirable so that redundancy is built into the system. In practice base station transceivers are combined into at least two 5 dBi (dB with respect to an isotropic antenna) colinear omnidirectional arrays.

As the base station will normally be located on a prominent geographical feature, to obtain good propagation paths, the antenna supporting structures will generally be guyed masts of from 10 metres to 60 metres in height. As an objective, the combined height of the base station and mast should not be less than 60 metres above the surrounding landscape. Where there are no prominent features in the region and the base station is located on flat ground it may be necessary to support the antennas with a steel tower or mast of more than 60 metres.

It is economically advantageous to use a tall structure at the base station and keep the large number of subscriber end structures as small and inexpensive as possible. A small structure on the subscriber's premises is also less conspicuous. A structure 10 metres in height is typical.

To reduce installation costs at the subscriber station, Queensland and New South Wales staff are developing standardised self supporting antenna and equipment shelter structures. Provision is made for power supply and battery mounting. Solar cell panels may also be mounted on the structure. The aim is to perform as much work as possible at the depot. At the subscriber station site the structure need only be placed in position and the radio equipment and power supply 'plugged in'. A trench is dug or alternatively aerial wires used for the telephone pair and power if available.

The subscriber station antenna is commonly a Yagi-Uda array. Subscribers close to the base station may only require an antenna of one or two elements while those remote may require, for example, a pair of 9 element arrays.

Power Supplies

Base station and subscriber transceivers require a + 13.6 volt supply and draw, on standby, about 80 mA and 150 mA respectively. When active each transmitter draws approximately 4 A. The exchange equipment requires a 48V supply.

Where the base station is located at a Telephone Exchange or at an existing carrier system repeater station or terminal, or near a line carrying power generated by an electrical power generating authority, use is made of these facilities to power the base station equipment. In each of the cases mentioned above one or other of the following power conversion methods are used:

- Telephone Exchange — Convert 48V DC to 13.6V DC.
- Carrier Terminals and Repeaters — Convert 48V DC or 24V DC to 13.6V DC
- Power Mains — Convert 240V AC to 13.6V DC and if necessary float a battery.

In cases where the base station is located remote from all the above facilities, the primary source of power may be any of the following:

- Petrol or diesel generators
- Wind generators
- Thermo-electric generators
- Closed cycle vapour turbines
- Air depolarised cells
- Solar cells

At the subscriber's premises power can be supplied by either the subscriber or Telecom. If reliable mains power is available from the subscriber no special equipment is required. A simple transformer/rectifier combination suffices.

In many areas of Australia, however, power is generated by the subscriber. This is generally a nominal 240V AC on demand system or 32V DC either positive or negative ground. In these cases a power supply is required to protect the radio equipment from power surges and to allow operation during periods when the generator is switched off. Special circuits are used to extend battery life and optimise charging rates.

As the cost of solar cells decreases, the cost difference between elaborate power supplies and more reliable solar power reduces. Due to the high cost of maintenance of remote systems it is more economical to power the subscriber station with solar cells if they operate for only 1 or 2 years without fault.

SPECTRUM USE

The VHF (150 MHz) and UHF (450 MHz) bands are suitable for concentrator subscriber radio telephone use. VHF signals provide good coverage with a tendency to cause interference due to anomalous propagation for only a small percentage of the time. As the frequency increases the probability of such interference reduces but the area coverage also reduces and equipment cost increases.

Wherever possible, VHF allocations are preferred with UHF reserved for areas of VHF congestion or restriction. In areas where substantial development is necessary both VHF and UHF allocations may be required, the UHF channels currently providing single channel systems (no UHF Concentrator Subscriber System is expected to be available before 1981).

The available spectrum has been arranged so that channels are allocated in a repeating pattern of seven cells. Each cell is assigned tentatively to a specific set of geographic co-ordinates and serves an area of approximately 50 km radius. The same group of frequencies may be re-used at situations separated by intervals of approximately 225 km. Allocations within the plan thus give protection against co-channel interference.

Each channel consists of a pair of frequencies, one for each direction of transmission. These are located 5.2 MHz apart so that the transmitter and receiver can be duplexed onto the one antenna using reasonably sized and priced filters. Channels may be spaced a minimum of 25 kHz apart.

FUTURE DEVELOPMENT

Repeaters

In some instances a number of subscribers are too remote from the base station to be reached in one radio hop. This may be overcome by installing repeating equipment with access to all of the system's channels. This type of repeater could be made up of a concentrator subscriber station 'back to back' with an exclusive service single channel system. The development of an interface between these two existing units is required so that a 4 wire connection is made. In the case of the existing system, performance objectives limit the number of repeaters in the base to subscriber link to one.

Wired Subscribers at the Base Station

Base stations may on occasions be located at a subscriber's premises. Presently, the subscriber needs to have a complete subscribers station installed even if only a few metres away from the base station equipment. It would appear to be more economical in these cases if the subscriber could be connected to the base station by wire but treated by the system as a 'radio' subscriber.

Subscriber End Line Voltage

The power supply voltage at the subscriber's station is currently a nominal 12V. Equipment without a voltage stepping-up facility can only apply a maximum of 12V to the subscriber's line. The resulting low telephone feed current severely limits the extension of the subscriber line beyond the subscriber radio station. In addition, some subscribers' equipment, a private meter for example, requires more than 12 volts to operate at all.

Power Consumption

The subscriber's station consumes approximately 2 watts average for a transmit time of one hour per day and an additional 2 watts continuously on standby. Receiver strobing or 'battery saving' techniques are now being applied to some subscriber radiotelephone systems, however, to reduce the average power drain in the standby mode to very low levels.

Base station transmitters are, of course, operating for much longer periods and the standby power is only a small portion of the total power consumed.

Since standby power is becoming negligible and there does not appear to be any significant transmitter power consumption reduction possible it would seem that there is little chance of further development in the area of total power reduction for the existing types of system.

Digital Systems

A time division multiplex system is being developed by Telecom. The advantages of digital modulation particularly applicable to subscriber radio services include reduced power consumption, inherent privacy and signal regeneration allowing systems to be extended through a large number of repeaters.

Delivery of the first digital systems is planned for 1984.

CONCLUSION

The concentrator subscriber radio system is a complex means of providing a subscriber link. There is a radio path to be examined for each subscriber, spectrum planning is required and the equipment itself, when compared with a cable connection, is extensive. There may be as many as 100 integrated circuits used for each subscriber connection. The concentrator system has, however, proven itself to be cost effective in the provisioning of a reliable telephone service in the remote and rural areas of Australia.

The successful introduction of this system into the Telecom network has resulted from a considerable amount of work both in Headquarters and the States. In particular, Queensland administration have conducted system field trials and network interface studies.

Automatic Call Distribution System — ASDP 162

P. A. BROWN, B.E., M.E., M.I.E.E.E., M.I.R.E.E., and D. W. CLARK, B.E.

The ASDP162 is a stored-program digital Automatic Call Distribution System (or Queue System) which has been developed and manufactured by L. M. Ericsson, Australia. It is presently in service in Australia and several overseas countries with organizations such as airlines, credit companies, betting agencies and telephone administrations.

This paper describes the way in which such organizations may use the facilities offered by ASDP162, and outlines the basic structure and operation of the system.

INTRODUCTION

Many large organisations such as airlines, taxis, newspapers, credit agencies, and service authorities like gas, electricity, police, employ large numbers of people for the purpose of answering incoming calls.

Facilities beyond those of a normal PABX are required, and an Automatic Call Distribution (ACD) System like the ASDP162 will provide sophisticated service to such organisations, enabling them to optimise the staffing arrangements for call handling and at the same time obtain detailed information concerning the performance of the system and its associated trunks and operators.

The ASDP162 system, marketed by L. M. Ericsson, is structured with duplicated central processors to provide close to 100% service availability and with regional processors to enable economical expansion for both small and large users. The system was wholly designed by L. M. Ericsson in Australia.

The digital switch is congestionless and provides full traffic availability for up to 500 operators and 500 trunks. Incoming calls are handled strictly in arrival sequence.

The system caters for up to a four-level operator structure, consisting of operators, monitors, supervisors and a master supervisor.

Fig. 1 shows the Basic System Structure.

Particular attention has been given to simplifying maintenance, and the modularity of the system permits specialised facilities to be added easily.

PRINCIPLES OF ASDP162

ASDP162 makes full use of its stored program control to provide a sophisticated facility package to satisfy the needs of a wide range of customers.

The basic administrative structure of a queueing system is shown in **Fig. 2.** Incoming trunks are divided into trunk routes, which define the origin of the call. Trunk routes are then associated with trunk groups, either by data tables in the case of direct-in routes or by indialled digits. The trunk groups are the actual queues, each with first-in first-served discipline. When a call arrives in a trunk group, the overflow pattern is consulted to decide to which operator group the call should be directed. The overflow pattern specifies, for each trunk group, a first choice operator group and up to three alternative operator groups. If a free operator is still not found the call goes into delay in the associated trunk group queue.

While in delay, the call receives ring tone until one of three events occurs. The caller may hang up, in which case the call is abandoned and removed from the queue. The call may wait for such a time that it is switched to a recorded announcement which advises that delays are being experienced and that service will be given as soon as possible. The third possibility is that an operator becomes available to take the call. When an operator becomes available, the operator group number is used to consult the priority pattern to decide from which trunk group a waiting call should be taken. The priority pattern

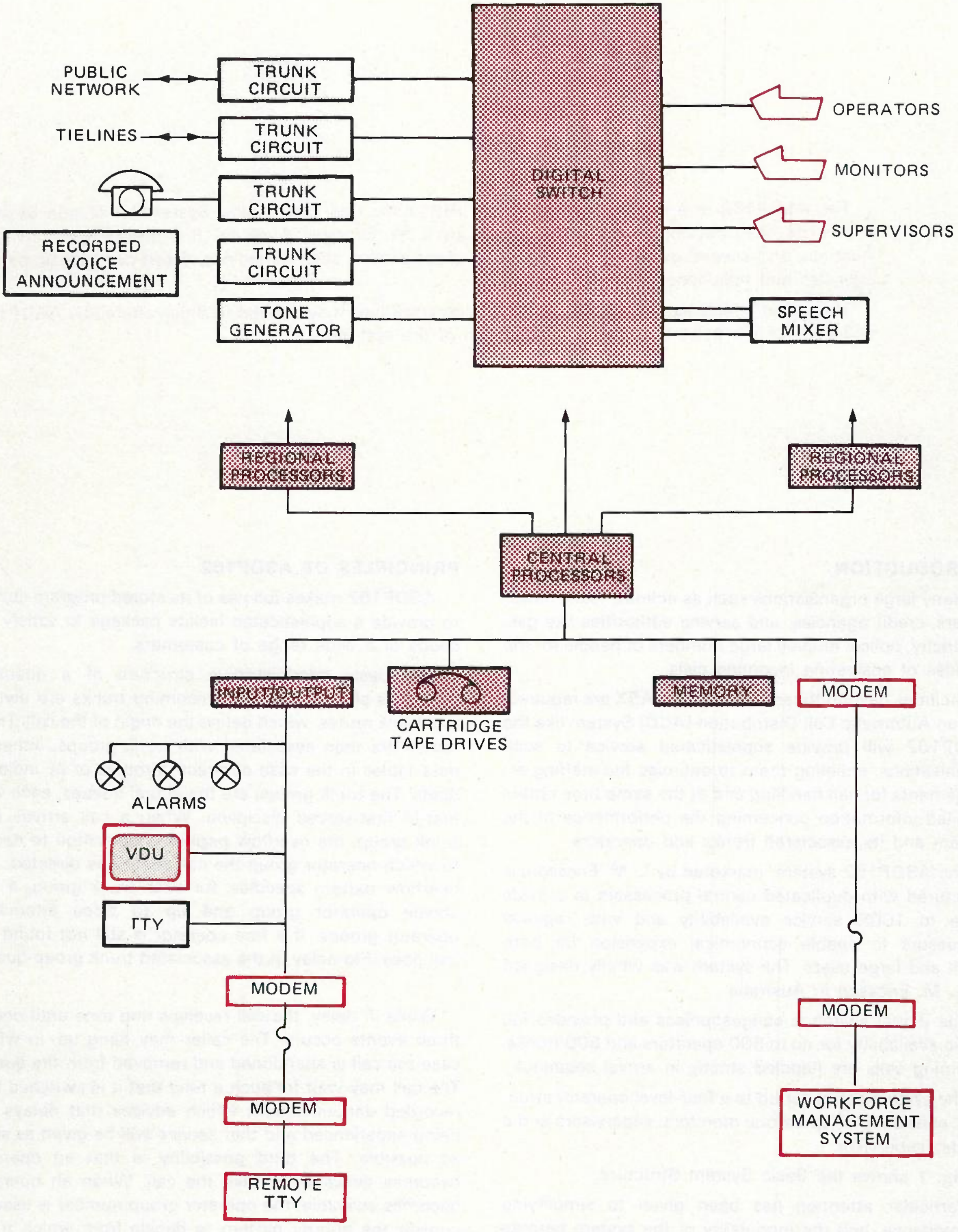


Fig. 1 — Basic System Structure

specifies for each operator group, a first choice trunk group and up to three alternative trunk groups. If there is no waiting call, the operator goes into the free list in the associated operator group. The operators are also organised into monitor groups for the purposes of supervision and assistance. This allocation is defined by data tables.

Monitor positions may be categorised as monitors, supervisors or master supervisors. Supervisors and master supervisors in general have no operators assigned to them and might not handle traffic. They do, however, have access to a higher level of system facilities and may use an I/O device (VDU) to reconfigure the system queueing structure to handle varying traffic conditions.

FACILITIES OF ASDP162

Having dealt with the broad principles of the system, the detailed facilities are now considered, in the following categories:

- general system facilities
- operator facilities
- monitor facilities
- supervisor facilities
- master supervisor facilities
- maintenance facilities

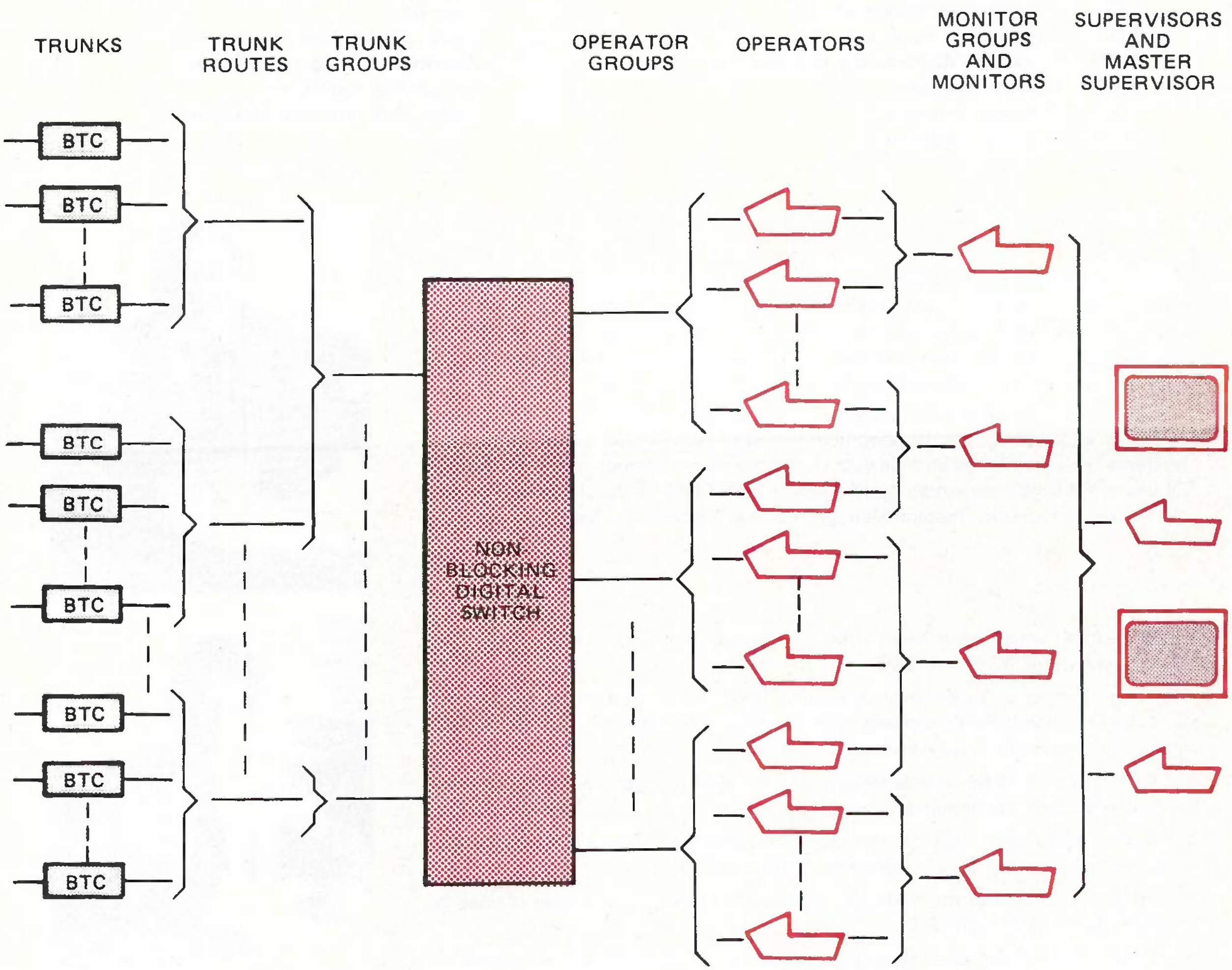
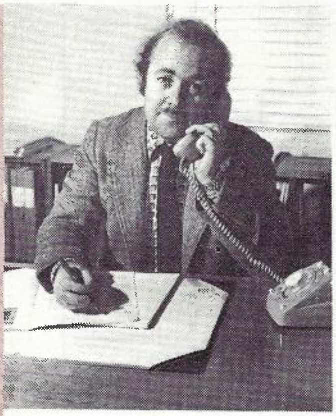


Fig. 2 — Queueing System Structure

Nomenclature

ACA	Asynchronous Communications Adaptor
APT	Switching System
APZ	Data Processing System
BDM	Bus Distribution Magazine
BDS	Bus Distribution Subsystem
BTC	Bothway Trunk Circuit
BTX	Bus Terminator and Extender
CLM	Communication Link Magazine
CML	Communication Link
CP	Central Processor
CPM	Central Processor Magazine
CPS	Central Processor Subsystem
CPU	Central Processor Unit
DDR	Differential Driver & Receiver
DPE	DDual Port Extender
DTX	Digital Switch
DWA	Direct Word Access
DXM	Digital Switch Magazine
DXS	Digital Switching Subsystem
I/O	Input/Output
IOM	Input/Output Magazine
IOS	Input/Output Subsystem
KDR	Keyset Data Receiver
MAS	Processor Maintenance Subsystem
MDM	Modem Interface
MEM	Processor memory
MYM	Memory Magazine
ODI	Operator Display Interface
OMI	Operator and Monitor Interface
OMS	Operation and Maintenance Subsystem
OPM	Operator Circuit Magazine
OPS	Operator Subsystem
OSM	Operator Speech Mixer
PIM	Power Interrupt Magazine
RGU	Ring Generator Unit
RP	Regional Processor
RPM	Regional Processor Magazine
RPS	Regional Processor Subsystem
RVA	Recorded Voice Announcement
SBM	Standby Bus Magazine
SDM	Standby Bus Distribution Magazine
SPI	Serial to Parallel Interface
TCM	Trunk Circuit Magazine
TCL	Tape Control Logic
TCS	Traffic Control Subsystem
TGU	Tone Generating Unit
TPM	Tape Drive Magazine
TRM	Bus Terminator/Repeater
TSS	Trunk & Signalling Subsystem
TTY	Teletype
VDU	Visual Display Unit
WMS	Workforce Management System
XBI	Switch Bus Interface
XBM	Switch Bus Interface Magazine



PETER BROWN joined Telecom in 1964 as a Cadet Engineer and graduated from Sydney University with a Bachelor of Engineering degree in 1967. He worked in the NSW Network Performance and City Exchange Service sections for two years, and obtained a Master of Engineering degree in the field of radio astronomy from the University of New South Wales in 1969.

He joined L. M. Ericsson in 1970 and spent several years in Australia and Sweden engaged in the development of SPC private and public switching systems. This was followed by a year participating in the study of the realisation of digital subscriber networks, and he joined the ASDP162 development team in 1976. He is currently Project Manager for the ASDP162 project.

DON CLARK joined the APO in 1956 as a cadet engineer and graduated from the University of NSW in 1960.

Before joining L. M. Ericsson in August 1966, he worked in the Telegraphs and Data division in NSW and was responsible for the installation and cutover of the initial automatic telex exchanges in NSW.

From 1966 to 1968 he was responsible for ARM register design for national and international applications.

During 1969 and 1970 he worked in Sweden and Australia on the international field trial of CCITT Signalling System No. 6.

He was Manager of the AKE 13 international gateway exchange project in Sydney during 1971-1973.

Since 1974 he has been Manager in charge of SPC systems development in L. M. Ericsson Australia.

General System Facilities

- Incoming, outgoing and bothway trunks, using ring-in/loop-out and loop-in/ring-out signalling interfaces.
- Trunks to the local main exchange, tie lines to an associated PABX, remote outdoor extensions, distant exchange services, etc.
- Incoming routes classed according to originating exchange type, destination queue, and special route facilities.
- Flexible queueing strategies, with first-in first-served discipline within each queue, priority distribution of queued calls to operator groups.
- Indialling to trunk groups and/or individual operators.
- Enquiry and transfer between an operator and other operators, operator groups, monitors, supervisors, etc.
- Separate transfer queues used for transfer before answer to operator groups, having priority over the normal delay queues.
- Three-party conference controlled by monitor.
- Night service to an operator group.
- Multiple recorded voice announcements.
- Abbreviated dialling.
- Conversation recording.

Operator Facilities

- Keyset signalling, LED and alphanumeric displays.
- LED display of incoming call origin and trunk number.
- Indication of calls waiting.
- Indication of status of held and transferred calls.
- Demand recall of all displays including connected trunk route, trunk number, operator group and operator number.
- Direct (one-key) signalling to associated monitor for assistance.
- Four outgoing call access categories including three-digit trunk discrimination analysis.
- Connection to specific waiting call, outgoing trunk, monitor or supervisor.
- Headset jack-in condition to enable all call connections except the accepting of queue calls, with an "available" key being pressed to accept queue calls.
- "Hands-free" operation by the operators in accepting and clearing from queue calls.
- Hold and park facilities with a customer-selected "hold-interest tone" (which may be music) being sent to trunks in hold, in park, in a transfer queue and after recorded voice.

Monitor Facilities

- Able to perform all operator functions.
- Expanded LED display to allow status display of an individual operator or trunk, and of a monitor group of operators.
- Secret or non-secret speech monitoring of individual operators.
- Intrusion into operator connection with two or three-party conversation, and takeover a call from the operator.
- Demand display of an individual operator status, showing call state, category, trunk groups allocated, trunk group connected, and type of call connected and/or held.
- Real time updated supervision display of a monitor group, showing the state of each operator in the group.
- Identification of any operators not meeting call handling performance time limits.
- Ability to program the abbreviated dial store.

Supervisor Facilities

- Able to perform all monitor facilities.
- Provided with a monitor console and I/O device (VDU and high-speed printer).
- Real time system performance supervision using the Trunk Group Status Report and Operator Group Status Report.

Master Supervisor Facilities

- Able to perform all supervisor facilities.
- Provided with a monitor console and I/O device (VDU and high-speed printer).
- Able to alter the following system configuration parameters:

  Operator categories
  Operator group allocation
  Monitor group allocation
  Trunk route-trunk group allocation
  Trunk group-operator group allocation
  Operator group-trunk group allocation
  Indialled code-trunk group allocation
  RVA-trunk group allocation

- Able to alter the following system performance level parameters:

  Clerical time limit per operator group
  Conversation time limit per operator group
  Answer delay time limit per trunk group
  Conversation time limit per trunk group
  Conversation time limit per outgoing trunk route
  Faulty trunks service limit per trunk route
  Maximum expected delay service limit per trunk group
  Non-seized trunks service limit
  Lost or abandoned calls service limit

- Able to activate special facilities such as night switching and spontaneous printouts.
- Indication of system alarm conditions.

Maintenance Facilities

- Ability to place individual trunk and operator magazines in and out of service.

- Ability to place individual regional processors in and out of service and to load a regional processor from magnetic tape cartridge during traffic handling.
- Ability to set up test connections through the digital switch.
- Provision of system diagnostics tests for testing the central processor bus, regional processor and bus, and paths to the regional processor.
- An informative alarm buffer, printed out on an I/O device which records all details of system alarms.
- Supervision of faulty trunks, non-seized trunks and lost or abandoned calls.

Other aspects of the maintenance facilities are discussed later in Operation and Maintenance.

SYSTEM DESIGN

Basic Concepts

The ASDP162 has the following features designed to meet the requirements of an automatic call distribution system:

- the system must be capable of handling a large volume of calls.
- a wide range of queueing configurations must be available with a strict first-in first-out discipline within each queue.
- the system must be flexible and modular.
- the system must achieve a high level of operational availability through the use of inherent reliability and built-in redundancy.
- a wide range of facilities must be available.
- the system must provide a comprehensive input-output system, handling teleprinters, VDU's and cartridge tape drives.

These features are provided by the ASDP162 system structure shown in Figure 1, and have been achieved by the use of stored program control and a non-blocking digital switch. A two-level processor hierarchy, consisting of duplicated central processors (CP) and up to five unduplicated regional processors (RP) is used, and the APN162 minicomputer is used at both levels. There is complete redundancy in the CPs, with one CP working as executive and the other as standby, and they communicate via a communication link. The redundancy structure of the processing system is such that no single component failure can stop operation.

Interworking between the executive CP and each RP is by means of a two-way communication buffer which is located in RP memory but into which the CP has direct memory access. Normal cyclic buffer working is used, with special measures taken to ensure that both the CP and RP do not attempt to access the buffer simultaneously. CP and RP service the buffer regularly during their job handling and distribute the signals to the appropriate subsystems.

The control of the system is handled by a job table in the executive CP. The scheduling of jobs is tied to a "primary interval" signal, which is generated every 8.3 ms by the real time clock. When this signal occurs, the executive CP commences a priority-structured job table. After each job, a check is made on whether the 8.3 ms has expired. If it has not, the next job is executed, whereas if it has, the job table is recommenced. Typical jobs in the executive CP are: read RP buffers, update standby CP, check RP integrity, handle I/O, and perform low-level maintenance tasks. Similar job tables control the operation of the standby CP and each RP.

If the CP detects that an RP is faulty, an alarm is raised and the CP takes over the control of the traffic devices normally served by the failed RP. The access to the devices is via a standby bus **(Fig. 3)**, and the CP enters a special emulation job table which contain extra jobs normally handled by an RP.

The switching subsystem in ASDP162 is a single-stage non-blocking digital bit-switch, which is controlled directly by the executive CP. The switch is one-way, and has capacity for 1152 terminations. Each operator and trunk circuit requires an inlet and outlet appearance on the switch, and a two-way speech connection requires two unidirectional connections to be established. The nominal capacity of the switch is 500 trunks and 500 operators, with other inlets being used for the connection of the digital tone generator units, recorded voice announcements, speech mixers, etc.

Software Design

The philosophy of the software system and its structure is based on both the characteristics of the ASDP162 processing system and experience gained in the development of other large software systems.

This philosophy is characterised by the following basic concepts:

- the software should be in modules able to be reassembled independently of each other.
- the modules should consist of both program and data and the interwork between modules should be by program.
- programs executed by the regional processors should consist of repetitive tasks which require no installation dependent data. Configuration data required for RP programs should be able to be derived by the programs themselves.
- the central processor should have sufficient capacity to be able to handle its own functions as well as the functions of one failed regional processor without significant degradation in response times.
- the RP program should be located in both the CP and RP and should be derived from the same source program.
- the standby CP should monitor the executive and take over its function in the event of failure of the executive.

- the executive CP should be able to update the standby in real time.
- the same generic program should be used for all similar installations with only the specific exchange data being different.

The concept of functional modularity involves the definition of a block, which is a "black box" in terms of implementation but which is precisely defined in terms of function, and which has a precisely defined interface, involving signals and data, to other blocks. The block is then broken into sub-blocks which are defined in the same manner as the block and which will realise the required functions of the block. This procedure is repeated until a level is reached where each block is a convenient handling unit for the purposes of design, testing and documentation.

The ASDP162 software design has a four-level functional structure:

- System level 1, which is the complete product ASDP162.
- System level 2, which is made up of the switching system APTP100 and the data processing system APZP100.
- Subsystem level, which comprises five APT subsystems and five APZ subsystems. APT is divided into subsystems according to the conditions and requirements of the traffic handling and operations functions. APZ is divided into subsystems according to the demand for a central and regional processor system. There must also be I/O and processor maintenance capabilities.
- Function block level, which is made up of fully-hardware and fully-software function blocks.

The software system consists of eight software subsystems, which interwork with each other through program signals. Three of the subsystems are implemented in RP and all but one are implemented in CP.

The subsystems are:

Central Processor Subsystem CPS

For scheduling of jobs in the central processor and for communication between the executive and standby CPs and between the CP and RPs. It also handled the job rescheduling necessary to enable the CP to emulate a failed RP.

Maintenance Subsystem MAS

For handling of hardware faults in any of the processors (CP or RP).

Input Output Subsystem IOS

For communication between the software system and the peripheral devices (VDU, teletype, cartridge tape units).

Traffic Control Subsystem TCS

For the traffic switching in the system.

Operation and Maintenance Subsystem OMS

For compilation of statistical data relating to system status and performance, and the administration of alarms.

Regional Processing Subsystem RPS

For scheduling of jobs in the regional processors and communication between CP and RP.

Trunk Signalling Subsystem TSS

For scanning and interpretation of signals received from trunk magazines and for sending of all signals to trunk circuits.

Operator Subsystem OPS

For scanning and interpretation of key signals from operator magazines and for sending lamp and tone signals to these operator magazines.

Hardware Design

The hardware structure of ASDP162, shown in block diagram form in **Fig. 3,** has the following characteristics:

- duplicated central processors, each with its own memory, bus, tape drive and access to the regional processors.
- up to five identical regional processors, each with a bus which gives it access to up to 16 magazines of traffic-carrying devices (a magazine may handle 16 operators or 15 trunk circuits).
- access from each central processor bus to each regional processor via two paths. The first path is used during normal operation and involves direct memory access between the executive central processor and the regional processors. The other path is used by the executive central processor during the emulation of a failed regional processor.
- access from each central processor to the digital switch and the input/output device magazine.

A description of the hardware can be related to the functions of the magazines:

Central Processor Magazine CPM

Contains the four-card APN162, 7K words of memory, ROM loader, the processor real time clock, interface to the tape drive, interface to the system bus and a control panel for use during maintenance.

Memory Magazine MYM

Contains up to 40K words of memory and an interface to the system bus. One MYM is provided for each CPM.

Communication Link Magazine CLM

Contains circuitry for supervising the communication between the executive and standby central processors, and for monitoring the integrity of each CP.

Bus Distribution Magazine BDM

Contains the central part of the interface between the CP buses and the RP bus of one regional group.

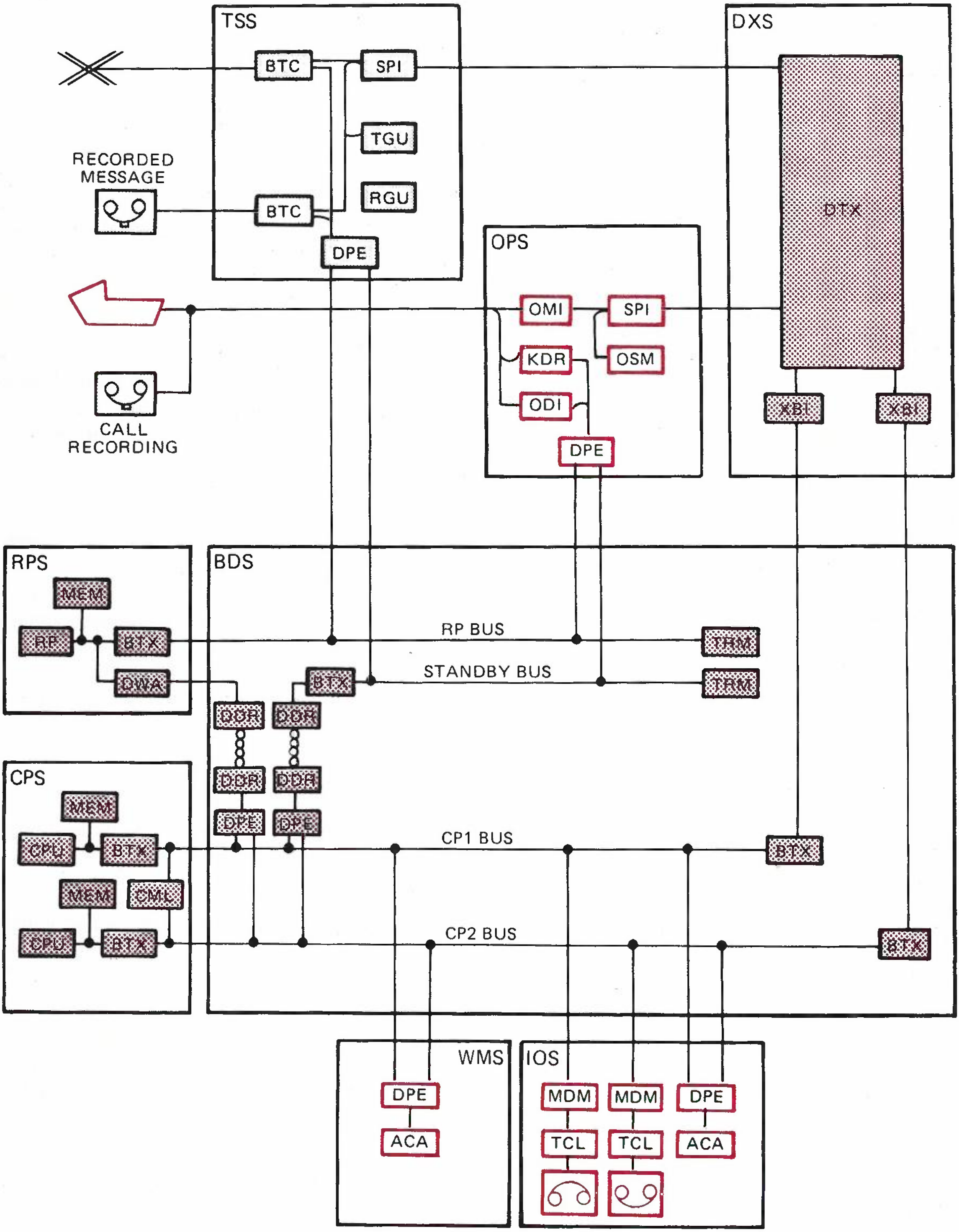


Fig. 3 — ASDP162 Hardware Structure

Standby Bus Distribution Magazine SDM

Contains the central part of the interface between the CP buses and the standby bus of one regional group.

Digital Switch Magazine DXM

Contains four 64-groups (each with its own power supply) of the digital switch.

Switch Bus Interface Magazine XBM

Contains the interface between the digital switch and a central processor bus.

Input-Output Magazine IOM

Contains the interface circuits (ACA) between the CP buses and the I/O devices such as teleprinters and VDUs.

Tape Drive Magazine TPM

Contains the cartridge tape drive mechanics and control circuitry. There is one TPM provided for each central processor.

Power Interrupt Magazine PIM

Contains circuitry which initiates automatically a system load when system-power is restored after power failure.

Regional Processor Magazine RPM

Contains the four-card APN162, 8K words of memory, ROM loader, the processor real time clock, interface to the system bus, and the regional part of the interface to the CP buses.

Standby Bus Magazine SBM

Contains the regional part of the interface between the central buses and the standby regional bus.

Operator Magazine OPM

Contains interface circuits for a group of 16 operators.

Trunk Circuit Magazine TCM

Contains 15 trunk circuits, together with their interface to the digital switch and the regional buses.

Mechanical Design

ASDP162 is built up in packaging system BYB101 which features the practical use of true functional modules, direct cabling between units by use of standard connector cables, cable connections accessible from the front, high natural cooling capability and flexible mounting of power supplies.

All components are mounted on double-sided fibreglass printed circuit boards and all boards are of uniform size (type TVF 113) and are mounted in BFD magazines. The full range of magazine widths is used, from number 1 (122 mm) to number 8 (975 mm).

L. M. Ericsson approved components are used throughout ASDP162. These include TTL integrated circuits (low power Schottky) for most processing and control functions, 4K dynamic MOS memories, and miniature relays for interfacing to the public network. A special component is used at the analogue-digital and digital-analogue interfaces. The ASDP162 has a digital bit-switch designed with delta modulation techniques and utilising codecs which are integrated devices with a small number of associated discreet components.

A feature of the mechanical design is the use of the BYB101 mechanical structure which permits comparatively short installation times.

OPERATOR CONSOLES AND FUNCTIONS

Two operator console types are provided in ASDP162. The standard operator console is installed in normal operating positions and can handle both incoming and outgoing calls. The more complex monitor console is installed in monitor positions, as well as in supervisor and master supervisor positions.

Standard Operator Console

The console includes a headset jack, a standard 12-digit keypad and also a number of function keys associated with system facilities. A second headset can be connected for operator training.

Operator Console Facilities

Staffing a Position

The procedure is to plug the headset into the console jack, perform a lamp test and make the console ready to receive incoming calls.

Answering Calls

The normal system operating mode is for a new call to be connected automatically to an operator following a warning tone. The warning tone can be directed to either the headset or both headset and console under operator control.

Alternatively a key-to-answer mode can be provided. When the call is connected, the call origin is displayed (route number) and the operator can answer accordingly with this prior knowledge.

Call Transfer

The operator can transfer calls.

Call Release

The normal operation is that a call will be disconnected automatically when the calling subscriber releases, but alternatively the operator can force-clear by key operation. After release the position is immediately available for a follow-on call.

Clerical Time

If an operator requires time after the call for clerical activity, the reception of further calls can be delayed by means of a key operation; follow-on calls will be withheld from that operator position until it is made available again.

Assistance Call

At any time an operator can request assistance from a monitor by a single key operation; the monitor can listen or intrude on the call.

Outgoing Calls

An operator can make internal calls to other operators or can make outgoing calls to the public telephone network.

Monitor Console Facilities

The monitor console has the same key and lamp functions as the standard operator console but is equipped with a number of additional displays. Monitors can perform all normal operator facilities as well as the following:

Listen and Intrusion

A monitor can listen-in to an operator position by key operation or can optionally form a three-party connection with the operator and the other party.

Time Out

All phases of operator calls are supervised. An indication of time-out will appear on the associated monitor position.

Operator Group Supervision

The 100-lamp display can be used by the monitor to display the status of up to 20 operators as a group with five lamps indicating the status of each operator.

Individual Operator Supervision

The 100-lamp display can also be used to display detailed information concerning the status and categories of any desired individual operator.

INPUT/OUTPUT FACILITIES

A typical provisioning of input/output devices in an ASDP162 installation is a 300 baud teleprinter in the equipment room for use during maintenance, a 2400 baud VDU for use by the master supervisor for system performance monitoring and reconfiguration and a remote 300 baud teleprinter (connected via a modem) in the Telephone Administration's maintenance centre.

Each I/O device interfaces into the system via the standard Asynchronous Communications Adaptor (ACA) and in principle each is handled in exactly the same manner.

There are some 60 commands available from an I/O device. Each command consists of a five-letter keyword followed by the required parameters. Each command causes a response, which may consist of a simple message (e.g. RECORDING GROUP 1 ACTIVATED), or a table.

Normal input/output facilities are also provided at each device.

Among the more unusual input/output facilities available in the basic system are the ability of the technician to enter a special "control panel" mode to read or write selected memory locations, and the capability of providing a "spontaneous printer".

OPERATION AND MAINTENANCE

The operation of ASDP162 is continuously supervised in two ways. The Operation and Maintenance Subsystem (OMS) provides the customer with a wide range of statistical and real time data. The Processor Maintenance Subsystem (MAS) provides a continuous and detailed monitoring of the system, and should a fault occur, it undertakes the appropriate recovery action and generates the necessary alarms.

System Operation and Control

OMS supervises the operation of the Traffic Control Subsystem (TCS) to derive statistical data from call event information.

Associated with the recording of these statistics is the checking of service supervision limits, and the raising of alarms when these limits are exceeded.

More detail on individual trunks or operators may be obtained by using the individual traffic recording facility. The details recorded using this facility are total incoming calls, total outgoing calls, total matured calls and total occupancy for trunks, and free list time, clerical time, occupancy time and total answered calls for operators.

Real time supervision of operators within a particular monitor group may be displayed on any monitor console. A monitor or supervisor may also obtain the detailed current status of an operator or trunk by calling up a display on the console.

During the monitoring of system performance with the extensive facilities described above, it may become obvious to the master supervisor that the system configuration should be changed to meet new traffic conditions. ASDP162 provides an extensive range of commands which display the current configuration and which allow the master supervisor to change the configuration and display the new configuration.

Processor Maintenance

The service supervision alarms referred to above cause a supervisory alarm to be raised in the equipment room and on the supervisor's console, and an entry to be made in the system alarm buffer. The main purpose of the alarm buffer however is to register urgent alarms that are raised by the Processor Maintenance Subsystem MAS.

Processor maintenance programs are continually executed in each control and regional processor, and provide the control system with the high operational reliability demanded for telephony applications.

Since it is not possible to fully test some of the standby processor units while that processor is on standby, part of the processor maintenance technique is therefore to initiate daily (usually at a low traffic period) an automatic controlled processor changeover, thus ensuring that all parts of the system are available and operational when fault recovery is necessary. These periodic changeovers are similar to those initiated by command in that they cause no disturbances to established calls.

The basic processor supervision technique utilises a series of "I AM OK" signals, which each central processor sends to the other and which each regional processor sends to the executive CP. If the executive processor does not receive any of these signals, the fault is diagnosed, recovery action is taken and the appropriate alarm is raised. In the case of a regional processor failing, the central processor will emulate the functions of the failed RP.

The majority of faults in the executive processor will cause the standby to assume control.

Other typical system failures which generate urgent alarms include switch testing faults, standby bus faults, RP bus faults, and tape interface faults. These faults, and all others, cause an entry into the system alarm buffer.

SMALL VERSION OF ASDP162 — ASDP162/1

The standard ASDP162 system has been designed to cater for installations of 100 operators and above. A smaller version, ASDP162/1, is available, having limited facilities and features.

No regional processors are provided and the trunk and operator functions are executed in the central processors.

There is little change to the software which behaves as if the central processor was permanently emulating a failed regional processor. There is thus no change to the facilities available in the system, which can be equipped for up to 90 trunks and 112 operators.

CONCLUSION

The L. M. Ericsson ASDP162 system provides a service for organisations which require a large number of operators to process incoming calls.

The ASDP162 is in service for:

Qantas Airways, Sydney
Charge Card Services, Sydney and Melbourne
Air New Zealand, Sydney
Royal Hong Kong Jockey Club, Hong Kong
Kingdom of Saudi Arabia, Riyadh
Televerket, Gothenberg, Sweden

Installations of the system are being commissioned for the Totalisator Agency Boards in Melbourne, Sydney and Canberra.

In Brief

Contract issued for Carphone System

On 4 June 1979 Telecom Australia issued a contract to NEC Australia Pty. Ltd. for the supply of equipment for Public Automatic Mobile Telephone Services (PAMTS) in Sydney and Melbourne. The NEC system was selected after extensive evaluation of tenders received from major world suppliers of automatic mobile radio and telephone switching equipment.

The equipment being provided includes stored programme controlled (SPC) switching equipment for the mobile control centres, radio base station equipment and the customer mobile radio units. A model mobile control centre is also being purchased for "off line" software and hardware validation and system support and enhancement.

The systems will provide coverage of the local telephone districts (unit call fee districts) in Sydney and Melbourne and will have an ultimate customer capacity of at least 4000 in each area. To achieve this, a number of radio base stations will be established (3 in Melbourne and 5 in Sydney) and 120 RF channels in the UHF band will be employed without frequency re-use in each capital city. The system will automatically hand-over a moving mobile telephone from one base station to another and maintain a call in progress if the signal strength from the first base drops below a satisfactory level and if signals of a higher level are available from another base station.

The customer mobile units will have microprocessor control and will access all 120 RF channels with the use of frequency synthesiser control. The mobile units will employ push button dialling, number display and a memory to store frequently called numbers. A mobile telephone will have all the facilities of a standard telephone including STD and ISD dialling if required by the customer. It will also be possible for a customer of Sydney or Melbourne to operate automatically in the other area.

The service is expected to commence in mid-1981 in Melbourne and towards the end of 1981 in Sydney. The automatic service will replace existing manual single channel services in each city.

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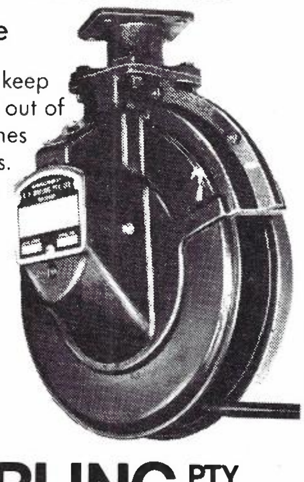
(I.B. refers to the "In Brief" items included in the Journal)



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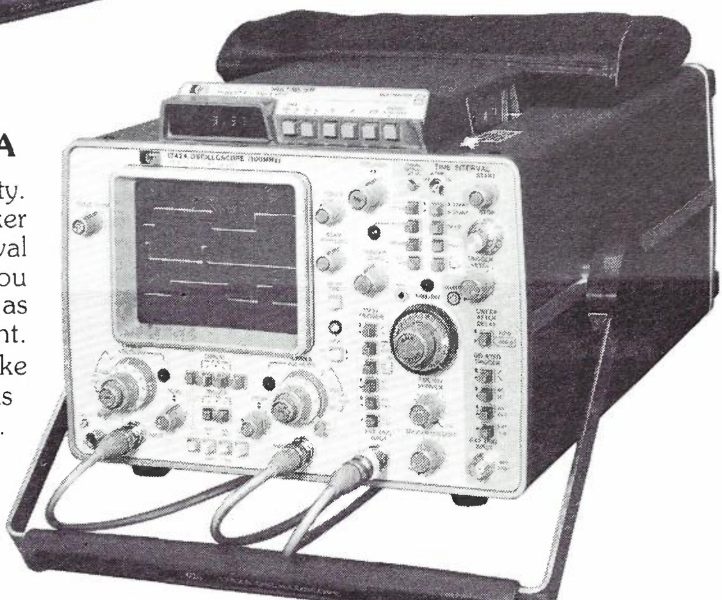

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The Telecommunication Journal of Australia

ABSTRACTS: Vol. 29, No. 3.

BANNISTER, G.: Concentrator Subscriber Radio Services; Telecom Journal of Aust., Vol. 29, No. 3, 1979, page 233.

The concentrator subscriber radio system has been developed following the successful use of exclusive service (single channel) radio systems to connect rural and remote subscribers. Both the concentrator and exclusive services are economic alternatives to connection by cable. Fields trials for the concentrator system have been completed and the way is now clear for the installation of these systems on a larger scale. This paper describes the concentrator and its application.

BARBOUR, G. R.: 'A Solid State Speaking Clock'; Telecom Journal of Aust., Vol. 29, No. 3, 1979, page 224.

The speaking clock service provided by Telecom Australia is the most popular recorded information service available to customers. Decreasing reliability and the increasing difficulty of maintaining the original electromechanical equipment in South Australia necessitated replacing the magnetic tape time announcer to provide for a continuing, reliable and economic service.

This article describes the Solid State Digital Speaking Clock developed and manufactured by the South Australian Engineering Department of Telecom Australia and installed in Adelaide. The design is based on dual minicomputers, for reliability, and uses an Adaptive Delta Modulation speech encoding scheme for digital storage of the vocabulary required. The equipment provides six different time zone announcements which are being fed to several States of Australia.

BROWN, P. A. and CLARK, D. W.: 'Automatic Call Distribution System — ASDP 162'; Telecom Journal of Aust., Vol. 29, No. 3, 1979, page 245.

The ASDP162 is a stored-program digital Automatic Call Distribution System (or Queue System) which has been developed and manufactured by L. M. Ericsson, Australia. It is presently in service in Australia and several overseas countries with organizations such as airlines, credit companies, betting agencies and telephone administrations.

This paper describes the way in which such organizations may use the facilities offered by ASDP162, and outlines the basic structure and operation of the system.

DICKSON, G. J.: 'X 21: An Interface Between Switched Data Terminals and Circuit Switched Data Networks'; Telecom Journal of Aust., Vol. 29, No. 3, 1979, page 206.

The subscriber signalling schemes used in switched data networks are generally more complex than the signalling used in telephony. This article discusses a signalling scheme recommended for circuit switched data networks and shows how graphical documentation techniques employing state transition diagrams can be used to give an improved description of the signalling scheme.

DUC, Nguyen Q.: 'Data Transmission Developments and Public Data Networks;' Telecom Journal of Aust., Vol. 29, No. 3, 1979, page 194.

Traditionally, data transmission is conducted over the public switched telephone network and over private lines. In recent years, the increasing use of automatic data processing by commercial and government organisations coupled with the advent of less expensive computers and associated terminal equipment has considerably boosted the demand for faster and more reliable data communications facilities. This demand has grown at such a rate and to such an extent that new specialised public data networks are deemed economical and necessary in order to meet the special transmission requirements of computer users.

This paper considers the various developments in data transmission. Special reference is made to the development of data services in Australia which culminates in the planned introduction of the Telecom Australia Digital Data Network (DDN) in 1980. Overseas developments and trends are briefly mentioned. The typical service and operational features associated with a public data network are highlighted, and different types of networks are described with illustrations of some well-known (public and private) networks.

LOFTUS, J. E. and JESSOP, C. W. A.: 'Manual Assistance in Australia — Its Future Role'; Telecom Journal of Aust., Vol. 29, No. 3, 1979, page 187.

The personal touch of the telephonist has been with us since the inception of the telephone service and will continue to play an important part in telecommunications in the years to come. This article outlines the future role of manual assistance services in Australia, and explains how modern technology can be used to benefit Telecom, telephonists, and the customer. A National Manual Assistance Plan is foreshadowed which will give direction to manual operations during the 1980's.

RENDLE, A. A.: 'Touchfone 12'; Telecom Journal of Aust., Vol. 29, No. 3, 1979, page 181.

Telecom Australia has released a tone signalling push button telephone, Touchfone 12, for use on exchange and PABX lines equipped with tone receivers. The paper gives a brief background on tone signalling in the subscribers' network, a description of the design of Touchfone 12, and a comment on future technology.

THUAN, N. K.: 'A Buck/Boost No-Break Telephone Power Supply; Telecom Journal of Aust., Vol. 29, No. 3, 1979, page 214.

This article describes the principles and performance characteristics of a new solid state, fully regulated, buck/boost no-break power supply dedicated to the powering of 10C electronic trunk switching equipment at the Wellington Telecommunications Centre, Perth, WA. The new power plant was installed and commissioned in August 1978 and is the first buck/boost system placed into service by Telecom Australia.

WAIN, N. L.: 'Radio-Relay System Path Survey Techniques — Part 2, Survey Methods'; Telecom Journal of Aust., Vol. 29, No. 3, 1979, page 171.

This second and concluding part of a study of radio-relay system survey methods outlines the techniques commonly employed to obtain the path parameters necessary for reliable design of transmission performance and cost estimation of proposed systems. Common survey practices are covered together with some of the more economic and novel methods used for small capacity and single channel systems.

THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

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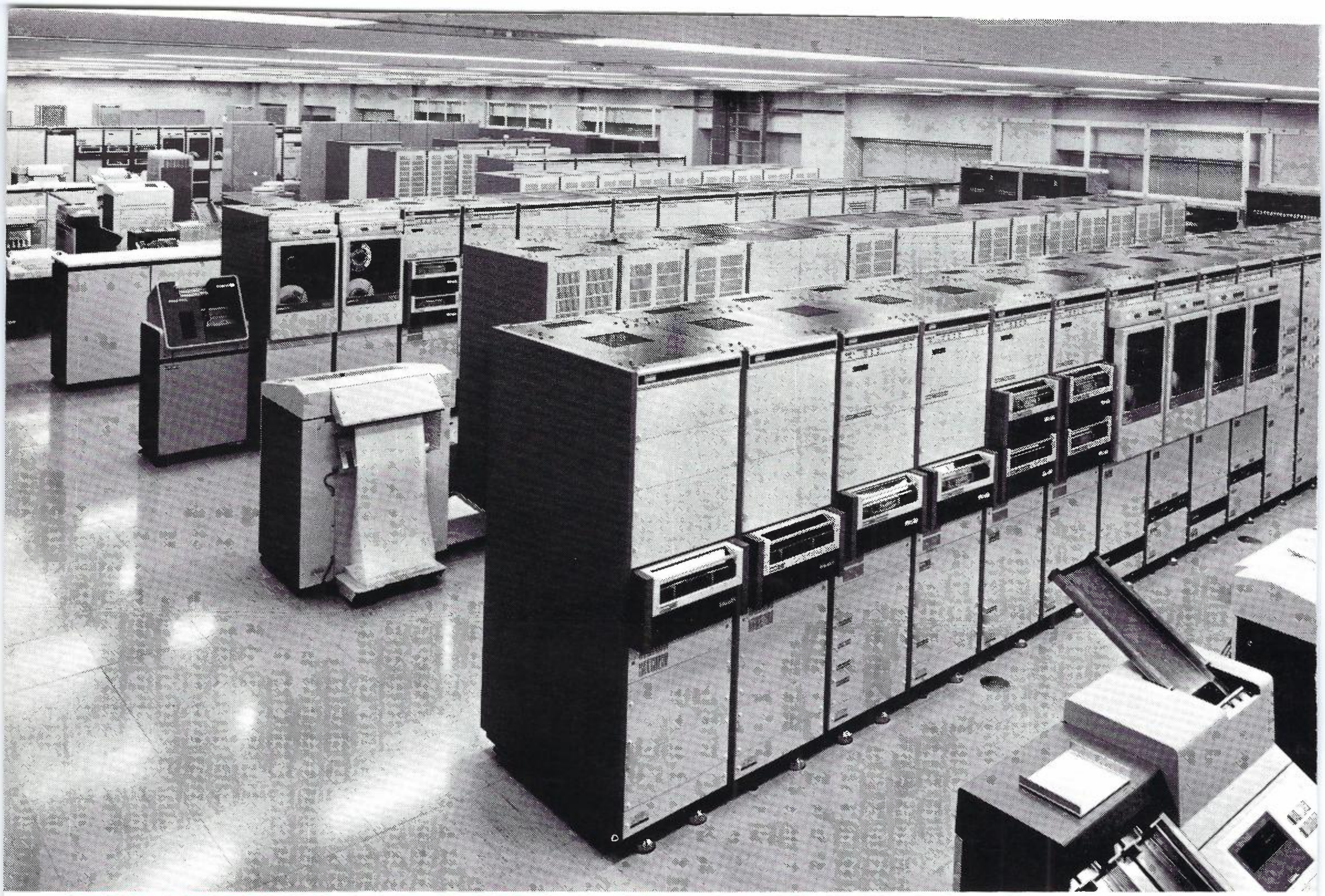

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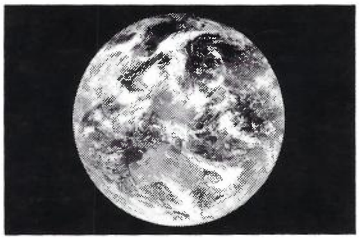

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