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IN THIS ISSUE

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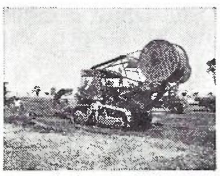

COVER
A Cable Unit from the Perth-Carnarvon Coaxial Cable Project

The TELECOMMUNICATION JOURNAL of Australia

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CAB AUDIT

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Mr. C. J. GRIFFITHS, O.B.E.

On March 27, 1970, Mr. C. J. Griffiths, O.B.E., M.E.E., F.I.E.E., F.I.E. Aust., retired from the position of First Assistant Director-General, Engineering Works, after a distinguished career which began in 1927 as an engineer in charge of subscribers installation and maintenance activities in Melbourne.

Mr. Griffiths' initial contribution to telecommunication engineering was in the external plant field particularly in the transposition design, cable corrosion and cable protection areas. Subsequently, as a senior engineer in the Headquarters Lines Section he played a prominent part in establishing the telephone cable manufacturing industry in Australia.

In between these landmarks there is a record of significant engineering association with many important projects such as the Sydney-Maitland, Melbourne-Ballarat, and Adelaide-Nuriootpa trunk cables, the Bass Strait submarine cable, the Adelaide-Perth, Adelaide-Darwin and Townsville-Cape York aerial trunk routes, and telecommunication facilities for the Woomera and Maralinga rocket range projects.

September 1956 brought a new phase to Mr. Griffiths' career with appointment to the senior administrative position of Deputy Engineer-in-Chief, Services. In this position he made his mark on the technical training, material supply, works programming, industrial engineering, workshops and automotive plant areas of activities and through them contributed significantly to such major projects as the Sydney-Melbourne coaxial cable and other broadband projects, as well as the various crossbar switching programmes.

In 1964 Mr. Griffiths was appointed to the top position in his Division. As First Assistant Director-General, Engineering Works, he became responsible to the Director-General for the management and control of engineering works, for the technical operation and all maintenance of telephone and telegraph plant, the maintenance and technical operation of National broadcasting and television services as required by the Australian Broadcasting Control Board and the Australian Broadcasting Commission.

International telecommunications became a major interest during the latter part of Mr. Griffiths' career. He played a leading role in the planning of COMPAC and SEACOM submarine cables and achieved a significant success in the effective integration of the separate ocean cable portions of the SEACOM system with the A.P.O.'s broadband network between Sydney and Cairns. Mr. Griffiths' contributions to international telecommunications through the International Telecommunication Union reached a happy climax in 1965, the centenary year of the Union. In that year he was Chairman of the Administrative Council, the main executive body of the Union and presided over important policy making meetings in Geneva and Paris. Mr. Griffiths has the honour of being the first Australian to occupy this important position.

A measure of the man and his contribution to telecommunications on the world scene is this extract from the I.T.U.'s January 1966 Telecommunication Journal:—

"From the outset of the recent Plenipotentiary Conference in Montreux it was clear that the most significant results for the future structure of the I.T.U. would depend on what was done in the key Committee on the organisation of the Union. With over 400 separate proposals to be considered and debated by more than 100 delegations in an atmosphere heightened by eager interest in the results, the Committee was faced with a formidable task. The fact that it nevertheless managed to complete its business in less than 60 hours of discussion is above all a tribute to its Chairman, Clyde J. Griffiths of Australia.

Quiet, courteous but firm, brisk yet unhurried, threading his way again and again through a maze of proposals and counter-proposals with the main point always clearly in view, this was a model of Chairmanship."

For all who have had the pleasure to work with Mr. Griffiths, these words reflect accurately the personal qualities which took him to one of the highest engineering appointments in the Post Office.

As a member of the Council of the Royal Melbourne Institute of Technology for many years, active on several of its committees, and currently its Senior Vice President, Mr. Griffiths has also made a valuable contribution to Victorian technical education.

The Telecommunication Society of Australia is very much indebted to Mr. Griffiths for sustained interest and active support as author, editor and administrator over a period of 36 years. He contributed several important articles on fundamental topics, the first in 1938 and the last in 1968. He served on the controlling body of the Society from 1934 to 1947; and from 1944 to 1956 he was Editor of the Journal. He was elected a Life Member of the Society in 1953 and was Chairman of the Council of Control from 1961 to 1962, and again from 1966 to 1968.

This thorough-going, loyal and sustained effort typified Mr. Griffiths' approach to whatever was before him. The Society therefore takes this opportunity to record its sincere appreciation for remarkable interest and support, solidly maintained over such a long period. On behalf of all members, the Board of Editors wishes Mr. and Mrs. Griffiths a very happy and successful retirement, hoping that retirement from office will not necessarily mean retirement also of one of our most notable authors.

STAFF CHANGES

The retirements of Mr. G. N. Smith, (See P. 112) and Mr. C. J. Griffiths have led to changes in senior staff appointments in the Victorian and Headquarters Administrations. Mr. H. S. Robertson, M.B.E., B.Sc., M.I.E.E., previously Superintending Engineer, Country Branch, Victoria has been appointed Assistant Director, Engineering, Victoria and is currently occupying the position of Director, Posts and Telegraphs, Victoria. Mr. I. M. Gunn, M.B.E., previously Assistant Director, Engineering, Victoria, has been appointed First Assistant Director-General, Engineering Works, at Headquarters.

Succession to positions previously occupied by Mr. Griffiths seems to have become a habit for Mr. Gunn. In 1956 he was appointed to the position of Deputy Superintending Engineer, Metropolitan Branch, Victoria, a position made vacant by the promotion of Mr. Griffiths to Headquarters. Then in 1957 Mr. Gunn was appointed Supervising Engineer, Lines Section, a position just vacated by Mr. Griffiths. Subsequently, in 1959, he succeeded Mr. Griffiths as Assistant Engineer-in-Chief, Services, and now he has been appointed to the top Engineering Works position, in succession once again to Mr. Griffiths.

Mr. I. M. GUNN, M.B.E.

Mr. Gunn's career began in Victoria with appointment as Cadet Engineer in 1928. Almost immediately he was given an opportunity to see how the other fellow lived when the Public Service economies of the depression years took him out of training as an engineer to become a clerk in the Research and Transmission Sections of Central Office. Appointment as Engineer occurred in 1935 and by 1940 he was acting at Divisional Engineer level in charge of the Melbourne-Seymour Trunk Cable project.

Other highlights in Mr. Gunn's career have been:

- Four years active military service in the Corps of Signals rising to the rank of Major in charge of substantial line and cable projects in the South West Pacific area.
- Committee on introduction of divisional store system.
- Committee on introduction of pressure treated poles.
- Award of the Coronation Medal.
- Chairman of the 1956 Victorian Olympic Games Branch Committee for communication facilities for the Games venues.
- Award of the M.B.E. in the 1957 Birthday Honours' List.
- O.C. of a C.M.F. Signals Unit from 1952 to 1956.
- President of the Victorian Branch of the Professional Officers' Association 1955 to 1956.
- Appointment as Deputy Superintending Engineer, Metro. Branch in 1956.

The Board of Editors on behalf of all readers have pleasure in congratulating Mr. Gunn on his new appointment and offer best wishes and full support in his new venture.

Congratulations are extended also to Mr. Robertson on his appointment as Assistant Director, Engineering, Victoria. He joined the Department as a Junior Mechanic-in-Training in 1922 and was appointed to an engineering cadetship some three years later. During 1929/30 he graduated Bachelor of Science from Melbourne University and took up duty as engineer in the Transmission Section. This was followed by some years in radio and then transmission planning until in 1962 he was appointed Deputy Superintending Engineer, Country Branch and later in 1964, Superintending Engineer of that Branch.

Mr. H. S. ROBERTSON, M.B.E.

Amongst other interests, Mr. Robertson is Chief of the Communications Division of the Victorian Government's 'State Disaster Plan Organisation'. In this role he is well known in State Departments as the author of the communications network plan that is used for control of disaster operations throughout the State.

As Victorian President of the Professional Officers' Association for several successive terms, Mr. Robertson played a major part, during the Association's Golden Jubilee year, in arranging the very successful Symposium of Public Lectures by eminent scientists and leaders in the other professions.

Mr. Robertson has maintained a keen interest in the Society since its inception as the Postal Electrical Society in the early thirties. During his term as Deputy Superintending Engineer of the Country Branch, he was involved in the expansion of the Society's Lecture Programme to include all of the main country centres.

THE SIEMENS CONCEPT FOR A 12-MHz COAXIAL CABLE SYSTEM

E. KÜGLER, Dipl. Ing.*

INTRODUCTION.

Siemens AG has developed three transistor carrier systems for the application on coaxial cables; the V300 system, with a bandwidth of 1.3 MHz, the V960 system with a bandwidth of 4 MHz, and the 12 MHz system. A system with an even greater bandwidth, the 60 MHz system V10800, is being developed at present. All four systems are laid out on the basis of similar aspects. The former can all be applied to coaxial lines with a diameter of 2.6/9.5 mm, the three first mentioned systems in addition also to small coaxial tubes of 1.2/4.4 mm.

The 12 MHz system was laid out in such a manner that it is suitable for the transmission of 2700 telephone calls (V2700) or also for the collective transmission of 1200 telephone calls and one TV programme with a bandwidth of 5.5 MHz (V1200/TV). This V1200/TV system, in comparison with the 6 MHz system which can be used for one TV programme with a bandwidth of 5 MHz or 1260 telephone calls, represents the more economical solution. As it were, double the number of lines are required with the 6 MHz system for the same transmission capacity (e.g., 1200 telephone channels and one TV channel). The equipment complexity is then about equal for both systems, since a 6 MHz system, due to double its length of repeater sections, only requires half the number of repeaters per route. The total costs are determined largely by the cable costs, including the charges for laying; for this reason the higher cable quota in two 6 MHz systems leads to higher total costs as compared with a 12 MHz system possessing the same transmission capacity.

BASIC CONSIDERATIONS.

Coaxial cable systems are normally designed to obtain the best possible quality for transmission of telephone calls. If a coaxial cable system, however, is also to transmit TV signals, a few additional points must be observed. The route equipment must be laid out in such a manner that delay distortion does not become too great in the range of the TV transmission band (e.g., from 6.3 MHz to 12.3 MHz in the 12 MHz system), in order to keep the requirement for delay equalisers as small as possible. An optimum choice of transmission levels for telephone calls and TV signals must be arrived at, taking noise and intermodulation distortion into account. This will now be explained in detail by using the 12 MHz system as an example.

Noise and Transmission Level.

The development objective was to obtain a weighted noise of less than 1 pWop/km even for the poorest voice channel using a standard route pattern for the 12 MHz system on a coaxial line 2.6/9.5 mm, i.e., in the case of a 4.65 km repeater spacing and 10 deg. C. mean cable temperature. The quota of the intermodulation noise in this connection should be small as compared with the basic thermal noise. Only with a sufficiently low distortion-noise contribution can the high linearity demands be met. This assignment must be laid down for 1200 toll calls plus a TV signal so that a satisfactory noise breakdown can also be anticipated in this instance. Accordingly, the transmission levels have been optimally selected. In the case of a pure telephone assignment (V2700), the relative level at the output of the line amplifiers for the uppermost channel is -13 dBr, and with pre-emphasis provided of 10 dB, at low frequencies is approx. -23 dBr (curve 1 in Fig. 1). With a mixed assignment (V1200/TV), all voice channels are transmitted without pre-emphasis, with the same relative level of -20 dBr at the output of the line amplifiers (curve 2 in Fig. 1). Here, the carrier-frequency TV signal corresponding to the load range of the picture signal possesses a relative level of -4 dBr (curve 3 at 6.8 MHz in Fig. 1). The

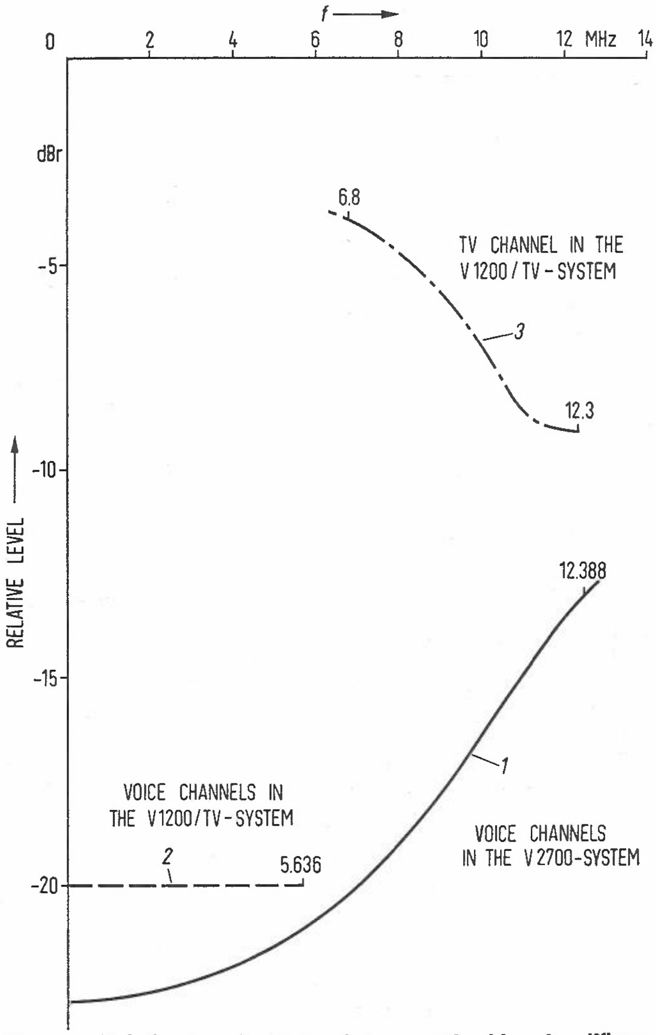

Fig. 1 — Relative Levels at the Output of the Line Amplifiers in the 12-MHz System.

* Mr. Kügler is Head, Line Repeaters Laboratory, Central Communications Laboratories, Siemens AG.

high video frequencies of the TV signal are attenuated by up to 5 dB by TV pre-emphasis. Consequently the nonlinear interference in the voice channels which may result due to intermodulation of the 6.8 MHz TV carrier with the picture information components of the TV signal remains sufficiently small. With such transmission levels, the loading of the 12 MHz system by the equivalent peak power of 1200 telephone channels and a TV signal will be less than the corresponding loading by 2700 telephone channels.

When operating over coaxial tubes with a 2.6/9.5 mm dia., a noise value smaller than 0.8 pWop/km is obtained for all telephone channels. The weighted signal-to-noise ratio of the video signal is better than the value recommended by CCI by a safe margin. With a standard route design, noise values of less than 2 pWop/km can be anticipated for a V2700 system using small-diameter coaxial tubes of 1.2/4.4 mm.

TECHNICAL SOLUTION.

It is not intended to describe the electrical and mechanical concepts of the 12 MHz system and the 12 MHz TV converters, since this has already been done elsewhere (Refs. 1, 2, 3, and 4). On the other hand, however, the aspects concerning level stabilisation and equalisation will be considered particularly in respect of TV transmission. This is followed by a brief survey relating to protective measures against induced interference, and to the power feeding and fault-locating systems. It is intended to publish measured results in other articles in this journal.

Automatic Level Control

The temperature-dependent variations in attenuation of the lines must be offset by the route repeaters in relation to their frequency response. From the technical aspect, a route is optimally laid out if each route repeater offsets the variation in attenuation associated with its repeater section. In that case the output level will always be the same at each repeater, thus ensuring an equal amount of overload margin. This, for example, is particularly important with a mixed assignment in the 12 MHz system in conjunction with one TV programme and voice channels with low-level continuous tone supervision. Furthermore, the systematic residual errors along a route, caused as a function of the frequency by the level control, will be lowest if each repeater produces the same small level correction, instead of only inserting an automatic level control with a correspondingly wider range after several sections.

A favourable level control will be obtained if each line repeater is controlled by the main control pilot (e.g., 12.435 MHz in the 12 MHz system). With systems incorporating transistor repeaters, in which the above-mentioned advantages are not to be waived, it is, however, more economical to provide temperature control for the major part of the repeaters and to apply pilot-controlled repeaters only at greater intervals. In this manner similarly good results can be obtained, yet with considerably less effort.

The repeaters, which require little or no maintenance, are accommodated in suitable underground containers, preferably directly buried in the ground. In this manner care is taken that the repeater temperature largely follows the variations in cable temperature, permitting favourable temperature control. In general it is best if approximately 11 temperature-controlled repeaters are followed by one pilot-controlled repeater.

Should route conditions not permit an adequate temperature control everywhere, e.g., when existing repeater buildings are to be used jointly, repeaters may also be installed with a fixed gain. In this case the pilot-controlled repeaters must be provided at shorter intervals. Thus by suitably mixing the available type of repeaters, which will be briefly described further on, it is possible to achieve a technically and economically optimum solution in respect of each route.

The pilot-controlled repeaters possess a transfluxor regulator with a memory store (Ref. 3), i.e., with a pilot failure, the gain last set is preserved, thus resulting in the correct level conditions along the route continuing to exist. Also with interruptions of the power supply (e.g., during line-up operations along a route), the transfluxor regulator proves its worth. In fact there are no undesirable regulating processes occurring during reconnecting, which might possibly lead to a control unit no longer being released for regulating purposes.

In the temperature-controlled repeater, a flux-controlled resistor is used (Refs. 2 and 3), as a 'controller' in the feedback path with a suitable temperature coefficient. With the aid of a permanent magnet which can be swung across the flux-controlled resistor, the resistance of the latter can be varied. Thus, in addition to the temperature control, a stepless adaptation of the gain for deviations of the nominal repeater-section attenuation is feasible within certain limits.

As Fig. 2 shows, the temperature control is an optimum at +10 deg. C in relation to the development objective, since in this instance the mean temperature coefficient of the temperature-controlled line amplifier coincides with that of the coaxial cable. On the —10 deg. C to + 20 deg. C range, the deviation from the temperature coefficient of the coaxial cable is smaller than 10 per cent., i.e., the

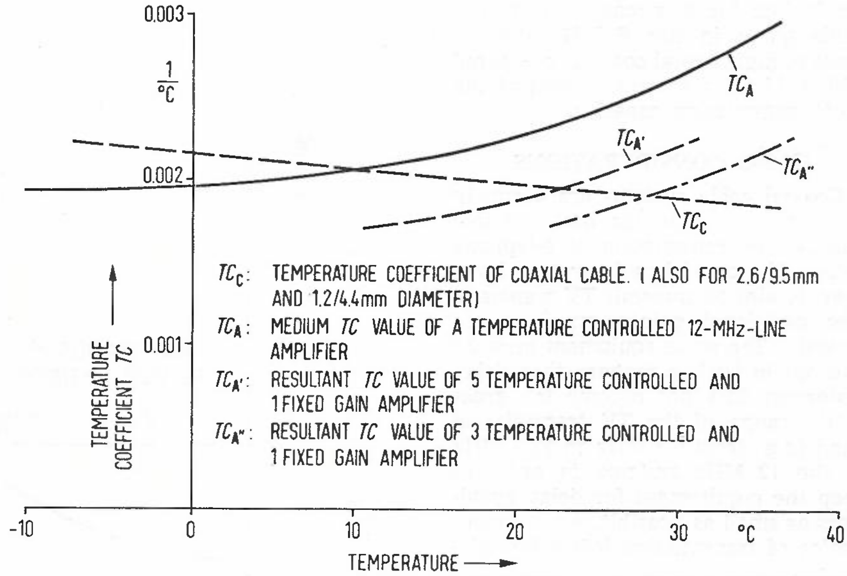

Fig. 2 — Temperature Coefficient of the Coaxial Cable as Compared with the Temperature Coefficient of Temperature-controlled 12-MHz Line Amplifiers.

temperature-dependent cable attenuation variations are reduced in this range by more than a factor of 10 by means of the temperature-controlled repeaters. At temperatures above 10 deg. C. an over-compensation occurs, which for example at 20 deg. C constitutes approx. 10 per cent. and becomes effective as a level advance. After ten repeater sections with temperature-controlled repeaters, the output level with temperature variations will then be higher by approximately the same value as the corresponding attenuation rise of the subsequent section. The input level of the 11th repeater is therefore independent of the temperature to a first approximation, so that the control range of the subsequent pilot-controlled repeater (e.g., the 12th of a section) is relieved by means of this level increase.

With still higher cable temperatures (T greater than 20 deg. C), overcompensation increases. Even in this case, pilot-type control is only required after every 12th repeater, since an adequate regulating range is available. A considerably more effective temperature control is obtained at higher cable temperatures, however, if a repeater with a fixed, temperature-independent gain is applied following a given number of temperature-controlled repeaters. In this manner the effective temperature coefficient of the entire repeater arrangement (temperature-controlled plus fixed-set) can be reduced approximately to that of the coaxial cable (cf. Fig. 2). Thus, for example, a route layout is recommended for mean cable temperatures between 17 deg. C and 26 deg. C, in which every 6th repeater possesses a fixed temperature-independent gain and in which every 12th repeater is pilot controlled. In tropical areas—with mean cable temperatures bebetween 25 deg. C and 34 deg. C—a layout is expedient in which each 4th and 8th repeater is permanently set and the 12th repeater possesses a pilot control system.

With the use of a suitable combination of temperature-controlled and permanently set repeaters an optimum adaptation thus becomes feasible in respect of any possible conditions. The overload margin of the route is preserved very largely in this manner, the systematic regulating errors become as small as possible and the regulating range of the pilot-controlled repeater is relieved.

Equalisation.

Equalising Attenuation Errors: An echo equaliser has been provided in the equipment above ground for the equalisation of the attenuation distortion of a route section (of say 25 repeater sections). In the range below 600 kHz, an attenuation equaliser is additionally effective, which can be set in steps corresponding to eight sections each. In this manner the remaining residual errors plotted as a function of the frequency in the line-frequency band between 300 kHz and 12.5 MHz assume a character which can be compensated to within a few tenths of a decibel with the 27 echo taps of the attenuation echo-equaliser. With the aid of a simple sweep method (Ref. 5) the echo equaliser can be set for smallest residual attenuation distortion quite rapidly (e.g., in 10 minutes). The small residual errors of preceding route sections are also corrected at the same time. Should a correction of the equalisation of very long routes be desired, this is also feasible with the aid of inter-channel pilot measuring frequencies, without interrupting the service.

Delay Equalisation: In order to transmit a TV signal in the 12 MHz system, the frequency range for the TV band between 6.3 MHz and 12.3 MHz must be delay-equalised. The essential delay distortion is given by the route repeaters and separating filters, which separate the telephone range between 300 kHz and 5.636 MHz and the TV band, and which are applied in the TV transmitting and receiving station respectively. Curve 1 in Fig. 3 illustrates as a typical example the delay distortion of a 308-mile route without any delay equalisation. In the range up to approximately 7.5 MHz the distortion of the two separating filters preponderates, whereas the distortion of the 110 repeater sections preponderates above approx. 8 MHz. The delay distortion per repeater section is approx. 10 nsec. The latter is considerably smaller than with the older 12 MHz valve system, since with the new transistor system the frequency response of the repeaters has been matched to the cable attenuation beyond the nominal band up to the RF fault locating frequency of 13.5 MHz, and even beyond this figure will only gradually deviate from the natural law of the cable attenuation changing with the square root of the frequency.

The fixed delay equaliser for the 308 miles of route was dimensioned on the basis of measurements on a test route with only 12 repeater sections without TV/multichannel separating filters. Delay distortion of the separating filters was ascertained separately, the former being included in the delay equaliser. As is confirmed by curve 2 in. Fig. 3, a good delay equalisation is already achieved with the aid of this fixed delay equaliser.

For arbitrary route lengths with up to 200 sections (approx. 570 miles) without intermediate TV equalising points, a complete spectrum of fixed

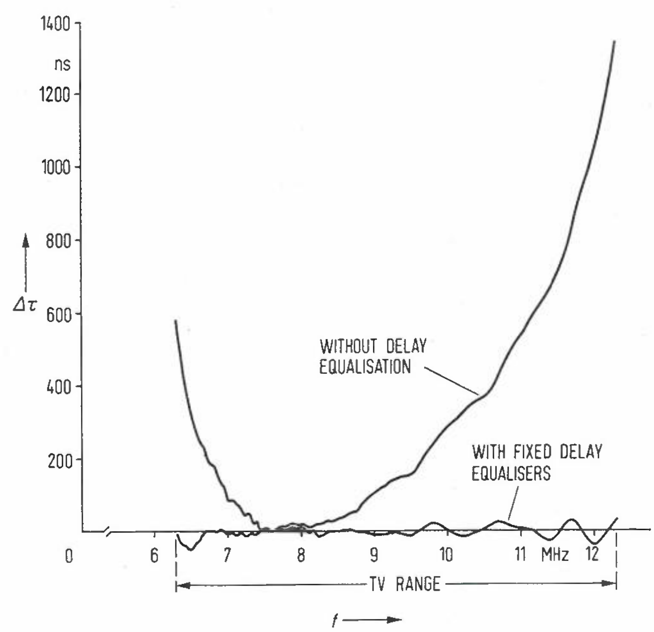

Fig. 3 — Delay Distortion of a 308-mile 12-MHz Route without and with Fixed Delay Equaliser.

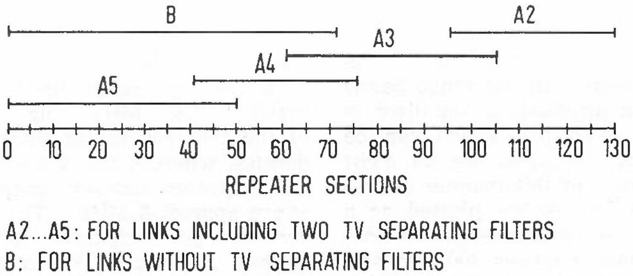

Fig. 4 — Spectrum of Fixed Delay Equalisers of the 12-MHz System.

delay equalisers is available (see Fig. 4). Four types with overlapping ranges for the equalisation of a maximum of 130 repeater sections (A2 to A5 in Fig. 4), also compensate for the delay equalisation of two separating filters. Another variant (Type B), which may, for example, be applied in the transmitting station as a pre-equaliser, is only intended for the delay equalisation (without separating filters) for a total of up to 70 sections. Each of the five fixed delay equaliser units referred to can be adapted to the prevailing route pattern, in steps in relation to five repeater sections. Thus it is feasible to effect a setting to a residual delay error of less than 25 nsec, apart from a residual 'fast ripple' appearing in a graph as a function of the frequency; this value of error already corresponding to a good transmission quality (cf. curve 2 in Fig. 3. If no dropping, together with a replenishment of TV signals, is required at the carrier-frequency range, a residual equalisation in the video position by means of a fine echo equaliser in the TV receiving converter is sufficient. Equalisation of the video signals can be achieved which is better than the values recommended by CCI.

If a flexible dropping and replenishing of TV signals is required in the carrier-frequency position, the respective carrier-frequency section must be adequately equalised in itself. This is already ensured by the fixed delay equalisers for routes which are not unduly long (see Fig. 3). Only when dealing with very long routes (e.g., greater than 400 miles) will additional fine equalisation be required in the carrier-frequency position. This may be achieved with the aid of two carrier-frequency echo equalisers, which can be set independently for small delay distortions and attenuation distortions.

In each fully regulated station it is possible to effect a simple parallel drop of the TV signal from the carrier-frequency band via a hybrid circuit. This may prove a practical consideration if a local TV transmitter is to be fed directly from the coaxial cable route. Such a parallel-drop unit can also be added later on at option without changing the equalisation of the continuing main transmission direction. For separating the TV signal from the multichannel signals, the high-pass section of the TV-CF (CF = Carrier-frequency) separating filter is used in the parallel drop unit. Thus, the available fixed delay equalisers can also be used for parallel dropping; the fine alignment is effected with the video echo equaliser at the output of the TV demodulator. A typical route layout with parallel dropping is indicated in Fig. 5.

In the case of this layout each section is individually equalised as far as the respective parallel drop and the terminal station respectively, by a following fixed delay equaliser. This is done in repeater station II by the type A5 for 40 sections, in station III by the equaliser type A3 for 85 sections and in receiving station IV by the type A2 for 110 sections. A route layout with a relatively low equaliser complexity is possible when the greater part of the route is pre-equalised in the transmitting station I, with a type already providing the equalisation of two separating filters. This is illustrated in Fig. 5 by dashed lines. In transmitting station I, the equaliser type A3 for 85 sections should, for instance, be used. In this case, the section up to dropping station III has already been pre-equalised; hence, no further fixed delay equaliser is required there. In repeater station II a delay line building out network C for 45 sections which may consist of the available delay line building out networks for 10 and 5 repeater sections, respectively, should be used. In terminal station IV, 25 sectoins would still have to be equalised with the delay equaliser type B. Thus, all possible cases can be optimally adapted both electrically and economically.

Protective Measures Against Extraneous Influences

The repeater units are protected against extraneous influence and lightning voltages at the input and output, as well as in the power-feeding current path. By using gas-discharge arresters, diodes and resistors, overvoltages are reduced, in several stages, to such low values that no changes of characteristics of the sensitive RF transistors or other components will occur (Ref. 3) Damage of a repeater is improbable, apart from exceptional cases in which a lightning stroke of high energy strikes the repeater directly or the cable close to it. In this case it is most probable that the cable will also be damaged.

In general, a route layout with floating outer conductors, i.e., with float-

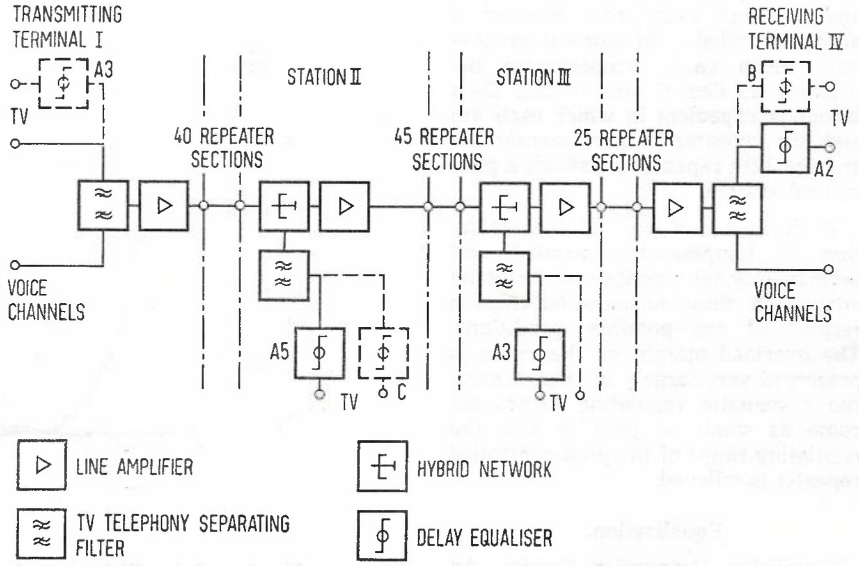

Fig. 5 — Parallel Dropping of the TV Signal in the Case of the 12-MHz System.

ing potential to ground, is recommended. Therefore the repeaters are also designed safe to the touch, i.e., insulated. However, the use of grounded outer conductors is also possible if no unfavourable cases of extraneous influence are present along the route.

Power Feeding.

Power-feeding sections with a maximum length of 200 km are possible in the case of a power feeding with a constant d.c. current of 90 mA via the inner conductors of the coaxial tubes only and a maximum voltage of 600V between the inner and the outer conductor. (Ref. 2). In this case, in accordance with a principle observed with all Siemens coaxial cable systems, no additional interstice wires are required apart from service channels, which will always have to be provided as an independent part of the transmission system. If additional interstice wires, which of course must have a sufficiently high dielectric strength, are made available, distances of up to 330 km without intermediate power-feeding points can be handled with the devices available. This is presented in Fig. 6 as a block diagram. The first 25 underground repeaters (one of which is pilot regulated) are fed, in the usual manner, from the feeding station by two power-feeding units connected in series (Ref. 3). After feeding the 26th section, the d.c. loop is closed in a fully regulated repeater station. This fully regulated repeater with equalisation, which can be accommodated in an accessible underground container (Fig. 7) is also power-fed via interstice wires (4 x 0.9 mm dia.) and a dc/dc power inverter 90 mA/24V. The dc/dc converter and the resistances of the interstice wires consume only a part of the power-feeding output available. For this reason a further 10 underground repeaters (one of these pilot-controlled as required) can be jointly supplied from the same power-feeding circuit. During normal service, the outer conductors of the two coaxial tubes are electrically dead, although they are interconnected as apparent 'return lines' of the various power supply circuits (see Fig. 6). A total of 73 sections can be covered in this manner. Still longer power-feeding sections can also be realised in special cases.

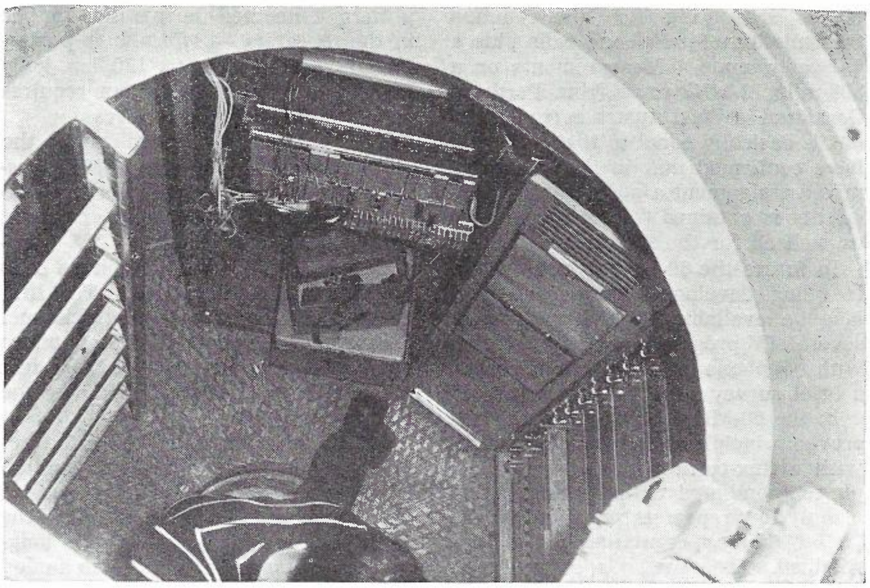

Fig. 7 — Underground Container Accessible to Entry, with Rack for Fully Regulated Power-fed Repeater.

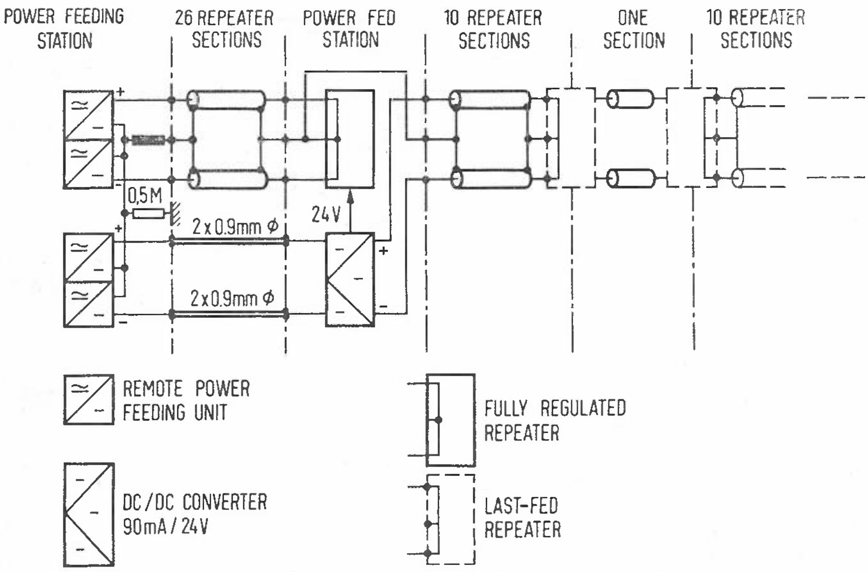

Fig. 6 — Power-feeding of Long Sections with the Aid of Interstice Wires (shown in detail for one half only).

Fault Location.

The methods of RF pulse location and dc fault location (Refs. 2 and 6) also do not require additional interstice wires. Furthermore, they have been chosen in such a manner that uniform fault-locating attachments can be used in the underground repeaters.

In general, a fault-locating section is identical with the associated power-feeding section. In special cases where the same power-feeding direction is provided in two adjacent power-feeding sections, fault-locating sections which are longer than the individual power-feeding sections can be formed as regards RF pulse location.

The fault-locating methods are in the main intended to serve for the perfect location of any possible fault locations which may arise. The RF pulse locating device, which operates at a carrier frequency of 13.5 MHz, also permits a check on the operating condition of a route (Ref. 2). Since the amplitudes of the individual RF fault-locating receiving pulses are a replica of the level states of the individual repeater sections, an opinion may, for example, be formed from the temporal variation of these pulse amplitudes, as to whether the level control is functioning satisfactorily.

SUMMARY AND PROSPECT.

The most important points of view concerning the concept of the 12-MHz system have been considered by specially accounting for the common transmission of telephone calls plus a TV programme. Measurements on a 308-mile 12-MHz route from Perth to Geraldton in West Australia (route layout is basically equal to that in Fig. 5) have confirmed that in the case of a mixed assignment a good transmission quality is obtained for telephone calls as well as for the TV signal.

In future the 60-MHz system, which is being developed at present, will also be available for transmission of several TV programmes in conjunction with telephone calls. For this reason a brief survey shall here be given.

In the 60-MHz (V10800-system), the proven principle of temperature control with a flux-controlled resistor ('Feldplatte') combined with the application of only few repeaters regulated by the 61.16-MHz main regulating pilot will be retained. The methods of level stabilisation with additional pilot regulating circuits (4.287 MHz and 22.372 MHz) and the equalisation with an echo equaliser will also remain unchanged. Despite the fact that three times as many repeaters per route length are required in the 60-MHz system (repeater section spacing about 1.6 km), the selected power-feeding mode —dc series feeding system with amplifiers connected in parallel for dc in the repeaters — still allows power-feeding sections up to 120 km long. Equally, the 60-MHz system requires no additional interstice wires.

The experience gained with the mixed assignment in the 12-MHz system led to the conclusion that even in the 60-MHz system the common transmission of several TV programmes together with telephone calls will become a possibility. The first 60-MHz route for pure multichannel telephone assignment will be put into operation early in 1972; a short test route is to be ready as soon as the beginning of 1971.

Almost simultaneously with the application of the 60-MHz system, the introduction of a videophone service may be expected. In developing the facilities for videophone signal long-range communications, using an analog basis, the experience gained with the simultaneous transmission of multichannel telephony and television in the 12-MHz system will be of great advantage. First considerations on this basis concerning a prospective transmission of videophone signals with a 1-MHz bandwidth over coaxial cable systems have shown that with systems suitable for this purpose (V300, V960, V2700 and V10800) good transmission quality may be expected even in the case of long routes.

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Mr. G. N. SMITH, B.Sc.

Mr. Glen N. Smith, Director of Posts and Telegraphs, Victoria, retired on 1st April, 1970 from a career that began when he joined the Department as a Cadet Engineer in 1926.

Mr. Smith completed the cadetship and graduated Bachelor of Science from Melbourne University in 1930. At that time he took up duty in the Research Section where, amongst other things, he formulated the A.P.O. Transmission Standards that are even now the basis of transmission design in the Department. In 1935, as engineer for submarine cables he was responsible for the testing and the acceptance of the Tasmanian cable. In 1939 Mr. Smith was transferred to the transmission division in Brisbane where he controlled an intensive communications installation programme during the war years.

Mr. Smith was promoted to the position of Inspector in the Central Office Telephone Branch in 1949 and later, as the result of reorganisation, to Controller, Planning and Development. His next promotion was in 1958 when he came to Victoria as Assistant Director, Telecommunications. Mr. Smith became Director, Posts and Telegraphs, Victoria in May 1960.

A man of very wide interests, Mr. Smith has served the community well in a number of different areas. He is a member of the Melbourne University's Graduate Council and the Standing Committee of Convocation. He is also a member of the State Executive of the Boy Scouts Association and is Chairman of the Melbourne District of that organisation. Mr. Smith is a member of the Advisory Council of Melbourne High School and he has maintained a lifetime interest in church affairs.

It is understood that Mr. Smith's first interest in retirement will be to develop a country property that he has recently acquired.

Mr. Smith has always taken a keen interest in the Telecommunication Society particularly during his term

as Director. We congratulate him on completing an outstanding career in the Department and we extend to him our best wishes in his retirement.

DEVELOPMENT OF THE S.T.C. 12-MHz COAXIAL CABLE SYSTEMS

*P. J. HOWARD**

INTRODUCTION.

Two transistorised 12-MHz coaxial line systems to provide multiple telephone and telegraph services have been developed in Britain. One system, which was designed to use 9.5-mm coaxial pairs, was put into service in Austria in May, 1968, the first of its traffic-handling capacity and design to be installed in Europe. The second system has been developed for 4.4-mm or 9.5-mm coaxial pairs and is undergoing a field trial of one power-fed section in conjunction with the British Post Office.

When planning the design of a new coaxial line system, consideration must be given to its area of application so that any requirements for compatibility with existing systems may be assessed. In the case of the 12-MHz system, it was considered essential that it could be applied to spares in cables carrying 4-MHz (960-channel) systems, or could replace such systems. The growth of traffic inevitably leads to a demand for additional bandwidth on most routes, and the further exploitation of existing coaxial cables represents the main demand for 12-MHz systems in most territories.

The 4-MHz systems in widespread use in many countries have a nominal repeater spacing of 9.6 km (six miles). A study of actual spacings on many existing routes, however, revealed a mean value of 9.0 km (5.6 miles). The aim was to use a repeater spacing of one-half of this for the new 12-MHz system, in order to minimise the number of points at which the cable would have to be cut. This led to a final choice of 4.5 km (2.8 miles), which involves a repeater gain at the top line frequency of 37 dB. A similar spacing had been adopted for the earlier 12-MHz system, using thermionic valves.

Requirements of compatibility also affect the choice of technique for automatic gain control to compensate for cable attenuation changes with temperature. The system is, of course, designed primarily for underground repeater installation, but the existing 4-MHz and 12-MHz systems use surface repeater buildings. It is often significantly more economic to continue to use these buildings than to re-terminate the cable and provide an underground repeater point. Wide ambient temperature variations are experienced in such buildings, and the conventional backward-acting type of pilot gain control employed is ideal for this application as it is effectively independent of temperature. Alternate repeaters are not gain-controlled, that is, they are operated at a fixed gain and provide a convenient method for compensation for repeater sections not exactly 4.5 km (2.8 miles) long. The gain can be adjusted by up to plus or minus six dB, corresponding to 720 metres (787 yards) of cable; line-building-out networks can also be provided.

12-MHz systems are now being installed in many countries for both the upgrading of existing cable routes from 960 channels to 2,700 channels, and as initial equipment on new cable routes. However, in parallel with this greater exploitation of the 9.5-mm cables, there has been a rapid growth in the installation of the 4.4-mm cables. Initially, these cables were equipped as 1.3-MHz (300-channel) systems, but nowadays most installations tend to be 4 MHz (960-channel) systems. In fact it is already clear that many of the routes would justify a larger capacity system, such as a 12-MHz (2,700 channel) for 4.4-mm cable. A system which is currently being developed is described.

COAXIAL CABLE SYSTEM—9.5-mm.

Line Amplifier.

The line amplifier is, of course, the heart of the system, and is worth discussing in some detail. Considerable development effort was expended in its realisation, as the choice of transistor types and circuit configuration have a profound effect on repeater spacing and power requirements. Thus one development was for an amplifier at three km (two miles spacing). By increasing the power dissipation to about 7.5 W per amplifier it was found possible to raise the signal levels so that a spacing of about 4.5 km (2.8 miles) between amplifiers could be achieved. However, with the advent of better types of silicon epitaxial planar transistors, and further development of the amplifier configuration, it was found possible to achieve this result with a power consumption of only 0.64 W.

A performance to enable a system noise of one pW/km to be achieved was set as a design target. This gives a good margin for any deterioration due to equalisation errors, in order to guarantee the CCITT requirement of three pW/km for the hypothetical reference circuit of 2,500 km (1,500 miles) under all conditions of service.

Desirable Properties.

The most important properties may be listed as follows:—

(a) Good input and output return losses (to minimise reflections and gain-errors).
(b) Low noise figure.
(c) Low intermodulation noise.
(d) Good overload margin.
(e) Low power consumption.
(f) Accurately shaped gain (to match the cable) and good stability of gain despite variations in power supply and ambient temperature variations.
(g) Accurate variable gain (to compensate cable loss change with temperature and cater for repeater spacing tolerances).
(h) Circuit flexibility (to enable minor changes to be easily made in both mean and variable gain-frequency characteristics). Then amplifier variants for use with older types of coaxial cable, which have slightly different characteristics, can be conveniently designed.
(i) Long life and high reliability.
(j) Ability to withstand induced power and lightning surges.

The requirements of low intermodulation noise and good overload margin conflict with low power consumption, and a compromise is therefore necessary. A major factor in the design has been the aim to restrict the power supply current fed along the cable inner conductors to the dependent repeaters to a maximum of 50 mA, at a maximum voltage relative to earth of about 300 V (250 V for the British Post Office). This is considered to be safe for maintenance personnel (Ref. 1). Work on the cable route is then possible without provision of the expensive safety precautions that were necessary on the earlier designs of coaxial system using valves.

Thus, the amplifier power consumption is severely limited if a reasonable number are to be fed remotely from widely spaced points along the route, and the remarkably low figure of 0.64 W (13 V, 49 mA) has been achieved. Other benefits arising from this low power consumption are low junction temperatures of the transistors (only 75 degrees C above ambient in the output transistor) and low ambient temperature rise of the amplifier components (about 2 degrees C). These are conducive to long life and high reliability.

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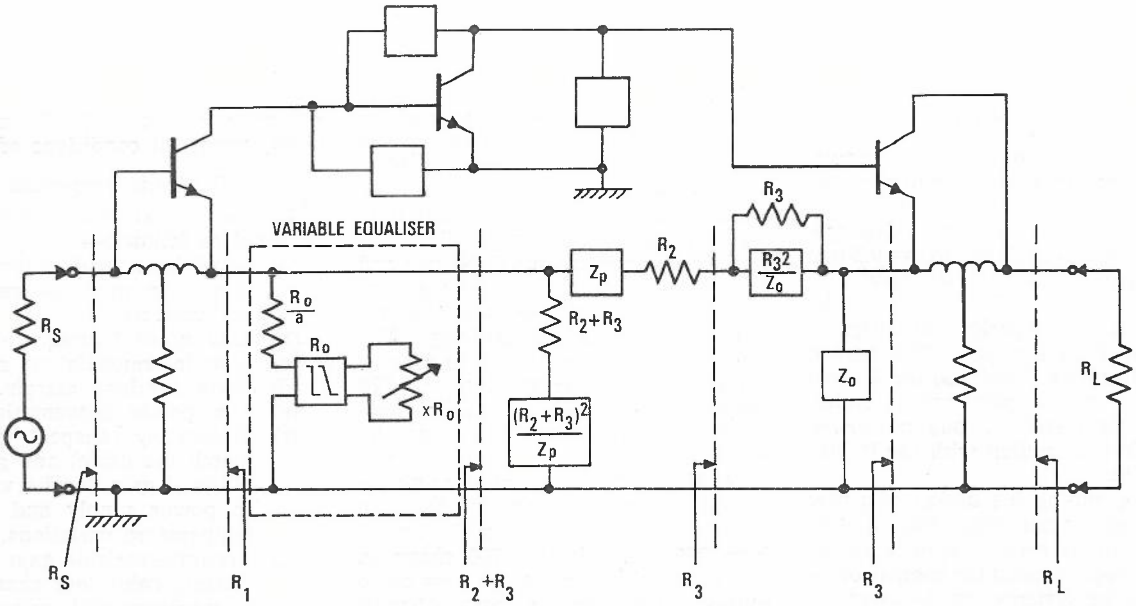

Fig. 1. — Line Amplifier Configuration.

Configuration.

Line amplifier circuit configuration is shown in Fig. 1. It is a feedback triple of silicon planar transistors, with hybrid circuits at input and output to provide good return losses against the cable, together with low noise figure and good output-stage efficiency. The mean forward gain-frequency characteristic is shaped mainly by the impedances $R_2 + Zp$ and Z_0 together with an input pre-equaliser (not shown). The pre-equaliser loss is small in the top portion of the band, to permit maximum slope of system pre-emphasis characteristic in that region and so optimise thermal and intermodulation noise and overload performance.

The gain may be varied to compensate for cable loss change with temperature and repeater spacing tolerance, by means of the variable equaliser in the feedback path. It is a well-known type described by H. W. Bode (Ref. 2), and employs the symmetrical constant resistance equaliser (characteristic impedance R_0) terminated in the variable resistance xR_0. This is either a thermistor, automatically controlled by a 12.435-MHz pilot regulator at regulated repeaters, or a fixed resistor at unregulated repeaters. The loss-frequency characteristic of the equaliser R_0 governs the variable gain-frequency shape of the amplifier.

To satisfy the requirements of the variable equaliser:

$$\frac{R_1(R_2+R_3)}{R_1+R_2+R_3} = \left(\frac{a^2-1}{a}\right) R_0$$

where a is a design constant, and R_1 and R_2+R_3 are impedances presented by the rest of the circuit.

The circuit provides the substantial amount of forward gain variation of plus or minus six dB at 12.5 MHz, and the configuration is notable in that this is achieved without appreciable variation in the overall loop gain. This is a valuable feature, because it is important to have as much overall feedback as possible to minimise intermodulation and achieve good gain accuracy. The more usual way of altering the gain of a feedback amplifier is to vary the amount of overall feedback. Sufficient amplitude and phase margin must be obtained at minimum gain (maximum feedback) to ensure freedom from oscillation. Thus, at maximum gain (minimum feedback) the amount of feedback may not be sufficient for good intermodulation or gain accuracy. However, the circuit is not subject to this limitation. A way of looking at it is to say that change of the variable equaliser varies the local feedback on the first stage, and not the overall feedback.

Similarly Z_0 may be changed to alter the forward gain without appreciably changing the overall feedback. Instead, the local feedback on the output stage is changed. This can be useful in shaping the forward gain of the amplifier without affecting the overall loop gain, giving considerable freedom in the design. Minor changes in mean gain-frequency and variable gain-frequency shapes, to cater for various cable types, may readily be made.

Regulation.

As will be explained later, pilot regulation requires more components than some other methods. However, failure of one or more regulators will not materially harm the system, and the pilot regulator can easily be arranged to produce an alarm in the event of pilot failure. The system now being described was therefore designed to use backward-acting pilot regulators, a technique found successful in earlier systems.

Whereas the thermionic-valve 12-MHz system used a control pilot frequency of about 4 MHz because of possible amplifier gain changes at the top frequencies due to valve ageing, the transistor amplifiers are highly stable over the whole band, and thus the use of a pilot frequency at the top of the band is permitted. A frequency of 12.435 MHz is used. It is, of course, at the top frequency where maximum cable attenuation changes occur, and hence a more accurate level control is obtained. The pilot detector produces a direct-current (d.c.) which controls the resistance of a thermistor located in the amplifier feedback circuit.

It was found feasible to obtain plus or minus four dB of automatic regulation range, and this, coupled with the excellent amplifier noise performance, permitted regulation at alternate amplifiers only. At the fixed gain amplifier, the control network can be used over its full plus or minus six dB range to compensate for excessive length errors. This means that sections of up to 5.25 km (3.25 miles) can be tolerated.

On any given route, the degree of 'stretching' is usually such that the resultant increase in random noise is tolerable, and a total noise of within three pW/km can be expected.

Method of Fault Location.

Closely allied to the regulation philosophy is the method of supervision used, so that staff at attended terminal stations can identify a faulty repeater. A pilot regulator of the type described can provide, at relatively little extra cost, a second output for driving an alarm circuit. A differential d.c. amplifier is used to drive a relay which puts a loop across an interstitial pair when the pilot error at the line amplifier output is greater than plus or minus two dB. The range of the regulator is such that only alternate amplifiers need to be regulated. In order that the unregulated amplifiers are also monitored, a simple output pilot level detector is used, and to keep this circuit as simple and cheap as possible, it is operated from the 308-kHz pilot.

If a cable breaks, current ceases to flow in the power feeding loop, and pilot alarms are given from all stations. A combination of a series- and a shunt-connected relay is used to give a unique power alarm from the station immediately before the break.

Large-core coaxial cables (9.5-mm diameter) are normally well supplied with interstitial pairs which can be used for extending the alarm conditions from the repeaters to the terminal as d.c. loops. Three alarm pairs are needed. At the terminal, after the presence of the loop has been detected, its resistance is measured and the distance away is proportional to the value obtained. If a fourth interstitial pair is used as a reference arm of the Wheatstone bridge, operation is independent of temperature variation.

A differential d.c. amplifier is used in the bridge to obtain a uniform performance over the operating range. The sensitivity is such that accurate discrimination is achieved on routes of up to 100 stations. An advantage of this scheme is that very long routes can be supervised from a single attended station.

Mechanical Features.

The attended station equipment is mounted on 2.75-m (nine-foot) double-sided rack-sides; one terminal repeater, complete with optional chart-recorders, occupies one rack.

The dependent repeaters can either be buried in underground housings or rack-mounted. The housing is of cast-iron, polyester-resin impregnated, externally zinc sprayed and epoxy-bitumen painted, and may be pressurised up to 0.7 kg/sq. cm (10 pounds/sq. inch) by means of a Schrader valve. The dimensions of the housing are 52 cm x 52 cm x 41 cm high (20.25 x 20.25 x 16.25 inches).*

System Performance.

A 50-km (31-mile) field trial route was installed, and extensive measurements confirmed that the design objectives had been met. The attenuation frequency characteristic was measured at regular intervals during a two-year period. These figures showed that the route was extremely stable. The biggest change recorded was 0.3 dB, and no general tendency could be detected.

Several of these systems have now been installed and are in commercial service. Typical performance data are shown on Figs. 2 and 3, which were recorded during the installation of a route in Austria. Thus Fig. 2 shows the attenuation frequency distortion in each direction, and the similarity between the two directions demonstrates the effectiveness of the factory quality-control techniques. Fig. 3 shows the response of the looped system (120 km - 75 miles) when loaded with white noise, and shows that the CCITT recommended maximum of three pW/km is met with good working margins to allow for equalisation and system line-up errors.

COAXIAL CABLE SYSTEM—4.4-mm.

Line Amplifier.

The parameters of a 12-MHz system for 4.4-mm cable have been discussed by the CCITT and the recommended spacing of two km (1.24 mile) defines an amplifier of virtually the same gain as the large-core design. However, as in any route there will be nominally two-and-a-quarter as many amplifiers in tandem, the noise performance needs to be correspondingly improved.

A suitable amplifier has been designed, based on the circuit configuration of the large-core amplifier described above but using the improved transistors now available.

* EDITOR'S NOTE: In Australia these systems use the standard APO underground repeater housing in accordance with Dwg. CL 1121.

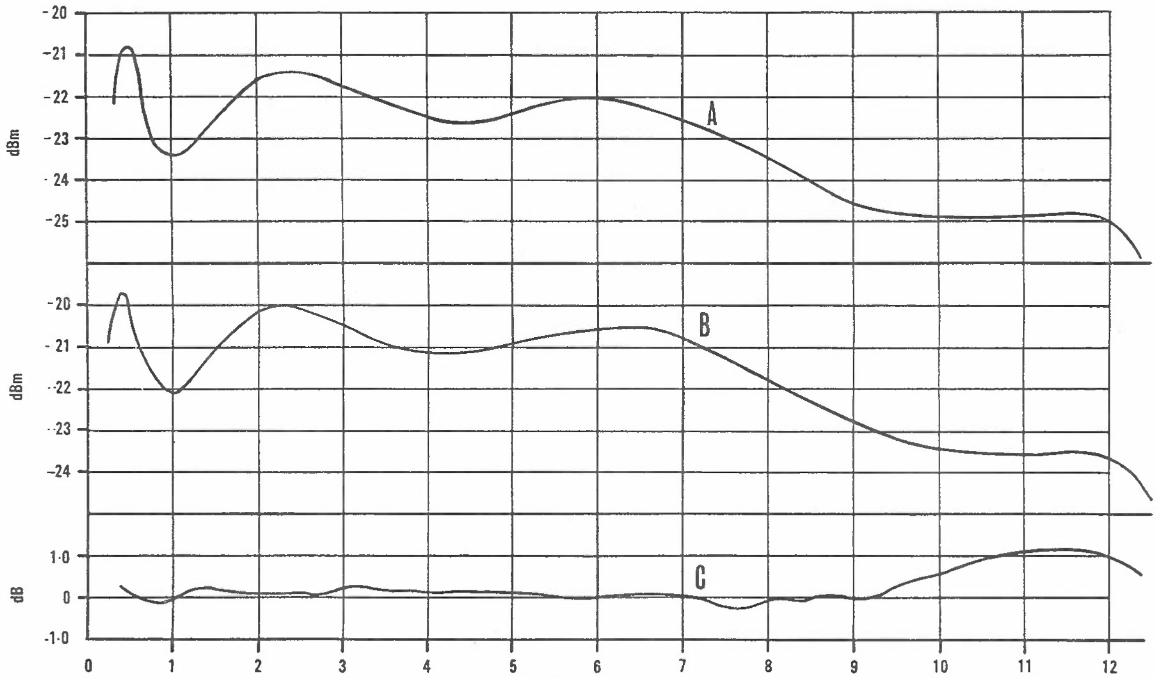

Fig. 2.— Attenuation-Frequency Characteristics of 50-km (31-mile) Line.

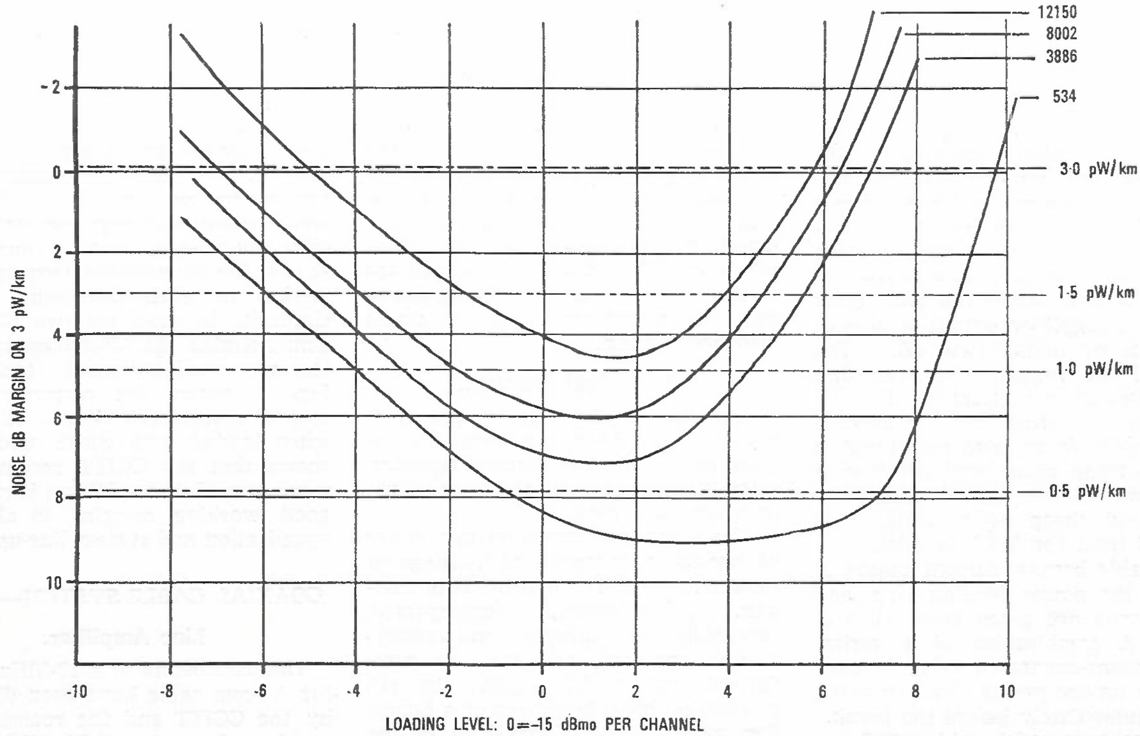

Fig. 3. — Response of 120-km (75-mile) Looped Line (Salsburg-Bischofshofen-Salsburg) When Loaded with White Noise

These devices have lower noise figures, giving improvement in thermal noise and higher cut-off frequencies, which has made it possible to increase the negative feedback, and hence reduce the intermodulation distortion. A further improvement in intermodulation performance has been obtained by increasing the power dissipation.

Regulation.

Several methods of gain regulation to compensate for cable loss changes due to temperature variation have been considered. An investigation of cable manhole and footway box temperatures with various degrees of thermal insulation was undertaken, and from these it was concluded that unless great care is taken, direct ambient temperature control of the amplifier gain is really only feasible if the repeaters are buried in the ground at cable depth. The alternative of using remote temperature-sensors in the ground or cable was considered too complex.

Many administrations and railway authorities prefer to house the repeater cases in shallow concrete footway boxes or sometimes in existing buildings, and in these situations a conventional pilot regulator must be used. Considerable advances have been made in the development of such regulators: for example, the ratio of the sizes of the 12.435 MHz pilot pick-off filter used on the 12-MHz valve system, the transistorised system of 9.5-mm cable and that available for the new system, are in the proportion 30:6:1.

The advantages of a pilot regulator over ambient temperature techniques are:

(a) Precisely defined levels.
(b) Simple and quick installation.
(c) Automatic compensation for monitoring errors and cable variations, including occasional exposed sections over bridges and so on.
(d) Repeater cases can be installed in manholes or existing buildings or be buried in the ground.
(e) The thermistor is included in the control loop, and compensation for variations due to ageing is therefore automatic.

The advantage of the ambient temperature controlled technique is essentially that less equipment is required and therefore reliability is improved.

The new system has therefore been designed to operate with either the pilot-regulator or ambient-temperature method, or a mixture of both. When, for constructional reasons, ambient temperature control cannot be used, pilot regulators are fitted at alternate amplifiers. The dynamic performance of the system is such that very many regulated amplifiers can be connected in tandem without instability. A circuit is provided to switch the repeater automatically to nominal gain should the pilot fail. If the repeaters are installed in such a manner that there is confidence that the repeater temperature excursions will coincide with the cable, then single thermistor networks, appropriate to the nominal section loss, can be connected directly to amplifier gain-control network. The resistance/temperature characteristic of these networks is such that the amplifier gain will be changed as required.

The first two stages of the line amplifier do not require the full line current and this surplus is used to power the regulator; that is, the power feeding distance is not affected by the choice of regulation method. Similarly there is no mechanical restriction on the number of regulators used, as sufficient space is always provided. If desired, both amplifiers in a repeater may be regulated, and, as described below, the supervisory system is independent of the pilot regulators.

Supervisory System.

In the large-core system, d.c. conditions on the interstitial pairs laid up between the coaxial tubes had been used to signal alarm conditions back to the terminal repeaters. However, with small-core cables, too few interstitial pairs are provided for this technique to be used. It was therefore decided that the supervisory information must be passed over the high-frequency (h.f.) path—that is, over the coaxial tubes. Many such h.f. supervisory schemes have been described, but most of these either tend to suffer from a proliferation of identifying frequencies requiring complex terminal equipment or can only be operated over a restricted range, typically over a power-fed section. As in the case of the 12-MHz on 4.4-mm cable system the repeaters are spaced at close (two-km-1.24 mile) intervals, it was considered essential that the supervisory scheme should have a long range, preferably terminal to terminal.

Some of the desirable properties of a supervisory scheme are:

(a) An alarm condition at any amplifier—that is, a change in amplifier gain of, say, plus or minus four dB at the highest frequency—should be signalled to the terminal.
(b) At the terminal station, unambiguous localisation of the alarm should be possible.
(c) The system should be capable of operating over a long distance, typically 280 km (174 miles), involving a chain of 130 repeaters.
(d) The equipment at every dependent repeater should be identical.
(e) It should be readily possible to integrate into the system supervisory information arising at non-attended power feeding points.
(f) The terminal equipment should be simple to operate and the information should be presented on lamps or meters.
(g) The scheme should operate without interfering with traffic.
(h) The scheme should operate in fault conditions.
(i) The scheme should provide level monitoring features of amplifiers selected at will.
(j) The scheme should have a high level of reliability.

A completely new supervisory technique has been developed to meet these requirements, and is incorporated in the 12-MHz system for 4.4-mm coaxial pairs. In principle, the operation is as described below.

An interrogation signal is injected at the terminal station as a transverse pulse between the inner and outer of the incoming h.f. coaxial tube. At the first dependent repeater the interrogation signal is filtered off, regenerated and passed on to the next repeater. At the same time, an oscillator operating at 13.5 MHz is connected for a short time to the output of the line amplifier. Thus, in response to the interrogation signal, the terminal receives a short high-frequency burst above the traffic signal. The regenerated interrogation signal passes from repeater to repeater and therefore each local 13.5 MHz oscillator is connected in turn. Consequently, at the terminal, a succession of pulses of 13.5-MHz signal is obtained, each originating at different repeaters, all incoming pulses of 13.5-MHz being spaced in time.

At the terminal, the incoming pulses are filtered off and fed into a counter. The result of the count is compared with the expected number for the route, and, if there is an error, an alarm is given. This cycle is repeated continuously.

A standard 12-MHz system was modified to incorporate this supervisory technique and tested on site. Excellent results were obtained, and it was shown that the supervisory circuits continued to operate, even in the presence of very high noise levels, including simulated high-level induction of power frequencies.

Further development of this pulse technique has confirmed it as an extremely powerful and effective supervisory system, giving the system designer and user great flexibility. As currently being engineered for the new 12-MHz on 4.4mm cable system, the facilities include:

(a) The receive counter display of numerical indicator tubes shows the number of responses received. If this does not correspond with the expected number, an alarm is given and the counter displays the number of the faulty station.
(b) The incoming pulses are checked for amplitude, and, if more than plus or minus three dB from nominal, the counter is stopped and an alarm is given.
(c) If it is required to monitor the level at a particular station, a decade switch is set to the appropriate number. This brings into circuit a second counter which opens a gate to a meter circuit at the time the selected pulse arrives. The output of this meter circuit is displayed on a decibel meter.
(d) The output from the meter circuit can also be used to drive a chart recorder.
(e) Supervisory units similar to those at the dependent repeater are provided at unattended power feeding points. These are operated from dry loops extended from alarm relays in the power equipment, door alarms and so on, so that in an alarm condition the response pulse is inhibited, and hence an alarm is given at the terminal.
(f) On some routes, or at certain times of night, it is convenient to supervise both directions of transmission from the end. This can be done by operating a key which sends a command tone, over the order wire circuit, to the far end, which turns round both the interrogation pulse and the response pulse. This facility can be provided at either terminal.

The equipment needed to provide these facilities occupies no more volume than the d.c. system used on the large-core system. Extensive use has been made of integrated circuits, with the result that the number of components used at dependent repeaters is quite small, this being conducive to high reliability. The supervisory system operates continuously, and any fault — be it in the transmission path or the supervisory equipment—is signalled immediately. This permanent, self-monitoring feature is to be preferred to an arrangement in which supervisory equipment is brought into use only when required.

The maximum length which such a system can supervise is determined by the noise falling into the bandwidth of the supervisory input filter. This has to be fairly wide to pass the pulses of 13.5-MHz signal, and the situation worsens in fault conditions when regulated amplifiers can rise to maximum gain. It has been found feasible to design the system for a 280-km (174-mile) route. However, this can be extended indefinitely by introducing regenerative repeaters in the response pulse path.

It is foreseen that this technique could in the future be developed further—for example, to provide direct maintenance control of line systems by a central computer, and the extension of the level monitoring facilities to give information on amplifier noise performance.

Power Feeding.

The system has been designed to operate with a constant current of 50 mA, and therefore no special precautions need to be taken to protect maintenance staff from the power feeding supply. Up to ten repeaters can be fed with a supply voltage of 320-0-320, and power feeding points are spaced at nominally 42-km (26-mile) intervals The h.f. equipment at alternate power feeding stations can be identical to that at dependent repeaters, and only the power feeding equipment is extra. The other type of power feeding station includes extra equipment in the h.f. path for equalisation and flat, level access points for dropping circuits.

The power feeding equipment includes metering circuits which, in the event of a cable fault, can be used to locate the faulty section. A four-wire order wire circuit with selective calling is provided between all power feeding stations on the route. A portable 'speaker box' can be used to obtain access to this circuit at dependent repeaters.

Terminal Repeaters.

A manually adjustable equaliser is provided to facilitate the rapid equalisation which may be needed, when routes are interconnected in a new pattern. This equaliser can be used to compensate for any long-term or seasonal gain changes that may occur. It was considered essential that it should be possible to adjust the equaliser without disturbing traffic. This precluded a sweep technique, which in turn makes the adjustment of a cosine type of variable equaliser very difficult. Consequently a 'bump' equaliser is used which can be adjusted in conjunction with the recommended CCITT additional measuring frequencies.

Line systems are frequently connected in tandem to make up the national network. Should one system go faulty and, for example, overload, the tandem connected systems also suffer, and the whole network can become affected. A similar situation can arise if a maintenance man inadvertently connects high-level test signals at a low-level point in the system. To safeguard against these situations, load monitors are used at the input and output of the system, to control a traffic cut-off switch.

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TECHNICAL NEWS ITEM

$3.75 MIL. TO IMPROVE FLYING DOCTORS' RADIO

The Royal Flying Doctor Service has one of the biggest fleets of light aircraft in Australia, operating 20 planes on the mainland.

These could not function effectively without radio telephony, and what has become the largest high-frequency radio communications network in the world is to be rebuilt shortly at a cost of about $3.75 million.

The Flying Doctor Service has three aircraft operating from Mt. Isa and Charters Towers, three from Broken Hill, four from Port Augusta and Alice Springs, two from Kalgoorlie, seven from other bases in Western Australia, and one from Wyndham and Broome.

In Tasmania the service uses chartered aircraft.

The RFDS aircraft made 3161 flights, amounting to 1,422,460 miles flown, in the 12 months to June 30 last. The flights represent 8489 hours in the air.

The radio communications system which enables the medical service to operate over the wide continent, beyond the reach of normal telephone and telegraph service, consists of 12 base stations and thousands of transmitter-receivers.

The RFDS does not know how many, but they probably number about 5000 transceivers.

Fixed or mobile instruments, they hook in to a network which covers two-thirds of the continent.

The radio network is to be converted from double sideband to single sideband operation. The changeover is dictated by international agreement on the use of radio frequencies.

It will double the number of channels available to the Royal Flying Doctor Service. Also it will effect a dramatic improvement in communications performance, by reducing the static to which traffic is now prone by reasons of climate and terrain. Furthermore, it will reduce interference from overseas transmissions.

The RFDS and the Postmaster-General's Department have collaborated in planning the conversion, with advice from members of the Australian Telecommunications Development Association.

The instruments have been improved vastly, of course, since the original pedal-generator wireless.

ATDA member-companies have put a lot of effort into lighter, more compact and more reliable equipment, so that when the conversion is completed the inland radio communications system should be the most efficient it is possible to attain.

The target date originally was 1975, but this will have to be extended, possibly by a year.

Tenders have been called for supply of transmitting and receiving equipment for the base stations. This first stage of the conversion is expected to cost about $480,000.

The Commonwealth Government will meet the cost of re-equipping the base stations, but the owners of individual transceivers will have to bear the cost of replacing their instruments.

These are scattered far and wide, in station homesteads and outstations, and in the trucks of drovers, geologists, prospectors, surveyors, hauliers and others.

The new transceivers probably will cost between $500 and $600 each and the total cost of the conversion programme is expected to reach about $3.75 million. It has been suggested that some leasing arrangement might be worked out to ease the burden of replacing transceivers.

The importance of efficient communications is emphasised by the fact that in addition to its primary purpose of summoning medical help the radio network handled 327,416 radiograms in the last financial year. The network also makes possible the School of the Air teaching service.

The present network enabled the Royal Flying Doctor Service's doctors to give 20,000 medical consultations by radio in the 12 months to June 30.

The service's aircraft, with the help of radio, enabled doctors to attend 55,000 patients in the outback and transported 4,000 patients to hospitals.

Radio informed people about dentists' visits and RFDS aircraft transported dentists who conducted clinics in various places, at which they treated 3791 patients.

DEVELOPMENTS IN UNDERGROUND BALANCED PAIR TELECOMMUNICATION CABLE IN AUSTRALIA SINCE 1945

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INTRODUCTION.

The balanced pair cable constructions used in Australia have comprised assemblies of twisted pairs of wires or of twisted four-wire quads in which each diagonally opposite pair of wires forms a circuit. The primary constants of cable pairs are resistance, inductance, conductance and capacitance. Balanced pair cable design is generally based on resistance and capacitance, the inductance then being determined by the geometrical spacing of the wires and the conductance by the choice of insulating material. The insulant is almost invariably either dry paper, applied with as much air space around the conductor as practicable, or polythene.

The two secondary parameters of main importance for signal transmission are attenuation and impedance, and at voice frequencies these are determined by the resistance and capacitance.

A large communication authority is faced with a wide range of uses for cables, and for economic reasons the designer is required to produce a minimum range of cables to meet these needs.

In the Australian Post Office 98.5 per cent of the sheath miles of balanced pair cables purchased annually is local type as distinct from trunk type or carrier type. Local type cables are used mainly at voice frequencies for subscriber, junction and minor trunk purposes in either the loaded or unloaded condition. To best suit this wide application they are designed with constant capacitance (0.072 microfarads/mile) and a range of resistance values (88 ohms/mile for 20 lb./mile conductors to 700 ohms/mile for 2½ lb./ mile conductors). When loaded, the impedance in the transmitted frequency range becomes approximately the same for all gauges and a choice of various attenuations and D.C. resistances remains. This also applies at carrier frequency in the unloaded condition. D.C. resistance remains important because of the direct current requirements of the switching equipment and subscribers' instruments.

Another factor affecting transmission is crosstalk caused by mutual impedance unbalances between the pairs, or between the pairs and outside sources of interference. The importance of crosstalk has been highlighted in recent years due to the tendency to reduce cable costs by permitting higher circuit attenuation, which can be economically offset by amplifiers, greater use of loading coils or multiplex methods of working.

Crosstalk is reduced within the cable by the continuous transposition of the pairs in relation to one another and using different lengths of twisting lays, more complicated twisting schemes being required for high frequency operation. At carrier frequencies magnetic couplings between the pairs become more important, and these are not substantially reduced by physical separation or shielding by other conductors as are electrostatic couplings.

The protection of the cable core against moisture entry, mechanical damage, lightning, pest attack and other hostile elements of the environment is an important component of first cost, and inadequacies of the protection measures are almost entirely responsible for the maintenance costs arising during service.

With these factors in mind, the developments that have occurred in outdoor cables are reviewed in relation to other components of the telephone system and to the cable manufacturing industry. Emphasis is placed on the constant interaction between improvements in technology over the whole communication field, and the changes that have been made in an effort to provide a system of the quality and capacity required today, whilst taking into account the predicted needs of the future.

THE EXPANSION OF CABLE MANUFACTURE IN AUSTRALIA.

The growth and demand for cable after 1945 quickly outstripped the capacity of the only local cable factory, established by Metal Manufactures Ltd. in 1923 at Port Kembla. A new company, Austral Standard Cables Pty. Ltd., was formed in 1948, and this company absorbed the Port Kembla plant and erected a new factory at Maidstone, Victoria (Refs. 1 and 2). In 1950-51 the Australian Post Office purchased approximately 275,000 pair miles of local type cable; in 1960-61 approximately 543,000 pair miles; and in 1967-68 approximately 1,107,000 pair miles. This demand has been met by expansion in the manufacturing industry, supplemented by imports during various periods. In 1959 Austral Standard Cables built a factory at Liverpool, N.S.W., in place of the old Port Kembla plant, and in 1960 Olympic Cables Pty. Ltd. entered the field of communication cable manufacture (Ref. 3) with a new plant at Tottenham, Victoria. In 1965, Austral Standard Cables opened a new factory for the production of plastic insulated cables at Clayton, Victoria, and in 1967 Conqueror Cables Pty. Ltd. commenced plastic communication cable manufacture at Dee Why, N.S.W. Expansion and change are taking place at all locations.

EFFECTS OF OTHER NETWORK COMPONENTS.

Subscribers' or Sub-Station Equipment.

The improvement in telephone receivers and transmitters has considerably reduced cable costs. The effect of different transmitters and receivers on the transmission limits is quite complex. (Refs. 4 and 5.) In general greater efficiency in these components allows increased attenuation in the outside line, but requires improved crosstalk characteristics in the cable if the same performance standards are to be maintained.

In 1956 the transmission limits were revised to take advantage of the 2P and 4T receivers (Ref. 6). For example, the limiting resistance for a line of 10 lb. cable was extended from 500 to 700 ohms. The increased limit enabled the use of 4 lb./mile conductors, first manufactured in 1952, to increase rapidly. This cable was of twin construction laid up in units as distinct from star quad concentric layer cable which had been the standard since about 1935.

Unit type cables offer advantages over concentric layer cables both in manufacture and in installation, these becoming more marked as pair sizes increase and with the use of twin construction. The main advantages of unit type cables, which were developed in 1927 by Western Electric (Ref. 7) to permit the manufacture of large pair size 26 AWG (4 lb./mile) cable, are:—

(i) Manufacture is simplified since the same basic cable unit is used

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for a large number of finished cable pair sizes. Only two operations are necessary for any size cable; unit making and stranding of units into cable. With concentric lay cables multiple passes through the largest machines are necessary.

(ii) Manufacturing productivity is improved. Longer lengths of the unit can be made on small machines at speeds higher than are possible with the drum stranders used for concentric lay cables. If stationary feed stands are used change-over times can be reduced by duplication, and spool loading can proceed while production is in progress.

(iii) In the field the jointer can work from the rear to the front of a joint, unit by unit, instead of commencing at the centre and working around layer by layer.

Price studies showed unit twin to be more expensive than star quad contric cables in the heavier gauges and the cable network evolved with twin 4 lb. and star quad larger gauges in the subscriber portion, loaded 10 and 20 lb. star quad in the junction and minor trunk portion, and 40 lb. star quad for carrier cables.

In 1963 a review of the transmission limits led to a further extension (from 700 to 770 ohms for 10 lb. cable). There were no changes to the transmitter or receiver, but the review led to a clearer definition of network levels and the establishment of a preferred near-end crosstalk performance of better than 65 dB at 1600 Hz for subscribers' lines. These crosstalk requirements were met by the 4 lb. unit twin cables, but 6½ lb. star quad unloaded cable without balancing was meeting them only marginally.

Specifications had been tightened, as a preliminary step, to values compatible with production achievements and by 1965 new specification limits had been derived. However by that year parallel investigations had shown that subscriber loading offered substantial economic gains, particularly in rural areas, where open-wire construction could be replaced by loaded cable. The effect of loading is discussed in the next section.

Loading.

The effect of loading on cable crosstalk can be judged from the equation used for capacitative coupling crosstalk.

$$C.T.U. = \frac{2\pi f K \sqrt{Z_a Z_b} \times 10^{-6}}{8}$$

where $C.T.U.$ is Crosstalk Units,
f is the frequency of measurement (Hz),
K is the capacitance unbalance (picofarads),
Z_a and Z_b are the impedances of the disturbing and disturbed circuits at frequency f (ohms).

When loaded, the impedance of the circuits increases and the crosstalk in C.T.U. increases proportionately. Furthermore, the attenuation of the circuits decreases and the near-end crosstalk deteriorates further due to the greater length of cable contributing to the accumulated value of K.

Loaded junction cables were balanced within quad to provide a crosstalk performance of generally better than 60 dB at 1600 Hz by reducing all capacitance unbalance values within quad to less than 450 pF in a 2000-yd. loading section.

The proposal to load subscriber cables meant that the preferred crosstalk objective could not be met without either a marked improvement in cable quality, or the balancing of subscriber cables, or both. Balancing of subscriber cables is not favoured because of increased initial installation costs and later problems of ensuring that the cable performance is maintained. The consequent design changes were not made in isolation, but became part of an overall change needed to solve this and similar problems in the junction network, and are described in the next section.

Amplifiers and Carrier Equipment.

Negative Impedance Repeaters: A proposal was made in 1966 to introduce amplified working into the junction network using Negative Impedance Repeaters. The N.I.R.'s would reduce losses in certain parts of the network and as a result the near-end crosstalk requirement in local type cables used as junctions needed to be increased to better than 65 dB at 1600 Hz, the same as for subscriber use mentioned previously. Investigations started in 1964 to determine the economies of meeting the crosstalk requirements in loaded cables by either balancing of an improved quality in star quads, or by changing to unit twins.

The advantages associated with quad type cables were their smaller diameter (about 10 per cent.), which affects both sheathing costs and the pair capacity of the ducts, and the fact that a substantial investment already existed in the industry for manufacturing this type of cable. The advantages associated with unit twin cables were that core costs are lower and capacitance balancing can be eliminated.

The net result was that in 1968 the Post Office decided to adopt unit twin construction for all local type cable for subscriber, junction and minor trunk purposes.

Other network considerations which made minor contributions to the decision were:

(i) Digital systems, particularly pulse code modulated (P.C.M.), are well suited to unit construction, where directional separation of 4-wire circuits can be achieved by unit selection.

(ii) Cables installed without voice frequency balancing are inherently more suitable for higher frequency operation.

(iii) Twin cables would allow some scope for further improvements in crosstalk beyond that required at the time of the decision. The scope arises from the use of 'random jointing' (any pair to any other pair from the corresponding unit) in paper cables or from the selection of polythene as the insulation.

Transistorised Carrier Equipment: Transistorised carrier equipment has changed the relativity of cable and equipment costs and increased the potential use of carrier systems in local type cables. This, followed by the development of Pulse Code Modulated systems, has led to a review of the high frequency characteristics of local type cables.

The characteristics considered for changes are:

(i) Mutual capacitance uniformity within and between lengths. In the past the maximum mean mutual capacitance for factory lengths has been specified. Variations in the mutual capacitance of pairs in a factory length at higher frequencies can represent impedance irregularities in the installed cable (at 1500 kHz the wavelength would be less than 200 metres).

(ii) Resistance and Resistance Unbalance. These characteristics are generally uniform, and in local cable only the maximum loop resistance is specified. Some limit for resistance unbalance is desirable for high frequency operation to assist in control of circuit noise. It could also become necessary to place limits on loop resistance variation to gain improved impedance uniformity.

Studies on these aspects are proceeding, but it is still too early to indicate what limits, if any, will be introduced.

RAW MATERIALS — DEVELOPMENTS AND EFFECTS.

The Impact of Plastics.

The impact on cable technology of thermoplastics has been far-reach-ing. In Australia, the first use was in about 1951 (Ref. 8), and since 1956 has been substantial.

Their application has been twofold, firstly as an insulation and secondly as a sheathing and jacketing material (Refs. 9 to 15). The first application to outdoor cables was the use of P.V.C. (polyvinyl chloride) for the insulation of conductors in lead-sheathed subscribers' lead-in cable.

Where longer distances are involved the preferred insulation has been and still is low density polythene. Other thermoplastics with good electrical properties, such a high density polythene and polypropylene, have not been used to date because of price. Although the price of polythene has dropped, it still remains more expensive than paper as an insulation. However, it is considerably cheaper than lead as a sheath and this more than compensates for the increase in insulation costs in small cables. The economic changeover point, depending on the relative costs of polythene and lead, has varied from about 74 pairs in 1960 to around 150 pairs at present. Polythene has many other advantages besides cost (in small sized cables) to support its increased use, and these are:

- (i) It is a very stable material and is virtually corrosion free.
- ii) It is light in weight, particularly when compared with lead.
- (iii) The high frequency characteristics of polythene are superior to those of paper.
- (iv) When extruded on to a conductor the uniformity is better than can be achieved with paper insulation, giving better crosstalk characteristics.
- (v) Polythene as an insulant is not affected by normal environmental conditions of humidity or temperature.
- (vi) It can be produced in a wide range of positive colours and so allows full colour-coding of subunits.

The Post Office now specifies polythene for the insulation and sheath of distribution cables, for the insulation of cables where direct termination can be used and of cables for special high frequency operation, for the corrosion protection of the lead sheaths on most trunk cables and many subscriber and junction cables, and for moisture barrier sheaths. The development of moisture barrier sheaths is described later.

This large penetration has been accompanied by developments of processes and machines designed for the new material, and plants entirely devoted to plastic cable have been established.

Copper Prices and Shortages.

The Post Office made preliminary examinations of the potential of aluminium as an alternative to copper in the late 1950's. Experimental aluminium cable of 20 lb. copper equivalent, polythene insulated and sheathed, was produced, but was not installed and only limited experience in manufacture was obtained. No emphasis was placed on further developmental work, particularly as reports on experience from the Bell System of America indicated that their trials during the same period were unsatisfactory.

From 1964, high copper prices and actual shortages, due to industrial problems, prompted the Post Office to resume the developmental work with aluminium. The aim is to reach a stage where the substitution can be effected should physical shortages of copper arise in the future. After that the use of copper or aluminium for conductors will be essentially a matter of relative economics. One of the penalties with aluminium cables is that their diameter is approximately 28 per cent. larger than equivalent copper cables.

Initial trials with aluminium conductors were confined to paper cables installed in the subscriber main cable area and placed under gas pressure. So far they have indicated that fully annealed aluminium can be satisfactorily substituted for copper in lapped paper ribbon insulated cables. Hauling problems due to the lower tensile strength of aluminium are offset by the reduced weight and electrically satisfactory joints have been achieved using electric welding or crimped sleeve techniques. Developmental work is being carried out on connector jointing methods to improve jointing productivity and trials are planned using 4 lb. equivalent aluminium.

To date, aluminium cables have been terminated with copper conductor tail cables so that the copper to aluminium joint remained in the gas pressure protected dry cable core. In the presence of moisture, and with battery on conductors, aluminium corrodes faster than copper, and what is of more importance, the corrosion by-product is hydrated and cannot readily be dried out. Replacement of the cable rather than repair is generally necessary for restoration of service. Since paper will fail as an insulant before the relative humidity reaches the level at which corrosion commences, a warning is given before conductor damage occurs.

The use of aluminium conductors in plastic insulated and sheathed cables has not been attempted as yet because of problems additional to the wire jointing. Existing sheath design and field practices do not sufficiently ensure freedom from moisture, but these aspects and the potential application are to be reviewed.

Lead Prices and Problems.

Shortages and high prices of lead in the U.S.A., after the 1939-1945 war promoted the development of Stalpeth (steel, aluminium, polythene) sheaths as a replacement for lead on most paper insulated cables. Lead continued to be used as the standard sheath in Australia until the moisture barriered polythene sheath, adopted by the British Post Office as standard for paper insulated subscribers' cables since 1964, had been examined. Successful field trials of cables with this sheath type have been made, but some installation and maintenance problems, arising from sheath jointing difficulties, have retarded the rate of introduction.

The moisture barrier sheath consists of a polythene extrusion over an aluminium-polythene laminate which becomes a uniformly integral part of the sheath. The aluminium acts as an effective barrier to moisture vapour permeation in addition to being an electrical shield. Without this barrier molecular permeation of moisture vapour through the polythene sheath could reduce the effectiveness of paper as an insulation to an unacceptable level. The advantages of the moisture barrier sheaths compared with lead sheaths will lead to the eventual replacement of lead except in special circumstances. These advantages are:

- (i) A saving of about 10 - 15 per cent. of cable cost is possible, depending on ruling lead prices.
- (ii) A moisture barrier sheathed cable is approximately one-half the weight of a lead-sheathed cable. This lowers transport costs and permits longer lengths of haul, eliminating some joints.
- (iii) The sheath is free from corrosion.
- (iv) Their use will permit exploitation of rail transport or long distance road transport without special precautions to avoid the vibration fatigue which occurs with lead.

EFFECTS ARISING FROM THE ENVIRONMENT.

Insect Attack on Cable Sheaths.

Termite attack is a problem with directly buried cables in some rural areas in this country, particularly in the north and for this reason steel tape armoured cables are standard for direct burial in these areas.

When plastic cables were introduced many of the areas previously regarded as safe proved disastrous because of ant attack from a number of species which had never attacked lead cable sheaths (Ref. 16). The first attack was reported in 1955 very shortly after the first plastic sheathed cables had been installed. In 1958 a special committee, under the auspices of the Plastics Institute of Australia, was established to investigate means of overcoming the problem of ant and termite attack on plastics in general. The Commonwealth Scientific and Industrial Research Organisation, Division of Entomology, and the Research Laboratories of the Department have carried out extensive laboratory and field tests with termites (Ref. 17). Attempts to have laboratory and field tests made with ants have not so far been successful, but there is every indication that a physical barrier to termites will be a barrier to ants.

In 1967 the Post Office issued a draft specification for an Insect Resistant cable jacket which reflects the present belief that a mechanical barrier to prevent attack offers the most reliable solution. The barrier specified is a thin jacket of Nylon 11 or other comparable material. For some years extrusion of thin nylon walls over non-uniform sheath profiles posed difficulties, but trial lengths have recently been produced on cables up to 1.6 in. diameter. Nylon jacketed cables are expected in the near future.

Other types of nylon which have been tested indicate an equally satisfactory performance as a barrier, but confidence in the Nylon 6 group is reduced by the fact that it is soluble in formic acid, which can probably be exuded by ants.

DEVELOPMENTS IN MANUFACTURING MATERIALS AND PROCESSES.

As 70 per cent. of the cost of cables lies in materials, the user largely controls the cost of these components of the specification. The cable manufacturer, in assessing the efficiency of the enterprise, is primarily concerned with the charges for labour and administration, scrap, capital, development and profit. This section is confined to an outline of the more important developments affecting quality and productivity.

Raw Materials.

Copper Wire: Marked improvements in the productivity of paper insulating machines followed the introduction in the late 1940's of spoolers on wire drawing machines, permitting longer supply lengths and eliminating the tangling experienced with coil supply. Wire may be batch annealed on the steel spools, but longer lengths, especially suitable for high-speed feeding behind extruders without trouble due to stickiness, are produced by use of continuous bright annealers between wire drawing machines and spoolers.

Insulating Paper: Manilla-wood pulp papers have become increasingly expensive owing to shortages of old ropes and the necessity to use virgin manila fibre. The manila content of the paper has been reduced from 60 per cent. to nil. The newer all-wood papers run well on the insulators, exhibiting about 15 per cent. higher tensile strength and reduced sensitivity to relative variations.

Polythene: Early insulating grades of low density (L.D.) polythene had a melt flow index (M.F.I.) of 7, but these have been replaced by harder and tougher grades of 0.3 M.F.I. The new grades have a much improved balance of properties in respect of extrusion performance with low defect rates at high speeds, freedom from foreign materials, thermal stability, and physical toughness.

For sheathing L.D. polythene of M.F.I. 2 was originally used with the addition of 10 per cent. butyl rubber and 2.5 per cent. finely dispersed carbon black. This has been replaced by a higher molecular weight grade of 0.3 M.F.I. with 5 per cent. butyl. It has always been thought desirable in Australia to include the carbon black as a safeguard against ultra-violet light degradation during storage and in use. The inclusion of the butyl content has prevented environmental stress cracking and has the additional advantage of making the sheath insensitive to residual stresses arising during extrusion

Manufacturing Processes.

Polythene Insulating and Sheathing: The original specifications called for a uniform insulation thickness of 0.012 in. for 6½ lb. to 20 lb. conductors inclusive, but to achieve comparable mutual capacitances for all gauges the present range of 0.0065 in. to 0.012 in. (4 lb. to 20 lb.) was specified in 1963. The consequent increased incidence of pinhole faults (small defects in the insulation) proved to be a pressing problem for some time, and it was found that extreme care is necessary in all the following respects:

(i) Selection of copper rod and control of wire drawing to produce clean wire free from surface imperfections.
(ii) Close control of tension adjustments and maintenance of guiding surfaces in clean and smooth condition.
(iii) Avoidance of contamination by air-borne dust bearing in mind that polythene readily accumulates static charge.
(iv) Selection of pigments with minimum tendency to form agglomerates.
(v) Controlled extrusion conditions in respect of temperatures, screen pack design and replacement frequency and head and die design to avoid stagnant zones.

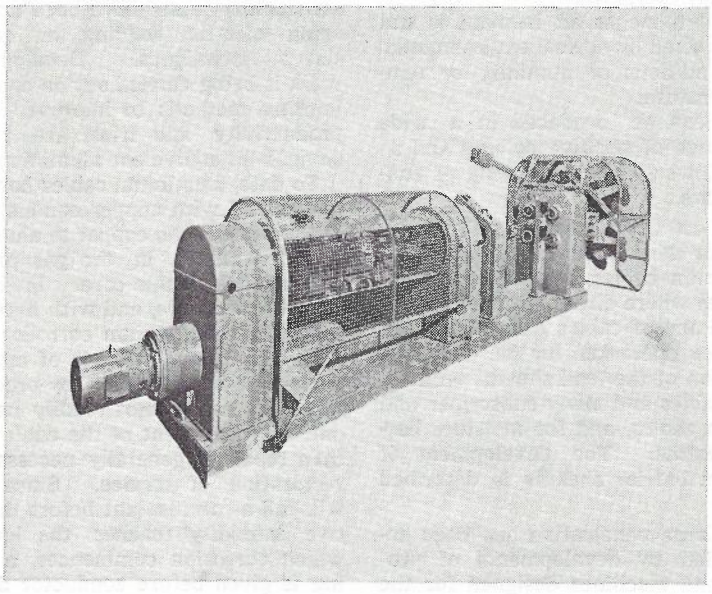

Fig. 1 — High Grade Quadding Machine.

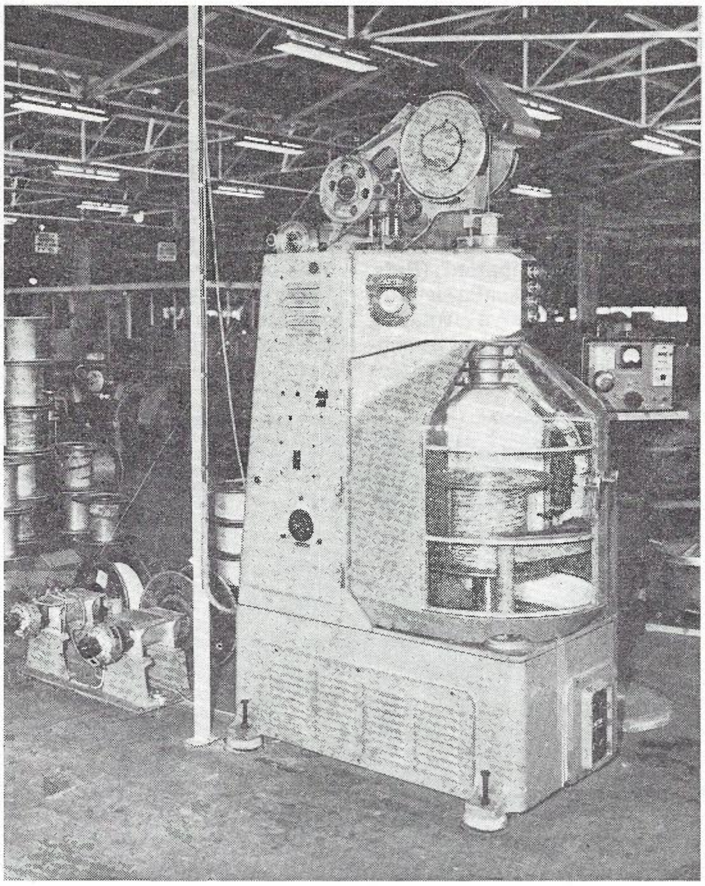

Fig. 2 — Single Twist Twinning Machine.

Outright pinholes can be detected at extrusion speeds by a high voltage electrode, but points of weakness in the insulation seldom show up at this stage. Very few faults occur during extrusion but a rate of about one fault in 30,000 conductor yards is generally found after the twisting operation. These faults are repaired in a separate injection moulding process. The defect rate in completed cores is now better than 1 fault in 40,000 conductor yards; the level first specified in 1963 required better than 1 fault in 25,000 conductor yards.

The spooling of bare wire has received considerable study and with the inner end brought out and cold pressure welding to the next length, reliable continuous operation of extruders is not difficult to achieve. With extruders of modern design production rates of 3000 ft./min. are maintained.

Sheath extrusion lines are scaled-up versions of those used for insulation. They have outputs up to about 1000 lb. of polythene per hr., but are typically operated at two-thirds of this rate. Plastic-sheathed cables do not cast satisfactorily on single drum capstans, and dual wheel capstans have progressively given place to the caterpillar type, simplifying stringing up and eliminating bending of the cable at this point.

Twisting: Tubular type machines with axially disposed floating supply spool cradles were used from 1945 to 1968 for paper cables, but were not capable of meeting modern capacitance unbalance limits owing to the sensitivity of quad geometry to variations in conductor tension at the closing die. Improved machines of this type, operating at 900 r.p.m. instead of 500, are however suitable for plastic quad to ordinary subscribers' cable limits.

Paper cable machines similar to that in Fig. 1 were introduced into Australia about 1965. These machines operate at 300-400 r.p.m. Rotating masses are reduced since the supply spool yokes turn independently to impart back twist. The quad is twisted by rotation of the capstan and take-up as a unit. Adjustment and indication of conductor tension are provided, but, without the use of a centralising helix of paper string under the paper insulation, the latest network limits could not be met.

Compact vertical high-speed double-twist (i.e., two complete helical twists per revolution of the Flyer) twinning machines were adopted with the introduction of paper insulated unit cables. Production rate is 1600-2000 twists/min., depending on conductor gauge, and the twin produced meets the new capacitance unbalance requirements. At some cost in extra floor space, horizontal machines producing up to 3000 twists/min have been used.

Double twist machines have been abandoned for polythene twin in the interests of avoiding damage arising from the tortuous path around the flyer. The single twist machine shown in Fig. 2 therefore has a reduced output, but yields a high grade product. The machine provides for

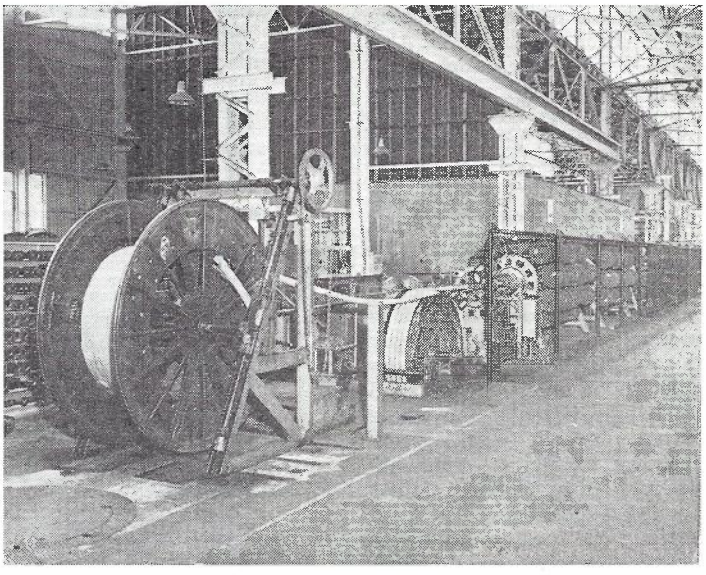

Fig. 3 — Concentric Stranding Machine.

accurate metering of the conductor lengths over a belt capstan, and the flyer guides are located so that under centrifugal action the twisted pair is practically floating. The take-up tension is correspondingly accurately controlled and ease of spool changing has received special attention.

Stranding, Bunching and Cabling: Concentric cables have almost invariably been stranded in reverse directions in successive layers with an increment of six quads or twins per layer, using machines similar to that illustrated in Fig. 3, which have typical speeds from 30 to 45 r.p.m., depending on carriage size. These machines are otherwise of low efficiency, since re-loading cannot be commenced until the previous run is finished and several hundred spools are needed for the larger cables. The first improvements were developed in the U.S.A. in the 1920's and 1930's with the introduction of paper insulated unit cable, and comprised a conventional spool carrier, which was however stationary, with a flyer revolving around it. At a later stage the supply spools were arranged in rows, and stranding was effected by bunching the pairs through a closing die, thence to a capstan and take-up drum rotating about the axis of the cable as well as about their normal spindles. In some cases the capstan was eliminated and the speed of the take-up drum was automatically monitored as the winding diameter increased so as to achieve a uniform length of stranding lay. The required number of units was then re-stranded, or cabled, on a similar but larger machine.

Both these processes have considerable advantages in speed. Bunching to about 150 r.p.m. is practicable. Also by provision of duplicate supply positions, new spools can be loaded during running, and in both America and Japan elaborate mechanical handling systems have been developed to reduce lost time still further. Cabling speeds vary with machine size, but 60-100 r.p.m. is reasonably achievable.

Early paper insulated unit cables were manufactured in Australia on adapted conventional stranders. The complete change-over to twin in paper insulated cables will be achieved by the installation of unit bunchers and cablers to handle virtually the whole of the output. A unit bunching machine is shown in Fig. 4. This machine was installed by Olympic Cables in 1967 and has been modified from pure bunching to include interlayer whippings which were then standard.

For plastic cables, relatively light pressures in core forming dies are all that are necessary or desirable, and this facilitates combining unit stranding and cabling in the one operation, because by imparting twist to the units alternately in opposite directions and applying a binder to hold the twist, the tension in the units is light enough to enable them to be led to a rotating assembly for cabling without straightening out the oscillatory twist already imparted (Refs. 18, 20 and 22). The oscillating process requires no massive rotating components such as capstans, but simply uses suitably disposed lay plates which oscillate over a range of about 180 deg. either way. The rate of oscillation is adjustable to minimise crosstalk between adjacent units. Fig. 5 illustrates a machine with supply spools, oscillators, and binding heads for 10 sub-units in the background, and the rotating capstan, wrapping heads, and rotating take-up for cabling the oscillated units in the foreground. This buncher-cabler has been in satisfactory use since 1965. It does not operate with best economy on small sizes, and a process has therefore been developed for cable up to 30 pairs

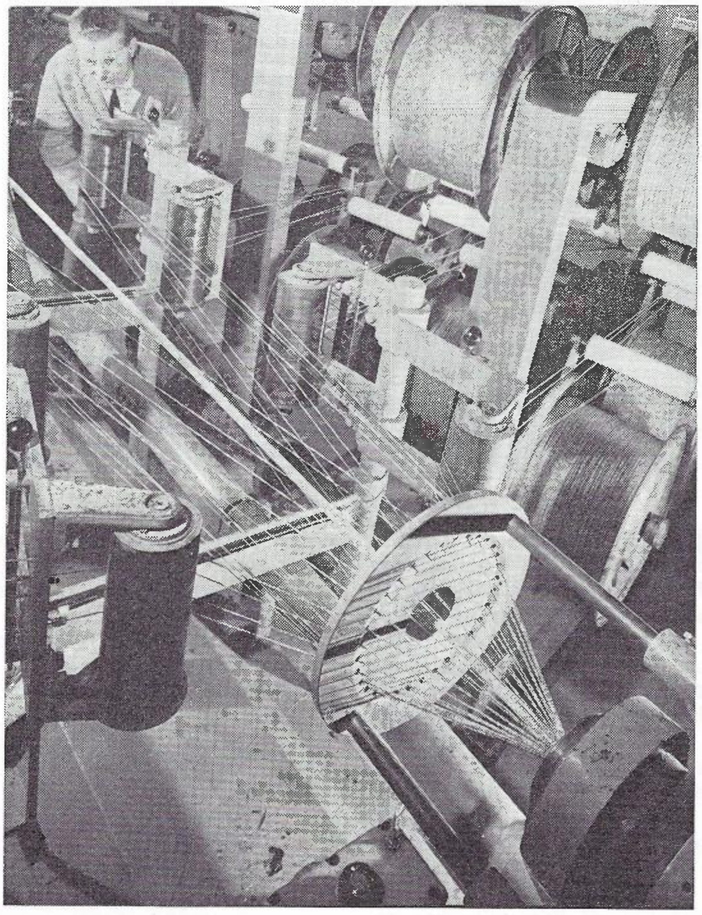

Fig. 4 — Paper Cable Unit Bunching Machine.

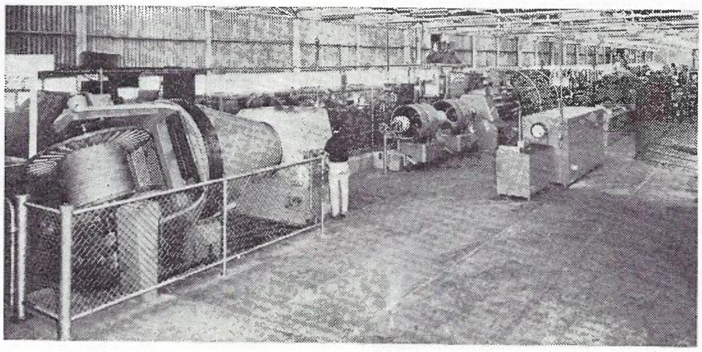

Fig. 5 — Plastic Cable Unit Bunching and Cabling Machine.

to oscillate and bind the units, with a further similar process to cable them. The equipment operates in tandem with a sheathing extruder.

Stranding involves compromises in respect of mechanical properties, electrical properties, and price, because shorter lays on the one hand improve flexibility, but on the other increase consumption of materials, increase resistance and mutual capacitance of a given cable length, and reduce output.

The bunching and cabling processes introduce further compromises, in that they are most economically carried out with a constant lay length in each operation. This represents a departure from the ideal situation, realisable fairly closely in concentric cables, where the stranding lays increase with the diameter so that the helix angle is substantially constant. It is also necessary to deform the units fairly severely in large paper cables to obtain a compact and circular core. These cables can be very troublesome to handle and it is a matter of considerable experiment to establish suitable operating conditions.

In bunched units some displacement of pairs can occur, and the introduction of additional pair twist lengths is helpful in preventing chance adjacencies of similar twists.

Drying of Paper Cables: Moderate use of electrical heating of the conductors with heavy D.C. currents whilst the cables were in the steam-heated vacuum ovens had been practised from about 1950 onwards, but by 1968 new equipment had been installed to dry all cables in this way, reducing drying times from about 14 hr. to as short as 3 hr., depending on cable size.

Moisture Barrier Sheath: The longitudinal application of the polythene-aluminium laminate round the core is performed behind the sheathing extruder, using relatively simple forming tools, but it is necessary for the core to be circular. Unit sizes in unit twin cables have been reduced in a number of cases to achieve this. The polythene coating is outermost and welds to the hot polythene emerging from the extruder die. The success of the process depends on the support provided by the bond to the sheath in preventing buckling or tearing of the aluminium during bending of the cable and the restriction of the moisture permeation path to that section of sheath immediately over the overlap in the foil.

Testing: Electrical testing methods themselves have undergone little change until recently, when automatic test sets were introduced. This equipment reduces the cost of testing and the risk of error, and removes much of the strain to which repetitive A.C. testing subjects the operator.

SOME FUTURE DEVELOPMENTS.

The use of bunching machinery for unit making will mean an increase in the number of lay lengths generally used in paper cable and the use of a minimum of ten lay lengths (alternating in threes in and between the roughly defined layers, plus an additional marker) is likely in place of the present six (alternating in twos in and between layers plus a marker in each layer). Any additional lay lengths would be chosen to give the lowest magnetic couplings and provide carrier frequency as well as voice frequency benefits. This would almost certainly be accompanied by a change in the colour coding of the paper insulation to assist identification at all stages.

Polythene insulated twin pairs are capable of being manufactured more uniformly than paper pairs, and some margin of crosstalk above that required to provide an acceptable level could be provided in areas where long lengths of plastic cable are installed. This applies particularly to rural areas, and developmental work on a long line telephone, including some form of amplification to improve transmitter and receiver levels, is expected to take advantage of this crosstalk situation. Tighter specification limits, compatible with the best modern manufacturing techniques, are likely in the future.

The present plastic insulated and sheathed distribution cables for direct burial do not include screens. The increasing numbers and voltages of power distribution lines are causing noise and induced voltage problems in some cables and these problems are expected to occur more frequently as the network develops. The development of a suitably screened cable for this application and also for use in rural areas of high lightning incidence is being carried out (Ref. 19). Initially moisture barrier sheathed cables will be installed only in ducts, but in the future protected types for direct burial are believed necessary. Nylon may be suitable for insect protection, but developmental work is being undertaken to design additional protection for cables in areas subject to lightning where some conductive screen over the sheath will be involved.

CONCLUSION.

This paper has attempted to define both the reasons for and the nature of developments which have occurred over the last 20-25 years in balanced pair communication cables.

In 1945, these cables were composed primarily of copper and lead. Both these metals are costly. Engineering design effort has been concerned with the provision of an installed cable at minimum cost to meet the network requirements, and three clear areas of development have stood out over the last two decades.

First, there has been the exploitation of development in other network components which have permitted cables to be installed with higher attenuations. This has meant less copper per circuit mile, but has necessitated a parallel development in cable design to provide better cable crosstalk.

Second, there has been the exploitation of new materials, particularly polythene . From an initial application to small size distribution cables, where its use as both insulation and sheath was cheaper than that of paper insulation and lead sheath, it is now replacing lead on large-sized paper cables. Also, the nature of the material has been exploited for many developments in manufacturing processes which have shown marked cost advantages. Another material, aluminium, is likely to challenge the market held by copper in communication cable if developmental work proves successful, since aluminium is substantially cheaper than copper.

Third, there has been the development of improved manufacturing processes: some to achieve the cable quality necessary to permit the exploitation of network developments, some to exploit the nature of new materials, and some simply to improve productivity.

The achievements can be judged from the approximate pair mile costs for outdoor cable. A cost of $30 in 1950-51, when copper was about $450/ton and lead about $105/ton, has been reduced through engineering design effort to $24 in 1967-68, when copper reached a peak $1350/ton and lead was about $220/ton, and further substantial reductions are expected in the future.

ACKNOWLEDGMENTS.

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ERRATA — Vol. 20, No. 1

Page 64, first column, fourth line: word "beginning", should be "incoming".

Page 64, second column, line 6: Fig. 4 should be changed to Fig. 5.

Page 65, second column, line 11: "8 dB" should be "O dB".

SERVICE ASSESSMENT OF S.T.D. TRAFFIC

P. BRAGA, B.E. and G. FOOTE***

INTRODUCTION.

This article is part of a series dealing with the subject of service assessments (Refs. 1 and 2). It describes the basic design of equipment for the assessment of multi-fee traffic at ARM exchanges and ARF minor switching centres. In order to check the progress of a call it is necessary to make a connection to the exchange equipment at a convenient point where line and information signalling and speech transmission can be monitored. This point of connection may vary according to the type of call to be sampled. Equipment recently designed for assessment of local service and subscriber traffic (Ref. 2) uses the cord circuit relay set (SR) in crossbar exchanges and the equivalent first selector in step exchanges because these points are at the commencement of the call. This arrangement is not suitable for the assessment of S.T.D. traffic, as the majority of the calls would be local and a very large number of calls would need to be monitored in order to obtain a reasonable sample of S.T.D. traffic. The point selected is the incoming relay set (FIR) in ARM exchanges and ARF minor switching centres where the percentage of S.T.D. calls is high. (The term FIR in this text also includes FDR.) This requires new equipment because tapping at the FIR involves detection of MFC, as well as different modes of decadic signalling, in contrast to the SR, which employs loop disconnect pulses only. The tapping points for local service and S.T.D. assessment are shown in Fig. 1.

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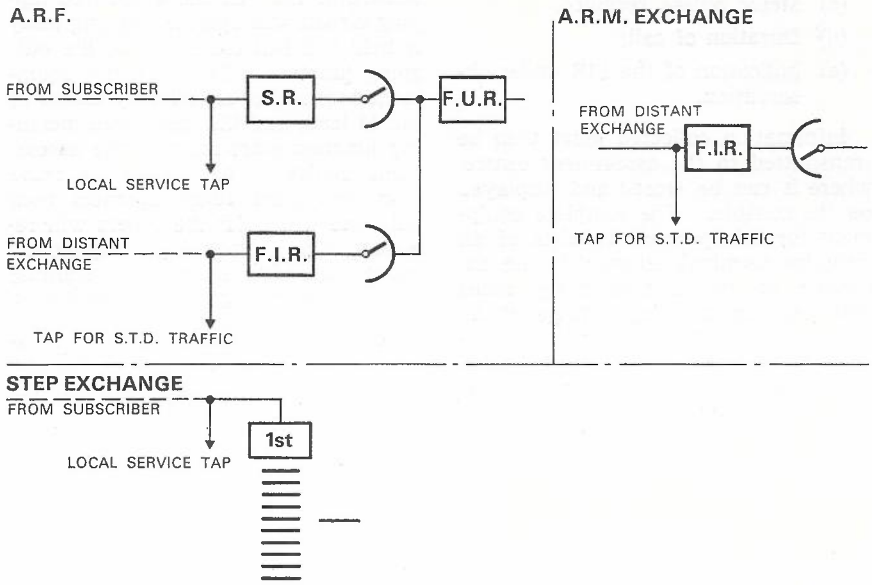


Fig. 1 — Tapping Points for Local Service and S.T.D. Assessment.

OUTLINE FUNCTIONS OF THE EQUIPMENT.

As well as providing a means of connection between the FIR and the assessment centre, the equipment must also be capable of monitoring the setting-up and progress of the call and extract the following information (Ref. 1):

(a) Zone of origin;

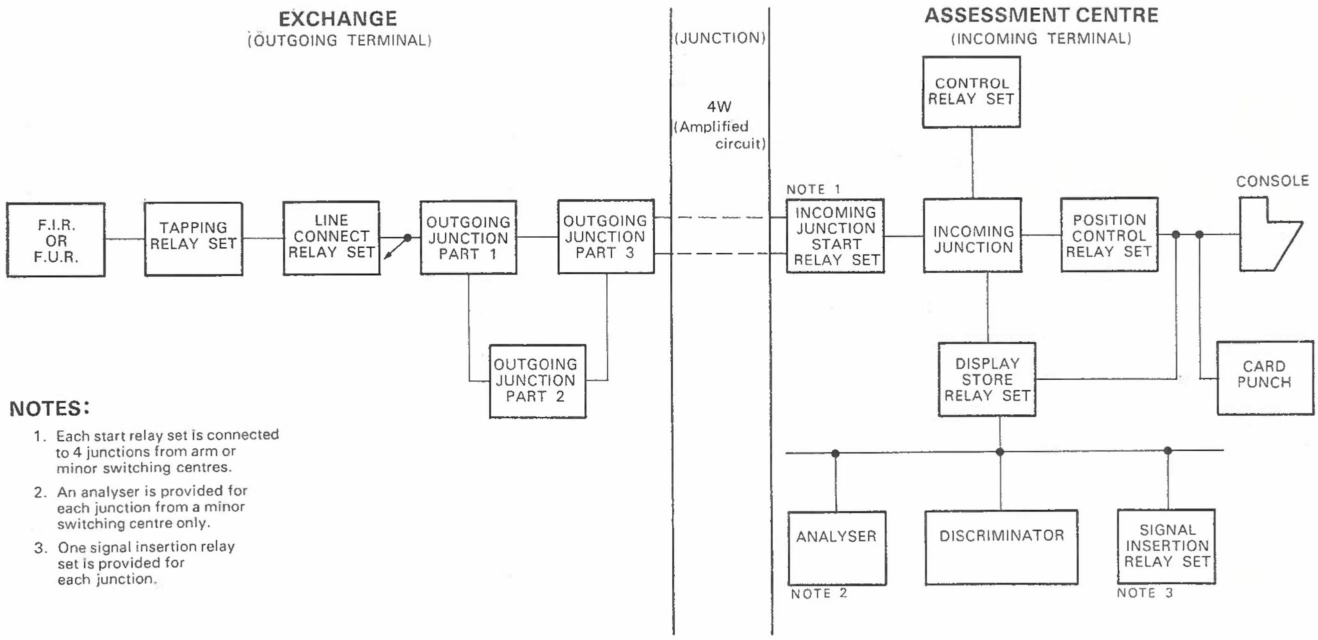


Fig. 2 — Block Schematic.

(b) Digits dialled, including national code;

(c) Meter pulses received.

(d) Duration of call;

(e) Indication of the FIR under observation.

Information collected must then be transmitted to the assessment centre, where it can be stored and displayed on the console. The complete equipment for this purpose consists of an outgoing terminal, situated in the exchange at which monitoring takes place, and an incoming terminal at the assessment centre. Connection between the two terminals is provided by means of a four-wire amplified circuit, which for the purpose of explanation will be called the junction. A block schematic of the equipment is given in Fig. 2.

Signalling.

Signalling between the two terminals is by means of multi-frequency code (MFC) as well as the 'E and M' leads. The signalling sequences for typical calls employing MFC and decadic signalling illustrate the principles involved and it is suggested that close reference be made to the figures showing these sequences during the reading of the text.

The In-Service Signal.

Each console is designed to accept calls from four different exchanges, made up of ARM exchanges, ARF minor switching centres or a combination of both. Normally the outgoing terminals are quiescent, but may be brought into service by the operation of the associated exchange key on the console, which applies a signal to the junction by means of the M lead. All or any of the four junctions may be brought into service as required.

The Tapping Relays.

Each outgoing terminal may contain up to 100 tapping circuits, each consisting of a tapping relay and partner line connect relay, by means of which an FIR can be connected to the junction via the tapping equipment. When an FIR is seized the associated tapping circuit operates. If more than one tapping relay operates, only one will be held and the others released; at the same time the operate circuit of all tapping relays is disconnected to preclude intrusion.

OPERATION ON AN MFC CALL.

Fig. 3 shows the service assessment equipment sequence of operation for a typical MFC call. Suppose the in-service signal has been given, then on seizure of the FIR the associated tapping circuit will operate: tapping relay is held and FIR connected to the outgoing junction. The outgoing equipment now makes an offer by means of the M lead, and the associated incoming junction start relay at the assessment centre is operated. If more than one start relay operates then only one will hold; the others will release. The incoming equipment accepts an offer merely by retaining the in-service signal and makes a rejection by disconnecting this signal. When an offer is accepted the junction is extended to the incoming equipment, which is now connected, via the junction, to the FIR. In the accepted call shown in Fig. 3 the area code has been dialled and the digit '0,' which appears at the FIR, is stored by the incoming equipment, translated into marks on two out of five wires and passed via a P chain to the first digit storage relays and displayed on the console. Ten digit stores are provided, each consisting of five relays for operation of a display digitron and the supply of data required for the card punch, etc. When the digit signal ceases the P chain is advanced in readiness for the next digit.

Zone of Origin.

The zone of origin store requires six relays and two display digitrons because this MFC signal is in the series 1 to 15 (two out of six code signalling). The store is controlled by the PZ relay, which is actually the first in the P chain, but which is normally blocked and unable to operate. This positions the chain on the second relay for storage of the first digit unless the PZ relay is made to operate; the chain will always be set in the first digit position. The requirement for zone of origin is indicated by the passage of the appropriate MFC signal through the FIR concerned. This consists of an A2 (restart) signal when the call is via an ARM exchange, or two successive A2 signals when FIR is situated at a minor switching centre. The incoming equipment responds to these signals by releasing all numerical storage relays, thus cancelling the display already set up, and stepping the chain completely back to the PZ position, which is now unblocked. The zone of origin signal, which then follows, is passed to the zone store relays and displayed. When the signal ceases, PZ is locked out and remains so during the progress of this call. Further restart signals will merely step the chain back to P0, the first digit position; the zone of origin store remains held until released by the operator. A1 signals are used only to determine the receipt of two successive A2 signals when junction is connected to an ARF exchange. This is done by counting one A2 signal by operation of a relay. This relay holds when signal ceases, but is released on receipt of an A1. If two successive A2 signals occur, then the second A2 will be received with this relay operated and can then be recognised as the request for zone of origin. In the case of an ARM exchange the first A2 signal seen is accepted as the request.

Identification of Tapping Circuit.

The identity of the tapping circuit in use is transmitted 1.25 seconds after seizure of the outgoing equipment as a two digits number (00-99), via the M lead to the outgoing terminal, where it is stored and displayed. The line connect relay, which partners the tapping relay, connects the FIR tapping points to the outgoing relay sets and also extends a +ve potential to each of two arcs of uniselector DS to mark the tens and units of the tapping circuit code. A self-pulsing relay then interrupts the M lead and, at the same time, steps DS to find the mark corresponding to the tens digit. When the mark is found, pulsing ceases, DS is homed, and the scanning circuit changes over to the arc holding the units digit, which is sent after an interdigital pause. The pulses are received at the incoming terminal by two uniselectors; CSA, which accepts the tens digit, and CSB, which responds to the units digit. (All uniselectors used in the assessment equipment are B.P.O. No. 4 miniature switches.) The ultimate position of these two switches controls the display of the tapping circuit code and also provides information to the signal insertion relay set.

The Signal Insertion Relay Set.

As the name implies, the function of this relay set is to insert into the appropriate store relays, those signals which are required, but not received at some of the FIR's. These consist of the digits used to route the call as far as the FIR, when decadic signalling is employed, and in certain cases, the zone of origin. These signals must be added not only to complete the display and card punch data, but also for control of the discriminator and analyser, as will be described later. The relay set consists of five multi-coil relays with a fork jack strapping field, and is provided one per junction. (See

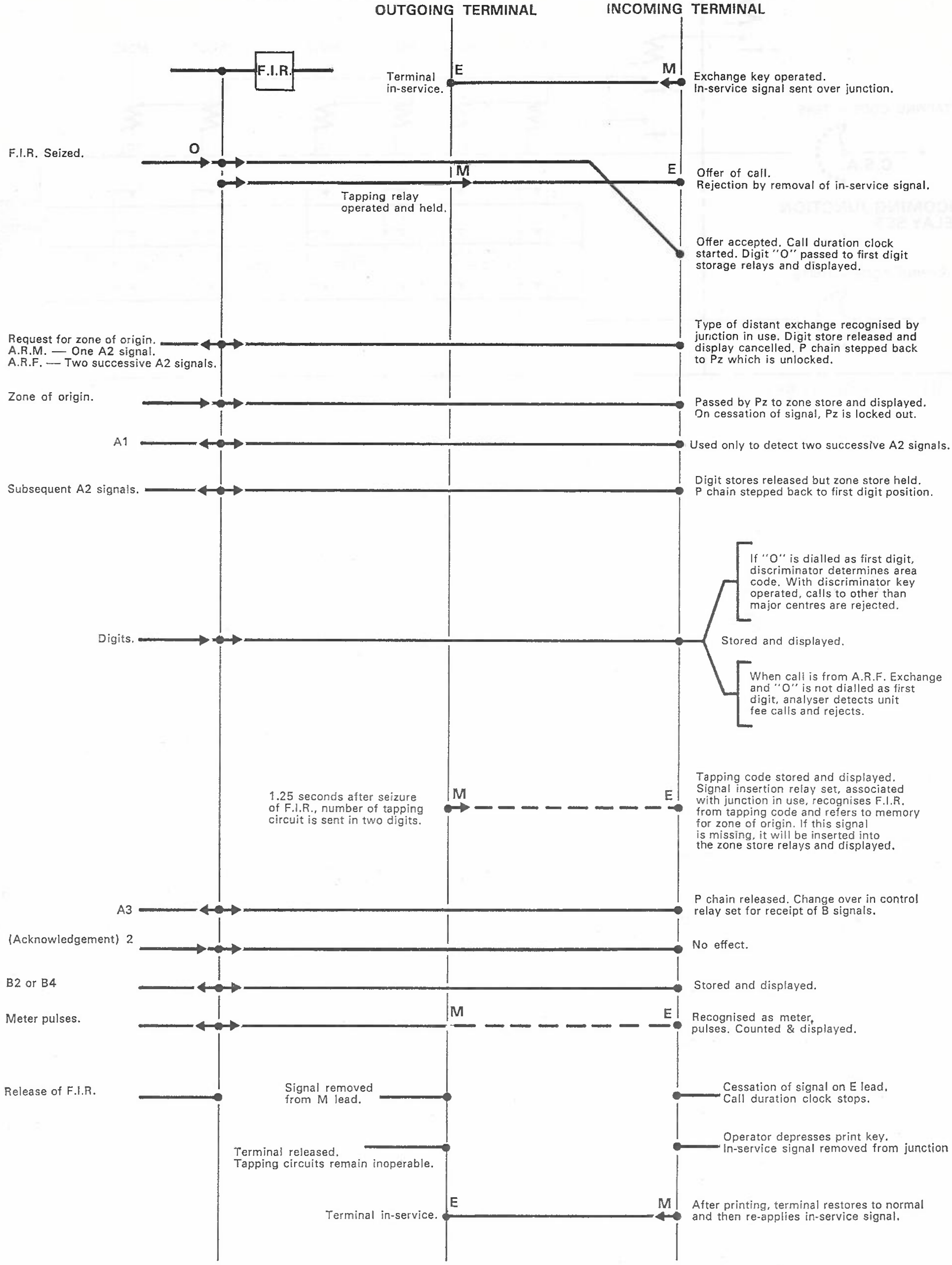


Fig. 3 — Signalling Sequences for Typical Call (MFC Signalling).

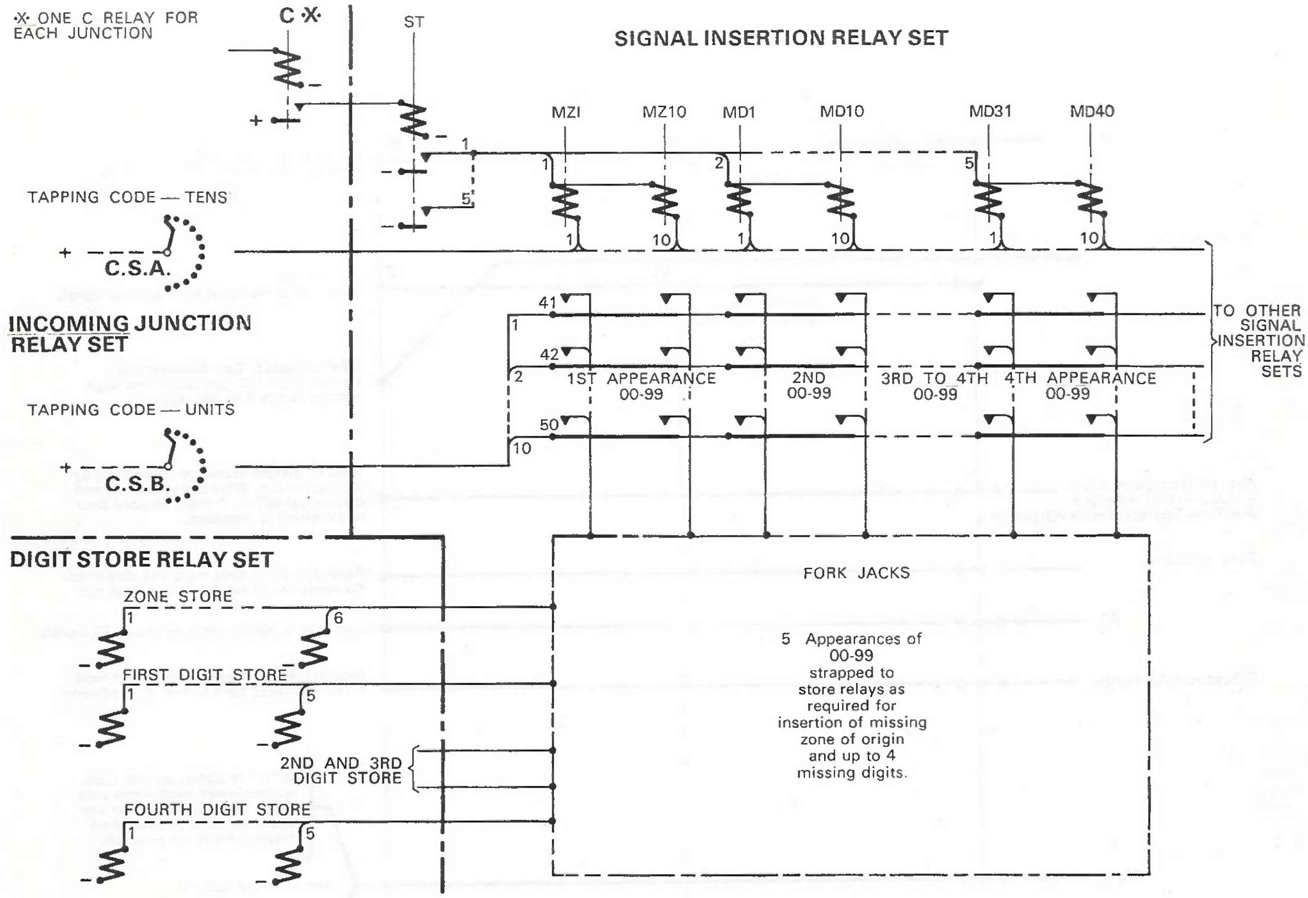


Fig 4 — The Signal Insertion Relay Set.

Fig. 4.) When the incoming terminal accepts an offer for assessment from a junction the associated signal insertion relay set is called in. As the tapping code is received and CSA is positioned, one of the ten coils in each of the five multi-coil relays is operated in accordance with the tens digit. On receipt of the units digit CSB connects a +ve potential to one of the first ten bars of all five relays in common. By this means the number of the tapping circuit code, 00-99, is marked on each of the multi-coil relays, thus providing five separate matrices, which are wired to the form jacks together with leads to the zone of origin and first four sets of digit storage relays. As the tapping circuit code reveals the identity of the FIR under assessment it is possible to insert straps between the terminals representing the tapping circuit codes and the storage relays which must be operated for display of the required signal. Thus the signal insertion relay set consists of a memory which can be referred to, when the FIR has been identified, so that the storage relays associated with the missing signals may be operated. In the call shown at Fig. 3 the zone of origin was transmitted and therefore insertion was not necessary. Had the zone signal not been transmitted then the necessary information would have been strapped into the memory and insertion would have taken place. Insertion of the zone of origin presents no problem as the zone storage relays will always be empty if the zone of origin is not signalled. This is not the case when the call is decadic and digits are missing as arrangements must be made to insert the missing signals into the correct stores. An explanation of the manner in which up to four digits can be inserted is given in the section dealing with decadic signalling.

The Discriminator.

The functions of the discriminator are—firstly, to determine the length of the area code, and secondly by examination of the code, to reject all calls which are not being routed to one of the major predetermined centres.

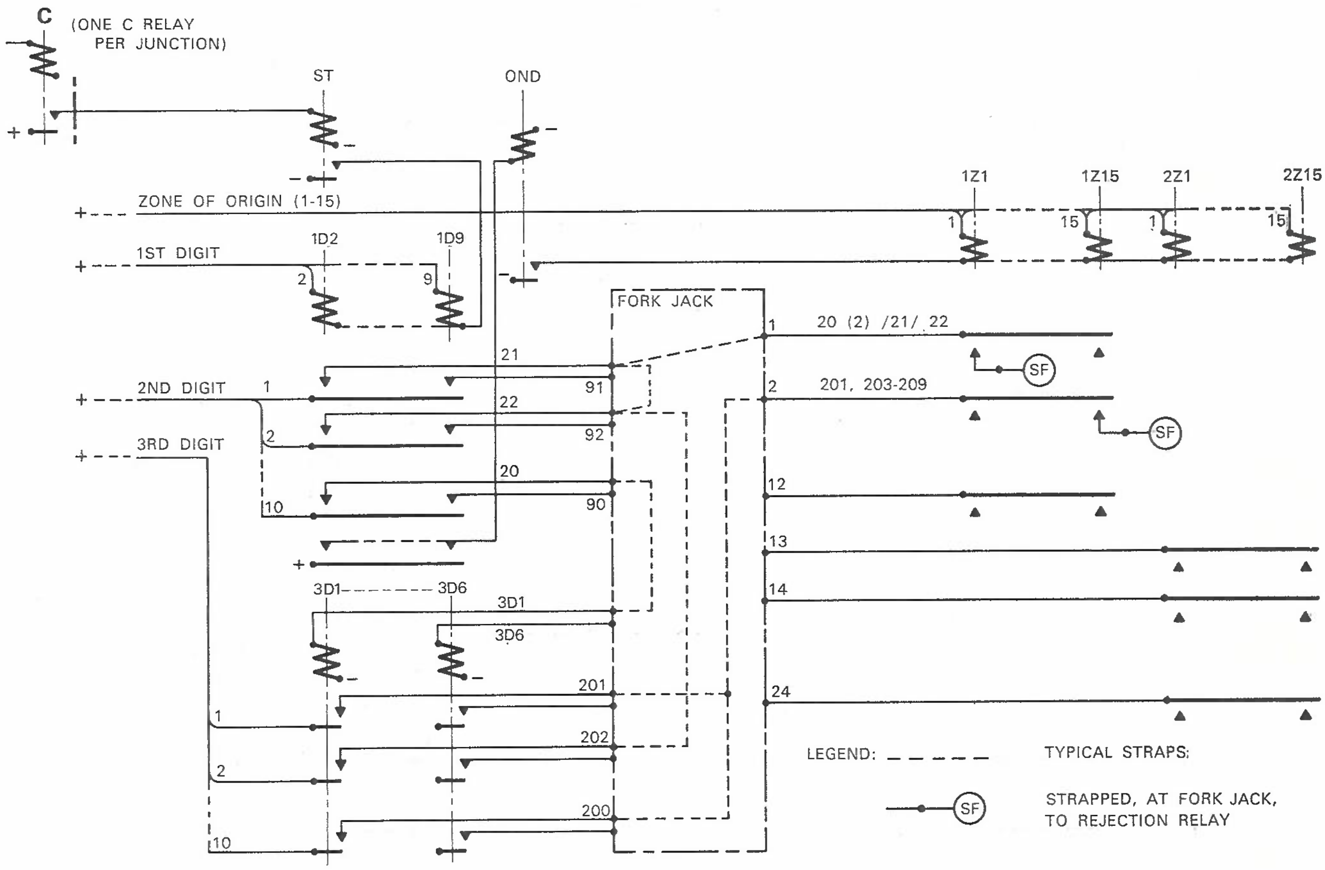
This relay set consists of two multi-coil relays, 2D1-10 and 4D1-10, together with a fork jack strapping field. Connections are made between the digit store relays in such a manner that the second digit controls the operation of the ten coils of 2D, whilst the third digit is connected to ten of the bars of the same relay. As the relay set is designed to operate only when '0' is received as a first digit, the matrix provided by the 100 contacts associated with ten coils and ten of the bars, represent the digits 000-099. By this means up to three digits of an area code can be recognised. For example, if 02 is dialled, then on receipt of the digit '0' the discriminator is engaged. The second digit 2 causes operation of coil 2D2. As all calls to Sydney are prefixed by 02 then the receipt of this code can be established at this point, i.e., in two digits. The code for Melbourne (03) can also be established in two digits. All codes prefixed by 04 or 05 are three digit area codes, so that when 04 or 05 is detected, by the operation of 2D4 and 2D5 respectively, there is no need to progress to the third digit for further examination. However, codes commencing with 06 may be three or four digits in length, four digit codes being 0648, 0649, 0675 and 0687, all other 06 codes being three digits in length. 064, 067 and 068, therefore all require four digit analysis as some of the codes are three digits in length and others four. For example, if we consider 0642, which is actually a three-digit code, as the '2' is part of the local number. Position 64 on relay 2D is connected to the coil of relay 4D1, which will operate when 064 appears as the first three digits. Ten contacts of 4D1 analyse 0640-0649 as the fourth digit from the store relays is connected to bars 41-50. In this way it is possible to analyse the three and four digit codes.

To increase the sampling of major exchange traffic, selective assessment may, at the option of the operator, be acquired by the operation of the discriminator key. This key sets the equipment to examine the area code and reject all traffic except that to major predetermined centres.

From the information of the number length of the area code the discriminator recognises the codes 3A4-3A9 when a change to the detection of decadic signalling is made, and the P chain is positioned to detect the next digit. For example, if a signal 3A5 is detected the P chain is positioned to receive the second digit after the area code in the decadic form. Generally, when the discriminator has established the length of the area code, one of four relays D1-D4 is operated in the control relay set. On detection of a 3A4-3A9 signal a translation is made according to the D relay operated and the P chain is set into the required position.

The Analyser.

As well as transmitting S.T.D. traffic the FIR in the minor switching centre also handles calls within its closed numbering area. As unit fee calls are not assessed, each junction from a minor switching centre has access to an analyser by means of which unit fee calls are detected and rejected. (Fig. 5.) A description of the method of selective analysis used can be simplified by first considering traffic within the closed numbering area. A typical area is divided into a maximum of 24 zones, each zone being served by a number of exchanges. Each minor switching centre handles calls from a maximum of 15 of these zones and imposes a charge rate according to the distance between the exchanges, calls to adjacent zones being unit fee. It follows, therefore, that the charge for a call to a certain zone will depend upon the originating zone and that, in order to establish the rate, the equipment at the minor switching centre must be able to recognise each zone of origin, of which there can be 15, with any of the 24 different zones of destination. As the zone of origin can be identified by the particular FIR in use and destination obtained by analysis of the dialled number, the rate for the call can be determined. Generally, three digits analysis is performed, but in many cases two digits



In this typical example, two zones have exchanges with numbering schemes as follows:— Zone A: 21xxx, 22xxx and 202xx.. Zone B: 201xx, 203xx — 206xx and 207xx — 209xx. Point 20 is strapped to 3D1; the contacts of which now represent 201 — 200. Points 202, 21 and 22 are strapped to Bar 1 whilst points 201, 203 — 209 are strapped to Bar 2. From Zone 1 comes 202, 21 and 22; are single fee and the first contact of 1Z1 is strapped accordingly. Likewise codes 201 203 — 209 are single fee when call originates in Zone 2.

Fig. 5 — Analyzer Operation.

will be sufficient to determine the charge rate. The analyser rejects from assessment all non-trunk traffic, and conversely all '0' traffic (except service codes) is connected for assessment.

Each analyser provides a facility to analyse a maximum of 24 codes through 24 bars of a set of three multi-coil relays arranged as 1Z1-15 and 2Z1-15. For example, if a zone of origin code 12 is fed into the storage relays, then 1Z12 and 2Z12 will operate in parallel and provide 24 bars representing the 24 zones of destination. Therefore, through the operation of a pair of Z relays, 24 different parameters are established, and by extending the Z relay contacts to the strapping field those representing unit fee destinations may be connected to the rejection which, on operation, brings about the resetting of the equipment. Each analyser must be strapped to suit the area concerned, and is required to identify unit fee calls only; no attempt is made to determine the charging rate. An auxiliary analyser is required when an area requires access to 25 to 48 zones of destination.

Revertive Signals.

The revertive, or control, signals through the FIR are passed to the assessment centre for interpretation. A1 and A2 signals have already been dealt with in the section dealing with the zone of origin; the interpretation of the remainder of the signals used in the assessment equipment are as follows:

(a) A10 (Send previous digit). On receipt of this signal the P chain is stepped back two places. This is necessary as on cessation of the last digit, before the A10, the P chain was advanced. The storage relays, however, remain held as the only effect of repeated digits will be an attempt to operate relays already in the operated position.

(b) A4-A8 (Start decadic first to sixth digit). This signal causes the P chain to be set in that position corresponding to the next digit to be sent in decadic form. If the area code has first been dialled then the control relay set has already registered the length of the code and is ready to translate the signal, as

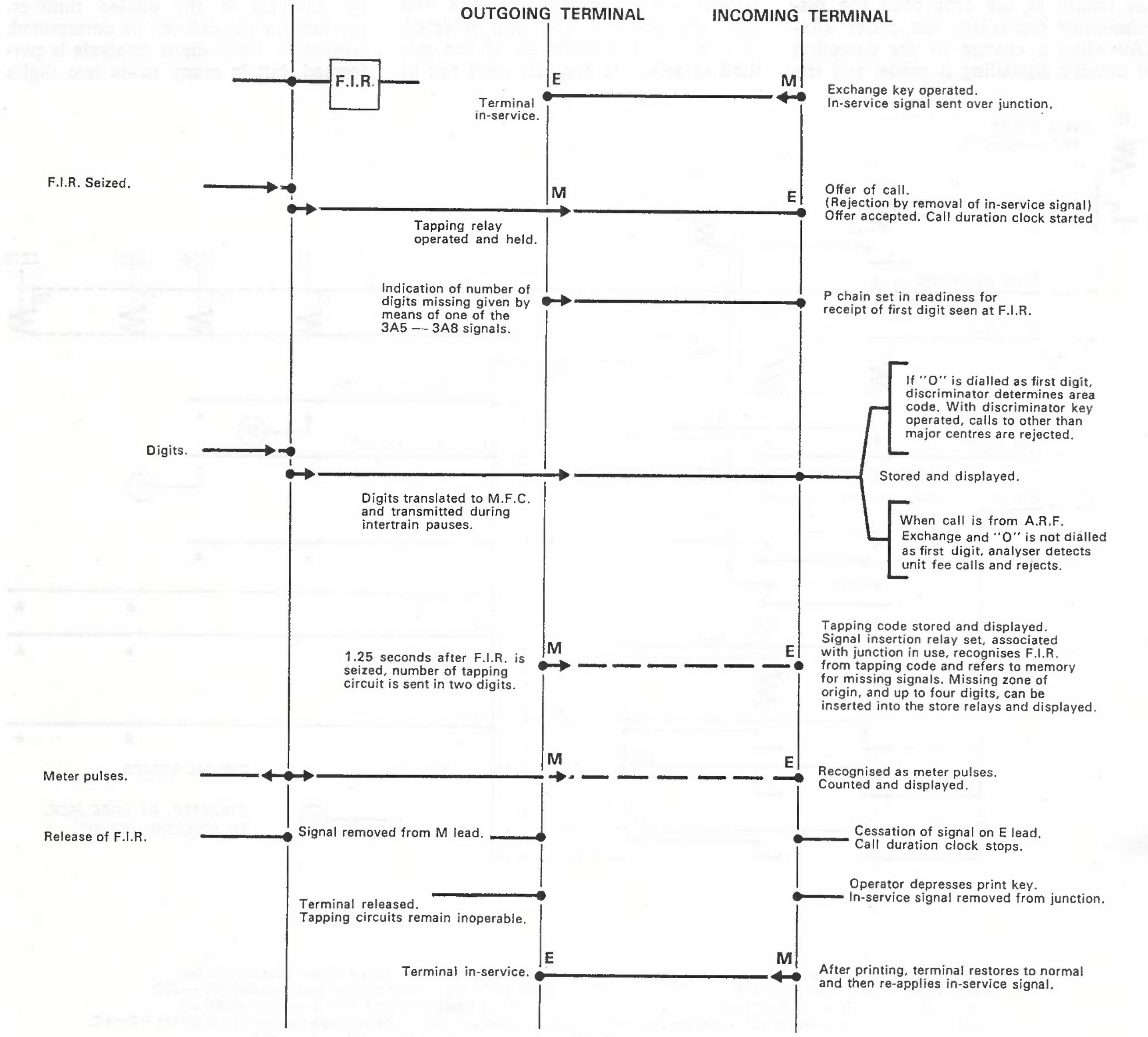


Fig. 6 — Signalling Sequence for Typical Call (Decadic Signalling).

already discussed in the section dealing with the discriminator.

(c) A3 (End of selection. 1B follows.) When this signal is received the P chain is released and so prevents the acknowledgment, digit 2, being passed to a digit store. The control relays now prepare to interrupt all other revertive codes as B signals.

(d) B2 (Busy Sub) and B4 (Congestion). A B2 or B4 signal is stored and displayed; other B signals are stored but no provision has as yet been made for display.

Meter Pulses.

After receipt of the tapping code the incoming terminal recognises a pulse on the M lead as a metering signal. These meter pulses are used to position three miniature uniselectors MPA, MPB and MPC, which control the display of the units, tens and hundreds meter pulses respectively. MPA is stepped at each pulse, at the tenth pulse MPB is stepped once and MPA homed. Similarly, at the hundredth pulse MPC is stepped, MPA and MPB being homed. The total display is 999 pulses, after which a second cycle commences. To guard against the possibility of the first metering signal arriving during sending of the tapping code the pulse is stored at the outgoing terminal and then transmitted when tapping code sending has been completed.

Call Duration.

When the incoming terminal accepts a call for assessment, a 'uniselector clock' is started to time the duration of the call. The clock is made up of three miniature uniselectors SPA, SPB and SPC, which are driven by a one second pulse and behave exactly as described for the meter pulse count. Again the total display is 999 seconds, followed by a cycle. When the distant FIR is released the clock stops.

Reset of Equipment.

The equipment is reset at both ends when the operator presses the print key. This causes the disconnection of the in-service signal and operation of the card punch mechanism. The outgoing equipment releases whilst the incoming holds until printing has been effected. Incoming terminal then releases and, after restoring to normal, re-applies the in-service signals to the chosen junctions. The equipment may also be released by operation of the reset key, but in this case both terminals are released at the same time.

OPERATION ON DECADIC SIGNALLING.

Reference should now be made to Fig. 6, which shows the assessment of a typical decadic signalling call. The incoming junction relay set recognises the type of signalling by the manner in which the FIR has been jumpered to the tapping circuit and also, where necessary, by information given by the line connect relay which extends the tapping leads from the FIR to the equipment. Under decadic signalling conditions the first few digits, representing the trunk access code, are absorbed in the network in the steering of the connection to this point. The insertion of the absorbed digits is described in the next section; the following describes the method of registering the decadic digits transmitted through the FIR under assessment.

In the incoming equipment two miniature uniselectors DSA and DSB are used, in turn, to temporarily store the pulses received (Fig. 7). DSA is stepped by the first digit and, at the interdigital pause, will have taken up a position according to the number of pulses contained in the digit. Two out of five S relays are now operated from the arcs of DSA and an MFC signal, corresponding to the dialled pulses, is sent to line. At the second digit DSB is set in position, the first digit signal disconnected and DSA homed in readiness for the third digit. This continues, each of DSA and DSB being used in turn, until all the digits have been repeated.

In order to ensure that the transmitted MFC signals, used for the transfer of information between the

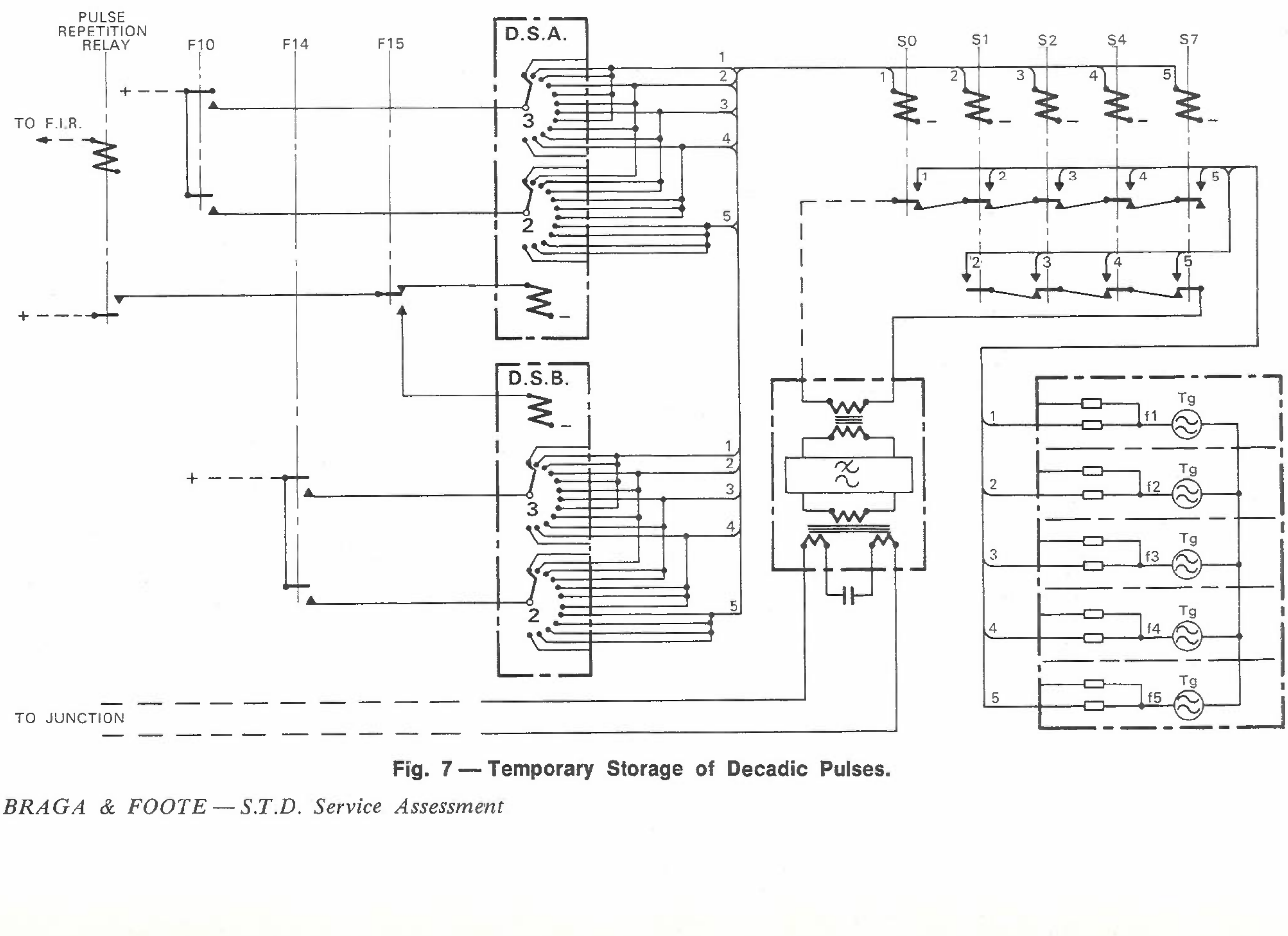


Fig. 7 — Temporary Storage of Decadic Pulses.

exchange and the assessment centre, are not passed to the calling party, the line to the FIR is 'split' during each interdigital pause when MFC transmission is taking place. It is therefore necessary to know when all digits have been sent in order to disconnect the last signal and restore the connection between FIR and the line tapping junction. As the number length is not known, this restoration is effected by means of a timing circuit which is started at the same time as the MFC signal is sent out and which is reset on receipt of a further digit. Should a pause of 1.25 seconds occur between digits then the MFC signal is discontinued and the FIR returned to the line tapping junction. Receipt of a further digit resets the timer. At the first meter pulse the repetition circuit is permanently released for that connection.

Missing Digits.

Decadic signals through the FIR under assessment are converted to MFC signals, transmitted to the assessment centre, and passed via the P chain positions to the store relays in the order of arrival. Suppose the first two digits are missing, then the first digit passing through the FIR will actually be the third digit dialled.

Therefore at the assessment centre it is necessary to advance the P chain to the third position in readiness for receipt of that digit, which first passes through the FIR. This is done by arranging for the line connect relay to pre-store this information and cause the outgoing junction to transmit this information to the assessment centre. This information is transferred over the junction by means of one of the four signals 3A5-3A8 (start decadic second to fifth digits), according to the number of digits missing, at the same time as the offer of assessment is made. It is not necessary to signal that a zone of origin signal is missing as insertion is effected from the identity of the line tapping circuit, which information is available at the assessment centre. If the offer is accepted the forward signal is extended to the control relay set where it is interpreted and used to operate one of four SD relays which control a setting of the P chain. If two digits are missing then a 3A-6 signal is transmitted and operates SD2. The P chain is advanced to position three in readiness for receipt of the third digit, leaving the first two sets of storage relays ready for insertion of the missing two digits. Like the zone of origin information, the missing digits can be extracted from the identity of the line tapping circuit, which is known at the assessment centre.

CONTROL OF TAPPING CIRCUIT.

The tapping circuit, comprising the tapping and partner line connect relays, is under control of the FIR, except in one case which will be explained later. As already mentioned, when a tapping relay operates and is held, the operate circuit of all 100 tapping relays is disconnected; this disconnection persists until the equipment is reset. Release of the tapping circuit causes the removal of the signal on the M lead, which stops the call duration clock on the console. As the operate circuit of all tapping relays is disconnected, a follow-on call to the same FIR will have no effect on the assessment equipment.

There is one departure from this principle, i.e., when the FIR is released before the tapping code has been sent. If the FIR is released at this instant the tapping relay is released, but the partner line connect relay remains operated. This is necessary because the information as to the number of the tapping circuit is held in the line connect relay, which, therefore, cannot be released at this stage. The multiple of the line connect relays is connected to the outgoing relay sets by means of the SL relay, which is controlled by the tapping relay. This ensures that release of the tapping relay will bring about a disconnection between FIR and assessment junction, even when the line connect relay remains operated. Under these circumstances release of the line connect relay takes place only after the sending of the tapping code.

REFERENCES.

1. M. D. Zilko, 'Service Assessment Facilities'; The Telecom. Journal of Aust., June 1968, Vol. 18, No. 2, p. 137.
2. V. R. Findlow, 'Service Assessment Equipment—Circuit Operation'; The Telecom. Journal of Aust., Oct. 1968, Vol. 18, No. 3, p. 264.

CHANGE IN BOARD OF EDITORS

The Council of Control of the Telecommunication Society has approved the appointment to the Board of Editors of Mr. R. W. E. Harnath, A.R.M.T.C., F.I.R.E.E. (Aust.), Grad. I.E. Aust., to represent the Long Line Equipment area. Previously one Editor took responsibility for both Radio and Long Line; the Council now recognizes the growing importance of both areas and the decision to enlarge the Board to eight members is consistent with policy to provide specialist representation at Editor level for the separate 'plant' areas.

Mr. Harnath has actively supported the Journal in the past both as an author and as a Headquarters Representative. He has had strong experience in the Long Line Equipment field spanning a period of fifteen years and covering most of the various long line activities. Prior to joining the Department in 1955, he was responsible for electrical and mechanical design of a wide range of communications equipment manufactured by Trimax Transformers Pty. Ltd., a firm he joined in 1947 following war service in Army Signals and RAAF radar units.

Currently, Mr. Harnath occupies the position of Engineer Class 3, Special Investigations, in the Service Sub-Section of the Long Line Equipment Section. His major fields of interest at present are video transmission and T.V. relays.

THE SUBSCRIBERS INSTALLATION MANAGEMENT CONTROL SYSTEM

R. KEIGHLEY, A.R.M.T.C.* and P. HIGGINS, B.E., Dip.Eng.Mngt.**

INTRODUCTION.

In the Australian Post Office the work of installing or rearranging telephone equipment in subscribers' premises is carried out by two different staff groups. Linemen-installers undertake the less complex installations, whilst technician-installers undertake the more complex work. The latter group work entirely on internal equipment and operate from subscribers' installation depots with a line of control through senior and supervisory technicians to an engineer with overall responsibility for the Subscribers' Installation function. The former group work on both internal and external plant, and operate from what is usually called a Line Depot with a line of control through Line Foremen and Line Inspectors usually to an Engineer with overall responsibility for External Plant installation and maintenance (District Works).

Technician-installer activities, which range over a wide variety of equipments and building types, present the usual supervision problems which arise when several small work groups are dispersed over wide areas at locations which are changing frequently. (Ref. 1).

The system described in this article was designed to test means of improving the supervision and management of technician-installer activities.

SYSTEM OUTLINE.

The objectives of the system are to supplement and strengthen the supervision of the depot supervising and senior technicians and to provide them, and engineering management, with an information and control system having the following features:

(i) Scheduled allocation of work to field staff.
(ii) Work load balancing between working groups and depots within a division.
(iii) Detection of non-productive effort and time.
(iv) Work content assessment in significant categories for management purposes.

The proposed system allows labour resources to be accurately and continually matched to work loadings and provides meaningful information to supervisors and engineers to pinpoint areas and conditions which may warrant improvement.

WORK MEASUREMENT.

In order to initiate the required work measurement, the total working time was broken down into direct and indirect work. The indirect work was further divided into lost times and overheads whilst the direct work was divided into clearly defined elements called activities. The total time to perform a task is also dependent on such variables as environment, class of service (provide, remove or disconnect) and type of service (internal or external). In the case of environment, a sample survey led to the description of five types of building situations, from single-storey houses or villa residences to multi-storey houses, offices and factories.

The Activity Definition Manual is an important document in the establishment of acceptable times for activities employed in the system. It must be centrally controlled to ensure that the integrity of the derived information is maintained and that the full system remains meaningful to management. The manual is divided into Commonwealth standard activities and activities of local (State) significance only.

The activity definitions have been made available at field level in two different formats. The full manual is used to estimate major and minor works, to schedule work to the installers, and to calculate work load figures for staff balancing. A condensed pocket-size handbook is issued to all installers for quick reference to identify tasks and determine the correct coding prior to reporting information to the depot.

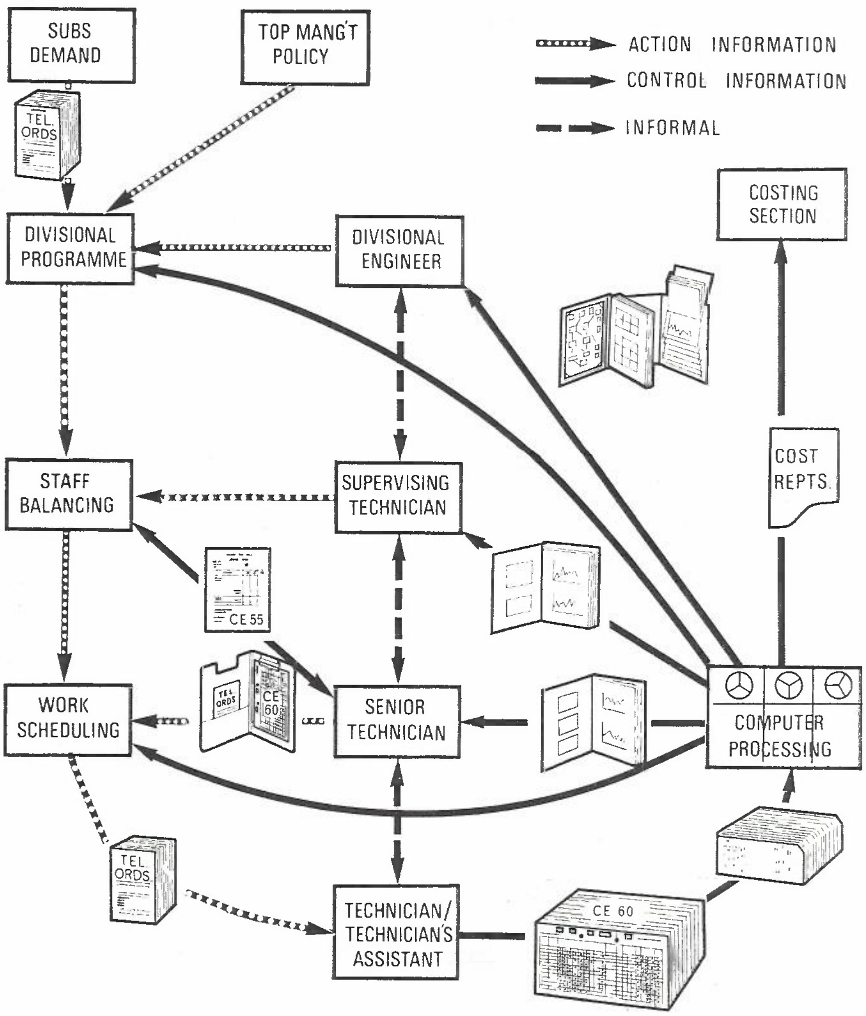


Fig. 1 — Subscribers Installation Management Information and Control System (SIMS).

* Mr. Keighley is Engineer Class 3, Industrial Engineering and Training, Headquarters. See Vol. 20, No. 1, p. 82.
**Mr Higgins is Engineer Class 2, Industrial Engineering and Training, Headquarters. See Vol. 20, No. 1, p. 82.

The activity manuals are used initially to establish acceptable performance times for each defined activity and these times will ultimately be used for job allocation and management. The activity times have been determined by the 'agreed times conference' technique. Representative technicians, senior technicians, supervising technicians and engineers who are familiar with the activities being discussed and who are capable of assessing the work content, form the conference, which is chaired by an impartial officer who is familiar both with the activities and the requirements of work measurement, generally an Industrial Engineer.

The procedures of the conference require that all representatives consider each activity in turn, confirm the definition and then agree to an estimate of the normal time taken by a qualified technician, operating under normal conditions, to perform the activity. This method has produced a reasonably high degree of accuracy, by a quick and economic and generally acceptable process. The agreed times may be employed with confidence in estimating, scheduling, work balancing and project control, but they should not be used for staff control purposes until their accuracy is confirmed. The early phases of the implementation of a control system should provide adequate data to statistically confirm the times. The activity times must be reviewed frequently during operation of the system to keep them in step with changes in the field situation.

SYSTEM DESCRIPTION.

The Subscribers' Installation Management Control System can be divided into two major segments.

(i) the work scheduling phase,
(ii) the information system.

The overall concept of this management control system is portrayed in Fig. 1 and depicts the flow of action and control information and the informal communication flows which exist within this system. This pictorial description of the system bears considerable resemblance to that of the generalised system displayed in Fig. 2 of Ref. 2.

The Work Scheduling Phase

Telephone orders (see Ref. 3) received at the depot are reviewed by senior technicians, who estimate times for completion of each job, using a Work Load Table in which unit times are derived from the basic activity times. This facilitates scheduling and

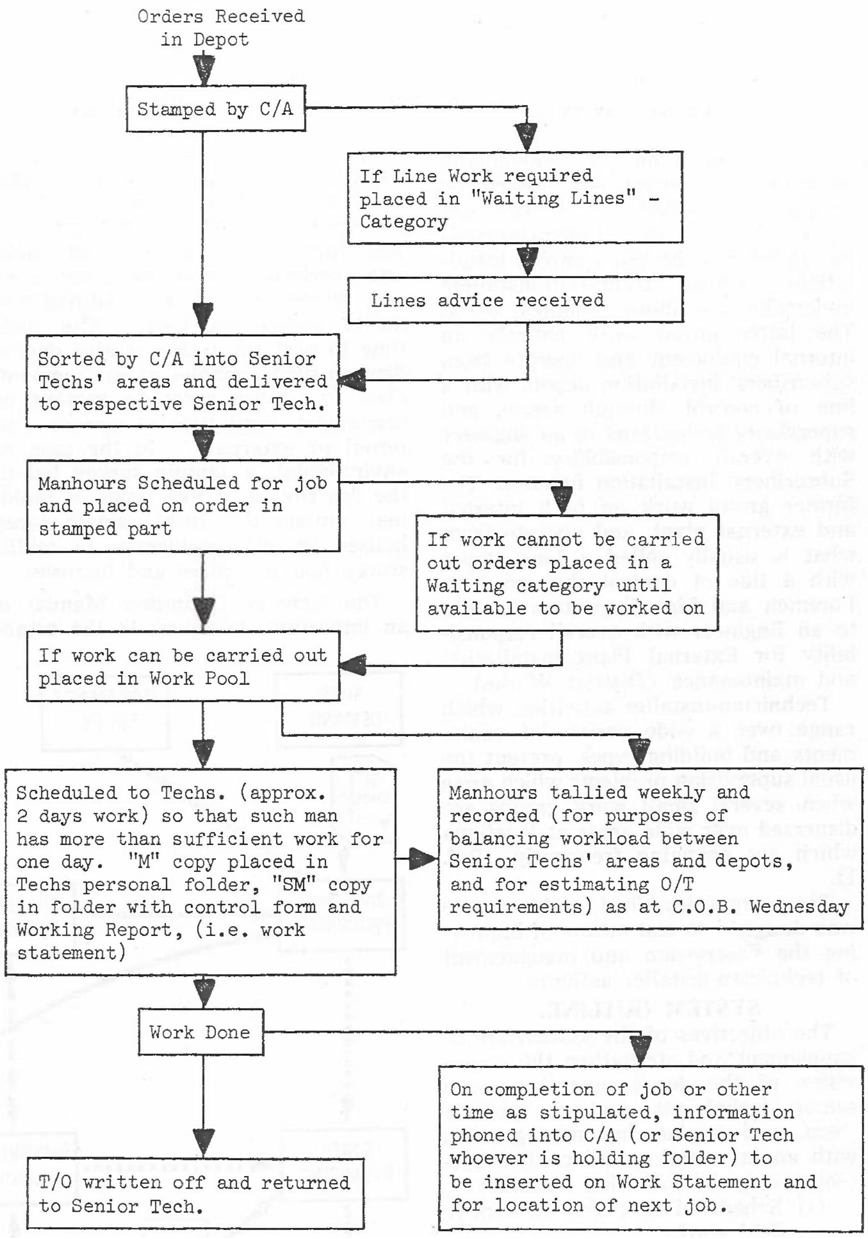


Fig. 2 — Depot Allocation of Telephone Orders.

permits allowance to be made for any known local factors which affect the time estimate.

Work is allocated to installers in volumes sufficient to cover a two-day period (see Fig. 2). The installer takes the M copy of the telephone order; the SM copy is retained at the depot in the pocket of an individual folder for each installer. The SM copies are sorted into the order proposed for attention and placed in the folders so that the top telephone order indicates the installer's location. The installer phones the depot on completion of each job, gives detailed information about the job and nominates his next location; these details are transcribed on to form CE60 (see Fig. 3), which is held in each installer's folder.

The CE60 form, in the initial phases of the system development, is completed in duplicate, the carbon copy (which replaces the working report WP1) being subsequently forwarded to Costing Section, as the work statement, at the end of each period. The SM copy of the order is marked 'completed' and placed beneath the incomplete orders in the folder so that the uppermost order, clearly visible in the pocket, is the one for the job in hand. M and SM copies of completed telephone orders are subsequently reunited for normal depot pro-

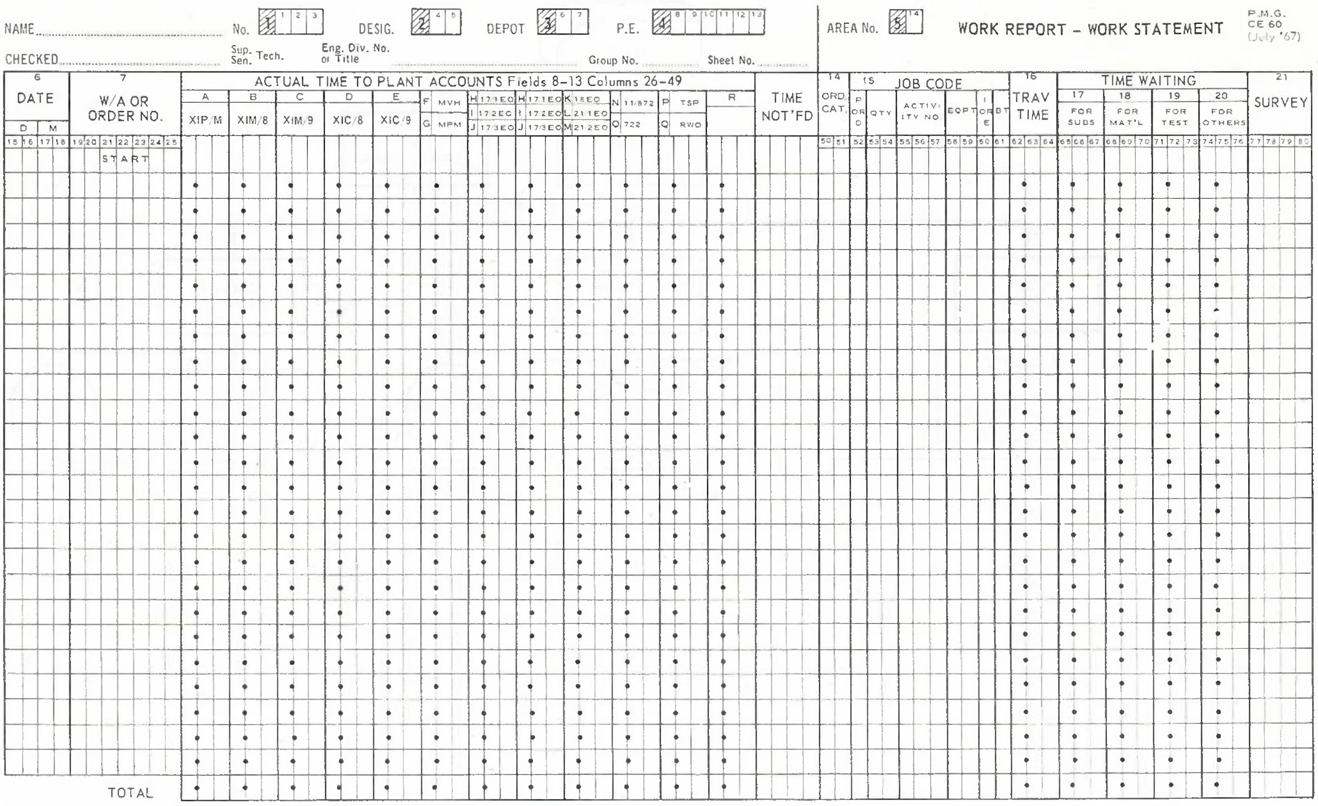


Fig. 3 — Computer Source Document. Form CE60.

cessing and despatching. A yellow slip is associated with the M copy and provides a record of information passed to the depot by the installer. Sample checks by the senior technicians ensure that installers are coding accurately and providing all the required data.

At the end of each week the CE60 forms are checked by the respective senior technicians and the two copies are forwarded to the divisional office, whence one copy is routed to the Costing Section, the other to the computer service bureau for transcription to computer punch cards.

The Information System.

The information system has been developed to meet the Subscribers' Installation Measurement System (SIMS) specification — Version 'A,' which details the requirements of data processing and includes the following information:—

- System description
- Source document and associated input forms
- Punching instructions
- Computer punch card verification schedule
- System analysis/flow process diagram
- Processing requirements
- File description
- Computer printout formats
- Acceptance test schedule
- Documentation required
- Basis for calculations
- System maintenance

Computer Processing.

Processing of information is by computer and is depicted in the Process Flow Chart, Fig. 4. Subject to acceptance at the edit validation phase of the program input, data is written in appropriate format as three distinct sets of records and stored on a magnetic tape file for subsequent processing. Costing information, sorted numerically within the different classifications of work, is subsequently grouped by plant accounts into overhead, leave and school, and field plant accounts and depot and divisional cost reports are printed out.

Performance information, sorted numerically within each work classification, updates the work-in-progress file by the inclusion of unfinished work and the extraction of man-hours relating to work, previously unfinished, which has been completed during the current processing period. Printouts of progressive expenditure of man-hours to work authorities and other orders are generated from the updated work-in-progress file.

Completed work is sorted into activity number sequence and the activity time is matched to each record of completed work from the activity master file. The unmatched activities printout incorporates those job codes inserted as input information which cannot be matched within the activity file. The summary file of activities performed within the quarter is updated and activity summary and activity comparison reports are ultimately generated quarterly from this file.

Completed activities having acceptable job codes are then numerically sorted within the different work classifications and recombined with overhead and field plant account records to produce summaries of overhead and performance information by depot and area. The performance data for the current period updates the quarterly performance file and generates the fortnightly depot and divisional performance reports. The multiple activity report and the category count report are also generated from the same file of completed activities having acceptable job codes. Survey data, which has been stored on tape from the edit stage, updates the quarterly performance survey file and provides fortnightly and quarterly printouts of survey statistics.

The Source Document.

The CE60 form is the source document from which data is transcribed

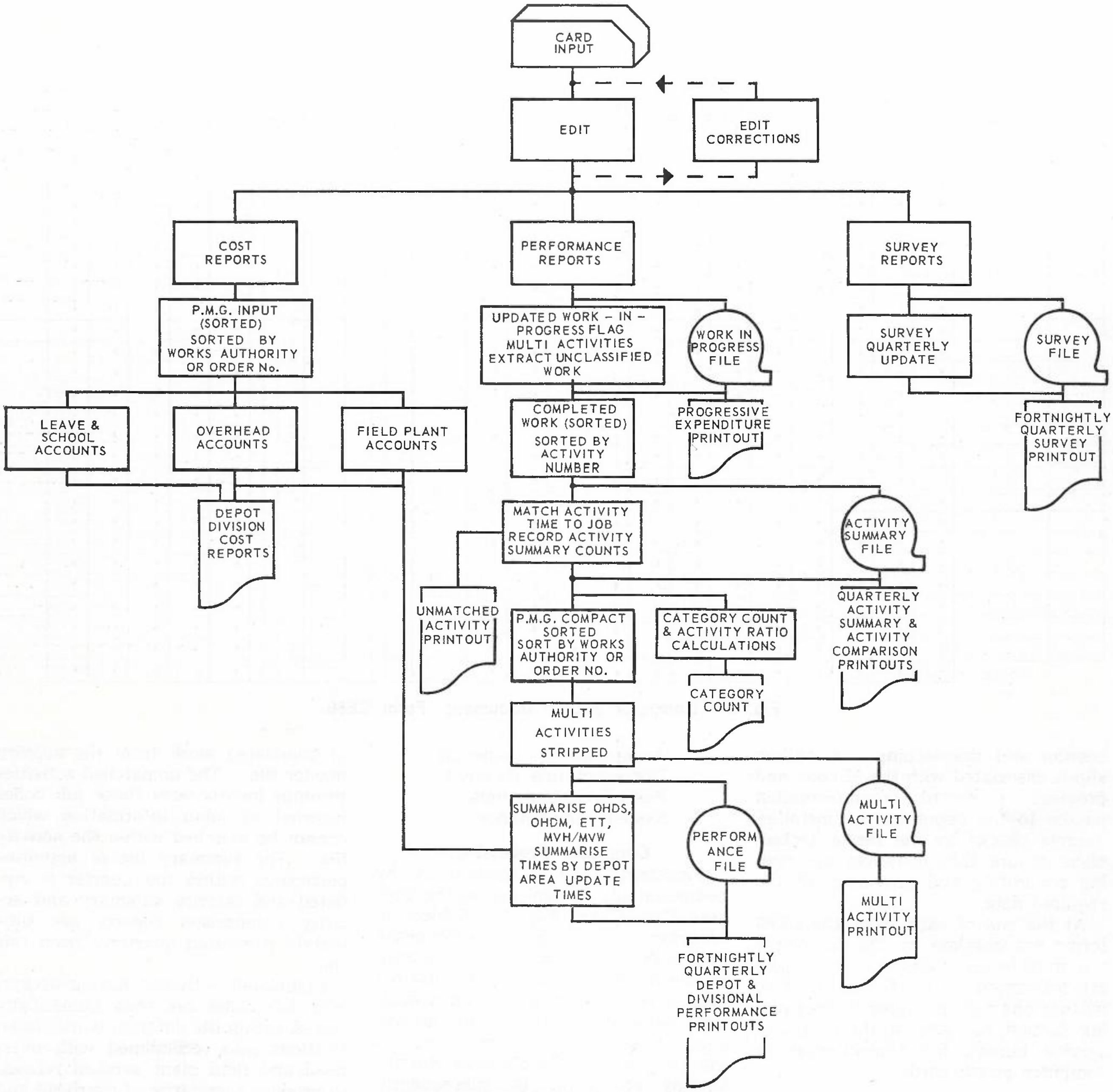


Fig. 4 — SIMS Process Flow Chart.

to computer punch cards as the computer input. Personal identification information is recorded in the header of the form. The body of the form makes provision for specific and detailed entries peculiar to each job performed.

Particular reference should be made to certain information fields of the source document.

Designation: Technicians-in-training are distinguished from other installation staff by the insertion of designations T1 to T5 for first to fifth year trainees. Other staff are designated T0. Designation factors are specified for each in accordance with costing procedures (T1 = 0; T2 = 0.4; T3 = 0.55; T4 = 0.70; T5 = 0.85 and T0 = 1.0), such that the effective work performed is assessed by multiplying actual time expended on the activity by the appropriate designation factor.

W/A Or Order No.: The telephone order or works authority number describes the activity on which work is being performed. Differentiation between the various works authorities and different types of telephone orders is possible by self-explanatory prefixes to the numbers. Supervisory overheads (OHDS) and miscellaneous overhead activities (OHDM), excess travelling time (ETT) and time expended on vehicles denoted by the vehicle number (e.g., BH 345) can also be recorded in this field as desired.

Actual Time to Plant Accounts: Times are recorded in hours to one decimal place in the appropriate plant account columns. Some columns make provision for alternate plant account entries and for the insertion of other plant accounts as desired. The recording of plant account times by columns permits their ready summation by the Costing Section. The daily hours recorded for each member of staff on the CE60 form must coincide with the hours recorded on the salary and allowance sheets.

Order Category: Analysis of the overall work pattern can be ascertained from the recording of a category or work type against each completed activity. Categories include new service work, additions and alterations to existing equipment, removals, disconnections, broadcast orders and service order docket work.

Job Code: The activity numbers, together with the type of equipment, type of building and the location within the building area are used to identify the job. All work is designated as providing, removal or disconnection work. The job code is so constructed that it can be recorded directly on to the CE60 form by a clerical assistant at the depot as the information is transmitted over the phone. For example, "I have disconnected (D) one (01) plan three service (P03) having two portable telephones and four sockets (24) internal (I) in a multi-storey building (D)," i.e., D01P0324ID.

Travelling and Waiting Times: Time lost in travelling, waiting for subscribers, waiting for material and waiting test are recorded on the source document. A further column 'waiting others' provides management with the facility to study any particular aspect of lost time desired.

Survey: Columns have been made available to permit the special study of any desired item of interest by the insertion in these columns of data information which can be processed, under direction to the service bureau, to provide the desired printout. The original survey performed has studied the times expended in testing subscribers' services using the exchange test desk by comparison with line test robots.

PROCESSING OF SOURCE DOCUMENTS

Source documents are processed and the various computer printouts are generated fortnightly and quarterly and dispatched to the divisional office for distribution to supervising and senior technicians at each Subscribers' Installation depot. Source documents are initially converted to computer punch cards at the Service Bureau and are subsequently machine verified before input to the computer. A verification schedule for conversion to punch cards has been drawn up which refers to information omitted or outside specified limits. The verification phase is restricted to checking within the limits of a single column or field and does not incorporate other checks as to the validity of the information. Errors at this stage are referred back to the Subscribers' Installation divisional staff office for correction. Source documents are delivered to the processing centre before 4 p.m. on Thursdays and all punch card conversion and verification must be completed before 4 p.m. on the Fridays following the end of the period at which time an edit validation computer check of the input data is performed.

Edit Validation

Edit validation is a detailed check of validity of the data input and is performed in conjunction with the writing of acceptable information on to magnetic tapes in a form suitable for subsequent processing. The edit program checks the accuracy of input information within a single column and the validity of groups of columns which form a single field. In addition, the edit program ensures that only certain combinations of information in different fields are acceptable. For example, recordings of lost time are only permitted with field plant accounts; leave and training school entries relate only to certain specified plant accounts, as do motor vehicle and overhead costs; works authority and telephone order identification numbers must meet specific constraints, and only certain combinations are acceptable in the formation of the job code. Time checks are incorporated into the edit validation run to ensure that only source documents for the previous period are included in the current processing run (e.g., the edit validation run must be performed within the seven days of the 'period ended' date shown on the source document and performance dates must be within 14 days of this period ended date). A computer printout of edit rejects denotes by arrows under the specific characters, that information which is incorrect. Invalid data is not stored in the computer memory, and the edit reject report requires correction and the punching of new cards, which are subsequently re-entered for edit and file storage.

COMPUTER PRINTOUTS

Four types of computer reports are produced — performance, costing, survey and control. Performance, costing and survey reports are generated fortnightly to the divisional engineer and depot supervising technicians. Depot reports are, in general, distributed to supervising technicians, whilst divisional reports and depot summaries are provided to the divisional engineer, who also receives quarterly summary reports. Control reports relating to the review of data recording standards are produced fortnightly and other control reports providing for the review of activity time standards are generated quarterly. The distribution of printouts is depicted in Fig. 5.

Costing Report.

Depot and divisional summaries of costing reports are generated fortnightly. Reports are divided into three sections — field plant accounts, overhead plant accounts and leave

	REPORT	DIVISIONAL ENGINEER	SUPERVISING TECHNICIAN	SENIOR TECHNICIAN	COSTING SECTION	HEADQUARTERS
FORTNIGHTLY REPORTS	EDIT VALIDATION REPORT	*				
	UNMATCHED ACTIVITY REPORT	*				*
	COSTING REPORT	S	*		*	*
	PROGRESSIVE EXPENDITURE OF MANHOURS REPORT	*	*	*	*	*
	PERFORMANCE REPORT	S	*	*		*
	WORK TYPE REPORT	S	*			*
	SURVEY REPORT	S	*			*
QUARTERLY REPORTS	ACTIVITY SUMMARY REPORT	*				*
	ACTIVITY COMPARISON REPORT	*				*
	PERFORMANCE REPORT	S	*	*		*

S = SUMMARY

Fig. 5 — Distribution of Computer Print-outs.

and school accounts — and each is further subdivided to the actual plant accounts. Hours (adjusted for trainee contribution) are shown, together with cost expenditure to each plant account. The duplicate copy of the CE60 form provides information to Costing Section which was previously recorded on the WP1 forms, from which plant account expenditure can be processed by the Costing Section. Ultimately the costing report may be the only working document provided to the Costing Section and the duplicate CE60 form will not be needed. This by-product of the SIMS system could lead to considerable staff savings within the Costing area.

Progressive Expenditure of Man Hours to Works Authorities

Man-hours expended against works authorities are recorded progressively and the printout summary depicts man hours expended to date against each plant account (adjusted for trainee contribution) on current work. Progressive expenditure reports are provided each fortnight to depot supervising technicians and highlight the senior technician area(s) in which the work is being performed.

Unmatched Activity Report.

The activity codes and their associated activity times are stored in the computer's activity master file and activity codes recorded as input data are checked against this file. Only certain combinations of information which form the activity code are acceptable, and although each segment of the job code may in itself be correct, combinations which do not form acceptable job codes are incorporated in this Unmatched Activity Report.

This reject report occurs during the computer processing run and complete rejection of the data at this stage would result in the loss of considerable amounts of otherwise acceptable data, including actual manipulative times, essential to the reconciliation of costing information. Accordingly the source data should not be rejected and, in practice, the unacceptable job code is treated as having zero activity time for performance calculations and all times expended are incorporated in the costing reports.

The Unmatched Activity Report identifies the job and the depot from which the source document originated. Investigations may show a need for further training of the staff concerned.

A downward trend in total hours recorded against unmatched activities would indicate a steady improvement in the operation of the system by field staff.

Maintenance Update Report.

Amendments to the master file are punched on cards for input to the computer. Whenever the content of the master file is changed or the activity times within the master file are amended, a maintenance update report is generated, indicating the acceptable amendments performed to the activity master file, together with edit listing of errors relating to unacceptable input data introduced in the update operation.

Performance Report.

The divisional engineer is provided with a fortnightly summary of performance reports produced for each depot, which are subdivided within each depot report into senior technicians' areas. A typical depot performance report is depicted as Fig. 6.

Two measures of performance are generated, manipulative performance and overall performance. Manipulative performance — the comparison of standard activity times with the equi-

SUBSCRIBER INSTALLATION MEASUREMENT SYSTEM A D E L A I D E

DEPOT PERFORMANCE REPORT CITY DEPOT PERIOD ENDING 26/03/69

AREA	ACTIVITY TIME	ACTUAL TIME	MANIP PERFORM	TOTAL LOST TIME	TRAVEL TIME	SUBS	WAITING TIMES MATERIAL	TEST	OTHER
			XXXXXX %					PM60	
A	296,00	351.87	84%	25,50	20,60	1.10	0,80		3,00
B	566,50	610.95	93%	43.40	33.80	2.20	1.00		6,40
C	221.50	171.40	129%	27.70	21.50	1.00	1,50	1,80	1,90
D	203,25	206,20	99%	51.30	29.60	7,90	6,80		7,00
E	537,25	586,12	92%	84,90	44,20	24,20	4,60		11,90
F	156,00	115.36	135%	18,90	7,40	2,30	2,50		6,70
G	57,25	56,50	101%	5,00	3,50	1,50			
DEPOT TOTAL	2037,75	2098,40		256,70	160.60	40,20	17,20	1,80	36,90
OHDM TIME		599,20							
OHDS TIME		792,00							
ETT TIME									
UNCLASS ACTY TIME		334,29							
VEHICLES TIME									
TOTAL		3823,89							

DEPOT PERFORMANCE STATISTICS

OVERALL PERFORMANCE 53%

MANIPULATIVE PERFORMANCE 97%

Fig. 6 — Typical Computer Print-out.

valent actual times for completed jobs — is provided for each senior technician's area. Overall performance— which incorporates depot overheads — is produced for each depot. Actual times expended on defined activities, travelling and waiting times, are itemised for each senior technician's area, whereas supervisory and depot overheads, ETT and motor vehicle times, are summarised on a depot basis.

Category Report.

Completed activities are categorised by work types for each depot and division and the activity ratio provides a measure of the percentage distribution of time between the different categories. This report highlights the relative emphasis on the different work types for such diverse purposes as the measure of effectiveness, cost/benefit analysis and loading and grading. For example, the prime function and major work content of Subscribers' Installation divisions might be considered to be the installation of new services. Analysis in Adelaide indicates that the installation of new services accounts for 6 per cent., provision of additional equipment to an existing service, 54 per cent., and alterations to existing installations, 25 per cent. of the work performed by the technician-installer staff group.

Activity Summary Report

The quarterly activity summary shows the number of occurrences of each activity on each type of work performed. This report provides information which is useful for material ordering.

Activity Comparison Report

The quarterly report is designed as a control report for continuing review of activity times initially determined at the Agreed Times Conference. The average actual time and the frequency of occurrence of each activity are tabulated, together with the variation of actual time from the activity time. The variation index is specified as:—

$$\frac{\text{Activity Time — Actual Time}}{\text{Activity Time}}$$

PRESENTATION OF INFORMATION

Analysis of information generated by computer printouts is assisted by the graphical recording of such information and the review of trends to detect changes in the various measures of performance. Action to effect productivity improvement could result from the review of these trends and the instigation of analysis and subsequent action to arrest unsatisfactory trends. It must be emphasised at this point that the computer processing of information and subsequent transcription of printout information to graphical format will never in itself result in productivity improvement. Essential to any productivity improvement is the need to analyse the information in detail, compare actual results in relation to the previous trends and anticipated results and instigate corrective action, where necessary. Control is the essence of all productivity improvement and the necessity for continuing control must be emphasised at all levels of supervisory management. To this end a three-section compendium has been provided which, in addition to graphical recording, has provision for recording of statistical data relating to depot and divisional reports and a reference to the distribution of computer printouts. The statistical information is arranged in such a manner that divisional summary totals are readily portrayed down the right-hand column of each page, the widths of which have been staggered such that all divisional information is immediately visible. The equivalent information relating to each depot is obtained simply by raising the appropriate flap, where such information is shown in the left-hand portion of each page.

Senior technicians are encouraged to perform their own recording from the depot printouts and to analyse the information in order to instigate corrective action.

IMPLEMENTATION OF THE SYSTEM.

This system was implemented as a trial in the Subscribers' Installation Division (SID), Adelaide. Field procedural manuals were prepared and pre-implementation training courses established. The scheduling of work to installers and the subsequent recording of data on to forms CE60 was introduced from the second period of January, 1968. During the next five months, programming and testing were completed in accordance with the SIMS specification and processing of current data commenced from 4th July, 1968. During these interim months, training of recorders and installers proceeded, with information recorded on the CE60 form being continually checked, firstly by the respective depot senior technicians and subsequently by the specialist senior technician nominated to provide assistance in the development of the system. Errors and omissions detected were referred back to the originating source and further explanation and guidance provided as an integral part of the training of recorders and installers towards the generation of accurate and complete input information.

Acceptance testing of the computer program was satisfactorily completed during the first week in June and corrected information generated in the interim period, transcribed on to punch cards, was processed progressively at the rate of two to three computer runs per week during the remainder of the month, primarily to create the necessary historic data within the computer files. In addition, progressive processing of back data further checked the capability of the program to handle large volumes of data, to correctly process and update information and to generally accommodate the variety and combinations of information which might normally be experienced in practice.

System Stability.

The effectiveness of the system in increasing the productivity of Subscribers' Installation activities has been assessed only after confidence had been gained in the trial system and it had become stable. To achieve this confidence, four criteria were aimed at:

(i) Errors produced by human action should be reduced to a low level.
(ii) Installers should be conversant with the concept of correct coding of jobs.
(iii) The identification of activities should be competently performed by installers.
(iv) The initial standard activity times which form the basis of the control function should be reasonable and acceptable times for the defined activities.

Monitoring of these criteria has been provided by control reports designed into the information system. The control features inherent in the information system are as follows:

Input Edit: Rejects are listed during the edit validation run prior to normal processing and a statement of total error rejects, together with total cards read, is provided. The ratio of errors to cards read has decreased from over 10 per cent. during the early periods of the system to less than 1 per cent. since August, 1968.

Uncompleted Work: The volume of uncompleted telephone order work should remain fairly constant if staff levels and overtime are reasonably steady and this feature is used to ensure that completed work is being coded off as required in the design of the system.

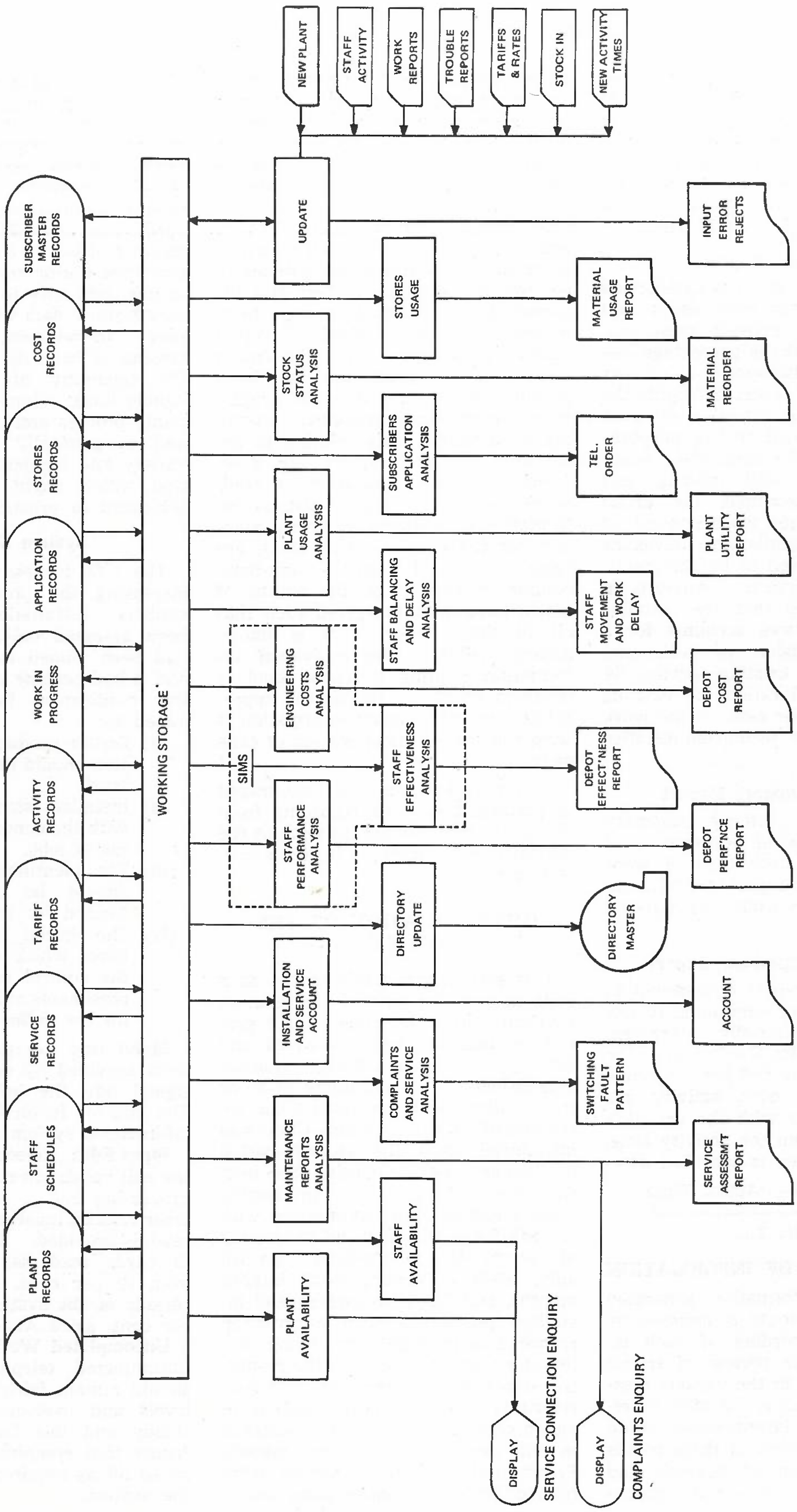


Fig. 7 — Possible Data Base for Comprehensive Management Information System, including SIMS. (See dotted area.)

During the early periods of the system many jobs were not being cleared by the reporting of the appropriate job code, which was indicated by a substantial buildup of uncompleted work. Job codes were subsequently inserted for these completed jobs and the volume of uncompleted work was thus reduced and has since remained fairly stable at about 5000 manhours per period.

Unmatched Activities: A number of codes are employed in describing a completed job, and the unmatched activity report depicts unacceptable codes. Reduction in the number of these indicates that the installers are translating the job identification into correct codes.

Activity Variation: The credibility of any control system rests on the accuracy of the standards employed in relation to the recorded data. Accordingly, the actual time for the activities are compared with the standard time and the variation of the average (expressed as a percentage) from this standard is listed. Variations greater than a predetermined limit indicate that the standard is at fault or that factors external to the system are affecting the activity times. This check is performed periodically. A variation index is employed to highlight the relativity of the actual to standard activity time, but because of the generally positive skewness of the statistical distribution of these recordings, the mode or median may be more appropriate.

RESULTS ACHIEVED.

Considerable benefits have been experienced by the management in Adelaide. Particular improvements achieved during the first 12 months of the trial were as follows:—

(i) Information relating to the previous period is available within three working days of the end of that period.

(ii) Divisional and supervisory management are provided with sufficient information to enable them to adequately assess performance and initiate corrective action when necessary.

(iii) Inefficient procedures which result in excessive time spent travelling, waiting for material, subscribers, test, etc., are highlighted.

(iv) Management is provided with costing details within three working days at the end of the period. Senior technicians also can more closely control expenditure on works authorities in progress.

(v) Supervising and Senior technicians become more management conscious.

(vi) Work scheduling can be performed more effectively, and staff locations can be readily ascertained from the depot by means of the work allocation procedures.

(vii) Facilities to effect work balancing and reallocation of staff reduce the build-up of backlogs of work at particular depots or areas.

CONCLUSION.

This article has described a complex management control system designed to suit the telephone subscribers' installation function. The system has taken just over three years from survey to audit of the trial situation, and present indications are that it will make a significant contribution to productivity improvement. The information generated by the system provides middle and top management with better opportunities to control their work, particularly in the following areas:—

(i) Budget control procedures may be implemented at sectional level.

(ii) The effect of the introduction of new equipment, methods or practices can be shown.

(iii) Staff loading and grading can be more accurately checked and updated.

(iv) Those areas of activity which offer the greatest prospect for productivity improvement can be identified.

(v) Material usage and therefore material ordering can be more accurate and stocks can be maintained at a lower level with safety.

The system has been designed with sufficient capacity to be used in all subscribers' installation units throughout the Commonwealth and with the information output integrated for the highest levels of management. Also, it was recognised that the information derived from the system is a small element in a larger, more comprehensive system for provision and service of the telephone subscriber (see Fig. 7).

The system aims at achieving better planning and control of work. The gain from the field staff point of view is reduction in frustrations at the work face caused by inadequate control using existing methods. Information made available to all levels allows all to participate in the continuing search for the most effective and efficient use of the available resources.

ACKNOWLEDGMENTS.

The development of this management control system has been the result of teamwork and the authors wish to acknowledge the contribution of their colleagues in the Industrial Engineering Unit, the Subscribers' Equipment and Telegraphs Section at Headquarters, the South Australian Administration and I.C.L.

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TELEPHONE ORDERS BY TELEPRINTER

N. A. CAMERON, B.A., M.I.E.Aust., and K. N. SMITH, A.R.M.I.T.***

INTRODUCTION.

When a customer applies to the Australian Post Office for a new or changed telephone service, the internal document which authorises the necessary work is called a Telephone Order. In the A.P.O., as no doubt in other telephone administrations, the handling of this document plays an important part in the efficiency of the main 'bread and butter' work of the administration.

In the A.P.O., the telephone order originates in the Sales Office of the Telecommunications Division, that part of the Post Office charged with dealing directly with the public. Several copies of the order are then sent to the Engineering Division, that part of the Post Office controlling the physical work. Conventionally the transmission of the information on the telephone order between these two divisions and between the various sections of the Engineering Division concerned with the installation has been achieved by manual delivery of the separate copies of the order.

This paper describes a system of teleprinted telephone orders which has been in use in the Melbourne metropolitan network since February 1967. Another variation of the conventional method is in use in Perth, W.A.

TELEGRAPH SYSTEM .

At the sales office the telegraph system for the transmission of telephone orders consists of two Siemens Model 100 machines — one with off-line tape preparation facilities, and a Siemens T Send 77 transmitter with associated switching relays (see Fig. 1). Model 7 machines are located at each of the 27 outstations (see Figs. 2 and 3.). Printed stationery is used at each location and all machines, with the exception of the order preparation machine at the sales office, are equipped with sprocket feed carriages.

In general, 15 different copies of the telephone order are required from each transmission.

The distribution of copies is as follows:—

Sub-station Installation Depots (3):
- T—Technician's copy.
- S—Senior Technician's copy.
- C—Clerical Assistant's copy.

Line Depots (2):
- L—Line-man's copy.
- P—Penman's copy.

Exchanges (1):
- EX—Exchange copy.

Sales Office (4):
- A—Accountant's copy.
- ST2—Statistics 2nd copy.
- M—Meter copy.
- CR—Cable Recorder's copy.

Directory Section (and Sales Branch Statistics Sub-section) (4):
- AL—Alphabetical copy.
- CL—Classified copy.

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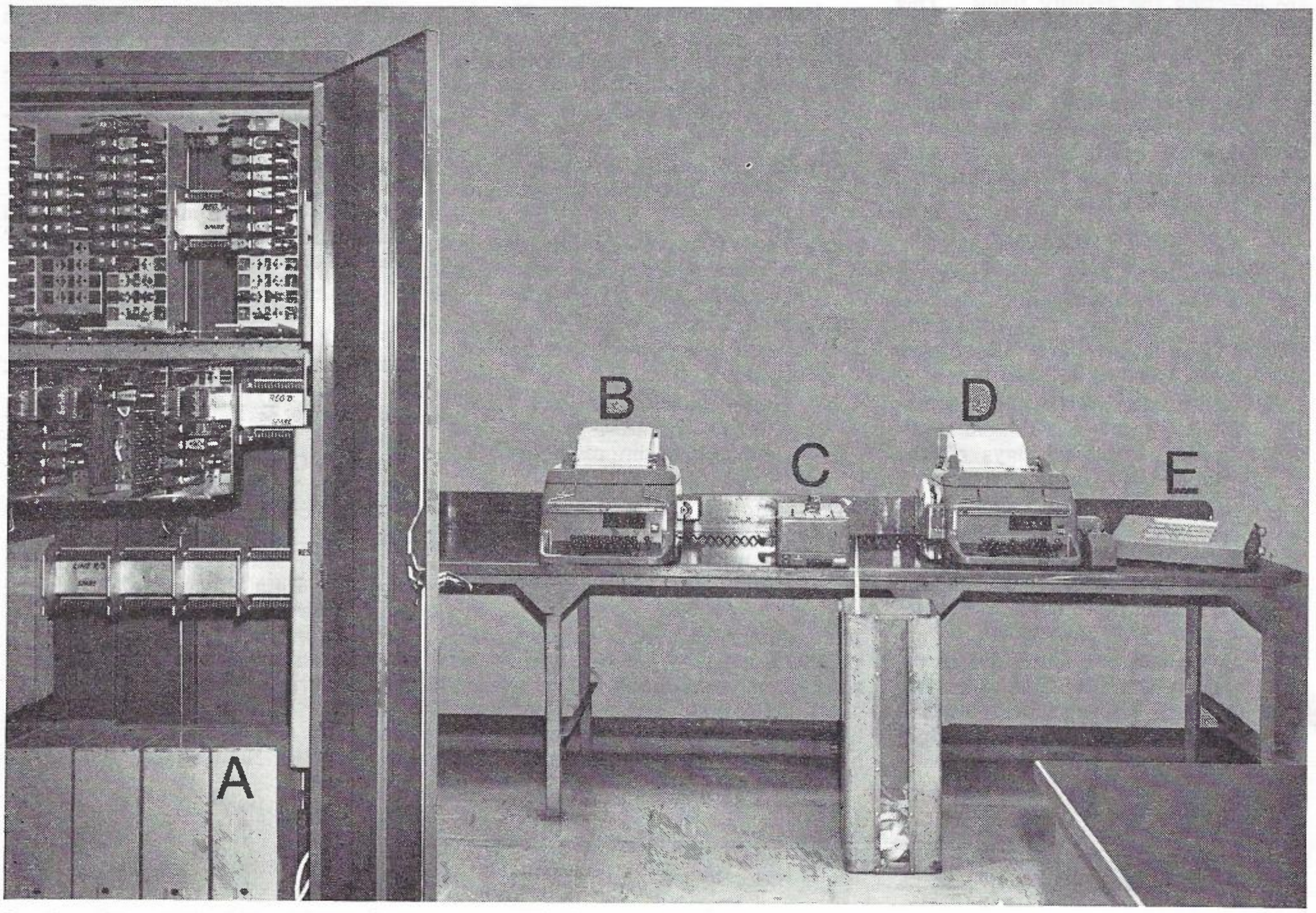


Fig. 1 — The Sales Office Preparation and Transmission Centre, Showing (A) Switching Equipment, (B) Local Copy Teleprinter, (C) Tape Transmitter, (D) Order Preparation Teleprinter, and (E) Operators Control Console.

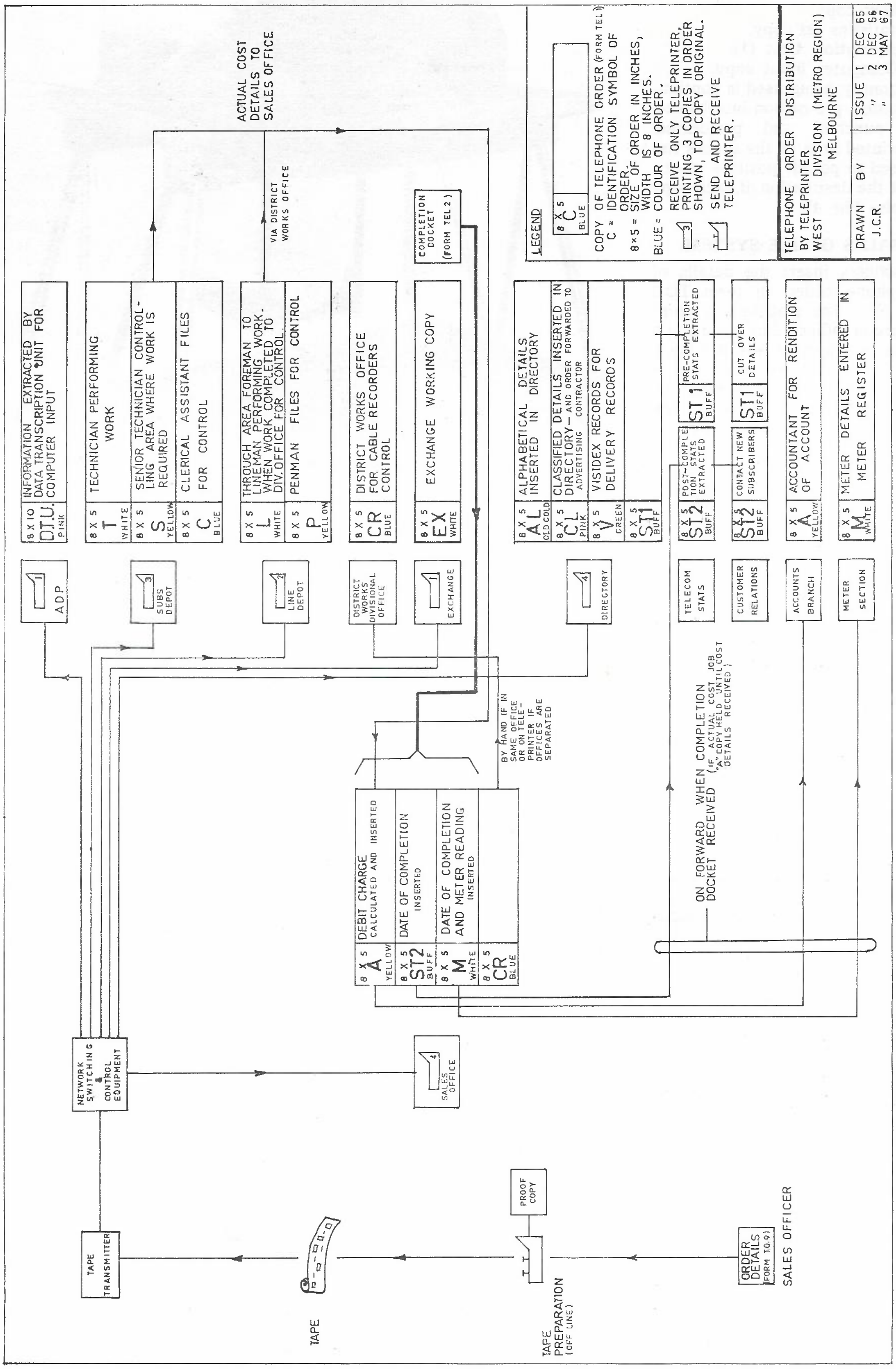


Fig. 2 — Telephone Order Distribution.

V—Visidex copy.
ST1—Statistics 1st copy.
Data Transcription Unit (1):
D.T.U.-Computer input copy.

All stationery being used is continuous, fan-folded, pre-carbon interleaved, sprocket punched and perforated. The pre-printed area of the orders has been revised to permit positive identification of the destination of each copy (see samples Fig. 4).

THE SALES OFFICE SYSTEM.

Sales officers insert the details of each telephone order on form TO.9 (see Fig. 5). The distribution point in each case is indicated by inserting a tick in the appropriate box provided. The Test Centre for each exchange is included on every order transmitted. The forms TO.9 are passed by the sales officer to the teleprinter operator, who sets out each order on a preparation machine simultaneously producing the required tape. In preparing tape a two-figure code for each outstation is inserted at the commencement of each order. As the connection of all outstations concerned is done automatically by the tape transmission; it is not necessary for the operator to pre-sort orders according to locations. After all order details are inserted on the tape, the operator pages-up to the 21st line and inserts a figure 5 Z (+), which is used as the end of message signal.

The operator inserts the tape in the tape transmitter, presses a start key, and the broadcast transmission to field points commences. Under normal conditions this is the only requirement of the operator until the tape completes its run through the transmitter. The operator may meanwhile continue to prepare further tapes without interference to the transmission taking place or to the copies being produced on the second machine for home office purposes.

The switching equipment reads and calls the first valid address code on the tape as it passes through the transmitter. The teleprinter, after "start-up" at the outstation, returns its verification answer-back to the control machine at the sales office. The machines so connected are held connected while each following location is similarly set up. When all machines are in circuit, the time and date of despatch is called for from the Chief Telegraph Office equipment and printed at all addresses (see Fig. 4). The tape then proceeds and the order details are transmitted in the one broadcast. When the end of message code passes through the transmitter, nine line feeds are fed to all

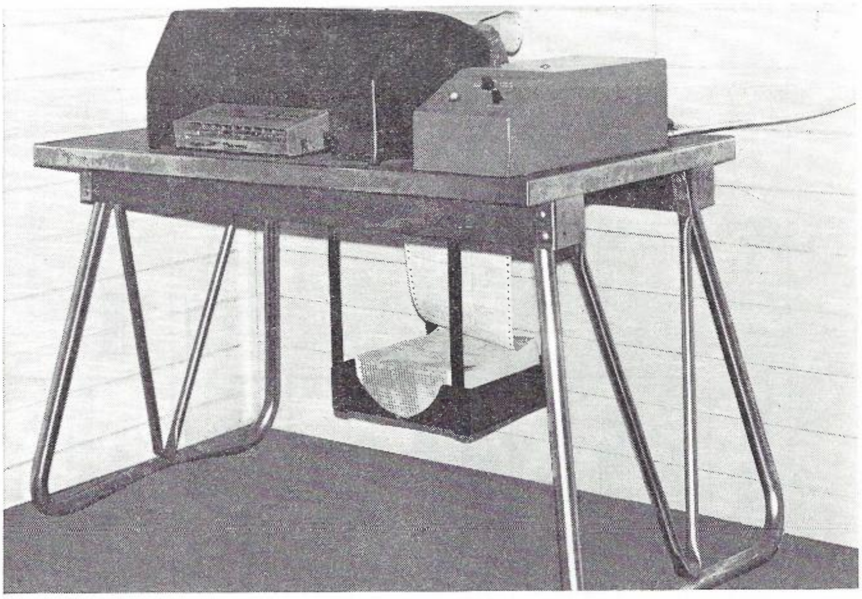


Fig. 3 — Outstation Teleprinter.

POSTMASTER-GENERAL'S DEPARTMENT — TO. 9 (June,'69)

Telephone Order

OPERATOR MESSAGE GUIDE

Insert tick (✓) where applicable

EXCHANGE AND TEST CENTRE		LINE DEPOT	SUBS. INSTALLATION
01 ☐ 05 ALTONA	10 ☐ 27 NORTH ESSENDON	16 ☐ ASCOT	22 ☑ FOOTSCRAY
02 ☐ 05 ASCOT	11 ☐ 05 SUNSHINE	17 ☑ FOOTSCRAY	23 ☐ AIRPORT WEST
03 ☑ 05 BROOKLYN	12 ☐ 05 WILLIAMSTOWN	18 ☐ GLENROY	
04 ☐ 05 FLEMINGTON	13 ☐ 27 BROADMEADOWS (also Bulla, Greenvale & Wst. Meadows)	19 ☐ NEWPORT	
05 ☐ - FOOTSCRAY		20 ☐ ESSENDON	
06 ☐ 27 GLENROY	14 ☐ 05 ST. ALBANS (also Deer Park, Derrimut and Sydenham)	21 ☐ SUNSHINE	
07 ☐ 05 LAVERTON			
08 ☐ 05 MAIDSTONE	15 ☐ 05 WEST ESSENDON (also Keilor)		24 ☑ DIRECT SECT.
09 ☐ 05 NEWPORT	26 ☐ 13-27 TULLAMARINE		25 ☑ D.T.U.CENTRE

ADDITIONAL COPIES *(Other areas)*

TELEPHONE NO.	ORDER NO.	A.D.P. CODE
314 5465	X 652394	10

NAME A BLACK

ADDRESS 62 CYCLEMEN AVE
NORTH ALTONA 3025

PARTICULARS NEW SERV PLAN 3 IVORY HSET
AND TWO SOCKETS
BN 3 . CE/K . 141 . B128 . PK 13 . 0141 .
DW . DA 138
BUS PRI 3
(B) BLACK A
PLUMBER

X 652394 (SAMPLE ORDER ONLY) 3145465

IMPORTANT: The Operator MUST always ensure that the "End of Order Message Code" is inserted on the 21st line of the Telephone Order.

Fig. 5 — Operator Message Guide Form T.O.9.

SUBSTATION INSTALLATION DEPOT

Dates and Details of Visits, N.I.A., Reason Waiting, Miscellaneous Notes | CONTROL DATA

22 12 NOV 69 1022
314 5465 X652394 10
A BLACK
62 CYCLEMEN AVE
NORTH ALTONA 3025
NEW SERV PLAN 3 IVORY HSET AND TWO SOCKETS
BN3 CE/K 141 B128 PK13 0141 DW DA138
BUS PRI 3
(B) BLACK A
PLUMBER

MATERIAL VOUCHERS: WP20... / WP20... / 1. Linework Advice / 4. Tech's Signature / 2. Commencement / 5. Completion / 3. Clearance Sequence / 6. Actual Costs Despatched / Inspection

P.M.G.'s DEPARTMENT TELEPHONE ORDER Tel. 1 (Oct. '66) T

X652394 (SAMPLE ORDER ONLY) 314 5465

TECHNICIANS COPY

Dates and Details of Visits, N.I.A., Reason Waiting, Miscellaneous Notes | CONTROL DATA

22 12 NOV 69 1022
314 5465 X652394 10
A BLACK
62 CYCLEMEN AVE
NORTH ALTONA 3025
NEW SERV PLAN 3 IVORY HSET AND TWO SOCKETS
BN3 CE/K 141 B128 PK13 0141 DW DA138
BUS PRI 3
(B) BLACK A
PLUMBER

Linework Advice / Clearance Sequence / Inspection

P.M.G.'s DEPARTMENT TELEPHONE ORDER Tel. 1 (Oct. '66) C

X652394 (SAMPLE ORDER ONLY) 314 5465

CLERICAL ASSISTANTS COPY

Dates and Details of Visits, N.I.A., Reason Waiting, Miscellaneous Notes | CONTROL DATA

22 12 NOV 69 1022
314 5465 X652394 10
A BLACK
62 CYCLEMEN AVE
NORTH ALTONA 3025
NEW SERV PLAN 3 IVORY HSET AND TWO SOCKETS
BN3 CE/K 141 B128 PK13 0141 DW DA138
BUS PRI 3
(B) BLACK A
PLUMBER

MATERIAL VOUCHERS: WP20... / WP20... / 1. Linework Advice / 4. Tech's Signature / 2. Commencement / 5. Completion / 3. Clearance Sequence / 6. Actual Costs Despatched / Inspection

P.M.G.'s DEPARTMENT TELEPHONE ORDER Tel. 1 (Oct. '66) S

X652394 (SAMPLE ORDER ONLY) 314 5465

SENIOR TECHNICIANS COPY

DETAILS OF MATERIAL USED					DETAILS OF MANHOURS EXPENDED		
Serial/Item	Title (as shown in Stock List)	Quantity	Rate	$	Name (Figure in brackets is year of training if T.I.T.)	Dates Manhours Incurred	Total Manhours Each Day

DETAILS OF MATERIAL RECOVERED | INCIDENTAL EXPENDITURE $ | Signature

TECHNICIANS COPY (BACK)

SALES OFFICE

ADDRESS CODE — DATE — TIME

RENT IN ADVANCE $ | CONNECTION FEE $ | RECEIPT NUMBER | PAID AT | DATE
Rental Charges: TOTAL ANNUAL RENTAL $ | INCREASE BY $ | OR | DECREASE BY $ | DATE | RENTAL AFTER ADJUSTMENT $
Second variation of rental on which concession allowed | INCREASE BY $ | OR | DECREASE BY $ | DATE | RENTAL AFTER ADJUSTMENT $
Explanation to appear on bill (21 characters) | MISC. CHARGE $ | DATE

03m05m17m22m24m 25mm 12 NOV 69 1022
314 5465 X652394 10
A BLACK
62 CYCLEMEN AVE
NORTH ALTONA 3025
NEW SERV PLAN 3 IVORY HSET AND TWO SOCKETS
BN3 CE/K 141 B128 PK13 0141 DW DA138
BUS PRI 3
(B) BLACK A
PLUMBER

EXPLANATION (21 CHARACTERS) / BILLING NAME AND ADDRESS / Code / FOR USE BY ACCOUNTS BRANCH ONLY / Rent in advance Checked / Batch Number / Ledger card noted / Checked / Addressograph plate altered

P.M.G.'S DEPARTMENT TELEPHONE ORDER TEL. 1 (APRIL '67) A

X652394 (SAMPLE ORDER ONLY) 314 5465

ACCOUNTANTS COPY

DETAILS OF MATERIAL USED					DETAILS OF MANHOURS EXPENDED		
Serial/Item	Title (as shown in Stock List)	Quantity	Rate	$	Name (Figure in brackets is year of training if T.I.T.)	Dates Manhours Incurred	Total Manhours Each Day

DETAILS OF MATERIAL RECOVERED | INCIDENTAL EXPENDITURE $ | Signature

SENIOR TECHNICIANS COPY (BACK)

Any alterations made in equipment provided must be amended in text of order.

DATE WORK COMPLETED....../....../......   Signature

03m05m17m22m24m 25mm 12 NOV 69 1022
314 5465 X652394 10
A BLACK
62 CYCLEMEN AVE
NORTH ALTONA 3025
NEW SERV PLAN 3 IVORY HSET AND TWO SOCKETS
BN3 CE/K 141 B128 PK13 0141 DW DA138
BUS PRI 3
(B) BLACK A
PLUMBER

P.M.G.'S DEPARTMENT TELEPHONE ORDER TEL. 1 (APRIL '67) ST2

X652394 (SAMPLE ORDER ONLY) 314 5465

STATISTICS 2nd COPY

DATE WORK COMPLETED | METER READING   Signature

03m05m17m22m24m 25mm 12 NOV 69 1022
314 5465 X652394 10
A BLACK
62 CYCLEMEN AVE
NORTH ALTONA 3025
NEW SERV PLAN 3 IVORY HSET AND TWO SOCKETS
BN3 CE/K 141 B128 PK13 0141 DW DA138
BUS PRI 3
(B) BLACK A
PLUMBER

P.M.G.'s DEPARTMENT TELEPHONE ORDER TEL. 1 (APRIL '67) M

X652394 (SAMPLE ORDER ONLY) 314 5465

METER COPY

03m05m17m22m24m 25mm 12 NOV 69 1022
314 5465 X652394 10
A BLACK
62 CYCLEMEN AVE
NORTH ALTONA 3025
NEW SERV PLAN 3 IVORY HSET AND TWO SOCKETS
BN3 CE/K 141 B128 PK13 0141 DW DA138
BUS PRI 3
(B) BLACK A
PLUMBER

P.M.G.'s DEPARTMENT TELEPHONE ORDER TEL. 1 (APRIL '67) CR

X652394 (SAMPLE ORDER ONLY) 314 5465

CABLE RECORDERS COPY

Fig. 4 — On This and the Next Page Are Shown a Complete Set of Orders For a Telephone Installation (Plan 3). Actual size 8 in. x 5 in. (D.T.U. 8 in. x 10 in.).

LINE DEPOT

17 12 NOV 69 1022
314 5465 X652394 10
A BLACK
62 CYCLEMEN AVE
NORTH ALTONA 3025
NEW SERV PLAN 3 IVORY HSET AND TWO SOCKETS
BN3 CE/K 141 8128 PK13 0141 DW DA138
BUS PRI 3
(B) BLACK A
PLUMBER
X652394 (SAMPLE ORDER ONLY) 314 5465
P.M.G.'S DEPARTMENT
TELEPHONE ORDER
Tel. 1 (Oct. '66)
L

LINEMANS COPY

LINEMANS COPY (BACK)

17 12 NOV 69 1022
314 5465 X652394 10
A BLACK
62 CYCLEMEN AVE
NORTH ALTONA 3025
NEW SERV PLAN 3 IVORY HSET AND TWO SOCKETS
BN3 CE/K 141 8128 PK13 0141 DW DA138
BUS PRI 3
(B) BLACK A
PLUMBER
X652394 (SAMPLE ORDER ONLY) 314 5465
P.M.G.'S DEPARTMENT
TELEPHONE ORDER
Tel. 1 (Oct. '66)
P

PENMANS COPY

PENMANS COPY (BACK)

EXCHANGE

* Delete as required

05 12 NOV 69 1022
314 5465 X652394 10
A BLACK
62 CYCLEMEN AVE
NORTH ALTONA 3025
NEW SERV PLAN 3 IVORY HSET AND TWO SOCKETS
BN3 CE/K 141 8128 PK13 0141 DW DA138
BUS PRI 3
(B) BLACK A
PLUMBER
X652394 (SAMPLE ORDER ONLY) 314 5465
P.M.G.'S DEPARTMENT
TELEPHONE ORDER
TEL. 1 (APRIL '67)
Ex

EXCHANGE COPY

* Delete as required

05 12 NOV 69 1024
314 5465 X652394 10
A BLACK
62 CYCLEMEN AVE
NORTH ALTONA 3025
NEW SERV PLAN 3 IVORY HSET AND TWO SOCKETS
BN3 CE/K 141 8128 PK13 0141 DW DA138
BUS PRI 3
(B) BLACK A
PLUMBER
X652394 (SAMPLE ORDER ONLY) 314 5465
P.M.G.'S DEPARTMENT
TELEPHONE ORDER
TEL. 1 (APRIL '67)
Ex

TEST CENTRE COPY

DATA TRANSCRIPTION UNIT

025 12 NOV 69 1022
314 5465 X652394 10
A BLACK
62 CYCLEMEN AVE
NORTH ALTONA 3025
NEW SERV PLAN 3 IVORY HSET AND TWO SOCKETS
BN3 CE/K 141 8128 PK13 0141 DW DA138
BUS PRI 3
(B) BLACK A
PLUMBER
X652394 (SAMPLE ORDER ONLY) 314 5465
P.M.G.'S DEPT
TELEPHONE ORDER
Tel. 1 (Oct. '66)
DTU

COMPUTER INPUT COPY

DIRECTORY SECTION

24 12 NOV 69 1022
314 5465 X652394 10
A BLACK
62 CYCLEMEN AVE
NORTH ALTONA 3025
NEW SERV PLAN 3 IVORY HSET AND TWO SOCKETS
BN3 CE/K 141 8128 PK13 0141 DW DA138
BUS PRI 3
(B) BLACK A
PLUMBER
X652394 (SAMPLE ORDER ONLY) 314 5465
P.M.G.'S DEPARTMENT
TELEPHONE ORDER
Tel. 1 (Oct. '66)
AL

ALPHABETICAL COPY

24 12 NOV 69 1022
314 5465 X652394 10
A BLACK
62 CYCLEMEN AVE
NORTH ALTONA 3025
NEW SERV PLAN 3 IVORY HSET AND TWO SOCKETS
BN3 CE/K 141 8128 PK13 0141 DW DA138
BUS PRI 3
(B) BLACK A
PLUMBER
X652394 (SAMPLE ORDER ONLY) 314 5465
P.M.G.'S DEPARTMENT
TELEPHONE ORDER
Tel. 1 (Oct. '66)
CL

CLASSIFIED COPY

24 12 NOV 69 1022
314 5465 X652394 10
A BLACK
62 CYCLEMEN AVE
NORTH ALTONA 3025
NEW SERV PLAN 3 IVORY HSET AND TWO SOCKETS
BN3 CE/K 141 8128 PK13 0141 DW DA138
BUS PRI 3
(B) BLACK A
PLUMBER
X652394 (SAMPLE ORDER ONLY) 314 5465
P.M.G.'S DEPARTMENT
TELEPHONE ORDER
Tel. 1 (Oct. '66)
V

VISIDEX COPY

24 12 NOV 69 1022
314 5465 X652394 10
A BLACK
62 CYCLEMEN AVE
NORTH ALTONA 3025
NEW SERV PLAN 3 IVORY HSET AND TWO SOCKETS
BN3 CE/K 141 8128 PK13 0141 DW DA138
BUS PRI 3
(B) BLACK A
PLUMBER
X652394 (SAMPLE ORDER ONLY) 314 5465
P.M.G.'S DEPARTMENT
TELEPHONE ORDER
Tel. 1 (Oct. '66)
ST1

STATISTICS 1st COPY

machines which then switch off. All machines are thus available with the printed stationery set up at the commencing point for the receipt of any further message. This process is continued throughout the running of the entire tape containing a series of telephone orders.

If an outstation machine fails to return its answer-back signal, the tape will stop in the transmitter gate and an intercept condition is signalled by a lamp. Whilst in this condition the tape cannot proceed. The operator may then repunch the identification if the tape is incorrectly perforated. If the trouble is beyond her control she may release the intercept condition, allow the transmission to proceed without the inclusion of the station concerned, and transmit that station's copy separately later. Hence, there is no chance that telephone orders may be lost in the system through line or equipment failure.

The cable recorder's copy of the order is detached from the sales office set immediately following a transmission, and passed by hand to the district works office if it is in the same building. Otherwise the district works office would be included in the network. The operator message guide (Form T0.9) is marked to indicate that the order has been transmitted, and the three remaining copies (A, ST2, M) are retained by the sales office until advice of completion is received.

Completion Advice System.

When the work on a telephone order has been completed, the exchange is advised of all details by telephone. In all cases the exchange sends to the sales office a Telephone Order Completion Advice docket (Form Tel. 2—see Fig. 6), which shows the order number, telephone number, date of completion, meter reading and any variations made to the original order. No copy of the telephone order is returned from the Engineering Division to the Telecommunication Division except where actual cost details are required.

The Meter and Statistical order copies (M, ST2) held in the sales office are updated and despatched to their respective locations on receipt of the Tel. 2 advice from the exchange. Billing advices to the Accountant on the A copy are prepared from the details on the Form Tel. 2.

There is no longer a need for lines and substation installation depots to return order copies to the sales office, except where actual cost details are required, e.g., provision of new switchboard, changeover of switchboard, line-work same property. In these cases an appropriate order copy is returned, but the completion docket system is unaffected, as a Tel. 2 advice is also returned from the exchange. The text of the order gives an indication that actual cost charges have to be included in the billing advice.

The Tel. 2 Telephone Order Completion Advice is a pre-carboned booklet, with triplicate copies of 50 sets per book. Each docket is pre-numbered, and this number is used for a completion sequence. The distribution of the copies on completion of the work required by the order is:

Copy 1—to the sales office.
Copy 2—to the test centre concerned.
Copy 3—retained in the book by the exchange.

Charging Symbols.

The introduction of standard charges for miscellaneous connections and alterations eliminated the need for a large number of charging symbols on telephone orders. In the teleprinter system the charging symbols have been abandoned altogether. Where actual cost details are required, they are specifically asked for in the text of the order.

Form S.E. 589—P.A.B.X. Facilities.

The use of this form has been abolished. At present nearly all P.A.B.X. services are installed by private contractor and a fixed annual maintenance charge is applicable. The value of this form has diminished to the stage where it is merely an indication whether an extension being provided or cancelled was a direct extension or one in parallel. This information is only required when the P.A.B.X. has been provided by the department and is being charged on a

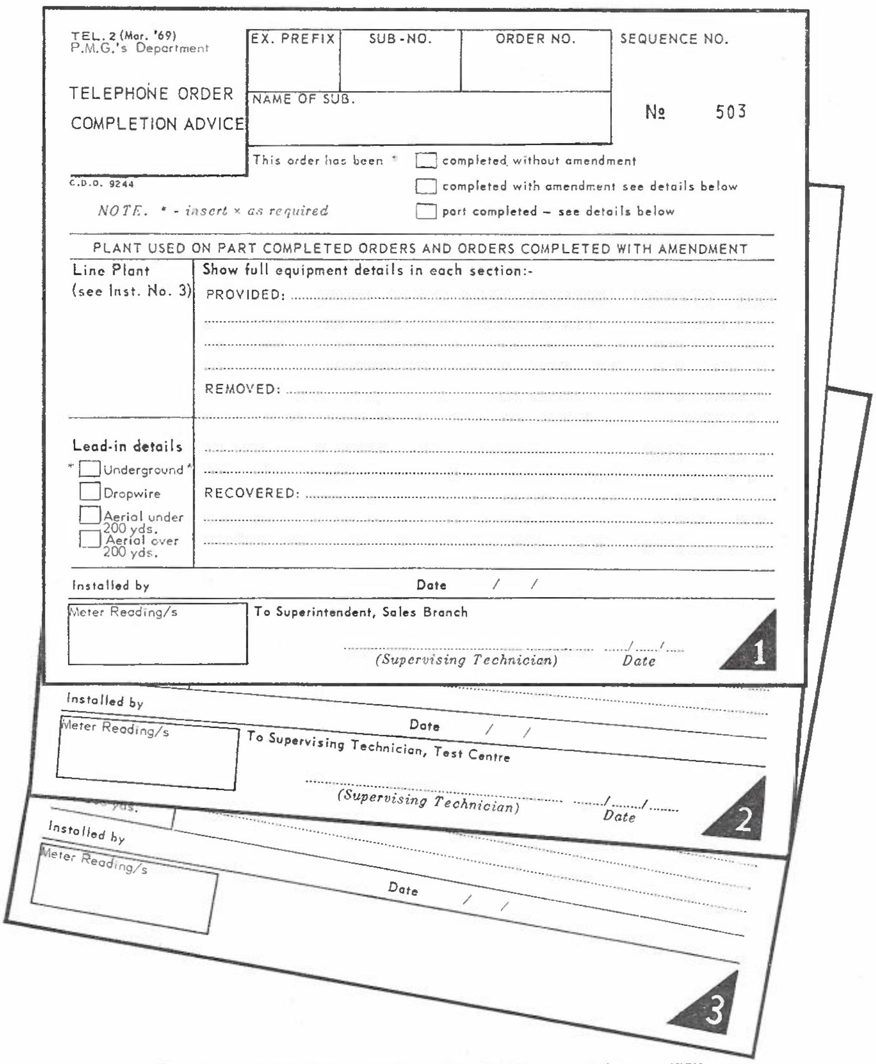


Fig. 6 — Telephone Order Completion Advice — TEL. 2.

rental unit basis. In most cases where major alterations are being undertaken on such P.A.B.X.'s the rental units to be charged have already been assessed and included in the text of the telephone order.

Temporary Services.

Two orders, one to provide service and one to cancel service, are issued for all temporary service installations. This replaces the one order to both provide and cancel and allows field officers to clear the advice of connection as soon as this portion of the work is completed. In the past it has been necessary to retain the order copies in the field until disconnection of the service has been effected. The new arrangement means that partially completed orders are not held and the early advice of connection permits better metering and statistical records to be maintained.

ADVANTAGES OF TELEPRINTER SYSTEM OVER MANUAL SYSTEM.

The preparation of carbon impression order masters, and their duplicating by hand with the manual sorting and mailing of copies to the field is both messy and tedious.

The new system provides a clean typed order and reduces the possibility of misinterpretation and loss of time checking back on illegible or faded text. It is unlikely that these problems will be overcome while handwriting exists. Typing of order masters would still require a duplicating, sorting and mailing process, as sufficient copies are not obtainable at one strike.

Use of pre-carboned stationery on teleprinters enables multiple copies of orders to be produced at outstations to meet or improve operating requirements without imposing any additional load on the sales office. The additional copy being made available to substation installation and line depots has overcome the necessity to perform recording functions at the inward/outward movement of orders, with an estimated saving of five hours of Line Depot Penman's (Lineman Grade 2) time per week and a similar saving in time for the Clerical Assistant Grade 2 in substation installation depots.

Transmission time is reduced by one to two days, allowing all customers' requirements to be completed and the new plant to become revenue earning at least this much earlier than under the mailing system.

It is not necessary to telephone order details of 'in-place' service connections, cancellations, temporary services or urgent alterations to the exchanges or depots, as the immediate transmission takes care of these requirements. The manual system does not cater for such everyday cases and causes loss of time in both the sales office and engineering locations in the passing by telephone and recording of details of orders which will eventually be received through the mail.

With the manual system the actual date of despatch of an order is often under dispute, but in teleprinting, since the time and date of actual transmission is automatically inserted, this situation does not arise.

Automatic answer-back facilities ensure that orders despatched are actually received in the field, thus eliminating any loss of order copies in transmission. A record is printed on the sales office copy of each point included in the transmission as well as the time and date of despatch Under the present manual system, there is no guarantee that all orders are received at their destination, and to establish a check-back procedure would be most time-consuming and costly.

The receipt of the authorising telephone order copy through the teleprinter network by the Sales Branch Statistics Sub-section enables more recent figures to be available when statistical information is sought. At least one day's delay is incurred in any mailing system.

Orders are transmitted only to stations where work is required. This eliminates the handling of 'no work' orders at receiving depots, with considerable saving of time. Previous attempts to overcome this problem in the manual area have been unsuccessful. When irrelevant orders are extracted after duplication they are sometimes extracted in error and for safety's sake the tendency has been to distribute every order to field units.

Regular transmission of orders throughout the day facilitates the Engineering Division planning activities for the following day.

Combined with the verbal acceptance of minor miscellaneous requests, the teleprinting of orders means that the authority can be at the local depot the same day as a subscriber telephones the sales office with his request. This could be essential if sales promotion activities are to be vigorously pursued in the future. Again, earlier completion of works leads not only to better customer relations, but the earlier receipt of additional revenue.

Teleprinting of orders meets the requirements of the Automatic Data Processing billing system introduced recently, which needs copies of all telephone orders involving exchange line movement to be received at the Data Transcription Unit at the same time as distribution to the field takes place. This is essential under computer operation to ensure that rejects from the computer, at input, are kept to a minimum. If a manual system exists at the time of A.D.P. implementation, special action for the handling of D.T.U. order copies at the sales office is necessary; the need to employ a courier to carry orders from the sales office to the D.T.U. has been suggested as a possibility.

The capacity of a teleprinter system is much greater than the present manual system. It will easily cope with the transmission of the quarter of a million telephone orders yearly expected by 1970, whereas the present arrangements would need to be substantially improved to meet such a commitment. At present, some 230,000 orders are issued in the metropolitan region each year.

The teleprinting of orders also clears the way for further improvement, as the selective despatch facilities available in the network permit procedures for the handling of certain types of orders to be reviewed. In the near future, Telegraph Orders, Broadcast Orders, and Disconnection Advices could be passed through the system. In the long term the production of exchange master cards, directory cards, and more detailed statistical information could be arranged by this mechanised system. In addition, the teleprinting back from the field of information to all points is a possibility. This could be most desirable under a computer billing system where immediate updating of computer history files is essential. The re-design of agreement form and other documents to permit additions to the information already supplied by the customer, could eliminate much transcription work in sales offices.

ADVANTAGES OF THE TEL.2 COMPLETION ADVICE SYSTEM.

The system eliminated the need for exchange, substation installation and lines staff to return a copy of every order to the Sales Office. An order copy is returned only where actual cost work is involved and such orders are less than 5 per cent. of all telephone orders issued.

In exchanges, it also eliminates much of the transcription of order completion details from exchange working documents to telephone order copies returned under the previous system.

Advice of partially completed orders is more easily passed to the Sales Office, where temporary installations are provided pending the supply of special equipment, or where not all the work required on an order is carried out simultaneously.

The Tel. 2 system permits the recording of more accurate statistics in the Sales Branch as both sales offices and the statistical sub-section operate from a common advice of outstanding order completion. Under the manual system advice of completion is returned to these points from different locations in the field.

Advice of completion is received by the Meter Checks and Statistics Sub-sections much earlier. By eliminating the transcription work at the exchange, an early advice is received in the sales office and the relevant information is then passed promptly to both these areas.

The system, with all order completion details being returned from one location in the field, lends itself to any further development of advanced or automatic means of speedily processing charging advices from telephone orders. Under the manual system, information returned from the field as separate advices would need to be collated in the Sales Branch before full information could be supplied for accounting purposes. The future A.D.P. billing system may eventually require more prompt or direct advice of completion from either the Sales Branch or engineering locations in the field. The return of only relevant information, rather than endorsed copies of the original order, seems far more adaptable to future possibilities.

FUTURE.

The teleprinter system has proved to be a successful one and in anticipation of the system being extended into other areas, the procedures associated with the system were introduced into the Melbourne Metropolitan area on February 1, 1968. What of the future?

There is already considerable use of teleprinters for departmental purposes in the Melbourne area. There has been a tendency for these services to be provided by separate networks, and consideration is being given to achieving the economies which could be expected by integrating all these teleprinter requirements into a common system.

It is feasible to provide an integrated network which would include the distribution of telephone orders with equal simplicity in operation and no fewer features than those obtained in the existing system.

Extension of the system in the Melbourne area on a single central exchange basis is being planned; the first transmission of telephone orders by teleprinter using centralised equipment is programmed to take place in July, 1970.

Later features of the system could include the transmission of Broadcast, Telegraph, Public Telephone and Miscellaneous orders and completion advice of Telephone orders from outstations via teleprinter. In addition it is anticipated that the centralised network will be capable of handling administrative messages in addition to telephone order traffic.

CONCLUSION.

The distribution of telephone orders by teleprinter has been in operation in the western area of Melbourne for three years. During this time over 72,000 telephone orders at an average of approximately 100 per day have been passed through the system without loss or mutilation and very favourable comment has been received from the recipients of the teleprinted orders. The receipt in such an expeditious and efficient manner of clear, legible copy in the field has had a beneficial effect on operational staff.

A similar number of advices of completion have been returned to the sales office by the use of the Form Tel. 2. This particular segment of the system has been favourably received by the various units of the Engineering Division as it has simplified the handling of orders and has achieved the benefits hoped for within the Telecommunications Division.

ACKNOWLEDGMENT.

The authors gratefully acknowledge the extensive contribution to this project by Mr. K. Brennan, Telecommunication Division, Victoria.

TECHNICAL NEWS ITEM

C.C.I.T.T. Meetings in Melbourne

Australia was host to teams of delegates from 23 countries in February and March, when two Study Groups of the International Telegraph and Telephone Consultative Committee (C.C.I.T.T.) met at the Southern Cross Hotel, Melbourne. This was the third occasion on which C.C.I.T.T. meetings had been held in Australia.

The Study Groups debated technical matters requiring international agreement in the field of telephone transmission quality and telephone transmission planning.

The Australian delegation comprised five engineers from Post Office Heaquarters, one from the Overseas Telecommunications Commission (Australia) and one from the Australian Telecommunication Development Association representing Australian manufacturers.

In addition, the Post Office sponsored an international 2-day seminar on national telephone transmission planning and contributed one of the seven formal papers presented on the first day of the seminar. The seminar proceedings will have world-wide distribution.

TRANSMISSION LINES AND MEASUREMENTS — PART 1: OPEN WIRE

*K. M. RAY, M.E.**

INTRODUCTION.

This article reviews developments, past, present and future, in transmission lines. It discusses the basic characteristics and limitations relevant to open-wire transmission lines and outlines the measurements made on them. Paired and coaxial cable transmission lines will be discussed in subsequent parts of this article.

For each transmission medium changing conditions, usually circuit quantities, installation and material costs (capital costs) and annual charges, together with the practical life of the system (depreciation rate) have their effect on the suitability of a particular system. In addition, developments in the electronic channel deriving equipment have a large influence on the requirements of the line bearer medium.

Background.

A characteristic which is common to all modern telecommunication networks today is their very high growth rate. This is further accentuated with the provision of, firstly, improved service, e.g., removal of delays and congestion and improved transmission quality, and secondly, additional facilities, e.g., automatic service and subscriber trunk dialling.

There are many statistics available to illustrate this; however, it is sufficient to quote one or two. The Sydney-Melbourne route — Australia's largest interstate trunk route — has experienced a growth rate of about 15 per cent. in recent years. With this growth rate the number of circuits required 10 years hence is four times, and 20 years hence, is sixteen times the present requirements. The overall growth rate of trunk circuits in Australia has steadily increased from less than 4 per cent. in the 1939-45 period to a value of approximately 12 per cent. today. This may be compared to a subscriber growth rate of approximately 6 per cent., for the whole of Australia.

In providing for such growth rates new systems and new or modified techniques of transmission have been introduced into the network. The systems most widely publicised are the Broadband systems, which may generally be defined as those systems having capacities of the order of 300 or more voice channels. At present they are being utilised to form the backbone or main trunk routes and to date operate over coaxial cable and microwave radio bearers. However, there remains a large area of circuit provision in the metropolitan type junction networks, as well as in the rural areas, which involves, in total, greater expenditure than the broadband networks, and requires careful designing and planning to meet the problems of increased circuit and quality requirements. It is the responsibility of planning engineers to determine which method or type of transmission system provides an integrated and economically sound solution to the problem of providing the necessary circuits over the required planning period. This may vary from one to three years for short term, to twenty years for long term planning.,

In this context then the importance of line plant cannot be over-emphasised because it is apparent that this will continue to carry the bulk of the telecommunication traffic for a considerable period. At present, line plant represents about 52 per cent. of the total engineering plant assets, local cable networks now contain approximately 9,000,000 pair miles, trunk cable network about 700,000 pair miles and 9500 tube miles.

Basic Characteristics of Line Transmission.

In any transmission system the fundamental properties which control the extent to which it may be used to carry information are:

(i) Insertion loss;
(ii) Crosstalk; and
(iii) Impedance characteristic

over the frequency bandwith being considered. There are other factors such as noise level, loop resistance, insulation resistance, etc.; however, the first three are the most critical and generally determine the bandwith over which the transmission line may be satisfactorily used. These characteristics will be considered in discussing each type of transmission line.

OPEN WIRE TRANSMISSION LINES INTRODUCTION.

While the use of other types of line plant has increased significantly over the last decade, open wire plant has decreased by about 6 per cent. overall. The decline in the construction of new wire routes is due to its inherent low circuit capacity, coupled with its relatively high annual charges due to high maintenance costs. Open wire routes are still extensively used throughout Australia, particularly in the more remote areas, and will continue to provide a transmission medium for many years to come.

CROSSTALK.

The characteristic which is controlling in limiting the circuit capacity of open-wire routes is far-end crosstalk ratio.

The standards set for far end crosstalk ratio are 60-65 dB for intelligible crosstalk, and 50-55 dB for the unintelligible crosstalk, which is obtained by systems employing inversion and/or staggering of channels.

The direct effects of near-end crosstalk are eliminated on open wire carrier systems by using different frequencies for each direction of transmission. Reflected near-end crosstalk is, however a significant component of the far-end crosstalk ratio. Other major components are far-end interaction crosstalk and irregularity crosstalk (Ref. 1). All components of crosstalk are affected by physical aspects of the constructed lines—the placement and spacing of the pairs, the transposition patterns used, and the uniformity of pole spacing and wire sag. The effect of placement and spacing of the pairs is expressed in the coupling coefficient; the effect of transposition patterns in type unbalance factors.

Over the years various means have been used to increase the capacity of open wire routes as new carrier systems are designed to derive more channels per pair of wires and as the demand for additional circuits has increased. These means include reducing the coupling coefficient and choosing transposition patterns with low type unbalance factors and the adoption of stringent construction standards.

Coupling Coefficient.

The coupling coefficient is a function of the mutual inductance M, and the characteristic impedance of the line, Z_0 and is given by the formula:

$$\text{Coupling coefficient} = \frac{2M \times 10^3}{Z_0}$$

The mutual inductance is given by the formula:

$$M = A \log \left(\frac{(d14.d23)}{(d13.d24)}\right)$$

* Mr. Ray is Engineer Class 3, Mechanisation of Planning Processes, N.S.W.

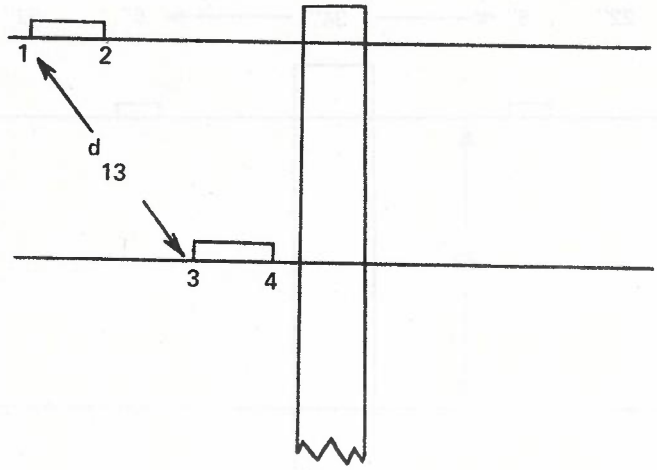


Fig. 1.

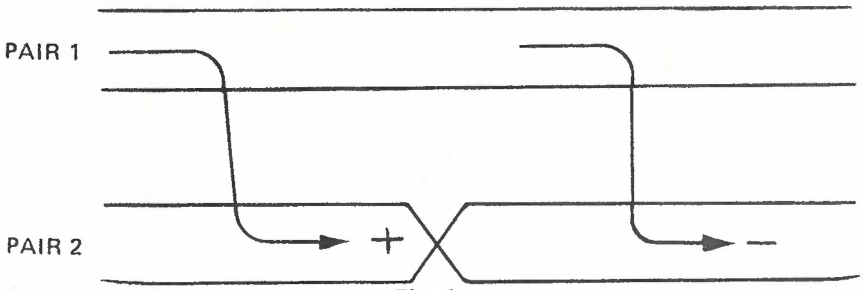


Fig. 2.

where A is a constant and d14, etc., are the wire to wire distances as shown in Fig. 1.

Hence is can be seen that if the 'geometry' of the wires is varied the mutual inductance between the pairs is changed. It is reduced by placing the wires of a pair closer together and/or by increasing the separation of the pairs. Placing the wires closer increases the incidence of wires touching, but this can be overcome to some extent by increasing the number of the poles per mile.

Type Unbalance Factor.

The type unbalance factor is the length of equivalent untransposed line which gives the same crosstalk. Transpositions are inserted in the pairs on the route to reduce the crosstalk as in Fig. 2.

Neglecting attenuation and phase changes along the line, the transposition of the legs in one pair will cause the crosstalk signals to cancel out on either side of the transposition. In a real situation, due to the attenuation and phase change of the disturbing current, the induced currents do not cancel out exactly and there will remain always some residual crosstalk.

Transposition patterns have been designed for open wire routes to reduce the crosstalk between various pairs to acceptable standards. The route is divided into basic sections known as E sections—8 miles long usually, in which there are 32 basic transposition types. This varies from the 'P' type with no transpositions to the 'a' type with 32 transpositions per section. For carrier operation a more complete balance is necessary and these fundamental patterns are further divided into 64 96 and 128 intervals by an extra one, two or three transpositions in every one of the 32 intervals. The derived patterns are known as 'extra' types.

As far as the type unbalance is concerned, only the relative pattern is of importance. Theoretical calculations of type unbalance factors are very complex, but the factors are now available, expressed as the product of type unbalance and frequency at various 'line angles' (see Refs. 1, 2 and 3).

Effect of Construction Standards.

Departures from ideal pole spacing and/or non-uniform wire spacing and sags lead to irregularity unbalance and its associated crosstalk. The crosstalk is approximately proportioned to frequency and therefore as higher maximum frequencies are used construction standards become more important.

INSERTION LOSS.

Ideally the insertion loss of an open wire pair is proportional to the square root of the frequency. However, crosstalk between pairs and fundamental properties of the transposition patterns lead to marked increases in the attenuation at certain frequencies. These are termed absorption peaks and it is important that the actual attenuation/frequency characteristics of each pair be checked by field measurement to determine its suitability for systems proposed for use on it.

CHANGES IN CONSTRUCTION

In the 1930's open wire routes were being designed to carry 3 channel systems (30 kHz). These were later modified to allow a small number of 12 channel systems (150 KHz) to operate on selected pairs. The standard scheme C1394 allowed two 12 channel systems to operate on the outer pin positions of the top arm. The standard of construction is shown in Fig. 3.

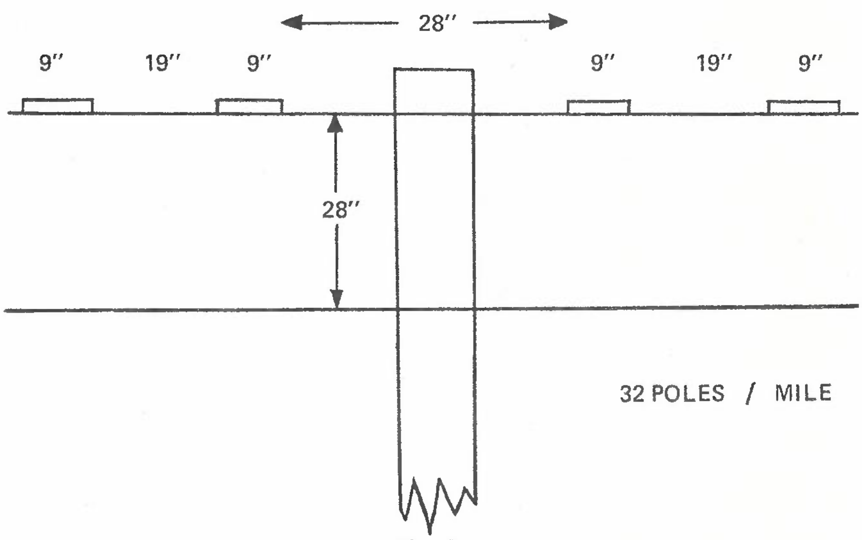


Fig. 3.

By the early 1950's the demand for additional circuits between Sydney and Melbourne had become so great that an additional route was constructed between Blayney, in New South Wales, and Echuca, for Victorian circuits, and Euston for South Australian circuits. By this time the original open wire route had exceeded its capacity; certain sections were carrying up to 10 twelve channel systems and the standard of crosstalk was less than that desired. In particular the V.F.T. systems operating on the route were causing interference to other system channels. The new route was designed using a reduced pole spacing by increasing the number of poles/mile to 40 (6.4 mile E. section), closer spacing of wires (to 6 in.) and wider separation of pairs (to 22 in.). The vert'cal arm spacing was increased to 42 in. The transposition scheme used double and triple extras (which left every second pole untransposed), as compared with quadruple and quintuple of the old Sydney-Melbourne route.

This design gave better crosstalk figures and enabled 12 channel systems to operate on all pairs, that is, 12 x 12 channel systems, 12 x 3 channel systems, plus VF physical pairs providing approximately a total of 180-200 channels. The crosstalk characteristics of a typical combination is shown in Fig. 5. The route is still being used

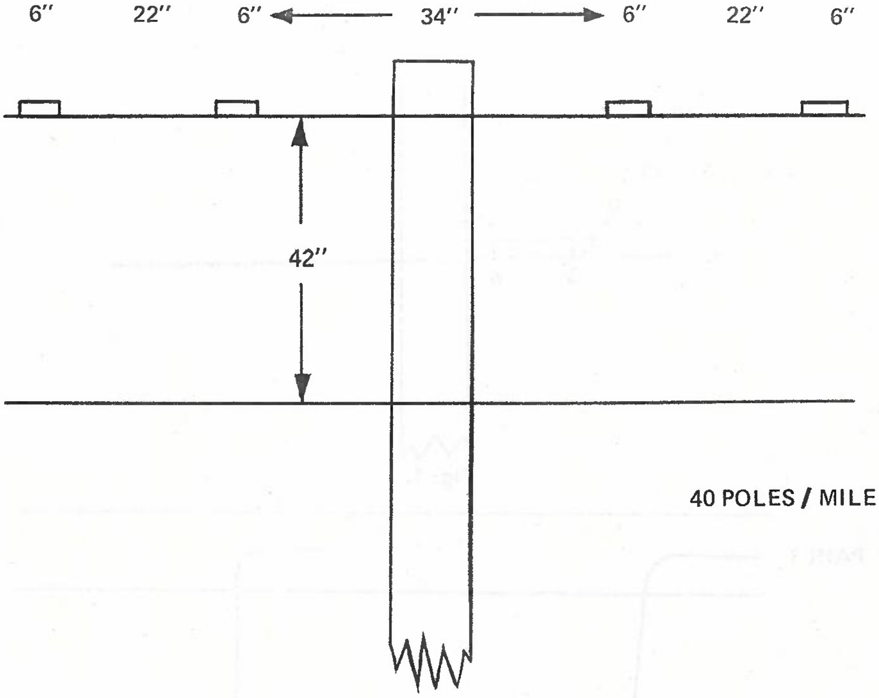
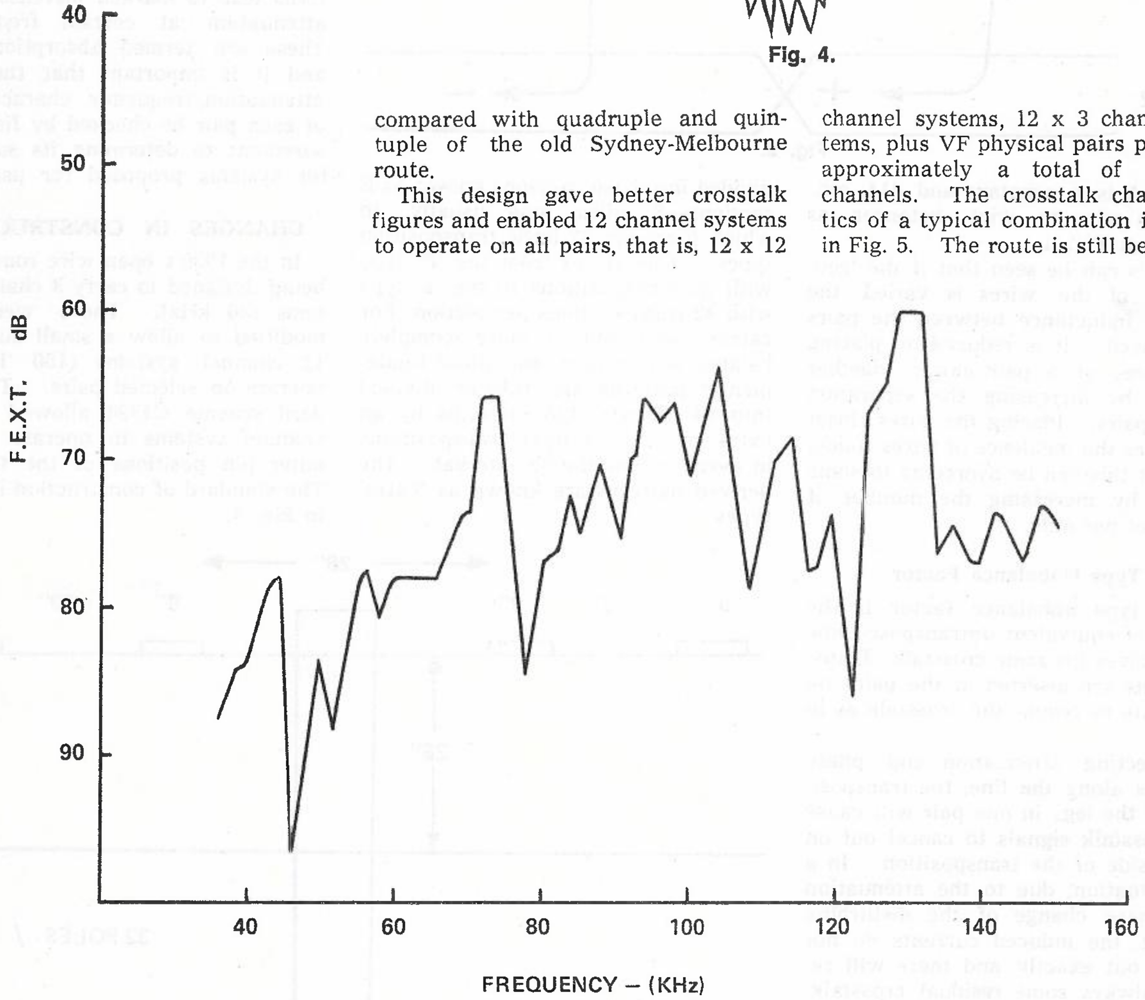
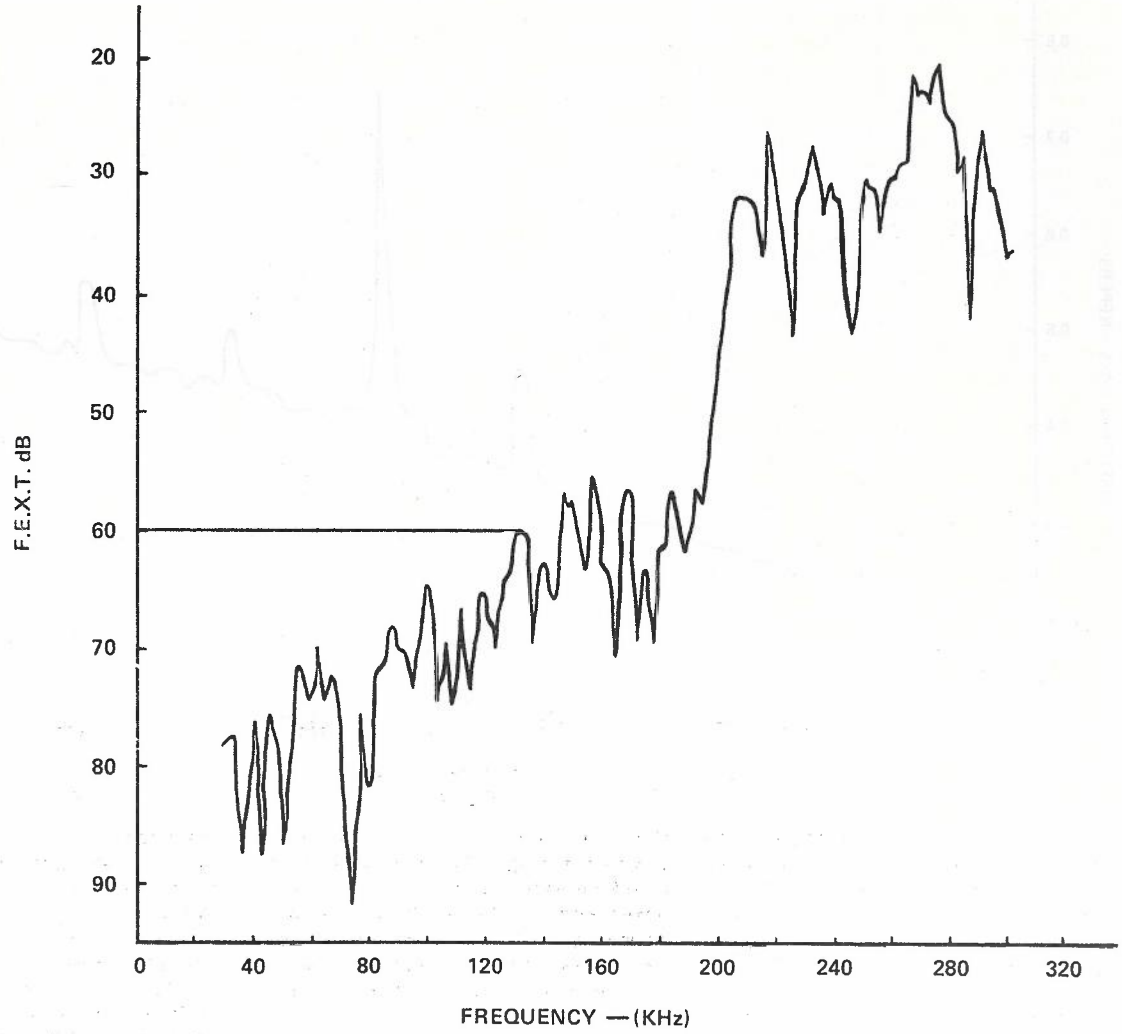


Fig. 4.



DISTURBING 1.½ – DISTURBED 1.¾
Fig. 5.



DISTURBING 1.1 – DISTURBED 1.3

Fig. 6.

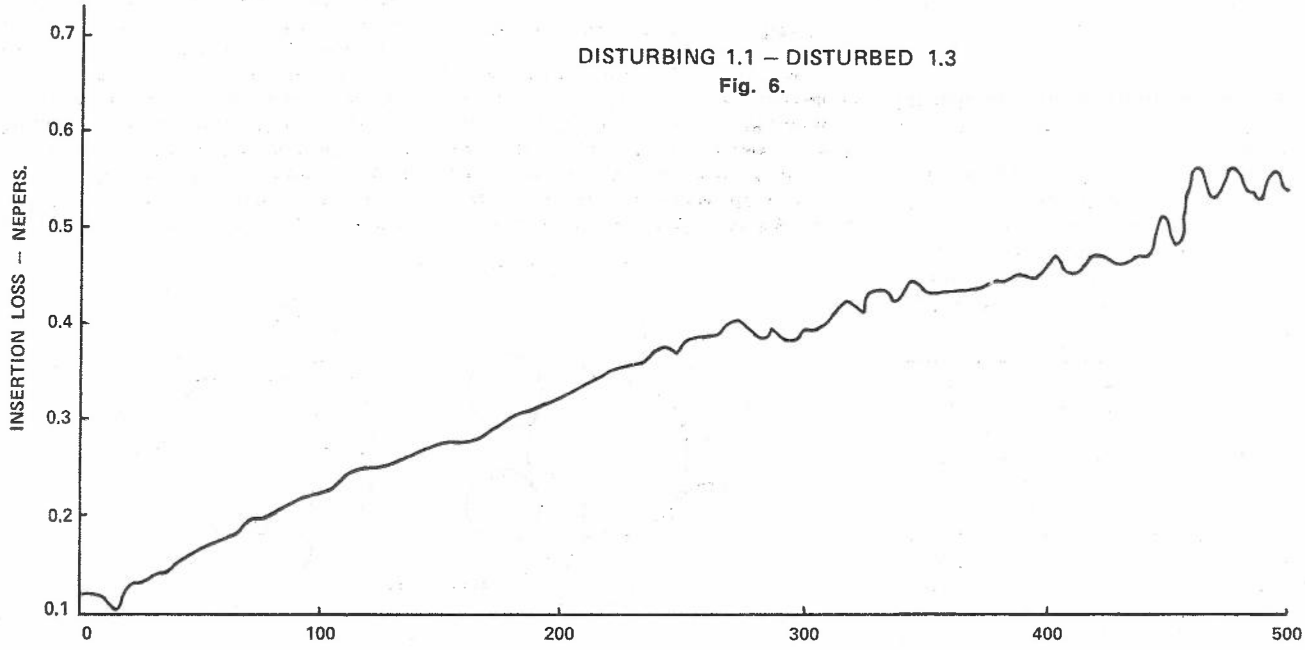


Fig. 7.

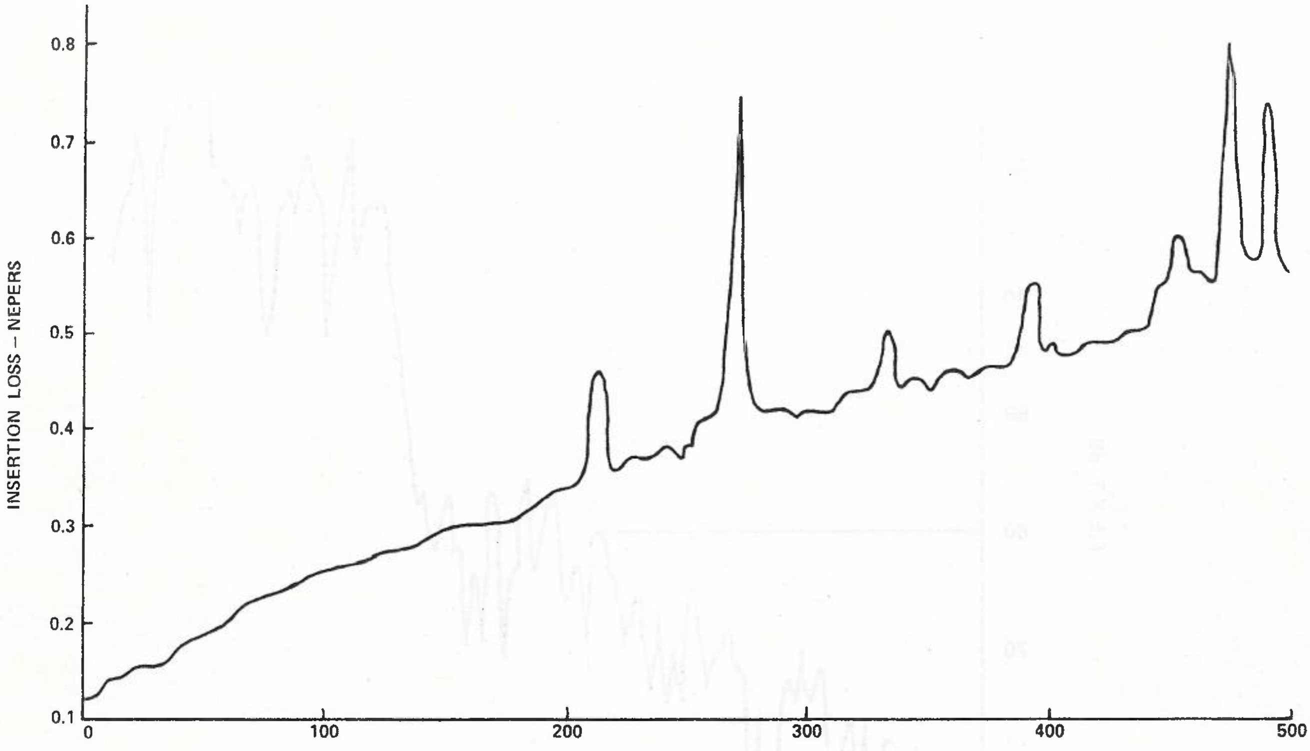


Fig. 8.

for short haul systems, together with some interstate systems, providing an alternative path to the main broadband routes.

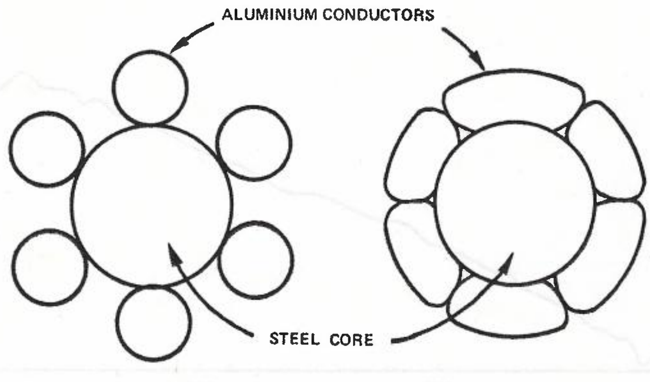
By the late 1950's additional new open wire routes were still required; however the cost of the above construction could not be justified by the required route capacity. An alternative design was prepared for the Moree-Collarenebri route, which reduced the number of poles per mile to 20. For this route, 9 in. wire spacing was used, but the 6.4 mile E section was reta'ned. A similar route was constructed for Dubbo-Coonamble. Measurements were made on this route up to 300 kHz and Figs. 6, 7 and 8 show crosstalk and insertion loss characteristics. 12 channel (150 kHz) operation is possible on all six pairs provided.

Recently calculations have been made on a modified design, in which the 9-19-9 in. configuration on 108 in. arms spaced at 28 in. has been altered to 7-21-7 in. on 108 in. arms at 28 in. spacing. These showed that a 5 dB far-end crosstalk improvement would result from this modification. A trial installation was subsequently carried out in Queensland to test the calculations. This wire spacing was obtained on non-transposition poles by tying the wires of a pair on the inner facing sides of the insulators instead of the outer faces. A new 7 in. transposition fitting was developed which could be used on either 9 in. or 7 in. bored arms. The results of the measurements have confirmed the theoretical values and it is expected that 12 channel system operation will be possible on all pairs.

LONG SPAN CONSTRUCTION.

In the early 1960's there was a need to develop a light capacity route of economical cost for use in the more sparsely settled areas of the State. As a result a new design was produced for use in the Western Districts of New South Wales. This was the nominal 8 chain span (10 poles/mile) construction using lightweight 26 ft. poles and an aluminium conductor steel reinforced (A.C.S.R.) l'ne wire. The long span length required a wire of considerable strength (greater than that provided by copper or cadmium/copper) and all suitable alternatives offering were investigated. The wire most suitable at the time was the CISCO wire, which consisted of a steel core with 6 strands of aluminium w're wrapped around it. Th's was then passed through a die to flatten the aluminium strands, forming a smooth-bodied wire as shown in Fig. 9. This reduces wind loading.

The wire has an ultimate tensile strength of 1400 lb. as compared to



CISCO WIRE
Fig. 9.

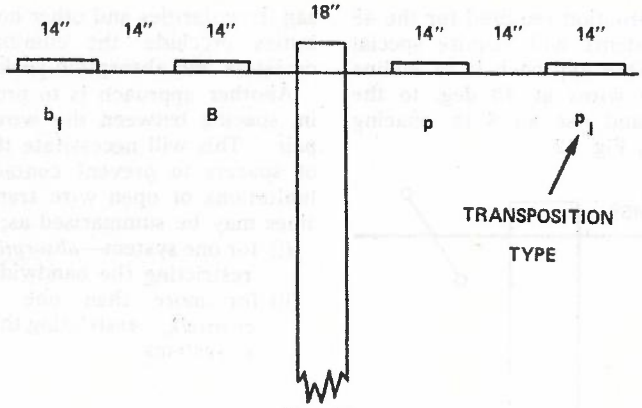


Fig. 10.

1000 lb. for 237 lb. cad/copper, and 600 lb. for 200 lb. copper. The resistance is slightly less than that of 200 lb. copper.

The ultimate design capacity is one arm (4 pairs) of wires with the outside pairs suitable for high frequency working. The remaining two pairs were designed for V.F. operation only. The long span construction necessitated wider wire spacing of the pairs as shown in Fig. 10.

This spacing was identical to that originally used in the early days of open wire construction for V.F. operation. In addition plastic wire spacers were fitted in each span to prevent wire contact.

The basic cost of one mile of route with one pair fitted was approximately 25 - 30 per cent. less than that of standard trunk construction of 4 chain spans with 200 lb. H.D.C. conductors.

The first two long span routes were constructed from Broken Hill to Packsaddle (a distance of 106 miles) and a 33-mile section between Yantabulla and Hungerford. The Packsaddle route has recently been extended another 75 miles to Milparinka.

Measurements made of:
(i) Insertion loss;
(ii) Crosstalk;
(iii) Impedance.
indicated that 12-channel systems may be operated on both carrier pairs. One of these pairs' pin position 1.1/1.2 (transposition type b1) has a smooth insertion loss characteristic up to 400 kHz (see Fig. 11), and therefore may be used for a high frequency 12-channel system on top of the standard 12-channel system. Thus the two pairs would provide a carrier channel capac'ty of 42 circuits, allowing for two 3-channel systems.

SUMMARY FOR OPEN WIRE ROUTES.

At present no new major open wire routes are being constructed, and in fact many are being replaced, particularly in the coastal and eastern half of the State, by cable and radio systems. Inherent low channel capacity

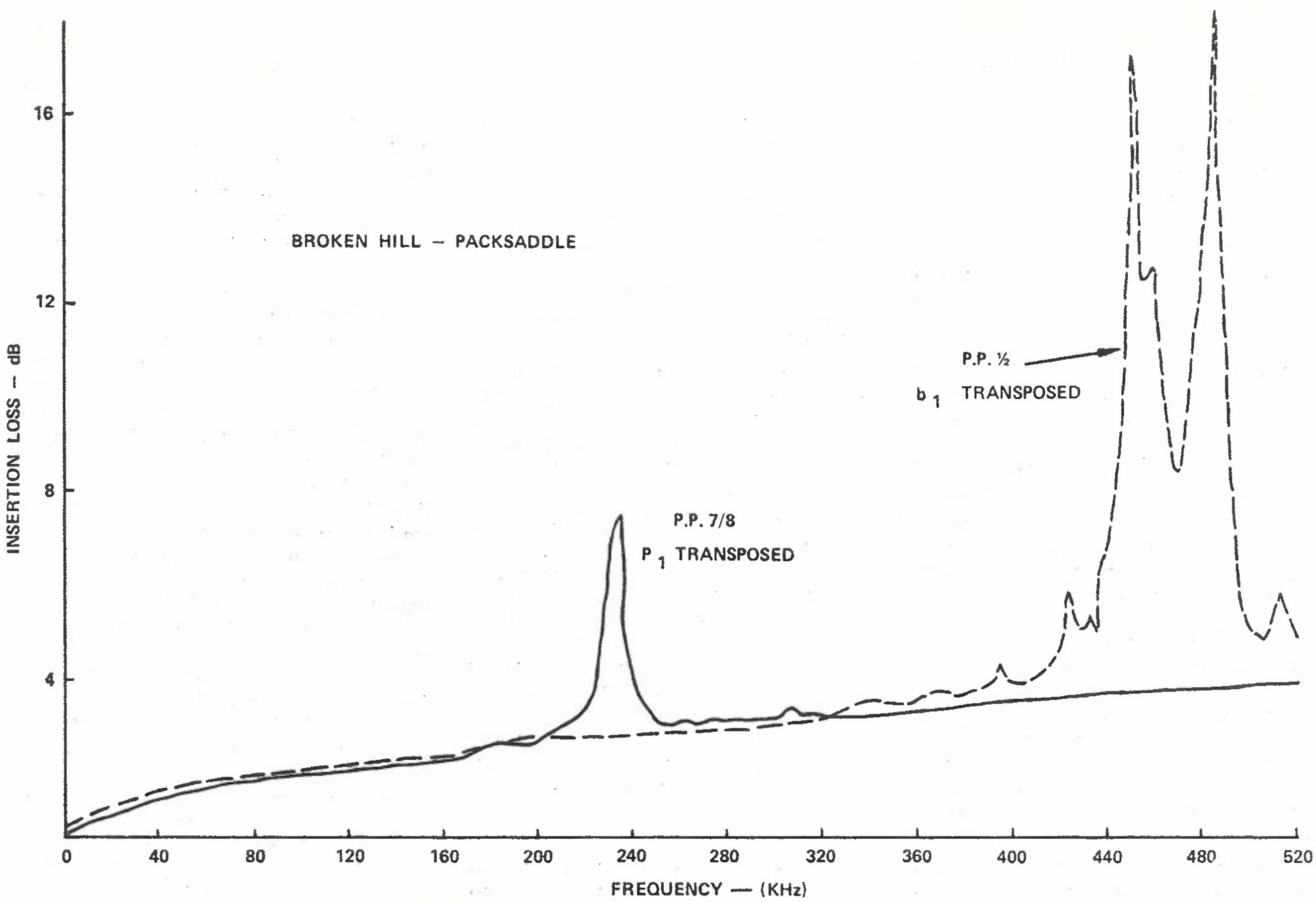


Fig. 11.

and high annual charges make the open wire route less attractive today for trunk routes. However, there are developments in construction and carrier system design which may economically extend the life of existing systems. Rural carrier systems, which utilise compandors, enable end link (3 dB) channels to be derived on routes where the crosstalk may be as low as 35 dB. Alternatively, high frequency 12 channel and now 48 channel systems have been designed for open wire routes, and in certain areas of Australia these may be economically applied. The high frequency 12 channel system uses frequencies 180 kHz to 300 kHz and operates above a standard 12 channel system (30 to 150 kHz). The 48 channel system is a more recent development; one design operates between 300 - 804 kHz and another operates up to 630 kHz. In New South Wales there may be cases where these systems can be economically used to defer the installation of expensive larger capacity systems.

The construction required for the 48 channel systems will require special features. One approach is to incline legs of the wires at 45 deg. to the horizontal and use an 8 in. spacing as shown in Fig. 12.

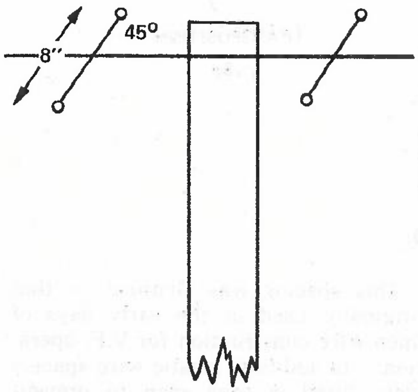


Fig. 12.

This has the effect of reducing the coupling coefficient considerably, but requires more elaborate fittings. Wire sag irregularities and other non-uniformities preclude the elimination of crosstalk and absorption peaks.

Another approach is to provide a 2 in. spacing between the wires of the pair. This will necessitate the fitting of spacers to prevent contact. The limitations of open wire transmission lines may be summarised as:

(i) for one system—*absorption peaks*, restricting the bandwidth.
(ii) for more than one system—*crosstalk*, restricting the number of systems

REFERENCES.

1. N. C. Watson, 'Crosstalk on Open Wires'; A.P.O. External Plant Information Bulletin, No. 42.
2. N. C. Watson, 'Extension of Operating Frequency Range on Open Wires'; A.P.O. External Plant Information Bulletin, No. 48.
3. A.P.O. E.I. Planning, Transmission and Line Systems, R2110.

LETTER TO THE EDITOR

Standards Association of Australia,
Clunies Ross House, 191 Royal Parade, Parkville, Victoria. 3052.
Telephone: 34 9321.
2nd April, 1970.
Dear Sir,

You are probably aware of the fact that the Association has recently reorganized its work in the field of Telecommunications and Electronics under the Telecommunications and Electronics Industry Standards Committee. A number of technical committees have been formed and are working actively on a wide range of subjects of interest to the Industry.

Wherever possible, the work of these committees is being related to international standards, particularly those published by the International Electrotechnical Commission. This has been done for several reasons, the major one being to achieve greater recognition of our national standards and thus promote acceptance of goods produced to these standards on the export market. There are many other benefits to the industry, which accrue by following this course.

One of the technical committees which has been formed is Committee TE/14, Radio Communications. The terms of reference of this Committee include consideration of standardization for radio and television receivers, transmitters and aerials. This is a very wide field and the Committee has decided, after due consideration, to set up three Sub-committees each related to one of the major fields of activity; reception, transmission and aerials.

The Sub-committees' initial efforts will be in the review of IEC Publications and other existing standards, to decide their relevance as possible Australian standards or as the basis for Australian national standards.

The documents currently being studied are:—

1. IEC Publication 107: Recommended methods of measurement on receivers for television broadcast transmissions
2. IEC Publication 244: Methods of measurement for radio transmitters
3. IEC Publication 138: Methods of measurement of essential electrical properties of receiving aerials in the frequency range from 30-1000 MHz.

Further documents of a similar nature have been listed for study when time permits.

In addition, the Sub-committee on Aerials has undertaken two further tasks:—

(i) The review of Australian Standard CC8: Radio and Television Receiving Aerials, with a view to possible revision or extension.
(ii) The production of a standard on community aerial systems to cover in particular, equipment, installation and safety.

The Committee agreed that the information quoted above should be brought to the attention of all interested parties, with the request that the various organizations concerned should request that their staff or readers consider this problem and submit comments to the Association on the need for standardization of aspects in the above fields.

It is considered that this action would be in the best interests of the organizations concerned, and of standardization in general.

On behalf of Committee TE/14, we earnestly commend these thoughts and request that you endeavour to assist the Committee in establishing their future programme.

Yours faithfully,
R. K. Profitt
Engineer-Secretary,
Committee TE/14.

RAY—Transmission Lines and Measurements: 1

DEVELOPMENTS IN POST OFFICE CO-ORDINATION WITH POWER AUTHORITIES 1966-1969

*N. G. ROSS, B.E.E.**

INTRODUCTION.

A Joint Conference was held in Melbourne between representatives of the Australian Post Office and the Electricity Supply Association of Australia (E.S.A.A.) during the period 15th to 17th April, 1969. The Conference was the sixth held between the two organisations since 1953, when the A.P.O. and the E.S.A.A. first agreed to formal co-operation through the medium of the Central and State Joint Committees.

The formation of these independent engineering advisory committees has been referred to in previous articles (Refs. 1 and 2). Briefly, the committees were established to facilitate the co-ordination of the construction and subsequent operation with freedom from interference of power lines and telecommunications circuits. These committees comprise a State Joint Committee in each State, with a Central Joint Committee in Melbourne. One of the primary functions of the Central Joint Committee is the preparation of codes and arrangements on co-ordination for use by the Post Office and the power authorities. Nowadays the role of the State Joint Committees is to act as advisory bodies to the Central Joint Committee on their particular State point of view and to refer problems which are likely to be of consequence on a Commonwealth-wide basis. The Committees also act in an advisory capacity to the Post Office and the electricity authorities' administrations in the States.

The E.S.A.A. is an association consisting presently of 63 members. The members are either State authorities constituted by statute for the purpose of regulating or controlling the supply or use of electricity throughout the State, or bodies generating, transmitting or distributing electricity for public supply under statutory authority. The Association, therefore, includes those municipal councils undertaking distribution of electricity to their consumers.

Membership of the Association is purely voluntary and it acts in an advisory capacity only. Despite this apparent lack of power, the Association has achieved a great measure of success in gaining uniform acceptance of co-ordination measures amongst its members. No doubt this is primarily due to individual participation of representatives in scheduled series of conferences enabling the representatives to put forward for consideration by the conference the views of their major organisations. The Association comprises five sections, with Section No. 2 representing Transmission and Distribution interests. Within each section are Committees with particular fields of interest. The 2/10 Committee of Section 2 is responsible for matters associated with the Co-ordination of Power and Telecommunications Systems.

The E.S.A.A. representatives at the Conference were drawn from the 2/10 Committee. The A.P.O. representatives at the Conference were members of the various Joint Committees. The E.S.A.A. was likewise represented by Joint Committee members from the various States.

The purpose of the Conference was to review progress since the 1965 Joint Conference, and to discuss current problems. A number of resolutions were adopted which will form the basis of the work of the Joint Committees over the next few years.

PROJECTS COMPLETED SINCE 1965.

Joint Use of Poles.

A Commonwealth Arrangement for Joint use of Poles was adopted by the A.P.O. and the E.S.A.A. in September, 1965, and has subsequently been published in a 9½ in. x 6 in. size handbook. The Arrangement comprises basically two parts: Part A sets out the general administrative and financial conditions and procedures, whilst Part B contains the engineering conditions in the form of a Code of Engineering Practice for Joint Use Construction.

It was noted that the existing Arrangement does not cover the situation of aerial joint use on private property where provision and ownership of the pole is the responsibility of the landholder. This aspect will require further investigation.

A Code of Practice for M.E.N. (Multiple Earthed Neutral) High Voltage Power Lines.

A new Code has been approved by the A.P.O. and the E.S.A.A. and has subsequently been published in new B5 international paper size. The Code is intended solely for use in Western Australia, where M.E.N. High Voltage distribution is the favoured form of power distribution to rural areas. Residual ground currents in the M.E.N. system are caused by unbalanced operating conditions which are introduced by the **direct** connection of phase/neutral spur lines to the three-phase backbone line. These residual currents can induce noise into nearby telecommunications lines unless effective co-ordination measures are practised.

Low Frequency Induction.

Also published in the new size format are Interim Recommendations on Low Frequency Induction as to suitable fault resistance values to be used in power line earth fault current calculations. These calculations are usually made by the power authority on the request of the A.P.O. where the degree of hazard of an existing or proposed exposure is desired to be known. Since 1963 the C.C.I.T.T. Directives allow for interposing a lumped resistance value at the site of a power fault. Previously it had been assumed as zero as a means of ensuring a factor of safety. In reality, the resistance at the fault can vary from zero ohms (for a fault at a main sub-station) to hundreds of ohms (for a broken power conductor), depending on the degree of contact with earth. The calculation is normally made for the worst exposure case, and the use of the appropriate resistance value results in a better approximation to the likely maximum current flowing under actual earth fault conditions.

Revision of the Crossings Code and an Arrangement for Common Use.

The existing Crossings Code—Issue 1, 1958, had been considered to require review to bring it up-to-date with changing circumstances. At the same time it was realised that 'common use' of poles as distinct from 'joint use' should, from engineering and safety considerations, be formalised in a separate code. The common use of poles is often required where one authority wishes to aerially cross the pole route of the other, both authorities having their separate routes or alignments. Since some aspects of common use — in particular the attachment of conductors to supports —were part of the existing Crossings Code, the review of the Crossings Code, now titled 'Code of Practice for Overhead Power and Telecommunication In-span Crossings,' and the preparation of an Arrangement for the

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Common Use of Poles were undertaken concurrently.

The revised Crossings Code now contains four sections. Section 1 contains essential definitions and draws attention to the related Codes. Section 2 defines the responsibility of the A.P.O. and the power authorities regarding the planning of crossings, their construction and subsequent maintenance and safe working conditions. It also includes principles for the apportionment of costs. Section 3 lays down conditions for the engineering of low voltage crossings (less than 650 volts) and Section 4 deals similarly with the requirements for high voltage crossings. No reference is made in the revised Code to crossings with contact wires (aerial conductors used for the supply of traction current to trains, trams and trolley buses). The need for such crossings rarely occurs but when it does arise, individual negotiation will be necessary.

The Arrangement for Common Use comprises two parts, Part A dealing with General Conditions, Financial Principles and Procedure, while Part B is a Code of Engineering Practice. In Part A it is stressed that common use is confined to the sharing of a single pole to facilitate the crossing of the lines of the two parties. The financial principles are consistent with those used in the Joint Use Arrangement in that payment to the owner of the actual cost of any additional expenditure incurred is arranged initially and on each occasion that the pole is replaced. If this expenditure involves only additional pole height a fixed scale of charges is recommended. Unlike joint use, common use is a reciprocal facility however, and the benefits to both parties are likely to be about equal. No 'occupancy' charge applies as in the case of joint use where, in the majority of cases, the economic advantage accrues mainly to the joint user rather than to the owner.

Revision of the S.W.E.R. Conditions.

As a result of decisions of the 1965 Joint Conference, the Central Joint Committee had established a working party to revise the existing Conditions for Single Wire Earth Return High Voltage Power Lines, and to develop Conditions for Unisolated S.W.E.R. HV Power Lines, i.e., S.W.E.R. power lines directly tapped off the three phase feeder without the use of an isolating transformer. While the existing Conditions were satisfactory in the majority of cases, and had the advantage of simplicity, it was considered that greater flexibility was required to enable the less usual application of S.W.E.R. systems to be designed.

The working party was able to satisfactorily merge the two subjects (isolated and unisolated S.W.E.R.) and the Code has been renamed the 'Code of Practice for Earth Return HV Power Lines — Control of Interference to Telecommunication Circuits.' The Code consists of two parts, Part 1 being the conditions under which the Department will give consent to the erection of earth return high voltage power lines as required by the Telegraph Lines Protection Regulations, and Part 2 being an application guide for the assessment of separations and other requirements to enable the conditions to be met.

There are some significant changes in approach in the new Code as compared with the previous S.W.E.R. Conditions. The Conditions limited the earth return current to 8 amps at full load from a consideration of a hypothetical exposure 20 miles long at 250 feet separation, under which conditions a standing voltage of 60 volts would be induced in the exposed telephone lines, and could cause injury to personnel who contacted the line and earth. The new Code places no such restriction, although faults which cause over 60 volts longitudinal e.m.f. to be induced must be positively cleared. The new limits imposed relate to the electromagnetically induced longitudinal psophometric e.m.f. in the telecommunication line. No minimum separations between the power and telecommunication lines are specified, but the emphasis in the Code is to maintain separations adequate to avoid noise interference. A further requirement of the new Code places responsibility on the A.P.O. to ensure that its 2-wire circuits are balanced to a particular standard in the event of excessive induction being experienced.

PROJECTS UNDER STUDY.

Investigation of Underground Joint Use Construction.

In the realisation that the future would see increasing pressure on both power and telecommunications authorities to underground their plant, special attention was given to this investigation from 1966, when an endeavour was made in most States to arrange underground joint use trials where practicable. Trials in some States were successful, but other trials foundered for various reasons involving co-ordination difficulties or doubtful economic savings. It has been established however that joint use underground is feasible from engineering and safety points of view without major departure from current techniques adopted for underground reticulation. The use of plastic pipe by the A.P.O. simplifies co-ordination in urban areas, in that one authority can be made responsible for all excavation and reinstatement and the placement of plant of both parties. Although the sharing of trenches offers economic advantages over separate trenches, it does involve considerably higher costs (power plus telephone) than does joint aerial construction, and at present underground joint use can only be justified where a subdivider or local authority is prepared to subsidise the undertaking. The conclusion at the Conference was that the Central Joint Committee, after further establishing the engineering construction and maintenance and safety requirements of underground joint use, together with relative cost savings, should work towards the preparation of an Arrangement.

Effects of Low Frequency Induction (50 Hz.)

In an effort to obtain more quantitative evidence of the effects of high voltage power line faults on parallelling telecommunications lines, a voltage recorder was installed in April, 1967, at the Geelong Telephone Exchange. The recorder is connected to several telecommunications cables which extensively parallel 22 KV power lines in the area, and will record induced voltages (between cable conductors and earth) and their duration in three ranges: between 50 volts and 215 volts; between 215 volts and 600 volts, and in excess of 600 volts. There has been found to be substantial correlation with State Electricity Commission fault statistics in the general area in regard to time of occurrence and location. Some of these faults resulted in induced voltages in excess of 600 volts for approximately one cycle only. Rarely did an induced voltage exceed 30 cycles (0.6 sec.) duration. Ammeters are installed in the neutrals of the five Geelong substations from which the feeders radiate to enable actual measurement of the earth fault current flowing.

The report of the working party which undertook this work for the Central Joint Committee, and which was received and accepted by the Conference, also referred to methods considered for providing economic relief from the present co-ordination measures.

These methods included:

(i) Restricted access to telecommunication cables and adoption of special isolated working practices. This was rejected for general application because of the complexity of the A.P.O. situation (cramped spaces, large numbers of conductors, etc.), and the low probability of danger. There may be application in special cases.

(ii) Restricted fault current on power plant where practicable. The use of earth fault current limiting techniques to limit the fault current to 3000 amps could be an economic measure in voltage systems of 66KV and 33KV. For systems of greater than 66KV, the cost would be prohibitive.

(iii) High conductivity shield wires on power systems to improve the shielding factor. Shielding factors down to 0.55 are obtainable and such shield wires may be economically feasible on some future power routes.

(iv) The assumption of a shielding factor of 0.25 in built-up areas. The working Party have concluded that such a value be allowed in calculations to account for shielding given by the various cables and other earthed conductors present in built-up areas.

(v) The raising of the level of tolerable induced voltage if certain clearance times of the fault can normally be anticipated. The working party considered references relating to fibrillation of the heart following electric shock, in which the heart muscles operate asynchronously and stop pumping blood. This is generally a cause of death. It has been experimentally shown (on animals) that if the duration of the fault voltage is less than the period of one heartbeat (0.75 seconds for man), the level of current that can be tolerated by the heart without causing fibrillation is significantly increased. The working party almost unanimously agreed on the following induced voltage limits:

(a) Where the fault will be cleared within 0.35 seconds or better under the normal clearing conditions of the power line, calculated maximum induced voltage must not exceed 1500V.

(b) Where the power line complies with the C.C.I.T.T. definition of a High Reliability Power Line, calculated maximum induced voltage must not exceed 1000V. Such power lines are required in the majority of cases to have earth fault current durations less than 0.2 seconds but never exceeding 0.5 seconds.

The Conference, whilst accepting the working party's report, agreed that the physiological effects as related to the duration of induced voltages, as well as the distribution of the voltage along the induced line, should be further studied in an effort to arrive at a voltage limit which would be reasonably safe. The working party have since initiated experimental tests on dogs in conjunction with Dr. Trethewie, of the Physiology Department, University of Melbourne, to obtain further experimental evidence.

Protection of Persons and Telecommunications Plant from Potential Rises Associated with Power Earth Faults.

This subject suffers the same difficulties as those of low frequency induction, in that theoretical predictions are often obscured by factors which cannot be assessed accurately. It was, therefore, decided to install meters to measure the maximum potential rise at selected main substations during earth fault conditions. Due to the recent installation of this equipment and the low probability of substation earth faults adequate comparisons have not as yet been made between theoretical predictions and actual potential rises. Pending the evaluation of these long-term studies, a working party formed by the Central Joint Committee has prepared some interim recommendations after considering the problem under four categories:

(i) The probability of danger to telephone users in the electrical installation or adjacent premises.
(ii) The probability of danger to A.P.O. staff in the electrical installation or in the potential gradient area.
(iii) The probability of danger to A.P.O. staff remote from the potential gradient area.
(iv) The probability of damage to cables in the potential gradient area. This could arise by breakdown from conductor to conductor, from conductors to sheath, or from metallic cable sheath to adjacent ground in cases where the sheath has a better earth connection at a remote location.

Whilst these recommendations have yet to be ratified by the Central Joint Committee, the A.P.O. and the E.S.A.A., they provide for the use of isolating transformers or a neutralising transformer on pairs entering the substation where the estimated potential rise exceeds 1000 volts. Various conditions are also imposed by the use of plastic insulated cables within certain distances of main and distribution substations, and steel towers or metallic power poles.

NEW STUDIES.

The Conference also considered further aspects which could require attention in forthcoming years. The use of tone injection systems over HV power networks for control purposes was occurring in some States, and in New South Wales injection into 66KV lines had been introduced, thus extending the area of possible interference to A.P.O. circuits. Further investigations into noise interference with a view to specifying standards to apply to the various types of power and telephone lines was also considered warranted. The installation of HV substations in suburban exchanges could give rise to noise and danger problems due to the interaction of the power and telecommunication earths, and the establishment of practices to eliminate these problems was desirable. It was also agreed by the Conference that very tangible benefits accrued to both parties by the decentralisation of the day-to-day responsibilities for power and telecommunications co-ordination to the local area level. An introductory manual on co-ordination which would outline the action to be taken in each type of case requiring co-ordination examination would be of great value to field engineers and would provide for more effective decentralisation. The Conference served to emphasise that development in co-ordination between power and telecommunications systems is a continuing process — increases in transmission voltages on power lines, more sophisticated means of signalling and data transmission and the increasing density of operations bring fresh problems in co-ordination to test the initiative of the engineers concerned.

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THE AUSTRALIAN POST OFFICE ROLE IN NASCOM: PART 1 — DEVELOPMENT

K. A. McKENZIE*

INTRODUCTION.

Part I of this paper records development of the domestic Australian sector of the worldwide network which provides communications support for the various space programmes of the National Aeronautics and Space Administration (NASA) of the U.S.A. This network is widely known as NASCOM. A symposium of three papers (Ref. 1) read in Adelaide in 1963 covered the early developmental period between the International Geophysical Year 1957/58 and the preparations for Project Mercury 1962-63. This paper has thus been directed towards covering the developmental period between 1962-63 and the end of 1969, which included the Apollo 11 and Apollo 12 missions. Part II will deal with operational aspects.

NASCOM WORLD NETWORK.

The space research programmes of the National Aeronautics and Space Administration require that satellites travelling in near circular to highly elliptical earth orbits, together with lunar and deep space probes, should be accessible at all times for command control and data acquisition purposes to the several mission control headquarters in the U.S.A.

To give global coverage, the command, control and data acquisition information must be relayed between overseas tracking stations and mission control. NASCOM provides the communication links to the various switching and tracking installations located at longitudes and latitudes critical to the respective space programmes. (See Fig. 1.)

NASCOM network control is exercised from the Goddard Space Flight Centre (GSFC), which is located in Greenbelt, Maryland, U.S.A. Remote regional switching centres have been established in London (European and African Sector), Canberra (Australian Sector) and Hawaii (Pacific Sector).

In the development of NASCOM, NASA has as far as possible leased communications facilities from common carriers. Thus the network shares national networks, international submarine telephone cables such as COMPAC and SEACOM and communications satellites in synchronous orbit with other users. HF radio is also used to certain remote locations. NASA tracking ships in the Indian, Pacific and Atlantic Oceans now employ satellite communications in place of the less reliable HF radio facilities which provided communications during the first decade of the space research programme.

Voice Facilities—SCAMA II.

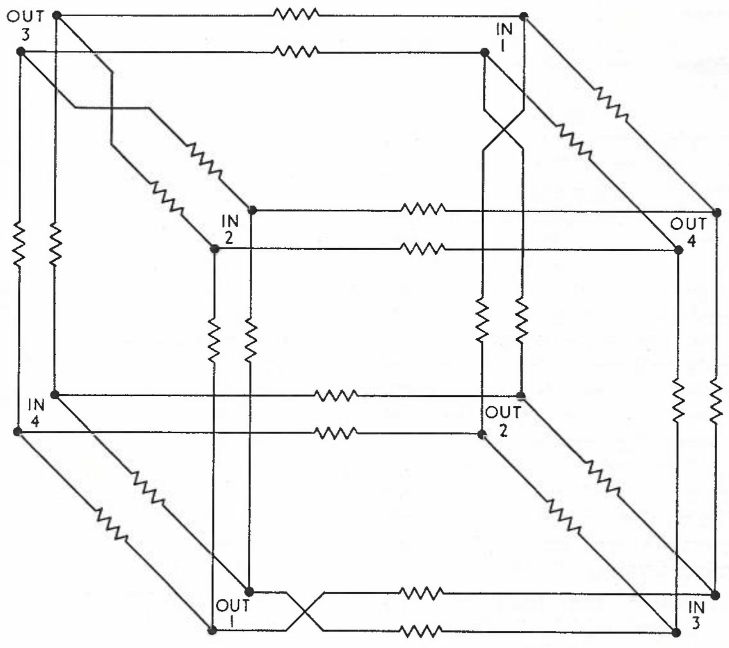
A Station Conferencing and Monitoring Arrangement (SCAMA) facility was established about 1960 to provide four-wire voice communications between Goddard and the various NASA tracking stations. (Ref. 2.) Multi-station operation was achieved by the use of a 44 type resistance hybrid, so called because it has four inputs and four outputs. This hybrid afforded a means whereby a four-party conference could be conducted with each party fully participating. The hybrid is of particular interest to telecommunications engineers. (See Fig. 2.)

The existing SCAMA II network is a development of the earlier SCAMA conferencing network and provides multiple dual operating consoles which enable an operator to devote full time to a particular mission conference. The SCAMA II operator at Goddard has full control over the network, adding and deleting conferences as necessary.

In addition to the SCAMA network, which essentially provides a NASA facility, an A.P.O. voice order wire communications network is provided in the Australian Sector of NASCOM to provide instantaneous communications between Australian Post Office centres vital to NASCOM security. This A.P.O. facility is provided to facilitate service activities and to assist in providing a high level of reliability to the leased services.

Data Facilities.

The NASCOM data switching system has been developed around the UNIVAC 490 communications processors at the NASCOM primary switching centre at Goddard and also at the Manned Space Flight Network (MSFN) Headquarters at Houston, Texas. The initial processor installations were effected about 1964 and these progressively replaced the earlier electromechanical and manual switching sys-



NOTES:-

1. ASSUMING 600 OHMS INPUTS & OUTPUTS THE RESISTANCE ELEMENTS WOULD BE 735 OHMS EACH. 2 % RESISTANCES OF HIGH STABILITY SHOULD BE USED.
2. INSERTION LOSS IS APPROXIMATELY 15dB. THE HIGH LOSS PATH FOR EXAMPLE BETWEEN INPUT 1 & OUTPUT 1 SHOULD BE APPROXIMATELY 40 dB UNDER GOOD BALANCE CONDITIONS.

Fig. 2 — Four-Four Type Resistance Hybrid.

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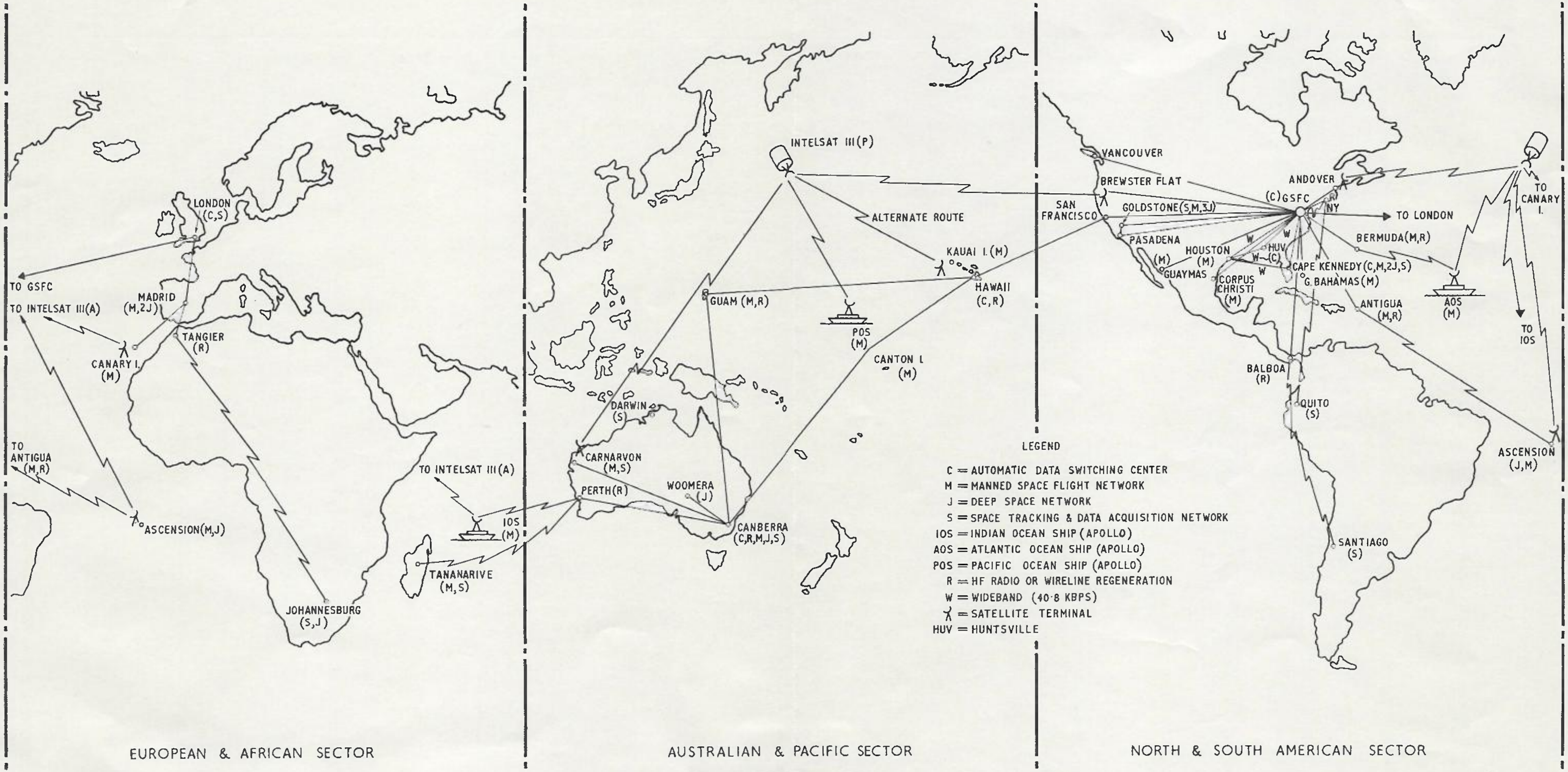

Fig. 1 — NASCOM World Network.

tem (83B2 and 111B teletype switches) which were in general use at GSFC stations.

The communications processor utilises a digital computer which receives, examines, stores, queues, routes and transmits messages electronically at very high speeds. The processor also exercises considerable pre-programme judgment thereby contributing to its own speed and reliability. For example, it attempts to deliver messages with garbled routing. It also automatically advises Facilities Control as to open-circuit line failures and other important operations data. It is understood that UNIVAC 494 Communications Processors (10 to 12 times faster than the 490) (Ref. 3) have been purchased by NASA for message handling duties. Dependent UNIVAC 418 Communications Processors are installed at Canberra and London and 2400 bits per second high speed data lines link these processors to the UNIVAC 490's at Goddard.

The communications processors having a store and forward facility are able to accept several 75-baud teletype messages from various sources and transmit them in the 2400 b/s mode. The original 75-baud teletype messages are derived for delivery or onwards transmission at the receiving processor. Where NASCOM data traffic justifies the provision, direct 2400 b/s links are provided between Goddard and overseas tracking stations clear of the communications processors. The equalisation of these circuits is dealt with in the chapter NASCOM Australian Sector.

Data System Equipment—Data Modems.

In 'Implementation of a worldwide high speed data transmission system for NASA mission support' (Ref. 2) the following paragraph describes the data modem equipment and its operation:—

> **Wireline Modem:** "The data modems employed in the NASCOM network (Western Electric Co. Model 205B) are capable of operating at 600, 1200, or 2400 b/s. The modem has a carrier of 1800 Hz and employs synchronous four-phase modulation. The data set can be used as a full duplex terminal or as a regenerative repeater. As a terminal data set it can operate in any of the three data rates independently in either direction. When used as a terminal data set the transmitted data stream is assembled in bit pairs (dibits), each dibit being transmitted as one of four phases. At 2400 b/s the data bits are examined in pairs to make up the dibit. At 1200 b/s each data bit corresponds to one dibit and at 600 b/s each data bit corresponds to two dibits. Thus the modulation rate is held constant at 1200 baud regardless of the data rate. Modem phase-shift logic at 2400 b/s is:—

Dibit Code	Phase Advance of the Carrier
00	225 degrees
01	315 degrees
10	135 degrees
11	45 degrees

> At 1200 b/s serial data 1's and 0's are encoded as 10 dibits or 00 dibits respectively. Consequently, only the 135 degree and 225 degree phase shifts are used at this data rate. At 600 b/s serial data 1's and 0's are encoded 1010 (two 10 dibits) and as 0000 (two 00 dibits) respectively. Thus two 135 degree phase shifts represent a 1 and two 225 degree phase shifts represent an 0. In the regeneration mode, the modem regenerates dibits and a 1200 Hz timing signal is transferred between the receiver and transmitter to maintain dibit encoding throughout the data set. This is necessary for proper operation of all three data rates regardless of the speed of the terminal data sets."

NASCOM: AUSTRALIAN SECTOR.

Growth of the Australian Sector.

As an integral part of the development of the world-wide NASCOM network to 140,000 circuit miles in 1963 (Ref. 1), 600,000 circuit miles in 1966 (Ref. 4) and 2,000,000 circuit miles in 1968, the Australian Sector developed from 10,000 circuit miles in 1963 (Ref. 1) to some 100,000 circuit miles in 1969 (Fig. 3 and Table 1).

TABLE 1: NASCOM NETWORK, AUSTRALIAN SECTOR 1963-1969.

Sector	Longitude	Control Stns and SCAMA	Satellite Tracking (STADAN) Station	Deep Space Probe (DSN) Station	Manned Space Flight (MSFN) Station
Australian and Pacific Sector	Mobile				Indian Ocean Ship
	114°E		Carnarvon		Carnarvon
	116°E				Muchea (1)
	116°E				Pearce (RAAF) (2)
	116°E	Perth (3)			
	131°E		Darwin		
	137°E			Island Lagoon (Woomera)	Red Lake (1) (Woomera)
	138°E	Adelaide (1)			
	146°E				Townsville (2)
	148°E	Canberra (Deakin)	Canberra (Orroral Valley)	Canberra (Tidbinbilla)	Canberra (Honeysuckle Creek)
	152°E		Cooby Creek (Toowoomba) (1)		
	Mobile				Pacific Ocean Ship

Notes:

1. The Adelaide switching centre and the Muchea MSFN station are now closed. Cooby Creek ATS station is temporarily employed by the A.P.O. in assessing the application of domestic satellite circuits to outback centres. The Red Lake station has been virtually phased out and its tracking equipment transferred to other locations.
2. The installations at Townsville and Pearce have been provid connection with the NASA Instrument Aircraft (ARIA), which operate manned space flight missions.
3. The installation at Perth (Bassendean) consists of serial/ conversion equipment at the interface of HF radio circuits landlines.

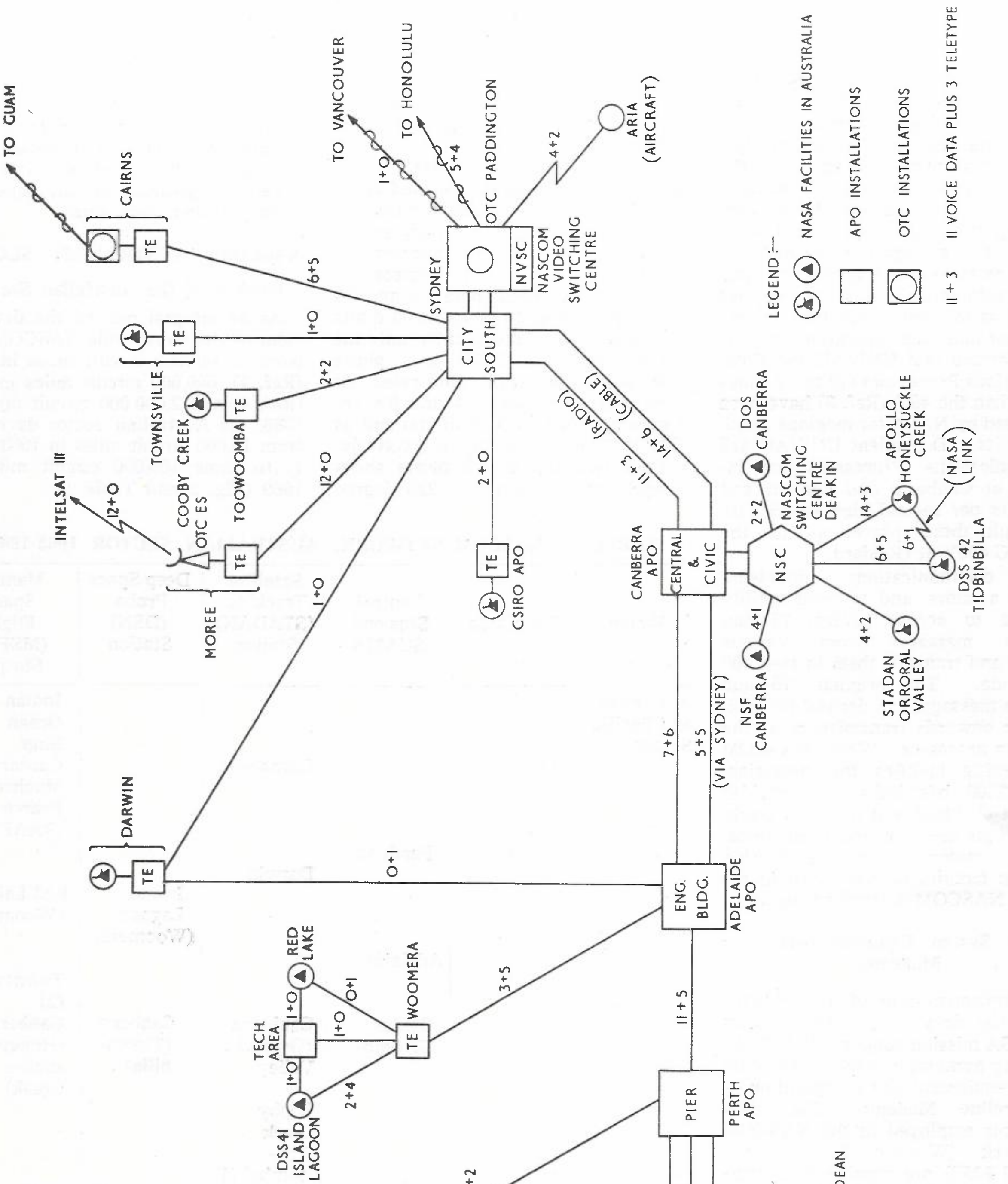

Fig. 3 — NASCOM Network — Australian Sector 1969.

Whilst the 10,000 circuit miles leased by NASA in 1963 consisted of 7000 miles of 50 baud teletype lines and some 3000 miles of station conferencing and monitoring (SCAMA) circuits, the 1969 total of 100,000 circuit miles had significantly changed in composition, being 60,000 circuit miles of alternate voice/data lines, 35,000 circuit miles of 75 baud telegraph lines, and 5000 miles of station conferencing and monitoring (SCAMA) circuits. These figures are approximate only and include both full time and part time facilities leased from the Australian Post Office. NASA Installations in Australia in 1963 (Ref. 1) consisted of a mintrack orbiting satellite—tracking installation plus a deep-space (85 ft. diameter parabolic cassegrain) antenna at Island Lagoon, some 20 miles south of Woomera, South Australia.

These facilities, together with the Mercury Tracking station No. 9, at Red Lake, north of Woomera, and Mercury Tracking station No. 8, at Muchea, north of Perth, were connected to the GSFC by a network of teletype lines plus a SCAMA voice facility. The Muchea station has since been replaced by a tracking station at Carnarvon. A NASA switching centre for these teletype and voice lines was established in the A.P.O. trunk exchange engineering building at Adelaide. This switching centre has since been replaced by a new centre at Deakin (Canberra)

As has been stated in the earlier notes on the NASCOM world network, the period between 1962-63 and the end of 1969 saw significant development due to the use of communications processors and voice/data facilities. The pattern already evident in 1963 of three discrete networks for (a) satellite tracking, (b) deep space probes, and (c) manned space flight was expanded and consolidated. Another factor which had a bearing on the development of NASCOM was the NASA decision to centralise mission control in the U.S.A. This called for reliable transmission of information in real time from all sectors. The availability of INTELSTAT communications satellites afforded support to the terrestrial networks.

In addition to these developments to the general NASCOM network, the Australian sector experienced several changes due to the extension of the Australian Post Office broadband network. This usually required re-equalisation of voice/data lines. The replacement of older 50 baud voice frequency carrier telegraph systems with systems having more efficient channel filters was effected. With the same channel spacing these new systems could accommodate 75 baud channels. A complication arose, however, due to the adoption by Australia of equipment having the C.C.I.T.T. standard transmission rate of 75 baud for 100 word per minute teletype lines. The 28A teletype machines in use in the NASCOM network operate at 74.23 baud (the US standard teletype transmission rate) and translation to the C.C.I.T.T. standard was necestary in Australia to facilitate fault location and clearance using standard 75 baud testing equipment.

The NASA installations in Australia served by the NASCOM network up to and including the Apollo (Honeysuckle Creek) tracking station, represent a capital investment of $64m. (A), composed of $52m (A) for equipment and $12m (A) for buildings, communications and roads. The cost of operating the Australian installations is approximately $13.5m (A) per annum.

NASA Installations in Australia.

Red Lake: Australia's involvement in the space programme began in 1957-58—the International Geophysical Year—with the tracking of the early earth orbital satellites from the Red Lake station. Red Lake was at this stage a missile tracking station and part of the Department of Supply (A) Woomera missile testing range which had been established some ten years earlier.

NASA, from its inception in 1958, was aware of the potential advantages of Woomera for visual and radio tracking of satellites and deep space probes, and installed Minitrack equipment and Baker and Nunn tracking cameras in this area. Communications were supplied by open wire carrier equipment (Ref. 1).

Island Lagoon: The installation of a deep space tracking station at Island Lagoon some 14 miles south of Woomera was commenced in 1958. This station was completed in 1960 and some Red Lake satellite-tracking equipment was transferred to the new site. Island Lagoon was the first Australian tracking station to be equipped with an 85 ft. diameter steerable parabolic antenna. With the establishment in May 1958 of the Goddard Space Flight Centre near Greenbelt, Maryland, U.S.A., the need arose for a consolidated global network of communications. Initially the network consisted of 50 baud telegraph lines plus the SCAMA speech facility. In Australia, leased telephone and telegraph lines provided communications to the Woomera installations. (Ref. 1.)

Muchea: Communications requirements in Australia remained virtually unchanged until a new tracking station was established in 1962 at Muchea (north of Perth) and further equipment installations effected at Red Lake to provide communications support for the initial (Mercury) manned space flights of 1962-63. Communications provided for these stations, plus the provision of a NASA switching centre in the A.P.O. Engineering Building at Adelaide to co-ordinate communications requirements are fully described in other papers (Ref. 1).

Darwin: In preparation for the EGO (Eccentric Orbiting Geophysical Observatory) project of 1964 (et seq.), a new Australian tracking station was completed in November 1963 at Darwin. Communications support for this station was relatively modest, consisting of telephone and teletypé access to Darwin exchange, and the part time provision for a period of 4 to 6 weeks in every eight or nine months of a teletype facility (non-real time) between the Darwin station and the Adelaide switching centre. No backup communications were requested. The Darwin station operated on this basis until 1968, but is unlikely to be required in the future.

Carnarvon: A station complex to participate in the satellite programmes and to replace Muchea in future manned space flight programmes has been built over a period of several years at Brown Range, about 4 miles east of Carnarvon. Equipment was transferred to Carnarvon from Muchea and Red Lake following the completion in 1963 of the Mercury project, and the new tracking station was officially opened in June, 1964. Communications support was provided by the transfer and extension of two teletype and the voice SCAMA lines from Muchea to Carnarvon. Transfer of these facilities was completed by Feb. 1964. The Australian order-wire network (4-wire voice), which linked Muchea and Red Lake to the Adelaide switching centre for project Mercury (Ref. 1), was disconnected from these centres and extended to Carnarvon and Island Lagoon.

A new 4-wire voice circuit was provided in Feb. 1964 for call-up between Carnarvon, Adelaide, Melbourne and Sydney, with extension to the U.S.A. via the COMPAC cable. (Between March and August 1965 the deep space station at Tidbinbilla had access to this 4-wire circuit at Adelaide.) An additional (third) teletype circuit was also provided between Carnarvon and Adelaide.

Of particular significance was the introduction late in 1964 of high speed alternate voice/data operation between Carnarvon and the Adelaide switching centre. Similar facilities were also provided between the Adelaide switching centre and Woomera, Canberra and the O.T.C.(A) International Gateway Exchange at Paddington, Sydney, to the U.S.A. via the COMPAC cable. These circuits were not equalised initially. Alternate path communications were provided in the overseas link by HF radio to Honolulu plus submarine cable to mainland U.S.A.

Within Australia, normal communications were provided by broadband bearers between Sydney and Melbourne and originally an open wire carrier route Melbourne to Adelaide. This section now uses a broadband bearer also. An alternative route between Sydney and Adelaide was provided by the open wire route via Deniliquin and Nuriootpa.

Between Adelaide and Perth normal communications were provided by the Interstate open wire pole route along the transcontinental railway.

Limited alternative communications were available in this section consisting of a HF radio system between Perth and Melbourne.

Beyond Perth, facilities to Carnarvon consisted of an open wire route through Mullewa and Gascoyne Junction. This section also now uses a broadband bearer.

After consideration of several engineering methods of providing alternative communications to Carnarvon, NASA sought A.P.O. permission to install a recovered REL Series 2300 single span tropospheric scatter system operating at 755/985 MHz between the Carnarvon tracking station and the A.P.O. network at Geraldton. This system, which was originally installed as part of a 5-span (1300 miles) D.E.W. (Direct Early Warning) Line complex in the Aleutian Islands in 1959, was not fully operational over the long unrepeatered distance between Geraldton and Carnarvon and afforded only four or five telephone circuits. It did, however, provide valuable backup to the AP.O. pole route facilities.

A.P.O. staff installed the Geraldton terminal and gave assistance with the Carnarvon terminal installation to have the system operative for the first two-man orbital mission (Gemini III) launching of March 23, 1965.

Fig. 4 shows the tropospheric scatter terminal installation at Carnarvon.

The Australian domestic sector has undergone further changes since the initial facilities were provided to Carnarvon. Late in 1969 alternate broadband routes were available between Sydney and Melbourne, diverse broadband and open wire routes between Melbourne and Adelaide (plus the direct open wire route Sydney-Adelaide already referred to), and a broadband route with open wire backup between Perth and Carnarvon. An Adelaide-Perth broadband route is due for completion in mid 1970 with the transcontinental open wire route as backup. In addition an O.T.C. (A) Earth Station had been built at Carnarvon adjacent to the tracking station complex and direct circuits to the U.S.A. via an INTELSTAT satellite are now available providing support to the terrestrial network.

Tidbinbilla: The first NASA installation in the Canberra area was the Tidbinbilla Deep Space Station (DSS No. 42), located approximately 20 miles south of Canberra. The station, which was completed in March 1965, was initially connected to the Adelaide NASA switching centre. A Tidbinbilla-Mt. Stromlo cable was provided at cost to NASA and connected through to Canberra via the Deakin telephone exchange on cable pairs leased from the A.P.O. An alternate route to Tidbinbilla was provided in 1968 by the provision of a NASA-

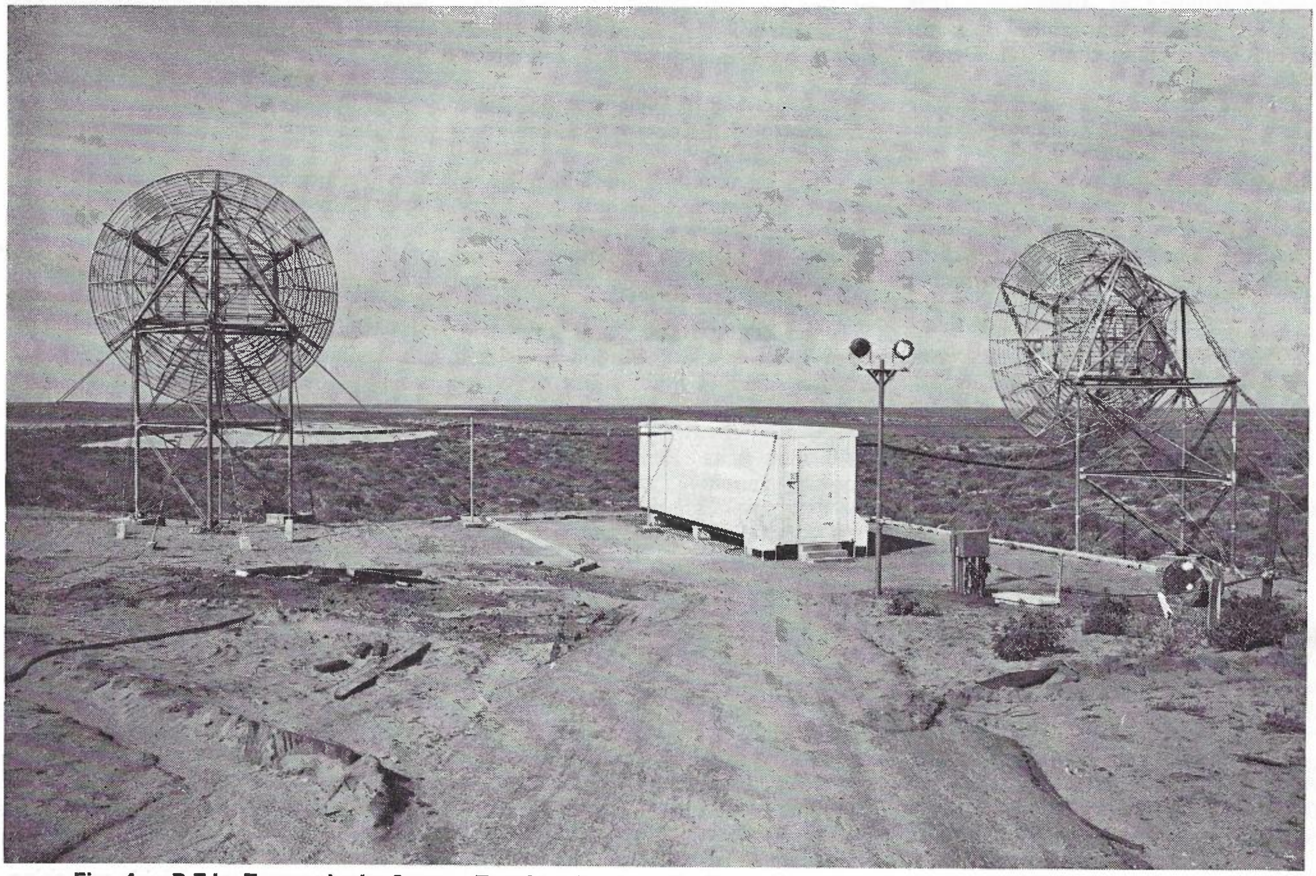

Fig. 4 — R.E.L. Tropospheric Scatter Terminal Looking South to Geraldton from Carnarvon Tracking Station.

owned microwave radio system to a new Apollo station at Honeysuckle Creek and thence to Canberra (Deakin) via an alternate cable route. This alternate route was provided mainly to support the Apollo station, but served the dual role of supporting also Tidbinbilla. Late in 1969 NASA were giving consideration to transferring deep space tracking facilities from D.S.S. No. 41 Island Lagoon to Tidbinbilla.

NASCOM Switching Centre, Canberra (Deakin): The completion in August 1965 of a NASCOM switching centre in the Deakin Telephone Exchange (some miles from the centre of Canberra) to switch all NASA communications to and from the Australian sector was a significant step in consolidating NASA communications in Australia. Voice/data circuits equalised to the C.C.I.T.T. Specification M89 were provided between Deakin and all NASA tracking stations in Australia and APO/OTC (A) interface terminals such as Paddington, and via Perth and Sydney O.T.C. HF radio terminals to NASA tracking ships. Data regeneration was provided on all voice/data lines from NASA stations through Deakin to the U.S.A. This regeneration was provided by back-to-back data modems and afforded flexibility in the Australian sector in addition to relaxing the equalisation objective to the full M89 specification between Deakin and the dependent NASA installations in Australia.

Central to the operation of the Deakin switching centre are the UNIVAC 418 Communications Processor installations. Two of these processors were provided to work via high-speed voice/data facilities with similar UNIVAC 490 Communications Processors installed at Goddard, and for manned space flight missions through Goddard to two UNIVAC 490 Communications Processors installed at the Houston Manned Space Flight Centre in Texas. The Australian Sector teletype network operates between the Canberra processors and the dependent NASA installations (see Fig. 3).

NASA approached the A.P.O. and O.T.C. (A) in 1969 regarding the feasibility and cost of data links between Deakin and Goddard having a group bandwidth of 48 kHz and a bit rate of either 40.8 kb/s or 48 kb/s, depending on the type of data modem employed.

Whilst the Canberra (Deakin) Switcher has virtually taken over all the switching and control duties exercised earlier by the Adelaide switching centre, full maintenance advantage has been taken of the flexibility arising from the availability of three groups of A.P.O. circuits between Adelaide and Canberra, that is (a) a direct group via Wagga, (b) a route via Melbourne and (c) a route via Sydney, avoiding Melbourne. In addition, some patching flexibility is available due to the sectional equalisation at Perth and Adelaide. The establishment of additional tracking installations in the Canberra area increased the economic justification for locating the NASCOM switching centre for the Australian sector close by. Diverse broadband (microwave radio and coaxial cable) routes are available between Canberra and the O.T.C. (A) gateway exchange at Paddington, Sydney. Beyond Paddington overseas carriers provide extension of the NASCOM circuits to the U.S.A. Communications for OTC (A) between Paddington and their installations at OTC Cairns (SEACOM cable terminal) and the OTC Moree Earth Station in northern N.S.W. are provided by the A.P.O.

Orroral Valley: A STADAN (Satellite Tracking and Data Acquisition Network) station was completed at a site in the Orroral Valley, some 40 miles south of Canberra, in July, 1965. The Orroral station was officially opened in February 1966 and uses an 85 ft. diameter parabolic steerable antenna similar to those already installed at Island Lagoon and Tidbinbilla. Whilst this type of antenna had previously been employed for deep space probes due to its high sensitivity and extremely low noise performance, the Orroral installation was directed towards the alternative use of the wide bandwidth available at normal signal-to-noise conditions. This need arose from the much higher rate of data acquisition necessary with the multi-experiment satellites such as Orbiting Geophysical Observatory—the second in this series being equipped for 20 separate experiments.

Regarding communications support for the Orroral station, it was shown to be more economical to extend the A.P.O. Canberra-Tharwa public communications route from Tharwa along the Gudgenby River Valley to Naas and thence into the Orroral Valley to the STADAN site. A part aerial, part underground cable was provided for NASA between Tharwa and Orroral with certain pairs suitable for 12 circuit cable carrier systems. Z12N systems were employed between Canberra and Orroral in addition to voice frequency circuits. Due to the lower security requirement, communications facilities to the Orroral Valley were not duplicated as is the case with manned space flight tracking installations.

Cooby Creek: In connection with the Applications Technology Satellite programme a satellite tracking station was installed in September, 1966, at Cooby Creek, some 19 miles north of Toowoomba, Queensland. The Cooby Creek station was similar and complementary in space role to the STADAN installation at Orroral Valley.

Communications support to Cooby Creek was provided by cable between Toowoomba and Cooby Creek, and from Toowoomba to Brisbane, Sydney and Canberra, by circuits derived from the A.P.O. national broadband network. As with the Orroral installation, alternative communications were not required. The Cooby Creek tracking station ceased duty early in 1969 and is currently employed by the A.P.O. in experiments directed towards the provision of Australian domestic communications services to outback centres by synchronous satellite.

Honeysuckle Creek (Apollo): In March 1967 the most recent of the NASA tracking stations in Australia, the Apollo Manned Space Flight Station, was completed at Honeysuckle Creek (35 miles south of Canberra) in an adjacent valley to the Orroral STADAN station. The Honeysuckle Creek station was involved in the Apollo programme, including the Apollo 11 and 12 missions of 1969. The high security requirement of the Apollo manned space flight missions arises from the long periods (some eight hours) during which each of the three Apollo stations around the earth—Goldstone, California (U.S.A.), Robeldo, Madrid (Spain), and Honeysuckle Creek, has sole access to the lunar expeditionary modules. For this reason each Apollo station was through connected to the adjacent deep space station. As already mentioned, the Apollo station and the DSS 42 at Tidbinbilla have been through connected by a NASA owned microwave radio link, so Tidbinbilla can support an Apollo mission if the Honeysuckle Creek station equipment fails.

In addition, the Apollo to Tidbinbilla radio link provides backup communications against the failure of the cable circuits provided from Canberra via Tharwa.

During Apollo 11 and Apollo 12 a video transmission from the lunar module was relayed from Honeysuckle Creek through an A.P.O. radio relay site at Williamsdale to Red Hill (Canberra radio terminal) and thence to the U.S.A. via the OTC (A) Moree earth station. Television stations in eastern States and South Australia received a video programme split from Sydney. In Western Australia the video programme was picked up by the Carnarvon earth station and relayed to Perth via the newly-completed coaxial cable. For a period after the lunar vehicle landed on the moon's surface and before a higher gain antenna could be established at Honeysuckle Creek, there was a foreseeable need for a higher gain earth antenna than the 85 ft. diameter parabolic dish available to pick up the relatively weak signal from the L.E.M. By arrangement with the CSIRO (A) the 210 ft. diameter radio telescope at Parkes, in central N.S.W., was made available to cover this phase. The television signal, together with bio-medical and other telemetry information from the LEM, was relayed from the Parkes CSIRO radiotelescope to Parkes and thence via the A.P.O. broadband network to a NASA Video Switching Centre in Sydney. The remaining telemetry information was relayed to the NASCOM switching centre at Canberra.

The A.P.O. could never foresee this demand, but the high quality of its construction and maintenance allowed it to provide these facilities at short notice and low cost. The overall quality of the television shots from the moon depended critically on A.P.O. facilities to a small town fairly remote from the populated region along the east coast.

As an adjunct to the Apollo programme, an Apollo Range Instrumented Aircraft (A.R.I.A.) was based either on Townsville or Pearce RAAF bases. During missions this aircraft operates directly into the O.T.C. (A) overseas HF radio terminals at Sydney. During nonmission periods checks of the airborne equipment may be made via A.P.O. leased land lines to the Canberra NASCOM switching centre.

Voice/Data Facilities.

Design Objectives: The data channel specification adopted by the National Aeronautics and Space Administration in 1964 was the Bell System Schedule 4B data design objective. This specification (with additional elaboration to include 'normal' telephone circuits in addition to 'special' quality circuits having transmission characteristics falling within defined limits) was adopted by the C.C.I.T.T. in plenary session at the Geneva 1964 meeting. It was formally issued as C.C.I.T.T. Recommendation M89, and with certain additions regarding frequency translation, phase stability and non-linear (harmonic) distortion became the NASA voice/data circuit design objective. A later design objective, C.C.I.T.T. Recommendation M102 was adopted by the C.C.I.T.T. meeting in Mar Del Plata 1968 for design objectives for data channels and has now superseded Recommendation M89. However, the M89 Recommendation was employed in the development of the NASCOM network and a 1966 NASA request for 'special quality' circuits was based on this objective as follows:—

"The prime technical objective is high end-to-end data circuit performance over various combinations and qualities of communications media that exist in the global environment. To transport economically the required amount of data throughout NASA tracking ranges, a data rate of 2400 b.p.s. per circuit is necessary. A performance goal of one bit error per 100,000 bits (one in 10^5 bit error rate) has been established for the longest combination of circuits that could be assembled, excluding HF radio. With these goals in mind, it became necessary to establish minimum performance limits for quality of voice-bandwidth data channels. The C.C.I.T.T. M89 'Data Channel Specification' has been chosen as the absolute minimum channel performance that would be allowed between data transmission terminals."

Brief comments concerning each of the characteristics specified are given below and in Table 2.

TABLE 2: C.C.I.T.T. M89 DATA CHANNEL SPECIFICATIONS.

Characteristics.	Limit
Envelope delay	500 microseconds from 1000 Hz to 2600 Hz 1500 microseconds from 600 Hz to 2600 Hz 3000 microseconds from 500 Hz to 2800 Hz
Frequency response (net loss variation from 1000 Hz)	—2 dB to +6 dB from 300 Hz to 499 Hz —1 dB to +3 dB from 500 Hz to 2800 Hz —2 dB to +6 dB from 2801 Hz to 3000 Hz
Net loss variation (long term: at 1000 Hz)	plus or minus 4 dB.
Impulse noise	90 counts per ½ hour at a 68 dBrn0 threshold as measured with a WECO 6A test set using voice-band weighting
Circuit noise	54 dBrnc0.

Envelope Delay: The limit, given in microseconds, is the maximum allowable variation in channel propagation in the bands of frequencies specified. No reference frequency is given and it is common practice to use that frequency at which the channel delay is a minimum as the reference point for any particular channel.

Frequency Response: It is important to note that the decibel (dB) values specified represent maximum permissible net loss variations of the channel in the frequency bands shown with respect to the net loss measured at 1000 Hz. Thus a reading of lower level at some frequency other than 1000 Hz is represented by a positive dB value.

Impulse Noise: This measurement as specified must be made with the Western Electric Company 6A impulse noise test set or any test set with identical static and dynamic characteristics. Both positive and negative pulses are counted where peak voltage amplitudes exceed a level of 68 decibels above reference noise level (90 dB below one milliwatt or —90 dBm) as measured at a 0 dBm test level point (TLP) in the circuit. The maximum counting rate of the 6A test set is 10 counts per second, and consequently, many impulses occurring on the circuit may not be counted. For a relative measure of channel impulse noise, however, the technique is valid.

Circuit Noise: The maximum noise allowable under this specification is defined as 54 decibels above reference noise level as measured through a 'C message' weighting network at an 0 dBm TLP. This specification is usually interpreted as the total value of all unwanted signal energy which may appear in the channel. This includes random or background noise —plus any interfering signals such as crosstalk and products of cross modulation or intermodulation.

Design Objectives not covered by C.C.I.T.T. Recommendation M89: In addition to the foregoing characteristics of the C.C.I.T.T. M89 listing, there are at least three channel characteristics which are not specified but which can be a severe problem if they are not controlled. The severity of this problem usually depends on the data modulation technique used and it is difficult to specify a universally applicable minimum performance limit. Implementation of adequate test techniques may also be somewhat difficult. These characteristics with a brief discussion of their nature, suspected cause, and suggested limits are:

Frequency Translation: Frequency translation is manifested on a channel as the output or received signal appearing as a higher or lower frequency than the input or transmitted signal. This occurs in single sideband multiplexing equipment as a result of a difference in frequency between the oscillator used to supply the modulating frequencies and the oscillator used to supply the demodulating frequencies. It is recommended that frequency shift be kept less than 5 Hz, although some data terminal equipments may allow up to a 10-Hz frequency shift without serious performance degradation.

Phase Stability: The condition of phase instability or jitter can be observed on sine wave signals transmitted through most voice channel multiplex equipment. This condition is apparently caused by short-term instability of the oscillators used to derive modulating and demodulating frequencies for multiplexing purposes. It appears that phase instability is more common on long-haul channels that are routed through multiplex equipments which transmit a pilot frequency for synchronising the carrier oscillator at the circuit receiving end. Accumulation of noise apparently causes the synchronising circuits to 'hunt,' which directly causes the phase jitter. Again it is quite difficult to establish a practical limit for this characteristic, but a rate of change of phase of 20 degrees per millisecond or less seems to be acceptable for operation at 2400 b/s. The seriousness of this problem again depends a great deal on the type of data terminal system used.

Nonlinear (Harmonic) Distortion: Non-linear distortion usually appears as limiting (flat-topping or clipping) on signals transmitted through the channel. An acceptable limit for this characteristic is 10 per cent. total harmonic distortion.

The C.C.I.T.T. Recommendation M102 is oriented towards a specification for non-speech telephone bandwidth circuits, including facsimile voice frequency carrier telephone system bearers and voice bandwidth data facilities. In addition, international circuits have been divided into fractions of the objective. For example, M-102 allocates one-third of the objective in both transmitting directions to the domestic carrier up to the outgoing gateway exchange. The remaining two-thirds of the objective is allocated between the sending country's gateway exchange and the receiving terminal equipment in the overseas country.

Typical Equalised Voice-Data Transmission Lines: In applying the M89 specification to the Australian Sector of NASCOM, two distinct stages were encountered. Firstly, about 1964, when the NASCOM switching centre was located in Adelaide, it was optimistically expected that circuits between tracking stations in Australia and Goddard could be equalised and maintained within the limits of the M89 specification. The difficulty was not so much the engineering of through circuits to M89, but one of maintaining them within the dynamic ranges of this specification. This was resolved in 1965 with the second stage — the transfer of the Australian Sector switching centre from Adelaide to Canberra and the provision of back to back data modems at that centre to regenerate the data streams. Thus the data circuits within Australia were now permitted the full allowance of the M89 specification between Australian tracking stations and Canberra against the fractional target objective required earlier.

Beyond Canberra to the O.T.C. International Gateway Exchange at Paddington Sydney, the Australian circuits were required to meet and maintain one-third of the M89 specification. This objective was achieved fairly easily due to the availability of stable broadband facilities between Canberra and Sydney.

In addition to the two stages of line equalisation, occasioned by the transfer of the switching centre from Adelaide to Canberra, subsequent adjustment to the equaliser components was necessary, as the A.P.O. broadband bearer network gradually replaced open-wire carrier systems equipped with less efficient channel filters.

The A.P.O. decision to purchase variable equalisers arose from our

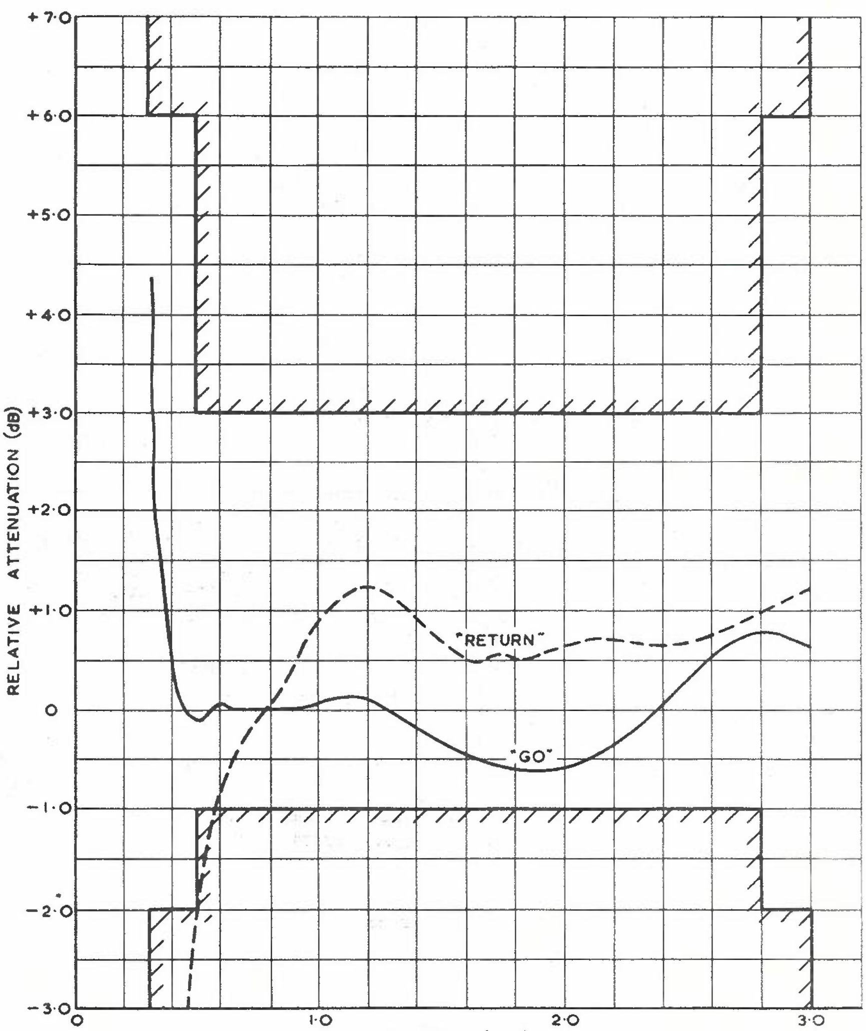

Fig 5 — Carnarvon (Brown Range) to Canberra (Deakin) — Typical Relative Attenuation v Frequency Characteristic of M89 Equalized Voice/Data Lines.

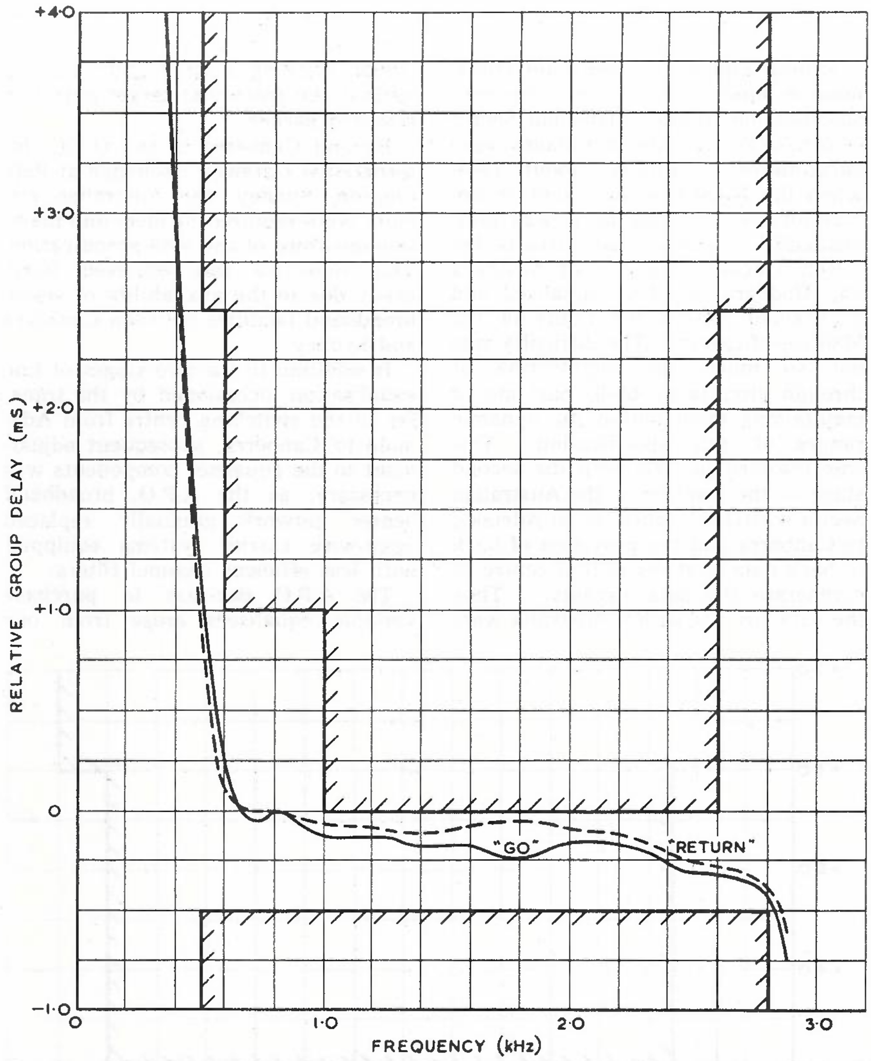

Fig. 6 — Carnarvon (Brown Range) to Canberra (Deakin), Typical Relative Group Delay v Frequency Characteristic of M89 Equalized Voice/Data Lines.

experience with the inflexible static equalisers.

Typical of the voice-data lines within Australia is the group of circuits between the Carnarvon tracking station and Canberra. These consist of three component links, one equalised to one-third of M89 between Carnarvon (Brown Range) and Perth, one to one-third of M89 between Perth and Adelaide, and one to one-third of M89 between Adelaide and Canberra (Deakin).

Figs. 5 and 6 show the transmission characteristics of relative attenuation and relative group delay respectively of typical through equalised circuits between Carnarvon and Canberra.

In these circuits amplitude and delay equalisers are located at Canberra, Adelaide and Perth. Designated patch circuits are also equalised and made available from public traffic in an emergency.

Reliability of Communications.

A very high order of reliability of communications has been achieved in the Australian Sector. Details analysed from the monthly NASCOM reports indicate a circuit-mile reliability of 99.825 per cent. (Standard Deviation 0.08 per cent.) as average for the availability of services in the Australian Sector when required for duty. This high reliability has been achieved by employing diverse operational routes and (in the case of manned space flights) a complete embargo on line work during missions.

CONCLUSION.

The establishment of a world-wide network of communications services employing high-speed voice/data transmission facilities and communications processors has advanced their introduction into the Australian communications environment and has in some measure afforded experience which will be of assistance in expanding the Post Office public communications (Datel) services and the later introduction of a Common User Data Network (C.U.D.N.), which will employ Communications Processors.

ACKNOWLEDGMENTS.

It is desired to acknowledge the help given by the Department of Supply communications staff of (a) Electrical and Communications Section of WRE Adelaide, and (b) Network Support Facility, Canberra, and also A.P.O. Research Laboratory and Long Line Equipment at H.Q. and the State Engineering groups associated with the Planning and Installation of NASCOM facilities in Australia.

Permission to use material from various NASA publications in the preparation of these notes is acknowledged with thanks.

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CO-ORDINATION OF TRENCHING WORKS IN NEW SUBURBS

*M. J. GOOLEY**

INTRODUCTION.

The basic principles and purposes of co-ordination of works involving excavation being undertaken by two or more authorities working concurrently in the one area have been fully examined in recent years. The advantages and disadvantages of laying distribution cables for telephone services in an area while the roads are being made and other service plant installed are particularly appreciated by those who have sought to make such arrangements.

In a rural area just beyond the outskirts of Adelaide, the capital city of South Australia, a housing estate development company proposed to subdivide land and build houses on nearly every allotment in the area and an experienced entrepreneur was to provide a shopping centre. The developer desired to have a telephone service available in each house when it was first ready for occupancy. It was established as a particular aim that no road nor footpath should be disturbed once it was first completed.

The author reviews matters which received attention in ensuring that underground cable provision and telephone instrument installation kept proper pace with the development of the estate.

PRELIMINARY PROPOSAL.

The developer proposed to construct a fully integrated residential estate on about six hundred acres of farm land (see Fig. 1) about one mile from the closest telephone exchange. It was proposed that single residential units be constructed on each allotment with very little, if any, vacant land left in between except for the area required to be reserved for public recreation. The land on all sides of the proposed subdivision was vacant farm land also, but no information was available that any early development should be expected there.

The initial rate of construction was proposed to be two hundred and fifty houses per annum, rising to six hundred per annum. The construction was to be undertaken in lots of fifty to one hundred houses, by subcontractors engaged by the developer. Fig. 2 shows a stage of development where two sections have been completed and the third and fourth sections are being processed. The developer arranged to sell vacant blocks of land in the third section.

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ADVANTAGES TO THE DEVELOPER

In preliminary discussions it was established as a particular aim that no road pavement nor footpath surface should be disturbed once it was laid. While narrow trenches could be tolerated across metalled road bases before the bitumen pavement was laid, the bitumen surface itself was not to be disturbed at all. Concrete driveways were to be provided into all houses. Footpath areas were planted with lawns which, apart from some shrubs and ornamental trees, were contiguous with lawn areas in front of the houses. All underground plant was to be installed before the driveways and lawns were laid. This aim was achieved almost in its entirety and because of this success, made the estate attractive to potential purchasers who would be repelled by disturbance and inconvenience caused by late excavations. The estate will be free of excavations in the streets for many years.

The second advantage was that a complete set of utility services could be offered to all clients. Sewerage, water supply, gas, electricity and telephones were all connected when each new home-owner first took up residence, and this at a time when rapid development was occurring throughout metropolitan Adelaide. The provision of a trunk sewer and connection of each house was an important item which attracted buyers, but the availability of telephone service was also a major influence, particularly in the early stages, in overcoming any feeling of isolation which residents might feel. The presence of a telephone in the house when it was offered for sale was a strong selling point.

A further advantage in installing telephone wiring during the construction of each house, is that the wiring can be readily concealed, whereas, if it is left to individual owners to have a telephone installed some time after they have taken up occupancy, wiring cannot be concealed at all in some designs of house, and only with considerable difficulty in other designs.

DEPARTMENTAL BACKGROUND.

Some applications for telephone service in the metropolitan area of Adelaide were, at the time, waiting up to two years before service could be provided because sufficient funds had not been available to the Department to enable the connection of services to match the high rate of development occurring in the State. The number of applicants waiting amounted to a high level of about 2 per cent. of the existing network. It was desired to provide the facilities which the developer required, but at the same time to avoid causing adverse affect on the delays already being experienced by applicants elsewhere. It was, therefore, agreed that the developer would pay for the cable distribution work within his area.

There was a small armoured cable, laid direct in the ground, passing the area. While this cable enabled the initial telephone requirements for site works offices to be provided immediately, a system of main conduits and a large-size cable had to be provided from the telephone exchange to the subdivision. These main conduits and the cable were installed at departmental expense. The telephone exchange was a small one with a new and large one planned to replace it on a larger site several hundred yards away. While this new building and equipment installation could be expedited, the development might outstrip the remaining equipment available in the old exchange before it could be completed. The developer was informed of the plans and advised that immediate telephone service could not be guaranteed if it should transpire that the estate developed more rapidly than could reasonably be anticipated.

DESIGN OF PLANT.

The overall progress was reviewed periodically at managerial level. At a suitable time, the developer provided a subdivisional plan to scale of two chains to one inch of the first section to be developed. For the purpose of designing the cable reticulation, the section was split into four cable distribution areas of 70 to 80 allotments. One area was served direct from a cable terminal cabinet to which the main cable from the exchange was connected, the remaining three areas being served by cable terminal pillars (see Fig. 3) via the cabinet. This design was repeated in further sections as required by the development. Plastic insulated and sheathed distribution cables were installed, providing 1.25 cable pairs per allotment, pairs in excess of one per allotment being provided for additional facilities which might be required later. Island Terminal Pole (I.T.P.) distribution from the street to the house was used, it being the developer's opinion that the extra expense of a fully underground

Fig. 1 — The Undeveloped Land Area.

Fig. 2 — An Intermediate Stage in the Development.

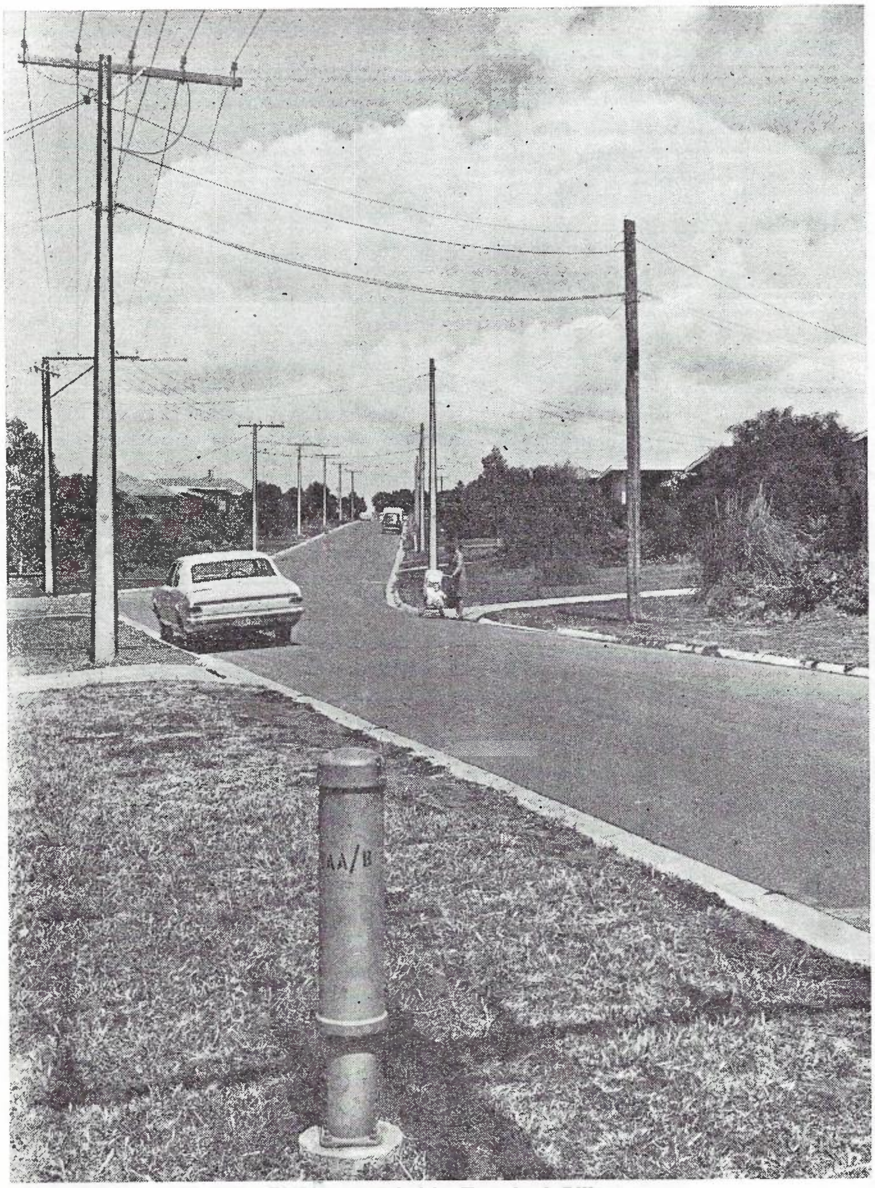

Fig. 3 — A Cable Terminal Pillar.

system (about $30 per allotment) was not warranted because the electricity mains and consumers leads were to be overhead.

The cost of connection from the I.T.P. to the house and installation of the telephone instrument is covered by a standard installation fee. This fee, together with the usual six months' rental in advance, was paid by the developer on behalf of each of his clients. A bulk advance of these fees was replenished by the developer as, and when, necessary. The agreement for the telephone service was completed by each client at the developer's office on P.M.G. stationery.

CABLE INSTALLATION.

When a preliminary financial arrangement for cabling reticulation had been completed with the developer, plans of the proposed cable work estimates were posted to the line foreman for the particular district. A copy of plans of proposed cable work is always sent to the local District Council with formal advice of intention to excavate in the streets. In this development, the simple act of also providing the developer with a copy of the plan was of considerable benefit to all those who worked in the project. The cable plan was displayed at the developer's site office and was frequently examined by sub-contractors. A close liaison with the developer's field supervisor resulted in satisfactory timing of cable installation work throughout the whole project. Main pipes for sewers, for water and for gas, were laid along the streets after the alignments had been surveyed and pegged. Conduits for telephone cables were then laid across the streets, while branch pipes for sewer, water and gas were being installed to each allotment. The road was then cut, formed and metalled and the footpaths graded approximately to finish level. By laying the telephone cables in the footpaths after all other pipes had been laid, damage to cables was completely avoided. One instance of damage to a shallow copper water pipe occurred while laying cables. This damage arose from a recent innovation in water pipe-laying — a branching "Y" feed from the main to two houses — and the surface line of trenching had become obscured. One of the advantages of close coordination of trenching work was that the line of trenching usually remained visible for sufficiently long to render electronic location of shallow pipes in the ground unnecessary.

When the construction of a group of houses had been completed and all the pipes for the houses had been laid, a sub-contractor laid concrete water tables and kerbing in the street and paved the roads with bitumen. Front garden and footpath areas were then topped with loam and seeded with grasses. Shrubs and trees were planted. Because of the careful attention to work sequences, no instances of pavement breaking have occurred in the sections now completed.

CONNECTION OF TELEPHONE SERVICE

While completing the house purchase contract with the client, the developer arranged for a date of occupancy of the house. When there was insufficient time for written advice, verbal arrangements for the installation of the telephone instrument were made. Many instances of this practice were accurately handled during the peak period of the development.

It was arranged that cable pairs be allocated from each pillar and/or cabinet to all of the houses in the distribution area during the preparation of the cable reticulation design. All necessary cross-connection jumper wires were run in advance in each pillar and cabinet by the cable jointer and not left to be run individually by the telephone installer. Copies of the cross connection sheets were also available to the installer, the exchange technician, cable recorder and the sales officer preparing telephone orders.

It is desirable that all wiring inside houses should be concealed. In the case of flat-roofed houses, wiring for the telephone service must be installed after the roof timbers have been fixed, but before the roof cladding has been installed. The timing is not so critical for a pitched-roof house. This timing of installation of wiring in a flat-roofed house is, of course, the same as that required for the electrical wiring. It was therefore arranged that the electrical sub-contractor would also install conduits and draw wires for the telephone wiring. After the detail had been discussed with the developer, a specification for house wiring was prepared and printed. Copies of this specification were given to the developer, who distributed them to the various electrical sub-contractors employed from time to time. The telephone installers also had copies of the specification, some of their work being described in it for the information of the electrical sub-contractor as well as for their own guidance.

The proposed location of the telephone within each house was specified on the building plan. It was thus practicable to specify, (a) that the cavity wall tie wires be omitted in a vertical line above the telephone point to facilitate telephone wiring; (b) that one brick be omitted from the inner leaf of the wall at skirting level to form a hand hole; and (c) that the carpenter bore a hole in the skirting board for telephone wiring and, before fixing the board, pull the telephone wire through the hole.

Because the estate had some houses at each of several stages of progress in close proximity to one another, it was economical for the installer to attend at the one house on more than the one occasion if some advantages arose from so doing. In many instances, the drop wire was run through without any joint or terminal point, reducing the fault liability of this item of plant, but it required two visits to obtain this continuity of run.

The close liaison between the site supervisor and the telephone installer made it easy for the latter to receive advice of any last-minute changes of occupancy dates and thereby to always attend on the day on which the new owner moved into his house. On this day, the telephone service was tested through to the exchange and subscriber satisfaction was enhanced by affording an opportunity of an immediate free change of instrument for one of a different colour, if the subscriber desired it. About 5 per cent. of instruments was changed in this manner.

CONCLUSION.

The aim of the developer that all underground plant should be installed early and no road pavements broken was fully achieved. The material success of the exercise was further emphasised by the economic advantages which occurred to the various parties to the arrangement. The completed costs of each of the sections of the work were consistently less than respective estimates which were prepared from average work rates. The early problems of suitably phasing the work of various authorities with such divergent interests were readily overcome in co-operation. This co-operation was in evidence to such an extent that it seems practicable in this State to arrange successful trials of schemes where the plant of more than one authority is placed in one trench.

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TECHNICAL NEWS ITEM

AUSTRALIAN POST OFFICE INVOLVEMENT IN THE APOLLO 13 EMERGENCY

As a result of experience with the earlier missions in the Apollo programme the arrangements used during the earlier stages of the Apollo 13 flight to interconnect the various N.A.S.A. installations in Australia by A.P.O. network circuits were well proven and could be set up and operated in what had come to be regarded as standard arrangements for Apollo missions.

However, the emergency situation which resulted from the explosion in the service module of the spacecraft led to requests being made to the Post Office by the N.A.S.A. authorities and by the U.S. Embassy for special facilities and actions which were successfully fulfilled in spite of the limited time available and the amount of office and field work involved.

The first request was made shortly after the explosion when it became necessary for the astronauts to close down communications from the command module and to work instead from the low power radio equipment in the lunar module. To maintain satisfactory communication and telemetry operations between the lunar vehicle and earth while Australian earth stations were in use it was vital that the higher aerial gain and superior receiver facilities at the Parkes radio telescope be pressed into service.

These facilities had been used on earlier missions, but with improvements in facilities in the spacecraft were not required under normal circumstances during the Apollo 13 flight. The temporary interconnections which had been used during earlier flights had therefore been dismantled.

In the emergency situation which developed on Tuesday April 14th the Post Office undertook to re-establish a broadband connection between the Parkes radio telescope and the N.A.S.A. station at Honeysuckle Creek which involved installing a microwave system between the Parkes station and the nearest Departmental microwave station at Coonambra and to also install a microwave system between the N.A.S.A. station at Honeysuckle Creek and the Williamsdale radio relay station. Existing radio bearers between Coonambra and Sydney, Sydney and Canberra, Canberra and Williamsdale also required to be interconnected to complete the circuit from Parkes to Honeysuckle Creek.

Equipment for the connection was found to be available from A.W.A. and teams of Departmental and A.W.A. staff worked overnight to complete and commission the installations by Wednesday morning.

The Department has received the following comment on its work on this project:

"The Director of manned flight support in expressing his thanks for the Australian support of the Apollo 13 mission has singled out those responsible for bringing up the Parkes antenna and associated data systems in record time. He has also stated that this response was so impressive that special mention of it was made to President Nixon during his visit to Goddard Space Flight Centre".

The second issue resulting from the emergency was raised in a Note from the Embassy of the U.S.A. on Thursday 16th April and which was received at Post Office Headquarters late on Thursday morning.

The U.S. Note advised details of the latest recovery plan and requested the co-operation of the Government of Australia in protection of the communication frequencies to be used by the spacecraft in its emergency descent. The Note included the following request:

"Although no radio interference has been experienced on the above frequencies to date, the Apollo 13 emergency situation is such that the United States is asking all countries to co-operate in avoiding any radio operation which might possibly interfere with reception anywhere on earth of the spacecrafts transmissions."

With less than two days available the Department undertook the work of identifying the services which "might possibly interfere", of assessing the level and effect of the interference and of considering the possible consequences of closing down the interfering services.

By late on Thursday three types of radio services emerged as interference sources:

(a) communication and radiolocation type transmissions of the Defence group;
(b) Radiolocation services ("Shoran") used by geophysical survey parties;
(c) trunk line radio systems operated by the Post Office.

The transmissions under control of the Defence Department were immediately regulated by signals from Canberra to all Services and to the Supply Department prohibiting transmissions on all N.A.S.A. operating channels and on potentially interfering channels until after splashdown.

A State by State (including New Guinea) check of the operations of Shoran users was undertaken and the controlling operators and ten field parties using this facility were asked to cease Shoran operations until after the return of the Apollo 13 spacecraft. One operator was located in West Irian which is beyond the range of Australian control but his agreement was nevertheless received to a request to stop transmissions during the emergency.

The greatest area of potential interference arose from the use of frequencies closely adjoining the spacecraft frequencies by the trunk line microwave radio systems of the Post Office and also by microwave radio systems operated by the Post Office and Commercial television companies to relay television programmes from television studios to the associated transmitting stations.

As studies continued it became apparent that many of these systems lay close to the track to be taken by the spacecraft on the last stage of its descent, while others were capable of interfering with reception in the special aircraft which were to be deployed along the recovery track to act as radio relay stations.

As the location of the aircraft and likely track of the spacecraft became known a hard core of about 50 microwave links emerged as the most troublesome.

By changing from "working" to "standby" frequencies some of the interference sources could be eliminated while in some cases the radio system could be closed down without serious effect upon trunk telephone traffic.

In the case of television relays, changes to alternative frequencies required the use of temporary systems in view of the short time available and the difficulty of retuning working equipment for operation on another frequency. As all National and most Commercial television stations proposed staying open all night to transmit the satellite television relay from the recovery area it was imperative that no television relays be dislocated. Two particularly difficult situations arose from this requirement.

The microwave radio systems in use between Sydney and the satellite earth station at Moree in northern N.S.W. and between Victoria and Tasmania via Flinders Island were very serious sources of interference. Both these links were critical in distributing the satellite relay which was to be received at Moree and relayed to all States by the Post Office broadband network.

By closing down the offensive channel on the Moree-Sydney system and operating on the protection bearer, with staff in attendance to remedy any faults that might occur, the satellite transmissions were successfully relayed without risking interference to the spacecrafts transmissions.

In the case of the Victoria-Tasmania radio system, telephone traffic (which was not high in the early hours of Saturday morning) was re-routed via King Island, the offending bearer was closed down and the remaining bearer was used for the television relay to Tasmania.

The cessation of transmission on all of the frequency assignments which were finally listed as potentially dangerous sources of interference to the critical descent and recovery of the spacecraft was completed by late in the evening of Friday April 17 some hours before the onset of the critical phase of the descent and all services were restored to normal during Saturday morning after the astronauts had "splashed down" safely.

THE LIGHT WITH A THOUSAND USES*

Looking back over the decade since the invention of the Laser (Light Amplification by the Stimulated Emission of Radiation) it seems surprising that for the first two or three years of its existence it was dubbed 'a solution in search of a problem'.

Like the Maser (the M is for Microwave—the rest of the acronym is the same), the laser is a device for generating an extremely narrow and powerful beam of electromagnetic waves.

The maser grew out of a need for very powerful microwave beams for communication purposes on earth and for the progress of radar systems both in defence and in space and astronomy research.

But whereas the maser fitted straight into an existing technology and a pre-defined purpose, the laser—producing visible light whose energy over the cross section of its tiny beam could be a million times as powerful as a sunbeam of the same area—was a development that seemed bizarre rather than useful.

Unique Properties

But the ingenuity of men is such that no potentially useful device, however bizarre, goes unused for long.

While physicists worked steadily on the laser to give it greater power or different wavelengths of operation, the physicist-engineers of our age of electronics and automated medicine looked hard at the unique properties of the new invention.

First, it produced electromagnetic waves which—like the waves you tune in to on the radio—were 'coherent'.

This is simply the physicist's word for 'in step', and in this instance it meant that the visible light not only had extreme purity of colour but that, like radio waves, it was an electromagnetic emission to which a receiver could be tuned.

A signal of other frequencies could be imposed on it and detected at the receiving end.

Now, a laser beam is so narrow and spreads so little that, if sent to the moon 240,000 miles away, it is only half a mile or so wide when it gets there.

Ordinary radio waves can be beamed to some extent, but this accuracy of beaming offers advantages of a kind unthought of in ordinary radio.

Value of Secrecy

First, there is the potential value of secrecy: such a beam can be directed at a particular receiver. Second, and perhaps more important, such a beam loses its power much more slowly with distance than other kinds of electromagnetic transmission.

In other words it offers a chance both of communicating over very great distances in space and also of measuring great distances accurately because again the reflected signal retains its energy more successfully than waves of lower frequency.

It is very much to the credit of India's technology, and to the vision of the late Dr. Homi J. Bahbah, that one of the first successful laser communication systems in the world operated between the Atomic Energy Commission headquarters in Bombay and the research centre out at Trombay. The distance—about 15 miles—may seem small, and in fact points to a serious snag in this most promising theoretical possibility.

Fairly Short Range

This is that, on earth, the atmosphere absorbs and scatters the energy of a light beam and even using the light at its most penetrating infrared frequencies (we cannot see infrared light but we feel it as warmth), the possible range for communication on earth is fairly short.

But this is also true of microwave beams (typically a microwave beam has a wavelength of a few centimetres, a radio signal has a wavelength of anything from a few metres to several thousand metres, while a laser beam's wavelength is a few thousandths of a millimetre!) and in that case the problem is not important because the receiver has to be in a direct line of sight.

The fact that the surface of the earth is curved and that high frequency radiation travels in a straight line means that the range is necessarily limited.

Why cannot lasers be used in place of microwaves, so that advantage can be taken of their higher frequency and therefore inherent ability to carry more information? The answer is that mist, rain and even smoke particles interfere with a light beam much more seriously than with a beam of longer wavelength.

A good analogy here is that you can shout through a forest successfully because the diameter of tree trunks is small compared to the wavelength of sound. But you could not shout through a forest of gasometers because the obstructions are of a similar size to the wavelength of sound and therefore absorb and reflect the noise energy. Smoke particles look like gasometers to light waves!

Space Role

So it seems that, as far as communications go, the laser will find its greatest use in space, although in Britain, the United States of America and elsewhere, experiments are being pushed forward with the idea of 'piping' laser light inside tiny glass fibres.

This is rather like sending sound down a tube—the traditional basis of ship's speaking tube communication systems—although on an extremely miniature scale. The light simply reflects off the internal surface of the glass fibre whenever there is a bend and is steered to the fibre's end.

Since glass is cheaper than wire, and since a light beam could carry several thousand simultaneous voice communication channels, there is a potential application of lasers which could revolutionise telephone communications and lead to very much lower costs.

Again the problem lies in developing glassy materials which absorb none of the light.

That has not yet been achieved anywhere, nor is a real solution in sight.

Another Potential Use

Accordingly, you could say that, in the communications field, the laser remains promising rather than useful, but the very fact that it is reflected by smoke particles or water droplets opens up another potential use, one which has already led to the development of very advanced equipment by instrument makers in Britain.

As in radar, or any other pulsed signal system where you can measure the time taken for a reflected pulse to return to the sender, a laser beam can be used for the measurement of range.

Because a laser has such a very short wavelength the measurement can be extremely accurate—as has been shown by the possible engineering applications developed by Britain's National Physical Laboratory at Teddington, 13 miles south of London. But, with much longer ranges in mind, the laser beam is also partially reflected by clouds.

Partial Reflection

The 'partial reflection' is important for it means that, in meteorological use, it is possible to direct a beam upward and get not only a measurement

* This non-theoretical review of a decade of developments in LASER technology written by A. Tucker, Science Correspondent of 'The Guardian' (London) was supplied by the Information Service of the British High Commission.

of the height of the lowest cloud layer, but also still fainter detectable measurements of a whole series of upper cloud layers that are invisible from the ground.

This measurement of the vertical structure of cloud systems is of importance to the forecaster and the technique has the advantage of also showing—by the degree of absorption of light—the density of the invisible cloud layers.

In a world occasionally worried by the potential threat of more sinister clouds, those of chemical or biological droplets being used as weapons, it is comforting to know that this radar technique can spot a spraying aircraft very easily, by day or night.

Further, because of its accuracy, laser rangefinding can be used to detect the tiny movements which precede a slippage in an opencast mine, an earthquake tremor or a geological fault, or the variation in distance of celestial objects like the moon.

Indeed, among the first objects left on the surface of the moon by men will be a laser reflector designed to provide astronomers with the most accurate measurements of the moon's wobbly orbit they have ever had.

Power Density

These uses, like that of employing a laser beam as a guide of straightness when making long tunnels, lean on only some of the laser's properties. But the most striking property of all is that of power density. A laser beam is capable of vaporising any material on earth.

Small boys are prone to play with a magnifying glass in such a way that the focused rays of sunlight burn holes in wood or plastic. The laser beam can be a million times hotter, a property which sounds, and certainly is, dangerous but which can be turned to a number of extremely valuable uses.

In fine engineering and in modern electronics—particularly in the manufacture of the latest tiny microminiaturised components—there is a need for etching, cutting and boring techniques on a scale far too small for conventional tools. Now a laser beam can have a diameter as small as a hundredth of an inch and can easily vaporise hard metals and metals or materials like gold or silicon used extensively in electronics.

It is, therefore, not surprising that for special tasks of etching circuit designs, punching tiny holes or cutting very refined shapes, the laser has already established itself as a technique of major importance. Its power can be controlled very accurately, as can its guidance, and both can be automatically controlled and 'programmed' for use on a production line.

Further, the technique can be used for carrying out welding on a scale much smaller than any known before. But welding and cutting accurately are activities by no means confined to engineering. For reasons that are not yet fully explained the laser beam affects living cells in a curiously clean way. Its damage is very closely confined to its point of impact.

Can Help Surgery

This means that it could become a valuable tool in surgery, offering the medical profession refinements of technique that are available in no other way. Already in Britain, International Research and Development at Newcastle upon Tyne, in the north of England with the backing of the National Research Development Corporation and the electronics firm of Elliot-Automation, have developed very small portable laser surgeon's welding tools which have been used in the treatment of a condition known as 'detached retina'.

The retina is the sensitive curved region at the back of the eye on which the image falls and is processed by the nervous system. Some diseases, or age alone, can lead parts of this very delicate area to separate from supporting tissue so that sight is either damaged or lost.

Re-attachment can be carried out in several ways but it has been found that a tiny burst of laser light—which does no damage to the clear lens of the eye through which it has to pass —forms a tiny and neat weld at the point at which it strikes the retina. The process is so simple and painless that it has immense promise and is already being used experimentally in several hospitals.

Equally there is promise that the laser will be valuable in excising surface tumours, for it creates an incision that is sealed, thus markedly reducing the likelihood of tumorous material entering the bloodstream and being distributed round the body.

Further, since laser light can be 'piped', there is a chance that it might eventually be used through flexible glass-fibre bundles for delicate treatments internally.

So, already, there is a very wide range of uses for this curious device which depends on making light buzz up and down inside a tube with reflecting ends and of such a length that the light's journey-time resonates at the natural molecular frequency of the material through which it is passing.

If that material is continually 'excited' by the addition of energy, the added energy will be given off as light each time the internally reflecting bunch of light waves passes by.

Great Precision Needed

In this way the energy of the 'bunch', whose frequency is that of the material, increases step by step and, if the mirror at one end is momentarily removed, will leave the tube as a burst of laser light.

If one of the end mirrors is only partially reflecting, then a continuous beam of lower energy will be emitted and different materials and tube lengths lead to laser light of different wavelengths. The engineering precision needed to make a laser of high efficiency is very great, but the truth is that if you put mirrors of the right kind on the ends of a neon light tube you would have a laser of sorts.

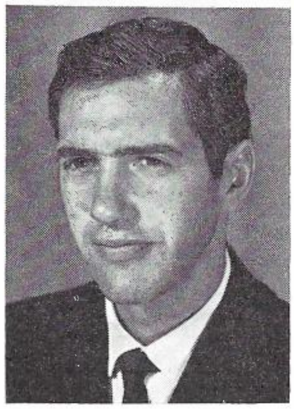
That it took half a century for the tubular gas-discharge lamp to evolve into something far more powerful and yet only a few years for the more powerful development to find a host of uses, is an indication of the strangely erratic development of science and technology.

One thing is certain, lasers are still in their infancy and we are only just beginning to exploit their enormous potential for human good.

OUR CONTRIBUTORS

C. F. BENNETT

A. W. SISSON



N. G. ROSS

C. F. BENNETT, co-author of the article 'Developments in Underground Balanced Pair Telecommunication Cable in Australia Since 1945', carried out plant investigations on non-ferrous metal production with the Electrolytic Refining & Smelting Co. at Port Kembla for about two years from 1939, then joined the telephone cable factory of Metal Manufactures when production of 12-quad carrier cable was introduced. With the formation of Austral Standard Cables in 1948 he worked on the planning of the new company's Maidstone factory. He was then appointed manager of the Covered Wire Division of M.M., but acted also as manager for A.S.C. at Port Kembla for a year when Maidstone went into production, and later co-operated with Aeronautical Research Laboratories in development of the wire dispensing system of the Malkara missile.

In 1965, he transferred to A.S.C. as Technical Manager in Melbourne, with Company responsibility for technical liaison with the Australian Post Office and other customers, for cable design and development and, later, new plant provision. The cable development laboratories are engaged in original work on problems special to Australia and New Zealand and the application of developments initiated by the overseas Associates of A.S.C.

Mr. Bennett has travelled abroad on various occasions, is a graduate of Melbourne University and a Member of the Institution of Engineers, Australia.

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A. W. SISSON, co-author of the article 'Developments in Underground Balanced Pair Telecommunication Cable in Australia Since 1945,' qualified as an Engineer in 1951 after joining the Postmaster-General's Department in Sydney as a Cadet Engineer in 1947. He spent four years in Lines Planning and Metropolitan District Works Division in Sydney before transferring to Country District Works at Narrandera, New South Wales, in 1955. He came to Headquarters in 1960 and started the new Division of Cable Design. During three overseas visits he has investigated developments in communication cables in Europe, North America, and Japan. He has played a major role in the significant changes in design that have occurred in communication cables in Australia over the last decade.

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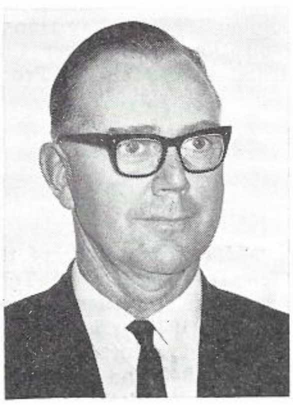

M. J. GOOLEY

N. G. ROSS, author of 'Developments in Post Office Co-ordination with Power Authorities 1966-1969,' joined the Postmaster-General's Department in 1955 as a Cadet Engineer, and completed the B.E.E. course at the University of Melbourne in 1958, obtaining First Class Honours and the Dixson Scholarship. He has obtained experience as a Class 1 Engineer in long line equipment and country exchange installation work in Victoria, and as a Class 2 Engineer in Lines Section, Headquarters and Frankston District Works Division, Victoria. Since 1968, he has occupied the position of Engineer Class 3, Plant Protection and Co-ordination, Lines Section, Headquarters. Mr. Ross previously contributed to the Journal in June, 1963, with the article 'Theory and Design of Gas Pressure Alarm Systems for Telecommunication Cables.'

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M. J. GOOLEY, author of the article, 'Co-ordination of Trenching Works in New Suburbs', joined the Department in 1935 as a Junior Mechanic-in-Training. After training as a Cadet Engineer he was appointed as Engineer, South Australia in 1943. As an Engineer, he has served in both country and Metropolitan District Works Subsections. He is at present an Engineer Class 3 in a District Works Sub-section in Adelaide, where close attention is being given to further development of work simplification techniques as applied to external plant work and telephone installation procedures. Mr. Gooley is also Branch Secretary for the South Australia Branch of the Professional Officers' Association.

K. N. SMITH

K. A. McKENZIE

K. M. RAY

K. A. McKENZIE, author of the article, 'NASCOM World Network — Australian Sector. Part 1 — Development', joined the Postmaster-General's Department as a Technician in 1938 after some years in the radio industry during which he studied Radio Technology at the R.M.I.T. After four years experience in the Victorian Transmission Measurements Laboratory he transferred to the Central Administration Transmission Section and was engaged on pilot testing of broadcast studio equipment. He was engaged as an Acting Engineer, Long Line Equipment Planning in 1945, qualified as an Engineer in 1948, and was advanced as a Group Engineer (Class 2) in 1952 and as Divisional Engineer (Class 3) in 1957. Subsequently, in 1962, he transferred to the then newly formed Headquarters Planning Branch. His interests include negotiations on the engineering planning aspects of telephone, data and television facilities required by overseas instrumentalities such as the National Aeronautics and Space Administration of the U.S.A., the European Launcher Development Organisation, and U.S. scientific and defence agencies. On the local scene he is engaged in the planning aspects of negotiations with mining companies seeking provision of normal Post Office facilities at their mine and port sites, and negotiations on planning matters with other Commonwealth Departments and State Government Departments and Instrumentalities, Mr. McKenzie was elected Chartered Engineer by the Institution of Engineers, Australia in 1956.

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K. M. RAY, author of the article, 'Developments in Transmission Lines and Measurements'. joined the Postmaster-General's Department as cadet engineer, N.S.W., in 1953. He completed the Bachelor of Engineering Degree at the University of N.S.W. in 1956, gaining First Class Honours and winning the Faculty of Engineering University Medal. After one year's full time postgraduate study on network design and further part time post graduate work in communication engineering he graduated in 1960 Master of Engineering Science.

Mr Ray joined the Transmission Planning Section, N.S.W. in 1958, was promoted Engineer Class 2, Bearer Utilisation in 1962 and Engineer Class 3 Transmission Measurements in 1965. In this period he was associated with the Sydney-Melbourne Coaxial Cable installation work. In 1964 he was awarded a Japanese Government Overseas Fellowship for 12 months study at the Electronic Communications Laboratories of the Nippon Telephone and Telegraph Public Corporation on such topics as transmission standards, system design planning, and channel provision programming methods.

In October 1969 Mr Ray transferred to the position of Engineer Class 3, Mechanisation of Planning Processes.

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K. N. SMITH, co-author of the article, 'Telephone Orders by Teleprinter', joined the Postmaster-General's Department in 1948 as a Clerk, Headquarters, was appointed as a Cadet Draftsman in 1949 and qualified as an Engineer, Class 1, Melbourne in 1955. For the last 15 years he has worked in External Plant in various divisions in Melbourne (Metropolitan District Works 14 years, External Planning 1 year) the last 8 years in the position of Engineer, Class 3, Metropolitan District Works. He holds an Associateship Diploma of Mechanical Engineering and an Associateship Diploma of Electrical Engineering, both from the Royal Melbourne Institute of Technology.

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E. KÜGLER, author of the article 'The Siemens Concept for a 12MHz Coaxial Cable System', graduated as a 'Diplom-Ingenieur' (equivalent to 'graduate engineer') at the University of Technology of Berlin in 1956. In the same year, he joined the Siemens & Halske AG and has since been engaged in the Central Communications Laboratories of the Siemens AG in Munich.

He developed equipment units for carrier systems, and, among other things, the TV converter for the 12-MHz system. Since 1966, Mr. Kügler has been the head of a laboratory for 'Line Repeaters' in which the route equipment for the 12-MHz coaxial cable system has been developed and in which today work is being carried out on the 60-MHz coaxial cable system.

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P. BRAGA, co-author of the article, 'Service Assessment of S.T.D. Traffic', joined the Postmaster-General's Department as a Cadet Engineer in

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G. FOOTE

N. A. CAMERON

1956. Upon graduation from Sydney University in 1956 he joined the Long Line and Country Installation Section in New South Wales, as an Engineer, Grade 1. In February, 1959, he was appointed Engineer, Class 2, still in the Long Line and Country Installation Section, from which position he was promoted to Engineer, Class 3, Telephone Exchange Equipment Section, Engineering Works Division, Headquarters, in July 1965.

G. FOOTE co-author of the article, 'Service Assessment of S.T.D. Traffic', served with the British Post Office for a very large portion of his career. In 1951 he was seconded by the Malayan Telecommunications Department where he worked until 1964. He then came to Australia and joined the Department as a temporary officer; shortly afterwards Mr. Foote was acting Technical Officer in the Telephone Exchange Equipment Section, Engineering Works Division, Headquarters.

N. A. CAMERON, co-author of the article, 'Telephone Orders by Teleprinter', joined the Postmaster-General's Department in 1947 as a Technician-in-Training, and became a Cadet Engineer in 1948. He has been engaged on Exchange Installation, Exchange Service, and latterly, on Substation Installation. He completed a Bachelor of Arts degree in 1969 and is a Member of the Institution of Engineers, Australia.

ANSWERS TO EXAMINATION QUESTIONS

Examination No. 6005, 22nd November, 1969, and subsequent dates, to gain part of the qualifications for promotion or transfer as Senior Technician (Telecommunications), Postmaster General's Department.

CONTROL SYSTEMS
PART A

QUESTION 1 (a).

Draw a logic schematic diagram for the function
$F = (A + B.C.)\ D + E$ *using,*
(i) 'And/or' Inverter logic.
(ii) Relay logic.

ANSWER 1 (a).

(i) See Fig. 1.

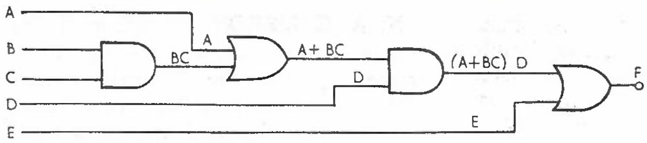


Fig. 1

(ii) See Fig. 2.

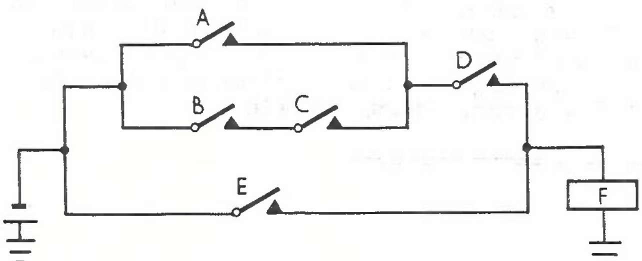


Fig. 2

QUESTION 1 (b).

Using Boolean Algebra, or otherwise, reduce by four the number of contacts shown in Fig. 3.

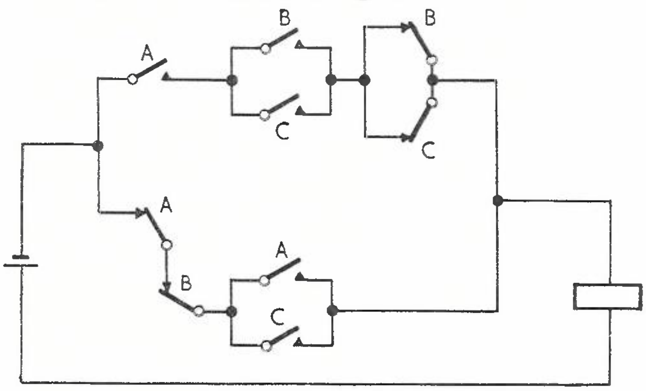


Fig. 3

ANSWER 1 (b):

$$[A.\ (B+C).\ (B'+C')] + [A.'B.'\ (A+C)]$$
$$= [A.\ (B.'C) + (B.C')] + A.'B.'C$$
$$= A.B.C' + A.B.'C + A.'B.'C$$
$$= A.B.C' + B.'C$$

(See Fig. 4)

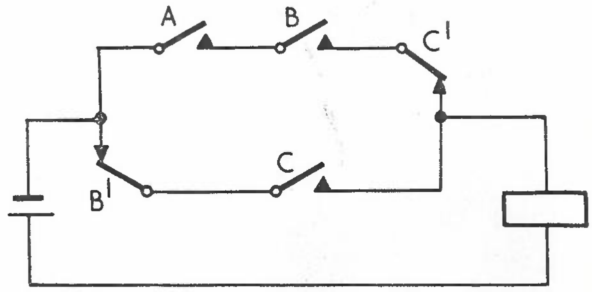


Fig. 4

QUESTION 1 (c):

A, B and C are light beams which are arranged to give a logic '1' at the output whenever an oversize article is detected on the conveyor (Fig. 5).

(*i*) *Describe briefly the operation of the logic circuit when*
(1) *an article within specified limits passes.*
(2) *an oversize article passes.*

(*ii*) *Complete Table 1, which is a truth table for Fig. 5.*

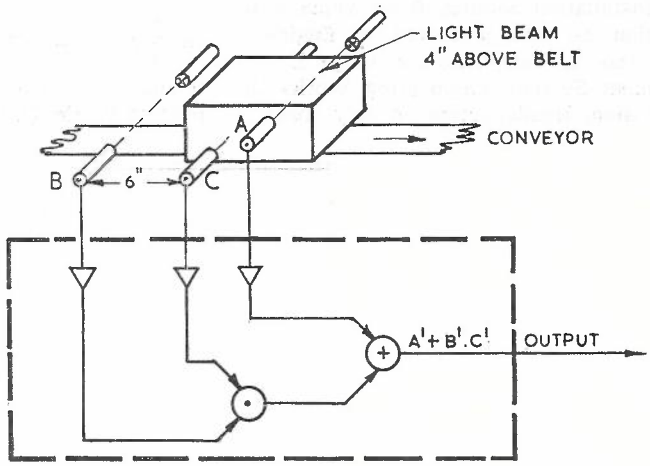


Fig. 5

ANSWER 1 (c):

(i) A B and C are each normally at logic 1 condition and will change to logic 0 when the relevant light beam is broken.

1. An acceptable size article:—
passes beneath light beam A thus leaving a logic 0 at the relevant input to the OR gate.
Sequentially, but not simultaneously, breaks light beams B and C so that the output from the AND gate presents a logic 0 at the other input to the OR gate. As both inputs to the OR gate are logic 0 the output is logic 0.

2. An oversize article, which is too high or too long will result in a logic 1 being applied to one or the other of the OR gate inputs, thus causing a logic 1 at the output.

(ii) See Table 1. Required answers are in **bold.**

TABLE 1

		A	B	C	A′	B′	C′	B′.C′	Output A′ + B′.C′
Acceptable Size Article Passes		1	0	1	0	1	0	0	0
		1	1	0	0	0	1	0	0
Oversize Article Passes	Long	1	0	0	0	1	1	1	1
	High	0	1	0	1	0	1	0	1

QUESTION 1 (d):

What is the operating function for the relay F in Fig. 6 in terms of A, B, C, X, Y and Z?

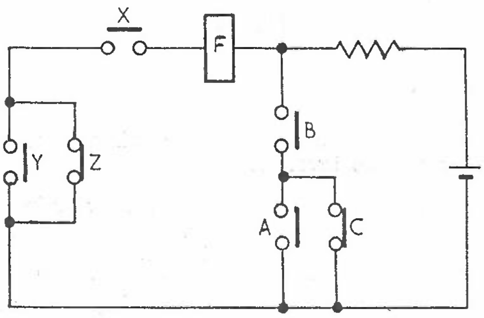


Fig. 6

ANSWER 1 (d):

F = X. (Y + Z′). [B. (A + C′)]′

QUESTION 2 (a):

Draw a block diagram of a feedback binary counter that will count up to 10 using flip-flops.

ANSWER 2 (a):

See Fig. 7.

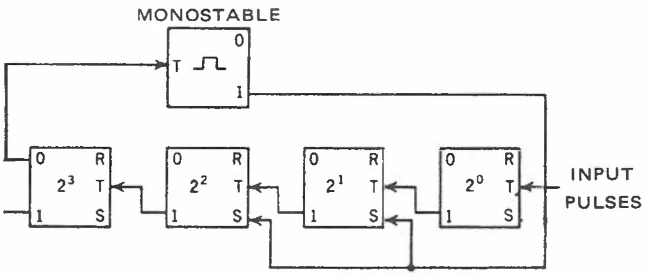


Fig. 7

QUESTION 2 (b):

Explain the operation of the counter with the aid of a truth table.

ANSWER 2 (b):

The count may be gated out from either side of the flip-flops depending on the circuit into which the count is to be fed. Consider that the count is gated out from the 1 side of each flip-flop and that each stage is initially in the reset state.

The counter acts as a simple binary counter up until the 7th input pulse. On the 8th input pulse, the 2^3 stage sets and triggers the monostable multivibrator which provides a logic 1 pulse to set the 2^1 and 2^2 stages. With these two stages set, an extra 6 is registered in the counter. Hence, the counter which would otherwise count to 16, has been modified so that an extra 6 is registered thus making it a decade counter.

Input Pulse	2^0	2^1	2^2	2^3
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	1	1	1*
9	1	1	1	1
10 or 0	0	0	0	0

*Count advances by 6.

QUESTION 2 (c):

Explain the operation of the circuit in Fig. 8 when the 6.6V supply goes:
(i) High.
(ii) Low.

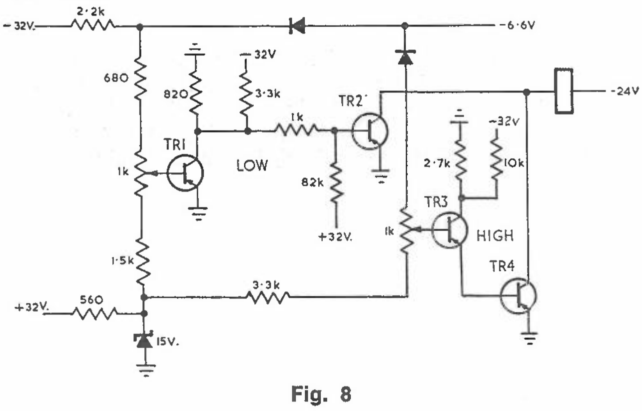


Fig. 8

ANSWER 2 (c):

With the 6.6 volt supply at the correct voltage level, the voltage divider circuit at the input to TR1 is adjusted so that TR1 is just switched on. This will bias TR2 in the OFF condition.

If the 6.6 volt supply decreases, TR1 will switch off, switching TR2 on and operating the alarm relay.
TR1 and TR2 make up the low voltage monitor circuit The input to TR3 is adjusted to just hold TR3 off. If the 6.6 volt supply increases, TR3 will switch on. The emitter follower circuit will cause TR4 to switch on, which will operate the alarm relay.

QUESTION 3 (a):

Draw a logic diagram for the circuit expressed by the logic equations below:

$$L = A.Z' + B.Y' + C.X'$$
$$M = A'Z + B'.Y + C'.X$$
Output $Q = L'M'$

ANSWER 3 (a):

See Fig. 9

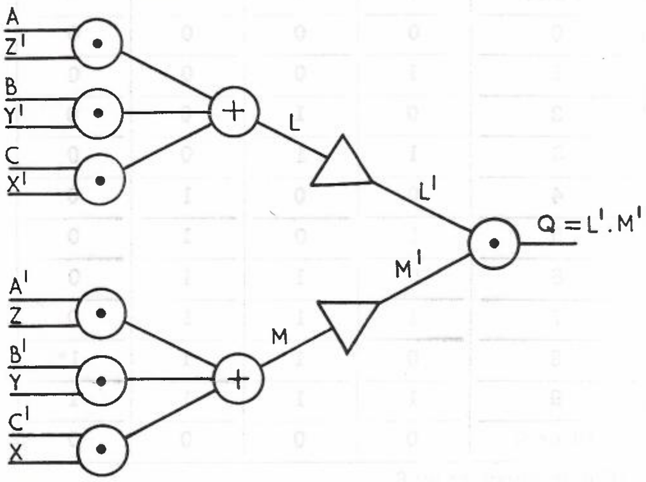


Fig. 9

QUESTION 3 (b):

Briefly explain the operation of the above circuit.

ANSWER 3 (b):

When A = Z AND B = Y AND C = X, one input to each AND gate is logic 0. L and M are both logic 0 so that L' and M' are both logic 1 and Q is logic 1. If A ≠ Z OR B ≠ Y OR C ≠ Z one AND gate output, and therefore L or M is at logic 1. Q is then at logic 0.

QUESTION 3 (c):

Mark the MOST obvious function of this circuit.

ANSWER 3 (c):

Accumulator
Comparator
Inhibitor
Schmitt Trigger
Buffer
Counter
Multiplexer
Shift Register

QUESTION 3 (d):

Describe the operation of the circuit in Fig. 10.

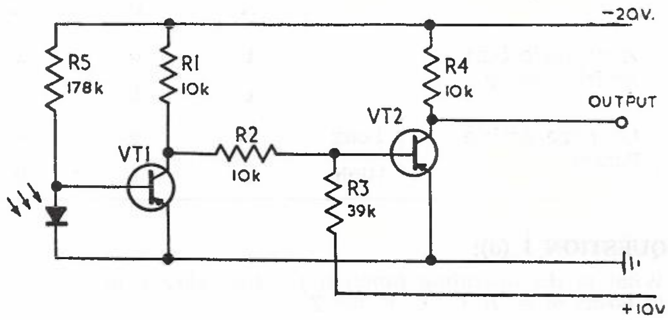


Fig. 10

ANSWER 3 (d):

The circuit comprises a reverse biased photo-voltaic diode, an amplifier and an inverter.

With light input, the diode by photo-voltaic action, drives the base of VT1 slightly positive, thus cutting off VT1 collector current. The voltage division across R1, R2 and R3 is such that the base of VT2 is made slightly negative with respect to emitter, thus causing it to conduct. R1 and R2 limit the base current to an amount just sufficient to saturate VT2, thus causing a logic 0 at the output.

With no light input, current from —20V (via R5) saturates VT1, thus its collector is at ground potential (logic 0). The +10V supply is divided across R2 and R3, thus reverse biasing the base of VT2 (+2V). The collector of VT2 is at logic 1 level.

QUESTION 4 (a):

(i) What is the circuit in Fig. 11 used for?
(ii) Why are two zener diodes used?
(iii) Describe briefly the operation of the circuit.

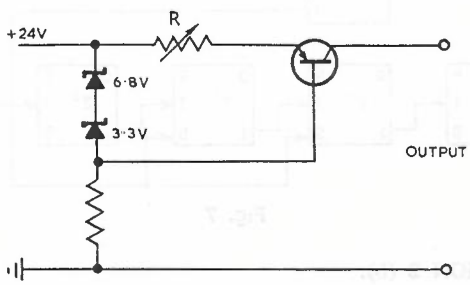


Fig. 11

ANSWER 4 (a):

(i) To provide a source of constant current when there is variability of either load resistance or supply voltage.

(ii) Temperature compensation.
6.8V zener exhibits a positive temperature co-efficient
3.3V zener exhibits a negative temperature co-efficient.

(iii) There will be a 10.1V drop across the zener diodes. This causes the base of the transistor to be negative with respect to its emitter and it will conduct.

Assume that for a given load, R is adjusted so that there is 0.1V bias on the transistor and a 10V drop across R.

If the load resistance decreases, the circuit will try to supply more current. This will increase the voltage drop across R and thus decrease the transistor bias which in effect increases the resistance of the transistor and compensates for the decreased load resistance.

QUESTION 4 (b):

(i) *Why are relay trees sometimes folded?*

(ii) *Identify counts X and Y in the relay trees shown in Fig. 12.*

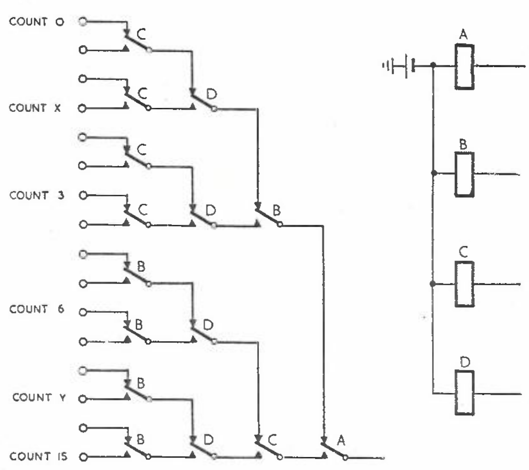


Fig. 12

ANSWER 4 (b):

(i) To distribute the contact load over the relays.

(ii) X = 10
Y = 13
The reason is as follows:
D + B = 3 = 2 + 1
D + A = 6 = 4 + 2
D and 2 are common, therefore
D = 2 A = 4, B = 1
and as A + B + C + D = 15, C = 8
Count X = C + D = 10
Y = A + B + C = 13

QUESTION 5 (a):

Complete Table 2 to show how the binary relay counter in Fig. 13 operates. Use O and R in the table to show whether the relays are operated or released. Assume all relays are released when the first pulse is applied. The A, B and C relays will operate on their 350 ohm windings alone, or when in series with a 350 ohm winding of another relay.

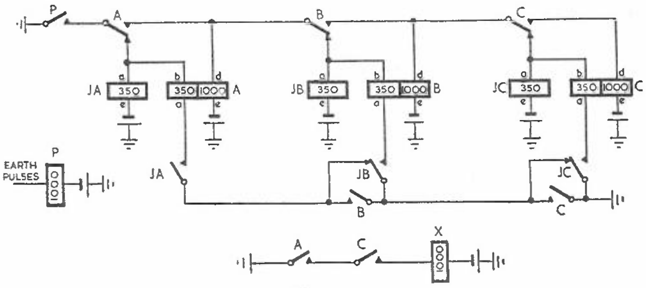


Fig. 13

ANSWER 5 (a):

The required answers are in **bold** type.

TABLE 2

Pulse	P	JA	A	JB	B	JC	C
1	O R	**O** **O**	**R** **O**	**R** **R**	**R** **R**	**R** **R**	**R** **R**
2	O R	**R** **R**	**O** **R**	**O** **O**	**R** **O**	**R** **R**	**R** **R**
3	O R	**O** **O**	**R** **O**	**O** **O**	**O** **O**	**R** **R**	**R** **R**
4	O R	**R** **R**	**O** **R**	**R** **R**	**O** **R**	**O** **O**	**R** **O**
5	O R	**O** **O**	**R** **O**	**R** **R**	**R** **R**	**O** **O**	**O** **O**

QUESTION 5 (b):

How many input pulses are required before the X relay operates?

ANSWER 5 (b):

5

PART B

The questions in this part all refer to the Automatic Letter Handling Plant used in Australian Exchanges.

QUESTION 1 (a):

What is the main function of the routiner and how does it carry out this function?

ANSWER 1 (a):

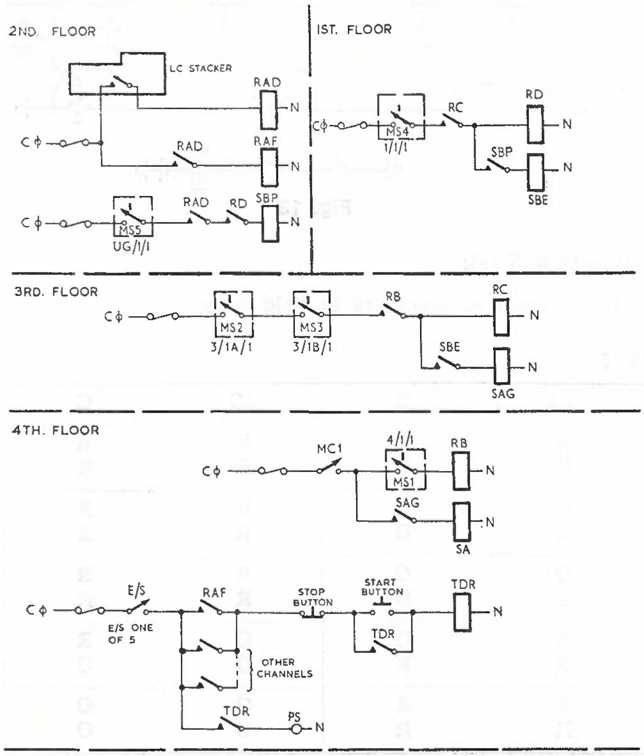
The routiner monitors the outputs of the distribution buffers on the operator's rack. This point being the final stage of buffering, the routiner monitors at this point. A check is made by changing the input of the buffers from 0 to 1 just prior to reading the output. Thus the output is checked for a permanent 0 output.

A special programme appears on the drum for monitoring purposes.

QUESTION 1 (b):

The circuit in Fig. 14 is typical of those used in the letter system for control of motors on a secondary channel terminating at a Large Capacity Stacker.

State the procedure for starting the secondary channel represented by this circuit, and describe the circuit operation. (Scope of answer should be limited to information contained in the circuit.)



Cϕ	= C Phase	MC	= Programme Starter Contact		In 3/1A/1:		
N	= Neutral	E/S	= Emergency Stop		3	= Floor number	
R	= Relay	PS	= Programme Starter		1A	= Chan. No.—Location	
S	= Starter	TDR	= Time Delay Relay		1	= Start Group	
		MS	= Micro Switch on O/L				

Fig. 14

ANSWER 1 (b):

LC stacker started.
RAD operates because LC stacker started.
RAF operates because RAD operated.
TDR operates because Start button pressed, RAF, E/S normal.
PS operates because TDR operated.
RB operates because MC1 operated and overload normal.
RC operates because RB operated and overload normal.
RD operates because RC operated and overload normal.
SBP operates because RAD and RD operated and overload normal. UG floor motors start.
SBE operates because SBP operated, 1st floor motors start.
SAG operates because SBE operated, 3rd floor motors start.
SA operates because SAG operated, 4th floor motors start.
No motors will start unless all overloads and emergency stop buttons are normal and then only if the preceding motor has started.

QUESTION 2 (a):

In relation to the Pitney Bowes facer-canceller:
State in general terms the action of the machine when a stamp is detected in the scan zone on BOTH sides of an envelope (Lead and Trail) as it passes through the 'A' machine.

ANSWER 2 (a):

Both stamps will be cancelled and the letter will be gated into the lead stacker.

QUESTION 2 (b):

If any preference is shown by the machine for either Lead or Trail systems, state what preference is given and how it is achieved.

ANSWER 2 (b):

Preference is given during the gating operation to the Lead system.
Both Lead and Trail gate timers will set.
The Lead gate timer set output gives logic 1 to the And gate of lead gate open solenoid driver and in conjunction with the gate allow pulse, opens the Lead gate. Its reset output applies logic 0 to And gate of Trail gate open solenoid driver, inhibiting the trail gate opening. This logic 0 passes through the And gate 1-20-23, is inverted to logic 1 at inverter output 1-14-17 and applied to the And gate of Trail gate closed solenoid driver, which, in conjunction with the Gate Allow pulse, closes the Trail gate.

QUESTION 2 (c):

Describe a method of setting the sensitivity control of a photomultiplier tube to ensure correct stamp recognition.

ANSWER 2 (c):

Set Fluorescent trigger level to maximum.
Set Phosphorescent trigger level to —2 volts.
Adjust photomultiplier tube sensitivity control until approximately 50% of mail with average stamps are gated correctly.
Reduce Phosphorescent trigger level to —0.6 volts.

Alternative Answer

Inhibit all cancel.
Run machine to reset logic, stop motors.
Place 'Standard Tag' in front of the read head aperture, being careful not to interrupt the edge detector.
Set Fluorescent trigger level to maximum.
Set Phosphorescent trigger level to —0.6 volts.
Connect an AVO 8 meter to test point 2-13-(5) trail or 2-13-(10) lead on 25 volt range. A logic 1 at the associated inverter is —19.5 volts. When the special amplifier fully switches, this value drops to —17 volts.

Adjust the Sensitivity control (high tension) until switching takes place, then reduce it until a 1 (—19.5 volts) is just attained.
Check the high tension voltage.
Remove the Standard Tag and run live mail to check gating.

QUESTION 3

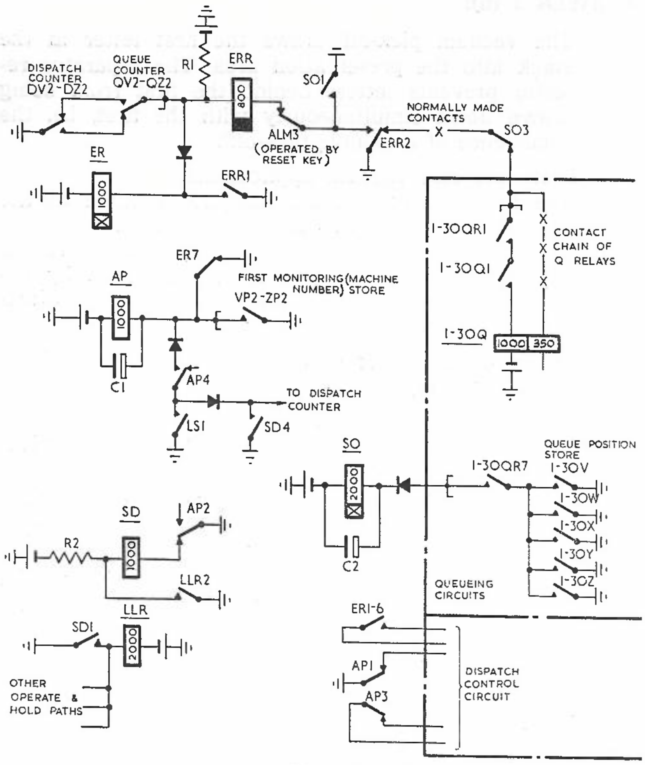


Fig. 15

The circuit in Fig. 15 illustrates the essential features of a section of the stream feed control circuit. The 1-30Q and 1-30QR relays are involved in allocating a queue position to a coder, which calls for mail. The relays V to Z store the queue position allocated. Relay LS operates when the light beam near each dispatch position is broken by a letter stream, and releases (slowly) after the beam is remade at the end of the stream.

QUESTION 3 (a):

(*i*) *State whether relays ER and ERR are operated or released under the usual operating conditions when several positions are calling for mail.*
(*ii*) *Under what circumstances will ER change state? What effect will this have?*

ANSWER 3 (a):

(i) ER is operated and ERR is released.
(ii) ER will release when the Dispatch Counter catches up with the Queue Counter (i.e. QV-QZ and DV-DZ are in the same state) so that no more positions are calling for mail. Dispatch will then be inhibited (by contacts ER1-6).

QUESTION 3 (b):

Explain the need for relay AP. Describe how it is called into operation in certain circumstances and how the circuit operation then differs from its usual mode of operation.

ANSWER 3 (b):

Relay AP is necessary to step the circuit over 'dummy' queue positions. It is normally kept operated as there is information in the VP-ZP store. When the D-counter steps onto a number no longer allocated to any machine (e.g. because the machine has been isolated), none of VP-ZP will be operated. AP will release (ER is still operated as long as some positions are awaiting dispatches) and operate SD, which will operate LLR which in turn releases SD. The D-counter will be stepped by the earth pulse from SD4 instead of the usual way by LS1, but dispatch will not take place because of the inhibits extended by AP1 and AP3.

QUESTION 3 (c):

Under what conditions will relay ERR be brought into action? Explain how this occurs and describe the resultant circuit operation until conditions return to normal.

ANSWER 3 (c):

If the Q-counter gets a full cycle ahead of the D-counter, ERR will be operated. As the last queue position is allocated, SO is operated and is slow to release. In the meantime the Q-counter steps on, assumes the same state as the D-counter and the earth is removed from R1. ERR will operate. ERR1 will keep ER operated to allow dispatch and ERR2 will prevent further queueing as well as hold ERR. On the completion of the dispatch, the D-counter will step on and ERR will be released as the two counters now differ. Another machine is allowed to queue, the process is repeated if necessary.

QUESTION 4 (a):

The following paragraphs describe, in jumbled sequence, the operation of a STACKER FEEDER.
Insert numbers against the operations listed to indicate the correct sequence of operation. Assume that there is no mail in the front stacker at the beginning of the operation.

ANSWER 4 (a):

9 The stack moves forward to the pick-off area. The front stacker arm moves to a vertical position exposing the mail to the vacuum pick-off and operating MS5.

8 The operation of MS4 causes the stack to be driven forward followed by the feed arm. The rear stacker arm moves to a vertical position and the rear of the stack is supported by the feed arm thereafter.

3 A stream of mail is deflected into the rear stacker tray and forces the front stacker arm off-normal, contacting MS1 causing the stacker arm drive chain to cycle, and the forward feed belts to drive.

4 The front and rear stacker arms carry the stack of mail forward until the rear stacker arm contacts MS2 whereupon the stack halts. The forward feed belts stop, also the inching and edging belts.

5 The feed arm chain starts to drive and the feed arm cycles to the rear of the stacker tray.

11 The front and rear stacker arms cycle to the normal position at the rear of the stacker tray. The coder joins the queue for the stream feed dispatch.

10 The operation of MS5 causes the feed arm to stop driving, also the forward feed belts.

6 The feed arm which has been moving rearward contacts MS3, and (if MS2 is operated) falls to a horizontal position behind the rear stacker arm, thereby operating MS4 which causes the forward feed belts to restart, also the edging and inching belts.

12 As mail is picked off the front of the stack, the stack pressure drops. This causes MS5 to operate and the feeder arm drives forward to restore stack pressure. Forward feed belts drive simultaneously with the feeder arm forward movement.

1 Machine reaches head of stream feed dispatch queue and mail is dispatched to it.

7 If MS2 is not operated, the operation of MS4 is delayed until this occurs.

13 When the entire stack has been picked-off MS7 is operated by the feed arm. No further movement takes place if there is no mail in the rear stack. If mail is present in the rear stack, MS1 being off-normal causes the feeder arm to return to MS3 and the cycle of operation is repeated.

2 Entry transfer deflector flap opens on signal from stream feed control circuit, entry transfer belts start up, also beater wheel, edging and inching belts.

QUESTION 4 (b):

List five basic functions of the Stream Feed Control System.

ANSWER 4 (b):

The basic functions are:

Control the mechanical movements of the stacker feeders.

Control the dispatch of letters from up to four dispatch units.

Control the entry transfer diverter flaps for each stacker feeder to ensure they operate at the correct instant to guide the letters into the desired stacker feeder.

Queue the stacker feeders as they empty so that they will be filled in the order in which they become empty.

Queue the dispatch units so that they will be emptied in the order in which they were filled.

QUESTION 4 (c):

Why is it essential to good working practices that cancelling dies be replaced on their spindles before restarting the cancelling machine?

ANSWER 4 (c):

The inertia of the die is required to recock it after a cancellation print has been made. The spindle alone has not sufficient inertia to recock, thus it will run with the spring clutch permanently engaging the drive shaft with a pawl holding the die spindle stationary, causing severe wear on the drive shaft or the spring clutch to break.

QUESTION 5 (a):

Describe how pick-off is achieved in a coding machine by answering the following questions:
(One mark will be deducted for each point that is either omitted or incorrectly answered.)

(i) *State the particular purpose of the Vacuum Pick-off and Separator Rejector.*

(ii) *State the number of vacuum applications and the purposes of each.*

(iii) *State the location of the weakest vacuum port.*

(iv) *State the number of spring-loaded fingers and briefly explain their combined purpose.*

(v) *Briefly explain the 'Slip/Stick' principle.*

(vi) *Name the two materials which cover the curved tips of the spring-loaded fingers and state the 'Slip/Stick' (friction) characteristic of each.*

(vii) *State the number of operating positions of the vacuum pick-off belt.*

(viii) *State the number of holes and slots in the belt at each operating position.*

(ix) *State the purpose of the holes in the vacuum pick-off belt.*

ANSWER 5 (a):

(i) The vacuum pick-off draws the first letter in the stack into the presentation area. The separator rejector prevents letters behind the first from being drawn down simultaneously with the first, i.e. the occurrence of a 'double pick-off'.

(ii) There are two vacuum applications.
The first is stronger, and supplies vacuum to the pick-off belt through slots cut in the belt.
The purpose of the second vacuum is to provide a means of retarding letters behind the first, by applying vacuum to the second letter opposite in direction to the pick-off belt vacuum.

(iii) At the centre finger of the three fingers comprising the vacuum rejector.

(iv) There are three fingers.
Their combined purpose is to prevent 'double pick-offs' whilst allowing forward stack movement.

(v) The second letter in the stack is prevented from moving down by being in contact with neoprene coating on the fingers (stick); letters behind the second are in contact with the PTFE coating on the fingers (slip); hence the forward movement of the stack is not retarded.

(vi) Neoprene — stick.
PTFE — slip.

(vii) Two.

(viii) 3 Holes 2 Slots.

(ix) To permit vacuum from the vacuum box to be applied to the first letter in the stack, thereby causing it to be gripped by the belt, and cycle with it.

QUESTION 5 (b):

What is the purpose of the spring-loaded rollers which are located between the spring-loaded fingers?

ANSWER 5 (b):

The purpose of these idler rollers is to keep the letter under positive control until it enters the presentation area. They hold the letter against the pick-off belt after the letter has passed the influence of the vacuum ports.

QUESTION 6:

Fig. 16 shows the Coder Intermediate Relay Store Circuit.

QUESTION 6 (a):

Two letters have been coded by operator 2 and are progressing through the letter-sorting system; operator 1 is not coding. The first letter received a translation of 27, 06, 30, 27, and has entered the 30 channel conveyor. The second letter received a translation of 14, 29, 09, 14, and is in such a position that its CO code has just been transferred into the second intermediate relay store. Indicate the condition of the relays in Table 3 at this instant by marking the appropriate column for those relays operated.

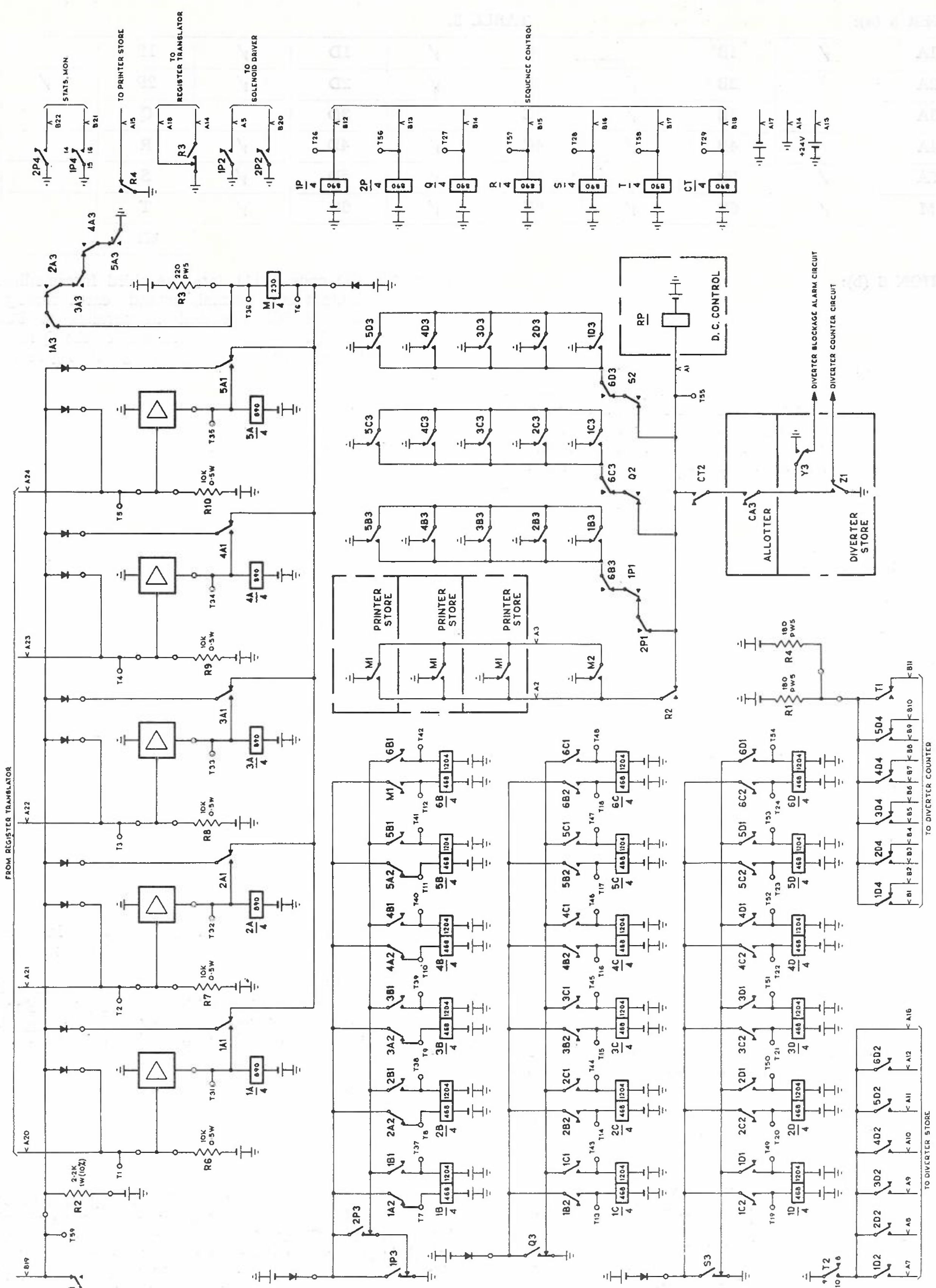

FROM REGISTER TRANSLATOR
STATS. MON
TO PRINTER STORE
TO REGISTER TRANSLATOR
TO SOLENOID DRIVER
SEQUENCE CONTROL
PRINTER STORE
PRINTER STORE
PRINTER STORE
D. C. CONTROL
ALLOTTER
DIVERTER STORE
DIVERTER BLOCKAGE ALARM CIRCUIT
DIVERTER COUNTER CIRCUIT
TO DIVERTER COUNTER
TO DIVERTER STORE

Fig. 16

ANSWER 6 (a):

TABLE 3.

1A	✓	1B		1C	✓	1D	✓	1P	
2A		2B	✓	2C	✓	2D	✓	2P	✓
3A		3B	✓	3C		3D		Q	
4A		4B	✓	4C	✓	4D	✓	R	
5A	✓	5B		5C	✓	5D	✓	S	
M	✓	6B	✓	6C	✓	6D	✓	T	
								CT	

QUESTION 6 (b):

If the 2C relay coil went open circuit, describe when and how this fault would be detected under normal working conditions.

ANSWER 6 (b):

(When the operator presses the reject key, the translation received from the drum will be either 31, 31, 31, 31; or 32, 32, 32, 32, to test the relays in the Print and Intermediate relay stores in their operated and released conditions.)
The first translation of 31, 31, 31, 31 to be received after the 2C relay coil goes open circuit, will set up the alarm. All C relays except 2C will operate when the Q relay transfers the CO code 11111 into the third Intermediate relay store. Contact 2C3 normal, extends earth through 1C3, 3C3, 4C3, and 5C3 operated, in parallel, to 6C3 normal and when Q2 makes on the release of the Q relay to RP relay and negative battery, operating RP to give the alarm.

QUESTION 7 (a):

Indicate in the appropriate columns of Table 4 which control wires of the Coder keyboard will change from their normal condition when the following keystrokes are made:

ANSWER 7 (a)

TABLE 4.

Keystroke	L6	L7	L8	L9	L10	L11	L12
7		✓					
A	✓	✓					
Cancel						✓	
Reject			✓		✓		
Repeat							✓
Air Mail	✓		✓	✓			
Victoria (short code)			✓		✓		

QUESTION 7 (b):

Below is a sample programme for the magnetic drum: :13076/0, *REFRN* = 10203010.13077
Briefly describe the meaning of the following.
(*i*) :
(*ii*) /0
(*iii*) =
(*iv*) .13077

ANSWER 7 (b):

(i) Write Marker. The information following this signal determines the time slot in which a temporary marker pulse is to be recorded.

(ii) State Code control signal. State 0 (NSW) is to be inserted into the address check store so that checking of all recorded addresses will also include a check of state information.

(iii) Write Translation. Indicates that translation information follows and has to be converted from telegraph code to translation code and to be recorded on the translation section of the drum.

(iv) Check Marker control signal and the number following is the location where the marker should be. Group 1, time slot 3077.

QUESTION 8 (a):

State the purpose of the 'clock' system in the Register Translator and briefly state how it works.

ANSWER 8 (a):

Purpose is to enable information to be written into the drum, on any required timeslot, with respect to a reference signal.
Clock is a 4000-bit counter, driven by strobe pulses and thus counting in synchronism with the drum. The clock consists of four stages of ring counters (units, tens, hundreds, thousands), each controlled by the state of the previous counter(s).

QUESTION 8 (b):

Describe how, with the aid of signals derived from the 'Clock Correction Track,' the clock is brought back into synchronism when necessary.

ANSWER 8 (b):

Whenever the clock reaches count 3999 at any time other than when it should, as indicated by a reference signal derived from the Clock Correction Track on the drum, the clock is stopped on the next count 0000, as an inhibit is placed on the unit counter. The inhibit is removed and the clock restarts when the reference signal indicates that the drum has reached the correct position.

QUESTION 8 (c):

Two other signals are derived from the 'Clock Correction Track.' Name these signals; state when they occur, and briefly describe their purpose.

ANSWER 8 (c):

The signals are the FW and FZ signals. The FW signal occurs between counts 3990 and 3999 and its purpose is to inhibit comparisons during track switching, when spurious comparisons could be found.

The FZ signal occurs every 8mS (5 times in one drum revolution) and its purpose is to ensure that short duration contact bounces of keyboard and relay signals fed to the R.T. are not registered by (and therefore do not confuse) the sensitive electronic equipment.

QUESTION 9:

It is required to show the correct time relationship between two waveforms on a cathode ray oscilloscope with a dual trace vertical amplifier, using 10x probes calibrated to the instrument. The waveforms are:

A 50 Hz square wave of 0 to — 10 volt amplitude.
A 1 mS pulse of 0 to — 1 volt occurring once every 20 mS.

QUESTION 9 (a):

Indicate in Table 5 the appropriate Volts/Division switch setting for each input to display each waveform 2 divisions high.

ANSWER 9 (a):

TABLE 5.

Volts/Division	Waveform 1	Waveform 2
20		
10		
5	✓	
2		
1		
.5		✓
.2		
.1		
.05		
.02		
.01		

QUESTION 9 (b):

In what mode should the vertical amplifier be operated to give the best display? Indicate your answer opposite the appropriate Mode switch setting in Table 6, and state briefly the reasons for selecting this mode.

ANSWER 9 (b):

TABLE 6.

MODE	
CH. 1 ONLY	
ALTERNATE	
CHOPPED	✓
ADDED	
CH. 2 ONLY	

'Alternate' mode flickers at this frequency.

QUESTION 9 (c):

What are the settings of the timebase SOURCE and SLOPE controls to obtain the waveform in Fig. 17 when a 50 Hz square wave is applied to the vertical amplifier input. The display should start at 0 volts.

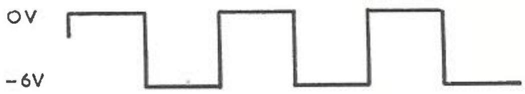


Fig. 17

ANSWER 9 (c):

It must be fed into channel 1 of the Vertical input and the Timebase Trigger switch set to channel 1 only.
Trigger source: Internal.
Slope: +ve.

or

It must be fed into channel 1 of the Vertical input and also fed to the External Trigger input terminal.
Trigger Source: External.
Slope: +ve.

QUESTION 9 (d):

If a probe has been over-compensated for high frequencies, sketch the effect it will have on the square wave calibrate waveform display.

ANSWER 9 (d):

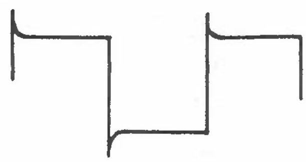


Fig. 18

QUESTION 10 (a):

Fig. 19 shows a section of the Decoder Sequence Control. Complete the timing diagram in Fig. 20 to illustrate the logic state of the following points in the circuit: ZPT3, ZD7, XU34, XV34, ZD9, ZD15, ZD11, XU37, XV37, F4,

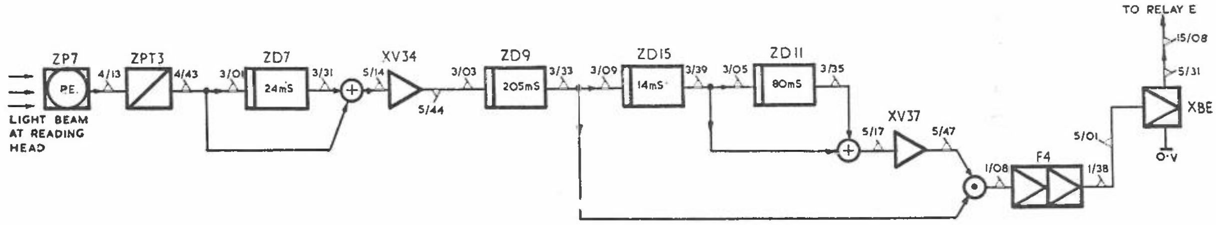


Fig. 19

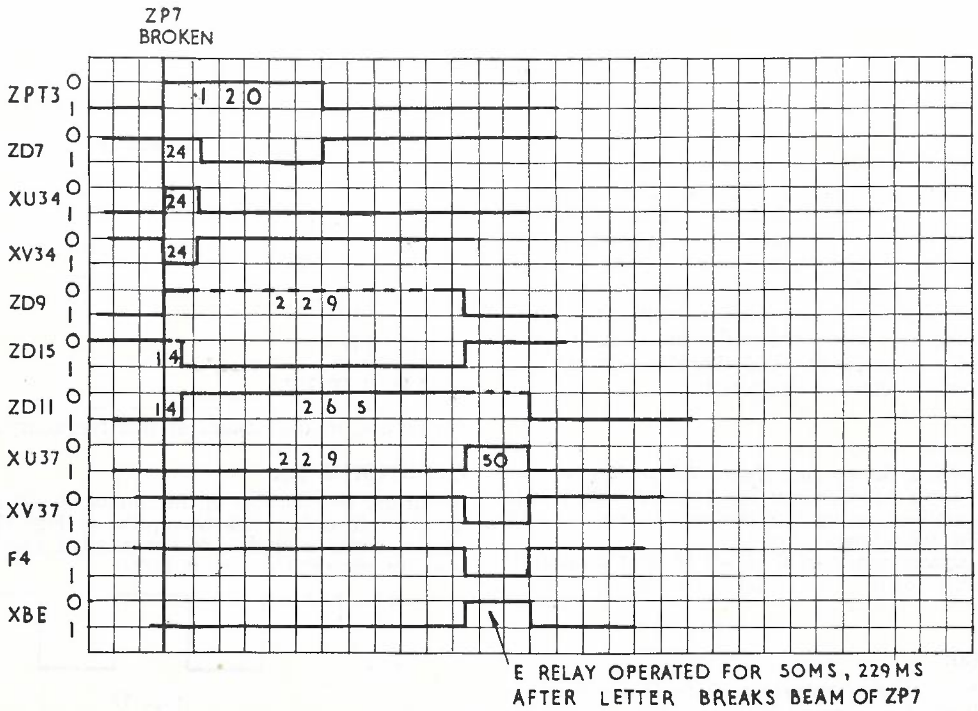


Fig. 20

XBE, and indicate the period when E relay is operated as a 10 inch letter passes through the reading head section at a rate of 12 mS/inch. 1 Division = 20 mS in Fig. 20.

ANSWER 10 (a):

See Fig. 20.

QUESTION 10 (b):

What is the function of the E relay?

ANSWER 10 (b):

It transfers the code from the Staticiser to the first intermediate relay store.

TECHNICAL NEWS ITEM

NEW SYSTEM FOR SEMICONDUCTOR PRODUCTION

Hitachi, Ltd. has completed a prototype of a highly sophisticated ion implanter for the manufacture of semiconductor devices. The new system, the first of its kind in the world, is expected to pave the way for thoroughly automated production of semiconductor devices.

Development of the ion implantation machine, with which impurities for determining the electrical properties of semiconductors are ionized and implanted into semiconductor crystals after being accelerated at high voltage, had been conducted by Hitachi with subsidies from the Research Development Corporation of Japan, a governmental organization.

Mass-production of diodes, transistors and MOS (metal oxide semi-conductor) field effect transistors have already been undertaken successfully with the new ion implanter, though on a trial basis.

At present, the thermal diffusion process is most popularly employed to manufacture semiconductor devices. This process, however, tends to cause uneven distribution of doping impurities and permits no automatic production, because quantitative monitoring of impurities is impossible.

By ion implantation, such impurities as boron and phosphorus are ionized and accelerated at 200 kV and implanted into silicon substrates.

The new system has many advantages over the conventional thermal diffusion process, including:

1. Ion beams can be implanted simultaneously into a maximum of nine silicon wafers, and processing of a large number of semiconductor devices with uniform characteristics is possible. About 40 wafers can be handled per hour with this machine.
2. Computer-controlled automatic production is possible. Adjustment of the ion source and acceleration voltage can be handled easily and safely at ground potential.
3. The amount of impurities can be monitored during the processing, because direct measurement and control of ion beam current is possible.
4. Processing can be made at relatively low temperatures ranging between 400 and 900 degrees C., while the thermal diffusion process requires 1,000 to 1,200 degrees C.

TECHNICAL NEWS ITEM

TRANSMISSION EQUIPMENT FOR I.S.T. PROJECT

The Integrated Switching and Transmission (I.S.T.) project being conducted by the A.P.O. Research Laboratories was described briefly in the June 1969 issue of the Journal (p. 126).

The digital transmission in this project is being performed by pulse code modulation (PCM) systems. Two 24 channels S.T.C. PCM systems will be installed in Victoria on junction cables between Windsor and Clayton, and Windsor and South Oakleigh. A normal and a standby bearer will be provided on each route. At present the PCM terminal equipment is being tested in the Research Laboratories and the line repeater housings are being installed in the field. Cable tests are about to commence and will include measurement of loss and crosstalk up to 5 MHz, and impulse noise. The PCM systems are expected to be installed and tested by mid July 1970.

I.S.T. switching equipment is being designed and built by the Research Laboratories. To facilitate the testing of this equipment in the Laboratories before its field installation at Windsor, the PCM route is being extended from Windsor to the Laboratories with compatible Marconi PCM equipment. The bearer extension is expected to be completed by October 1970.

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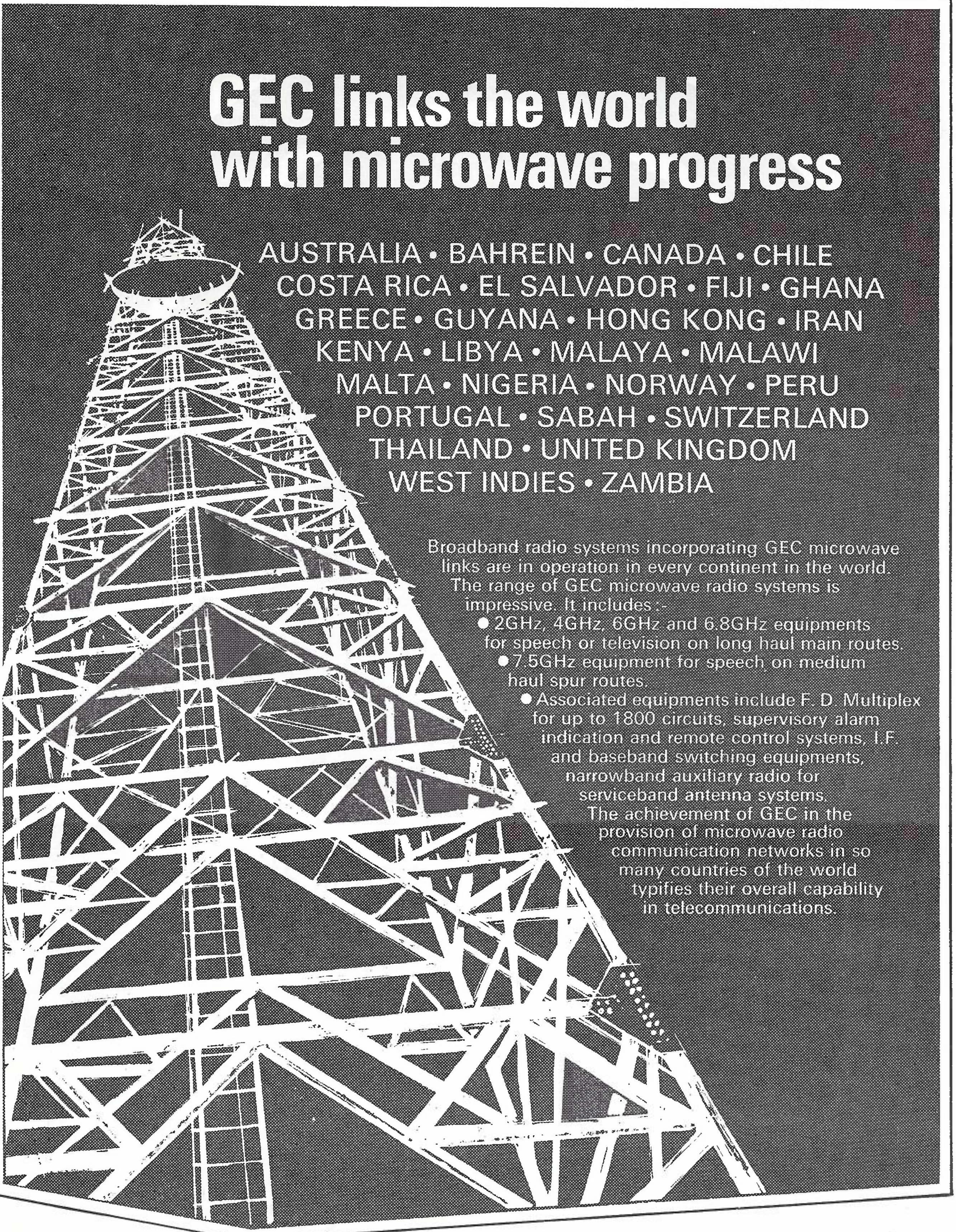
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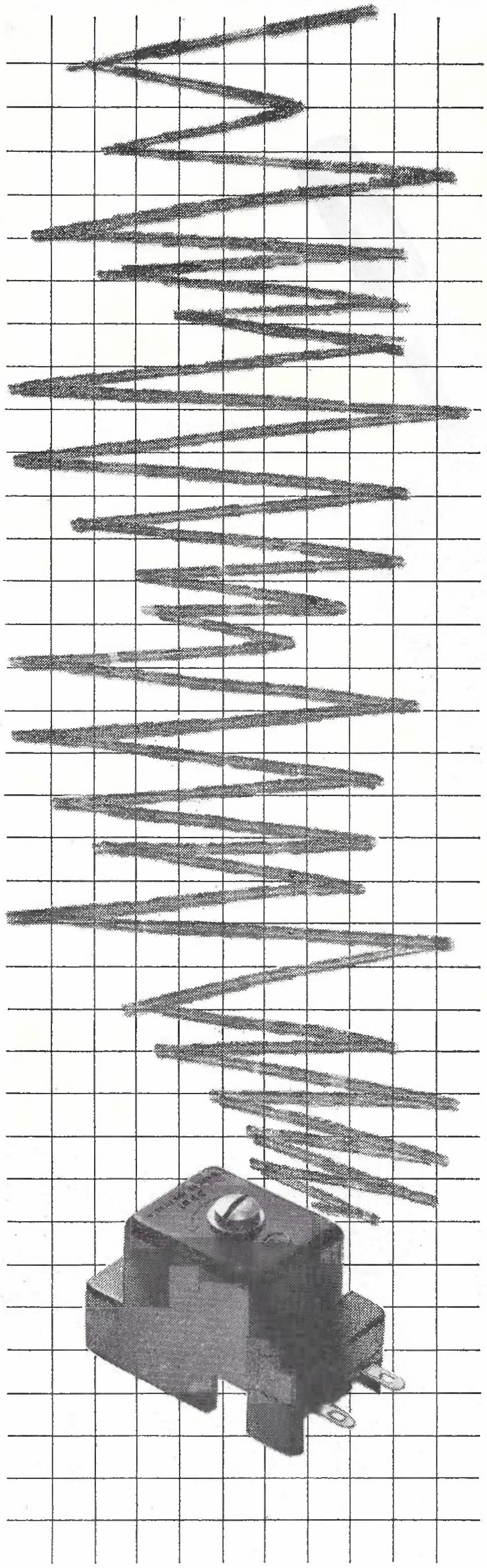

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THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

VOL. 20 No. 2
JUNE 1970

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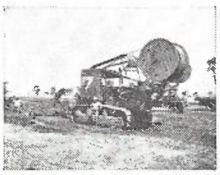


COVER
A Cable Unit from the Perth-Carnarvon Coaxial Cable Project

The TELECOMMUNICATION JOURNAL of Australia

ABSTRACTS: Vol. 20, No. 2

BENNETT, C. F., and SISSON, A. W.: 'Developments in Underground Balanced Pair Telecommunication Cable in Australia since 1945'; Telecom. Journal of Aust., June 1970, page 119.

The developments which have occurred since 1945 in underground cables used by the Australian Post Office are reviewed. They have been related to the growth and development of a manufacturing industry, and to the other network components which form the speech circuits for telephone calls. The effects of raw material prices and the advent of thermoplastics on cable technology are considered, and a probable pattern of future development is predicted.

BRAGA, P., and FOOTE, G.: 'Service Assessment of S.T.D. Traffic'; Telecom. Journal of Aust., June 1970, page 127.

This article describes the details and principles adopted in the development of service assessment facilities for S.T.D. traffic. Broadly, equipment is required at both the assessed exchange and assessment centre. The equipment provided at the assessed exchange incorporates the tapping and transmission facilities required for the transfer of information to the assessment centre. This includes the identification of the inlet to the assessed exchange and the line and information signals. All the information obtained at the exchange end is transmitted and analysed by the incoming equipment at the assessment centre. This equipment has been designed to provide adequate display of all the relevant signals and information extracted at the assessed exchange. The circuit components and mounting arrangements for this service assessment equipment are based on current crossbar practices and hence conform with other equipment presently being installed.

CAMERON, N. A., and SMITH, K. N.: 'Telephone Orders by Teleprinter'; Telecom. Journal of Aust., June 1970, page 144.

A system for transmitting the information needed to authorize, record and account for the installation or modification of a telephone service in the A.P.O. is described. Teleprinters in the exchanges and the work depots connect with an order centre at the sales office where a tape transmitter enables automatic broadcast transmission of the required operational information.

GOOLEY, M. J.: 'Co-ordination of Trenching Works in New Suburbs'; Telecom. Journal of Aust., June 1970, page 173.

The paper describes how utility installations to a new housing estate were coordinated to the mutual benefit of the utilities, the developer and the individual householder.

HIGGINS, P., and KEIGHLEY, R.: 'Subscribers Installation Management Control System'; Telecom. Journal of Aust., June 1970, page 135.

This article describes the design of a complex, computer based, management control system to assist supervision and management of subscribers equipment.

HOWARD, P. T.: 'Development of the S.T.C. 12MHz Coaxial Cable Systems'; Telecom. Journal of Aust., June 1970, page 113.

Two transistorised 12MHz coaxial line systems are described. One system uses 9.5mm coaxial pairs, the other either 4.5mm or 9.5mm coaxial pairs. The 12MHz system can be applied to spares in cables carrying 4MHz systems or can replace such systems. Aspects discussed include line amplifier, regulation, fault location, supervisory system and system performance.

KUGLER, E.: 'The Siemens Concept for a 12MHz Coaxial Cable System'; Telecom. Journal of Aust., June 1970, page 107.

The essential points of view of the concept of the 12 MHz coaxial cable system — with particular consideration of the common transmission of telephone calls and television — are demonstrated. In addition to basic considerations (noise, transmission level), the technical realisation is considered somewhat more closely (attenuation and delay equalisation means for dropping the TV channel, power-feeding, fault location). In taking a look into the future, the new 60MHz system, which will be suitable for the transmission of telephone calls and several TV programs, is dealt with in brief.

McKENZIE, K. A.: 'The Australian Post Office Role in NASCOM: Part I — Development'; Tel com. Journal of Aust., June 1970, page 162.

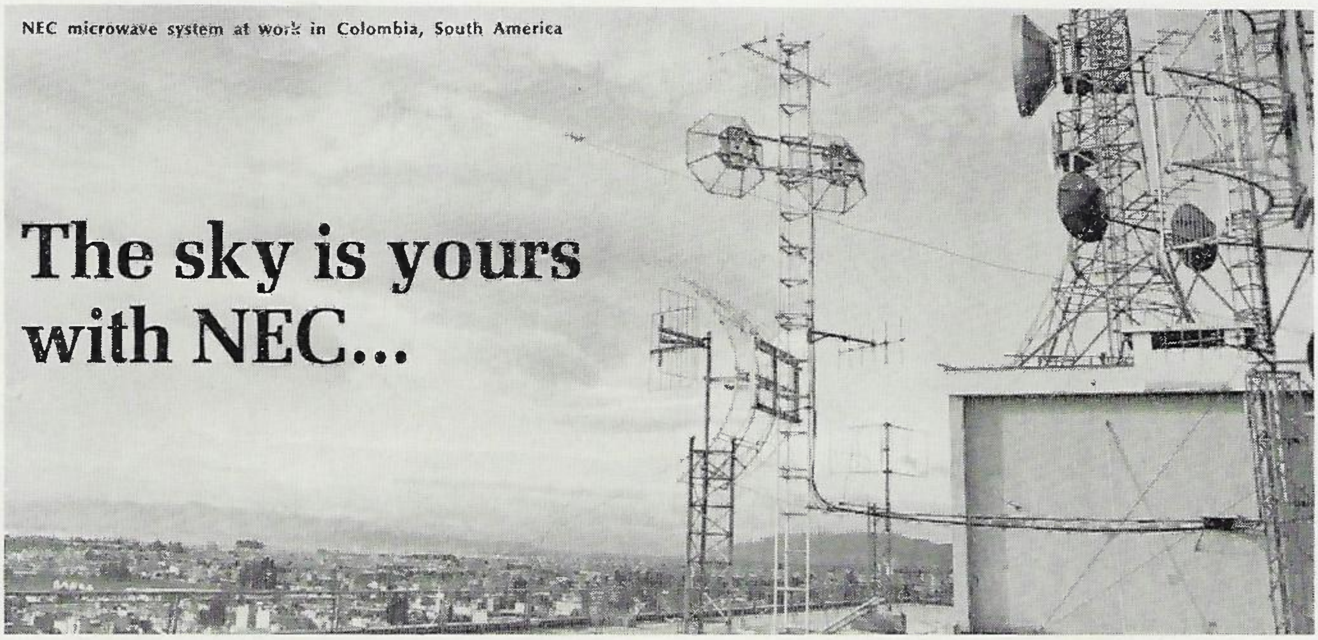
Part 1 of this paper records the development of the domestic Australian Sector of the worldwide network which provides communications support for the various space programmes of the National Aeronautics and Space Administration (NASA) of the U.S.A. This paper covers the development period between 1962-63 and the end of 1969 which includes the Apollo 11 and Apollo 12 missions. Part II will deal with operational aspects.

RAY, K.: 'Transmission Lines and Measurements; Part I: Open Wire'; Telecom. Journal of Aust., June 1970 page 152.

Developments in open wire transmission lines and transmission measuring techniques are reviewed against a brief background treatment of the basic characteristics of line transmission. Results achieved on modern open wire routes are presented.

ROSS, N. G.: 'Developments in Post Office Co-ordination with Power Authorities'; Telecom. Journal of Aust., June 1970, page 159.

A conference between Post Office and electricity supply representatives in April 1969 confirmed advances made in co-ordination practice since the previous conference in 1965. The paper briefly describes joint projects completed since 1965 in the areas of joint use poles, MEN H. V. lines, low frequency induction, crossings and common use, and S.W.E.R. lines. Reference is also made to current projects on underground joint use, effects of low frequency induction, and protection from effects of power earth faults.



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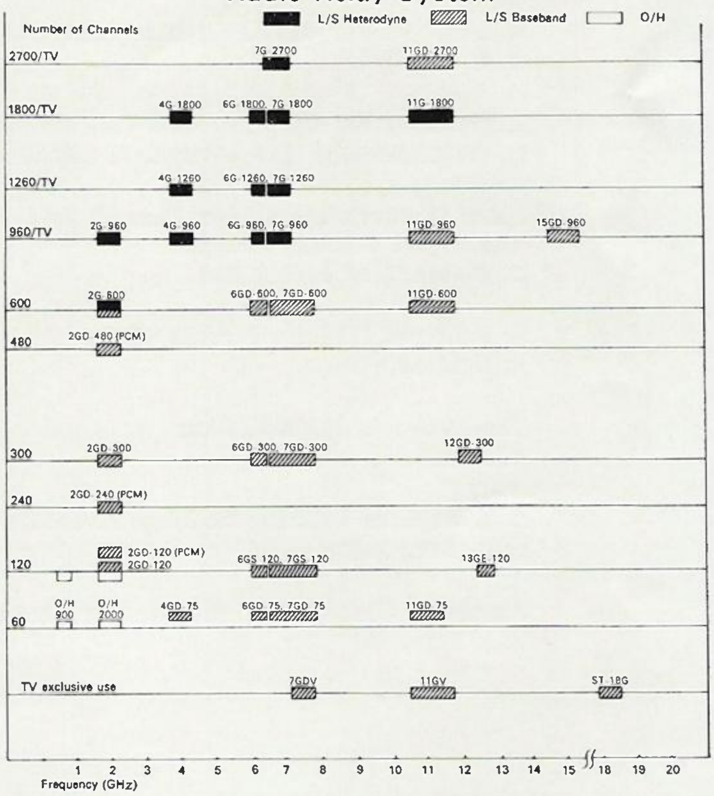

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