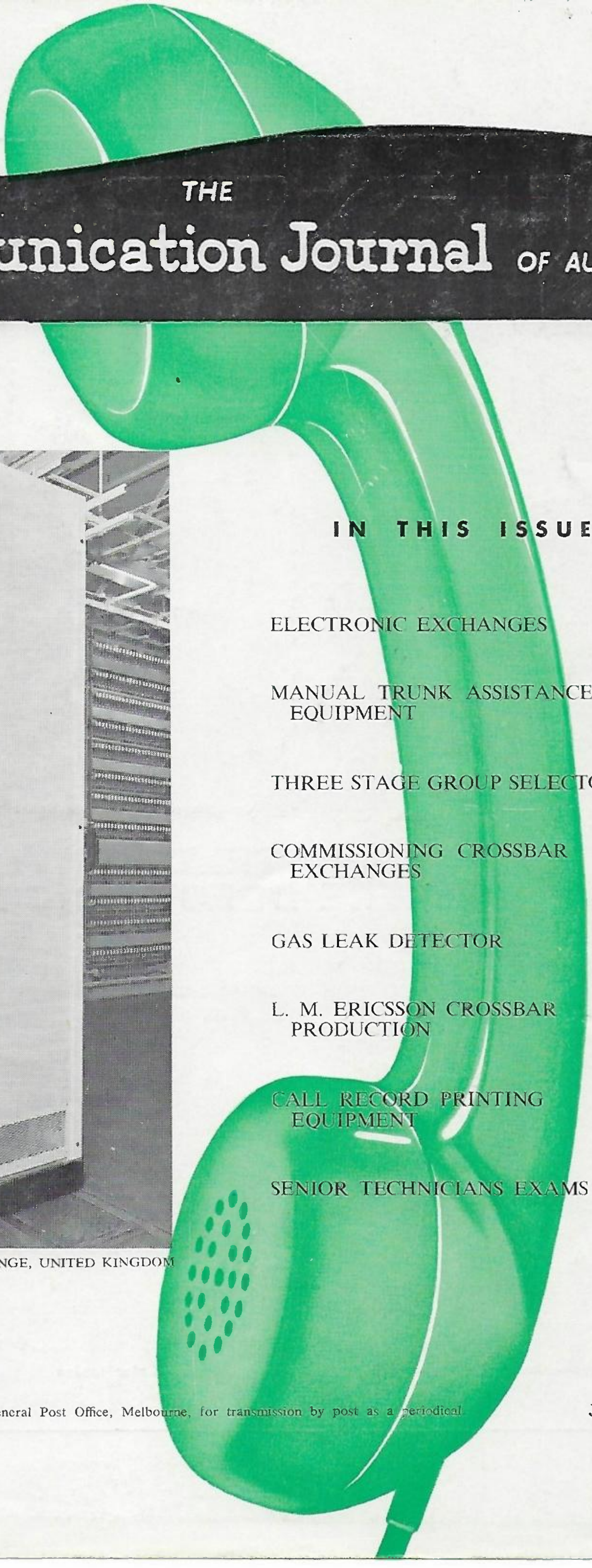

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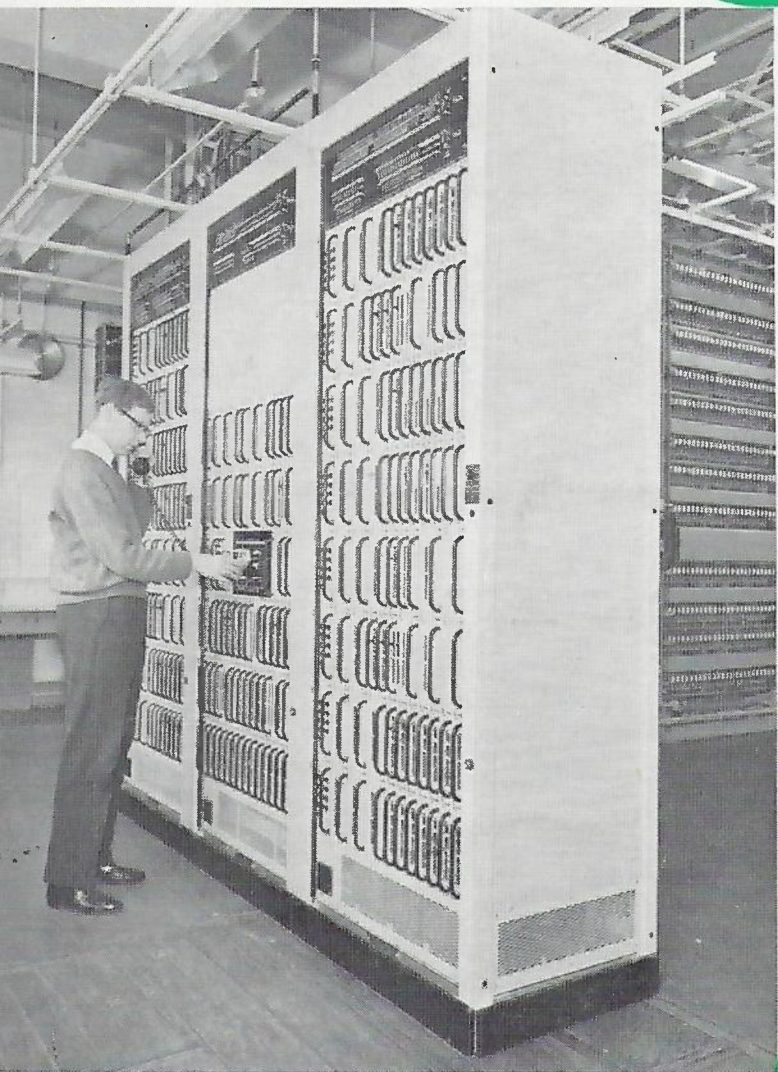

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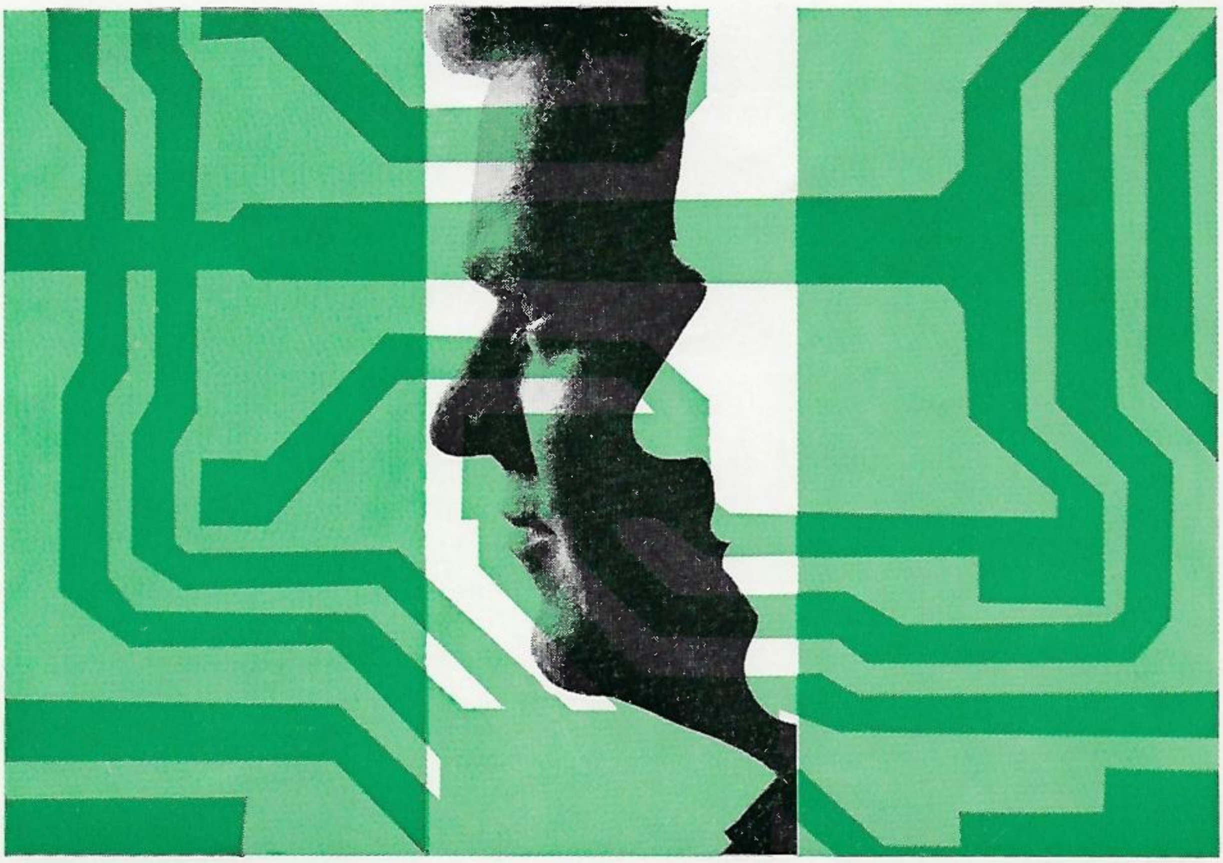

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CONTENTS

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RECENT DEVELOPMENTS IN ELECTRONIC EXCHANGES

*H. S. WRAGGE, B.E.E., M.Eng.Sc., M.I.E.E., A.M.I.E. Aust.**

INTRODUCTION

Considerable effort has been devoted towards the development of a technically satisfactory and economically viable electronic exchange over the past two decades. Technically satisfactory solutions have now been reached in several countries, with very good promise of commercial success. This was made clear at the International Conference of Electronic Switching held in Paris during March 1966.

In this article a summary of the Paris Conference (which was attended by the author) is given, followed by a review of the status of electronic switching generally on the world scene.

THE PARIS CONFERENCE

Scope

This conference followed on an initial conference held in London in 1960, and had as its aim the assessment of developments in the technical and industrial fields as well as the provision of a forum for the discussion of developments which are still in the laboratory stage.

The conference was attended by about 1000 delegates, including the author and the A.P.O. Liaison Officer for London, Mr. R. C. M. Melgaard, Mr. G. Page-Hanify from S.T.& C. and Mr. S. Zarda from T.C.A. A total of 162 papers was presented, including 42 each from England and France, 12 from the United States and a smaller number from other countries. A paper was also presented by the author. (Ref. 1.)

The topics discussed covered a very wide range, from network planning aspects through to detailed circuit techniques under 18 major headings. One session was devoted to examining the operating performance of systems which have already been in operation, while several sessions were devoted to discussion of systems which are at, or near, the final development stages.

Summary of Main Conclusions

At the final session, the major points and impressions which had emerged from the conference were summarised, and these are reproduced here (Refs. 2, and 3).

(i) Developmental work is still being carried out in a number countries, while several countries have already announced firm plans for the introduction of electronic switching. At this stage, it appears that the use of space division techniques are favoured, particularly in the United States and in England.

(ii) Time division techniques are not favoured at present for individual exchanges, but they are being applied to P.A.B.X.'s It appears that time division techniques do hold promise, however, when used on an area basis in combination with digital modulation techniques.

(iii) The presently favoured crosspoint is an electrical contact rather than a semi-conductor crosspoint. This is due to both cost and transmission considerations. At present, the reed appears to be the most widely favoured crosspoint, and is used in all exchanges which are at present in commercial service. However, crossbar switches and miniature fast acting open contact switches operating on a co-ordinate selection principle are being seriously considered in a number of instances.

(iv) Work on time division techniques directed towards the Integrated Switching and Transmission (I.S.T.) principle is proceeding in a number of countries, but this is not yet as well advanced as are the developments using metallic contacts. However, it appears that the integrated system is firmly advocated by many workers in the field, although decisions have not yet been finalised with regard to the method of modulation to be used, (e.g. pulse code modulation or delta modulation) or the mode of synchronisation (synchronous or asynchronous).

(v) The control system which appears most advantageous, particularly in the larger systems, is the stored programme approach rather than the wired logic approach, which is suitable for the small system. System integrity (or reliability) is usually provided by a duplicated control system in which both sections are working on a load sharing basis. There is now, however, a tendency to rationalise many functions such as routing, metering, signalling requirements, etc., in a more centralised organ with some of the more routine functions being carried out in highly autonomous and peripheral organs operating themselves under stored programme control and lightly co-ordinated by the central organ. It does not seem that adoption of a business type computer is a practical solution to control, as a very specialised form of "computer" (processor) is required. A universal language for telephony-type processors is very much needed for programming purposes, and would also be of value to both administrations and manufacturers.

(vi) Metering using highly sophisticated automatic methods does not yet appear to be attractive, although technically successful trials of centralised metering equipment have been held in France and in Japan.

(vii) In the P.B.X. field there are a wide variety of techniques; wired logic or stored programme control are used in combination with reed or fully electronic or time division switching together with many other subtle variations.

(viii) The integration of a data network with the telephone network was considered but this is still an open question.

(ix) The main innovation in the signalling field is the increasing acceptance and advocation of a "data channel" type of signalling link between electronic exchanges which would convey both line and information signals. These would be passed on a message basis when needed rather than on a continuous basis as are line signals in conventional telephony.

(x) Modular construction is universally accepted.

(xi) The advantages of electronic switching appear to be the following:

(a) A rationalisation of manufacture and greater facilities for the use of modular constructional techniques thus leading to a greater proportion of automation in manufacture.

(b) A separation into hardware and software via stored programme control enabling greater flexibility to be achieved in the application of electronic equipment without requiring a greater diversity in the manufactured equipment.

(c) An improvement of reliability and also of maintenance facilities.

(d) The stage has now been reached at which we can consider the non-duplication of many control functions bearing in mind the high degree of reliability attainable from electronic components.

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(e) Greater automation of network management, traffic monitoring, metering and telemaintenance, etc. (Note: This latter term refers to re-arrangements in the functional organisation of a distant exchange by a technician at a central point by amending the programme in the distant exchange to locate faults and also provide an optimum service when faults actually exist.)

(f) It would be possible with stored and wired programme control to provide many new services for the benefit of subscribers without significant increase in equipment cost.

(g) It should be possible to replace existing exchanges more readily.

(xii) There is an economic problem involved in the use of electronic exchanges but the time has not yet come at which this can be fully evaluated. However, it appears that the use of electronic switching equipment could not only decrease the initial cost of the equipment but it could also reduce the space requirements, reduce maintenance, increase the performance, and optimise the automation of network management. For a given investment it appears at this stage that electronic telephone exchanges should show up with the most advantage.

It must be stressed that the above comments relate to impressions gained from this conference. They are based on the papers submitted to the conference and take no account of developments which have not been reported. The author, however, has no reason to believe that these factors would seriously influence the conclusions drawn.

PRESENT STATE OF ELECTRONIC SWITCHING

Commercial Production Commenced or Programmed

Several countries have now either adopted, or have announced their intention to adopt electronic exchanges.

U.S.A.: The first to commence commercial production was the Bell System in U.S.A., where the first exchanges are now in operation. These are large scale stored programme control exchanges which use ferreeds* to switch the speech paths. These exchanges have a basic upper capacity of 64,000 lines, but will probably not be used to their full capacity as this can provide problems in loading of the stored programme control processor. Bell are now stepping up their production of these exchanges, and planned to produce 700,000 lines of electronic equipment in 1966. The statement has been made that the Bell System expects to be cuting over new electronic exchanges at the rate of one/day by 1973. (Ref. 4).

General Telephones & Electronics in the U.S.A. (Automatic Electric) are also producing stored programme control exchanges using ferreeds. An experimental system is on field trial and a variant of this has been selected to perform the switching functions outside the U.S.A. for the U.S. Armed Forces global communications network known as AUTOVON. (Ref. 5). A total of 22 centres using G.T. & E. exchanges will be installed for Autovon outside the U.S.A.

U.K.: The United Kingdom is the only other country which has already installed production electronic exchanges on a commercial basis. Two types of exchange are envisaged, one in the range 200-2000 lines, and the other to cover the range greater than 2000 lines. These all use electrically held reeds under wired logic control. The first of these exchanges were installed on a trial basis at Leamington Spa by G.E.C., and at Peterborough by Plessey. (See Fig. 1).

* **Methods of Using Reeds.** There are two main methods of using reeds, using either electromagnetic or magnetostatic means to hold them operated. In the former case, one or more reeds are inserted into a solenoid, and the contacts will remain operated for as long as current is passed through the solenoid. This forms a "reed relay" and is similar in principle to a conventional relay.

In the other method, use is made of the field of a permanent magnet to hold the contacts operated. Included in the solenoid is a rod of material having a high remanence which can be magnetised in either direction by passing current in the appropriate direction through the solenoid. In close proximity, but not in the solenoid, is a further rod of highly remanent material which is parallel to the other and the reeds. The field from the first rod can either aid or oppose that from the permanent magnet and will cause the contacts to open or close depending upon the direction in which the first rod is magnetised. A current pulse is sufficient to operate the contacts, and they will remain operated until a current pulse is applied in the opposite direction. Relays operating on this principle are known as ferreeds.

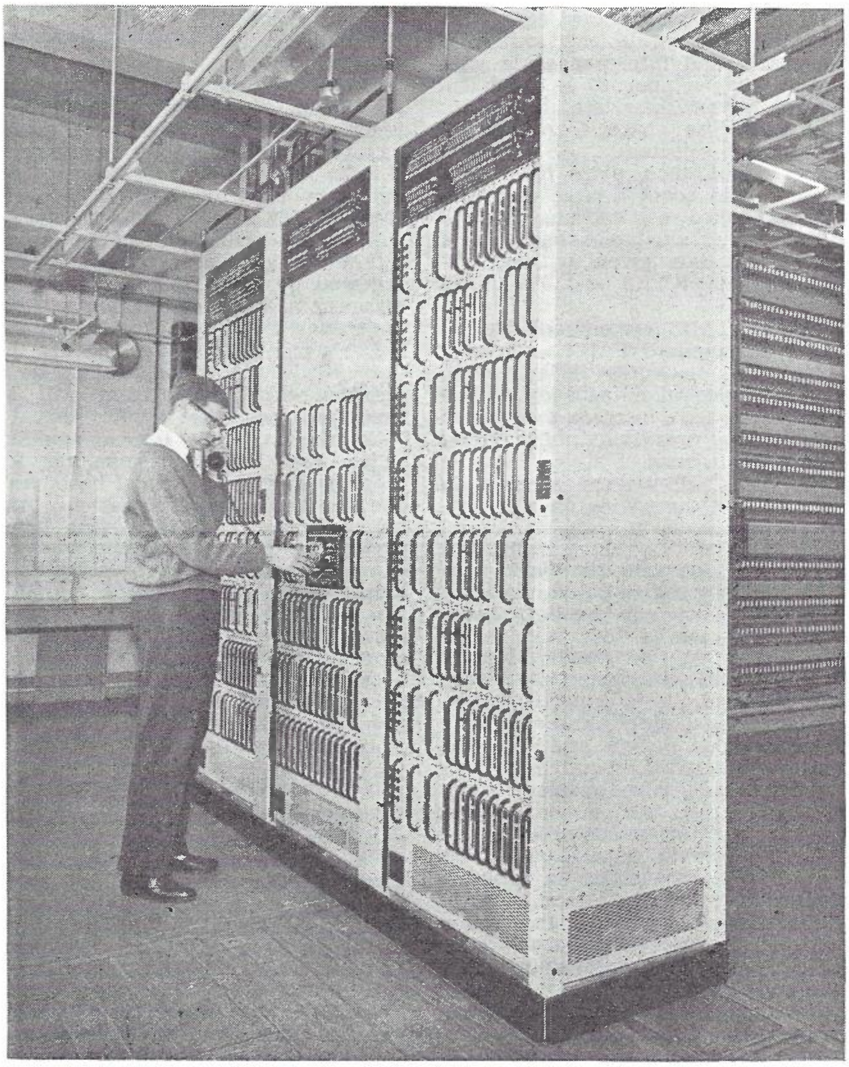

Fig. 1 — Leamington Spa Exchange.
(Photo by courtesy of the General Electric Company Limited).

The first production exchange was cut over at Ambergate on 15 Dec. 1966. The name which has been given to this system is PENTEX.

The development of the large exchange has now been completed and the first two orders placed. This is known as the REX system.

In the United Kingdom there is a network including roughly 6,000 exchanges which serves 10,000,000 subscribers, and the B.P.O. expect the network to treble its size by 1980. There will be an increasing proportion of development with electronics. In 1972 they expect to provide 50% of the demand with electronic exchanges, mainly in the 200-2,000 lines size. In 1966 the B.P.O. expected to order 50 exchanges and 75 in each of the subsequent years and that by 1970 30,000-40,000 lines of electronic exchange equipment will have been installed.

In the U.K., step-by-step exchanges will be extended in future with equipment using reeds under electronic control. Group selector equipment has already been designed which is compatible and interchangeable with step-by-step equipment in function, racking, interworking, etc., but which will need less space than conventional group selectors.

France: In France, plans have been announced to adopt a large electronically controlled reed exchange in 1968 and a smaller similar exchange from 1966. The names given to these systems are PERICLES and ARTEMIS respectively.

The ARTEMIS system will be installed as standard PABX equipment in the Paris network. It is a small system (maximum capacity 1,000 lines) which uses ferreeds to perform the switching operations under stored programme control.

The PERICLES system is based on the use of a three-wire reed switching matrix under a form of stored programme control and is scheduled for introduction into the Paris area in 1968. It is probable that a miniature crossbar switch will be introduced into this system a few years later. This system will be standardised by the P.T.T. and will remain as a long-term standard. It is expected to be introduced on a large scale by 1975. This particular system can satisfy a number of network requirements, as it can be used for the medium urban centres in range 0-10,000 lines or as a high capacity urban centre (as a control exchange) to serve 5,000-30,000 lines or as nodal centres up to international level (as control exchanges). This exchange is based on the use of multi-registers which are small control equipments operating under their own stored programme control but with access to a central decision-making unit which has facility for translation, metering information, routing information, maintenance data, etc. If used as a control exchange this control centre would be provided and would serve all the multi-registers within that exchange and also those of other exchanges which are dependent upon that exchange. If an exchange of this type is used as a small urban exchange it would be dependent upon a higher level exchange and would only have multi-registers. It would refer to the higher level exchange for charging, translation etc. Centralised metering will be provided at control exchanges on magnetic drums. With this system, a number of new innovations will be introduced including meters at subscribers' premises, prepayment trunks, etc. There will also be facilities for maintenance staff to communicate with the central control equipment from all exchanges. Emphasis is being placed on high reliability components.

Japan: In Japan, the major present developmental effort in the electronic exchange field is the development of a stored programme control exchange using ferreeds which will have a maximum capacity of the order of 20,000 lines. This system will be designated DEX-1.

This system is being developed by the Japanese Administration in conjunction with the four major manufacturers of telephone equipment, N.E.C., Oki, Fuji and Hitachi. An initial model is expected to be available in 1967 after which the design will be finalised; the manufacture of a prototype should commence in 1968 followed by field trials for final assessment in 1969. Production will get under way in 1970 and the first standard electronic exchange should go into service in about 1973. It is intended that this system will be used for local office applications.

The system will use a modified rather than standard computer (or processor) on a duplicated basis with one processor operating at any one time. Computer technology is being exploited wherever possible to save equipment, space and processing time. Examples of this include variable length instruction formats, simultaneous processing of five instructions at one time, etc. Facilities will also be provided for connecting the processor to a general purpose computer for programme and memory testing if required.

Field Trials in Progress

Field trials are being carried out in a number of countries, and some quite encouraging results have been obtained. Countries in which trials are being, or are shortly to be carried out include Germany, France, Denmark, Sweden, Holland, Belgium, Austria, Italy, Finland, and Japan at least.

Some of those at present in service include exchanges at Vienna and Stuttgart developed by Standard Elektrik Lorenz, known as the HE60 system. This is an electrically held reed system using wired logic. A large exchange using the ESK switch known as SEAM has been placed in service in Rome to serve 20,000 subscribers. This was supplied by Siemens and Halske, who also supplied a trial reed exchange in Munich. A large exchange known as the AKE12 is being installed at Tumba, near Stockholm, by L. M. Ericsson. This uses codebar switches under stored programme control.

Operational Results

The operational results obtained from electronic exchanges so far have been very encouraging. In the first two years operation, the Leamington Spa exchange handled over two million calls successfully from subscribers with only two minor faults, neither of which caused any interruption to service. The S.E.L. HE60 exchange serves 1000 subscribers, and in its first 18 months service, 14 component failures occurred, and 10 wiring faults. (The method of wiring has since been altered to eliminate this type of fault). (Ref. 6.)

The Bell System experiences with the No. 1 E.S.S. have also been encouraging. In this case there were both programme and hardware faults to contend with; however, most programming matters have now been cleared, and the fault reports received per week per 100 subscribers are now less than about 0.6. On the hardware side, again a small number of failures has been experienced, bearing in mind the large number of components in this system. The faults for the initial six months service amount to one resistor, one capacitor, three low power transistors, two power transistors, two relays, six connectors and five transformers. (Ref. 7.)

While these component fault rates are in themselves impressive, care must be taken not to draw the conclusion that electronic exchanges will require only minimal maintenance. Sophisticated methods are available for location of faults within the exchange, but a large proportion of faults will be generated outside the exchange which require staff at the exchange. For example, the Stuttgart exchange experienced 142 faults in subscribers' equipment and 167 in adjacent exchanges and connected cable plant in its first 18 months service, which completely dominates the fault statistics in comparison with the electronic equipment faults described earlier.

INTEGRATED SWITCHING AND TRANSMISSION

Development is already being carried out to provide an even more advanced switching system than the present generation electronic exchanges. The present electronic exchanges will in the main take the place of the existing exchanges in communcations network without greatly affecting the network external to the exchanges.

A new concept which could have a significant effect on both exchanges and automatic networks, known as Integrated Switching and Transmission (I.S.T.), has now reached an advanced stage in France, and developmental experiments are being carried out in the U.K., Sweden, Japan and Australia.

The I.S.T. concept, or system, does not apply specifically to either switching equipment or to transmission equipment but rather to a communications system on a broad basis extending over an area which would contain a number of exchanges if conventional techniques were used.

In an I.S.T. network, voice signals are sampled and digitally encoded in time division multiplex (t.d.m.) form on entering the system (network) and transmitted in t.d.m. form over the various communication links in the network. The switching of these communication links is also carried out on a t.d.m. basis using digital techniques. The t.d.m. speech signals are "demodulated" only when leaving the I.S.T. network. Pulse code modulation (P.C.M.) is the t.d.m. modulation method used in most current work here and overseas.

An I.S.T. network exhibits several noteworthy characteristics:

(i) from the transmission viewpoint, a circuit, even when switched at intermediate points, would appear as one P.C.M. transmission link,

(ii) P.C.M. has a distinct and narrow threshhold at which noise interference becomes significant. This is different from conventional analogue systems in which increase in noise level produces a progressive deterioration in performance.

(iii) by using t.d.m. techniques for switching purposes, the elements of time and space switching can be combined so that the number of physical crosspoints can be reduced significantly even though their complexity is increased.

An I.S.T. system would necessarily operate with an electronic control system, probably based on stored programme techniques. This introduces the possibility of increasing the separation between switching and control to the extent where each can to a large extent be engineered separately to meet the needs of the network. Thus, there would be a number of "exchanges," or switching centres, which would be equipped with very little control apparatus and others which would function as powerful control centres. The switching centres would thus combine concentration with a certain amount of local switching or even ultimately degenerate to perform an elementary concentration function only. This introduces the concept of control on an area basis, rather than on a "per exchange" basis. A network based on this concept is shown in Fig. 2.

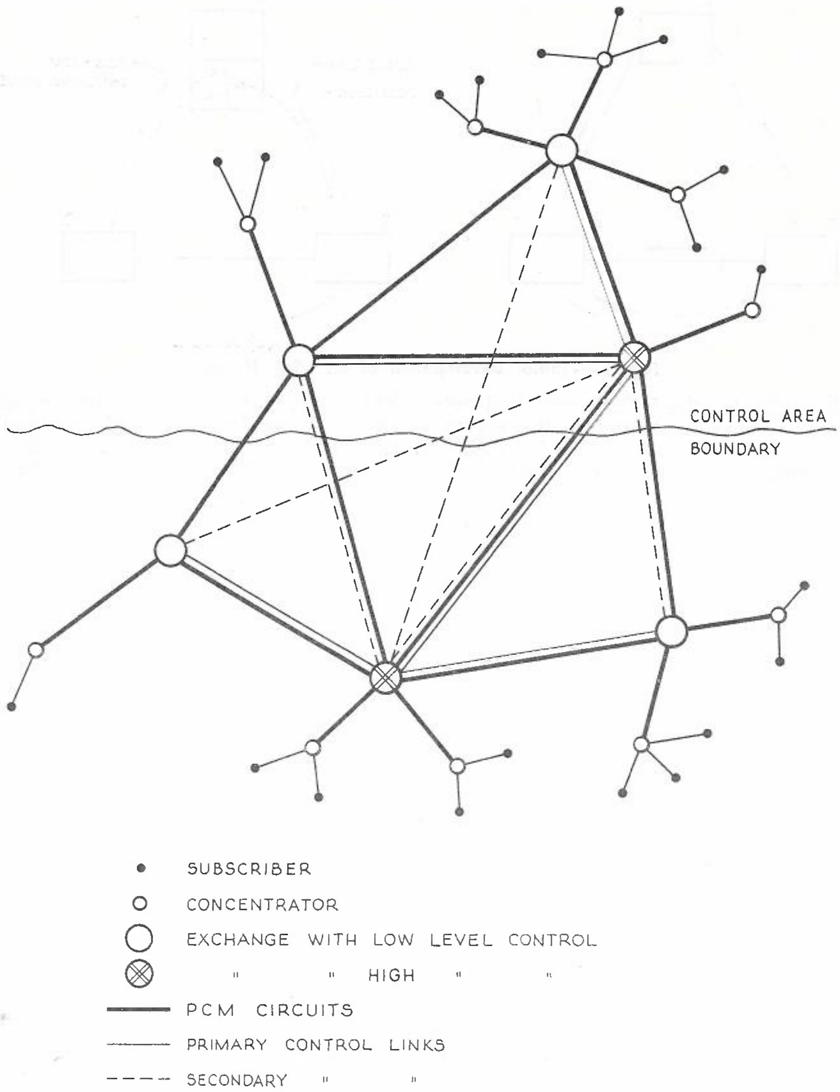

Fig. 2 — General I.S.T. Network.

Introduction of an I.S.T. System into the Existing Network.

The introduction of I.S.T. into an existing network falls naturally into three distinct phases:

Phase 1: The introduction of junction carrier systems in their own right using some form of digital modulation on a time division multiplexed basis. Currently there is considerable interest in P.C.M. systems and several telephone administrations have either already commenced or are preparing to commence the introduction of this type of equipment. The main factor of interest at this stage is that this will lead to the establishment of a junction (and possibly trunk) network operating on a t.d.m. basis. These systems are available in various channel capacities, 24 channels being common. The main area for application of P.C.M. systems at the present time appears to be in metropolitan networks. This is the junction network development phase.

Phase 2: This can commence as soon as a particular exchange, A, has P.C.M. routes established to a number of different exchanges, B, C, . . ., and there is a significant flow of traffic between, B, C, . . . etc., which can be carried by direct routes, via A or via other switching centres (see Fig. 3 (a)). In this phase, the exchange A would be effectively divided; the existing audio junctions would continue to be served by the existing electromechanical switching equipment, but a t.d.m. electronic switching stage would be installed to switch the traffic flowing in the P.C.M. channels on an originating, terminating and transit basis. A t.d.m. control centre would be set up at A to take charge of the t.d.m. switching operations there (see Fig. 3 (b)). This is the tandem switching development phase.

Phase 3: After the P.C.M. switching stages and control equipment have been established at a particular tran-

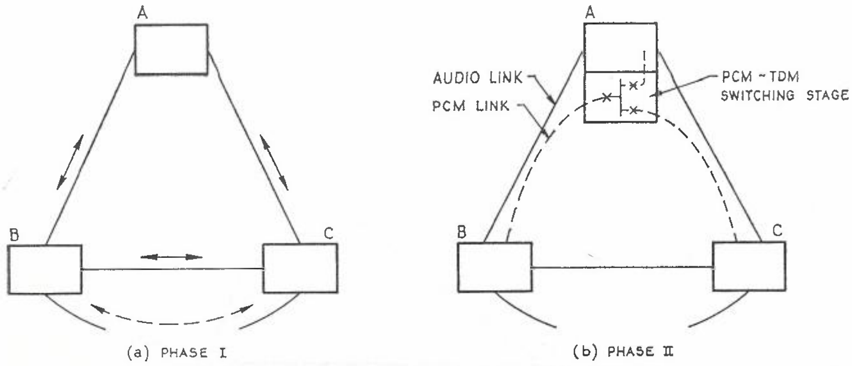

Fig. 3 — Initial Development of an I.S.T. Network.

sit exchange, the P.C.M. switched network can be expanded in several ways, as illustrated in Fig. 4. P.C.M. systems may be used to connect local groups of approximately 24 subscribers to the transit exchange, or they may be associated with an expansion stage to serve local groups of about 200 subscribers. Switching stages can also be set up at adjacent exchanges to carry out local P.C.M. switching within those exchanges under the control of the transit exchange. This network can be expanded under the control of the transit exchange until the control equipment reaches saturation, following which a further "control centre" would be established and the I.S.T. Network divided for control purposes into two parts, each under the control of its own control centre. (The question of whether two control centres rather than one should be initially provided has been avoided at this stage to enable the basic concepts to be more clearly demonstrated.) By this means the I.S.T. network can grow as dictated by traffic needs in an incremental manner using the available control capacity existing within the network. Control equipment can also be added on a progressive basis to meet needs as they arise. This introduces the concept of an increasing separation between the switched network and the control system in much the same way as switching equipment has been traditionally considered as being separate from transmission equipment. This is the subscriber's development phase.

Implications of I.S.T.

There are a number of implications inherent in the I.S.T. concept which could have a distinct impact on the future structure of communication networks, apart from those aspects relating to performance quoted earlier. Some of these are discussed hereunder from the speculative viewpoints.

Integration of Techniques: The use of the same digital techniques to handle both transmission and switching can have a significant effect on manufacturing of equipment, which will be discussed later. It will also have a unifying effect on the training of installation and maintenance staff, which would tend to increase the range of equipment which could be handled by the one technician.

Routing: As the transmission is via P.C.M. and demodulation is carried out only once when leaving the I.S.T. network, the quality of transmission within the I.S.T. network will be ideally invariant with regard to both distance and the number of links in tandem. Signalling will also be independent of the length (and resistance) of the links between switching points. This divorce of quality from number of tandem-connected links and link length will confer additional degrees of freedom on the selection of network topology. Since the per unit cost of circuit per route decreases as the number of circuits increases, there will be a greater emphasis on fewer basic routes of very high capacity and fewer exchanges in a network than would be encountered in an equivalent electromechanical network. This could significantly change the emphasis on alternate routes used in present network planning. The route followed by a call through an I.S.T. network could well take a more circuitous route and therefore pass through more switching points than in an equivalent electromechanical network, but it would in the main traverse high density routes.

Use of Concentrators: The I.S.T. exchange would in general be a "tandem" exchange in that it would switch only high traffic circuits, and would serve high density routes. Local traffic would be gathered and distributed by concentrators of up to 500 lines capacity and connected to the tandem points.

Divorce of Speech Network and Control: The separation of control and switching was briefly mentioned earlier; this concept can be readily extended to encompass the provision of a total control network which controls not only the speech transmission and switching networks, but also telegraph, data, facsimile, broadcast and TV networks as well. It would appear at this stage that the speech network could also provide the facilities requiring wider bandwidth by combination of channels; the inclusion of the telegraph network in a predominantly I.S.T. system may be practical under heavy traffic conditions, but it will require a considerable amount of study before this aspect becomes clear.

Developmental Work in I.S.T.

In the United Kingdom a team from the B.P.O. Research Station is preparing to carry out an initial I.S.T. exercise in the Earls Court area in the near future. This will be a purely experimental project aimed at gaining experience in the design and operation of an I.S.T. system. In the initial stage four concentrators will each be connected by two P.C.M. links to a central P.C.M. switching exchange. It will handle about 50 erlangs of traffic.

The French appear to be the most advanced in the development of integrated switching and transmission. The Central Telecommunication Laboratories in Paris (L.C.T.) have almost completed the development of a military version and are now well advanced with a model for civil use and have constructed all of the necessary hardware in laboratory form.

The National Centre for Telecommunication Studies in France (C.N.E.T.) have already completed their first phase in an I.S.T. developmental project; this includes the development of a model operating within their laboratory to gain experience in the design and operation of such a system. A model is now in operation at Lannion and is connected into the experimental network which has been constructed in that area by the C.N.E.T. They are now proceeding to the second phase of their development which will include the design and construction of a system which will be placed in network operation using subscribers in the Lannion area. This will include several P.C.M. switching centres and a number of concentrators.

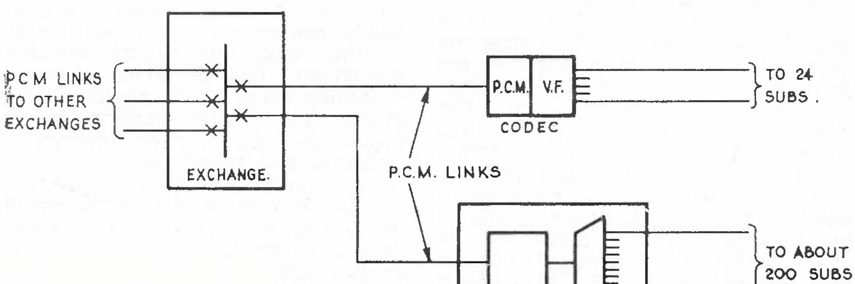

Fig. 4 — Later Development of an I.S.T. Network.

Advantage is being taken of this opportunity to obtain working experience with various types of transmission media as bearers for the P.C.M. systems. These will include a 7 Gc/s and a 2Gc/s microwave link (carrying 256 and 32 channels respectively) coaxial cable and normal trunk cable (32 channels in each case). Subscribers cable will also be used to carry P.C.M. in a parallel mode at lower speed than normal to concentrators. This model network will include satellite centres, urban centres, nodal centres and an information processing centre. They will not be full size but will offer the facilities that full size installations must provide. The number of subscribers concerned in this area wil be about 8,000. In this phase a number of changes will be incorporated as a result of the experience gained in the initial experiment, the most significant of which will be that the system will be operated on an asynchronous basis rather than on a synchronous basis as was the laboratory model.

L. M. Ericsson are also active in this field and commenced the development of their E.M.A.X. 300 system in 1962. The system will use a P.C.M. exchange operating under the control of a stored programme control processor and using P.C.M. links to concentrators. The concentration stages in these concentrators will employ metallic crosspoint switching. The reason for this is that this will considerably reduce the number of filters in the system and thus improve the economy. It has also the advantage that the use of standard telephone instruments is possible without modification. Little further detailed information is available concerning this system at this stage.

In each case the I.S.T. network concept is based on large P.C.M. exchanges having capacity of the order of tens of thousands of lines with dependent concentrators having capacity in the range 200 to 500 lines. The French envisage an incomplete mesh network interconnecting the P.C.M. exchanges, with P.C.M. links being provided on a traffic basis. The British envisage having no closed loops in their system at this stage, but rather provide their network security by means of geographical splitting of junction routes.

PROGRESS IN AUSTRALIA

Current developments both in the Australian network and in the development of electronic exchanges overseas are being watched closely, and it would appear at this stage that the initial application of electronic switching techniques in Australia could well lie in the trunk transit switching area where a high growth rate is being experienced. This could well involve the larger centres such as the capital cities where multiple A.R.M. installations would otherwise be required. Detailed studies are being carried out at present with the object of determining whether large electronically controlled trunk exchanges should be commissioned in the early 1970's.

On the more advanced front, studies of I.S.T. are also being conducted and a model network is being developed for experimental purposes in the Research Laboratories. (Ref. 8).

CONCLUSION

Developments in the electronic switching area have been successful, and the introduction of electronic switching on the world scene is now commencing. In general, the "current generation" electronic exchange uses reeds as the main switching medium under stored programme control. It is probable that this will be followed within the next decade by the integrated switching and transmission system.

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TECHNICAL NEWS ITEM

TELEX SERVICE EXPANSION

Since the Post Office telex system was converted to automatic operation in June 1966, expansion has been rapid. Figures for the first nine months of the year indicate that the growth rate is now approximately 850 subscribers/annum, as compared with 257 for the last year of manual operation. The service now connects approximately 3,000 subscribers in Australia who have access to the international network through the international exchange operated at Sydney by the Overseas Telecommunications Commission, Australia, to approximately 250,000 subscribers in other countries.

Although exchanges are located in the capital cities and a few large provincial centres, subscribers can be connected to the system from any part of Australia covered by the Post Office line network. Subscribers at remote points are charged as if an exchange exists in their area even though the actual subscriber connection may be taken some hundreds of miles to an exchange, most often using a channel of a voice-frequency telegraph system for the major portion of the connection.

The demand for telex services in remote areas such as the north west of Western Australia, where conventional line communication plant is not available, has presented problems. The Postmaster-General's Department is now seeking error detection and correction equipment suitable for use on sub-standard telex subscriber circuits provided over low-power radio circuits. Equipment of this type will be used to provide an interim service until standard quality communication links become available.

MANUAL TRUNK SWITCHING DEVELOPMENTS IN AUSTRALIA

*L. M. WRIGHT, B.Sc., A.M.I.E. Aust.**

INTRODUCTION

This article is the first of a series of five on recent developments in manual switching of trunk traffic in Australia. In this article the present and expected demand for manual switching service will be reviewed, the equipment available will be surveyed and the decision to proceed with two new developments will be set against the background of the alternatives considered, the timing and integration problems, and the likely cost of alternative developments. Chamberlain and Elliott (Ref. 1.) discuss the operating and technical facilities required by the A.P.O. in manual switchboards and Chamberlain (Ref. 2) describes the 4-wire cordless switchboard being developed by L. M. Ericsson for the A.P.O. Future articles will describe (i) a 4-wire cord-type switchboard being developed by the A.P.O. and, (ii) the physical design of the switchboard operating consoles.

PRELIMINARY CONSIDERATIONS

Methods of Handling Trunk Traffic

Apart from isolated experiments, until 1940 all trunk traffic was handled in Australia over trunk lines terminating at both ends on manual switchboards. This meant that on every trunk call an operator was used in the originating exchange area and in the terminating exchange area to handle the call. Operators at intermediate stations were frequently involved in setting up calls, and, although it was by then quite rare, the author has observed a call with six trunk links in tandem with manual operations at seven exchanges within the last 10 years. Since 1940, automatic switching equipment has been provided in the trunk network in increasing quantities, so that the operator at the originating network who accepted the trunk booking from the subscriber and recorded all the details of the call could then complete the call without further manual assistance. By 1960 approximately 90% of trunk traffic in Australia was being handled by only one operator. As a result of this and improved operating techniques, the number of operators in Australia has remained substantially constant for many years, while the trunk traffic has been increasing by at least 10% per annum.

Manual Switchboards in Use

Initially trunk lines were connected to magneto switchboards and the trunk operating load represented a small proportion of the telephonist's work. As the trunk network expanded, however, installations of special suites of manual positions for handling trunk traffic became necessary in the larger centres. During the last 30 years or so, these have been mainly CB sleeve control cord-type switchboards, but some semi-automatic 4-wire cordless switchboards have also been used.

Four-wire Switching

From a transmission viewpoint 4-wire switching of 4-wire trunk circuits is desirable. The sleeve control switchboard was designed to permit this, but the 4-wire switching operation required the use of two pairs of cords. In practice, operators have rarely used this facility after they have discovered that the call could be completed using one pair of cords only; the transmission impairment was not obvious to the operator, and if circuit instability was encountered this was usually recorded as a trunk line fault. The switchboards have therefore been used almost entirely as 2-wire switchboards. The cordless semi-automatic positions used were of A.E.I. design (formerly Siemens, London) and provided 4-wire switching where required. They have been very successful in practice both as regards operating facilities and from an engineering viewpoint. They are closely tied to the motor uniselector switching technique and also the 2VF trunk line signalling technique developed by A.E.I. Because most of the automatic trunk switching and signalling equipment installed in Australia between 1940 and 1960 was of A.E.I. design, the CB sleeve control switchboard was also designed to be compatible with this trunk switching equipment.

Effect of Crossbar Switching Decision

Inherent in the broad decision to introduce crossbar switching equipment in Australia was the intention to cater for the expansion of automatic trunk switching in the network with crossbar equipment. Because 4-wire switching is required at secondary and higher order switching centres, the use of the CB sleeve control-type switchboard for the complementary manual switching was not attractive. The use of the A.E.I. type switchboard specifically designed to fit in with motor uniselector switching was not attractive either in situations where the bulk of the trunk switching would be carried out with crossbar equipment. A complete review was therefore made of the manual switching requirements of the Department, resulting in the development of two new types of manual switching equipment, each being suitable for use with both old and new trunk switching equipment and each giving 4-wire switching.

Likely Demand and Field of Use for Manual Switching

Even if the number of operators in the Australian network were to remain relatively constant for many years to come (and there is no justification for an unqualified assumption that the manual switching load will remain static) there would still be a demand for new switchboards. One reason for this demand is that replacement of equipment which has reached the end of its economic life is often necessary. A second reason is that it is often necessary to relocate manual switchboards now located in Post Office buildings to provide for growth of telecommunication and/or postal services. A third and major demand for new switchboards arises from the increasing centralisation of manual switching; larger suites of manual positions are generally installed at the higher order centres, while older manual suites (often magneto switchboards) at the smaller centres surrounding it are closed, particularly when the smaller areas are simultaneously converted to automatic working.

A first order estimate of the likely demand for new positions made about three years ago suggested that approximately 1,500 new manual switching positions would be required in Australia within 10 years. More detailed examination during the last three years of the needs of specific manual centres indicates that this estimate may well be low.

Location of Manual Positions

Detailed studies of particular areas generally suggest that manual switching centres at the secondary switching centre should serve the whole secondary area. In some cases further centralisation to higher order centres serving several secondary areas and possibly several numbering areas appears justified. This gives rise to some interesting problems in ensuring that the telephonists will correctly docket the calling subscriber's number; these possibilities have been taken into account in the detailed design of the equipment. In a few cases retention of manual service centres at minor switching centres is justified by special circumstances such as relative isolation of the area.

A small switching centre is not economic from a staffing viewpoint, but conversely a very large centre having more than about 300 to 400 operators gives rise to special staffing problems also. The optimum size from many points of view ranges between 20 and 100 positions, but because of the sparsely-settled nature

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of many areas of Australia there will still be many centres with less than 20 switchboards installed. It should be noted in passing that it is in these more isolated parts of Australia that serving more than one secondary area from the one manual switching suite is least attractive because of the danger of isolation of the subscriber from the point at which he may obtain manual assistance and to which he would normally report service difficulties. In trying to find the likely distribution of sizes of manual switching installations, the interplay of these various factors was not well enough defined for a clear distribution to emerge. It was clear, however, that some centres would require less than 15 positions even within a 15 to 20 year period, while others would require approximately 100 positions almost immediately, thus indicating the extremes likely to be encountered.

Timing Considerations

Apart from the numbers of positions required, the immediate demand for major installations at Newcastle and, to a lesser extent, Brisbane, exerted a major influence on the decisions made. At Newcastle a new telecommunications building is already being built at Hamilton, three miles from the existing manual switching suite housed in the Post Office building. The existing suite of 40 switchboards is nearly 40 years old and should be replaced because an uneconomic amount of maintenance is required. The space in which the manual boards are at present housed is required for postal purposes, and for transmission reasons the manual switching should be associated with the main trunk line plant which is now concentrated at Hamilton. Because of the obvious disadvantages of using manual switching equipment of earlier designs, this project has already been unduly delayed, and the earliest possible solution was desired for this particular project. In addition the Brisbane manual switching centre requires expansion and modernisation, whilst the need for expansion at Canberra has also emerged as a strong requirement.

When new designs of manual switching equipment were being considered, these timing considerations were a major constraint resulting in emphasis on providing a satisfactory solution quickly, rather than a more sophisticated or elaborate solution which would require a longer development time.

Integration into the Crossbar System

Another major constraint was the desire to use, if possible, the same switching equipment for S.T.D. and for manual trunk switching. The ARM trunk transmit switching system had already been selected for S.T.D., and it was therefore very desirable that the manual switching system be completely compatible with it. This would not be an overriding consideration in the larger centres such as Brisbane where a separate manual exchange would not result in greatly increased switching costs, but in smaller centres the establishment costs for two separate exchanges, one for S.T.D. and one for manual switching, would be significant and should be avoided. This meant therefore that no matter what form the manual switchboard itself took, it was highly desirable that the associated switching equipment be ARM 4-wire switching equipment of the L. M. Ericsson design.

Economic Consideration

In general cordless installations have a higher cost than cord type installations, but have a lower incremental cost per switchboard. In the early stages of the study of manual boards, the order of cost of these two different types of switchboards could only be set approximately and it was not clear whether either type of switchboard had a clear economic advantage over the other. However, it seemed probable that the cord type switchboard would be economic below 20 positions and the cordless would be economic above about 40 positions. It was therefore decided to develop our ideas further on both cord and cordless switchboards since it appeared likely that the cord type switchboard would be required in small centres and the cordless switchboard would be the only satisfactory switchboard from the economic and operating points of view in the larger centres.

When both cord and cordless switchboard developments had proceeded further it was possible to make a better comparison of probable costs, but there was still no clear indication that either would be the more economic. Indeed, it was apparent that a small error in estimating the costs of either type of switchboard would result in a big change in the crossover point in costs.

ALTERNATIVES CONSIDERED

For the cord type switchboard only one type of development was seriously considered. The previous method of using two cord pairs for establishing 4-wire calls was not entertained at all; it was decided to base the development upon the use of 6 part plugs and jacks which have been in service in Germany for some years. Consideration was given to using the switchboard in such a way that it would bridge across automatic equipment which would be used to establish the actual connections on a 4-wire basis, but this appeared to offer no cost advantage at all compared with a cordless solution. In essence, unless the plugs and jacks plus the operator's intelligence replace switching stages, there is no cost advantage in using a cord type switchboard. The choice thus fell naturally on a conventional 4-wire switchboard with the transmission path taken through the plugs and jacks of the switchboard. In the article on the cord type switchboard other more detailed choices made in deciding just how this switchboard would fit in with the existing network will be discussed, but at the stage of a broad selection of the type of switchboard to be developed, only the one solution was seriously considered.

Although the 4-wire cordless switchboard used in the trunk network had proved very satisfactory, it was realised that some overseas developments, and in particular the American Traffic Service Position (T.S.P.), offered attractive operating features. A study of all the information available on this development and others in many parts of the world was therefore made.

The American T.S.P. is quite different in basic concept from the cordless switchboards which we have used in Australia and which are in general use in Europe, and because of its general interest a little more detail is included on it. It was developed initially in one of the Bell system operating companies and has since been developed further in the Bell Telephone Laboritories. The Automatic Electric Company of Chicago has also developed an operating position which is similar in concept.

From an operating point of view the T.S.P. operator handles all types of calls, such as normal trunk assistance calls, coin telephone calls, reverse charge calls, credit card calls, and such specifically American types of service as the enterprise service in which large Department Stores advertise reverse charge arrangements on calls from specific areas. The operator only retains supervision of the call after it has been set up if she nominates this at the time. Ordinarily the call is completed through the switching equipment and the manual operating position is completely disconnected. Reference back to an operator may be made in special circumstances, e.g. when a coin call has run to the time limit allowed, but the call is not necessarily referred back to the operator who originally handled the call; some display of the status of the call and the charges involved is therefore required.

The position design is influenced a good deal by the very complex tariff structure in the United States where literally hundreds of separate charge rates apply for various calls. Some of the factors with which we do not have to contend are such things as city, State and Federal taxes levied on telephone calls, and financial arrangements set by independent Commissions, both State and Federal. Automatic toll ticketing is widely used in America and a major emphasis in the T.S.P. design is to get the charging data recorded in such a way that the automatic processing system associated with the toll ticketing can be used for processing the call charges. This alone was a reason why the T.S.P. could not be used directly in the Australian network; we do not have calling line identification equipment, and therefore the display and automatic recording of the calling subscriber's number would not be possible.

Another feature of the American T.S.P.s is that provision is made for the operating consoles to be separated by some miles if necessary from the switching equipment. It is understood that this feature is not used very often, but in some big cities it is very difficult to obtain operating staff willing to travel in the immediate vicinity of a downtown switching centre in the early moring or late at night.

An interesting adjunct of the T.S.P. is the provision of special training facilities. By means of a series of 20 punched paper programming tapes and associated speech on magnetic tapes, operators may be trained first with slow and simple calls, progressing to complex situations on the later tapes, finishing with very difficult cases, e.g. an obstreperous drunk demanding rather indefinite service.

PARTICULAR SOLUTIONS ADOPTED

In the long run the dominant considerations were:—

(i) that any solution should be available quickly;

(ii) that any solution must be closely integrated with the ARM exchange design.

As outlined above the cord type switchboard will be of conventional design using 6 part plugs and jacks. In order to produce a quick solution it was decided to proceed with this development using the Department's own design resources. Design commenced in fact before finality had been reached on some operating procedures; this was a calculated risk, and fortunately only minor changes were necessary part way through the design phase. It was initially intended that this new switchboard would be an adaptation of the previous CB sleeve control switchboard so as to minimise design time and effort. In practice, however, it was found fairly quickly that ready adaptation of the earlier design was not feasible and therefore the circuit design used completely new circuit elements. It was also envisaged in the early stages that the same sleeve control switchboard console would be used, but this too proved to be unduly restrictive and so a complete redesign of the console was also undertaken, particularly as this part of the work could be done in less time than was required for the electrical design.

For cordless switchboards, it was clear that only L.M.E. could reasonably be expected to produce a well integrated design within the time available since ARM equipment was not then in full scale production and the information available to the other companies on the ARM system was too limited for detailed design. Also because of the time factor it was decided to use the existing L.M.E. cordless manual positions with minimum change to suit Australian operating procedures and practices.

One major point of difference between L.M.E. practice and Australian practice was that L.M.E. do not recommend queueing of calls incoming to manual switchboards but prefer a call distribution technique which requires much less equipment. Australian experience with queueing systems, however, has been so satisfactory that the Telecommunications Division required that calls incoming to the larger manual switching suites be queued. Some other features such as caller-in-circuit and overlap operating which had been used here for many years and had given substantial operating economy were also different from L.M.E. practice.

At this stage, although the general pattern of the cordless switchboard appeared fixed, many trunking variations were considered; more detail will be included in subsequent articles.

SPECIFICATION OF TECHNICAL AND OPERATING FACILITIES

Once the broad pattern of development had begun to crystalise, the preparation of a detailed specification of technical and operating facilities required for both cord and cordless positions was undertaken. This apparently simple task required a great deal of discussion between the engineering and operating sections of the Administration. To enable the designer to proceed with some confidence, the general objective was to provide a clear statement of such things as the periodicity of flashing of lamps, and the types of key operations desired, and this in itself implies that an operating procedure has been clearly defined.

It was initially intended that separate specifications be developed for cord and cordless switchboards, but only one specification emerged as the differences were quite small.

STAGES OF DEVELOPMENT

The stages of development foreseen were that the specification should form a basis for a quotation on a cordless manual switchboard, and should be the design basis for the Department's team developing the cord type switchboard. It was proposed that the costs of the cord and cordless switchboard should be compared when a quotation had been received for the cordless board, and that one or other of the two developments should then be dropped. In the event, however, no clear difference in cost emerged and both developments are proceeding. The cordless switchboard will clearly be better in larger installations, but the cord type switchboard will be available sooner than the cordless, and there are several installations where a delay would not be acceptable, and the cord type switchboard has been accepted for these projects.

In the case of the cordless switchboard, when quotations were called the tenderer was requested to make alternative suggestions if his experience suggested that there were better ways of providing the facilities required. The equipment offered included many departures from the facility specification, and it was necessary for the Department to send an engineer to Sweden to discuss these in detail with the designers. These discussions in March, 1967, resulted in substantial agreement except on the nature of the switchboard operating console itself. Because of the relatively small demand for manual operating positions on the world market, the L.M.E. operating console has remained virtually unchanged for approximately 20 years, since it has provided for a wide range of operating facilities and is very durable in service. The A.P.O. considered, however, that it was desirable to have a more modern operating console, and ultimately decided to develop this within the Department and to marry it with the rest of the L.M.E. cordless design. It is not wished to overstress this particular factor; it so happened that in connection with the cord board design a manual switching console of modern design had already been prepared which, with a small amount of modification, would be suitable for cordless switchboard application and the opportunity was therefore taken to have a more up-to-date operating console.

MISCELLANEOUS SERVICE POSITIONS

All the foregoing refers only to the trunk assistance position, i.e. the position at which the subscriber books trunk traffic which he cannot complete or does not wish to complete. The whole question of other miscellaneous service positions to provide such things as telephone number information, service difficulty reporting etc., has only been studied in outline. This has arisen from the same timing constraint which led to the trunk assistance solution taking the particular form outlined above. Although it appears very easy to make quick and firm decisions about the technical and operating facilities required on miscellaneous service positions, there are considerable difficulties in the way of quick solutions to these problems. As a simple example, the positions for the recording of service difficulties encountered by the subscribers are influenced by many different factors such as transmission considerations, the numbering plan, the switching plan, the proper use of operating staff, timing of trunk calls and the particular practices already in use in various States. Elaborating on this a little; if the subscriber has to dial one number only to report difficulties encountered, and if it is desired to offer to him immediate connection once the difficulty has been noted, then trunk calls must be extended via these service positions. Since, in general, the manual operating centre will serve some outlying areas served by 4-wire circuits, it will therefore be necessary to extend some of these trunk calls on a 4-wire basis. However, only a 2-wire connection is necessary for the reporting of purely local troubles and there may be a case for suites of 2-wire and 4-wire service positions. The extension of trunk calls via these positions also raises the question of the charge to be applied; in fairness to the subscriber multimetering rates should apply for a call which he attempted to set up through the S.T.D. network but which was unsuccessful due to failure of Departmental plant. At the present time, however, the feeding of multimetering pulses over the circuits used from the step-by-step network to code 1100 would not be possible and therefore docketing of the call must be considered. From an operating point of view the question arises as to whether miscellaneous service operators should be expected to time calls or whether the whole call should be handed on to a trunk operator who will also be skilled in obtaining a call through the trunk network when the subscriber has been unsuccessful, i.e. when there is some possibility at least that some circuits are faulty or undue congestion has occurred. There will be other occasions when the operator will wish to use the priority features provided in the manual network, but in general it would not be economic to keep all the service difficulty recording staff trained in the special procedures for this purpose. Add to this the difficulty of reconciling the divergent views of the various State Administrations of the optimum way of handling service dificulties, and the problems of obtaining a satisfactory specification of technical and operating facilities just for this one particular miscellaneous service position are obvious. Similar considerations apply to some of the other types of miscellaneous service positions.

CONCLUSION

The developments outlined in this and the associated articles are in the nature of interim solutions only. With the development of the network more sophisticated switching techniques will become available and there will be better ways of providing more extensive services to the subscriber. However, the detailed development of the types of service to be offered and the operating services and techniques which would be satisfactory and the integration of these with the numbering, charging, switching, transmission and signalling plans of the Department will necessarily take some time, and it is to cover this interim period that the developments outlined have been put in hand.

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TECHNICAL NEWS ITEM

FIRST DIRECT SATELLITE TELECAST FROM NORTH AMERICA TO AUSTRALIA

Arrangements are being made to establish the first international satellite television relay between North America and Australia for a telecast of the proceedings during Australia's Special Day at the Universal and International Exhibition, EXPO '67, which is being held at Montreal, Canada.

The programme will begin at 1.45 a.m. Australian Eastern Standard Time, on 7th June, and may run continuously to about 9.30 a.m. The relay will be broadcast live over A.B.C. television stations in all States except Western Australia which does not have a television relay facility from the Eastern States. Commercial television stations have been invited to share the facilities because the event has been declared one of national importance.

The U.S. National Aeronautical and Space Administration has agreed to provide, free of charge, its communication satellite link comprising the ATS-B satellite with earth stations at Rosman, North Carolina, in the U.S.A. and Cooby Creek, near Toowoomba, in Australia. Both the satellite, which is in a synchronous equatorial orbit over the Pacific Ocean, and the earth stations form part of an extensive N.A.S.A. experimental programme called the Applications Technology Satellite Project. The Cooby Creek earth station is operated on behalf of N.A.S.A. by Amalgamated Wireless (Australasia) Ltd. under the control of the Department of Supply.

In North America, arrangements are being made for the hire of microwave links between Montreal and Rosman over a distance of approximately 1,000 miles.

The extension of the relay from the Cooby Creek earth station to Sydney will be over microwave systems provided jointly by the Australian Post Office and the Australian Broadcasting Commission. The A.P.O. broadband network leaves some gaps between Toowoomba and Sydney and these will be bridged temporarily by the use of portable microwave relay equipment. In order to guard against interruption of the relay on the Australian land section between Cooby Creek and Sydney, alternative relay links will be provided over critical sections of the route. In all, 1,000 miles of television relay will be established on the routes between Cooby Creek and Sydney, comprising 550 miles of A.P.O. broadband network and 450 miles of A.B.C. and A.P.O. portable relay equipment.

The programme will be relayed from Montreal to Sydney at the American standard of 525 lines 60 c/s and will be converted to the Australian 625 line 50 c/s standard by conversion equipment at the Gore Hill studios of A.B.C. The transmission of American standard television signals over the Australian relay network between Cooby Creek and Sydney creates some difficulties but tests recently carried out by the A.B.C. in conjunction with the A.P.O. have indicated that the difficulties can be overcome.

After conversion of the picture to the Australian standard of 625 lines the programme will be relayed to Brisbane, Melbourne, Adelaide and Launceston over the Post Office coaxial cable and microwave network, and from each of these cities it will be transmitted to all A.B.C. regional transmitters. It is likely that 34 national television stations in five States will broadcast the programme and over 6,000 miles of Post Office television relay will be used to distribute it from Sydney.

DEVELOPMENT OF CORDLESS MANUAL TRUNK ASSISTANCE EQUIPMENT

L. CHAMBERLAIN, Dip.P.A., A.M.I.E. Aust.*

INTRODUCTION

This article discusses the technical requirements for equipment to provide manual trunk assistance facilities as set out in Australian Post Office Specification No. 994 "Australian Manual Assistance Equipment", and in detailed specifications which have been prepared for individual items of equipment. It also describes a system using cordless positions developed to meet these requirements. The more general aspects of the project are discussed in a companion article in this issue (Ref. 1.) and the main operating requirements are given in another article in this issue (Ref. 2.). The design of the operators' desks will be dealt with in a future article.

The trunk assistance operating positions consist of operators' desks located in the manual exchange room, and relay sets and switching equipment installed in the associated crossbar automatic trunk switching exchange. Apart from the operators' desks, the equipment is based on existing L. M. Ericsson designs which have been modified to give special operating facilities such as overlap working, priority operation, and indication of the origin and category of calls, as required by the Australian Post Office. Special registers, in conjunction with the trunk exchange common control equipment, provide the signalling and the queueing facilities required on incoming calls and the signalling and control facilities for establishing outgoing connections. Standard ARM 20 4-wire trunk exchange selector stages are used for switching incoming and outgoing calls.

BROAD REQUIREMENTS

The basic problem was to develop 4-wire cordless trunk assistance positions to switching incoming traffic from local crossbar and step exchanges via operators to the S.T.D. trunk network and to provide access to and from the semi-automatic trunk network. The apparatus had to be developed quickly so that it could be manufactured and installed in time to meet certain urgent commitments. It had to be capable of interworking with Type ARM 20 crossbar trunk exchange equipment. More specifically the new equipment had to be trunked to meet the following conditions:—

(i) The equipment should interwork readily with crossbar trunk exchanges of the type to be installed at secondary and higher order switching centres, i.e., with ARM 20 exchanges.

(ii) All trunk assistance positions (and all connecting circuits) should be capable of handling demand and reverted trunk traffic.

(iii) 4-wire switching should be used throughout.

(iv) The main incoming access would be from local crossbar and step exchanges but incoming access from the S.T.D. trunk network and the semi-automatic trunk network was also required. (The semi-automatic (2VF) trunk network constitutes a major asset and, although it will not be extended, it will be used for operator dialled traffic for many years.)

(v) All incoming trunk assistance traffic should if possible be connected via a common queue with access to all positions.

(vi) Information regarding the origin of calls should be passed to the operating positions.

(vii) Outgoing access should be available to the S.T.D. trunk network and to the semi-automatic trunk network.

(viii) Priority access to the S.T.D. network should be possible.

(ix) International calls would be handled by special positions having access to the international network via the national S.T.D. trunk network.

(x) The system should be flexible enough for use at a continuously staffed trunk assistance exchange, a non-continuous assistance exchange, or at a point of concentration for after hours assistance traffic.

(xi) The system design should be flexible enough to allow additional devices offering further refinements in manual operating techniques to be introduced at some future date.

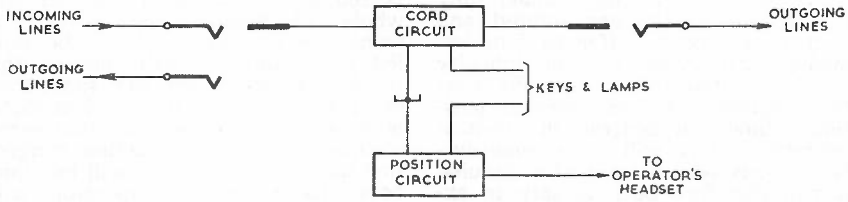

Fig. 1 — Cord Type Position.

DEVELOPING THE TRUNKING SCHEME

Basic Switchboards

Fig. 1 shows a simple cord type switchboard with incoming and outgoing lines appearing on jacks which can be connected together by cords and plugs; any cord circuit can be used for connecting incoming lines to outgoing lines (demand calls) and for connecting outgoing lines together (reverted calls). For economy the equipment which is used by all cord circuits is located in a common device termed "the position circuit". In Fig. 2. the cords and jacks have been replaced by automatic switches, and to economise in switching equipment, incoming access has not been provided on the "call" side of the "connecting circuit". This is not a restriction as incoming calls can be received on the "answer" side and outgoing calls can be made both on the "call" and the "answer" sides; demand and reverted calls can still be made from any connecting circuit. Each connecting circuit is provided with a set of control keys and supervisory lamps on the operator's desk which may be located some distance from the relay set equipment. As each operator can handle only a small number of simultaneous trunk calls, only a few connecting circuits are provided on each desk; the average traffic occupancy of the connecting circuits is low. The speech path traverses the connecting circuit relay set for the full duration of the call.

To increase the occupancy of the connecting circuits and to ensure that each position is offered a reasonable amount of the incoming traffic, the capacity of the automatic switching equipment on the answer side may be increased so that any connecting

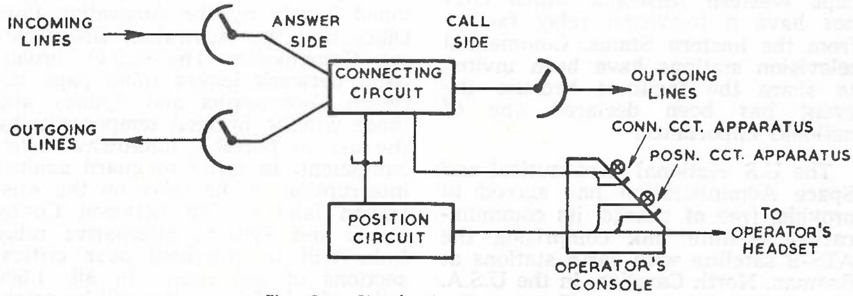

Fig. 2 — Simple Cordless Position.

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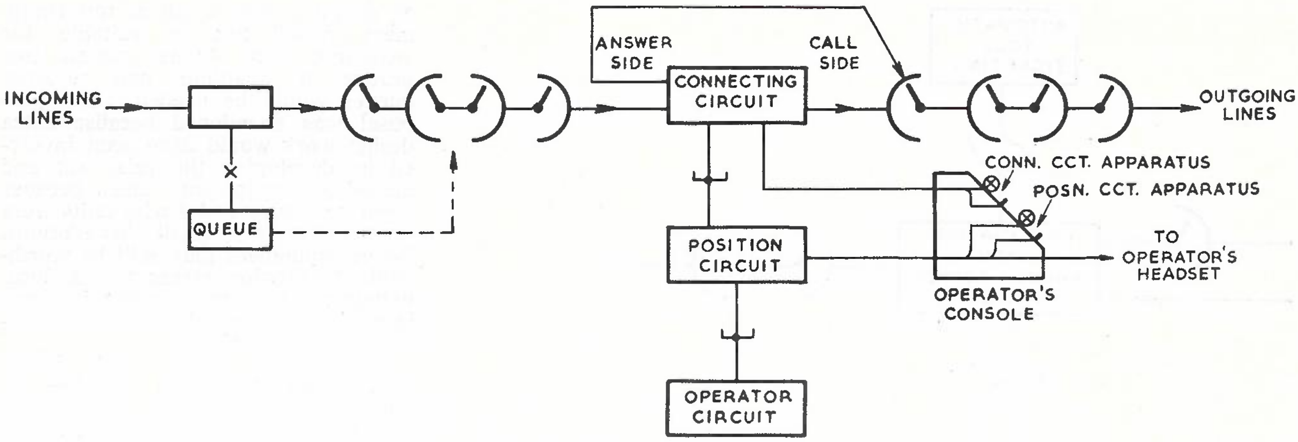


Fig. 3 — Large Capacity Cordless Exchange.

circuit on any position can be used to answer calls from any incoming line. Similarly the switching equipment on the "call" and "answer" sides can be extended to give access to all the outgoing lines. This is illustrated in Fig. 3 which is the basis of the current development. Other refinements shown include a queueing device to ensure that incoming lines are connected to the operators in order of arrival of calls, and registers associated with the position circuit to assist the operators in setting up outgoing calls.

Other Possible Approaches

A great deal of interest has been shown here and overseas in an American development often referred to as the Traffic Service Position and it is worth digressing to answer the obvious question "Why hasn't the Traffic Service Position trunking been adopted?"

In Fig. 4 a switch has been included between the speech path relay sets (links) and the operator's desk equipment to increase the traffic occupancy of the speech path relay sets. Superficially, this may appear to decrease the amount of automatic switching equipment required. but actually about the same overall number of cross points as in the conventional trunking are needed because the switching stage between the link circuit and the position equipment must consist of a multiwire coupler capable of interconnecting large numbers of devices; the control of the coupler must be fairly complex especially if devices such as queueing and reversion of calls are included.

The number of sets of equipment on the operator's desk can be reduced as shown in Fig. 5 if the operator is permitted to through-switch the link circuit and withdraw from the connection after each call has been established. (The use of this trunking scheme also reduces the cost of separating the operating desks from the trunk switching machine.) The provision of automatic charging equipment is a basic requirement of this scheme as otherwise the operator would have to supervise the call to completion. This implies some form of automatic toll ticketing equipment, as metering by means of periodic pulses is unsuitable for reverted calls and not very suitable for some types of demand calls; furthermore the transmission of metering pulses through the trunk switching machine to the originating exchange is not practicable on some types of connections and some of the older exchanges are not equipped to receive multimetering pulses.

The savings which can be achieved by installing automatic charging equipment and releasing the connecting circuits as soon as the calls have been set up are only marginal unless calling line identification is available or unless the subscriber is able to assist the operator to obtain the outgoing connection by dialling the called subscriber's number. Therefore although this type of trunking has been used successfully with the American Traffic Service Position, it has not been developed for the crossbar equipment in Australia, and the more conventional arrangment outlined in Fig. 3 has been adopted.

Queueing of Incoming Calls

Some administrations use equipment which distributes incoming calls to free trunk assistance positions in a somewhat random manner and, when all operators are engaged offers one further call to each position. With this system it is possible to achieve reasonably high operator loadings but the waiting time for answer may vary considerably from call to call. A refinement would be to offer a second call only if the first call has been connected to an operator for a considerable time.

Although a random distribution technique may be cheaper than using a special register for queueing incoming calls, the latter has been adopted as it is considered that the extra expenditure is justified to improve service. The use of queueing registers also provides a satisfactory technical solution to obtaining information on the origin of calls and passing it to the operators.

Most of the trunk assistance traffic enters the exchange via incoming relay sets associated with the queueing register and is connected to an oper-

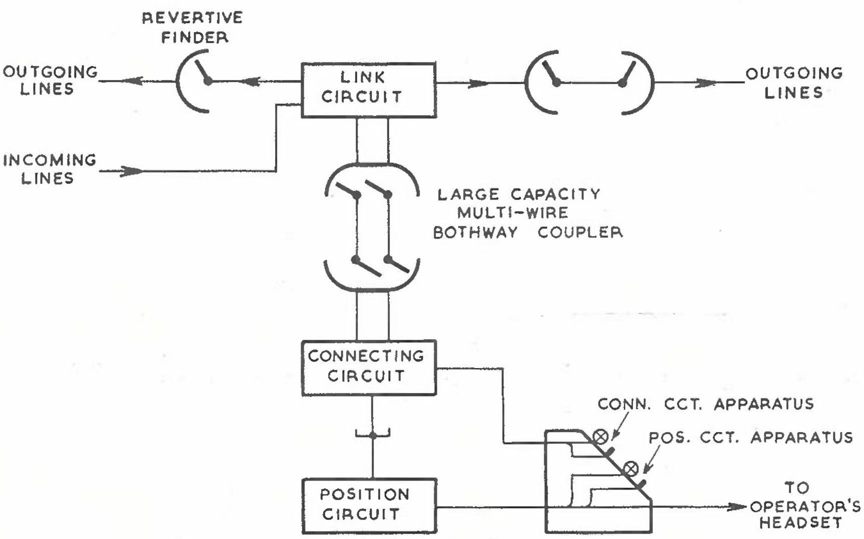


Fig. 4 — Cordless Position with High Occupancy Links.

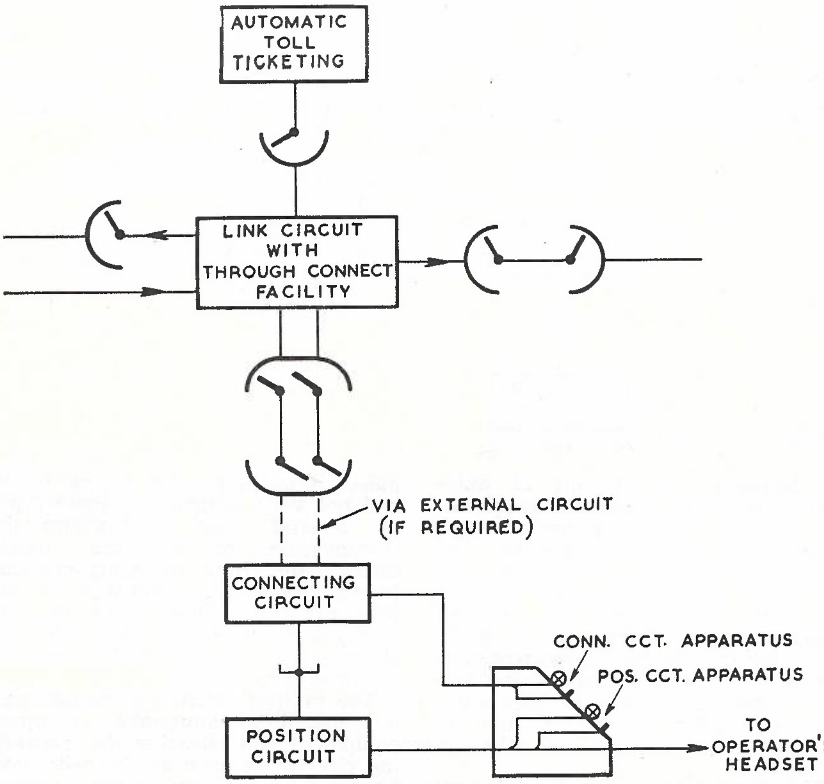


Fig. 5 — Traffic Service Position.

ator by a single switching operation (4 partial stages) although the traffic which enters the switching machine on general purpose S.T.D. junctions may traverse two switching stages (8 partial stages) before being connected to an operator. As only a small portion of the trunk assistance traffic requires two passes through the switching equipment for connection to an operator, the use of special queueing registers as outlined above is fairly economical. The use of a number of switching stages in tandem on incoming assistance calls could have been avoided by building queueing into the general purpose registers which serve S.T.D. traffic, but this would have increased the cost of all registers in the trunk exchange for the sake of a small fraction of the traffic; the more expensive registers would have been held for long periods while calls were waiting in the queue and congestion on the manual exchange could have been reflected to the incoming S.T.D. lines; any saving in selector stages would have been out-weighed by the extra register costs. Alternatively, a queueing device could have been associated with the incoming S.T.D. line relay sets; the registers would not have been held for long periods but would have been recalled when required to switch the call to the operator; this too would have been uneconomical because the cost of the line relay set and the coupling equipment would have been increased. Another obvious queueing technique considered was to switch the call to a queue device and subsequently to re-switch it to the operating position by "jumping" from the queue device to the operator's connecting circuit; this technique has not been used as the "jump" capability was not immediately available in the standard ARM switching equipment.

Use of ARF Type Crossbar Equipment

Before it was decided to use ARM type switching equipment with the connecting circuits, several other arrangements were considered in the hope of finding a cheaper way of meeting all the requirements. On the "call" side it soon appeared that ARM type equipment offered the most convenient means of providing 4-wire access to common outgoing trunk circuits, jointly from assistance positions and from the S.T.D. subscribers. On the answer side of the connecting circuits, 2-wire ARF GV equipment could be used for switching calls from the local network if connecting circuitry were developed as shown in Fig. 6, but as this equipment would not be suitable for switching from 4-wire trunks, two groups of positions and separate queues would be needed. The proposal was abandoned because extra design work would have been involved in developing the relay set and queueing equipment and because separate 2-wire and 4-wire units were unattractive for small installations. 2-wire equipment may still be worthwhile to provide access to the local network for reverted traffic in some large installations, but the cost advantage is marginal.

Development of an ARF 4-wire group selector stage capable of queueing calls was also investigated but the scheme was deferred because the available design resources were already fully committed and only a relatively small number of units would have been required initially.

THE DEVELOPED SYSTEM

Physical Considerations

The manual trunk assistance operating positions consist of desks on which keys, timers and lamps for up to six connecting circuits can be mounted. Push buttons are used for key functions which are common to the whole position, but lever keys have been specified for the individual connecting circuits as it was hoped that this would reduce the time required for design work by avoiding the redesign of some equipment. The timers are of a standard B.P.O. pattern which provides the desired timing intervals.

The desk equipment is connected to relay sets located in the automatic trunk exchange room by cables which, in the first installations, must have a single wire resistance not exceeding 50 ohms. Later designs should allow this limit to be increased to 200 ohms to permit the consoles to be located further from the automatic trunk exchange, although it is recognised the penalty for using separate locations may be prohibitive except for large city exchanges as it involves about 150 wires per position.

The relay equipment consists of connecting-circuit relay sets (SNOR-U) and position circuit relay sets (OPR-U) which have access to the operators' registers (Reg-OA) via register finders. The connecting circuit and position relay sets are linked also to the ARM common control equipment and to miscellaneous equip-

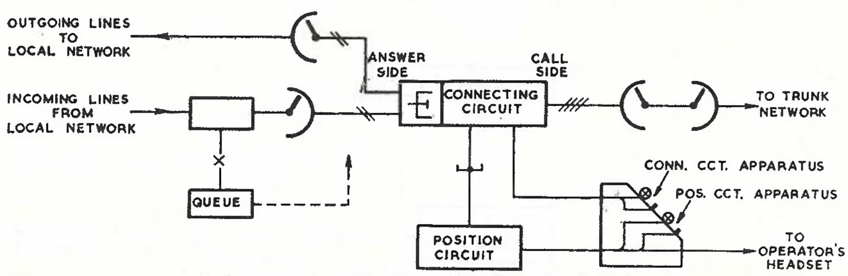


Fig. 6 — Suggested 2-Wire/4-Wire Positions.

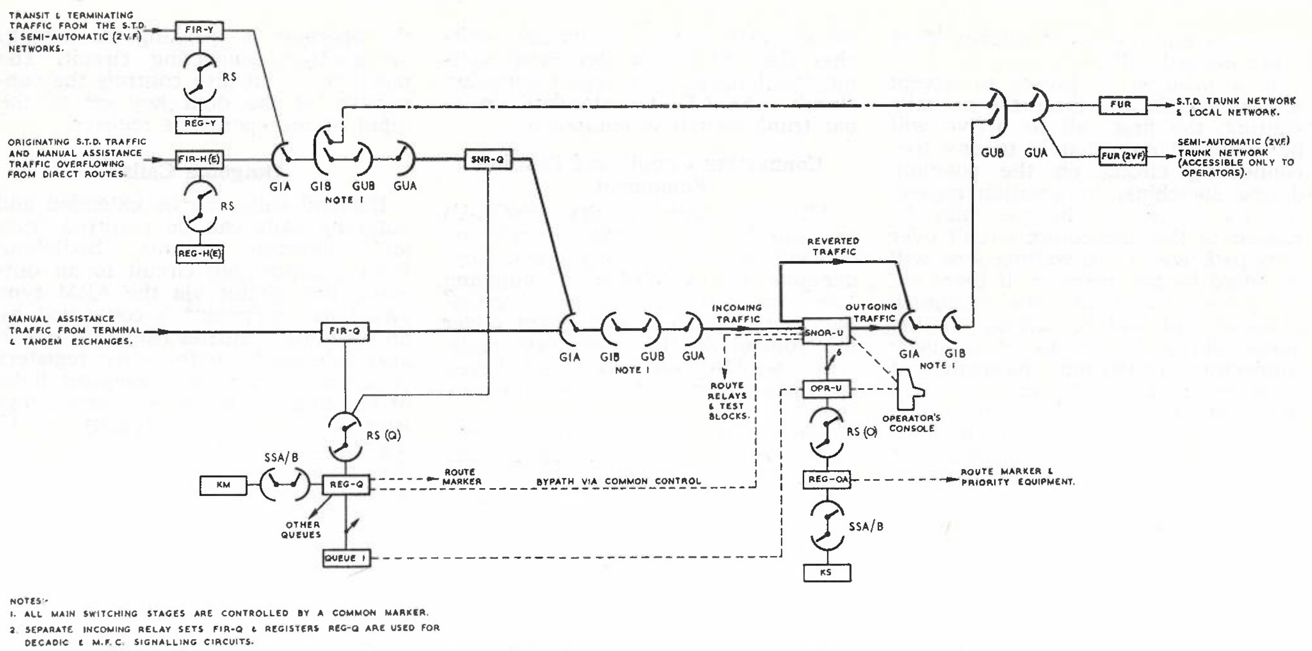


Fig. 7 — Manual Trunk Assistance — Basic Trunking.

ment on the delay supervisor's console.

Each connecting circuit employs one inlet and one outlet for demand traffic and an additional outlet on the answering side for reverted traffic. The design allows each position to be equipped with six connecting circuits, depending on the nature of the traffic and a fully equipped position usually requires approximately 16 inlets to the automatic trunk exchange and 10 outlets from it (including 4 FUR outlets to trunk lines).

The Actual Trunking

The trunking scheme which has been developed for the new trunk positions is shown in Fig. 7. It was adopted because it appeared to be the cheapest way of meeting the broad requirements set out above, with the available crossbar technology and without engaging too large a proportion of the available design resources. Some of the advantages are:—

(i) The operating position equipment, connecting circuits, position circuits and queue control etc., use well known techniques for the basic functions.
(ii) The equipment can be readily integrated into the S.T.D. network as it employs standard trunk switching apparatus operating on a directional 4-wire basis.
(iii) The large availability ARM 20 switching device with 4 partial stages (and the grouping of all the free connecting circuits as a single route), allows calls to be connected from any incoming line to any operating position, thereby avoiding in most cases the need for multiple queues and "link" positions.
(iv) The use of queueing registers to control the switching of incoming calls to the positions allows traffic from a number of assistance services to share a common group of incoming junctions and provides a convenient point for obtaining information regarding the origin and category of calls from crossbar sources.
(v) The use of a common switching stage for S.T.D. and manual assistance traffic should ensure economical utilisation of equipment particularly in the smaller exchanges.
(vi) The equipment design will permit the addition of facilities such as automatic charging without much difficulty.
(vii) The operating positions can if necessary be separated from the trunk switching machine by means of cables (or perhaps ultimately by data links).

Some disadvantages of the scheme are:—

(i) It uses a large number of automatic trunk exchange inlets and so tends to reduce the number of inlets available for S.T.D. traffic. (This factor is not very serious as the number of lines which can be connected to an ARM exchange is determined by the traffic capacity of the trunk switching equipment; the inlets used for trunk assistance traffic have a very low occupancy and tend to compensate for high occupancy trunk inlets, so reducing the average inlet loading.)
(ii) It is rather expensive for switching 2-wire traffic, e.g., traffic to information positions.
(iii) It is not the ideal arrangement if the manual assistance and the automatic trunk exchanges have to be installed a long way apart as a large number of cable pairs is needed.
(iv) The ARM common control system is designed primarily to handle S.T.D. traffic; it might be easier to provide other special facilities for reducing operator effort at large assistance centres if an independent switching and control system were used.

Equipment Used on Incoming Calls

Incoming calls from local subscribers' exchanges are offered primarily to junctions served by special incoming relay sets (FIR-Q). (Routes to FIR-Q from local terminal and tandem exchanges are not usually allowed to overflow via the backbone S.T.D. route.)

Traffic from exchanges not having direct routes, overflow traffic from remote subscribers' exchanges and traffic from distant trunk exchanges enter the trunk assistance exchange via the normal S.T.D. incoming relay sets to be switched to internal relay sets (SNR-Q) via the normal trunk switching equipment.

The incoming line relay sets (FIR-Q) and internal relay sets (SNR-Q) have access to queueing registers (Reg-Q) of which there are two types, Reg-Q1 for use with m.f.c. signalling lines and Reg-Q2 for decadic signalling lines. The queueing registers examine the address information and if necessary store the calls in sequence.

A single group of queueing registers may control the switching of calls to a number of services on a queued or non-queued basis and may have access to a maximum of four different queues depending on how many separate services require queueing, e.g. intrastate, interstate, international, information, etc. Specially marked calls such as calls from overseas operators may be given priority over other queued calls.

If a position is preset to accept incoming calls and there are no calls waiting, the first call to arrive will be switched immediately to any free connecting circuit on the position; during switching, information regarding the origin of the call may be passed to the connecting circuit over a by-path and a call waiting tone will be heard by the operator. If there are no preset positions, the queueing register will obtain access to the queue device by means of a queue connector, consisting basically of crossbar switches. The call will wait in the queue and receive ringing tone from the queueing register until an operator indicates she is ready to take a call by operating the call acceptance key; the call at the head of the queue will then be switched to any free connecting circuit (SNOR-U) on the position and origin information may be passed to the connecting circuit over the by-path. When the appropriate queue is full, subsequent calls for the particular service will receive busy tone or a verbal announcement.

The objective is to have only one queue for each service because division of an exchange into small sections each served by different queues reduces the trunking efficiency of the automatic equipment and makes it extremely difficult to keep the operating load balanced over all staffed positions. In practice the size of position groups will be limited by the circuit techniques available for sequential switching of calls from a queue; the most serious problem foreseen is the time required to take a call from the queue as this determines the time for recovery from queue overload. It should be possible to couple a queue to at least 40 positions and preferably to 100 or more but in some large exchanges it may still be necessary to divide the exchange into several groups. In such a case it is possible to arrange a common group of queueing registers to distribute traffic evenly into several queues each handling the same class of traffic and to give the exchange supervisor some control over the distribution of calls to the different queues to simplify staffing changes.

Only one call acceptance key is provided on each position. Usually the call acceptance key allows calls to be taken from only one queue, but to improve staffing efficiency in some large exchanges, equipment will be available to allow a call to be taken automatically from a second queue if there are no calls in the primary one. For example, a position arranged to accept trunk assistance traffic from distant operators may be required to accept calls from subscribers when there are no calls from operators waiting to be answered.

When an operator in the required group of positions becomes free, the queueing register, in conjunction with the common control equipment, switches the call which has been waiting the longest to a free connecting circuit (SNOR-U) via standard crossbar trunk switching equipment.

Connecting Circuit and Position Equipment

All connecting circuits (SNOR-U) are suitable for setting up calls on demand or for reverting them. Connections are established to outgoing line circuits (FUR) via normal crossbar trunk switching equipment under the control of the operators' registers (Reg-OA) on receipt of keyed information from the operators' key sets.

The main interconnections of the 4-wire transmission path between the connecting circuits and the operator circuit and between the connecting circuits and the operators' register are shown in Fig. 8. Speaking access for the operator is obtained by diverting the directional 4-wire transmission path through the connecting circuit so that it passes through the position relay set. This simplifies connection to the operator on a speak-both basis and permits the circuit to be divided easily. For overlap (monitoring) access, the operators circuit is bridged across the connecting circuit path on a 4-wire basis. To connect the operators' registers to the connecting circuits, by-path connections are also provided via the position circuit. This prevents speech interfering with the signalling and allows the signalling to continue while the operator is speaking (or keying) on another connecting circuit. The position circuit also controls the connection of the digit key set to the input of the operator's register.

Outgoing Calls

Demand calls can be extended and outgoing calls can be reverted from all connecting circuits. Switching from a connecting circuit to an outgoing line circuit via the ARM type switching equipment is controlled by an operator's register (Reg-OA) which also interworks with other registers required to establish subsequent links of the connection. The operator's register has a storage capacity of 15 digits; this gives a margin of one digit over the longest national or international number foreseen. International calls will use the special digit fifteen for access to the out-going international exchange, and this will be followed by a language digit and up to twelve digits for country code and national code. Some national calls which leave the S.T.D. switched network and enter the semi-automatic (2VF) system may also use number lengths of up to 14 or 15 digits. Digits are keyed into Reg-OA from the operator's digit keyset, and the end of keying is indicated by operation of the "finish" key.

For reverting calls, it is possible to connect two registers simultaneously to a position relay set (OPR-U), one on the call side and the other on the answer side.

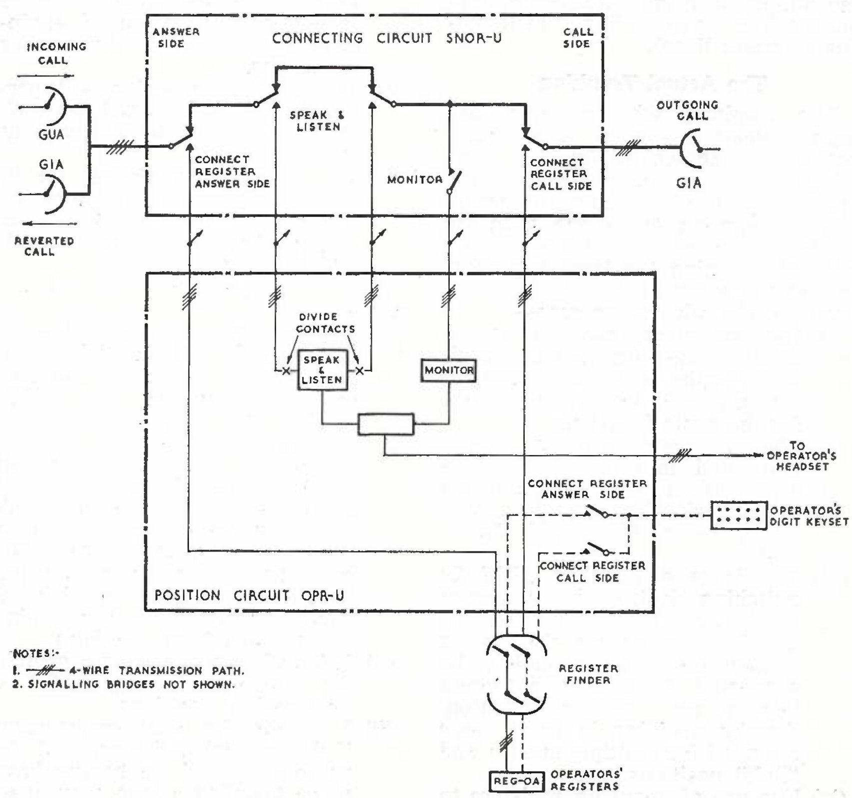


Fig. 8 — Trunk Position Equipment Speech Path and Register Connections.

Equipment Used on Priority Calls

Equipment can be provided to allow outgoing calls to be established to particular routes on a priority basis. The facility will be available only to operators and only on specially equipped routes, initially routes to trunk-distance switching centres. The use of the facility will be controlled from the supervisor's console. The priority apparatus will be mounted on special relay set racks which will be associated with the trunk exchange route markers (VM). Similar apparatus can be provided in distant ARM exchanges to allow subsequent links of a call to be set up on a priority basis on receipt of a special m.f.c. signal from Reg-OA.

SIGNALLING

Information Signalling on Incoming Calls

Two types of queueing registers have been specified, register Reg-Q1 which receives information signals in m.f.c. form and register Reg-Q2 which receives decadic pulses. Incoming calls will usually be trunked via crossbar trunk local, tandem or trunk switching equipment to register Reg-Q1, and m.f.c. signalling will be used to pass the address information to the queueing register. Register Reg-Q1 will call for the category of the originating line and the national prefix of the originating area if required; m.f.c. signals have been reserved in anticipation of calling line identification but additional equipment will have to be installed at the originating exchange and at the manual assistance centre before this facility can be provided.

The signals used on a typical call are shown in Fig. 9. (The designations given to special m.f.c. signals, in this article, are provisional, as some changes to the present m.f.c. signalling system have been anticipated e.g., transfer of the decadic impulsing control signals from the "3A series" to a new "4A series"; the main aspects of the revised signalling scheme have been finalised but some details are still under discussion).

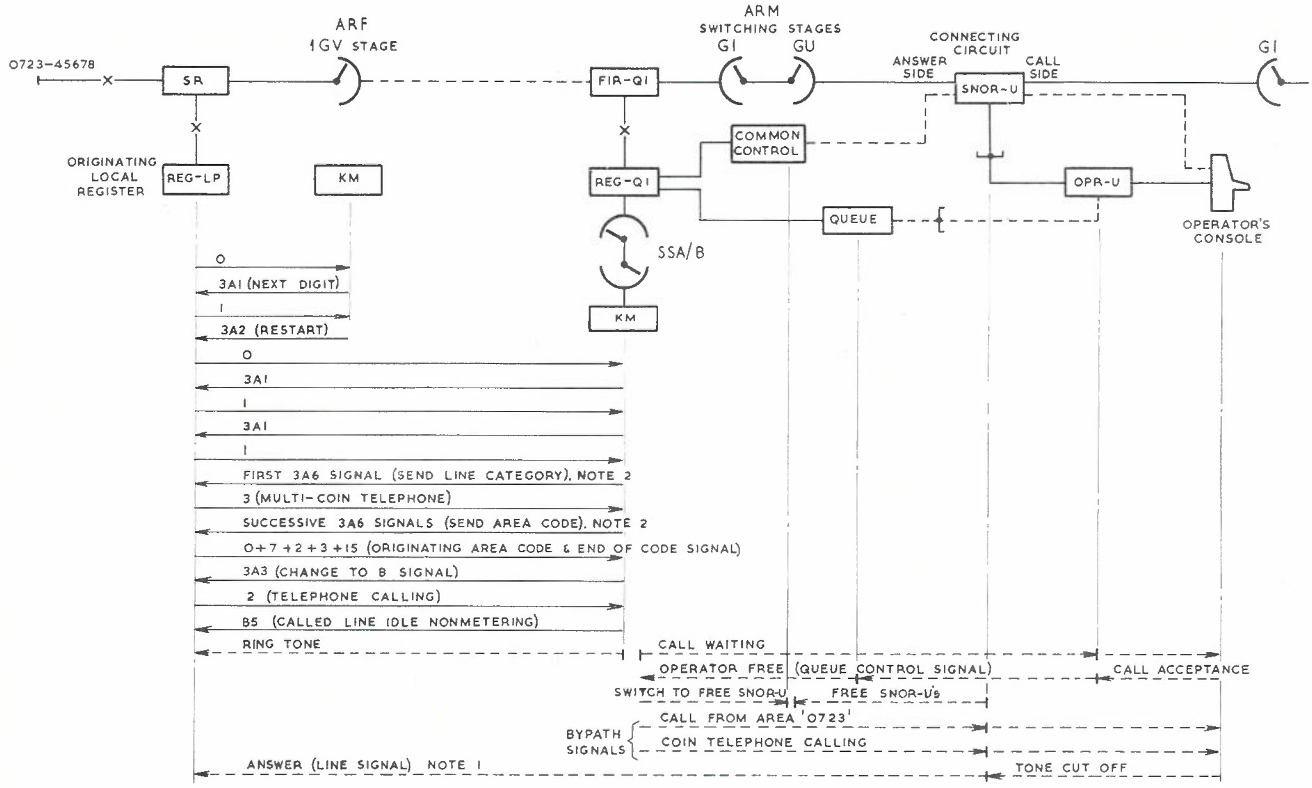
Calls from step exchanges will normally be trunked via the S.T.D. crossbar trunk exchange to register Reg-Q1 unless there is sufficient traffic to justify a separate group of registers (Reg-Q2) to receive decadic pulses. As Reg-Q2 can receive only the last part of the address information, it must be able to reinsert various combinations of digits corresponding to the digits used up in the step-exchange trunking, as indicated by d.c. marks from the line relay sets. Register Reg-Q2 cannot receive category information and therefore on calls from step exchanges the operators must rely on special tones from the originating exchanges for coin-telephone identification.

During the switching of a call to an operating position, a by-path is established from the queueing register to the connecting circuit. At this stage, this will be used to distinguish one out of six originating numbering areas and to indicate the category of the call. Initially the only category information transmited over the by-path will be whether the call has originated from an ordinary subscriber's line, a coin telephone, or an operator.

When the equipment serves only one closed numbering area, some of the special m.f.c. signals may be omitted as it is not necessary to transmit the national access code of the originating area from the calling exchange.

Information Signalling on Outgoing Calls

Outgoing calls must be set up by operators using digit key sets. The keyed information is passed to register Reg-OA which controls the switching to the outgoing lines. Register Reg-OA then passes information signals to the distant exchange equipment using m.f.c. signals or decadic pulsing. Special m.f.c. signals are used



NOTE:-
1. IN CERTAIN CASES THE ANSWER SIGNAL IS TRANSMITTED AUTOMATICALLY ON OPERATOR ANSWER.
2. PROVISIONAL DESIGNATIONS, IN ANTICIPATION OF CHANGES TO THE M.F.C. SIGNALLING SCHEME.

Fig. 9 — Outline of Signalling on Incoming Call. Typical call when multi-coin telephone 0723-45678, (connected to crossbar exchange in 0723 numbering area) dials 011 (Trunk assistance).

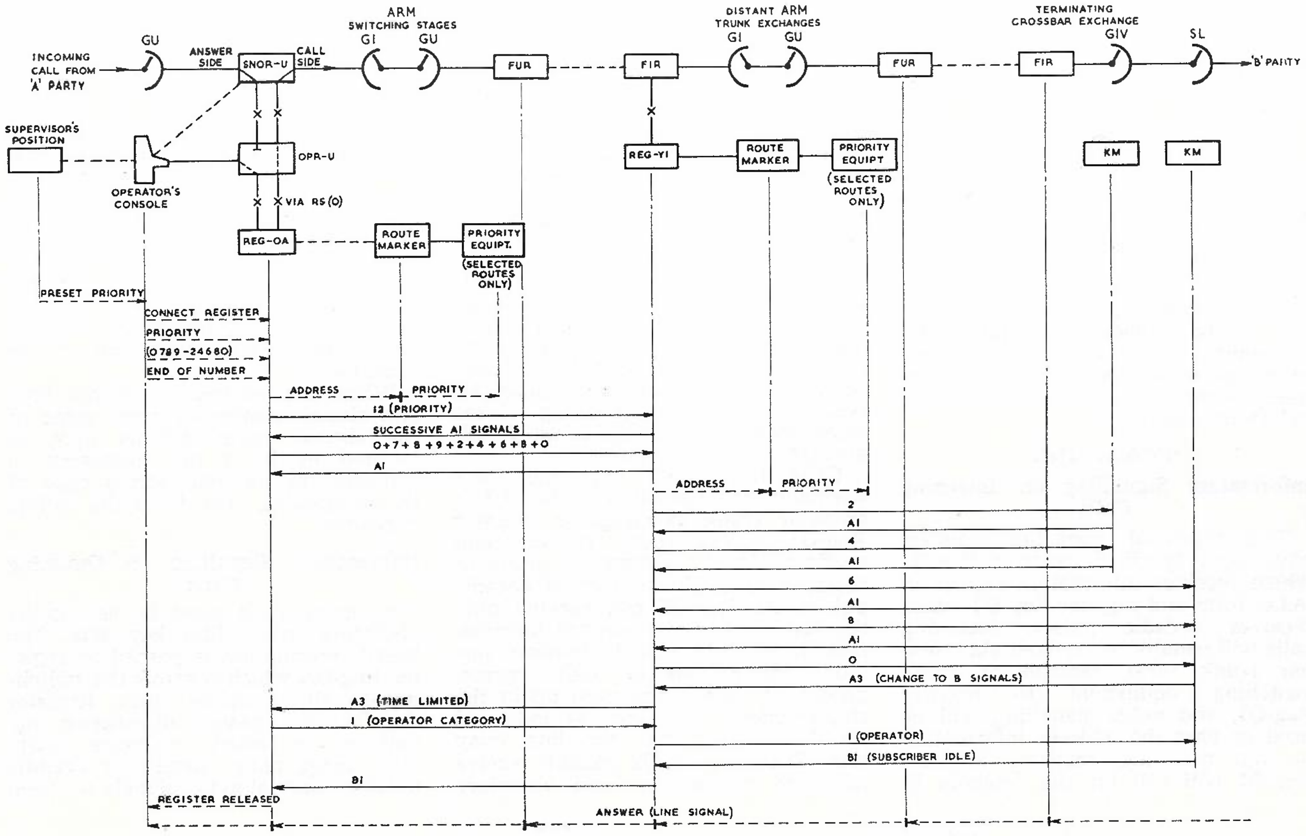


Fig. 10 — Signalling on Outgoing Priority Call to 0789-24680.

on calls requiring echo suppressors. If priority operation is required on the call, the single m.f.c. digit twelve is transmitted from Reg-OA ahead of the address information. The signals transmitted on a typical priority call are shown in Fig. 10.

If a call is to be routed via the semi-automatic (2VF) network the operator will use a special 2-digit access prefix, 1X (where X = 2 to 9), in lieu of the S.T.D. national access code, to route the call through the S.T.D. network to an appropriate exit point for connection to the 2VF equipment. The access prefix will be followed by further routing digits and by the subscriber's number. All the digits required by the 2VF equipment will be converted from m.f.c. to decadic pulses by register Reg-Y1 at the last S.T.D. exchange on the connection, and forwarded in the loop disconnect mode.

Calls to overseas countries are handled on special positions equipped with extra digit keys for sending the special digits 11, 12 and 15 to register, Reg-OA. Digits 11 and 12 are used for special routings to assistance operators in the country of destination, and digit 15 is used as an access code through the Australian crossbar trunk switching network to the automatic outgoing international exchange. The operator's register also transmits the special digit 15 as an "end of number" signal on international calls. The signals proposed for use on a typical call to an international subscriber are as follows:—

— access digit 15 (for routing to the outgoing gateway exchange),
— followed by category digit 1 — call originated by operator (in answer to 3A6),
— followed by the country code (1, 2 or 3 digits in response to successive A1 signals),
— followed by the language digit (in response to signal A1),
— followed by the significant number of the called subscriber (in response to successive A1 signals),
— followed by the end of number signal — digit 15 (in response to A1),
— followed by digit 1 — call originated by operator (in response to A3),
— which is answered by signal B1 (called line idle).

Line Signalling Mode

Several incoming line relay sets (FIR-Q) have been specified to suit the types of direct incoming circuits likely to be used e.g. 2-wire physical circuits from ARF exchanges, carrier circuits from ARF exchanges, and 2-wire physical circuits from step exchanges. Interworking relay sets are also being developed to provide connection to and from the semi-automatic (2VF) network. The normal S.T.D. incoming and outgoing relay sets are also used on some assistance calls.

Normal ARM exchange internal line signals are used for signalling between the incoming or outgoing line relay sets and the relay sets associated with the operating position. Separate forward and backward signalling paths are derived over the 4-wire transmission path, and signalling is accomplished by interrupting the signalling leads for short (150 ms.) or long (600 ms.) timed intervals. The incoming and outgoing relay sets convert the internal line signals to the appropriate signalling mode for the particular incoming or outgoing line.

Line Signalling on Incoming Calls

On incoming calls from subscribers and coin telephones, the line signals used are "seizure" and "clear forward" in the forward direction, and "answer" and "forced release" in the backward direction; "meter pulses" from metering services can also be transmitted through the direct incoming relay sets. In areas where all subscribers have access to the S.T.D. network, the answer signal will normally be transmitted when the operator first enters the circuit, but in areas where some subscribers' equipment is not capable of receiving an answer signal separate and distinct from the metering signals, the equipment will be strapped so that the answer signal is sent only if the operator presses the "tone-cut-off" key. (One of the functions of the answer signal is to remove coin telephone identification tone on calls from step exchanges.) The forced release signal will be sent when the operator presses the appropriate release button. (On some calls the actual release of the connection may not take place immediately after the forced release signal is received.) On calls to metering services e.g. phonograms, the meter pulse is generated in the relay set associated with the particular service.

On incoming calls from distant operators the forward line signals are "seizure", "forward transfer" (to recall the operator), and "clear forward"; the backward signals are "answer" and "clear back". Normally the answer and clear back signals indicate the condition of the called subscriber's line but it will be possible to strap the equipment to send the forced release signal when the operator presses the appropriate release button.

Line Signalling on Outgoing Calls

The forward line signals used on outgoing calls are "seizure", "forward transfer", and "clear forward". The equipment is capable of receiving the "answer", and "clear back" line signals but it transmits them through the switchboard to the incoming line only on calls originated by distant operators.

TRANSMISSION

A policy has been established that new manual trunk assistance exchanges must meet the transmission standards adopted for S.T.D. calls. As the great majority of assistance exchanges will be at secondary or higher order switching centres equipped with crossbar automatic trunk switching exchanges, the equipment must provide a directional 4-wire transmission path through the trunk assistance exchange. These requirements can be met by using normal ARM trunk switching equipment as described by Wright (Ref. 3), but two problems peculiar to manual assistance traffic arise:—

(i) the differing transmission levels encountered at the manual switchboard connecting circuit require special action to ensure that the operator can speak and monitor at the correct levels (whether the circuit is split or in the through condition.)

(ii) there is an increased loss involved in the additional switching stages and relay sets in the through connection. For S.T.D. traffic, only one connection through the switching multiple is necessary, at least until the exchange becomes very large. With the manual assistance call, at least two (and in some cases three) connections through the switching stages are necessary, thus involving up to 12 partial stages.

The ARM S.T.D. exchange uses directional 4-wire switching as a basic transmission pattern but one switching case, that of the interconnection of two 2-wire circuits, involves bi-directional transmission of speech over the 4-wire switched path. For this particular connection, a marginally greater transmission loss is accepted, and correct poling in the speech path is necessary on all connections because of the possibility of bi-directional transmission; a reversal within the pair in either of the two 2-wire paths through the exchange would introduce a high transmission loss. In addition, the connection of 2-wire circuits as well as 4-wire, results in differing levels at the switching point on different connections.

The basic difficulty encountered in the development of the trunk assistance equipment was that any 2-wire circuit without amplifiers in the 2-wire paths would give rise to bi-directional speech on one or other of the 2-wire paths through the exchange, and in the 2-wire to 2-wire case there would be bi-directional speech transmission on both 2-wire paths, whereas the interconnection of two amplified circuits would give undirectional transmission on both speech paths. This would give rise to some difficulties in adjusting the levels to and from the operator. If the operator spoke and listened at points of +1dBr transmission level, speech from a 2-wire circuit might be received at the two inputs to the position circuit at +1dBmO and -7dBmO. If the two signals were in phase the transmission level would be increased by 3dB, whilst if they were antiphase, there would be a reduction of transmission level of 4.5dB.

Several different arrangements were examined with a view to obtaining, if possible, an arrangement which would:—

(i) give correct loss conditions,
(ii) be readily integrated with the existing ARM installations,
(iii) be simple in principle,
(iv) give correct levels to the manual operator, and
(v) avoid poling problems (if this could be accomplished cheaply).

The difficulties mentioned above disappear if all circuits through ARM exchange are directional 4-wire. When the basic decisions on the S.T.D. ARM exchange were taken in 1961, this arrangement was specifically rejected because it was considered that the cost of amplifying all 2-wire inlets was out of proportion to the advantage gained, and it was felt there were advantages in including pad switching in order to retain flexibility in transmission design without variation of line levels. In the case of manual boards however, it is clear that considerable complication would be introduced if there were a mixture of 2-wire and 4-wire line relay sets (FIR and FUR) with and without amplifiers in the 4-wire paths, and many amplifiers would be required in the connecting circuit and position circuit relay sets (SNOR and OPR).

The most straightforward way of providing satisfactory transmission is to ensure directional 4-wire operation on all trunk assistance calls by fitting amplifiers in the line relay sets. Amplifiers are required in each direction of transmission in all incoming and outgoing 2-wire line circuits (FIR and FUR) which can interwork with the trunk assistance equipment (SNOR-U). The arrangement is shown in Fig. 11. This is not necessarily the cheapest solution in particular installations, and in a few exchanges it may be desirable to introduce routing restrictions to avoid installing as many amplifiers, but it does avoid most of the complexity inherent in the other schemes investigated. It also permits flexibility in future transmission improvement in the network by making possible some reduction of link loss on the 2-wire circuits by using the gain available in the amplifiers in the 4-wire path of the exchange. As a by-product of using this technique, the necessity for correct poling in the speech path no longer exists, nor is this necessary in the connections to the operator's circuit, although correct poling within the operator's circuit is necessary to maintain stability in the amplifiers.

The technique for compensating for additional loss introduced in calls switched via the cordless switchboards is also shown in Fig. 11. It is proposed that on calls via SNOR-U relay sets, the 8dB level adjusting pads in the line relay sets will be switched out and fixed 7dB pads will be introduced in the SNOR-U relay sets. This will compensate for an estimated loss of approximately 1dB due to the extra passes through the exchange and the SNOR-U relay set. The actual losses encountered will be measured when some exchanges have been placed into service, and if necessary the values of the pads will be changed retrospectively.

The logic to control the pads is built into the registers which detect the type of circuits to be switched together. If dissimilar circuits are interconnected the 8dB pads are switched out of circuit while the particular selector stage is being set. For this application all the incoming and outgoing line circuits (FIR and FUR) are considered as 4-wire circuits, while the manual connecting circuits (SNOR-U) are regarded as 2-wire; when a call is switched to or from a trunk assistance position, the pads in the line circuit relay set are cut out. (On the other hand, if two amplified line circuits are directly switched together for a S.T.D. call the 8dB pads are left in circuit.)

Special arrangements are necessary for interworking with 2VF circuits which operate in the tail-eating mode. The principle is illustrated in Fig. 11, which shows an outgoing connection to a 4-wire 2VF line via an ARM

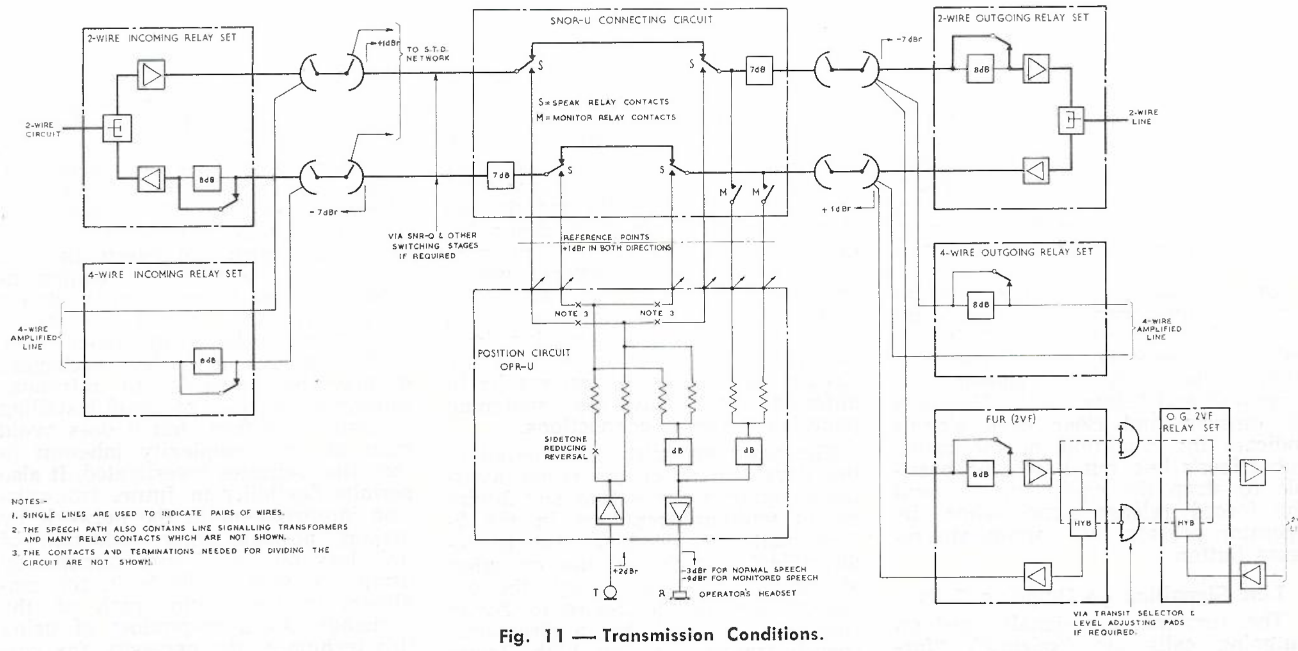


Fig. 11 — Transmission Conditions.

switching stage and a 2VF transit switching stage. Although not shown, 3dB switchable pads are required on either side of the 2VF transit stage in some installations to provide complete flexibility for interconnecting 2-wire and 4-wire lines.

EXCHANGE MANAGEMENT

Night Switching

The trunk assistance equipment is intended for use in a variety of situations, including exchanges which are staffed only during the busy hours and centres to which traffic is concentrated during slack periods.

Night switching may be accomplished under key control from the manual assistance exchange to be night switched, by altering the exchange routing patterns to divert m.f.c. traffic to a higher order centre. Special techniques are necessary to divert traffic from exchanges having direct incoming junctions from step exchanges as the queueing registers have no facilities for transmitting m.f.c. signals to a subsequent register; for example, some of the early choice direct junctions may be back-busied and the later choice junctions switched to the backbone S.T.D. route.

At continuously staffed centres, no special supervisory action is needed to set the equipment to receive after hours traffic from other closed numbering areas. The queueing registers can automatically identify the origin and category of the call by m.f.c. signals from the originating exchange register.

Delay Working

Delay working has been used extensively with manual trunk switching systems but slightly different facilities are proposed for the new trunk assistance positions as some of the trunk lines will be accessible to S.T.D. subscribers as well as operators. In normal circumstances preference must be given to the S.T.D. calls because S.T.D. operation involves less ineffective time than manual working. Short duration overloads in the trunk system must be avoided as much as possible as these could cause subscribers to book traffic with manual operators rather than make further attempts to dial their own trunk calls. Additional operators might then be needed and the extra traffic generated by the operators could lead to still greater congestion, lasting perhaps for several hours.

In order to prevent operators overloading the circuit groups which are available both to subscribers and to operators and to control the traffic offered to the semi-automatic network the following facilities are proposed:—

(i) An occupied circuits indicator on the supervisors position to show the number of circuits occupied on backbone routes to trunk distance centres. A single meter will be provided which can be connected to selected backbone routes in turn by means of keys.

(ii) Delay control keys on the supervisor's position will permit selected routes to be barred to demand operators. The keys will also be used to select the announcement to be fed to demand operators for various address codes.

(iii) Position control keys on the supervisor's position will allow selected demand positions to be set to gain access to routes temporarily barred to other demand operators.

The delay facilities will be incorporated into the operators' registers in conjunction with the route markers in such a way that traffic from S.T.D. subscribers or from operators at distant exchanges is not affected. Audible and visible indications will be given to demand operators to inform them of the delay to be quoted to subscribers.

Supervisory, Monitorial and Observation Equipment

The equipment associated with the monitors' posts for incoming and outgoing calls is basically similar to that used on demand positions but as some of the special operating facilities are not needed some simplification is possible. Special connecting circuit and position circuit relay sets (SNOR-E and OPR-C) have been specified but whether or not these are put into production will depend on economic considerations. Similar relay sets will be used with the supervisors' positions.

It will be possible to monitor the trunk assistance operators' position circuits from the monitors' posts as well as from the service observation position. The monitor and the observation supervisor must be able to overhear all incoming and outgoing speech (including monitored speech). Visual indication of the main key and lamp operations will be provided on the service observation position.

DIMENSIONING THE EXCHANGE

The number of operating positions required is determined on the basis of providing sufficient operators to handle assistance calls on a demand basis with a reasonable speed of answer. The A.P.O. objective is for 90% of the demand trunk calls to be answered within 20 seconds during any hour. To avoid occasional excessive delays, traffic is queued and the length of the queue is limited so that about 1% of all calls which cannot be switched to an operator without delay will encounter a full queue and be allowed to overflow to busy tone or recorded announcement.

A rough "rule of thumb" method sometimes used for calculating the approximate number of operating positions required is to assume two erlangs of switched traffic per trunk assistance position, but more precise methods are necessary for most purposes. These involve forecasting the amount of operator traffic (as distinct from the traffic switched by the positions), and allowing for factors such as the permissible delay, the size of the installation, the class of traffic, and the number and size of queues.

In the initial studies which have been made it has been assumed that the operating effort per call will tend to rise as the percentage of simple calls decreases but this effect will be partly off-set by the better operating facilities provided by the new positions. The average connecting-circuit holding times will be affected considerably by geographical factors and there will also be a time variation, call holding times tending to be greater at times when concessional charge rates apply. The average connecting circuit holding time is normally about 5 to 7 minutes and the average conversation time is usually in the range 3.5 to 5.5 minutes. About 8% of calls are ineffective and are cancelled within 15 seconds of the operator answering and it may be assumed that up to 20% of all calls will be reverted for various reasons such as the called line being busy or the particular person unavailable.

Operating times range from about 60 seconds per call for simple demand calls to about 200 seconds for the more complicated reverted calls. For the year 1975 the average total operating time per call has been estimated at 140 seconds ± 10%, depending on the locality and the extent to which S.T.D. is accepted by the public, but it is hoped that these estimates will prove conservative and it will be possible to revise them in a downward direction when the new positions are placed in service and new traffic patterns develop.

If a large number of positions is served by a single queue and overlap working is employed, the average proportion of time that the operators staffing the positions are effectively employed can be quite high. say 0.8 occupancy or perhaps higher. Graphs are available for estimating both the proportion of calls likely to be delayed and the average delay on delayed calls for various operator loadings and numbers of positions (for example the well-known delay probability graphs by E. C. Molina) (Ref. 4). A monogram has also been attached to A.P.O. Specification No. 994 for estimating the number of queue positions required for various grades of service.

In calculating the number of queueing registers it is usual to estimate the average number of calls likely to be delayed, the average delay time, and the functioning time for the equipment. It must also be remembered that the queueing registers may be used to switch calls to other queued or non-queued services, and that a shortage of registers can reduce the effective length of a queue.

Operators'-register traffic will be influenced largely by the average number length, the percentage of calls to decadic signalling destinations, the average number of repeat attempts per call and the percentage of reverted traffic.

FUTURE DEVELOPMENTS

It is hoped that the basic system concepts, the signalling scheme and the design of the apparatus will prove flexible enough to permit some refinements to be added if necessary at a later date, but any decision to proceed with further development of the crossbar system will depend largely on the pattern and volume of assistance traffic after the effective introduction of S.T.D. Public acceptance of subscriber trunk dialling and the effectiveness of special devices such as S.T.D. coin telephones and subscribers' private meters will be very significant factors, but the growth of international traffic and the demand for special facilities such as credit card and reverse charge services are likely to become increasingly important. The possibility of changes in the tariff structure cannot be overlooked.

A facility which should, if introduced, greatly reduce operating effort, is for subscribers to set up assistance calls automatically by dialling a special service code followed by the national number of the called line. The maximum benefit of such a system would be obtained if automatic number identification and automatic docketing were also provided to further reduce the work of the operator. Even if the present policy of setting up all assistance calls by means of the digit keys on the operating positions is retained, there would be some advantage in installing automatic docketing equipment, with or without calling line identification. It should be possible to add automatic charging to the system without a great deal of re-organisation as this has been allowed for in the information signalling and by-path equipment. Automatic number identification could be added if the capacity of the by-paths and of the information store were increased. More re-arrangement would be needed to cater for operator assistance on calls set up automatically under the control of the subscriber.

Developments of this nature using crossbar equipment may become necessary in several years time, particularly for large assistance centres which are being installed in the near future. Apart from this however the timing for the next stage of manual assistance equipment development may depend on some major changes in technology such as the likely introduction of electronic trunk switching equipment in several years time. It seems reasonable at this stage to postpone further major development of the manual assistance equipment to take advantage of what promises to be a more flexible system.

CONCLUSION

The system which has been described represents an important step in the application of crossbar equipment in Australia as it provides the basis for a sophisticated manual trunk assistance service. There is still room for further mechanisation in this area but the techniques to be used and the timing of developments will depend on future traffic patterns and possibly on the availability of new types of switching plant. In the meantime the equipment which has been described should prove a satisfactory and economical means of handling trunk assistance traffic.

ACKNOWLEDGMENTS

Development of the system described has been a complex undertaking involving specialised knowledge and judgment by experts in many fields, and progress to the present stage could not have been achieved without the contributions of colleagues in the Planning and Research and the Engineering Works Divisions of the P.M.G.'s Department at Headquarters and in the States. The information provided by L. M. Ericsson Pty. Ltd. is gratefully acknowledged. Development of the system has also taken account of experience gained in this field in Australia and overseas. (Refs. 5 and 6.) Thanks are due as well to those who assisted in the presentation of the information in this article.

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OPERATING FACILITIES FOR MANUAL ASSISTANCE CENTRES

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INTRODUCTION

The Community Telephone Plan for Australia is designed to provide a wholly automatic system throughout the country, so that it will eventually be possible for subscribers to dial most of their trunk calls. However, because of the nature of some calls and the need for subscribers to obtain assistance, manual assistance centres will be established to cater for these classes of traffic. The assistance positions will normally be located at secondary or higher order switching centres. Cordless type switchboards will be used in most cases, but in some country areas cord type switchboards will continue to be used for a considerable time.

This article describes the main facilities to be provided by the equipment proposed for handling trunk assistance traffic. It discusses the philosophy underlying the development and suggests possible future trends. It refers only briefly to other classes of manual assistance equipment. The facility requirements are set out in more detail in Australian Post Office Specification No. 994 "Australian Manual Assistance Equipment" which has been prepared to cover both cordless and cord type manual trunk assistance exchanges associated with crossbar automatic trunk exchanges. It also outlines the general requirements for other classes of positions such as information, service assistance (complaints), and service assessment.

BACKGROUND

Ever since the establishment of telephone communication, manual switchboards have been used for switching telephone circuits together, or for providing an answering point for a number of telephone circuits. Successive technological advances have made automatic switching cheaper than manual switching and consequently a large proportion of the simple switched traffic is now connected automatically.

Large automatic exchanges have for many years been more economical than manual exchanges for simple switched traffic, particularly for calls which can be handled in a uniform way and for which a single charge rate can be applied. Recognition of this led to automisation of the local networks and then to the enlargement of the local service areas of individual automatic networks. The next step, converting the manual trunk network to automatic, is being accomplished in two stages, firstly, semi-automatic working normally requiring only one operator to set up a call, and secondly subscriber trunk dialling (S.T.D.). Transmission performance is also being improved progressively. Under S.T.D. conditions a very large percentage of all calls is set up automatically but, on a small percentage, an operator is required to assist the caller in establishing the connection or to provide some special service.

New manual assistance equipment and operating consoles for the Australian network have been developed in this context of changing traffic patterns and advancing technology. The aims are to simplify the handling of the type of calls which will still require manual switching after the effective introduction of S.T.D. and to take advantage of recent developments in switching and transmission equipment. To simplify integration into the trunk network, the new positions will be associated with the crossbar automatic trunk switching exchanges which also provide for S.T.D. traffic.

The Changing Composition of Trunk Assistance Traffic

As the percentage of automatically switched trunk traffic increases, the composition of the residual manual trunk assistance traffic will change and, on the average, this will require a higher order of operating skill and effort than has been needed in the past for the predominantly simple station-to-station traffic. This in turn is creating a demand for improved operating aids. To allow the economic integration of the manual equipment and the ARM exchange, some deviations from operating practices previously adopted in Australia are being accepted.

The development of automatic trunk and local networks and automatic alternate routing renders the connection of all subscriber or operator dialled calls over the common routes a desirable objective. Therefore, all operators should have access to the local and trunk networks by way of digit keysets to establish trunk calls or revert calls to local subscribers. The existing 2VF network will continue to be used for direct links and for some switched calls but growth will be met by converting some 2VF routes to the common network and using the recovered 2VF equipment to augment other 2VF routes.

Apart from the trunk assistance traffic, there is also a need for service type positions, e.g., service assistance (complaints) and for directory information positions. The demand for for these is less affected by the introduction of S.T.D. and, in fact, the growth of S.T.D. tends to increase the need for information and service assistance positions. S.T.D. is however likely to have a marked effect on the facilities to be provided by these positions.

Prior to the widespread introduction of S.T.D. the Community Telephone Plan established for Australia the policy of a wholly automatic trunk network as distinct from the limited S.T.D. which had existed between certain points. Up to this time operators were needed to set up all long distance trunk traffic as well as some short distance and local traffic. Most of the trunk traffic consisted of uncomplicated station-to-station calls but some of the expensive long distance traffic was booked on a person-to-person basis and there was a small component of traffic on which some other special assistance or service was required.

With the advent of S.T.D. it became obvious that station-to-station calls could be virtually eliminated and person-to-person calls could be greatly reduced as it was advantageous for callers to dial their own numbers at a cheaper rate. The differential charging structure which allows S.T.D. calls to be recorded on meters on the basis of trunk line time actually used, rather than in 3-minute periods as under manual conditions, is a distinct encouragement for all callers to use the S.T.D. facility to the maximum.

By 1975 a comprehensive grid of trunk terminal exchanges will have been established and manual assistance traffic will consist mainly of calls requiring some special service such as immediate information on the price of the call, calls from coin telephones, reverse charge calls, credit card calls, etc. There will be a small amount of traffic from subscribers who cannot or will not use S.T.D. and some traffic to destinations not available via the S.T.D. network. Table 1 shows the likely trend in the composition and proportions of trunk assistance traffic from the introduction of S.T.D. until 1975.

Naturally, during the transition period there are some exchanges which will not have been adapted to permit the dialling of S.T.D. calls; sufficient circuits will not be available on some routes; and certain exchanges cannot be dialled directly, for example exchanges in some sparsely settled areas could be too uneconomic to convert. By 1975, it is expected that these factors will have been reduced to a minimum and manual assitance traffic should, in the main, comprise only those calls which will always require manual assistance.

It is interesting to note that in 1965 about 15% of trunk traffic was handled by S.T.D. and that on some particular routes only about 10% of the traffic required manual assistance.

It is realised that trunk traffic from coin telephones could grow to large proportions and plans are well ad-

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TABLE 1: COMPOSITION OF RESIDUAL MANUAL TRUNK TRAFFIC AT LARGE ASSISTANCE CENTRES

Type of Traffic	Percentage of total trunk traffic before S.T.D.	Percentage of total trunk traffic after S.T.D. (1975)		Remarks
Particular person calls	60-84%*		8%	Appreciable transfer to S.T.D. but some p.p. will remain for business calls
Station to station calls and calls from subscribers who won't or can't use S.T.D.	15-40%*		3%	Will be influenced by subscriber education
Calls on which statements are required.	10%		3%	Will reduce due to private meters and the cost advantage for S.T.D.
Calls from coin telephones	10%	1.5%		S.T.D. coin telephones to be used extensively to limit the growth of manual cash calls
Reverse charge calls	1%	1%		
Credit card calls	1%	1%		
Calls to public telephones Press calls Conference calls	1%	1%	Approx. 6% (coin telephones to incoming international calls)	
Outgoing international calls	0.2%	0.7%		
Incoming international calls	0.2%	0.5%		
Total manual calls	100%		20%	

*Wide variation exists for different localities.

Assumptions:

(i) By 1976 70% of all trunk calls in the Commonwealth will be set up by S.T.D.

(ii) All but 3% of subscribers will be accessible by S.T.D.

(iii) 80% of trunk traffic from coin telephones will be handled by S.T.D.

(iv) Private meters will be used by subscribers requiring individual call charges

(v) There will be no significant changes in the charging pattern.

vanced for the development of an S.T.D. coin telephone. Whilst the provision of S.T.D. public telephones could be costly, the convenience to callers and the removal of a high proportion of manual assistance traffic could warrant an extensive S.T.D. public telephone program.

With the changing composition of assistance traffic, a greater percentage of calls can be expected to require complex operating techniques, and the average setting up time will increase. It may be assumed that even with improved operating facilities the average call holding time including booking and setting up, will be approximately 6.5 minutes and the average operating time per call about 2.3 minutes. The percentage of total trunk traffic handled from large centres will probably be 20 per cent by 1976, decreasing to 10 per cent by 1986; however in spite of the decreasing percentage, the total volume of trunk assistance traffic may increase due to normal development and the elimination of other manual exchanges.

The figures given above have been derived from a preliminary appraisal of the impact of S.T.D. during the introductory stages and caution should be exercised in applying the figures as different trends could develop as the tempo of S.T.D. increases. Further detailed studies are already being undertaken to form a more reliable basis for estimates of future requirements. Vigorous steps will have to be taken to develop sophisticated operating techniques or equipment for the handling of special categories of traffic if the percentage of manual traffic is to be reduced further in the intervening period. Re-appraisal of system costs and of charging policies will be involved together with subscriber re-education programmes.

Concentration of Traffic

For economic reasons, particularly the decreasing cost of carrier equipment and the use of automatic alternate routing techniques, the present trend is to reduce the number of automatic trunk switching exchanges. The manual assistance service is also being concentrated and there is a tendency to close some exchanges during periods of light traffic and to transfer calls to another exchange.

The conversion of local exchanges to automatic and the introduction of S.T.D. has led to the progressive centralisation of manual trunk assistance and the disappearance of most of the smaller manual exchanges. Generally assistance centres are staffed on a 24-hour basis but at very small centres it may be found practicable to divert calls to a parent manual assistance centre during the periods of slack traffic such as during non-business hours. Small assistance centres serving exchanges can be connected to a parent assistance centre serving up to a maximum of six closed numbering areas. Special arrangements will be necessary to indicate the origin of the call to the central trunk assistance operator so that the calling subscriber's number will be accurately recorded even if the subscriber does not quote his full national number.

The new cordless manual assistance positions are being developed for association with the four-wire crossbar trunk transit exchanges. Because of the present trend to reduce the status of some transit switching exchanges from secondary to minor, more "minor" switching centres may require a local assistance exchange. Two wire crossbar exchanges with automatic charging capabilities will usually be employed in lieu of four wire exchanges at minor centres, and therefore the associated manual assistance positions will normally be of the cord type. Two wire cord type switchboards would be satisfactory for this application but the new four wire pattern will be used for standardisation reasons, and to take advantage of the technical and operating facilities available.

BASIC APPROACH TO TRUNK ASSISTANCE

The basic assumptions used in the development of facilities for trunk assistance positions have been:—

(i) All calls requiring trunk assistance will be set up by operators using digit key sets.

(ii) A single group of operators will handle a mixture of trunk calls from subscribers and coin telephones and from other operators, but a special group of operators will handle international traffic.

(iii) A small percentage of calls will involve trunk assistance operators at two exchanges.

(iv) The trunk assistance operator will have automatic access to any exchange or operator within Australia by either the S.T.D. network or the semi-automatic network.

(v) The operators will record details of trunk assistance calls from subscribers and coin telephones for accounting purposes.

(vi) Calls will normally be connected on demand but all trunk assistance positions will be equipped to allow calls to be reverted either for verification or if the call cannot be connected immediately.

(vii) There will a use for two distinct types of trunk switchboard console, one equipped with cords as an integral part of the speech path, and the other without cords but equipped with keys which are used to remotely control the speech path.

(viii) The cordless trunk assistance positions will use crossbar trunk switching and control equipment.

(ix) Assistance in the establishment of S.T.D. calls will normally be provided from service assistance (complaints) positions.

(x) Incoming calls will, as far as practicable, be answered strictly in order of arrival.

Charging

The need to manually record the details of all calls at the assistance centres was a major factor in choosing the basic trunking configuration and the operating procedures. At this stage, the Australian system does not provide automatic calling number identification or automatic recording of charging information. This precludes the use of the American traffic service position (T.S.P.) approach by which the charging and the release of the call usually takes place automatically; the operator merely bridges across the connection to supervise the setting of the call and the commencement of charging. The use of multimetering pulses for the automatic charging of manually assisted calls is considered impracticable at this stage for the following reasons:

(i) There are difficulties in selecting the appropriate multimetering rate as each manual assistance exchange may serve a number of originating charge zones;

(ii) Some originating exchange equipment is incapable of accepting more than one metering pulse per call;

(iii) Some exchange relay sets will not repeat multi-metering pulses; and

(iv) Some types of calls present special difficulties, for example, calls requiring particular person service, after hours opening of non-continuous exchanges, press rates, credit card service, or a record of the time and charges.

Toll ticketing was also considered but, in the absence of calling line identification, the operator would have to key-in the calling subscriber's number. In these circumstances toll ticketing would produce only marginal savings and in view of the tight schedule for the design and introduction of the new equipment, manual recording of call details has been retained at this stage.

Setting Up the Connection to The Called Number

Another major factor in determining the basic trunking pattern for trunk assistance positions was the decision not to expect the calling subscriber to dial the called subscriber's number. The American T.S.P. approach depends on the subscriber dialling the called number as this reduces the number of operations which have to be performed by the trunk assistance operator. At present, Australian policy is to use only one dialling code for all national calls requiring manual trunk assistance, and not to require further effort by the subscriber. It is recognised however, that some subscribers would be prepared to dial the significant number of the called subscriber in addition to a manual assistance access code particularly if they believed this was likely to result in faster connection; such a procedure would be feasible for calls on which a record of the time and charges was required, for particular person calls, and for calls from non S.T.D. exchanges. If the called number were dialled by the subscriber, and displayed to the operator, operating effort and time would be saved as there would be no need for the operator to ask for the called number. If, in addition, automatic call charging equipment were installed, further savings would be possible, for example, no action would be required of the operator on "time and charges" calls until the end of the call.

Source of Traffic

It has been decided not to segregate coin telephone traffic and operator originated traffic from demand traffic from ordinary subscribers. Australian experience with earlier types of operating positions indicates that any disadvantages there may be in mixing all types of traffic are out-weighed by the overall smoothing of the operating load brought about by the combination of traffic with non-coincident peaks. Every operator must be able to handle all types of calls, but in practice, a monitor is readily available to assist the operators on difficult calls, and a visual or aural indication will be given automatically of the type or origin of individual calls.

Sequential Answering

Various arrangements have been considered for ensuring a reasonable speed of answer at all times without having to provide operating staff and positions extravagantly. Service to subscribers and staff morale are significant factors and from both points of view, queueing was considered the most satisfactory way of achieving that objective with the type of trunk assistance traffic envisaged. Such a system eliminates the "unfortunate call" which is quite a serious service difficulty under manual operation. It also lends itself to the provision of alarms or control lamps to show if the speed of answer becomes unsatisfactory and remedial action is required of the supervisory staff.

A defect of some earlier queueing systems is the limited number of connecting circuits which can take calls from a single queue, and the consequent need on large exchanges to have several groups of positions fed from separate queues; "link positions" are then used to even the load by taking calls from either one of two queues. If all the positions in an exchange can be fed from a single queue, greater efficiency is possible and it is easier to make staffing changes to meet traffic fluctuations.

With the new positions it is hoped to avoid the need for link positions, although in some very large exchanges, a separate group of positions may be provided to handle special traffic such as that originated by other operators. In these cases, the queries may be arranged so that the special positions will be offered traffic from the general queue whenever there are no calls in the special queue.

Cord Circuits

In some cord type systems used overseas the line circuits have switchboard jack appearances but are also connected to automatic switching equipment. The connection is controlled by the cord and jack but the actual connection is via the automatic switches. This arrangement seems uneconomical as compared with cordless positions or simple cord type positions under Australian conditions, and therefore it will not be discussed further in this article.

DIFFERENCES BETWEEN CORDLESS AND CORD TYPE POSITIONS

Appearance and Grouping of Positions

Cordless type positions can readily be grouped in short suites and as the position equipment is not very high, they resemble tables with low turrets which do not obstruct the telephonist's vision. Normal office chairs can be used. On the other hand cord type trunk assistance positions are normally linked by a multiple jack field which increases the height of the positions and restricts the way in which positions can be economically grouped. With small exchanges of up to 30 positions it is possible to avoid a very high jack field, and the height of the position can be reduced further by using cord retraction rollers.

Connection of Incoming Calls

As discussed earlier, incoming calls to the new cordless positions will be queued even though the equipment required is appreciably more expensive than that for distributing calls at random. However with cord type positions the difference between the cost of equipment for queueing and for call distribution is greater and other less expensive compromise techniques should be satisfactory in most cases.

With simple cord type switchboard installations, the incoming lines may be accessible on a number of positions. Although each incoming call is indicated by a separate line lamp, the calls are apt to be answered at random particularly during periods of heavy traffic when the "unfortunate" or "neglected" call is most likely to occur. A relatively inexpensive alternative to full queueing and cord type positions is a simple gating system. Waiting calls are gated or corralled in groups until all calls in the preceding group are answered; the next group is then connected to the answering display field. This is a satisfactory compromise as it smoothes the time taken to answer calls within a group.

Outgoing Access and Routing Codes

Unlike cord type positions, cordless switchboards cannot provide direct access to particular circuits, routes or portions of the network. All calls from the new cordless positions will be routed through the associated ARM exchange, by means of the standard national access code or the subscriber's local area number for calls which can be established entirely through the ARM (S.T.D.) grid and special routing codes to provide access to the semi-automatic (2VF) network. The equipment associated with the cordless switchboards will ensure that all calls are correctly routed.

Party lines, multi-office trunk circuits and small non-official manual exchanges will probably be retained in remote areas for many years. Cord type switchboards provide a simple means of connecting to this type of circuit but automatic access may be necessary even to these types of lines if the manual assistance service is to be centralised to higher order centres during periods of light traffic.

Release of the Connection

On some of the old type positions "operator release" conditions applied; all connections were held until released by the operator. On the new suites there will be through clearing on demand calls when the caller hangs up and on reverted calls both out-going circuits will release when the A and B parties clear; alternatively the operator will be able to release either side of the connection. This will reduce the likelihood of either party being held and it will free all links involved on either side of the call earlier than would be possible under operator release conditions. This will apply to cord type as well as cordless positions except that the first link of the connection will be blocked to other calls until the plugs are removed from the jacks.

Signalling

On cordless switchboards the connecting circuits and the line circuits are selected automatically. This places some restrictions on the method of operation and consequently the use of some types of line circuits (such as conventional ring down circuits) is unattractive. On the other hand the greater flexibility of the cord type positions may introduce complex design problems, particularly if the operator's registers are associated with the position or cord circuit.

Field of Use

From an operating point of view, cordless positions are more attractive than cord type positions not only aesthetically but because they ensure more uniform operating procedures for all calls. Whilst the choice between cordless and cord type positions can usually be made on the relative costs in a particular traffic and switching situation, cordless positions are somewhat less suitable than cord type positions in remote areas where uniformity would require expensive upgrading of line circuits. However the state of the network should improve as additional circuits are provided and even in the rural areas most circuits will eventually be suitable for automatic access. There will then be less advantage in using cord type positions.

MANUAL SWITCHBOARDS — PHYSICAL FEATURES

The physical characteristics of the position consoles have an important bearing on the operation of manual trunk assistance exchanges. The present trend is to design positions which are aesthetically pleasing and to group them so that this produces an atmosphere similar to that encountered in commercial and business offices as this helps to attract and to retain suitable operators. Experience with the semi-automatic cordless positions since they were introduced in Melbourne in 1940 has highlighted the advantages and efficiency of this type of cordless equipment in the Australian environment. The latest example of this type of switchboard, the Dalley Street Trunk Exchange in Sydney, is in keeping with recent developments overseas.

When considering the purchase of switchboards to operate in conjunction with the ARM equipment it was decided to design a new console which incorporates the best features of previous positions, and allows space for the subsequent addition of keys, lamps and digit displays which may be required if improved facilities are developed. Local experience in the development of modern switchboards was available and in fact the A.P.O. had already embarked on the design of a new cord type operating console which could be readily adapted. Local production of a cordless switchboard carcass was therefore feasible and this offered the best means of meeting the firm target dates which had been set for the installation of the new switchboards. The layouts proposed for cordless and cord type trunk assistance positions are shown in Figs. 1 and 2 while Fig. 3 illustrates the type of construction envisaged. Figs. 4 and 5 are typical operating room layouts.

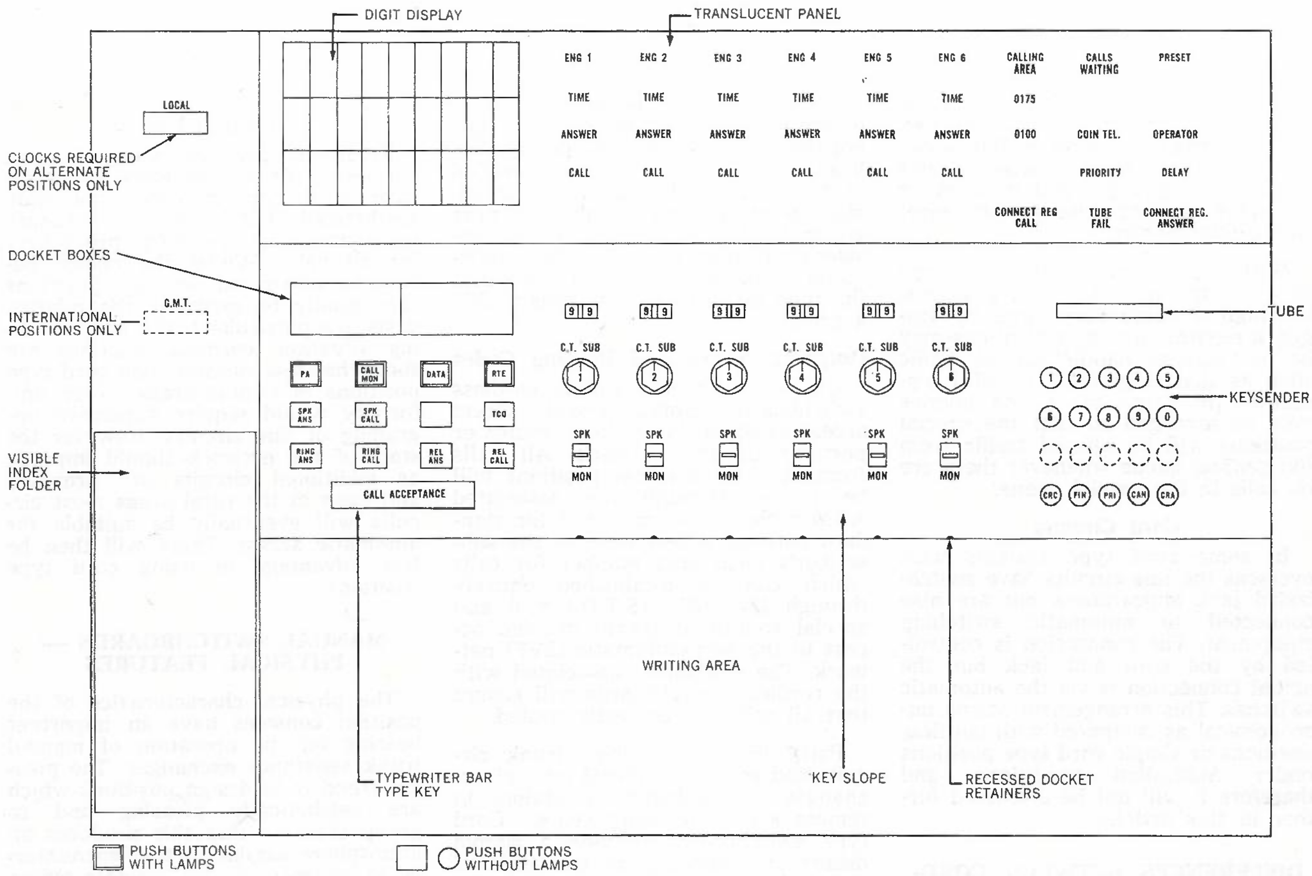

Fig. 1 — Apparatus on Cordless Type Trunk Assistance Position Console.

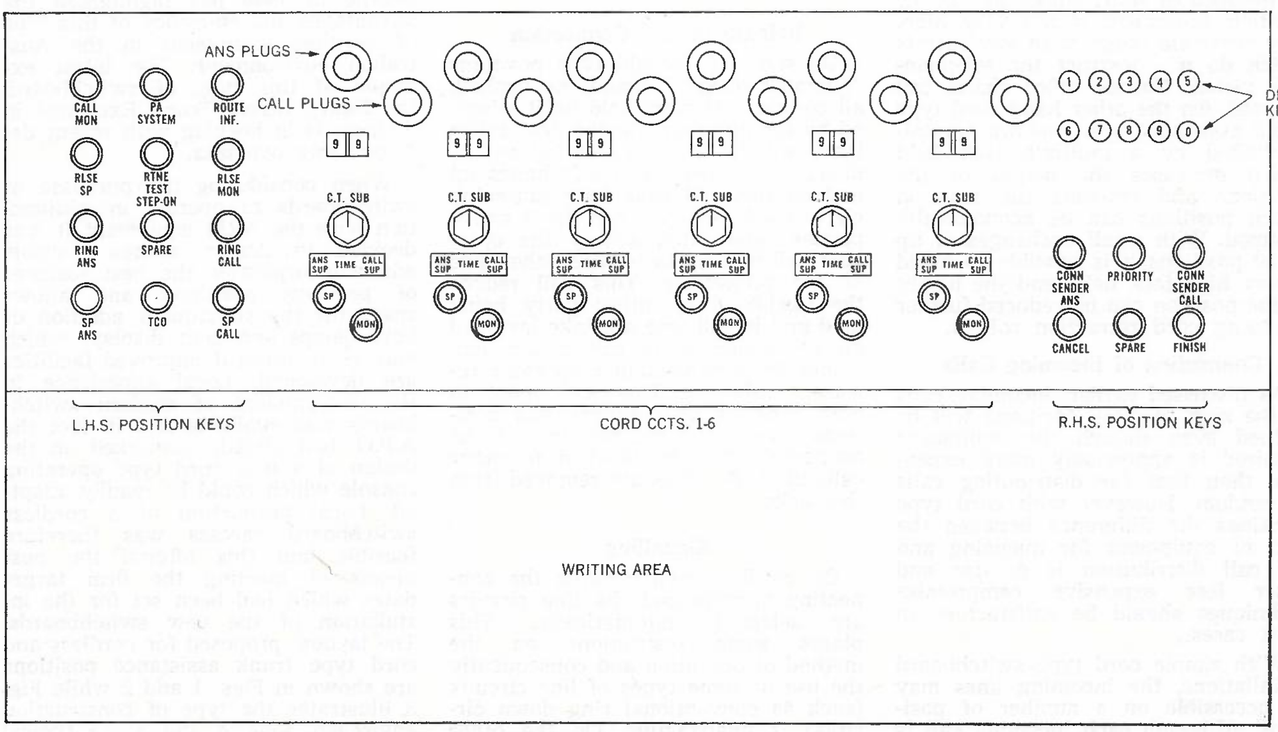

Fig. 2 — Cord Type Trunk Assistance Position Keyshelf.

The cordless trunk position console features a translucent panel on which designations are illuminated during the progress of the call. Below this is a sloping key shelf and a horizontal writing space. The keys and timers for the six connecting circuits are mounted in the centre portion of the key shelf below the associated lamps on the translucent panel. The digit key strip and some of the other common position equipment is on the right hand side of the key shelf and the remainder on the left hand side. While it is felt that push button keys are preferable to lever type keys for both the cord and cordless type positions it has been agreed that lever type keys will be used for speak and monitor keys on cordless positions to avoid delaying the design of the equipment. Push buttons, some with illuminated tops, will be used for functions which are common to all connecting circuits. A routing index, docket boxes, and two jacks for the connection of operators' headsets are also required, and at the larger exchanges pneumatic tubes will be used for transferring the trunk dockets from the operating positions to the sorting and pricing positions.

The cord type trunk assistance positions will have a multiple jack field normally arranged for three complete appearances per five positions; there should be no need for extra multiple sections adjacent to the switchboards

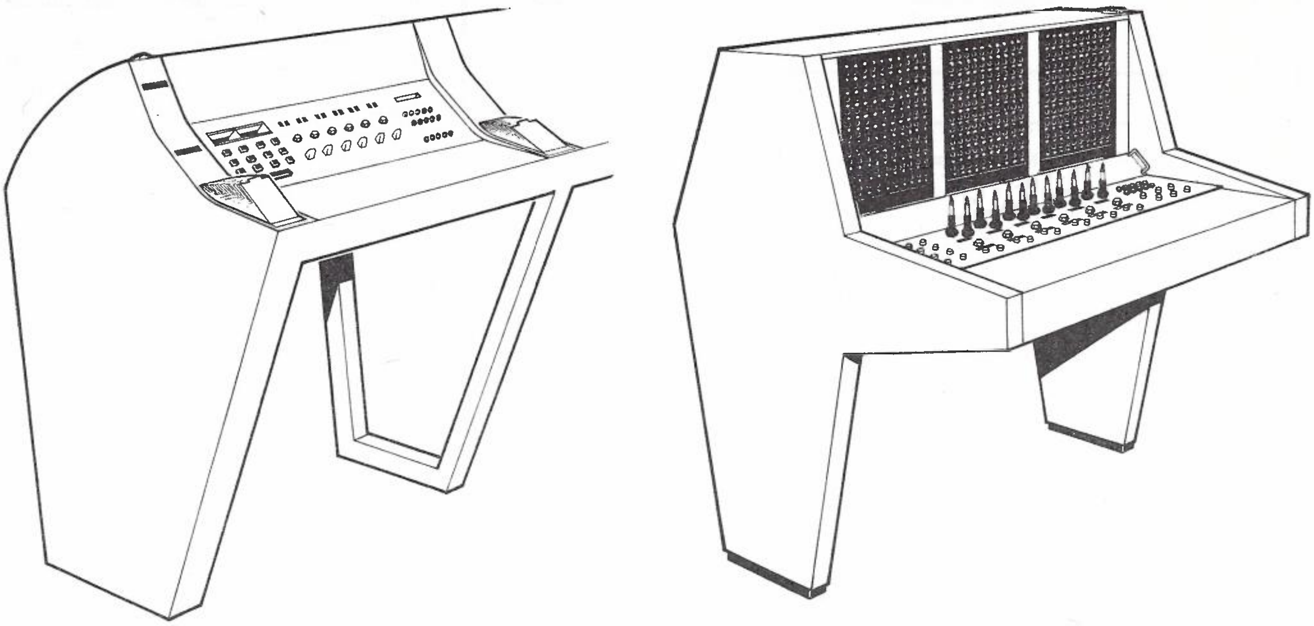

Fig. 3 — General Appearance Envisaged for Operators Consoles. Left: Cordless Type. Right: Cord Type.

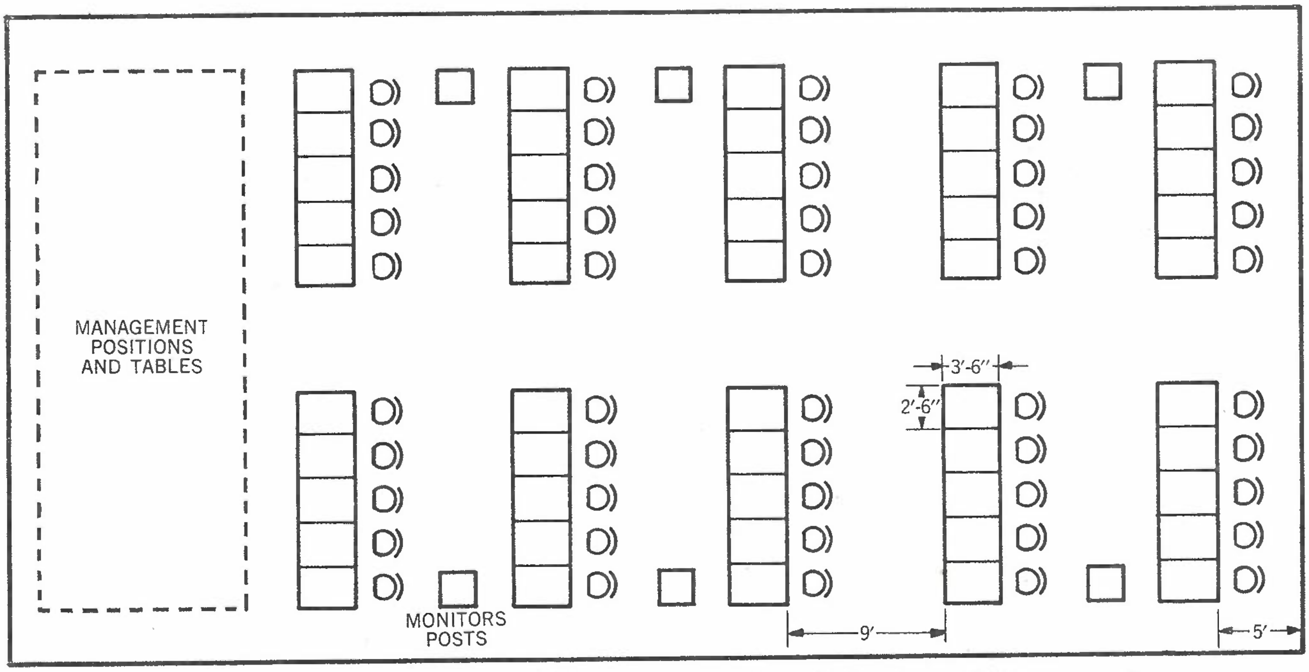

Fig. 4 — Trunk Assistance Exchange Room Layout — Cordless Type Positions.

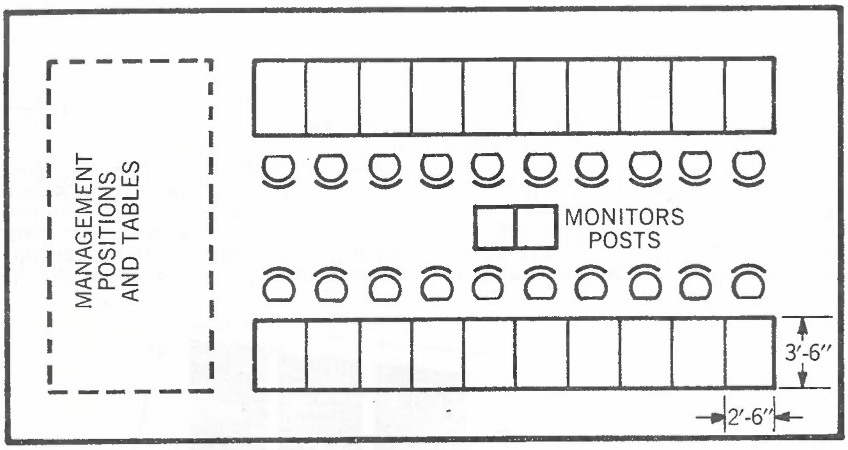

Fig. 5 — Trunk Assistance Exchange Room Layout — Cord Type Positions.

at either end of the suite. Retractable cord rollers will be used to minimise the height of the positions. Push buttons will be used instead of lever keys throughout.

OPERATING PROCEDURES AND TERMS

The facilities which are to be provided by the new operating positions can be readily understood by studying the operating procedures and terms which are described below. The operation of the trunk switchboards will not be described in detail but typical calls will be used to illustrate the general approach. Particular reference will be made to the new cordless positions but the operating technique will be very similar for the cord type positions.

Demand Working

"Demand Service" is given when an operator completes an incoming call originated by the caller who waits on the line; this is known as demand working. In general terms, the operator answers the call, notes whether it originated in a particular service area, accepts from the subscriber the details of the call required and, after referring to a routing index or to a special operator for routing directions, sets up the call, generally without the intervention of other operators. She then supervises the call, obtaining the called party on a particular person call, introducing the parties or leaving word etc., as appropriate. When the conversation commences she starts the timing equipment and records the timing details.

If the particular person asked for by the calling subscriber is not available the call may be reverted or a message may be left for the particular person to advise when he is available. The call would then be established by demand or revertive working from a distant assistance exchange serving the called subscriber.

Revertive Working

When a call cannot be set up on demand, the details of the service required are recorded, the subscriber is advised of the likely delay, and the call is later set up by revertive working. This requires the operator to recall the originating subscriber and to call the wanted number; the two circuits outgoing from the manual switchboard are then switched together. When the call is set up, the normal supervisory conditions and charging procedure are used.

Caller-in-Circuit and Overlap Working

In setting up the call, the calling subscriber is normally left in circuit so that he can hear progress tones and the answer from the distant end, etc.; this is known as caller-in-circuit working. The operator, however, has the option of dividing the circuit if necessary and speaking with either party independently.

The operator is also able to operate and speak on one connecting circuit while monitoring a second connection without there being significant coupling between the two connecting circuits. In practice, the operator may use this to set up a connection A to B and, while waiting for a particular person at B to come to the telephone, start to set up a further connection C to D, leaving A to B in the monitored condition. At other times, she may use the monitoring connection for supervising or monitoring other connections during brief breaks in the action on the particular circuit with which she is primarily engaged. Therefore the maximum number of circuit keys operated simultaneously is one speak key and one monitor key.

Call Timing

To time the call for charging purposes a digital clock is provided as part of each connection circuit on the position console. This operates in six second steps and has two starting positions, one for timing calls from ordinary subscribers and the other for timing calls from coin telephones.

The timer is started (and reset) manually but it does not commence to operate until the called party answers and it stops when either the calling or the called party clears; i.e., the timer does not operate when either of the supervisory lamps is operated. It cannot be started on a subsequent call until it has been reset. Each timer has an associated timer lamp which flashes on calls from coin telephones at 2.8 minutes, 5.8 minutes, etc. (The timer is set manually for either ordinary subscriber or coin telephone operation.) As the timer has a restricted range of 9 minutes it must be reset after this time; the time lamp flashes on all calls when the time limit has been reached. On completion of the call the time lamp glows steadily until the time key is restored.

With the arrangement of timing clocks outlined above all calls must be recorded in writing on dockets which are subsequently passed to sorting tables for processing. It is hoped eventually to provide equipment to allow the details of certain classes of calls to be recorded automatically by means of electrical signals initiated from the position circuit and various schemes have been put forward for reducing the amount of manual effort involved in recording and computing charges. Automatic equipment could be provided to identify the calling subscriber's line thus eliminating human errors. Unless this is done the operator will have to key the calling subscribers number (or the credit card number, etc.) and the class of call in addition to the normal routing information. The calling and called subscribers' numbers and the class of call information should be stored and displayed to the operator while the call is being set up. Subsequently the time at which answer and clearing occur would be automatically added to the stored information which would then be fed to an accounting computer. A printed statement of charges would be required immediately on completion of certain calls.

Identification of the Origin of Calls

For charging purposes the operator must ascertain the calling subscriber's number. If a manual trunk assistance position serves several closed numbering areas the calling subscriber's number must include the significant portion of the national prefix to avoid ambiguity. To simplify operating procedures and to reduce the amount of information which has to be obtained from the subscriber it is necessary for cordless position equipment to provide a visual indication of the particular closed numbering area in which the call originates. In some exchanges arrangements may also be made to indicate whether the call has originated in the immediate charging zone in which the manual suite is situated or in some other zone. This is a useful operating aid for calls which have to be charged on a zone-to-zone basis, particularly if most of the traffic to the trunk assistance position originates in the local zone, but the facility will not be provided in cases where it would involve additional expense.

Demand traffic is predominantly from subscribers and coin telephones, but a small amount of traffic from operators may be mixed with it. As a slightly different operating procedure is used on calls originated by other operators, a visual signal is provided on the position to alert the operator. This also helps to guard against fraudulent practices.

Identification of calls from coin telephones is also required because of the special operating techniques and as a safeguard. This is achieved by a lamp signal or by the insertion of a special tone which is audible to the operator. If identification tone is applied, it is removed automatically 8-10 secs after the call is answered by the operator or when a tone cut-off key is pressed; operation of the tone cut-off key will also cause the coin telephone identification lamp to glow.

On cord type positions identification of the type of origin of a call may be achieved by means of segregated incoming circuits.

Delay Working

When the trunk network is overloaded the available trunk circuits should be reserved as far as possible for subscriber-dialled traffic. This may be accomplished by the manual exchange supervisor who is able to place final choice routes to trunk distance switching centres "in delay". This prevents local manual assistance trunk demand operators from obtaining access to the routes and when codes corresponding to these routes are keyed, the demand operator receives an indication of the length of delay likely to be encountered. The call docket is then passed to a special position which has been set to "override delay". The call is later reverted.

Digit Keys, Routing Codes and Registers

The address information for routing the call from trunk assistance positions is inserted by means of digit keys on the operating positions. For calls within Australia the digits 1-0 are used but on international calls auxiliary digits 11 and 12 are sometimes used. The maximum number length which will be catered for is 15 digits which gives a margin of 1 digit over the longest national and international number foreseen. The maximum storage requirement for international calls is related to the single digit international access code fifteen (15), plus a maximum of the 12 digits for country code and national code combined as recommended by C.C.I.T.T.; a language digit is also necessary. On some national calls which leave the ARM switching network and traverse the semi-automatic (2VF) system, dialling codes of the order of 14-15 digits can also be expected. Facilities are to be provided in the equipment to reduce the likelihood of operators making use of unauthorised routing combinations to reach the destination. This control over the routing of operator established calls is needed so that the traffic loading of the ARM and 2VF trunk systems may be kept reasonably balanced, particularly on the main interstate routes.

The address information is transmitted from the digit keys to operators registers which control the establishment of the call; a common group of registers serve a number of positions; a register connect key is used to call a register.

Two lamps are provided to indicate that a register has been coupled to the switchboard positions circuit on the calling or answering side respectively and that the register is ready to receive information from the digit keys. Each continues to glow until the register has completed its action and has uncoupled from the position. If the call encounters congestion within the crossbar network the lamps flash to indicate that the outgoing line has been released. A tone will also be heard by the operator.

The operation of the key strips and registers will be different to that of the key senders used on existing types of switchboards in that, on a reverted call, it will be possible to key up the wanted number on the call side and follow on immediately keying up the calling subscriber on the answer side.

Call Acceptance Condition

When there are no calls waiting in the queue the operators will depress a "Call Acceptance" Key and a "Preset" lamp will glow. This indicates that the position is ready to receive a call and that a signal has been given to the queue which will cause a subsequent call to be immediately connected to the position which is preset. The preset condition is cancelled either on acceptance of an incoming call, on operation of a connecting circuit speak key or on withdrawal of the operator's headset plug. Operation of a monitoring key will not cancel the preset condition.

Priority

During busy periods most of the available trunk circuits will be occupied on calls dialled by subscribers. There is a requirement for a manual operator to obtain priority access to trunk routes in the event of emergencies, such as major disasters, hostilities, etc., as well as to connect calls booked by cabinet ministers, and some other urgent calls on which priority must be given.

This facility is available only under the control of the supervisor who is able to preset a position to connect one call under priority conditions. If all possible routes are congested the equipment will make repeated attempts to set a connection until a circuit becomes free; the priority call will then be set up. In special circumstances the exchange supervisor may make a random selection of calls on the required route and request the caller to terminate his conversation so that a priority call can be connected. No provision has been made to automatically break down established connections in order to set up priority calls.

Data Transmission

Calls involving data transmission are sometimes established over the switched trunk line network. When these calls are connected via manual assistance positions special precautions are necessary to avoid mutilating the data. Pip tone timing pulses normally transmitted to subscribers automatically every three minutes could interrupt the data. In addition, operation of the speak key associated with the data call could cause interference. To overcome this a key and an associated lamp are provided so that if the key has been operated, pip tone will not be injected and the operator cannot speak across the data connection. The call can be monitored and if the operator considers it necessary she may cancel the data setting and speak across the connection.

Miscellaneous Aspects

Conference Calls: Facilities are provided on selected positions for the connection of up to ten parties in addition to the caller.

Check of Busy Subscribers' Lines: Trunk assistance positions do not have access to busy lines. If busy tone is encountered repeatedly, the trunk assistance operator calls a service assistance position from which the subscriber's line can be checked.

Automatic Coupling of Switchboards: Automatic coupling is provided to permit an operator to use the connecting circuits of an adjacent unstaffed switchboard, using the position equipment of her own switchboard. When an operator's headset plug is withdrawn the position is coupled automatically to a staffed position on the left or right hand side, depending on the connections made during installation.

Night Switching: When it is desired to close an exchange during the slack periods of a day the queues feeding the demand positions are blocked and the traffic is automatically diverted to a permanently-staffed assistance centre. The night switching is controlled from a key on the supervisor's position at the exchange to be night switched.

PROPOSED METHOD OF OPERATION

Simple Demand Calls

Operator Waiting: If there are no calls in the queue the operator will depress the CALL ACCEPTANCE key and the position is then said to be "Preset". The PRESET lamp will glow.

Arrival of a Call: If an incoming call arrives when a position is preset, it will be connected immediately to a free connecting circuit, and a short signal will be transmitted to the operator's headset to alert her that a call is waiting. The ANSWER lamp associated with the particular connecting circuit will glow.

Booking the Call: When the SPEAK KEY of that connecting circuit is operated, the operator will be able to converse with the caller; the ENGAGED lamp will glow, and the PRESET lamp and the ANSWER lamp will be extinguished. One or more displays may be illuminated to indicate the type or origin of the call. The details of the service required will be taken from the caller and recorded on a trunk docket. The caller is left across the circuit during the setting up of the call.

Establishing the Connection: The REGISTER CALL key is operated to couple a register to the DIGIT KEY STRIP and the wanted number is keyed, after which the FINISH key is depressed to indicate to the register that all digits have been keyed. (If the operator does not know the calling code of the required distant station, she operates the ROUTE order wire key and obtains the information from the ROUTING POSITION where comprehensive records are maintained.)

The CALL SUPERVISORY lamp will glow from the time a register is associated with the call side of the connecting circuit until the called subscriber has answered and will again glow when he clears. During the time a register is connected to the connecting circuit the brilliance of the CALL SUPERVISORY LAMP will be reduced.

Conversation: Having assured herself that the connection has been satisfactorily established, the operator closes the SPEAK key and operates the TIMER key to the "Subscriber" position to start the TIMER. The call is supervised by the operation of the MONITOR key at frequent intervals during its progress to ensure that conversation is proceeding satisfactorily. Should it be necessary for the operator to speak again on the connection, the SPEAK key is operated; this also causes the "type or origin of call" information to be displayed again.

Timing and Release: The time lamp will flash rapidly when the TIMER has been operating for 9 minutes to indicate that it requires resetting. During the course of the conversation three short pips of 900 c/s tone are applied to the circuit shortly before the end of each three minutes period to warn both parties that a charging period is about to conclude. When either the calling or called party restores his receiver the ANSWER or CALL SUPERVISORY lamp and the TIME lamp glows steadily until the TIME key is restored. The TIMER cannot be started on a subsequent call until it has been manually reset. If the calling party replaces his receiver both sides of the connection will release and subsequent resetting of the TIMER will extinguish the ANSWER and CALL SUPERVISORY lamps, the TIME lamp and, the ENGAGED lamp.

At the end of the call, the operator completes the trunk docket and despatches it to a central position via the PNEUMATIC TUBE.

Special Calls

Reverted Calls: It may be necessary to revert a call either because the trunk route is busy or because the called party was not available. Assuming the operator elects to establish the connection to the called party before recalling the calling party, a typical call would be handled as follows:

The operator selects a disengaged connecting circuit and operates the SPEAK key. The ENGAGED lamp will glow. Operation of the REGISTER CALL KEY will couple the register to the DIGIT KEY STRIP via the calling side of the connect circuit and the called party's number will be keyed, after which the FINISH key will be depressed. Immediately following this the REGISTER ANSWER key may be operated to couple a register to the DIGIT KEY STRIP via the answer side of the connecting circuits; the calling subscriber's number will be keyed after which the FINISH key will be depressed.

The subsequent establishment of the conversation, timing and supervision would be similar to that for demand calls. When both the calling and the called parties replace their receivers both sides of the connection will release. The operator can release either side of the connection by pressing the appropriate RELEASE key.

Calls from Coin Telephones: When a call from a coin telephone is received at a demand position the operator will receive either an audible or "visual" coin telephone indentification signal. If an audible signal is received, it must be disconnected by the operation of the TONE CUT-OFF key; this will cause a visual indication to be given on the transluscent panel immediately, and on each subsequent operation of the SPEAK key.

The details of the service required will be obtained from the caller and recorded on a trunk docket. Connection will be made to the called party but before the conversation is allowed to proceed the operator will divide the circuit and supervise the collection of coins from the caller.

The TIME lamp provided in conjunction with the TIMER will flash rapidly at 2.8, 5.8 and 8.8 minutes and continue to flash rapidly for approximately 10 seconds after the end of each three-minute period or until the TIMER key is restored.

In all other respects the operation is similar to that for a simple demand call.

Priority Calls

When congestion is encountered on a demand call and the subscriber indicates that the call is of an extremely urgent nature the operator will call the monitor. If the monitor considers that priority service is warranted she will arrange for the operation of a PRIORITY key on the supervisor's position. This, in conjunction with the PRIORITY key on the operating position will cause the PRIORITY lamp on the operating position to glow and the particular connecting circuit will be set for priority operation. The priority condition will be automatically cancelled on completion of the call.

Calls Requiring the Assistance of the Monitor

If the operator finds difficulty on a particular call she will press the CALL MONITOR key to attract the monitor's attention. This will cause the MONITOR CALL lamp on the top of the position to glow and will give an audible signal at the monitor's post. The monitor call setting can be cancelled either from the monitor's post or from the operating position. By operating a key on the monitor's post the monitor may speak and listen across the operator's position circuit.

SIGNALS

Audible

Apart from the normal service tones used on calls dialled by subscribers such as dial tone, ring tone, busy tone, NU tone and recorder connected tone some special audible signals are needed on manual calls —

Call waiting to indicate that a call has been switched to the position.

Coin telephone identification tone to indicate that the call was originated from a coin telephone.

Coin tones to indicate to the operator the number of and value of coins deposited on calls from coin telephones.

Pip tone to inform the caller that a 3-minute period is nearing completion.

Delay announcements to advise the operator of the expected delay on the particular route.

Visual

The visual signals to be used are set out in Table 2. Identical signals are used if possible for cordless and cord type positions. Steady signals are preferred but some use is made of flashing signals to denote urgency.

TABLE 2: VISUAL SIGNALS

Location	Lamp	Function	Periodicity	
Connecting circuit (T)	Engaged	Connecting circuit engaged	Steady	*
Connecting circuit (T)	Time	(a) 2.8, 5.8 or 8.8 minutes (coin telephone calls) (b) Timing limit of timer reached (c) Call completed but timer key not restored	Rapid flashing for 12 to 22 secs. Rapid flashing. Steady	
Connecting circuit (T)	Answering Supervisory	(a) Call unanswered or cleared (b) Recall	Steady Slow flashing	
Connecting circuit (T)	Calling Supervisory	Call unanswered or cleared	Steady	
Position (T)	Pre-set	Position preset to receive incoming call	Steady	*
Position (T)	Call Waiting	(a) Call waiting (b) Call waiting longer than pre-determined time (nominally 20 seconds but variable in three steps — 10, 20, 30 seconds ± 25%)	Steady Slow flashing	*
Position (T)	Coin Telephone	Call from coin telephone	Steady	*
Position (T)	Distant Numbering Areas (one lamp per numbering area)	Calls from (particular) distant closed numbering areas.	Steady	*
Position (T)	Operator	Call from an operator	Steady	*
Position (T)	Register Connect Call (or Answer)	(a) Register connected (b) Congestion (c) Called subscriber busy (This latter function is highly desirable but not essential)	Steady (reduced brilliance) Rapid flashing Slow flashing	
Position (T)	Delay (one lamp per position)	Route in delay	Steady	*
Position (T)	Priority	Connecting circuits set for priority working	Steady	
Position (T)	Tube Fail	Pneumatic tube system out of order	Steady	*
Position Key Unit	Data (one lamp per position)	Connecting circuit set for data call	Steady (when speak key operated)	*
Position Key Set	Call monitor	Assistance of monitor required	Steady	
Position Key Set	Route	Routing position busy	Steady	
Position Key	PA	Public address system in use	Steady	
Multiple	Incoming Line	Call waiting	Steady	†
Multiple	Incoming Call Pilot	(a) Call waiting (b) Call waiting longer than pre-determined time	Steady Slow flashing	† †
Multiple	Outgoing Line	Line is free and should be used next	Steady	†
Multiple	Delay (one lamp per route)	The particular group of lines is in delay	Steady	†

(T) Translucent panel on cordless position or position key set on cord type positions.

* Cordless positions only.
† Cord type positions only

MANAGEMENT POSITIONS

Monitors' Posts

The work of the trunk assistance operator is supervised by monitors who each look after a specific number of positions. One of the duties of a monitor is to assist the operators in handling any difficult traffic. A monitor's post is fitted with a call monitor lamp to indicate that a particular operator requires assistance. By means of keys on the monitors post the monitor can obtain direct access to the speech circuit of any of the positions under her control. The design will allow a monitor to have access to up to 10 operating positions. Each monitors post is also equipped with a bothway line to the local automatic exchange and a bothway miscellaneous services circuit for intercommunication within the manual exchange. It is proposed to use digit key strips rather than dials.

Supervisors' Positions

The supervisors' positions should permit quick assessment of the staffing and call handling situation of all positions in the part of the exchange controlled by the supervisor. In the larger exchanges it will be necessary to locate certain of the facilities on separate positions for more efficient operation by specialist staff; alternatively in the smaller centres it may be necessary to include some of the facilities mentioned below on the monitor's post.

At cordless trunk assistance exchanges the following facilities are required, (only minor differences are required at cord type exchanges):—

An Occupied Circuits Indicator to show the number of circuits occupied (at least on backbone routes to trunk distance switching centres).

Rotary Delay Switches to select a recorded announcement to indicate the delay conditions applying on particular routes. Operation of a delay switch will bar access from local demand operators to the particular backbone route, but it will not prevent S.T.D. subscribers, suspense and delay operators or demand operators at other assistance exchanges from gaining access to the route. Delay switches will normally be fitted on final choice trunk routes.

Delay Override Keys to allow demand positions to gain access to backbone routes temporarily barred to other demand operators.

Staffing Lamps to indicate which positions are staffed.

Calls Waiting Display to indicate the number of unanswered calls and the number of calls which have been waiting longer than a predetermined period.

Waiting Time Control Key to vary the time a call will be allowed to remain unanswered before the call waiting lamps on the trunk assistance positions commence to flash.

Priority Control Keys and Lamps to allow particular positions to be preset for priority access.

A Busy Override Facility to allow the supervisor to obtain access to a busy outgoing circuit via the crossbar trunk exchange test access equipment.

Three Connecting Circuits

Cyclometer Type Meters to record:—

(i) Total calls answered from each queue.
(ii) Total number of calls not answered within the specified time.
(iii) Total number of demand calls through connected by each position.
(iv) Total number of demand calls through connected.
(v) Total number of offered incoming calls from subscribers and coin telephones.
(vi) Total number of offered calls from other assistance exchanges.
(vii) Total number of calls reverted.

Queue Control Keys to:—

(i) Permit each queue to be bypassed for fault and test purposes.
(ii) Allow each queue to be blocked for concentration of traffic during slack periods.
(iii) Halve the length of each queue and
(iv) Allow traffic for different services to be concentrated to a single queue during light traffic periods.

A Night Alarm Control Key

A Night Switching Key at exchanges which are closed during some periods.

MISCELLANEOUS SERVICES AND ANCILLARY POSITIONS

Telephone Number Information Positions

These positions handle directory enquiries. Calls can be switched to a supervisory position and operators can make outgoing calls either to the local or trunk network. Incoming calls may be received from the local network, distant parts of Australia, and overseas countries. Calls from overseas will be identified so that they may be given priority.

Trunk Enquiry Positions

These positions are for enquiry traffic such as for the charge of a call and the likely time of connection of a delayed call. In large installations, switching positions will be used to distribute the enquiry traffic to specialised auxiliary positions.

Service Assistance Positions

Service assistance positions are for handling calls from subscribers reporting faulty service or requiring assistance in establishing a call. On these positions details of the difficulties reported by subscribers will be recorded. No testing facilities will be provided other than access to a local or distant subscriber's line to test whether it is free or busy or to confirm a D.N.A. condition. A facility to listen and challenge on the line, even if it appears to be busy, will be provided. Extension of local calls with normal metering, or without metering and S.T.D. calls with the relevant multimetering charges where applicable, will also be provided.

Service Assessment Positions

These positions will be such that highly-trained and experienced operators will be able to assess the quality of service given to subscribers on normal calls without being able to break in on any conversations. Provision will be made for observation of the actual metering and answering conditions and a display of the number dialled by the subscriber. Local area service will be assessed by sampling calls at first selectors or DSRs in step exchanges and SR relay sets in crossbar exchanges. The objective is to provide these facilities in all exchanges exceeding 400 lines in both metropolitan and country areas. In particular cases, perhaps remote rural areas, this may not be practicable or economic and alternative arrangements may have to be made. S.T.D. traffic will, where practicable, be observed separately from local traffic at a point as close as possible to its source and immediately after its separation from local traffic. This will permit the taking of fairly large samples of this important traffic in a relatively short time.

Interception Positions

Interception positions will handle traffic which for any reason must be diverted to a manual operator; for example, calls to lines with incorrect directory entries or which are on temporary interception, changed number service or similar special category. In general, the intercepted traffic will be diverted to the interception centre from crossbar exchanges in a local network but some of this traffic will be connected to recorded announcements and tones. Some of the calls coming into the interception position will be extended to the number dialled or to another number.

Routing Positions

These positions provide answering points for the order wires from the operating positions. An index panel containing the routing codes for all destinations is mounted on each position.

Docket Collecting and Distribution

In large exchanges a sorting rack is provided having access from both sides for sorting, pricing, enquiry or call back purposes. Dockets are normally conveyed from the demand and delay positions by means of a pneumatic tube system and docket receiving and distributing positions.

Training Positions

These are requred at large exchanges where cordless positions are provided. They are similar to normal operating positions and can be used for either simulating the various types of calls an operator would be required to handle or for handling live traffic.

Suspense/Trunk Enquiry Positions

These positions will handle trunk enquiry traffic and particular person calls which have not been completed because the particular person was not available. When he becomes available he advises his local exchange and the operator calls the suspense position at the originating exchange and completes the call. Access to the suspense position is obtained via special calling codes. In addition to the normal facilities provided on demand positions, the suspense positions have equipment for receiving and storing dockets for suspense, "particular person to advise" calls, and fixed time traffic.

Mobile Radio Telephone Positions

In some exchanges facilities will be required for providing assistance on calls to and from mobile radio telephones.

Multi-purpose Positions

In order to achieve maximum staffing economy and operating convenience at small exchanges and during periods of very light traffic at larger exchanges it will be necessary to provide for some combination of the various functions to suit local circumstances. This may be done either by providing specially equipped positions or by modifying one or other of the functional type positions.

Emergency (000) Positions

Special positions are installed in some exchanges for the termination of direct lines to the 000 emergency services (police, fire and ambulance) or for access through the network to the services. Special alarm facilities are provided.

Appointment and Reminder Call Positions

These are simple positions or turrets for the acceptance and verification of appointment and reminder requests. They are fitted with suitable time alarms and docket storage.

International Positions

Subscribers requiring outgoing international calls are required to dial special service codes which ultimately will route the calls to large selected assistance centres at which special international positions are installed. These are similar to demand positions but have additional equipment such as additional digit keys for the codes 11, 12 and 15 used on the international service. In addition to the digital clock indicating local time an extra clock is required to show Greenwich mean time.

Additional equipment is also required on the international positions for handling incoming calls from overseas.

CONCLUSION

The trunk assistance positions being designed to provide the facilities described in this article will meet the basic requirements of the A.P.O. for many years, and the Specification should be a valuable reference document for subsequent developments as it describes not only the facilities but also the boundary conditions between the manual equipment and the automatic network.

Commercially the telephone service cannot continue to operate profitably if the rapidly-expanding demand for trunk service continues to be manually handled. As a matter of policy therefore, the Australian Post Office is vigorously extending the S.T.D. network to minimise the growth in manually-handled traffic with its related costly accounting processes. Nevertheless, it is forseen that improvements in the efficiency with which operators handle manually-connected calls will be essential in order to limit the rate of increase of manual call handling costs. New techniques and new equipment are already under study and will be introduced in the future, including no doubt new manual facilities.

Preliminary assessments indicate that the introduction of a service permitting the subscriber to dial the called number while awaiting operator assistance would produce significant savings and would probably be welcomed by many subscribers. Calling line identification, automatic preparation and processing of charging information, automatic billing, and subscriber dialling of international calls are other potential means of reducing the operating load. Some equipment economies would also result from switching certain calls clear of the operating position once they are established. The actual form of the new manual facilities and the timing of their introduction will depend primarily on subscribers' reactions to the introduction of S.T.D. on a broad scale and to the resultant effect on the growth of particular manual exchanges. The technical capabilities of any major new items of equipment adopted could also be significant, for example, the impetus for new facilities could come with the introduction of electronically controlled exchange equipment in several years time.

While the positions which have been specified do not provide all these refinements they represent an economic compromise at this stage in the development of the network.

ACKNOWLEDGMENTS

The specification of facilities for manual switchboards is perhaps one of the most complex specification problems in Telephony and the authors wish therefore, to thank all those who contributed to the preparation of the Specification, in particular those officers of the Planning and Research, Engineering Works and Telecommunication Divisions of the Australian Post Office who have been closely associated with the project. They also appreciate the assistance received in the presentation of the results in this article.

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SEACOM-E — RADIO BEARER SERVICE ORGANIZATION

*A. ELLIS, B.Sc.**

INTRODUCTION

This seventh article in the SEACOM series describes the service organization responsible for the operation and maintenance of the SEACOM-E radio bearers and the way it has been developed to assure the high standards of performance and reliability set down for this link during the Kuala Lumpur Conference. (Ref. 1.).

Briefly, the desired standards exceed those of the usual Departmental trunk systems in the following ways:

Noise Allowance: The noise allowance for the section between Brisbane and Cairns has been reduced by approximately 5 dB from the usual C.C.I.R. limit.

Traffic Loading: The loading of the supergroup which carries the SEACOM traffic is approximately 6 dB higher than C.C.I.R. loading.

Reliability: The maximum outage limit during any four-week period must not exceed 0.1 per cent over the entire route from Sydney to Cairns.

Maintenance Radius: The distance from any radio site to a maintenance centre should not exceed that requiring 1½ hours' travel by road.

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With these objectives in mind, it is not difficult to understand the need for the highly developed service organization now operating along the route, which is staffed, equipped and organized to a level higher than that previously felt necessary for internal trunk routes.

GENERAL

The two major radio sections of SEACOM-E (Sydney to Lismore — 425 miles and Mt. Gravatt to Cairns — 960 miles) are linked between Lismore-Mt. Gravatt (140 miles) by a coaxial cable system.

Because of the differing administrative, geographic and equipment parameters which apply in these three sections, the service organization has been decentralised so that responsibility for performance, operations and maintenance is vested in Brisbane for the cable section, and at Redfern and Mt. Gravatt for the radio sections. As shown in Fig. 1, each of these stations (called Line Section Control Stations), occupies a similar level in the overall service organization and carries out its functions within it with a great deal of autonomy. Each is, however, subject to direction from the line control station at City South (Sydney) for activities concerning the performance and co-ordination of the route as a whole.

Within the radio sections, the maintenance function has been further decentralised to provide direct co-ordination of these activities at various points along the route. These levels in the organization are known as Maintenance Control Centres and are physically located at the baseband terminals which conveniently separate the route into approximately 200 mile intervals (Fig. 2).

There is only one other level in the organization, and this is the one which provides the vital 'first-in' maintenance attention to the unstaffed repeaters within the 1½ hour time limit mentioned previously.

The staff for this level is drawn from the permanent district staff located at the various telephone exchanges along the route.

RADIO LINE SECTION CONTROL

Within their respective Sections, the Line Section Control Stations at Redfern and Mt. Gravatt carry out the detailed duties shown below. Both stations are staffed continuously and are operated at all times under the direction of senior supervisory staff.

(i) Carry out or arrange line-up and noise measurements over

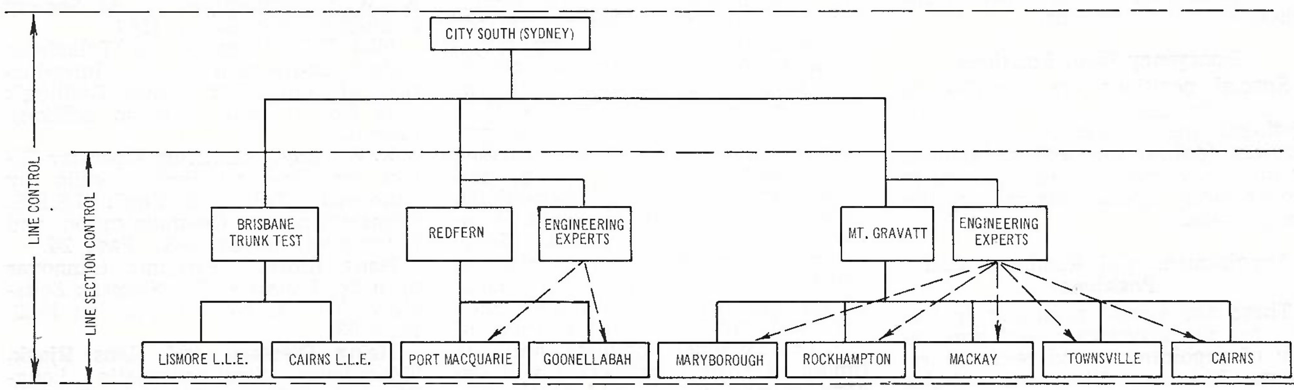

Fig. 1 — Coaxial and Radio Line Section Control.

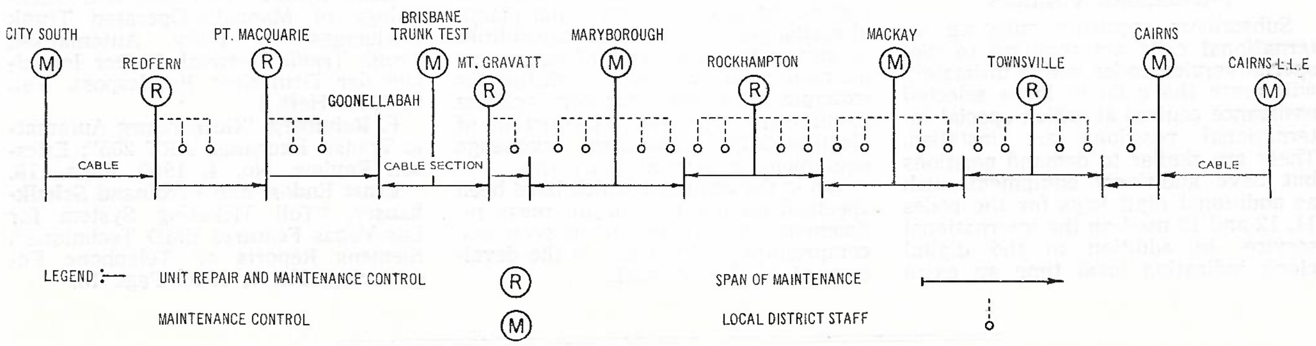

Fig. 2 — Maintenance Section Control.

the bearers and whole sections to ensure that the performance standard set for the Section is being maintained.

(ii) Supervise the testing and clearance of faults other than those delegated to the maintenance control centres.

(iii) Advises line control of all conditions which may affect the operation of the Section under its control.

(iv) Arranges for the release from traffic of the Section as required for routine performance measurements and maintenance.

As well as having a very experienced staff, both of the line section control stations are equipped with two resources which play a major part in the co-ordination of the overall section performance:

(i) an extensive supervisory system which shows the operational status of each bearer at each site along the section; and

(ii) an auxiliary engineering order wire with express circuits in each of the maintenance control centres and which can be patched to communicate directly with any repeater site in any section as desired.

The tele-signalling system at each line section control station plays its major role during the hours when the maintenance control stations are unstaffed, by accurately and quickly locating faults, and 'off normal' conditions which might cause faults if allowed to continue. The line section control does not personally attend the fault clearance at these times, but operates a well-defined system of staff recall to alert staff from the appropriate maintenance centre and local district. The use of the order wire to allow demand calls to each maintenance centre is an obvious requirement of a service 'line' command, whilst the ability to communicate with any site along the section is designed to cover emergency periods at the maintenance centres.

MAINTENANCE CONTROL

These centres are staffed on either a one or two shift basis and during these hours, have the responsibility for ensuring the rapid clearance of faults within the maintenance section. Although the centre is mainly concerned with providing expert assistance to the staff performing the 'first-in' maintenance, in some cases where travelling time is a consideration, the actual repeaters adjacent to the centre are maintained directly by staff from the centre. After the above normal hours of duty, this staff is available on a 'recall' basis.

Each centre is equipped with a supervisory system similar to that at the line section control station, except that the tele-signalled indications are limited to those from bearers which terminate at their centre. The supervisory display is arranged so that indications from sites are transmitted to both adjacent maintenance control centres so allowing control from an adjacent centre. This feature permits the specialist at the Maintenance Centre to personally attend nearby repeaters without control being lost throughout the maintenance section.

As shown in Fig. 2, certain of these maintenance centres are equipped and staffed to carry out detailed unit repair. All maintenance centres are of course equipped to test repaired units before they are placed in service.

District Staff: Although the work of the district staff at the radio sites is closely directed by 'Maintenance Control', they exercise a great deal of initiative in locating alternative emergency routes from their base to the radio site and in dealing with emergency transport problems as they arise in the very rugged country traversed by the route.

As in the case of the Maintenance Control Centres, the district staff operate on a 'recall' basis after normal hours.

Special Service Groups: A group of experts under the control of an experienced engineer is attached to each of the radio line section control stations (Fig. 1). The group acts in a 'staff' capacity to the route as a whole by providing expert assistance when required, and also as an auditor to line section control with respect to the overall section performance.

COMMUNICATION WITHIN THE ORGANIZATION

Communication problems within the organization fall into three main areas as follows:

Staff Recall: During the period when the Maintenance Centres are unstaffed, recall of staff to effect fault clearance is carried out by the line section control stations at Redfern and Mt. Gravatt, both of which are staffed on a continuous basis.

Service Activity Affecting Bearers: In order to control the overall system performance as seen by the user, service activity at any site which may result in a bearer outage exceeding 2 msec., is only authorised by line control. When an outage is expected to be less than 2 msec., authority is only required from line section control. Hence, close communication is essential at these times between the control stations concerned. Further, during the clearance of faults or the performance of routines at repeaters, communication regarding the status of the bearers, the usage of spare units and general technical advice is required between the repeater and its maintenance control centre.

Assessment of Reliability and Performance: Because the reliability of the route is conveniently defined in terms of a four-week period, some recorded form of communication is required between the field staff and the control centres. This permits individual records to be integrated to produce a route summary, and allows maintenance centres to obtain a long term view of the bearers under their control so that they may observe and correct adverse trends. The assessment of performance also involves a two-way communication system, that is, a flow of raw data from field to control and a flow of 'exception reports' back from control to field.

The first communication problem of after-hours recall raises little difficulty, as the facilities of the internal trunk network are available along the entire length of the route. As mentioned previously, an internal supervisory and order-wire system is used to solve the second problem which entails the immediate recognition of distant fault conditions and the concomitant demand telephone connection.

With regard to the third problem, no simple solution exists, since the required communication must provide for the flow of permanent records from the field to control, their subsequent analysis and the final flow of integrated performance and reliability summaries back to the field. On the performance side, the flow of routine measurements occurs at regular, planned intervals and by virtue of the measuring process, yields an integrated picture which needs little processing other than that required to attract attention when limits are being approached. The picture is considerably different with regard to reliability however, since the data concerning it is generated frequently and at random times throughout the entire length of the route, and requires a great deal of processing before its information content can be effectively used.

The solution to this problem which has been adopted by the Radio Sections, involves the application of modern computer techniques to the sorting, assessing and correlation of field service reports to produce the desired summaries in forms suitable for the various levels of management concerned. Circulation of this information is made both up and down the organization regularly each month, and at other times as found necessary.

The types of analysis being carried out at present fall into the three major categories of equipment, site and route. The first two are produced primarily for use within the maintenance section, whilst the route analyses are of major importance to the radio line section control and also the line control station. The same basic data is used to produce each of these analyses.

Q. RADIOCOMM SERVICE ANALYSIS JULY 1966 PAGE NO. 11

SITE NAME AND	NUMBER	BRR NO.		...REPORTED AS FAULTS... NO.	OUTAGE HRS.MN.SC	MANHOURS HRS.MN.SC	.....PLANNED ACTIVITY..... NO.	OUTAGE HRS.MN.SC	MANHOURS HRS.MN.SC	TRAFFIC LOSS HRS.MN.SC
MARYBOROUGH	406	000	COM EQUIPMNT	2	4 40 0	3 40 0	3	0 0 0	21 30 0	0 0 0
MARYBOROUGH	406	021	NEC TR4G12	0	0 0 0	0 0 0	0	0 0 0	0 0 0	0 0 0
MARYBOROUGH	406	022	NEC TR4G12	0	0 0 0	0 0 0	1	0 10 0	0 10 0	0 0 0
MARYBOROUGH	406	023	NEC TR4G12	1	0 5 0	0 5 0	0	0 0 0	0 0 0	0 0 0
MARYBOROUGH	406	024	NEC TR4G12	1	0 10 0	0 15 0	1	0 5 0	0 10 0	0 10 0
MARYBOROUGH	406	029	NEC TR4G12	3	0 10 0	0 25 0	0	0 0 0	0 0 0	0 0 0
MARYBOROUGH	406	031	NEC TR4G12	1	0 55 0	4 0 0	0	0 0 0	0 0 0	0 0 0
MARYBOROUGH	406	032	NEC TR4G12	0	0 0 0	0 0 0	1	0 6 0	0 6 0	0 0 0
MARYBOROUGH	406	033	NEC TR4G12	1	0 5 0	0 5 0	0	0 0 0	0 0 0	0 0 0
MARYBOROUGH	406	034	NEC TR4G12	0	0 0 0	0 0 0	1	0 5 0	0 9 0	0 0 0
MARYBOROUGH	406	039	NEC TR4G12	2	0 8 0	0 8 0	0	0 0 0	0 0 0	0 3 0
MARYBOROUGH	406	071	NEC TR4G12	0	0 0 0	0 0 0	0	0 0 0	0 0 0	0 0 0
MARYBOROUGH	406	073	NEC TR4G12	2	0 1 0	0 25 0	0	0 0 0	0 0 0	0 0 30
MARYBOROUGH	406	121	NEC TR4GD SY	0	0 0 0	0 0 0	0	0 0 0	0 0 0	0 0 0
MARYBOROUGH	406	122	NEC TR4GD SY	0	0 0 0	0 0 0	0	0 0 0	0 0 0	0 0 0
MARYBOROUGH	406	131	NEC TR4GD SY	0	0 0 0	0 0 0	0	0 0 0	0 0 0	0 0 0
MARYBOROUGH	406	132	NEC TR4GD SY	1	0 55 0	4 0 0	0	0 0 0	0 0 0	0 0 0
MARYBOROUGH	406	171	NEC TR4GD SY	0	0 0 0	0 0 0	0	0 0 0	0 0 0	0 0 0
MARYBOROUGH	406	172	NEC TR4GD SY	0	0 0 0	0 0 0	0	0 0 0	0 0 0	0 0 0
MARYBOROUGH	406	990	STE ADMIN	0	0 0 0	0 0 0	6	0 0 0	48 9 0	0 0 0
MARYBOROUGH	406	996	TST INSTMNTS	0	0 0 0	0 0 0	1	0 0 0	7 0 0	0 0 0
MARYBOROUGH	406	997	SPL ASSIST	0	0 0 0	0 0 0	0	0 0 0	0 0 0	0 0 0
MARYBOROUGH	406	998	EQT REPAIR	0	0 0 0	0 0 0	0	0 0 0	0 0 0	0 0 0
MARYBOROUGH	406	999	RTE CONTROL	0	0 0 0	0 0 0	5	0 0 0	33 20 0	0 0 0
TFC INTERRUPTIONS-	3			14	7 9 0	13 3 0	19	0 26 0	110 34 0	0 13 30

Fig. 3 — Radio Bearer Site Analysis.

DETAILED SITE ANALYSIS MARYBOROUGH

COMPLAINT OR OBSERVATION. BEARER OUTAGES

TYPE	NO.	HRS.MN.SC
SYSTEM OFF	2	0 13 0
NOISY	2	1 50 0
URGENT ALARM	2	0 10 30
DET BY INSP	2	4 30 30
HIGH LEVEL	4	0 20 0
NO PICTURE	1	0 2 0
VIDEO BRKING	1	0 3 0

....PLANNED ACTIVITY..... BEARER OUTAGES

TYPE	NO.	HRS.MN.SC
ADJUSTMENT	2	0 11 0
N/S SET RTNE	2	0 0 0
PERF RTNE	3	0 15 0

PLANNED ACTS. MANHOURS

TYPE	NO.	HRS.MN.SC
ADJUSTMENT	2	0 15 0
N/S SET RTNE	2	14 30 0
PERF RTNE	3	7 20 0

....COMMON EQUIPMENT..... BEARER OUTAGES

TYPE	NO.	HRS.MN.SC
LOC PRI SUP	1	4 30 0
EMERG SUPPLY	1	0 0 0
SUPV EQT	2	0 20 0

FAULT OCCURRENCES

TYPE	NO.	DURATION
NIL		

.......FAULT CAUSE....... BEARER OUTAGES

TYPE	NO.	HRS.MN.SC
ADJUSTING	1	0 10 0
UNIT CHANGED	2	0 6 0
CONTACTOR	1	4 30 0
COAX CONNCTR	1	0 0 30
INTERFERENCE	2	1 50 0
POORS	5	0 22 0
UNLOCATED	1	0 0 30
HUMAN ERROR	1	0 10 0

OTHER RADIO EQPT FAULTS - BEARERS NOT AFFECTED -

NIL

Fig. 4 — Detailed Site Analysis.

Q. RADIOCOMM SERVICE ANALYSIS DECEMBER 1966 ROUTE SUMMARIES

ROUTE	TRAFFIC NR	TIME LOST HRS MIN SEC	TOTAL BEARER OUTAGES NR	HRS MIN SEC	B E A R E R MAINS FAIL HRS MIN SEC	O U T A G E S EQUIP FAIL HRS MIN SEC	D U E T O INSTL ACTION HRS MIN SEC	ROUTE RELIABILITY PERCENT
MT GRAVATT PASSCHENDAELE	4	0 3 42	9	1 49 24	0 1 4	1 3 0	0 45 0	99.99
CENTRAL AUTO MT GRAVATT	0	0 0 0	0	0 0 0	0 0 0	0 0 0	0 0 0	100.00
MT GRAVATT MT NARDI	5	0 7 50	12	7 29 40	0 0 0	3 59 0	0 0 0	99.98
BRISBANE CABOOLTURE	5	6 48 0	10	13 32 0	0 0 0	8 17 0	1 0 0	98.99
BRISBANE MARYBOROUGH	0	0 0 0	1	0 40 0	0 0 0	0 40 0	0 0 0	100.00
BRISBANE ROCKHAMPTON	0	0 0 0	1	0 40 0	0 0 0	0 40 0	0 0 0	100.00
BRISBANE MACKAY	0	0 0 0	2	1 13 0	0 0 0	1 13 0	0 0 0	100.00
BRISBANE TOWNSVILLE	0	0 0 0	5	5 53 0	0 0 0	2 53 0	0 0 0	100.00
BRISBANE CAIRNS	0	0 0 0	5	5 53 0	0 0 0	2 53 0	0 0 0	100.00
ROCKHAMPTON MACKAY	0	0 0 0	1	0 33 0	0 0 0	0 33 0	0 0 0	100.00
MACKAY TOWNSVILLE	0	0 0 0	2	1 40 0	0 0 0	1 40 0	0 0 0	100.00
TOWNSVILLE CAIRNS	0	0 0 0	1	3 0 0	0 0 0	0 0 0	0 0 0	100.00
MT GRAVATT MT GOONANEMAN TV	2	0 5 0	6	35 6 0	0 0 0	6 34 0	0 0 0	99.99
MT GRAVATT MT HOPEFUL TV	2	0 5 0	9	35 41 0	0 0 0	7 9 0	0 0 0	99.99
MT GRAVATT MT STUART TV	2	0 5 0	6	35 6 0	0 0 0	6 34 0	0 0 0	99.99
MT GRAVATT CAIRNS TV	4	0 22 0	10	38 30 0	0 0 0	6 58 0	0 0 0	99.95
MT GRAVATT MOWBULLAN TV	4	0 3 42	8	1 4 24	0 1 4	1 3 0	0 0 0	99.99

Fig. 5 — Route Summaries.

The equipment print-out (see Fig. 3) shows the performance of bearer-terminals and bearer-repeaters at each site in terms of the number of faults (due to all causes), the number of routines and the resulting outages and manhours summed over the month of analysis. It is used as an indicator of equipment trends and as a record of the preventive/corrective maintenance ratios being employed in each maintenance section.

The site analysis (see Fig. 4) integrates this information to show the level of activity at each site required to cope with the problems associated with different types of complaints, routines and faults, and so provides an indicator of the efficiency of the station which is not masked by the equipment performance at other sites.

The third type, called Route Summaries (see Fig. 5), shows the duration of bearer outages and their major causes for each route, and produces traffic statistics which are time-correlated with those from other sections to show the overall route performance as seen by user. These analyses are also used to highlight unusual occurrences along the entire route such as the differentially high (or low) outages of bearers within the various sections.

It is perhaps of interest to note the cost of each monthly group of computer analyses is comparable with the costs associated with one clerk-week.

CONCLUSION

The service organization described above was developed to meet the challenge raised by the introduction of international traffic into the Australian trunk radio system.

The organization is, of course, only a means of assembling a team of skilled men so as to make best use of their vast potential, and with the staff now operating along the route, if this is achieved in even a moderate degree, then the performance of the SEACOM-E route will have been assured.

ACKNOWLEDGEMENT

The development of the above organization was the result of ideas and field experience of many people in both State and Central Administrations.

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TECHNICAL NEWS ITEM

NOSFER—AN INTERNATIONALLY RECOGNISED REFERENCE STANDARD OF TELEPHONE TRANSMISSION

One of the functions of the P.M.G. Research Laboratories is to investigate the transmission performance of representative telephone circuits and to assess the range of circuit and environmental conditions which enables a satisfactory transmission performance to be achieved. The planning rules for the Australian telephone network currently prescribe that the transmission performance of any subscriber/subscribers connection is not worse than the performance provided by a circuit incorporating two telephones (APO Type 300) with local lines of specified gauge and length and various other specified circuit and environmental parameters.

This limit-connection which is known as the Overall Transmission Performance Standard was formulated many years ago to represent the practical limit of useful performance. The performance of a connection just meeting the prescribed limit permits effective conversation over the connection but not without conscious effort on the part of the subscribers.

The transmission rating of a practical telephone circuit relative to this standard is obtained by adding loss to either the standard or to the practical circuit as required, until equality of performance is obtained using a team of trained talkers and listeners and comparing the circuits either for relative articulation quality or loudness (volume).

With the rapidly-growing proportion of international calls to and from the national network it has become very important that the transmission performance experienced on such calls be adequate and one of the requirements in this regard is that the sending and receiving efficiencies within all countries which have international calls be compatible so that interconnections are possible without either excessive or inadequate listening levels.

The International Telephone and Telegraph Consultative Committee (C.C.I.T.T.) which has its headquarters in Geneva, has made recommendations relevant to the desirable ranges of loudness (or volume) performance both for sending and receiving circuits in national networks in order that compatible performance on international connections will be achieved. These loudness ratings are specified in terms of volume "reference equivalents", which are ratings of the telephone send and receive circuits against a standard reference transmission system installed in the laboratories of the C.C.I.T.T. and known as NOSFER, using the loudness of speech as the basis of rating. NOSFER represents the abbreviation of the French title "The New Fundamental System of Determination of Reference Equivalents". The NOSFER supersedes an earlier reference transmission standard known as SFERT (The European Master Reference System for Telephone Transmission). The NOSFER utilises a high quality microphone and head receiver with high quality amplifiers and attenuators plus the addition of special sending and receiving equalisers which convert the frequency response to be similar to that obtained with the old SFERT reference system. It is feasible to reproduce the essential transmission characteristics of NOSFER using any appropriate high quality transducers and amplifiers providing the overall electro-acoustic response and efficiency is met.

To assist telephone administrations in determining their reference equivalents of the national part of international connections they may forward telephone sets (with simulated local circuit conditions) to the Geneva Laboratory for rating against the C.C.I.T.T. NOSFER. However, the demand on the C.C.I.T.T. Laboratories for such determinations is high and a substantial back log of work exists. Administrations are therefore encouraged to set up their own reference standards and to carry out their own determinations.

The setting up of a NOSFER reference system in the Department's Research Laboratories was completed in 1966. Its overall response and sensitivity matches that of the C.C.I.T.T. NOSFER. A team of five persons trained in speaking and listening over this system is maintained in the Laboratories. In 1965, a set of five carefully selected and tested telephones and local line circuits were sent to the Geneva Laboratories for rating. The same sets were later rated using the Laboratories' NOSFER reference system, and good agreement was obtained. A programme of measurements of reference equivalents of telephones and associated local lines as used in the Australian network is now in hand in order to provide the basic information necessary to assess the volume performance (reference equivalent) of the present telephone network and to plan and design for the future. E.J.K.

THE A.P.O. THREE STAGE GROUP SELECTOR – INITIAL PLANNING

*M. FARDOULY, B.Sc., B.E.**

INTRODUCTION

Since the introduction of crossbar switching equipment into the telephone network, the Australian Post Office has been investigating possible methods of retrospectively increasing the availability of conventional L. M. Ericsson metropolitan type group selector equipment in order to reduce costs and permit greater exploitation of the alternate routing facilities at tandem and larger terminal exchanges. This article outlines some of the factors which were considered by the A.P.O. in developing an acceptable grouping plan, facility specification and survey diagram to be used as the basis for the final design and documentation of the A.P.O. three-stage group selector by a joint L.M.E. and A.P.O. team. The three-stage group selector equipment developed jointly by this design team, is described in this issue (Ref. 1.).

BACKGROUND INFORMATION

The announcement in April 1959 by the Postmaster-General that the Australian Post Office would adopt the crossbar automatic switching system was followed soon after by a further announcement that the type of system would be that developed by L. M. Ericsson of Stockholm, Sweden. The main reasons for adopting this new system in favour of step-by-step equipment were based on economical, technical and operational considerations outlined in Ref. 2.

One important feature of the crossbar system is its ability to increase the traffic-carrying capacity on links by the use of direct and alternate routing techniques. This is made possible by the use of common control selector equipment with its alternate routing facilities and larger availability. The Department realized during the early stages of negotiations with L.M.E. that although the 400 outlet availability provided by the standard L.M.E. selector equipment was satisfactory for smaller exchanges, it would restrict the efficient utilisation of the alternate routing facilities at tandem and larger terminal exchanges. The method used by L.M.E. to increase availability by connecting 40 or 80 outlets of the 1GV stage to a subsidiary 2GV stage, was considered unsuitable for general application in the A.P.O. network for the following reasons:—

- (i) Calls switched by the 2GV stage required four partial stages in tandem.
- (ii) Alternate routing from the 2GV stage to the 1GV stage was not economically practicable.
- (iii) An additional marker rack was required for each 160, 2GV inlets.
- (iv) There was an increase in the average register holding time due to the need to retransmit the routing information to the second marker.
- (v) The necessity to make frequent strapping changes to the analyser.

The first three-stage group selector scheme was proposed by Mr. N. M. H. Smith of the Australian Post Office during discussions with L.M.E. representatives in Stockholm during 1959. This proposal envisaged the adoption of conventional L.M.E. GV equipment initially, with conversion to three-stage operation when traffic growth made this economic. (Ref. 3.). The third stage was to be added in units of 200 outlets in effective full availability trunking. The design objective was for a maximum of ten, 80 inlet GVA/B groups to be interconnected by grading to a normal maximum of five, 200 outlet GVC groups. This proposal provided a maximum availability of 1,000 in increments of 120 per GVC group.

Due to the pressure of other commitments and the need to introduce ARM automatic trunk switching equipment into the A.P.O. network, the development of the three-stage group selector was delayed until September 1965 when an L.M.E. engineer arrived in Australia to work in collaboration with the A.P.O. on its development.

ALTERNATIVE SCHEMES

Internal Trunking Arrangements

A new design approach for the three-stage group selector was put forward by L. M. Ericsson in September, 1965. The proposal was to take 80 outlets from a 160 GVA/B group and connect them to a GVC stage with 320 outlets to give an overall increase in availability of 240 per "C" stage. It was also proposed to restrict the number of GVC stages per 160 GVA/B group to two, thereby limiting the overall "B" and "C" stage availability to 880.

The A.P.O. considered that the L.M.E. scheme did not meet the long term objectives for the economic development of the A.P.O. network as it would restrict routing arrangements at tandem and larger terminal exchanges. The A.P.O. therefore, devised three variations of the L.M.E. scheme for consideration. These were as follows:—

- (iii) A GVC stage of 100 inlets and 300 outlets accessible from two 160 inlets 1GVA/B groups and controlled by two modified IGV marker organisations operating in parallel for calls via the GVC stage.

An evaluation of the four schemes was based on a comparison between the following factors:—

- (i) Route sizes
- (ii) Traffic characteristics
- (iii) Grading facilities
- (iv) Increments in availability
- (v) Maximum availability
- (vi) Depth of availability
- (vii) Rack requirements.

The comparisons were made for selector stages with from 320 to 4,000 inlets for a range of availability from 400 to 1,600.

It was found that the best internal trunking arrangement for application in the A.P.O. network was one where 100 outlets from each 160 GVA/B inlet group were connected to 100 inlets of a GVC stage with a total availability of 400. This meant that increments in availability would be 300, giving a total "B + C" stage availability of 700, 1,000, 1,300 and 1,600 for 1, 2, 3 and 4 "C" stages respectively.

A grouping plan of the preferred link trunking arrangement is shown in Fig. 1.

- (i) A GVC stage of 100 inlets and 400 outlets accessible from a single 160 1GVA/B group and controlled by a modified IGV marker.
- (ii) A GVC stage of 80 inlets and 240 outlets accessible from two 160 inlets 1GVA/B groups and controlled by two modified IGV marker organisations operating in parallel for calls via the GVC stage.

Marker Organisation

The second aspect to consider was the most suitable marker organisation to control the three partial stages. Two schemes were considered. The first scheme proposed by L.M.E. permitted the existing 1GV marker to be modified to control the GVC stage associated with each 160 inlet GVA/B group. The second scheme, proposed by the A.P.O., was to permit two markers associated with two 160 inlet GVA/B groups to control calls to a common GVC stage. With this technique free marking of outlets was mandatory whereas with the L.M.E. scheme it was optional.

In order to compare the two schemes a complete survey diagram was prepared for each, showing all the relays and switches required. A comparison was then made between the following features:—

- (i) Call handling capacity
- (ii) Design complexity
- (iii) Link path selection
- (iv) Outlet selection
- (v) Network switching requirements e.g. alternate routing capabilities
- (vi) Economic considerations.

Although the A.P.O. scheme permitted a single GVC stage to be shared by two 160 inlet GVA/B groups it required a more costly and complex marker organisation and would have

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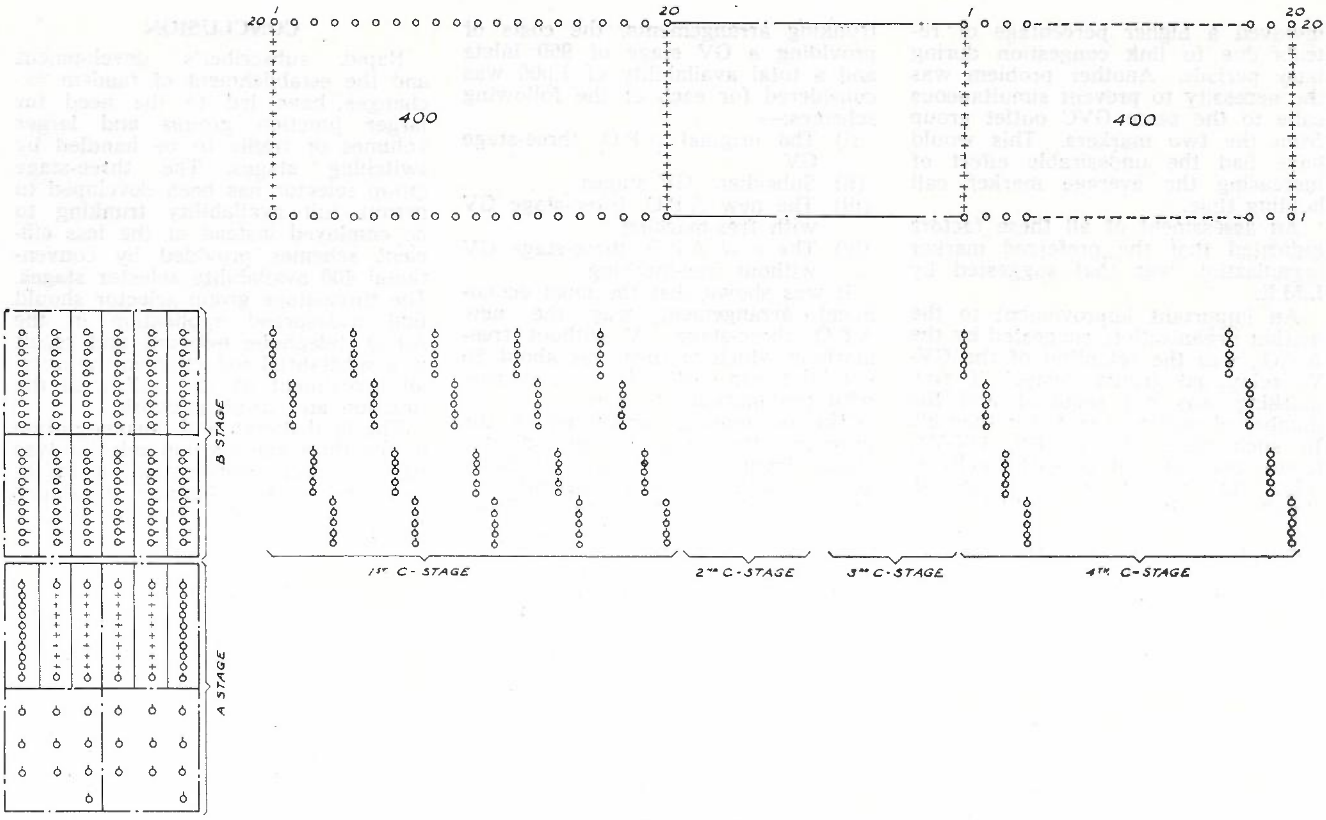

Fig. 1 — Grouping Plan.

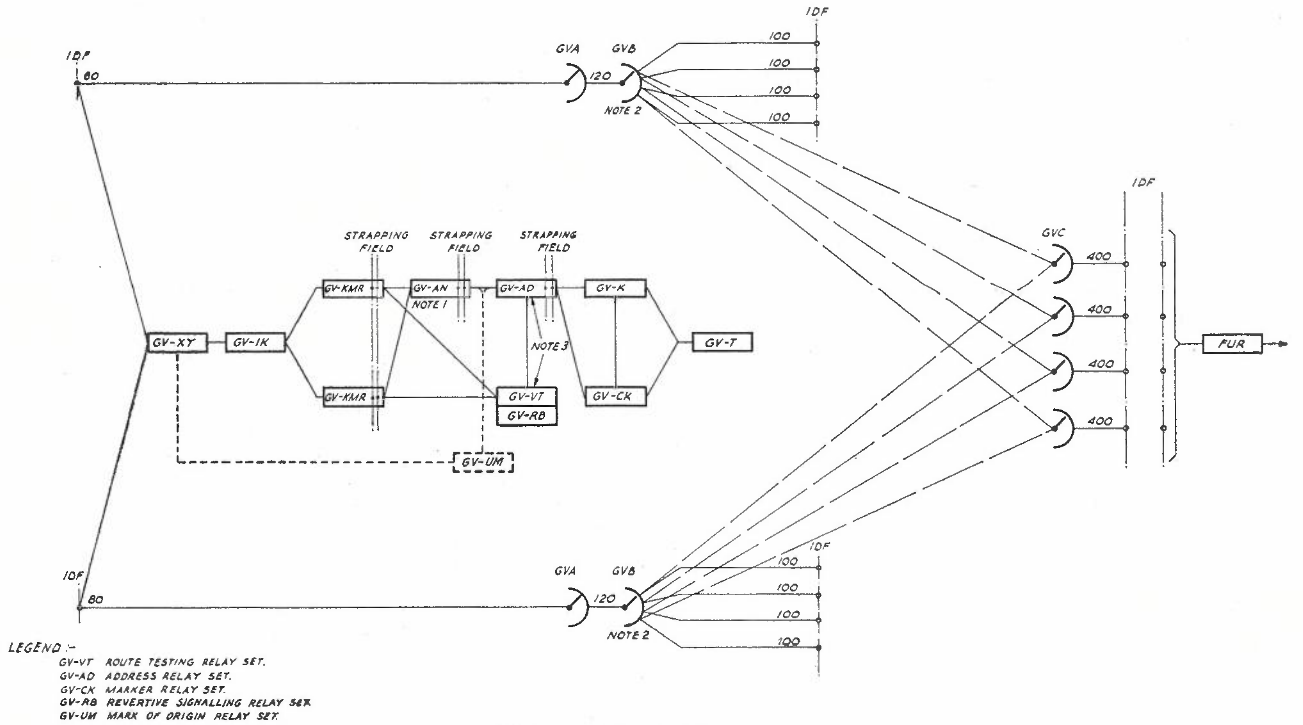

Fig. 2 — Trunking Arrangements.

NOTES:
1. Analysers will be available to perform the following functions:—
   (a) GV-AN parts 1a and 2a for route determination for 80 routes.
   (b) GV-AN parts 1b and 2b for number length and type of terminating equipment analysis.
   (c) GV-AN parts 1c and 2c replaces GV-AN parts 1a and 2a when the number of routes exceeds 80.
2. The GVB outlets trunked to the GVC stage shall be directly connected by plug ended tie cables and not via the IDF.
3. The GV-AD, GV-RB and GV-VT relay sets will replace the GV-W relay set only in cases where free marking is required or there are more than 80 routes.

involved a higher percentage of retests due to link congestion during busy periods. Another problem was the necessity to prevent simultaneous calls to the same GVC outlet group from the two markers. This would have had the undesirable effect of increasing the average marker call holding time.

An assessment of all these factors indicated that the preferred marker organisation was that suggested by L.M.E.

An important improvement to the marker organisation, suggested by the A.P.O., was the retention of the GV-W relay set (route relays) if free marking was not required and the number of routes were fewer than 80. In such cases the GV-RB, GV-VT, (route testing) and GV-AD (address) relay sets would not be required, thereby retaining the GV-W relay sets in use for most three-stage applications. Other important changes proposed by the A.P.O. related to the design of the GV-AD relay sets and the equipping of the GVC rack with ten crossbar switches instead of the eight originally suggested by L. M. Ericsson, thereby conserving rack space.

A block diagram showing the proposed marker organisation for the A.P.O. three-stage group selector is illustrated in Fig. 2. Two methods are shown and the one used will depend on the number of routes required and whether free marking is required. The two methods are:—

Where Free Marking Is Required or There Are More Than 80 Routes: The additional marker control equipment required for C-stage working when using this method will be GV-VT, GV-CK (marker) and two or more GV-AD relay sets. The existing GV-W relay set will not be required. The method provides the routing and alternate routing capacity outlined in Table B of the Appendix and can be used to control up to four GVC stages.

Where Free Marking Is Not Required and There Are Less Than 80 Routes: In this method the existing GV-W relay set can be retained and used in conjunction with the GV-CK relay set which will be the only additional marker control equipment required for three-stage working. This method provides the same total number of routes, route sizes and alternate routing capacity as the present 1GV marker and it can be used to control up to three "C" stages giving a total availability of 1,300.

FACILITIES REQUIREMENTS

The final specification of technical facilities to be met by the A.P.O. three-stage group selector is set out in the Appendix to this article. (See also Ref. 4.)

ECONOMIC CONSIDERATIONS

In order to determine the likely overall network economies that would result from the use of the three-stage group selector compared with other trunking arrangements, the costs of providing a GV stage of 960 inlets and a total availability of 1,000 was considered for each of the following schemes:—

(i) The original A.P.O. three-stage GV
(ii) Subsidiary GV stages
(iii) The new A.P.O. three-stage GV with free-marking
(iv) The new A.P.O. three-stage GV without free-marking.

It was shown that the most economical arrangement was the new A.P.O. three-stage GV without free-marking which in turn was about $5 per inlet less costly than the scheme with free-marking.

The economical advantage of the proposed three-stage group selector stems from its greater availability and its ability to more efficiently exploit the alternate routing facilities. Another advantage is the more efficient traffic arrangement which enables circuits connected to the GVC stage to be accessible through five parallel link paths. This results in less internal congestion which permits each outlet to carry traffic more efficiently. The main economies from the use of the proposed three-stage group selector compared with subsidiary GV stages are:—

(i) A reduction in group selector equipment costs
(ii) Greater efficiency of junction plant
(iii) Fewer SL and GV inlets.

The three-stage group selector should therefore find widespread application in both metropolitan and provincial exchanges and will provide more efficient network designs and consequent substantial overall savings.

FEASIBILITY OF CONVERTING EXISTING 1GV EQUIPMENT

In order to establish the feasibility of introducing the third partial stage into existing equipment, a Working Party was convened by Switching and Facilities Planning Section of the A.P.O. Central Administration. This Working Party consisted of representatives from Metropolitan Installation in New South Wales and Victoria, Telephone Exchange Equipment in Central Office, L. M. Ericsson and Switching and Facilities Planning. The Working Party investigated the practicability of retrospectively adding the GVC stage to existing and working metropolitan type 1GV equipment. The conclusion reached by the Working Party was that the proposed new three-stage group selector proposal was practicable and could be added to existing and working equipment without disrupting services. In addition, the Working Party made certain recommendations to facilitate the future introduction of the three-stage equipment into the network. These recommendations were incorporated into the specification and design of the three-stage group selector.

CONCLUSION

Rapid subscriber's development and the establishment of tandem exchanges have led to the need for larger junction groups and larger volumes of traffic to be handled by switching stages. The three-stage group selector has been developed to permit full availability trunking to be employed instead of the less efficient schemes provided by conventional 400 availability selector stages. The three-stage group selector should find widespread application in the A.P.O. telephone network and result in a substantial reduction in the overall investment by the A.P.O. in the junction and trunk network.

The final design and documentation of the three-stage group selector was based on the Specification of Facilities, and survey diagram developed jointly by the A.P.O. Planning Branch and L. M. Ericsson.

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APPENDIX
FACILITY SPECIFICATION — A.P.O. THREE-STAGE GROUP SELECTOR

General

The three-stage group selector is required to increase the availability of conventional A.P.O. metropolitan type 1GV equipment at large terminal and tandem exchanges to permit greater exploitation of the alternate routing facility. The third stage, which will be used when traffic growth renders it economic, must be designed so that it can be added to existing 1GVA/B crossbar equipment with minimum modification to existing equipment. It must also be capable of interworking with the existing Reg-LM and the proposed Reg-LP and Reg-ELP.

Traffic Handling Capacity

It is anticipated that the GVC stage may be added to existing 1GV equipment when the number of inlets reaches 320. The range of traffic capacities the three-stage group selector must be designed to handle is set out in Table A.

TABLE A: TRAFFIC HANDLING CAPACITY

Number of inlets	Input traffic erlangs	Availability
320	160- 240	700
480	240- 360	700-1000
640	320- 480	700-1000
800	400- 600	700-1000
960	480- 720	1000-1300
1120	560- 840	1000-1300
1280	640- 960	1000-1600
1440	720-1080	1000-1600
1600	800-1200	1000-1600
,	, ,	, ,
,	, ,	, ,
2400	1200-1800	1000-1600
,	, ,	, ,
,	, ,	, ,
3200	1600-2400	1000-1600

Link Trunking Arrangements

The A.P.O. has considered a number of alternative link trunking arrangements, which are variations of the original L.M.E. proposal, and the conclusion has been reached that the arrangement most suitable is one providing a C-stage with 100 inlets accessible from a single 160 inlet GVA group and 400 outlets. This arrangement, which is outlined in Fig. 2, permits a B to C stage link loading of approximately 39 Erlangs per 160 GVA inlets per C stage.

Routing Capacity

Where Free-marking Is Required or There Are More Than 80 Routes: In this case the three-stage group selector should provide the route sizes, availability and number of alternative routes outlined in Table B.

Where Free-marking Is Not Required and There are Less Than 80 Routes: In this case the total number of routes, route sizes and alternate routing capacity shall be the same as the present metropolitan 1GV equipment and the maximum total B plus C stage availability 1300.

Connection of Outlets

Routes requiring larger availability than 20 will be distributed over as many C-stages as possible and not restricted to a single C-stage. This will assist in distributing the traffic more evenly and lessen the possibility of lost calls due to congestion in any C-stage.

For routes made up of two or four sub-routes, provision shall be made in the design to permit either sequential or random selection of the basic 5, 10, 15 or 20 availability group in which the outlets will be tested.

Testing and Selecting Outlets. The method of testing, selecting and seizing a free outlet should not affect reliability and should guard against dual seizure, the selection of a busy connection or the selection of a releasing connection. In addition the selection of an idle outlet should be conditional on a free path being available through the partial stages.

Call Handling Capacity

The design of the marker to control the three-stages should enable as many calls to be switched per hour as the present metropolitan 1GV marker.

Re-Testing

The marker should be designed to test on the next route alternative under the following conditions:

(i) If a free circuit cannot be reached because of link congestion.

(ii) If a free circuit to the tested route is not available.

It is desirable that the retest be performed in a different B-C link path. The number of re-tests shall be limited by normal 1GV time out organisation. To enable testing over all route choices to be completed within the time out period, it may be necessary to free-mark all route choices greater than four.

The marker should be designed to re-test in the same route if the selected outlet is busied from some other marker or distant exchange before it is properly seized.

Free-Marking

In order to reduce the marker holding time and to expedite the switching process particularly on small sized routes, it may be desirable to indicate free routes with a free-mark from the FUR relay sets. Free-marking will not be required in most cases where the number of route choices is limited to four. Provision shall be made for free-marking any of the 400 GVC outlets by inserting a rectifier between the e and f tags on the IDF strips and extending 20 free-marking leads per GVC rack from the IDF to the relays set for free-marking.

Analysing Capacity

The marker for the three-stage group selector should provide the following route analysing capacity:

(i) all first digits
(ii) expansion of 10 first digits to second digits
(iii) expansion of 90 or 100 second digits to third digits
(iv) expansion of 38 or 48 digits to fourth digits.

Number of Routing Codes

The design of the new analyser relay set GV-AN Parts 1c and 2c should permit mounting in place of the existing GV-AN Parts 1a and 2a. The

TABLE B

Description of Facility	Capacity Required
Basic Availability	5, 10, 15 and 20
Maximum number of routes which may be used to obtain additional availability or route alternatives and which may have either sequential or random selection between the sub-routes.	30 routes made up of four sub-routes with availability 5, 10, 15 or 20; or 60 routes made up of two sub-routes with availability 5, 10, 15 or 20.
Number of route alternatives	120 1st (direct) route choices + 45 1st or 2nd route choices + 45 2nd or 3rd route choices + 15 1st, 2nd, 3rd or 4th route choices + 15 2nd, 3rd, 4th or 5th route choices
Availability per C-stage	400
Total B + C stage availability	
one C-stage per 160 GV inlets	700
two C-stages per 160 GV inlets	1000
three C-stages per 160 GV inlets	1300
four C-stages per 160 GV inlets	1600
Maximum number of addresses (route codes)	180
Maximum number of routes	160
Maximum depth of availability to a particular address (2 route choices of 20 availability) (3 route choices each of (80 availability)	280

number of marking leads from the GV-AN Parts 1c and 2c relay sets should be 80 and 60 respectively. The aim is to permit the number of route marking leads (addresses) to be increased as required from 80 to 140 or 200.

Alternate Routing

The equipment shall be equipped with the following alternate routing facilities:

(i) Routes connected to the GVB stage may have alternate routes to either the GVB or the GVC stage.

(ii) Routes connected to the GVC stage may have alternate routes to either the GVB or the GVC stage.

Each route alternative shall be tested in a fixed order of choice.

IDF Terminations

Provision shall be made to enable the outlets of GVB racks to be connected to the inlets of GVC racks by plug-ended tie cables. The aim is to conserve IDF space and reduce the high cost of terminating and interconnecting on the IDF. Two appearances of the GVC inlets will be required on the GVC rack connecting field to give access from each 80 GVA/B group.

Traffic Recording

Provision must be made in the design of the control equipment for the connection of A.P.O. call dispersion equipment to enable extraction of details of the identity of the code receiver or marker and the number of the route choice taken.

Statistical Recording

Provision shall be made for the connection of counters to record information concerning congestion, the number of occupations, the number of timed throw-outs of particular items of equipment, and the occupancy of the B to C stage link paths.

Occupation Indicators

An occupation indicator consisting of specially treated paper chart is required for plugging into a jack box provided on the switch racks. The terminals in the jack box will produce a mark on the paper whenever a particular vertical of a crossbar switch is operated. This equipment will be used to check that each vertical of the crossbar switch is being utilised.

Re-routing under Special Conditions

The facility shall be provided to alter the routing of 12 route codes for night switching or other special purposes.

Retention of Existing GV-W

Provision shall be made to use the existing GV-W relay set in place of the GV-VT and GV-AD relay sets to control two GVC stages at exchanges where free-marking is not required and the number of routes is less than 80.

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THE A.P.O. THREE-STAGE GROUP SELECTOR — DETAILED DESCRIPTION

B. J. McMAHON, B.E.* and G. P. E. SVENSSON, Ing.**

INTRODUCTION

The initial planning considerations leading to the design of the Australian Post Office 3-stage group selector are discussed by Fardouly (Ref. 1). This article discusses the detailed design considerations and describes the operation of the new equipment.

In the ARF crossbar system, calls are switched by two basic switching stages, the SL and GV stages. The SL stage provides switching for a group of 1000 subscribers. The GV stage is used for selection of the appropriate SL group for a call within a particular exchange, or for selection of a free route to another exchange. The trunking diagram of Fig. 1 illustrates the possible inlet and outlet connections to the GV stage which can occur in a network with both crossbar and step-by-step equipment.

The GV stage will be called either by SR relay sets for calls which originate in a local 1000-group, or by junction relay sets FIR when the call is from another exchange. The outlets of the GV stage are connected either to the SLD or via junction relay sets FUR to the inlets of other group selectors.

In the Australian network, two group selectors, the metro IGV and the GIV, have been used. These differ mainly in the call-handling capacity and the analysing capacity. The group selector known as the "Metro IGV" will here be referred to as the GV2/160/400, and it is this group selector which has provided the basis for the design of the three-stage unit.

Two new group selectors will now be available as a result of this design work. Both of these will be capable of working as 2-stage selectors, similar to the GV2/160/400 with 160 inlets and 400 outlets. With the addition of GVC switching equipment and the GVC marker, 3-stage working can then be added as the traffic handling requirements are increased. With the GV2/160/1300, the marker equipment can control up to 3 C-stages, giving a maximum outlet capacity of 1300, and up to 80 addresses. The group selector GV2/160/1600 can handle a larger number of addresses (up to 180), provides a free-marking test to reduce marker holding time, and has a maximum capacity of 1600 outlets. The additional outlet capacity available from one group selector stage, and a link arrangement which increases the traffic-carrying capacity of C-stage outlets will lead to low internal congestion and efficient use of junction routes. Thus the 3-stage group selector will find application in both terminal and tandem ARF exchanges.

FACILITIES AND APPLICATION OF THE GROUP SELECTOR

A basic requirement of this group selector is that it should be possible to build a 3-stage selector by addition of C-stage equipment and minor modification of existing 2-stage racks and relay sets. As a result of this constraint, the two new group selectors use the relay sets GV–XY, –IK, –KMR and –T without modification; modification of GV-K and the GVM rack has been kept to a minimum; and the relay set GV–W has a simple modification for use in GV2/160/1300 or is replaced by new relay sets GV–VT, –RB and –AD in the group selector GV2/160/1600. The additional equipment required for 3-stage working is the relay set GV–CK and the GVC–racks.

This arrangement allows considerable flexibility in the provision of

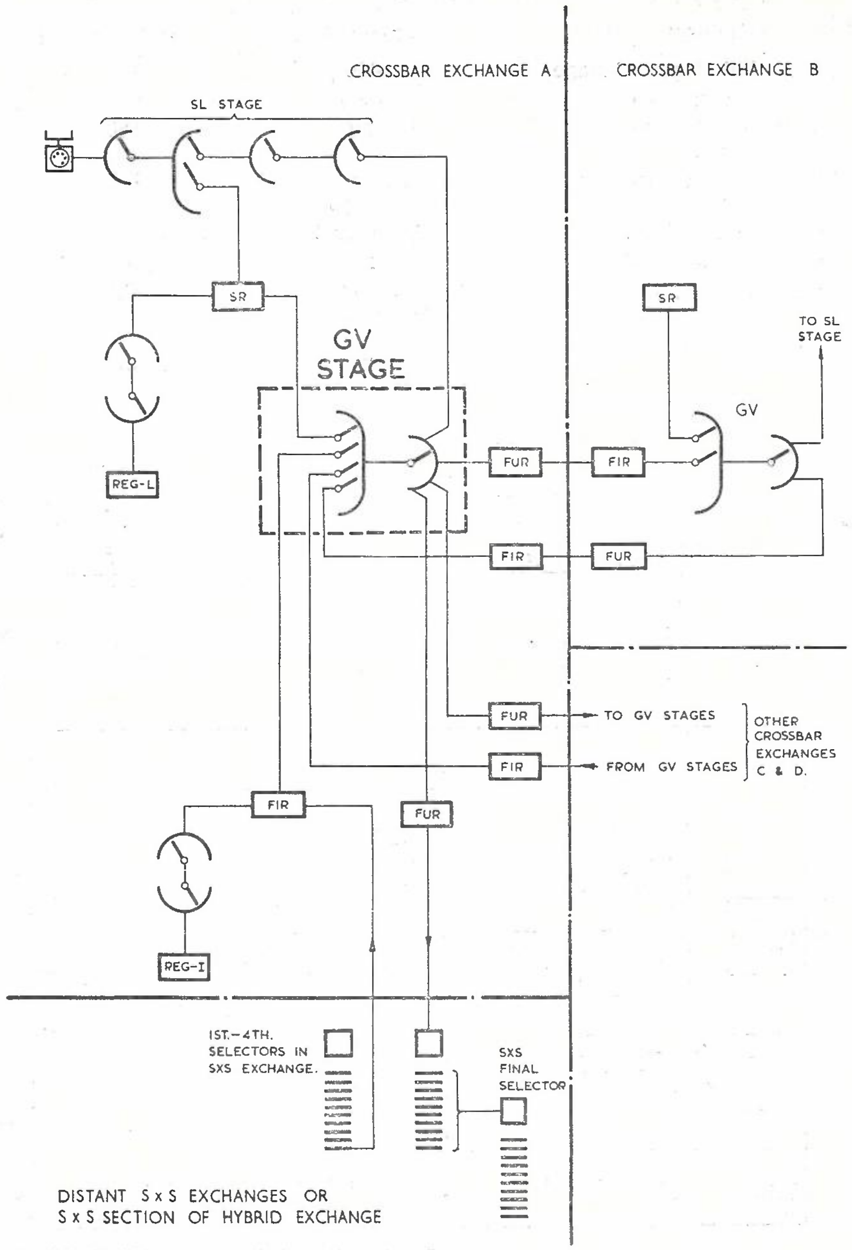

Fig. 1 — Trunking Diagram.

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** Mr. Svensson is Group Leader, Telephone Exchange Division, L. M. Ericsson, Sweden.

group selector equipment, as the outlet capacity can be increased in steps of 300 outlets from the basic size of 400. The choice of the group selector appropriate to a particular installation will be dependent on the expected maximum outlet capacity required and the traffic load to be carried. In addition, if an installation will have an eventual need for more than 80 addresses, then the GV2/160/1600 should be used as it has the facility for using the extra addresses available from new analyser relay sets which have been designed for this application.

A comparison of the facilities available from the two group selectors is made in Table 1.

Analyser Relay Sets GV-AN

The existing relay sets GV-AN 1a (b) and 2a (b) allow translation of codes to a maximum of 80 addresses, these being common between each relay set. The new relay sets, which are designated 1c (d) and 2c (d), each contain 60 individual address outlets, and provision of two relay sets GV-AN 2c (d) gives a total capacity of 180 addresses. Each analyser relay set is associated with an address relay set GV-AD which can handle the 60 address inputs, so that these relay sets can be added as the number of route codes required by the group selector increases.

The analysing facility has also been modified in the new relay sets, and is summarised below.

In GV-AN 1c (d)

(i) Analysis of one-digit codes 15 (1-10 plus 5 special codes)

(ii) Analysis of two-digit codes 110 (from 1-10 plus one special code in (i))

(iii) Analysis of three-digit codes 300 or 400 (from 30 or 40 codes in (ii))

(iv) Analysis of four-digit codes 100 or 0 (from 10 codes in (iii)).

In GV-AN 2c (d)

(v) Analysis of three-digit codes 300 (from 30 codes in (ii))

(vi) Analysis of four-digit codes 190 (from 19 codes in (iii) or (v)).

In comparison with the analysis available from AN 1a (b), the main difference here is that the option has been given in AN1c (d) to provide 3 to 4-digit analysis as an alternative to 2 to 3-digit analysis for 10 codes. The facility has also been made for extended analysis of one of the special codes "11-15".

Under certain circumstances, further analysis of special codes may be needed, and another relay set GV-AN4 has been designed for this purpose. It extends the analysis of all special codes to two digits, and allows further analysis of up to 9 of these codes to three digits.

Mark of Origin Relay Set. GV-UM

As an additional facility available for use with the group selector, a relay

TABLE 1

Facility	GV2/160/1300	GV2/160/1600
Availability per C-stage.	400	400
Maximum availability.	1300	1600
Maximum number of addresses.	80	180
Number of routes per address.	Limited by GV–W straps	1–5
Route availability.	5, 10 or 20	5, 10, 15 or 20
Sub-route availability.	20	5, 10, 15 or 20
Maximum no. of sub-routes.	14 (One C-stage): 4 (Three C-stages)	120
Number of sub-routes per route.	2	2 or 4

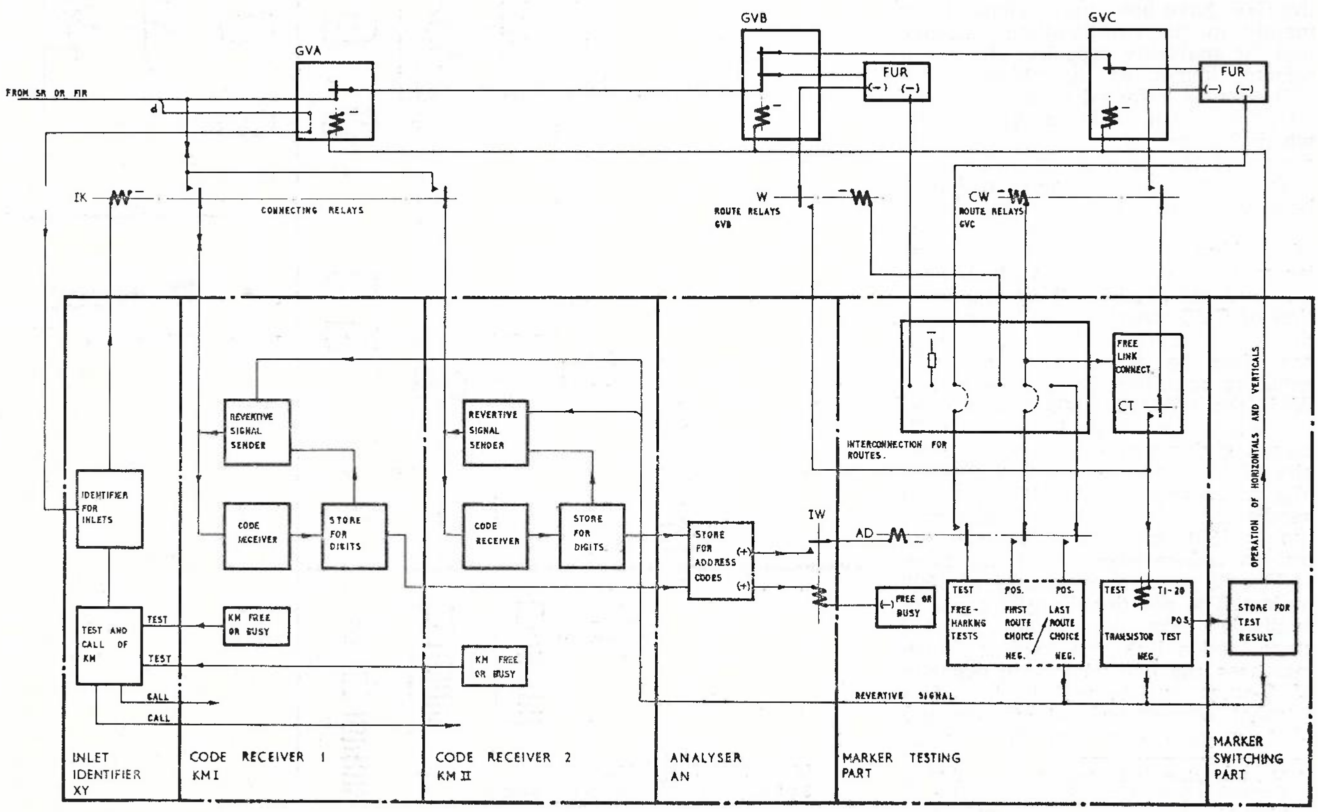


Fig. 2 — Simplified Survey — GV2/160/1600.

set has been designed which determines the origin of an incoming call. It can then signal the appropriate code receiver with a special mark, and can use the analysis result to allow switching of the addresses from the analyser GV-AN.

In the group selector GV2/160 there are 160 inlets, and these have been subdivided into 52 origin groups each of 3 (or 4) inlets. After identification is completed by GV-XY, and a code receiver is selected, the calling inlet is further identified by its mark of origin in GV-UM. When this has been stored a signal is available for use by the code receiver. A second output from the GV-UM store is energised when this call is connected to the GV-marker. If the origin is one for which addresses must be transferred, strapping in GV-UM connects this second store to relays which switch a number of the incoming addresses.

GROUP SELECTOR OPERATION

In this section, an outline of the processing required for connection of a call from inlet to output of a GV stage will be given. This is illustrated by the simplified survey diagram, Fig. 2, and the flow charts for marker operation, Figs. 3 and 4. The following section will then expand this general description by a detailed consideration of some of the steps taken during marker operation.

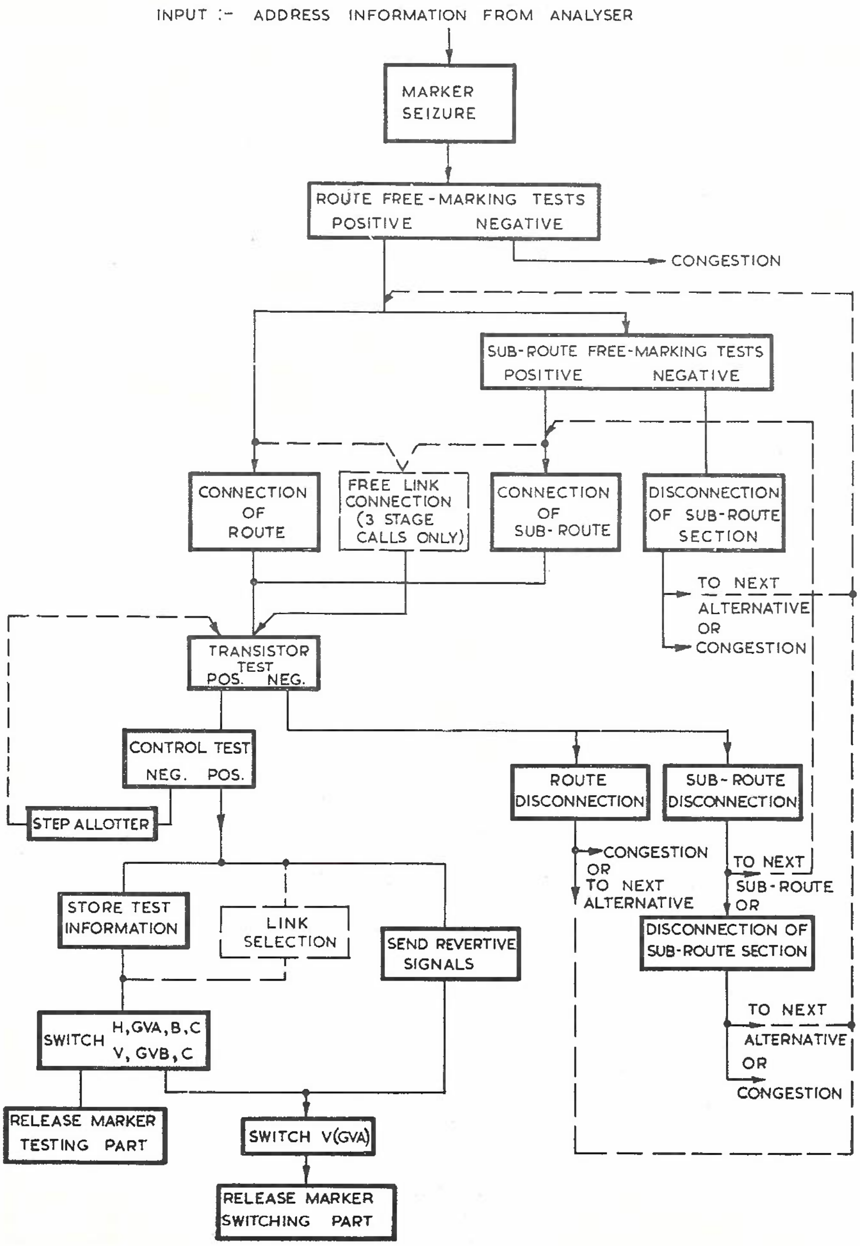


Fig. 3 — Flow Chart for Marker Operation — GV2/160/1600.

Identification, Code Reception, and Analysis

A call is made to the group selector from an SR or FIR by application of positive to the d-wire of an inlet. The calling inlet is first identified by the identifier GV-XY. This is a 2-stage process in which X-identification determines the switch associated with the calling inlet, and the Y-identification locates the vertical within that switch. During identification of the calling inlet, one of the code receivers is called, and the relay set GV-IK then connects the inlet to the selected code receiver when identification has been completed. The identifier is then released and the code receiver is ready to receive the MFC signal applied to the a-b wires by the register.

The code receiver is capable of receiving up to four digits from the register. These are received and stored sequentially, and internal strapping in the KMR is used to call the analyser if either one or two digits are sufficient for route determination. If three or four digits are required, the analyser is called during reception of the third digit by the KMR.

The analyser is divided into two sections, one for determination of the address or route code of the call, and the other for analysis of the number, length and type of terminating equipment associated with the call. This second function is not required when the calling register is able to determine this result, as for example, with REG-LP.

The analysing process is simply a translation of the stored digit code to either address or number length information. This translation is achieved by transferring the stored digits in KMR to relays in the analyser, and strapping on terminal strips from tags representing a particular digit code to an output address or number length signal.

Marker Operation. GV2/160/1600

Seizure, Free-Marking Tests, and Route Connections: When analysis has been completed, the analyser checks that the testing section of the marker is free, then operates the IW relays to connect the address information to the marker. As shown on the accompanying figures 2 and 3, this initiates the seizure of the marker. At this stage, the AD relays associated with the selected address are operated, and when an AD relay operates, one or two routes associated with the address are known. Thus the free-marking test, which is used to determine if there is at least one free line in a route of 5 to 20 lines, can be made over contacts of each operated AD relay. This test is made by a relay individual to each route which operates from a negative potential in any of the free FUR's associated with the route. An unsuccessful result for the route free-marking is indicated when none of the test relays operate during the testing period.

Further tests for this address are then unnecessary, and a congestion signal is generated.

When one or more of the test relays operate to indicate a positive free-marking test result, the next step is taken for the earliest choice route which is free-marked. As shown on the diagram, the resultant action will be modified when the route is divided into sub-routes. In this case, a free-marking test is necessary to locate the sub-route which has a free line available. The probability of making a negative free-marking test on all sub-routes of a large route will be very small. However, if this occurs, the sub-route testing section is disconnected, allowing the next free-marked alternate route to be processed.

Following a successful free-marking test on a sub-route, positive is connected through the operated test relay to operate the route and route size relays appropriate to the sub-route selected. For a 2-stage call these could be the W, WT, and R1-4 relays; and for a 3-stage call, some of the CW and CR relays would be operated.

In a similar manner, route connection is made over contacts of the operated route test relay when the route is not divided into sub-routes.

Link Connection and Transistor Test: In the 2-stage group selector GV 2/160/400, the bypath test of the outlets is made over all available A-B links by testing through the A-B connecting relays and break contacts on the verticals of GVB switches. With the addition of the third partial stage, the test organisation is modified so that the transistor test finds and selects an available outlet from the C-stage. Since this test is made only over all the free A-B-C links from the calling inlet, the result of the transistor test includes the condition of link availability to the C-stage.

This procedure takes place immediately after the route or sub-route has been connected. The relays CT1-20 will operate to indicate free links to the C-stage and each operated CT relay completes the testing path of one of the relays T1-20.

If there is no T-relay operated at the end of the transistor test period, then it is known that no free line is available from a free link. The relays associated with the route or sub-route are then released, and if a further route or sub-route is available for testing, it is then connected. If there are no further alternatives, a congestion signal is generated.

Following a successful transistor test, a further test is made on the selected outlet to ensure that it has not been seized by another marker. This is the control test and if it is unsuccessful, the allotter giving priority to the relays T1-20 is stepped before a re-test is made over the transistor test circuit.

Switching: After positive transistor and control tests have been made, relay TK5 will operate and call the switching section of the marker. When this is free, the test information is transferred, and revertive signalling is initiated. Switching of all stages except V(GVA) takes place before the testing section of the marker is released. Revertive signalling between the marker and the register must be finished before switching is completed by operation of V(GVA). The switching section of the marker is then released to complete the release of the group selector, and the call is held through all stages from positive on the d-wire of the switched inlet.

Marker Operation. GV2/16/1300

The marker for this group selector consists of the GV2/160/400 Marker relay sets GV-K, -T and -W, with the addition of GV-CK for control of the C-stages. The operation of this marker is therefore similar to that of the existing 2-stage group selector. When the relay set GV-W is used for translation of the input address to a number of alternate routes, there is no free-marking test. Thus the pre-test period for 2-stage calls with this group selector includes only marker seizure and route connection. In the case of a 3-stage call, the free A-C links must also be connected prior to the start of the transistor test period.

The sub-route organisation with this group selector is restricted to 2-stage routes of 40 lines which are divided into two sub-routes of 20 lines. The flow chart shows the pro-

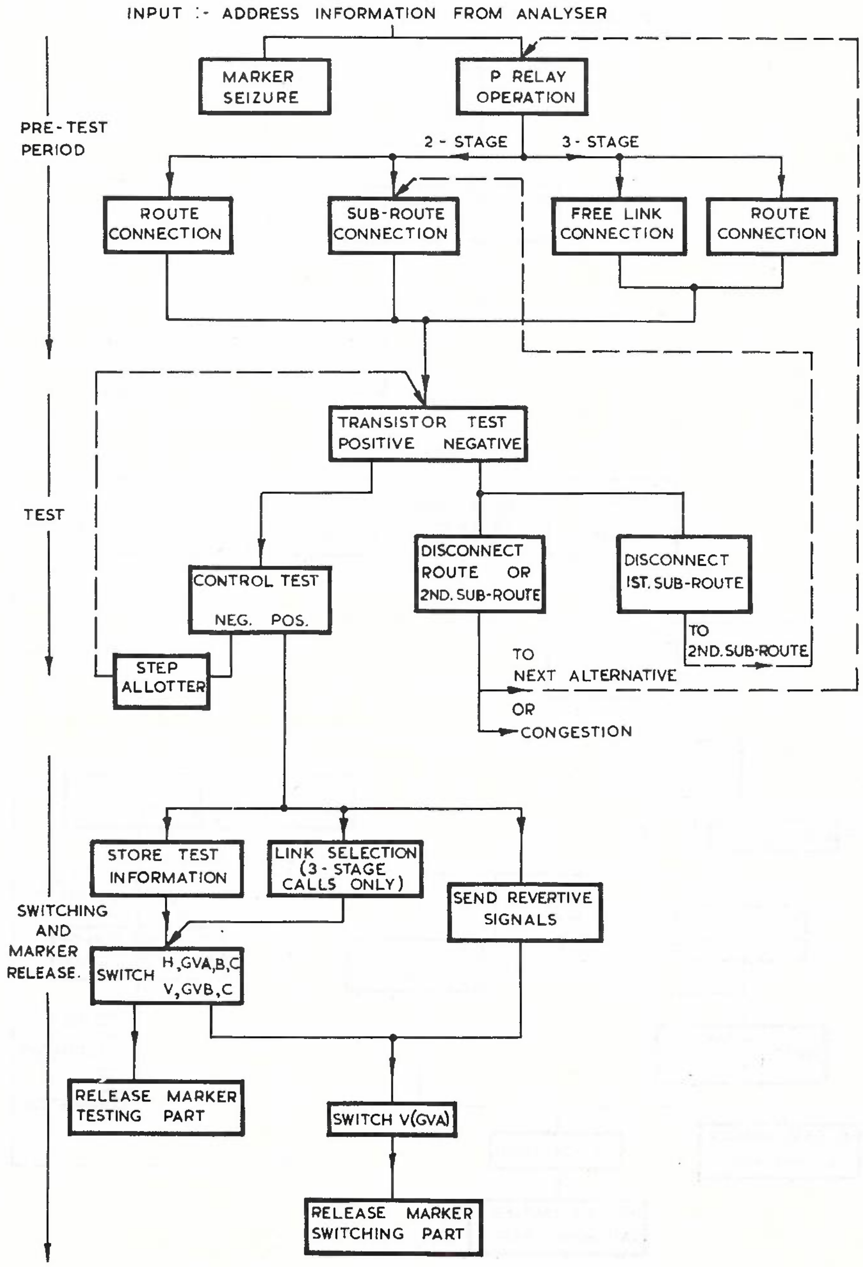


Fig. 4 — Flow Chart for Marker Operation — GV2/160/1300.

cedure for connection and release of these sub-routes and also indicates the method of selection of an alternate route after a negative transistor test.

Following a positive transistor test, the general operation of this group selector is similar to the switching, revertive signalling, and release of the GV2/160/1600. For a summary of this phase of operation, references should be made to the previous section.

DETAILED DESCRIPTION OF MARKER PROCESSES

The operation of the group selector outlined in the previous section was treated in terms of a number of distinct processes indicated on the flow chart. The more important of these will now be considered in detail, and for clarity a particular case will be considered. We will assume that the address found from analysis has a direct route with two alternate routes available. Further, we will assume that the free-marking tests are positive, but no free line is found from the transistor test until we test on the second alternative route. The route connection is strapped as shown below:—

Direct route AD1 relay-10 line, 2-stage route on W1, WT10, R3-4,
1st alternate on AD41 relay - 30 line route with two sub-routes.

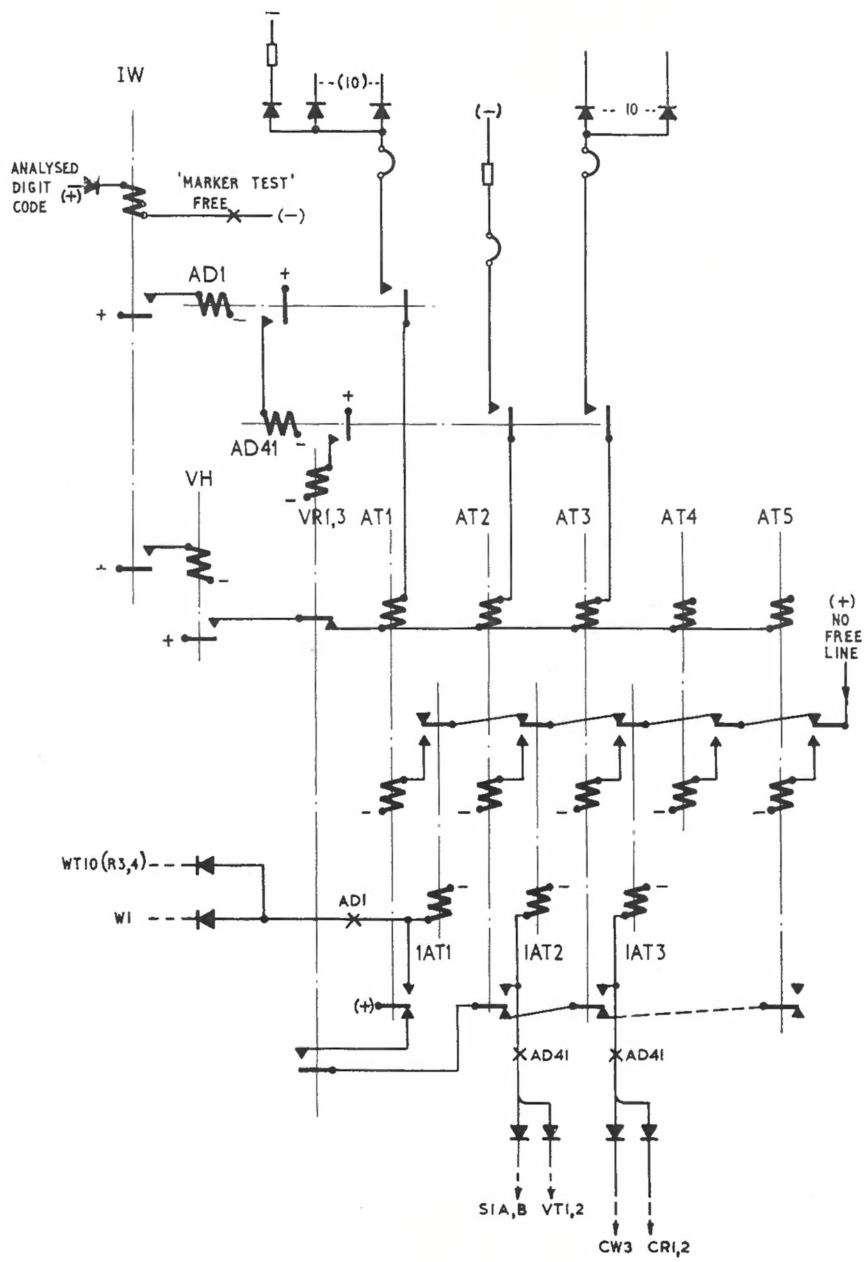


Fig. 5 — Route Free-Marking Test.

(a) Tested on VT1 is a 15 line, 3-stage sub-route on CW1, CR1-4.
(b) Tested on VT2 is a 15 line, 3-stage sub-route on CW2, CR1-3.

2nd alternate on AD41 relay - 10 line 3-stage route on CW3, CR1-2.

Free-Marking Tests. (Figs. 5, 6.)

The analysis function is completed when a positive is extended from the input digit code to operate the IW relay. This circuit checks that the testing section of the marker is free and IW operates VH to seize the marker. For this address, the strapping is arranged so that IW also operates AD1, which then operates AD41. Since AD41 connects the test path on the final choice route, a contact of this relay is strapped to operate VR1; the operating time of VR1 then controls the duration of the free-marking test.

A test is made for each alternate route of the address, and in this case the test is made over relays AT1-3. If at least one of the 20 FUR relay sets for the direct route is free, then AT1 operates from negative in the relay set, via contacts of AD1, VR1 and VH. Similarly, prior to the operation of VR1, AT2 operates from an internal strapped negative and AT3 operates if there is a free mark available on any of the 10 lines associated with the final choice route. Since the relays ATI-5 are bi-stable Clare relays, they will all remain in their selected condition until another switching current is applied.

When AT1 operates, the first route connection is made as a positive connected to the relays W1 and WT10 associated with this 2-stage route. In addition, relay 1AT1 operates to indicate the alternative under test. Now if we assume a negative transistor test, then the signal indicating that no free line is available will cause AT1 to be reset through the 1AT1 contact. This initiates disconnection of the route, and when this process is completed, positive is returned to the chain of AT1-5 contacts.

Since AT2 is still operated, this positive now operates 1AT2 and transfers control to the sub-route testing section, by operating the connecting relays S1A, B. From Fig. 6 it may be seen that these relays extend the operate windings of VT1, 2 to the free-marking negatives for the two sub-routes. The S1 relay also provides operating current to VR4, so that the period for the sub-route free-marking test is controlled by the operate time of VR4.

Assuming that a free mark was found in each sub-route, both VT1 and VT2 will have operated. Selection of the first sub-route to be tested is made by the allotter OV1-4. If priority is given to the VT1 sub-route, the relays CW1 and CR2-4 connect the required 15 test wires for the transistor test, and 1VT1 prepares the reset path for VT1. Fol-

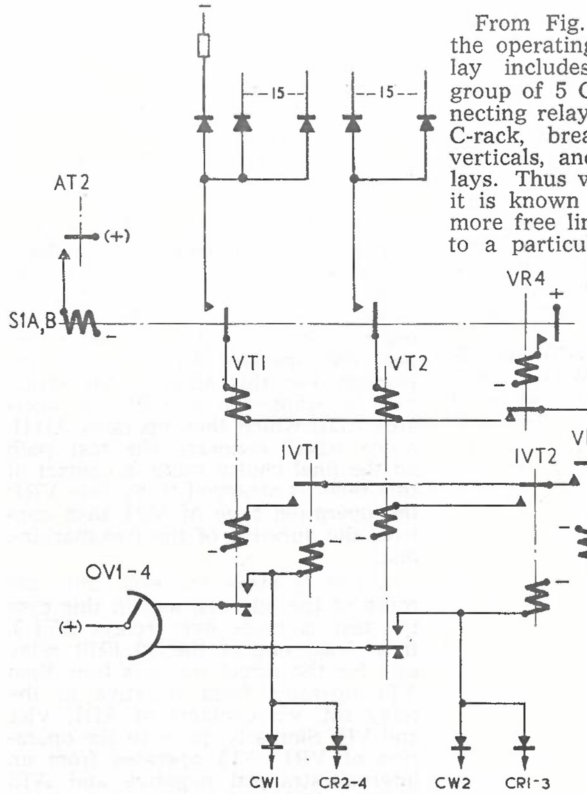


Fig. 6 — Sub-Route Free-Marking Test.

lowing a negative transistor test VR6 operates to initiate release of the sub-route, and when this is completed positive is returned to the allotter output to select the next sub-route. When the last of the free-marked sub-routes has been tested, the sub-route testing section must be released before transfer to the next alternative. This transition being completed, positive is then reconnected to the chain of contacts on AT1-5.

Connection of the final choice route for this address is then made through the operated AT3 contact, over contacts of AD41, to operate CW3 and CR1, 2. Further processing of this call will now be considered in the following sections.

Link Connections

At the same time as the route size relays for a 3-stage call are being operated, a link connection is made to ensure that the transistor test for a free line is made only for outlets which are accessible from free links.

The simplified grouping plan, Fig. 7, shows the 400 outlets from one C-stage arranged in an array of 20 columns and 20 rows. Each row forms a basic 20-line route connected by one CW relay, and this row is sub-divided by CR1-4 into four groups each of 5 outlets. Each column of this array is associated with one of the relays CT1-20 and has outlets which are accessible from a group of 5 C-stage verticals.

From Fig. 8, it may be seen that the operating circuit for each CT relay includes break contacts on a group of 5 C-stage verticals, the connecting relays 1-8 CC1 of the selected C-rack, break contacts on B-stage verticals, and the A-B connecting relays. Thus when a CT relay operates it is known that there exists one or more free links from the calling inlet to a particular column of outlets.

In the example selected, free links to columns 1-10 of the output array are required, since the test will be made over contacts of the relays CR1-CR2. Contacts of the relays CT 11-20 will not be used by the transistor test, even though they operate as an indication of free A-C links. We will assume that the relays CT1, 2 and 5 have operated to connect available links.

Transistor Test. (Fig. 9.)

It may be seen that the test windings of the relays T1-20 have two separate paths depending on whether they are used for testing a 2- or 3-stage call. In the example being considered, the relays T1, T2, and T5 will be connected through CT1, 2 and 5 over CR1 and CW3 to test for 1000 ohm negative. The outlets being tested are shown with shading on Figure 7. The test is initiated by operation of TK1 which gives a start pulse to the feedback circuit of all the relays T1-20. All three of the

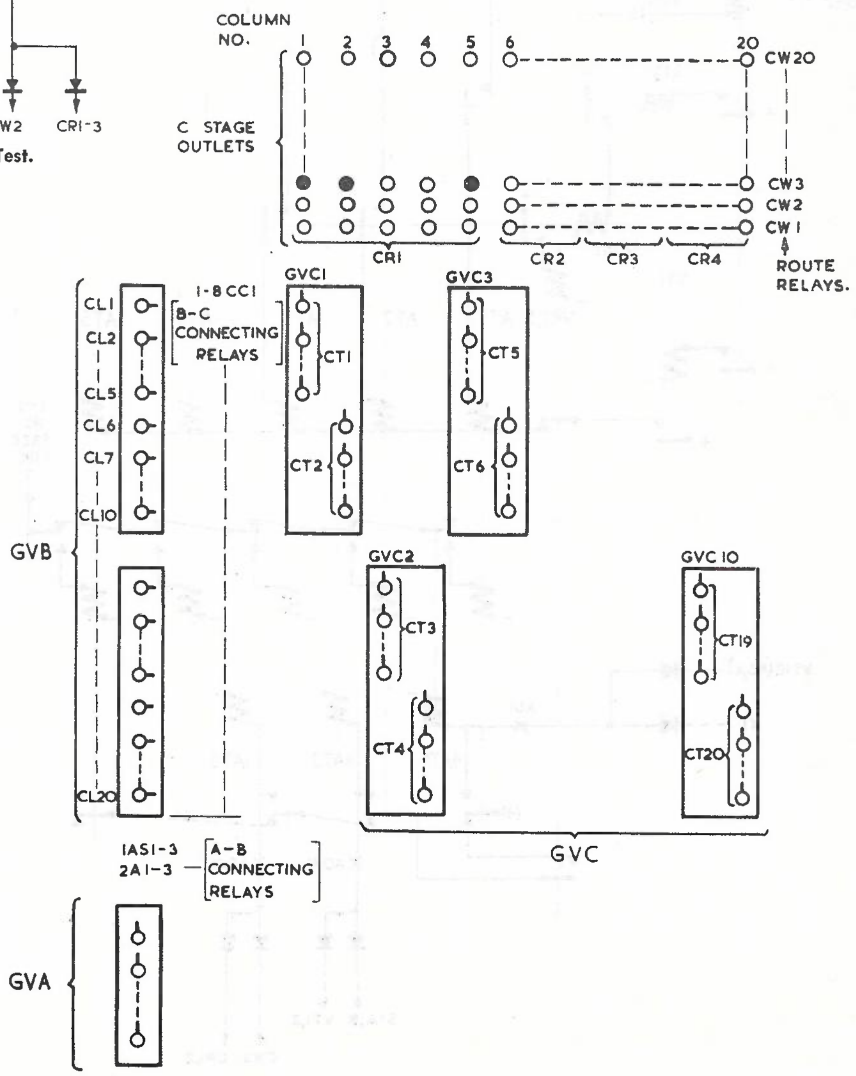


Fig. 7 — Simplified Grouping Plan.

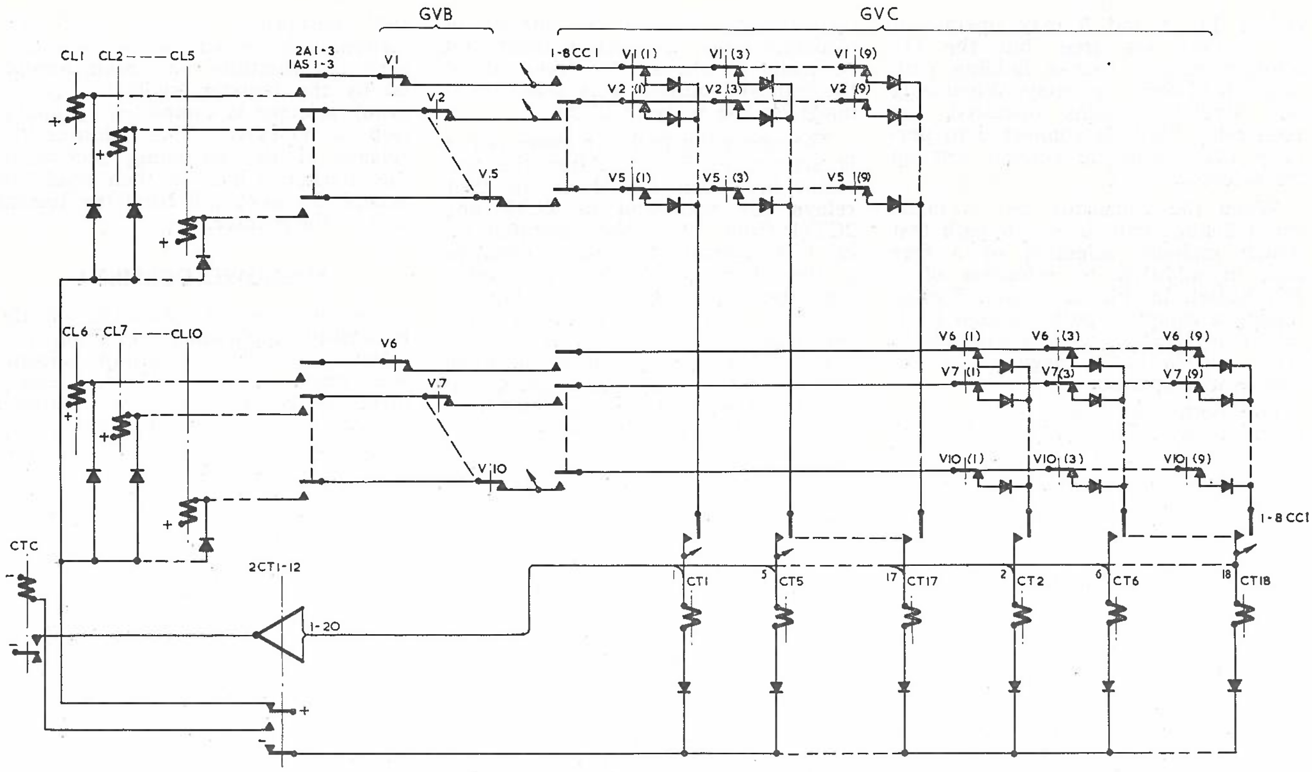


Fig. 8 — Link Connection and Selection.

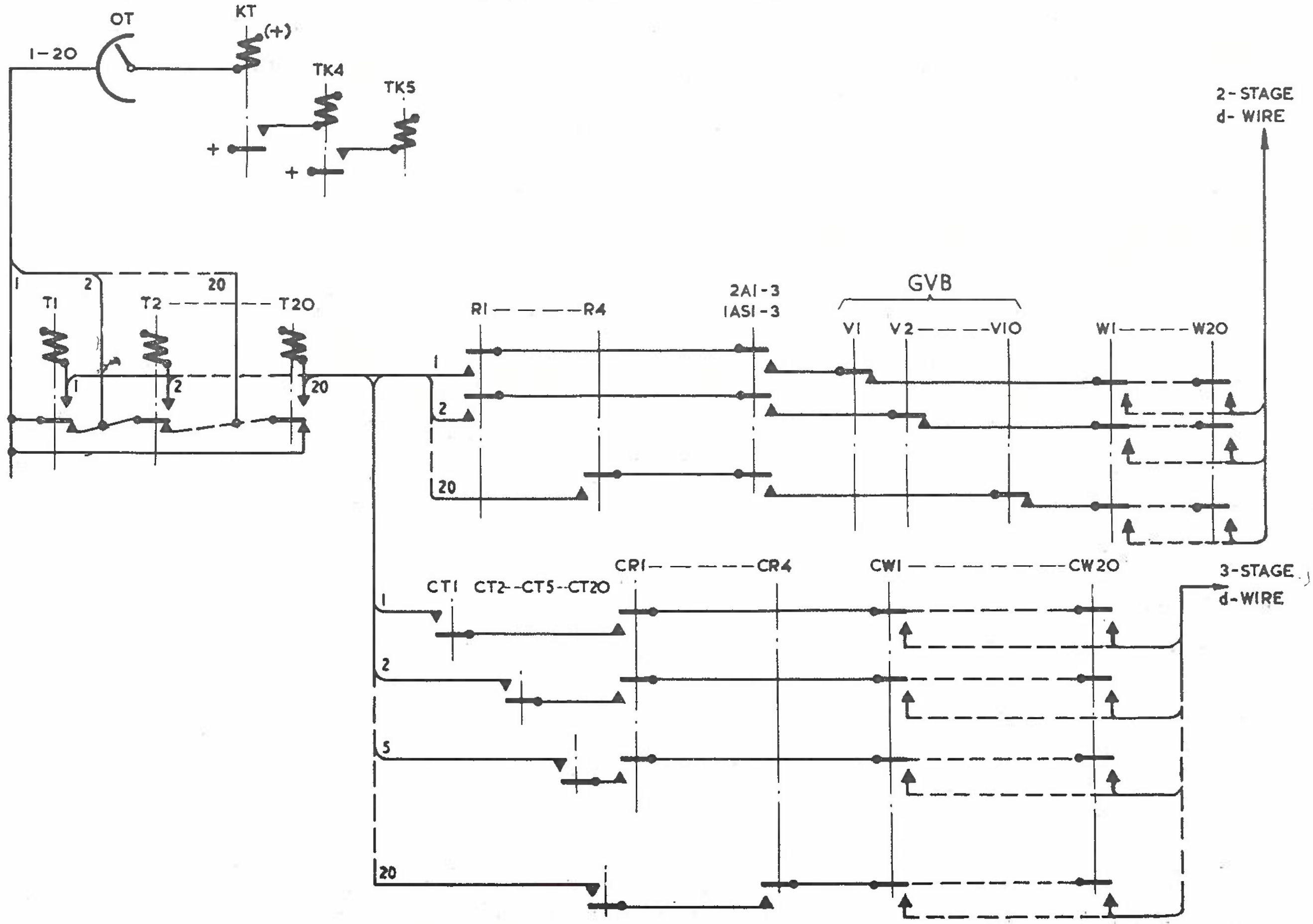


Fig. 9 — Transistor Test.

relays T1, 2 and 5 may operate if the outlets are free, but the OT allotter ensures that a holding path is given to only one relay. When only one T-relay remains operated, the reed relay "KT" is connected to perform the low-ohmic control test on the selected outlet.

When the transistor test is made for a 2-stage call, it is a bypath test which includes selection of a free link in addition to selection of a free outlet. In this case, each T-relay having a complete path through R1-4, 2A1-3 or 1AS1-3, vertical contacts in GVB, and W1-20 to negative on the d-wire will operate.

For both cases, a positive result from the transistor and control tests results in the operation of relay TK5. This relay then calls the switching section of the marker, but may have to wait for this to become free if the previous call is still being switched.

When the transistor test has a negative result, indicated by the failure of any of the T-relays to operate during the test period, the route or sub-route under test is disconnected. It may be seen by reference to the flow chart that the next sub-route or alternate will then be connected when available. If the test was made on the final choice route, then a congestion signal will be generated and the marker released.

Switching

When the switching section of the marker is called, the information from the test procedure is not sufficient to allow storage of the test result and switching to proceed immediately. Since each CT relay may have operated to indicate a number of available links, a selection must first be made to choose one free link to the required outlet. This selection is made by the relays CL1-20.

The operating path for these relays is shown on Fig. 8. After the test result has been stored in the 2CT relays (by operation of 2CT2 and 2CT11 from T2 in the example) relay CTC operates to connect negative to the CL relays. It should be noted that the operating path for the CL relays is part of the circuit used previously for operation of the CT relays. This correspondence between particular CT relays and groups of five CL relays is also indicated on the grouping plan. In this case, the negative from CTC is used to operate any of the relays CL6-10 which have free links to the chosen outlet. An allotter then selects one of these CL relays to give a dispersion of traffic through the switching equipment.

When this process of link selection has been completed, switching of the horizontal bars of all partial stages can proceed. After a time interval sufficient to ensure satisfactory operation of all horizontals, the vertical switches in GVB and GVC will also be operated. At this point the holding path for the operated switches is complete through the test result storage relays, all the test information has been used, and so the testing part of the marker can be released to accept a new call from the analyser.

During switching of the call, signalling between the group selector and the register takes place. These signals prepare the register to send the appropriate digits to the next switching stage, and when the necessary information has been accepted by the register, switching of the group selector is completed by operation of V(GVA). This initiates the release of the switching section of the marker, which is then ready to accept the next call from the testing part of the marker.

ACKNOWLEDGEMENT

The original investigation of the feasibility, application and implementation of a 3-stage group selector was made in the P.M.G.'s Department by N. Smith of the Planning Branch. This work anticipated the need for a group selector which would provide adequate outlets and alternate routing facilities for efficient utilization of equipment in the Australian network.

Following this work, an alternative design was proposed by J. Nordin of L. M. Ericsson, and a new survey diagram for this realisation was prepared. A facility specification related to this solution was then made by a joint P.M.G.-L.M.E. Study Group. (See Ref. 1.) The detail design reported in this paper is based on this survey and specification, and covers work carried out by the authors at L. M. Ericsson, Broadmeadows.

REFERENCE

I. M. Fardouly, "The A.P.O. Three Stage Group Selector — Initial Planning"; Telecommunication Journal of Australia, Vol 17, No. 2, Page 120.

TECHNICAL NEWS ITEM

SURVEY FOR THE EAST-WEST RADIO RELAY SYSTEM

Work has commenced on the $8 million project to establish a 2 Gc/s radio relay system between Port Pirie in South Australia and Northam in Western Australia, a distance of 1400 miles. The system will have an initial capacity of 600 telephone channels which will be extended with existing systems to Perth and Adelaide.

The route survey and site selections being undertaken by the Postmaster-General's Department, with the assistance of the Department of the Interior, are almost complete. This phase of the work has involved methods new to radio relay path selection work in Australia.

From Port Pirie to Ceduna and Kalgoorlie to Northam, the repeater sites have been selected by conventional techniques using map information and ground surveys. Between Ceduna and Kalgoorlie the route follows the main highway which crosses the edge of the Nullarbor Plain and, because of the lack of map information and the remoteness of the area, conventional survey methods would have been time-consuming and expensive. The use of aerial photogrammetry was therefore proposed for the 36 paths on this 900-mile section.

The approximate position of the sites was chosen after an extensive study of available topographical information and ground and air inspections of the route. Factors considered in the site selection were tower height, length of access road, overshoot angles to other repeaters using the same frequency and the requirement to have a repeater near certain towns. In some areas it was necessary to move paths to areas with favourable propagation characteristics.

The Department of the Interior then undertook a photogrammetric survey of the area between repeaters, to give a contoured strip about 2½ miles wide and a profile of the longitudinal section between the repeater sites. The survey results were then used to determine the optimum position of the repeaters. The final sites were then surveyed by a ground survey party.

This survey method has given excellent results and it is anticipated that the method will be used extensively on future long-distance radio relay routes.

The Department of the Interior proposes to establish permanent survey marks at each repeater site. With the contour and photogrammetric information, this should be of substantial benefit to future works in this remote region of Australia.

ESTABLISHING L M ERICSSON CROSSBAR PRODUCTION IN AUSTRALIA

*C. A. SPONGBERG, M.A.I.E.E., Dip.E.E., B.M.E.**

INTRODUCTION

In previous issues of this *Journal* announcements have been made of the adoption by the Australian Post Office of the L. M. Ericsson crossbar system as the new standard for automatic switching in the Australian telephone networks. References have also been made to the manufacturing agreements between L. M. Ericsson, Sweden and two Australian manufacturers Standard Telephones and Cables Pty. Ltd. and Telephone and Electrical Industries Pty. Ltd, both of Sydney, New South Wales, for the production of subject equipment.

It is the intention of the author of this paper to describe the third phase of this development — the production of L. M. Ericsson crossbar equipment by L. M. Ericsson Pty. Ltd. in Victoria, Australia.

In order not to repeat what has already been published by other writers in the crossbar production field, it is not intended to give a detailed explanation of the various production processes, but rather cover the subject of production from an administrative and organisational point of view. It is hoped by this to bring to light some important factors which are to be covered in the establishing of production facilities.

Background of L. M. Ericsson in Australia

L. M. Ericsson Telephone Company Pty. Ltd. was formed in 1951, primarily as a Sales Company of the L. M. Ericsson Group. Ten years later the Company acquired its first factory in Australia by entering as a main partner in the former Trimax Transformers Pty. Ltd., Coburg, Victoria.

Trimax had, since 1937, been a supplier of transformers, amplifiers, power supplies and other telecommunication equipment to the Australian Post Office. At the time of the acquisition, the name of the Company was changed to L. M. Ericsson-Trimax Pty. Ltd., and the Company undertook, in addition to earlier production lines, the assembly of crossbar P.A.B.X. equipment.

When L. M. Ericsson Telephone Company Pty. Ltd. was granted contracts with the Australian Post Office for crossbar equipment, both for city and rural exchanges as well as trunk and telex exchanges, it became apparent that additional production facilities were required adequately to cope with the volume of orders. The contracts stipulated that the bulk of the equipment should be produced in Australia, and detailed plans for the implementation of local production by L. M. Ericsson were drawn up during 1961-62. The name of the manufacturing and trading company became L. M. Ericsson Pty. Ltd.

PLANNING AND ERECTION OF FACTORY

Factory Facility Planning

The successful conveying of technical production know-how from one country to another is a matter of balance. The appropriate importing of a product, a process, a management system or control, is influenced by the interaction of the technical, cultural, political and economic systems of the two countries.

Attitudes and regulations regarding such things as labour, importation, investment have a bearing on the forecasting and controlling of costs for labour, material, overhead and capital. The most suitable production processes have to be chosen together with machine and tool investment, in conjunction with effective production planning, to establish adequate and economical output and inventory levels. All these factors play a vital part in the decisions and actions to be taken when planning for production.

Experience from similar operations in other parts of the world is of course advantageous, as long as such experience is effectively combined with local practices. Each new situation must be thoroughly considered.

Within the L. M. Ericsson Group an internationally-trained staff of people is available for new factory facility planning. This group of engineers and economic advisers is located at the parent company in Stockholm, Sweden and helps to establish factory layouts, suggests machine and tool procurement and the selection and training of specialist personnel. After the commencement of production, the group's services are available for helping further development of production processes and factory management procedures.

Due to continued technical developments in the equipment to be produced, and the possible introduction of improved processes of production, the factory must have a layout which is also able to handle changes. Such changes are usually governed by the general plans for stages of growth which can vary from one factory to another depending on local circumstances.

Location of Factory

When selecting land for a factory for the production of crossbar equipment, there are five main points which require thorough investigation and subsequent decision:

(i) Supply of labour.
(ii) Gas, water, sewerage and electricity supply.
(iii) Access to main transport facilities.

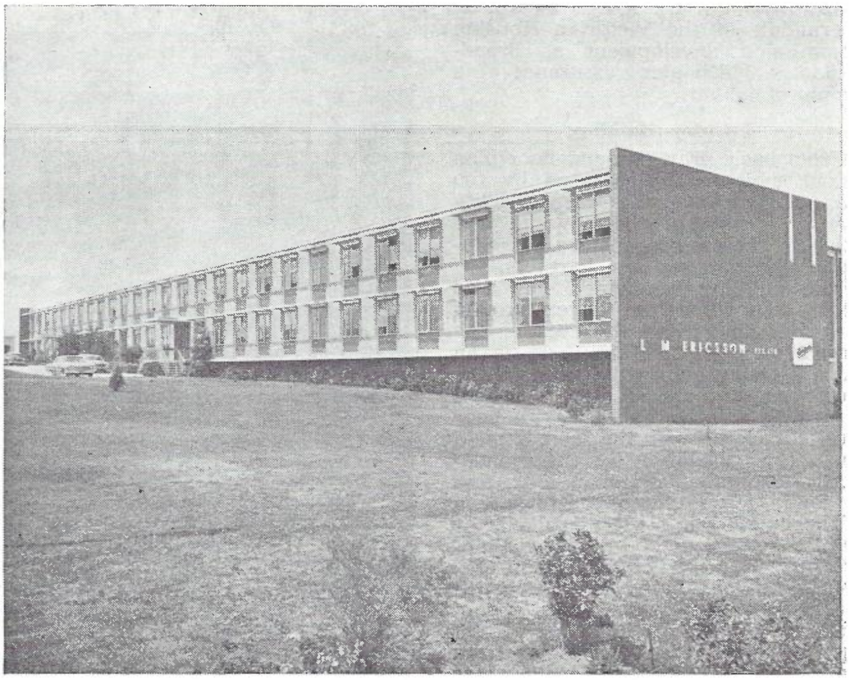


Fig. 1 — L. M. Ericsson Pty. Ltd., Broadmeadows, Victoria.

* Mr. Spongberg is Factory Manager, L. M. Ericsson Pty. Ltd., Victoria.

Fig. 2 — Tea Break in the Cafeteria.

Early in 1967 a company-sponsored Child Minding Centre opened to take up to 90 children in the 3-5 years age group. This building is fully equipped with beds, play rooms and facilities for the serving of hot and cold meals. The Centre is on a strictly non-profit basis, with a staff of one matron and about nine nurses. A Social Hall has also been built on the premises for the employees of L. M. Ericsson. It offers facilities for evening entertainment such as dancing, movies, study and other various club activities.

(iv) Air cleanliness.
(v) Financial aspects.

After a study of the conditions in Victoria, it was decided to locate the L. M. Ericsson factory in the northern part of Melbourne at Broadmeadows. In our study, areas such as Frankston, Dandenong, Greensborough, Lilydale and others were considered, but in each of these places one or more of the requirements were not at that time fully met. The site is located in the middle of the Victorian Housing Commission development at Broadmeadows which gives assurance of a supply of labour.

Factory Building

From basic drawings and floor plan layout which were prepared by the parent company, the responsibility for the design of the building was given to the Melbourne firm of architects, Garnet Alsop and Partners.

The building is divided into two floors, of which the lower ground floor has about half the area of the main floor. In addition there is an office building across the front of the factory, and there is also a central store adjoining the factory with floor level coinciding with the factory main floor. The excavation for the foundations started in December 1962, and the building was completed to such a

The building is made of solid brick and has a new method of natural roof lighting. This method of lighting has given excellent light at work bench height even during winter days, with a minimum of artificial light. This lighting method increases the temperature in the factory during the summer months, compared with, for example, a saw-tooth roof construction. The factory is ventilated through mechanical filters, and is pressurised to keep dust out. In the Paint Shop, there is an additional pressurised system over and above the factory pressure, for the same reason. The building was erected by F. T. Jeffrey Pty. Ltd. and was officially opened on December 6, 1963 by the former Postmaster-General, the Hon. C. W. Davidson.

HIGHLIGHTS OF PRODUCTION

The production of crossbar equipment is facilitated by a high degree of standardisation of piece parts. The main components, the RAF Relay and the RVD Switch, are employed in such large quantities as to permit a well developed mechanisation of both machine-shop processes (primary departments) and of the assembly-wiring-testing operations (secondary departments).

In the primary departments the emphasis is on making full use of the standardisation by investing in high speed, advanced tooling to minimise production lead-time and tool maintenance. The predominance, (70%) of the work is in the press-shop, making it possible to employ simple automatic feeding and stacking devices. Wherever progressive tooling has not been introduced, the arrangements of the required machines and the associated operations for a particular piece-part is such that it achieves a progressive flow of work operations with a minimum of inter-operation delays.

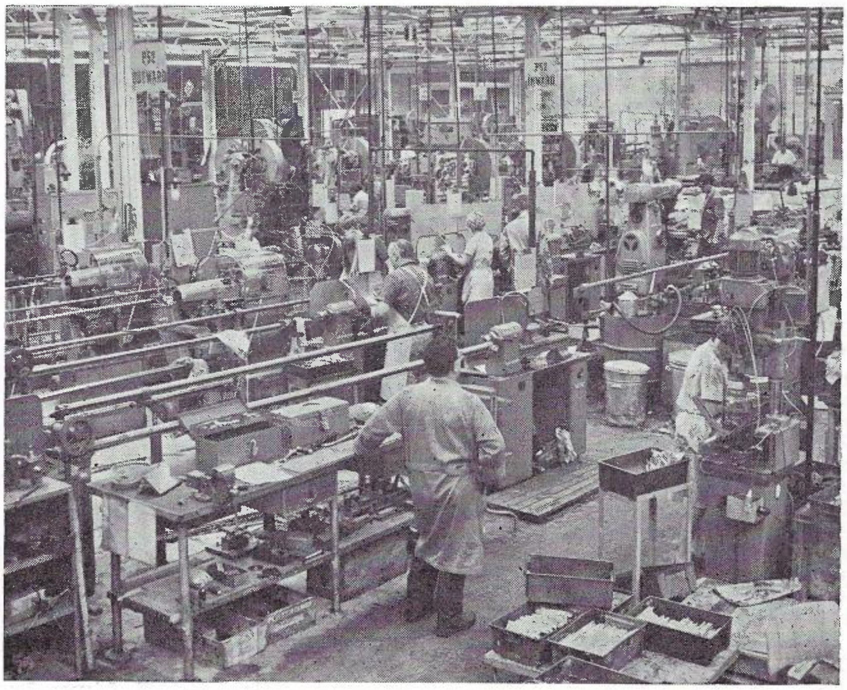


Fig. 3 — Primary Production Departments.

Fig. 4 — Secondary Production Departments.

In general the machine tools are of standard types. Only a few special purpose machines are in use, for example, contact riveting, jack and plug assembly and strip tinning. These machines were designed by L. M. Ericsson in conjunction with the design of the piece parts.

A flow-line concept has also been introduced in the secondary departments. The successful implementation of a relay set production flow-line, including all operations from coil winding, relay adjustment, cable-form making, wiring, testing and packing has been in operation since the end of 1966. Further improvements of the individual handling operations are being undertaken to gain additional reductions in lead-time and work-in-progress.

Another highlight of production which may be of interest, is the successful introduction of the metric measuring system including established tolerances in accordance with the recommendations of the International Organisation for Standardisation (I.S.O.) in all phases of our production, including the production of tools. Contrary to some opinions in the industry, the training of the operators, leading-hands, tool-room and inspection personnel is less difficult with metric than commonly assumed. A course in measuring technique was arranged for a few people in leading and supervisory positions. No other arrangements were made except a ban on all measuring devices not graduated in metric dimensions.

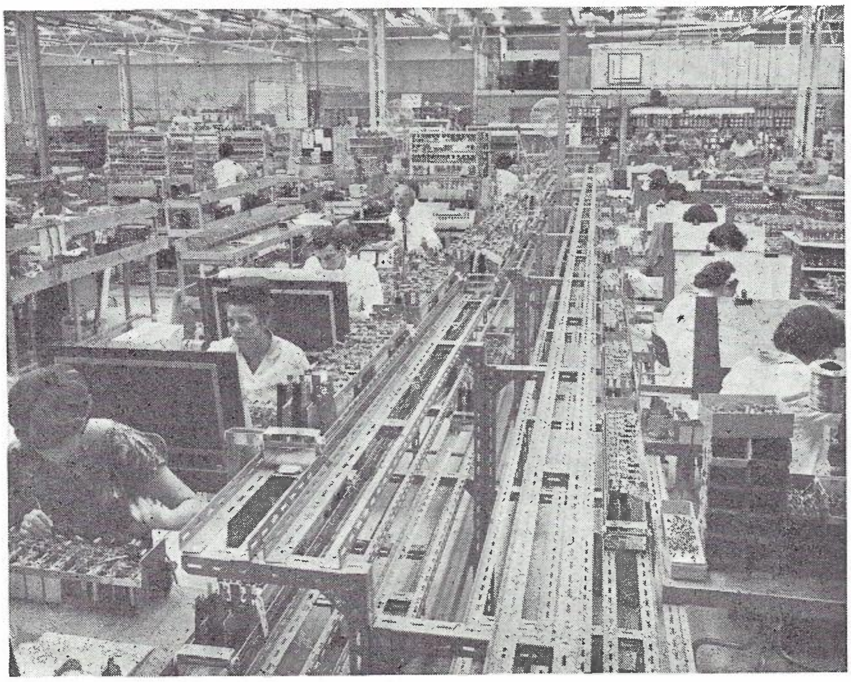


Fig. 5 — Flow-Line Production of Relay Sets.

MANPOWER REQUIREMENTS

The estimate of manpower requirements is a part of the factory facility planning. As such, it was originally a plan showing the numbers and types of managers, technicians and workers needed at the start of production in Broadmeadows. The plan outlined a program for supplying these needs from local and overseas sources and included specific steps to develop local manpower into successively higher supervisory levels.

The original team from the parent company for the factory consisted of a Factory Manager, Production Manager, Technical Manager and six Foremen. The personnel selected had previous experience in similar work positions in the Swedish factories or abroad. The team was engaged on this project for periods ranging between six months to three years. Their main task was to help select and train local personnel at all levels of production supervision and technical support. The training not only included the conveying of information of various production processes, but also the know-how of making full use of documentation supplied and acquiring knowledge of the inherent company policies not always documented.

The Production Engineering, Planning, Procurement and Personnel Management was handled by locally employed people, some of whom were sent to the parent company for study. Exchange of knowledge continued through the years and will continue to do so as the factory grows and new products and/or production methods are being contemplated. It is recognised that the different stages of growth of the factory will require different contributions of knowledge from the parent company.

Training of Factory Personnel

With the establishing of production facilities in Melbourne the Management was faced with problem of starting production operations from scratch. Speed was essential because of contractual requirements. This in itself imposed a heavy load of selection-recruitment on the Personnel Department.

Speed was also essential from another point of view. The training scheme had to be short and efficient to reduce precedents of low performance and productivity which could have become a problem in time. It was decided to organise training facilities under the supervision of the Personnel Department with assistance from a professional group of training consultants. The organisation selected to undertake this project was chosen mainly because of the new process analysis method of training which had been developed by the consultants and been used successfully in other parts of the world. The essence of the technique is the thorough analysis of the operation to be taught so as to determine the precise skills required for its proper performance. This skill analysis is followed by the design of appropriate selection tests and training procedures. The training method incorporates special methods for the development of both skill and consistent output.

Relay adjustment was the first process analysed in accordance with this method. The result was encouraging and as a consequence all major operations in the secondary departments are today covered by this scheme.

ENGINEERING TO SUPPORT PRODUCTION

It is essential that strong engineering support for factory operations be provided. This type of engineering, to be distinguished from design-development engineering, is giving support and guidance to the production operations from the point of product engineering, including the setting of quality standards, provision of tooling and methods to the point of appraising the conformity of set quality standards of the product produced or purchased. In other words, function controls of all required technical input information of the products for the production/purchasing, and by means of its own inspection activities in the factory and of sub-suppliers, it is able to obtain all necessary output information of the products-in-process or completed, to adequately control quality at the most efficient level.

In a broad sense the organisation covers four major functions:

(i) Product Control
(ii) Production Engineering
(iii) Quality Control
(iv) Inspection.

The four functions constitute an integrated control effort in an overall company quality control system to assure quality of the products at minimum costs and render assistance to the production in cases of non-conformity to set standards.

Product Control

The Product Technique Section is in charge of all product drawings related to production. It is responsible to accumulate performance requirements of the products, act in the capacity of a common pool of product know-how and instigate actions to assure full use of existing L. M. Ericsson documentation. It is responsible for issuing of requisitions for alterations or changes of the products being produced. It investigates production problems related to design and suggests changes in design to facilitate production. Furthermore, the section is responsible for planning and availability of documentation to be used by the Production Planning Department in formulating the production program.

The Record and Print Distribution Section is in charge of the recording of official technical documentation used within the company. It serves as a printing and distribution centre of copies for a number of permanent drawing files located in various areas of the office and factory buildings. It is the responsibility of this section to issue new copies of these files whenever the originals are subject to changes or obsolescence.

The Chemical and Metallurgical Laboratory is in charge of any raw materials testing required for the purpose of establishing sub-suppliers. Any subsequent test requested by the Incoming Goods Department on batch deliveries of raw materials is also carried out by this section. It is the responsibility of this section to assist production in the control of electroplating, painting, impregnation and heat treatment processes.

Production Engineering

Work Study is responsible for the critical analysis of the way and conditions under which work is done and the development of better and more economic methods and measurement of the labor required.

Tools and Methods is responsible for the design of tooling, special machine and ancillary equipment, the preparation of tooling schedules, estimating tool production times and investigation of production problems related to tooling.

Quality Control

Inspection Planning has the responsibility for any action required to determine that quality objectives and goals are sufficiently defined to permit adequate production. It plans and directs the inspection measurements and controls to be provided on processes and products. It is also responsible to analyse quality assessment reports and other feedback information from the field and make recommendations for adjustment to product design, production processes and inspection procedures.

Quality Assessment is responsible to designate quality characteristics to be measured in establishing methods and procedures for performing a continuous assessment of the quality of products being produced. Its main objective is to determine the actual level of quality and to detect any significant variation to such levels. The information is reported to Management and the parent company and is used by Inspection Planning in the direction of corrective actions.

Reliability Laboratory is in charge of reliability studies of components being produced and/or purchased. The standards of reliability required for the products are determined by the technical departments of the parent company. It is then the responsibility of this section to appraise conformity to these standards. Reports of the tests performed are submitted

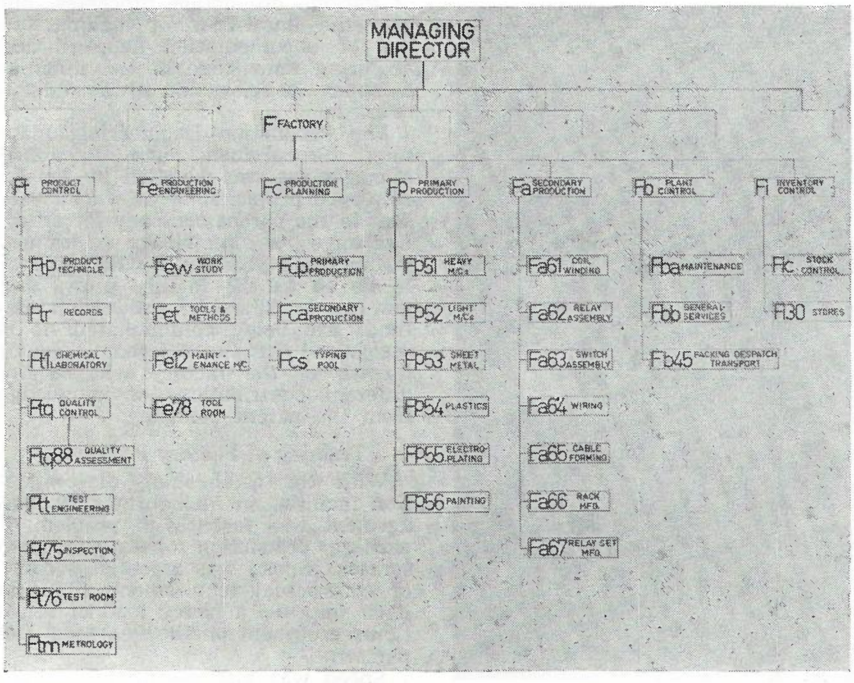


Fig. 6 — Factory Organization.

to the parent company and to certain customers on their request.

The reliability activities may be grouped under three headings:

(i) Establishing the reliability requirements.

(ii) Reliability analysis of components prior to production.

(iii) Continuous reliability testing of components of approved design, purchased or of own production.

Establishing the Reliability Requirements: The initial new design control activity is the responsibility of the technical departments of the parent company. The reliability targets and standards have been chosen with due attention to the state of the technical art and the overall functional requirements as experienced from actual operations in the field. The standards are thus very realistic and cannot be altered without the consent of the parent company.

Reliability Analysis of Components Prior to Introduction: This portion of the reliability activities is covered by the parent company in its approval of the design for production. In the design approval is also included the recommended production processes and tools to be used to attain desired reliability level. It is a well established L. M. Ericsson practice to keep the production of a newly-introduced product for several years as close as possible to the department responsible for the design. This practice is for the purpose of obtaining adequate attention to production processes and their effect on the product reliability. Not until the design is proved feasible to be produced in large quantities is the product authorised for production in other factories within the L. M. Ericsson group.

Similar caution is exercised on the introduction of purchased components. The reliability testing facilities are being utilised to assess all aspects of the component reliability before approval is granted to use such component in an L. M. Ericsson product. As a reference, a list of approved suppliers and their components is issued to the Purchasing Departments within L. M. Ericsson. The list is maintained by the Quality Control Department.

Continuous Reliability Testing of Components of Approved Design, Purchased or of Own Production: Continuous testing is necessary for the purpose of making sure that the design and production data continuously and repeatedly result in the production or purchasing of products with required reliability. This will normally involve the taking of random samples from the running production or Incoming Inspection. The samples are subjected to detailed examination and accelerated tests in accordance with established procedures and standards. In addition to the continuous reliability assurance on the products, the continual testing provides exhaustive data on which to base reliability improvement programs.

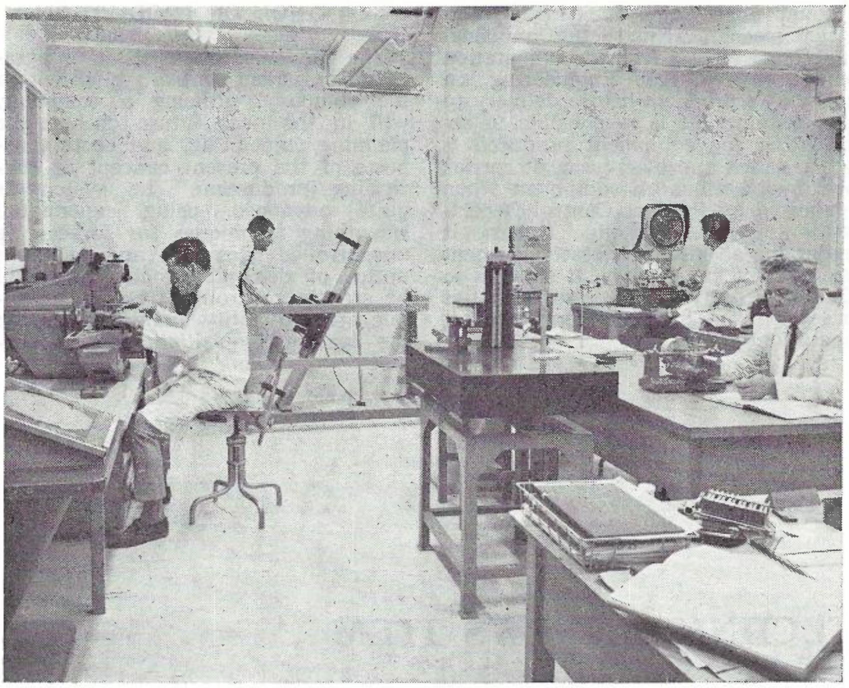


Fig. 7 — Metrology Department.

Production Test Engineering is in charge of test methods, instructions and the design of electrical test equipment used by inspection authorities and certain production departments in the factory. Included here are techniques for creating measurement practices and instrumentation procedures for the application to those quality information requirements that are established by the Inspection Planning Section.

Metrology is in charge of calibration and re-checking of electrical and mechanical measuring devices used within the company. It conforms with N.A.T.A. (National Association of Testing Authorities) requirements for registration. The section is also responsible to carry out "First-Off Piece Part Examination" from new or modified tools and to render service to tool room and production when special examinations are required.

Inspection

Incoming Goods Inspection is responsible to ensure that incoming raw material and components from subsuppliers are subjected to test and inspection as laid down by Quality Control. It acts in this capacity as a receiving and distribution point working from test schedules and sampling tables. The actual tests are performed by the various specialised test authorities within the factory organisation. The section is also responsible to maintain a suppliers' quality rating system.

Piece Part Inspection is carrying out quantitative and qualitative inspection and sorting of parts being produced. It works from inspection instructions and sampling tables provided by Quality Control. It is responsible to record fault rate on piece part production and submit weekly inspection reports. On request from Quality Control it performs special quality auditing.

Assembly Inspection is responsible to carry out test and inspection procedures required during the various stages of assembly and adjusting operations. It works from test instructions and sampling tables provided by Quality Control. The section is requested to record fault rate on a daily basis and submit reports to Quality Control.

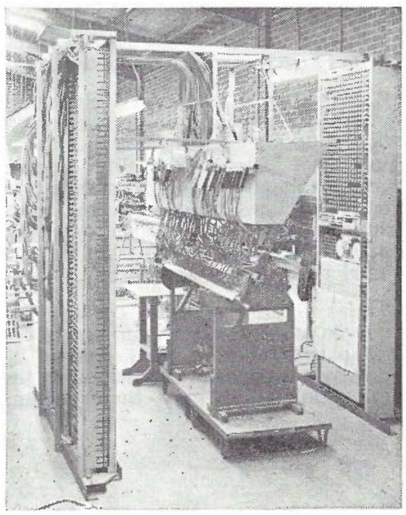


Fig. 8 — Automatic Test Equipment for the Final Inspection of Rack Wiring.

Final Test Room is carrying out visual mechanical inspection and final functional testing from documentation submitted by Test Engineering on company's products before delivery to the customer. It is responsible to assure that the equipment produced is of the latest approved issue. It carries out modifications on equipment when requested by Product Control Department on official change orders. It maintains all electrical test equipment used within the factory. It submits to Quality Control fault rate statistics based on the findings from the test operations.

CONTROL OF PRODUCTION

The implementation of an integrated management control system within the company, utilising a computer, will in the near future change the planning, expediting, and costing aspects of the present concept of controlling production. The system is quite advanced, using exponential smoothing techniques for forecasting uncontrolled demand and advance notice of demand. Stock levels will be strictly controlled from an economic order quantity analysis based on the cost of acquisition, cost of possession and some safety stock parameters. It is not possible to cover adequately the complexity of this system in this paper.

CONCLUSION

In conclusion it may be said that the factory today is effectively producing equipment, but that quite a lot of work always lies ahead to keep pace with the competition in the telecommunication field. It is a true challenge with real incentives, for both the customer and the supplier.

TECHNICAL NEWS ITEM

STORED PROGRAMME CONTROL OF JUNCTION RELAY SETS

The functions of a telephone exchange can be treated under two categories:

(i) the establishment of connections, and

(ii) the subsequent supervision of the connections.

In step-by-step networks, individual control circuitry is provided in each connecting device to establish the connections, and supervision is performed by a specific device included in the connection (relay set repeater or final selector).

Crossbar equipment used in the A.P.O. network provides common control of the connecting processes, but supervision is still performed by a specific device (cord circuit relay set, FIR or FUR) in the connection.

By the use of high-speed electronic devices it is possible to perform supervision functions at a common control point also. The supervising devices in the connection can be reduced to simple circuits detecting line conditions with the necessary logic and control functions performed at a central point by a "processor".

The use of common control for supervision functions can introduce serious problems if it is desired to change the signalling conditions on the connection, as it may then become necessary to modify the processor as well as individual line circuits. Flexibility in these circumstances can be obtained by the use of a stored programme in the processor. The order in which functions are performed by the processor is determined by the configuration of the programme store, which may be in the form of a magnetic pattern on a magnetic drum or in the pattern of diodes in a hard-wired diode store. In either case the pattern may be readily changed; in the former case by re-writing on the drum and in the latter case by rewiring the diode matrix.

The concept of a stored programme has been the basic operating principle of electronic digital computers since their inception, and is finding increasing application in telephone switching as manufacturers and administrations resort to electronic control of exchanges, to gain greater traffic capacity and more sophisticated subscriber facilities.

To gain first hand experience in stored programme techniques, the A.P.O. has started the design of a processor to control carrier signalling relay sets. A preliminary model to control some of the functions of such a relay set is nearing completion. Work will soon commence on the construction of a processor to control an actual relay set in a working situation. The experience gained from the design and the construction of the first model will provide a firm foundation on which the main project can confidently proceed.

The model processor has been constructed using micrologic elements and a hard-wired diode store for programme storage. The choice of the programme storage technique is largely determined by the size and the complexity of the programme and its probable amendment rate. For the control of line signalling relay sets, a simple, relatively-short programme is used, and changes to the programme should not occur at frequent intervals, so a hard-wired store is suitable.

The controlled relay set is significantly reduced in number of components by use of common control, and lends itself more readily to realisation in solid state devices, thus producing a very great reduction in size.

Aspects of stored programme control that are being given close consideration include reliability and the optimum allocation of functions between the controlled device and the processor. Security is a major consideration when a large number of line relay sets are controlled by one processor, and the use of two processors working in parallel will almost certainly be necessary. As regards the allocation of functions between the controlled device and the processor, the decisions taken during the design of the small model have been supported by similar investigations conducted overseas. G.L.C.

COMMISSIONING OF CROSSBAR EXCHANGES

C. S. LAVERY, B.E.*

INTRODUCTION

The introduction of crossbar equipment into the Australian network in 1962 posed many new problems for engineers and technicians, and the one which was of most concern to the installation staffs was the technique of testing. Up to that time, testing had consisted of using a multiple tester on a number of switch multiples, and the adjustment and checking of a large number of individual items (selectors and repeaters) which all performed the same function. Because of the repetitive character of these items it was not difficult to build up proficiency in detection and correction of faults. Common control equipment then presented the problem of fast operation of a large amount of equipment during a very short interval of time. Obviously the technique had to be different to that used in step-by-step, and the problem resolved itself when a set of instructions was produced having been prepared for the APO by an L. M. Ericsson Installation Engineer.

These instructions set out the basic principles of the tests required, and the technique of testing, systematically, all the various switching paths associated with the common control system. At the time there was little specialised equipment available for the testing required, and the instructions reflected this in their concentration on manual or simple detector type of testing techniques, while at the same time, indicating the principles of testing where more sophisticated instruments were available.

The early techniques have now been well learnt, and the proficiency of technical staff in their use has improved, but there is a limit to the improvement which can be gained using manual techniques. What are now to be described are techniques and test sets which have been applied successfully in an attempt to introduce some automatic process into the installation phase of work, and which offer substantial gains in productivity.

This article describes the various installation testing units supplied as standard equipment by L. M. Ericsson together with additional units developed by the author when working as a P.M.G. Installation Engineer in South Australia prior to taking up employment with L. M. Ericsson.

PRINCIPLES OF TESTING

Productivity and Testing

Before proceeding to discuss technical aspects of fault finding an important aspect should be considered and that is, what is useful and what is redundant work in the testing stages? It is obvious that if a technician's time is fully occupied with clearing faults then his productivity cannot be increased. But some work must be performed to encounter a fault before corrective action can be taken. Then if productivity is to be maximised the time expended encountering faults has to be minimised. Or expressed differently, the technician has to be moved as quickly as possible from fault to fault. This can be done in two ways, firstly by providing testing techniques which are routine and can be rapidly applied, or by some form of test set which can automatically find the faults. Both systems relieve the testing staff of much routine work and enable them to concentrate their efforts on the location and correction of faults.

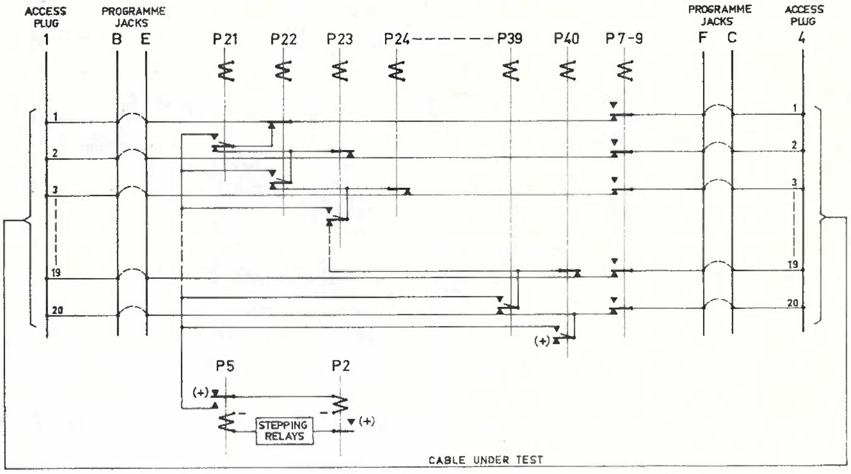


Fig. 1 — Automatic Wiring Tester Insulation Test (Simplified).

Testing of Installation Cabling

The conditions which predetermine the technique to be employed in testing installation cabling are the types of faults and mistakes which are normally encountered. These can be briefly enumerated as below, where the first few are technical faults, the latter are due to human error.

(i) Crossed wires.
(ii) Open circuit wires.
(iii) "Dry" joints.
(iv) Insulation faulty due to faulty cable manufacture.
(v) Insulation faulty due to faulty cable terminaton.
(vi) Wrong terminations from temporary loss of concentration.
(vii) Wrong termination from gross miscalculation.

A system is then required which will check all the common technical faults, that is (i) to (iv) above, and which will also guard against the personal factor when the operator has tested his own work and has made the same mistake twice.

A buzzer, or lamps, can be used to check a limited range of faults, for example continuity and crosses, with a limited coverage of wires, but where a cable joins two points with terminations in close proximity something better than a test from one wire to the previous and next is obviously required. As well a buzzer or

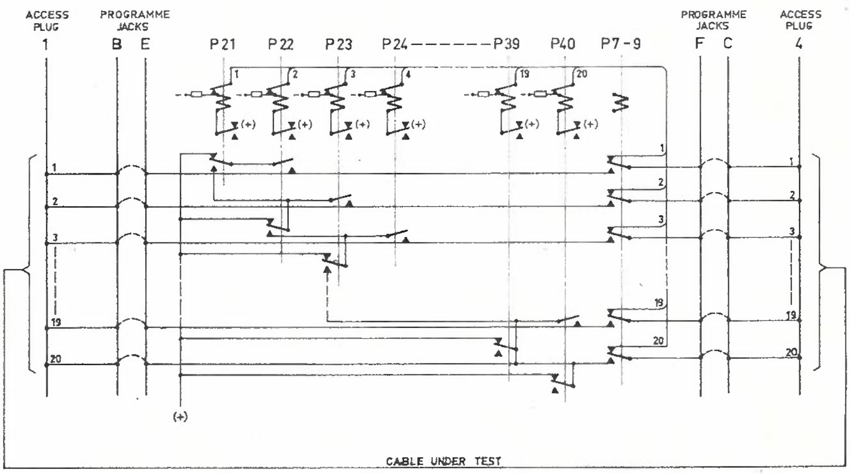


Fig. 2 — Automatic Wiring Tester Continuity Test (Simplified).

* This article was prepared by Mr. Lavery whilst he was employed as an Engineer Class 2 on exchange installation in the South Australian Administration of the P.M.G.'s Department. Mr. Lavery is now Senior Design Engineer, L. M. Ericsson, Melbourne.

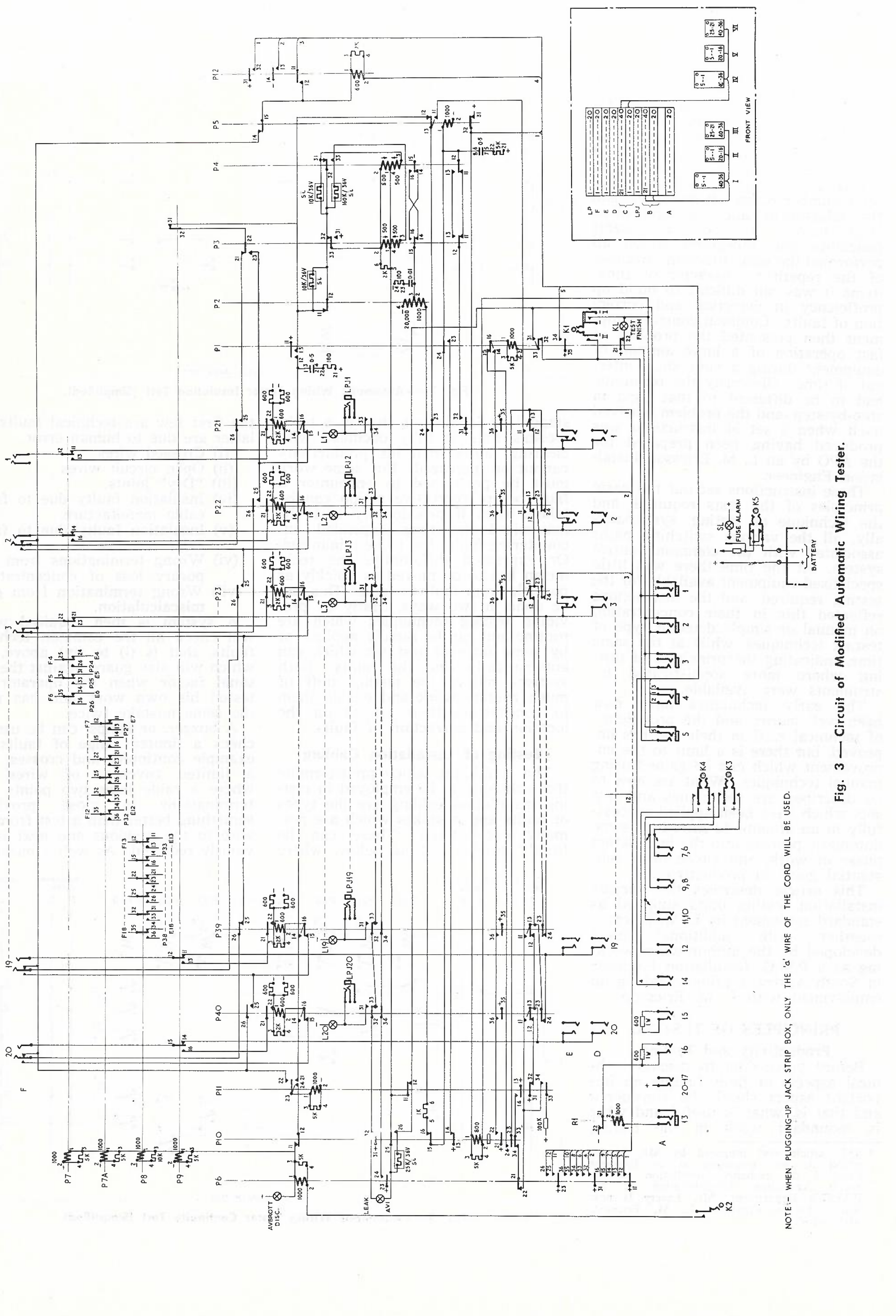


Fig. 3 — Circuit of Modified Automatic Wiring Tester.

lamp leaves open the human error factor.

Another problem also needs a solution. When testing the insulation of cables how far should testing go, for a test could be made between one wire, and all other wires in the exchange. To go beyond the same cable with such testing is surely of academic interest only, for, with quality control during cable manufacture, it is rare that a fault within a cable is found.

When determining the coverage of testing what should be examined is the grouping of wires on a terminal block, compared with the grouping of those wires in the cable since it is the installation work which is being tested. Obviously the wires which are terminated on adjacent lugs, and are also in the same group in the cable need to be tested as a group, as the probability of a fault is highest in this case. Similarly for forty wire cable links, it is preferable that they be all tested at one time, or because of the physical construction of forty point terminal plugs, as two twenty point units. However, to avoid duplicate testing of the cabling it is necessary to compromise between breadth of testing and time taken, keeping in mind that wires which consistently occupy adjacent terminals need to be tested as a group. Several items of equipment have been designed for such testing but the one used, and described below, is the L. M. Ericsson Wire Tester (A.W.T.) and a unit developed to allow more rapid testing procedures, known as a selector setting unit (S.S.U.).

Testing of Marker Equipment

Once the installation cable testing has been completed the relay sets can be fitted to racks and the system made to work. The current specified method of testing is the push up tests where particular relays in the markers are manually operated and the reactions to them checked by watching the operation of the other relays and switches. This again requires a large amount of effort but always leaves an open test, the opening being the manually operated relay, for it may not be known how it will operate electrically, or what the effect of its electrical operation will be on later stages.

The purpose of these push up tests is to check that the marker by-path selection, information transference, and selector operation functions are operating correctly. This work can be effectively, and rapidly carried out by dynamically testing each marker as a whole, by judiciously selecting specified operating paths, and forcing the marker to work over each path at least once. The functions indicated above can be all tested simultaneously using the techniques described below. A brief description will be given of two familiar testing instruments, the L. M. Ericsson load tester, and the L. M. Ericsson auto exchange tester (A.E.T.) and a third recently developed, the Auto Exchange Tester Auxiliary Test Unit (A.T.U.).

STATIC TESTS

Automatic Wiring Tester

Provision is made to connect and test a maximum of 20 wires to the tester, the tests being the insulation of each wire to the others under test, and to earth, thereby covering such faults as transpositions and crosses, and the continuity of the wires which enables detection of dry joints and open circuits. The tester is adjusted to accept insulation resistance above 100,000 ohm, and to reject wire continuity above 60 ohm.

For the insulation test (Fig. 1), both ends of the wires connected to the tester are joined at contacts of the P7-9 relays. The insulation test relay P2 is pre-operated and then connected to wire 1 by the operation of the P21 relay. If the insulation resistance is greater than 100,000 ohm P2 will release, P5 will operate and the stepping control relays will initiate a new test on wire 2 by operating relay P22. All the wires will be tested similarly. The standard A.W.T. was modified to provide changeover contacts on the P7-9 relays; this allows a complete test on all wires. When the insulation test is completed the P7-9 relays operate and allow the continuity test to be made (Fig. 2). The test commences at wire 20 with the P40 relay being applied to one end of the wire, and shunted by an earth at the other end. If the shunting resistance is less than 60 ohm the relay will release and subsequent wires tested similarly.

If a fault is encountered, either on insulation or continuity the testing process stops and the faulty wire is indicated by a lamp. The full circuit of the A.W.T. is given in Fig. 3.

It is possible for less than twenty wires to be tested at a time and, so that any arrangement of wires can be tested from amongst the twenty connected, a jack field is provided between the two ends of the cables, and the test and selection unit of the tester. This can be seen in the circuit, and diagrammatically indicated in Figs. 2 and 3. The only requirement is that

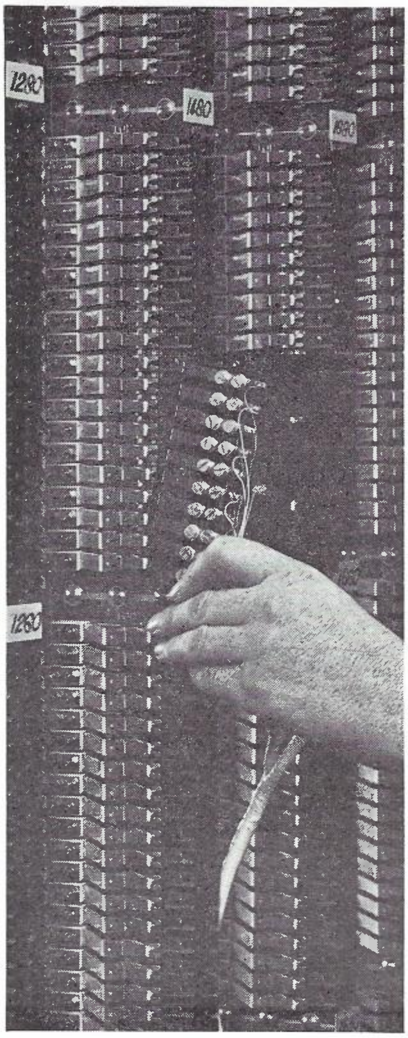


Fig. 4 — A Connection to an MDF Protector (H.C. and T.40B) Being Applied.

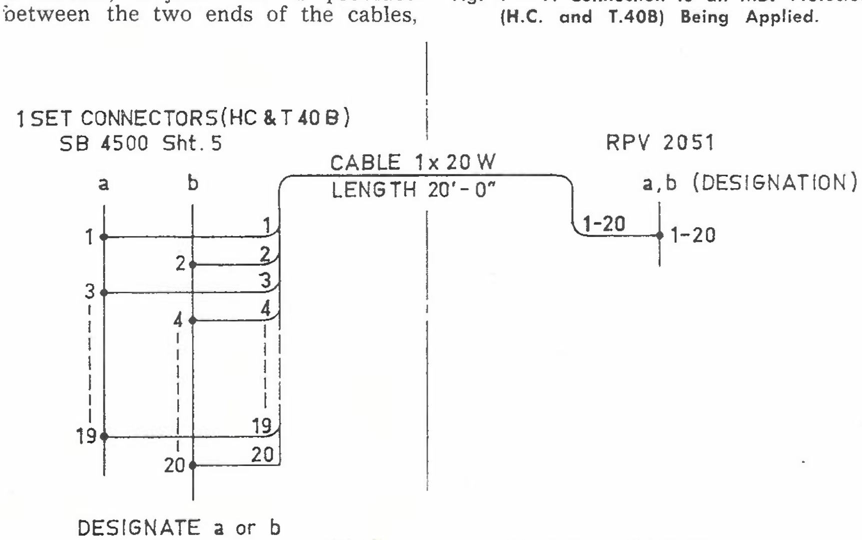


Fig. 5 — Cable Type 6, for Connection to H.C. and T.40B.

Fig. 6 — An LR/BR Connection Being Fitted.

the wires can be tested in any order from among the twenty but must be arranged sequentially from the lowest numbered jacks having access to the test unit.

Programmed Testing: The A.W.T. makes available an instrument which checks the common technical faults and which, if it is used, has to be programmed by the installation staff in the field. Such programming can be determined from the cabling charts used for terminating the cables but this leads to two further problems:—

(i) The human factor — the same chart may be misread by the operator who terminated the cable.

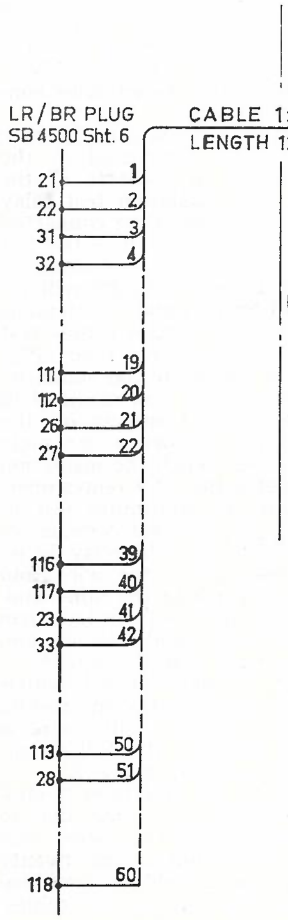
(ii) The inefficiencies which occur through the same programmes being repetitively determined on each installation for which the test is required.

Both problems are overcome by the preparation of installation wire testing programmes which specify in detail how the equipment is connected to the A.W.T., which programme cords are to be used, and what moves to make to carry out the tests efficiently. This system also leaves little room for the human factor problem outlined previously, in the section-testing of installation cabling.

A series of programmes have been prepared for all regular cable runs for ARF 102 equipment and as an example the programme to test the cable from LR/BR relay sets to the MDF is given in Appendix 1. To allow the full programming of the equipment, a range of cable connectors was produced to allow temporary connection to PBX-X and Y strips, meter plates, 2000 type terminal blocks, IDF's, LR/BB relay set jacks etc. An example of these can be seen in Figs. 4, 5, 6 and 7.

The cabling from BDD (switch) racks to the marker racks has also been programmed for testing, and organised such that there is a minimum of changes to the programmes on the A.W.T. it being quicker to shift plugs on the racks than re-arrange cords and plugs on the jack-field.

Other tests of interest are those through the register finders and code sender finders. Consider the SR to RS-L to REG-L (M) link. By plugging into the SR, and the REG-L (M), and fitting the RS-L relay sets, testing through the RS-L connecting crossbar



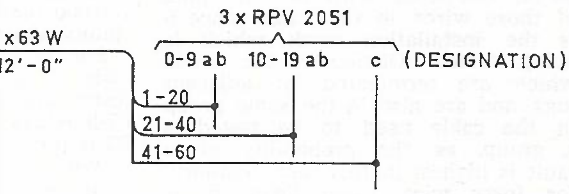


Fig. 7 — Cable, Type 2, for Connection to LR/BR Plug Unit.

switches can be accomplished by using the programme given in Appendix 2.

From the above examples it can be seen that a number of links can be tested simultaneously, where they can be readily connected in series with each other, and this is conveniently done by following the trunking diagram of the exchange, a simple one being as shown in Fig. 8.

Testing through Switching Stages: One important group of tests not so far discussed is that of cabling into and out of the switching stages. These routes form a large bulk of the cabling in the exchange, and are quite readily adaptable to rapid testing techniques. Appendix 3 specifies portion of the testing of the cables SR-SLB-SLA and uses the technique of setting 2 SLA switches to the same subscriber's number, from the SLA's via 2 SLB switches to two SR positions and hence to the A.W.T. The test is

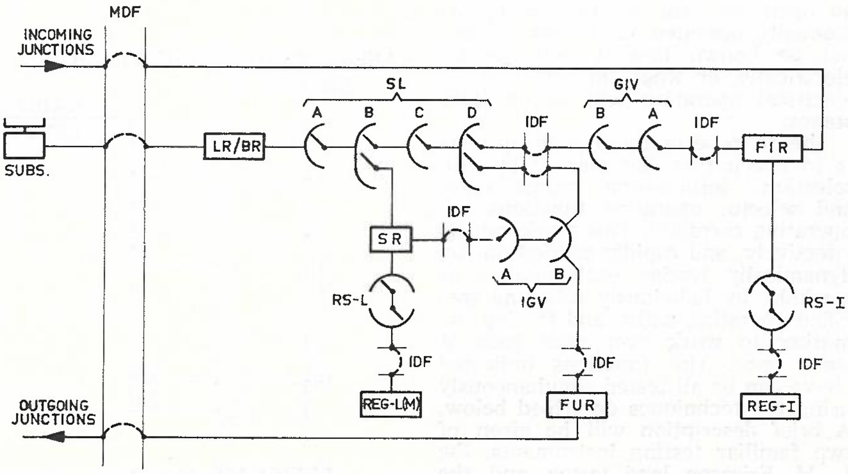
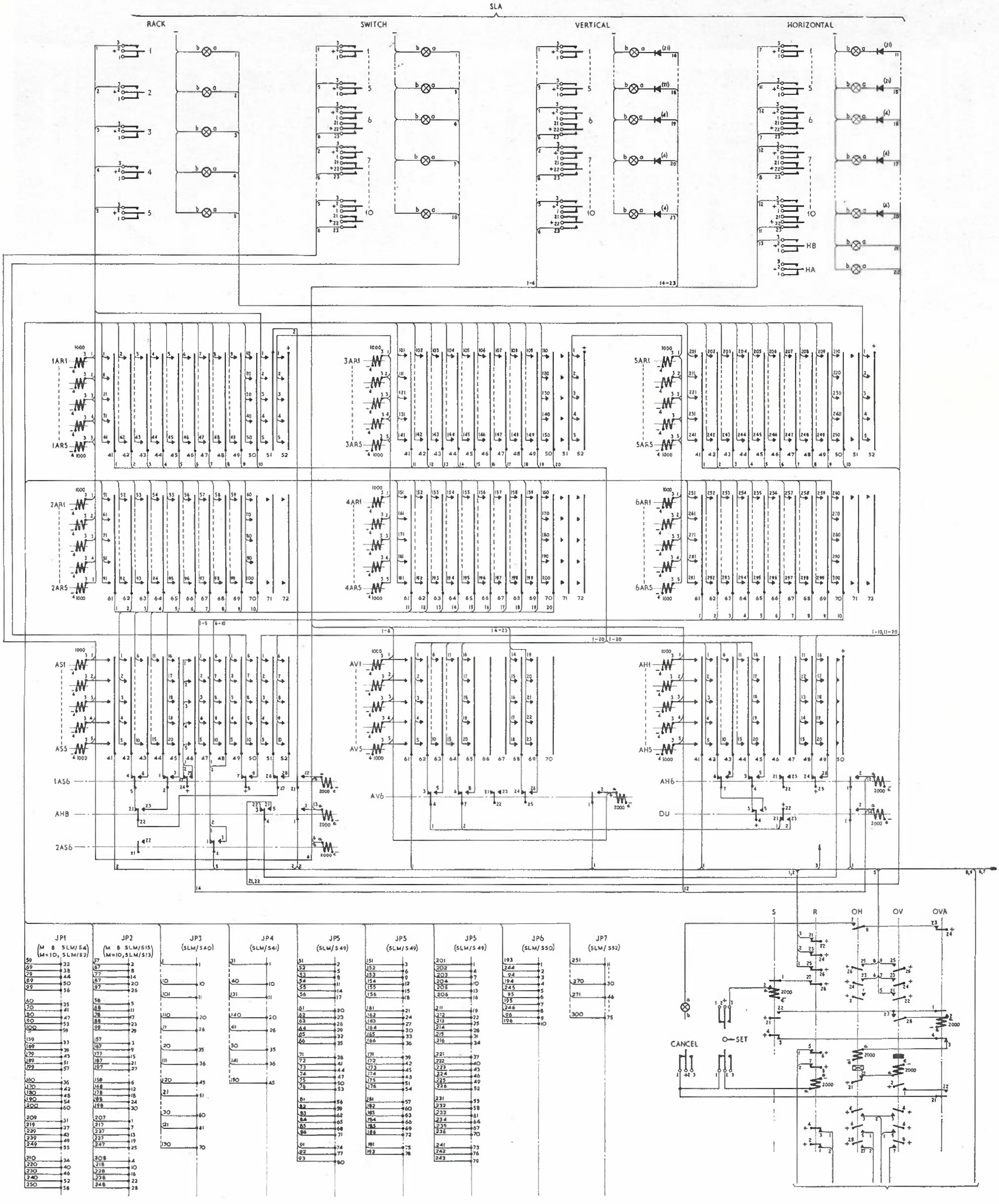


Fig. 8 — Typical ARF 102 Trunking Diagram Indicating IDF Points.



NOTES:—

1. DIODES TERMINATED ON SPARE SPRING TAGS ON KEY No. IN BRACKETS (21) INDICATES SPRING No. ON KEY. DIODES WILL BE ALL OA210 OR SIMILAR.
2. BATT I WIRED TO ALL MULTI COIL RELAY COILS; BATT II AT ALL OTHER POINTS.
3. KEYS HAVE BEEN CONVENTIONALLY NUMBERED FROM THE FRAME (MOUNTING BAR) SIDE.

Fig. 9 — Circuit of SLA, B Switching Stages of Selector Setting Unit.

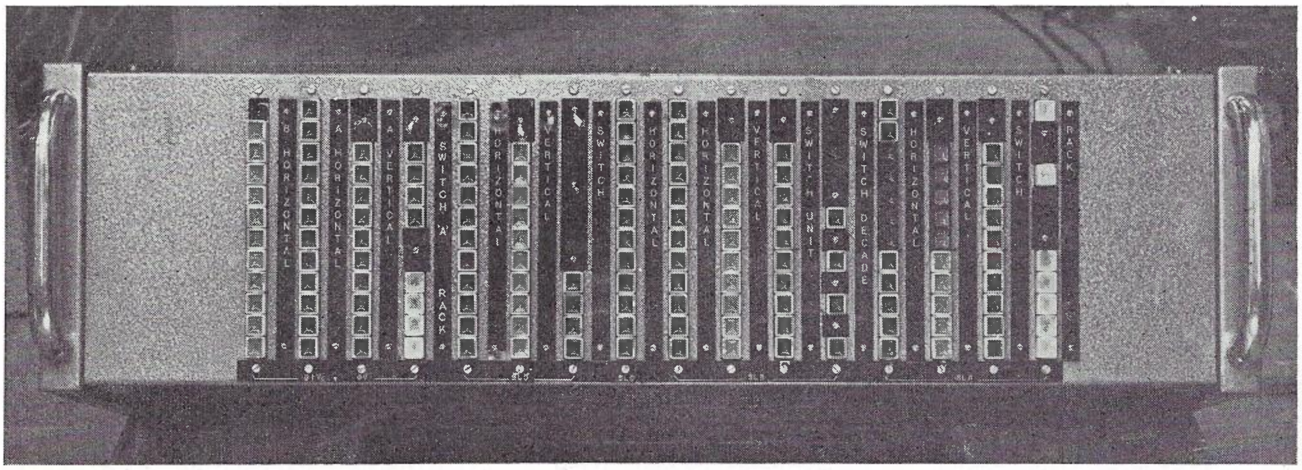


Fig. 10 — Selector Setting Unit Key Panel.

now made via the loop formed in the subscribers multiple. These tests are designed to check all of the installation cabling and terminating, but only that part of the manufacturers' work as is incidental to the requirements of testing other work. Similar methods are used for testing the cabling around FUR, FIR, IGV and GIV stages, but it can be seen that using such techniques involves a deal of setting of selectors by hand, and this can be time consuming and wearying on the part of testing staff.

Selector Setting Unit (S.S.U.) (See Fig. 9)

Because of the time consumed in setting selector stages, three or four men being employed setting swiches, a unit was developed which allows one operator to be stationed close to the racks at which the A.W.T. gains access to allow plug units to be conveniently altered and to control the A.W.T. and S.S.U. By pressing keys on the face panel of the S.S.U., the operator can select and operate any vertical and horizontal in any switch of any stage to which the S.S.U. is connected. In the initial design the selection is made by using multicoil and 3000 type relays to mark the wires terminated on the marker racks and which operate switch horizontals and verticals. Access is gained to the marker racks by 80 point fork units and cables, the connections being so arranged that any cable with a standard termination can be used anywhere, the knife units on the S.S.U. being designated with the jack position of the appropriate marker to which it should be connected. The S.S.U. is designed to handle an m = 1OB exchange, which has the largest traffic carrying capacity of all the existing ARF 102 crossbar exchanges. Figs. 10, 11 and 12 show the face panel layout, and the key designations, the layout and designation of the jack-field and a general view of the relays used. Fig. 13 shows the completed machine set up and working at an installation.

When in use, the operator presses the buttons specified in Table I of Appendix 3, under the columns headed Set 1. Internal lamps in the press buttons light to confirm that the correct buttons have been pushed before the operator presses the SET button which sets the selectors. When they are set, and the holding transferred to the A.W.T. on the d wire, the S.S.U. is automatically cleared for the setting of selectors under Set 2. The complete link has now been made and the test carried out. Selector setting has to be carried out in this two stage fashion since the marker equipment is organised to handle one call at a time in the one rack, and if more than this is attempted from the S.S.U., multiple paths, which are not required, will be set up.

This unit now enables one operator

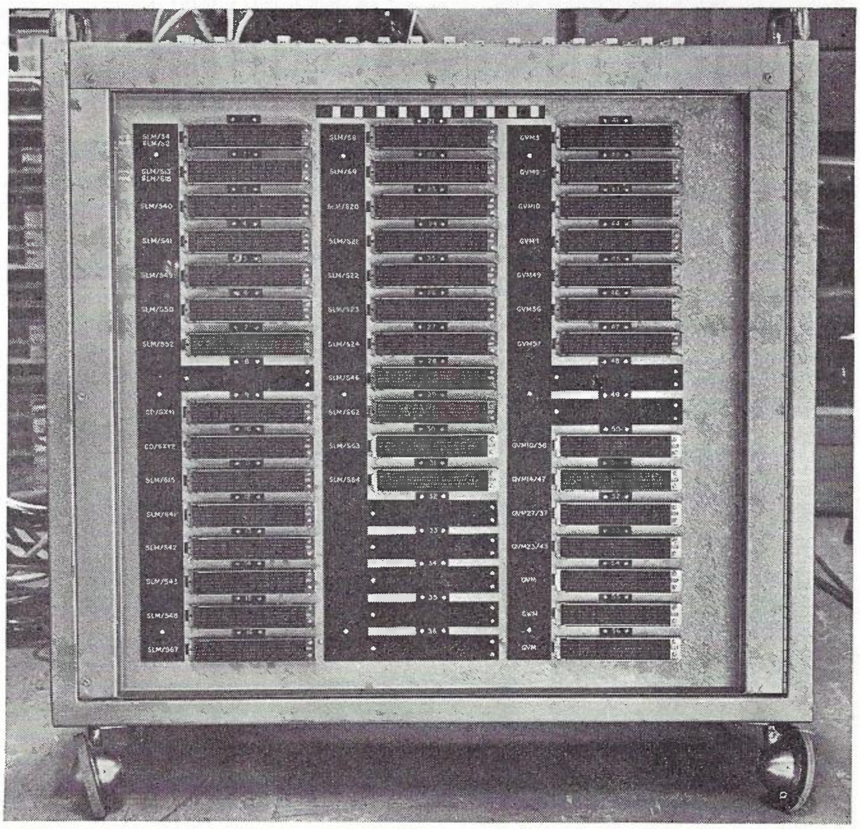


Fig. 11 — Selector Setting Unit Jackfield.

to do, from the floor and at a faster rate, what four men were doing under the previously-mentioned system of testing. It is now possible to give this systematic routine work to a less highly trained operator allowing the technician to be freed for fault finding, and to be called in when the operator encounters a fault.

The circuit of the SLA/B switching stages of the S.S.U. is given in Fig. 9.

DYNAMIC TESTING

Equipment

Load Tester: This instrument can be connected to a maximum of 10 A lines having access to a register which receives decadic impulses as its information input. A further maximum of 10 B lines, toward which the tests will be made, can be connected. Ringing signal is the identification of a correct switching function. At start, the load tester simultaneously applies all connected lines to the marker and checks either for receipt of dial tone, if connected to a REG L (M), or for correct polarity of battery and earth, if connected to a REG 1. Once this check is completed satisfactorily, impulsing commences to the predetermined B numbers set on the load tester, and it is so designed that the last pulse of each digit is transmitted simultaneously on all lines, so that when the last digit is stored in the register, even though these digits may all be different, the registers all call for the GV marker simultaneously thus simulating a very heavy calling load to the marker.

Switching now takes place toward the called test lines and if switching is successful the identification is indicated on the load tester which automatically resets to commence the cycle again.

The load tester can also be set to identify that the calling A line is connected to dial tone and to reset itself at that stage. It is this function which is used for the SL Marker Outgoing Switching Tests.

Automatic Exchange Tester (A.E.T.): This instrument is in common use in crossbar exchanges and is capable of initiating calls at any point in the exchange which is capable of receiving decadic pulse or MFC inputs. It is a one to one device in which the B number is set up on switches and the call controlled by the relevant parts of a register, KSR and KST which are fitted to it. Various arrangements of detection devices are available, and when a call is successfully switched the tester is automatically reset and initiates a new call.

Auxiliary Test Unit (A.T.U.): This has recently been developed to allow the expansion of test lines from the exchange tester to a maximum of ten. From Fig. 14 it can be seen that via the A and AA relays the A and B test lines of the A.E.T. can be connected to any of the test lines of the A.T.U. The relevant digit information for each test line which is preset on "Contraves" digit switches, is also connected to the KSR leads by the AA relays, the particular digit being selected from the P chain in the register part of the Exchange tester. When a call is initiated an A relay will operate to the + put on the 'd' wire by the A.E.T. The A relay sets the A.T.U. for the call and calls the marker on the outgoing 'd' wire. When the call is completed and identified the A.E.T. removes the + on the 'd' wire and the B relay operates to hold the call. The next call initiated from the A.E.T. operates a subsequent A relay, and the process is repeated until all the calls programmed are completed when relay C operates and clears the unit. The F1 relay is also included in the A.T.U. as an FUR termination for GV stages. By connection to the 'd' wire of a GVB outlet it will determine correct switching through a group selector stage.

A further facility provided is that when the GV SWG key is thrown, the first two digits for each line are then set on the fourth and fifth digit switches for each line. This was made necessary for use in GV Marker Switching Tests since three digit switches were provided as common switches for the first three digits of all lines.

There is one limitation of the Unit and it is that it can only be used on inlets where MFC signals are the normal information input. This is not a serious limitation however, since the load tester is available with similar facilities for decadic impulse inputs.

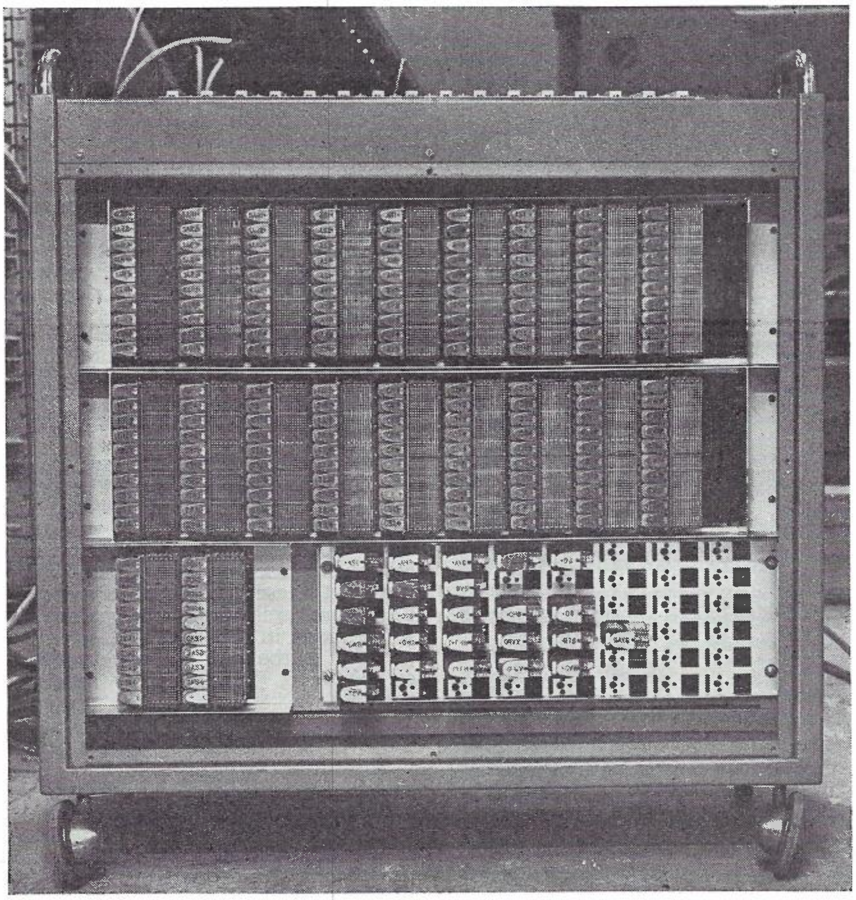


Fig. 12 — Switching Relays of Selector Setting Unit.

Marker Switching Tests

SL Outgoing Marker Switching Tests: Appendix 4 details the steps to be followed in carrying out this test, initially the marker needs to be checked that it will switch, that is, that calls can be made to the REG L, before the test is applied.

The principle of the test is that in a full SL suite five calls are made from the load tester through one line only on each of the SLA racks, and that one path through one SLB is left open for each call to select. Any of the grouping plans for any size of exchange can be used to determine the path nominated together with Tables 1 and 2 of Appendix 4. By forcing the calls through the various paths and watching the operation of the SLM, and RSM relays, faulty switching can be rapidly determined.

While it may seem that slow progress is being maintained on cycle 1, it has been regularly experienced that this feeling is rapidly dispelled on subsequent cycles. The programme thus completed will have ensured that each vertical and horizontal of each SLA and SLB switch in the outgoing path of the SL stage will have operated, that each digit to be transferred from the SLA/B racks to the marker has been transferred correctly, and that all bypaths involved have been checked. Subsequently it is only necessary to use the load tester for each subs line to check that identification is correct, and the LR/BR relay set can be checked at the same time. This test has not checked that selection relays will not operate in parallel, but load testing subsequent to Marker Switching tests will show any evidence there may be for this to happen.

Switching Test in Metropolitan GV Stage: Appendix 5 details the method of testing the GVM and includes temporary strapping required for the test, a total of 25 straps in all. Temporary connection is required to the 'd' wires of specific outlets of the GVB 1-10, and the outlets to those specion the IDF. Having set up the Auxiliary Test Unit, and the Auto Exchange Tester, to the inlets (GVA verticals) fied the test can proceed. Again one specific path only is available for each call made. Thus it can be confidently asserted that each vertical and horizontal has been operated if this series of tests is carried out successfully. That each vertical and horizontal is concerned in the test can be checked from a grouping plan when it will be seen that the GVB route outlet determines to which GVB vertical the call is directed from the GVA, and hence the GVA horizontal, and that the route determines the GVB horizontal that is operated.

Because GVB horizontals 1-10 are operated for routes 1-10, and 11-20, with the difference of HA or HB respectively, it is not necesary to check the operation to all routes, as this is only a marker switching test in which the correct operation of horizontals and verticals is being determined. Hence the change in route number in the middle of the testing table. Once again the early tests will encounter most of the faults.

Incoming SLM and Provincial Marker Tests: Similar marker switching tests can be applied to the incoming subscriber's marker, and the provincial marker, but these are not specified here since they use exactly the same principles as those already described.

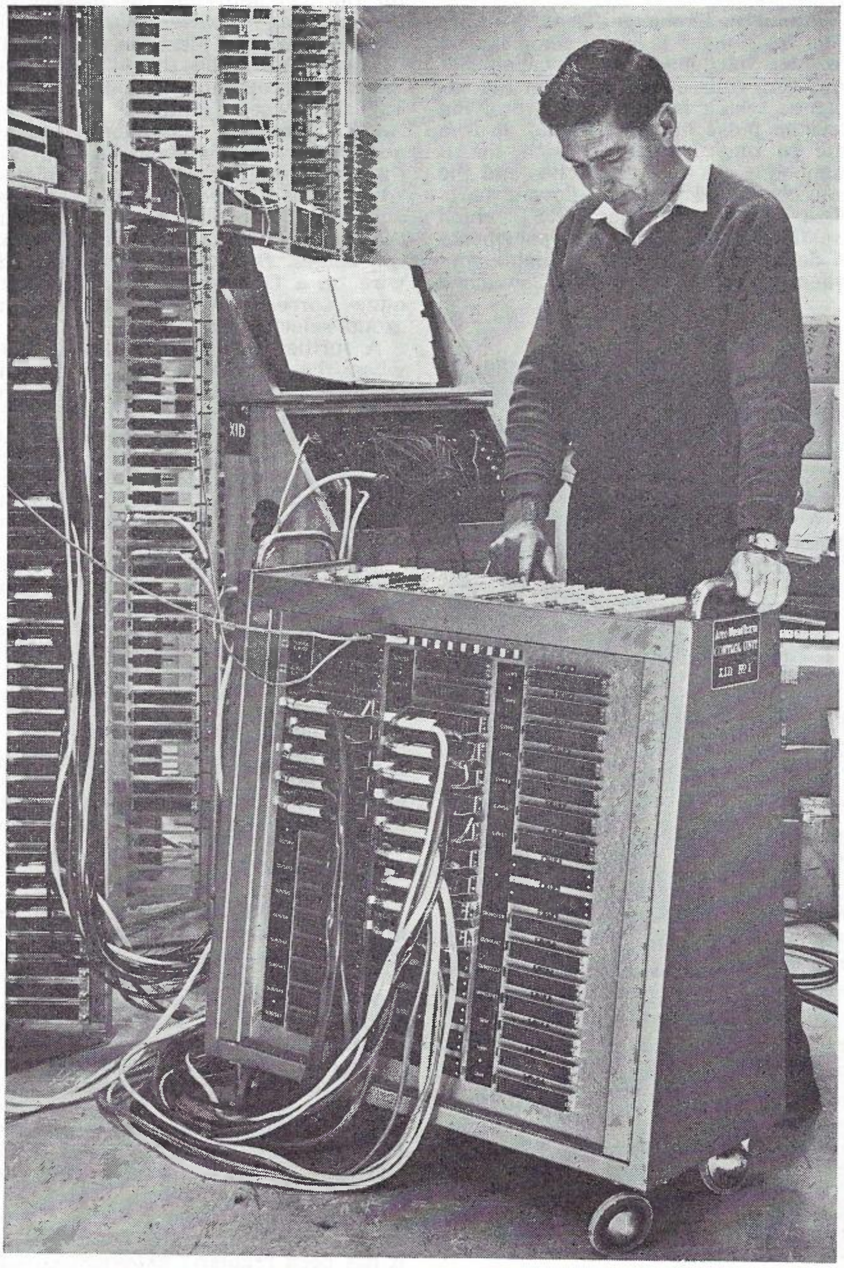


Fig. 13 — The Selector Setting Unit and the Automatic Wiring Tester on an SR-SLB-SLA Test.

CONCLUSION

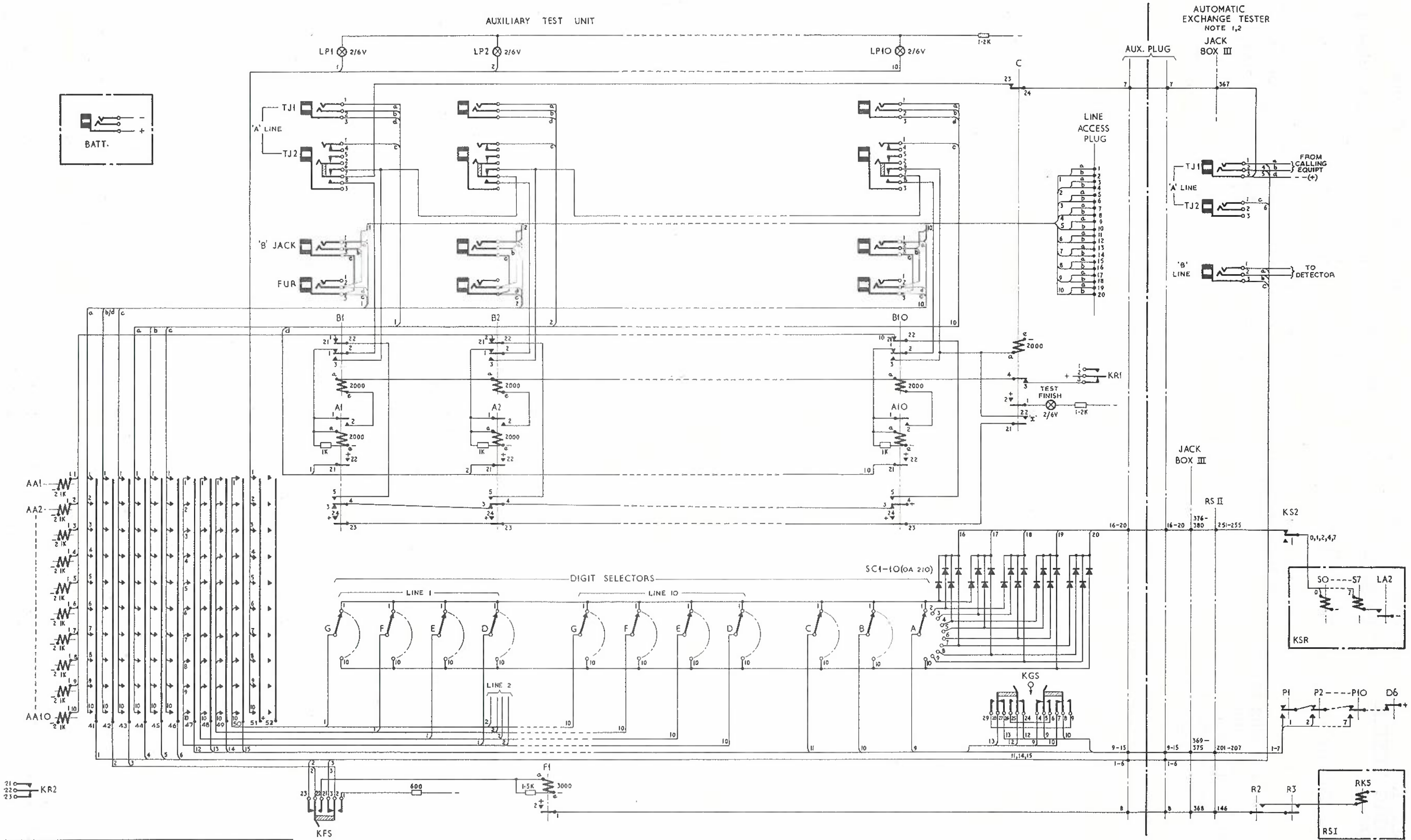
The principles of testing described above have been put into practice and have led to practical and efficient methods of testing. However, it will be quickly recognised that well trained staff are necessary when using the marker switching tests, if full advantage is to be taken of the rapid procedures; the switching of a call of this nature is rapid, and demands the full concentration of the staff to detect faults.

The emphasis of these tests has been to find faults at the earliest stage possible. With the introduction of a comprehensive wire testing programme it was noted that the incidence of installation wiring faults found in the later testing stages of push up tests and load testing was greatly reduced. A similar effect was noticed with the introduction of marker switching tests, the combined gains being such that a very restricted programme of load testing was possible.

The methods outlined above do offer improvement in productivity in the field of installation testing, and where properly carried out the gains could be quite large. Much emphasis has been placed on gains in terminating, and these have been significant, but there are worthwhile gains still to be made in the field of testing, especially in the rationalisation of tests on registers, junction relay sets, and the like.

ACKNOWLEDGMENTS

The author wishes to acknowledge the assistance given during the development stages of these techniques by Mr. O. G. Bartlett, the late Mr. A. R. Pennifold, Mr. L. R. Waller, and the technical staff, all of the Metropolitan Installation Division, Adelaide.



KEY G.V. SWG. TEST (KGS)	+	KEY RELEASE (KR)	KEY FUR/SUB (KFS)
4		2	2

NOTE: 1. ADD 20 POINT KNIFE UNIT & MOUNTING SB.... SHT. 1 TO AUTO EXCHANGE TESTER NEAR DIGIT SWITCHES.
2. EXTEND STRAPPING ON DIGIT SWITCHES 1-0, ARC G,H, TO POSITION 11 FOR START OF 'P' RELAYS.

RELAY	LABEL	ARMATURE No.	ARMATURE RESID.	COIL	SPRINGSETS		REMARKS
A1 — 10	W	2	B	1/SCO/441	1/SSP/807	7/SSP/805	
B1 — 10	W	2	B	1/SCO/441	1/SSP/803	7/SSP/802	
C	W	2	'X' B	1/SCO/441	1/SSP/806	7/SSP/864	
F	W	2	B	6/SCO/441	1/SSP/801	—	
AA1—10							MULTI-COIL RAM 11220

Fig. 14 — Circuit of Auxiliary Test Unit for Automatic Exchange Tester.

APPENDIX 1. AUTOMATIC WIRING TESTER PROGRAMME

MDF to LR/BR Cabling.

Cabling Diagram.

(1) Use cable type No. 2 and plug to LR/BR to be tested. Connect wires 1-20 to plug 2 of tester. Use cable type 6 and connect 10 subs to plug 5 wires 1-20 of tester.

(2) Programme Cords.

B1 — E1	C1 — F1
B2 — E2	C2 — F2
B3 — E3	C3 — F3
B4 — E4	C4 — F4
B5 — E5	C5 — F5
B6 — E6	C6 — F6
B7 — E7	C7 — F7
B8 — E8	C8 — F8
B9 — E9	C9 — F9
B10— E10	C10— F10
B11— E11	C11— F11
B12— E12	C12— F12
B13— E13	C13— F13
B14— E14	C14— F14
B15— E15	C15— F15
B16— E16	C16— F16
B17— E17	C17— F17
B18— E18	C18— F18
B19— E19	C19— F19
B20— E20	C20— F20

(3) Press K1, K1A to test 20 wires.

(4) Replace wires 1 - 20 from LR/BR with wires 21 - 40 in plug 2 of tester. Shift MDF Access to next 10 subs.

(5) Repeat Test.

(6) Use cable type 3 to connect 20 C wires on X and Y block PBX rack to plug 5 wires 1-20 of tester.

(7) Throw K1, K1A to test for insulation and continuity.

APPENDIX 2. AUTOMATIC WIRE TESTING PROGRAMME.

SR-RS-(L) - REG-L(M) Programme.

Cabling Diagrams.

Disconnection and Insulation test and checking of disconnection in RS. co-ordinate, RSM and RS-L relay sets plugged in.

1. Use four cables type No. 1.

   Fit 80 pt. plug cable 1 to SR jack.

   Fit 80 pt. plug cable 2 to REG-L1, pt. 1, place 1.

   Fit 80 pt. plug cable 3 to SLM1-K place 2.

   Fit 80 pt. plug cable 4 to REG-L1 pt. 1 place 3.

   Fit wires 1-20 cable 1 to plug 2.

   Fit wires 41-60 cable 3 to plug 3.

   Fit wires 21-40 cable 2 to plug 3.

   Fit wires 41-60 cable 4 to plug 6.

   Hold 1MA1 in RSM-L operated and RE relay associated with Reg. being tested.

2. Programme cords.

B1 — F1	C1 — D1
B2 — F2	C2 — D2
B3 — F3	C3 — D3
D4 — F4	C4 — A6
B5 — F5	C5 — D5
— —	— —
— —	— —
— —	— —
B10—F10	C10—D10
B21—F11	C33—D11
B22—F12	C34—D12
B23—F13	C35—D13
B24—F14	C36—D14
B4 —LPJ 20	A15 tip —C31
	A15 ring —C32

3. From A15 connect TIP and RING to REG 1 pt. 1, 351 and 352 using an 80 pt. plug.
   From A12 conect TIP to TJ sleeve of circuit 1 being tested.

4. Operate K2, then K1A. When the relay chain has completed the insulation test, relay P6 operates putting earth on the tip of plugs D1-12 via the break spring on E1 12. Lamps 1-3, 5-10 and leak should light. If a contact fault has occurred on any of the wires through the RS co-ordinate, then that lamp will not light. The P21-40 relay associated with the faulty wire is short circuited from the earth put on by the E relay, but only if the fault produces a resistance of less than 60 ohms. Higher resistance contacts would not be detected. Release K2 and K1A.

5. Press K3 and K4 to call RSM (release K4). The vertical in RS holds to earth at K3. Operate K1 and K1A to test wires connected.

6. Release K3 to restore RS.

7. Replace wires 1-20 cable 1 with wires 41-60 cable 1, in plug 2. Repeat test.

8. Check SR's to accompanying table using paragraphs 4-6.

SR	REG
1 — 10	1 — 10
11 — 40	— 10

9. Shift cable 3 to SLM2 - K place 2 to test last SR.

NOTE I: Jack D4 is plugged to F4 so that continuous testing can take place and that the wires are kept in a close number rotation from the lamps to the SR's and REG's.

NOTE II: Special IDF Conns. required for RSL-REG-L.

APPENDIX 3. AUTOMATIC WIRING TESTER PROGRAMME.

SR-SLB-SLA Links

Cabling Diagrams.

Grouping Plan.

(1) Remove meter rack earth and unplug any LR/BR relay sets.

(2) Use 2 cables type 1.

   Plug 80 pt. jack cable 1 into SR connected to SLB1, vert 1.

   Plug 80 pt. jack cable 2 into SR connected to SLB2, vert 1.

   Plug wires 21-40 of cable 1 into plug 2 of tester.

   Plug wires 21-40 of cable 2 into plug 5 of tester.

(3) Programme cords

B1 — E1	C1 — F1
B2 — E2	C2 — F2
B3 — E3	C3 — F3
B4 — A6	C4 — A7
B5 — E4	C5 — F4

(4) Throw K3 to hold verticals.

(5) Set up SLB and SLA verticals according to the schedule specified for the particular size of exchange. A loop is now formed — Tester, SR, SLB, SLA, SLA, SLB, SR, Tester.

(6) Throw K1 and K1A to test for continuity and insulation. Release K3 to release verticals.

APPENDIX 3.

SR - SLB - SLA. A.W.T. TEST SCHEDULE.

FROM	SET 1								SET 2							TO	
Cable 1 wires in Plug 2	SR	SLA				SLB			SLA				SLB				Cable
	No.	R.	No.	V.	H.	No.	V.	H.	R.	No.	V.	H.	No.	V.	H.	SR	Wires in Plug 5
21-40	21	1	3	1	B1	9	1	B1	1	4	1	B1	10	1	B1	61	21-40
21-40	21	1	3	2	B1	9	1	B2	1	4	1	B2	10	1	B1	61	21-40
21-40	21	1	3	3	B1	9	1	B3	1	4	1	B3	10	1	B1	61	21-40
21-40	21	1	3	4	B1	9	1	B4	1	4	1	B4	10	1	B1	61	21-40
21-40	21	1	3	5	B1	9	1	B5	1	4	1	B5	10	1	B1	61	21-40
21-40	21	1	3	6	B1	9	1	B6	1	4	1	B6	10	1	B1	61	21-40
21-40	21	1	3	7	B1	9	1	B7	1	4	1	B7	10	1	B1	61	21-40
21-40	21	1	3	8	B1	9	1	B8	1	4	1	B8	10	1	B1	61	21-40
21-40	21	1	3	9	B1	9	1	B9	1	4	1	B9	10	1	B1	61	21-40
21-40	21	1	3	10	B1	9	1	B10	1	4	1	B10	10	1	B1	61	21-40
21-40	21	1	3	1	B1	9	1	B1	1	3	1	B1	10	1	B1	61	21-40
21-40	21	1	3	1	B2	9	2	B1	1	3	2	B1	10	1	B2	61	21-40
21-40	21	1	3	1	B3	9	2	B1	1	3	3	B1	10	1	B3	61	21-40
21-40	21	1	3	1	B4	9	2	B1	1	3	4	B1	10	1	B4	61	21-40
21-40	21	1	3	1	B5	9	2	B1	1	3	5	B1	10	1	B5	61	21-40
21-40	21	1	3	1	B6	9	2	B1	1	3	6	B1	10	1	B6	61	21-40
21-40	21	1	3	1	B7	9	2	B1	1	3	7	B1	10	1	B6	61	21-40
21-40	21	1	3	1	B8	9	2	B1	1	3	8	B1	10	1	B8	61	21-40
21-40	21	1	3	1	B9	9	2	B1	1	3	9	B1	10	1	B9	61	21-40
21-40	21	1	3	1	B10	9	2	B1	1	3	10	B1	10	1	B10	61	21-40
61-80	22	5	1	1	A1	9	2	A1	5	2	1	A1	10	2	A1	62	61-80
21-40	23	5	1	1	A1	9	3	A1	5	2	1	A1	10	3	A1	63	21-40
61-80	24	5	1	1	A1	9	4	A1	5	2	1	A1	10	4	A1	64	61-80
21-40	25	5	1	1	A1	9	5	A1	5	2	1	A1	10	5	A1	65	21-40
61-80	26	1	5	1	A1	11	1	A1	1	6	1	A1	14	1	B1	66	61-80
61-80	26	1	5	2	A1	11	1	A2	1	6	1	A2	14	1	B1	66	61-80
61-80	26	1	5	3	A1	11	1	A3	1	6	1	A3	14	1	B1	66	61-80
61-80	26	1	5	4	A1	11	1	A4	1	6	1	A4	14	1	B1	66	61-80
61-80	26	1	5	5	A1	11	1	A5	1	6	1	A5	14	1	B1	66	61-80
61-80	26	1	5	6	A1	11	1	A6	1	6	1	A6	14	1	B1	66	61-80

APPENDIX 4.

SL — OUTGOING MARKER SWITCHING TEST.

Bypath, Switch, Identification Testing Using Load Tester.

(1) Set up Load tester on subs numbers, shown in Table 1, for cycle 1.

(2) Block all SLA switches except those shown in Table 2 for Test 1.

(3) Block all but 1 SR available on each of the SLB's. Select these from the exchange interconnections.

(4) Set the Load Tester to "Identification", and make Identification calls for test 1 on the odd hundred test numbers.

(5) Watch the relays in the marker for faulty operation. If a 30 lamp lampset is available, use it to check the stage the marker reached at any fault which may occur.

(6) If a fault does occur on any line check that line alone to localise the fault to Bypath, Switch Vertical on Horizontal operation or identification.

(7) When the test is satisfactory, block out the SR used, and free another; repeat the test. Free further SR's individually until all SR's connected to the SLB have been checked.

TABLE 1: SUBS NUMBERS TABLE

CYCLE	NUMBERS									
1	111	211	311	411	511	611	711	811	911	011
2	122	222	322	422	522	622	722	822	922	022
3	133	233	333	433	533	633	733	833	933	033
4	144	244	344	444	544	644	744	844	944	044
5	155	255	355	455	555	655	755	855	955	055
6	166	266	366	466	566	666	766	866	966	066
7	177	277	377	477	577	677	777	877	977	077
8	188	288	388	488	588	688	788	888	988	088
9	199	299	399	499	599	699	799	899	999	099
10	100	200	300	400	500	600	700	800	900	000

TABLE 2: SWITCH BUSYING TABLE

TEST NUMBER	RACK 1	RACK 2	RACK 3	RACK 4	RACK 5	REMARKS
1, 2	1	1	1	1	1	Check SR's
3, 4	2	2	2	2	2	Check SR's
5, 6	3	3	3	3	3	
7, 8	4	4	4	4	4	
9, 10	5	5	6	6	6	
11, 12	6	6	5	5	5	Check SR's
13, 14	7	7	8	8	8	
15, 16	8	8	7	7	7	Check SR's
17, 18	9	9	10	10	10	
19, 20	10	10	9	9	9	

(8) Repeat the test for even hundred test numbers through one SR — Test 2.

(9) Block out SLA's used for Test 1, 2 and free those used for Test 3, 4. Repeat stages 3 to 8 above.

(10) Repeat (9) above for all other tests in the table. Check SR's completely only where indicated on the test table.

(11) Set up test numbers for cycle 2 and repeat (2) to (10) above, but omitting tests of SR's.

(12) Repeat for all other cycles nominated.

(13) The table is set out for an m=10 exchange. For smaller exchanges, all the test numbers in the test cycles are to be tested, but only the number of tests to check the SLA switches on each rack.

(14) Only one test call need be made on each test.

(15) When the testing as laid out above is complete, use the load tester from each subscriber to check the identification. One call only is necessary.

(16) Hand operating techniques may be useful for localising individual faults after detection as above.

APPENDIX 5.
IGV MARKER SWITCHING TESTS.

Programme of Tests.

1. General.

The purpose of these tests is to test the identification of an inlet, bypath selection, and operation of horizontals and verticals of all switches.

To accomplish this, the Automatic Exchange Tester and the Auxiliary Test Unit are required, and temporary strapping is necessary in the relay sets. (See Table 1).

The method of use of the equipment, and the straps required are specified below. It is not necessary in these tests to check every path through the stage, only the switching circuits are being tested. Refer to CE 14041 and CE 14077 for grouping plans.

2. Setting Up.

2.1 Attach the Auxiliary Test Unit to the Auto Exchange Tester.

2.2 Connect the 10 B lines, FUR jacks to the outlets as in Table 2, Column A. The d wires only are required from the IDF.

2.3 Plug TJI and TJ2 of 10 A lines into inlets 1-10 of GV racks. Use plug holder for the 20 plugs so that they can be shifted rapidly to the next 10 inlets.

2.4 Operate the GV SWG Test key and FUR key on Auxiliary Test Unit. This terminates the B lines in an FUR, and rearranges the digit selection switches so that digit A and B of a code can be set on switches D, E respectively of each line. Set the D switches on 1 — 0 for lines 1 — 10 respectively.

2.5 Strap up the relay sets in the marker according to the strapping in Table 1 from 1GV. Once strapped up the strappings can be transferred to other markers as required.

2.6 Set up the keys on the Auto Exchange Tester to the required test.

3. Operation.

3.1 Once set up, a series of 10 calls will be sequentially switched through the stage, each call being held until all 10 calls are completed when they will be released and a new series commenced. All H and V of GVA1, GVB1, have now been checked for current operation, bypath, and identification.

3.2 When the first 10 are completed, shift the inlet plugs to the next 10 inlets and repeat the test, GVA, B2 have now been checked.

3.3 Repeat the tests for inlets 1-30 of both racks of the group. GVA1-3 racks 1, 2 and GVB1-3 racks 1, 2 have now been checked.

3.4 Leaving IDF links on route 1-5, outlets 1-5, shift the remainder to routes 16-20, outlets 16-20. Shift inlet plugs to 31-40, rack 1. Refer to Table 2 Column B. Repeat Test. H and V of GVA4 is checked.

3.5 Shift inlets to 31-40 of rack 2 and repeat.

3.5 Shift 1DF links on routes 1-5, to outlets 11-15. Refer to Table 2 Column C. Repeat test from inlets 1-30 of each rack in turn.

3.6 All tests of H and V, bypath, and identification are now complete.

TABLE 1: TEMPORARY STRAPPING

1st DIGIT	KMR-PT 2			AN 1b			AN 1a		W						
	*	*		*	*		*	*		*	*		*	*	
	1st Digit Term	Term	Rev Sig.	1st Digit Term	Term	Rev Sig.	1st Digit Term Cont. Strip	P Coil Term	P Relay Nos.	P1-10 Cont. Term	Term	Route No.	P11-20 Cont. Term	Term	Size of Route
1	1A1	2c4	RV6	3a15	4hl	1A8	3a15	4e1	1-11-21	1a5	1a2	1	2a5	2g4	WIT20
2	1B1	2c4		3b15	4hl	1A8	3b15	4a1	1-11-25	1a9	1b2	2	2a9	2g4	WIT20
3	1c1	2c4		2c15	4hl	1A8	3c15	4j1	2-12-21	1b5	1c2	3	2b5	2g4	WIT20
4	1d1	2c4		3d15	4hl	1A8	3d15	4c2	2-12-25	1b9	1d2	4	2b9	2g4	WIT20
5	1e1	2c4		3e15	4hl	1A8	3e15	4a7	2-13-21	1c5	1e2	5	2c5	2g4	WIT20
6	1f1	2c4		3f15	4hl	1A8	3f15	4g2	2-18-25	1h9	1f3	16	2h9	2g4	WIT20
7	1g1	2c4		3g15	4hl	1A8	3g15	4e7	2-19-21	1j5	1g3	17	2j5	2g4	WIT20
8	1h1	2c4		3h15	4hl	1A8	3h15	4j7	2-19-25	1j9	1h3	18	2j9	2g4	WIT20
9	1j1	2c4		3j15	4hl	1A8	3j15	4c8	2-20-21	1k5	1j3	19	2k5	2g4	WIT20
0	1k1	2c4		3k15	4hl	1A8	3k15	4g8	2-20-25	1k9	1k3	20	2k9	2g4	WIT20

* indicates strappings.

TABLE 2: ROUTE AND OUTLET TESTING

Aux. Test Unit Line	Digit Set	A: A test lines to inlets 1-10, 11-20, 21-30 each rack		B: A Test lines to inlets 31-40 each rack		C: A test lines to inlets 1-10, 11-20, 21-30 each rack	
		Route	Outlet	Route	Outlet	Route	Outlet
B1	1	1	1	1	1	1	11
B2	2	2	2	2	2	2	12
B3	3	3	3	3	3	3	13
B4	4	4	4	4	4	4	14
B5	5	5	5	5	5	5	15
B6	6	16*	6	16	16	16	16
B7	7	17	7	17	17	17	17
B8	8	18	8	18	18	18	18
B9	9	19	9	19	19	19	19
B10	10	20	10	20	20	20	20

*Where Route 1-10 only are cabled to the IDF, substitute Route 6-10 for 16-20.

FOR 1GV SWITCHING TEST

KMR-PT 2				W			KMR-PT 2
	*	*			*	*	Congestion Signal A3 + B4
Q Relay Nos.	Q Relay Cont. Term	Term	Rev Sig.	A Relay Nos.	A Relay Cont. Term	Term	Congestion via BS 5
1-11	2a8	2j1	2A9	1-11	2a13	2j4	2b4+2h3
1-15	2a12	2j1	2A9	1-15	2a17	2j4	2b4+2h3
2-11	2b8	2j1	2A9	2-11	2b13	2j4	2b4+2h3
2-15	2b12	2j1	2A9	2-15	2b17	2j4	2b4+2h3
3-11	2c8	2j1	2A9	3-11	2c13	2j4	2b4+2h3
8-15	2h12	2j1	2A9	8-15	2h17	2j4	2b4+2h3
9-11	2j8	2j1	2A9	9-11	2j13	2j4	2b4+2h3
9-15	2j12	2j1	2A9	9-15	2j17	2j4	2b4+2h3
10-11	2k8	2j1	2A9	10-11	2k13	2j4	2b4+2h3
10-15	2k12	2j1	2A9	10-15	2k17	2j4	2b4+2h3

A TRANSISTORISED HALIDE GAS LEAK DETECTOR FOR CABLE GAS PRESSURE ALARM SYSTEMS

*B. M. BYRNE, B.E., M.I.E.E.**

GAS PRESSURISATION OF CABLES

In common with most telecommunication authorities the Australian Post Office commenced a planned pressurisation of underground metal sheathed telephone cables, shortly after the 1939-1945 War. A few special cables had indeed been pressurised well before this. The benefits to be obtained from this scheme were fully obvious to external plant engineers and staff, most of whom had personal experience of long wet hours, even days at a time, restoring service after heavy rain. It used indeed to be customary to check the availability of test instruments and staff when dark rain clouds began to appear.

Commencing with trunk and junction cables, in the late 1940's, and continuing for some 10 years, the practice continued, without much change, of sealing and fitting alarm equipment to these cables, finding and repairing hundreds of leaks, especially in joints which were either defective or had failed from their inability to withstand the undesigned-for pressure. Many faulty sections were located and replaced or repaired. In the case of corroded or split sheaths the repairs were often only temporarily effective.

By about 1957, in Queensland, all trunks and junctions and a few selected subscribers' cables carrying important circuits were under pressure in the metropolitan area and the greater part of the equivalent network was in like condition in the country. The apparently immense task of pressurising the main subscribers' cables was undertaken to spread further the benefits of this system. It was at this point that the inevitable change followed.

The make-up of an average exchange subscribers' network is built up over perhaps 40 years, with a growth depending on population habits, natural boundaries, cable types currently available, municipal practices and so on. The final result differs considerably from a long junction or trunk cable of uniform cross-section and hence uniform pneumatic resistance. Also, the quantity of compressed dry air contained is considerable. Again, the network radiates from one point, rather than exists as a continuous line.

The problems of leak location are multiplied many times. The practice of taking pressure readings along the five or six mile run of a uniform junction cable, giving a fairly regular pressure/distance graph is much less informative. Again, multiple leaks in the large network give rise to varied pressure gradients. The use of a foaming solution to find sleeve failure on joints is as good as it ever was, but there are a greater number of sleeves. For all these reasons, the manhours required per leak location rise steeply. It is not unusual for many gas leaks to involve several hundred manhours each in their location on a pressure gradient basis.

With this background, many telecommunication authorities have reappraised the position with rather different results.

One school of thought has been to ignore as many leaks as possible and continue to feed dry air from inexhaustible sources (i.e. machine desiccators) to the cable network. Only the large leaks are found, sufficient to extend pressure to all extremities of the network. Needless to say, this calls for an outstanding degree of reliability of the machine, particularly in wet areas, where air supply failure would be catastrophic.

Other authorities have not proceeded past the pressurisation of trunk and junction cables. This appears to be a negative attitude, although local factors, such as the use of deep, sealed cable tunnels or other types of construction unaffected by a light local rainfall, may make it acceptable to proceed no further in pressurisation.

Some authorities have proceeded with pressurisation of subscribers' cables on the original basis.

The A.P.O. practice, at this point, has varied somewhat from State to State, depending on local network layout, cable condition and other factors.

An appraisal of the general problems would be appropriate at this point. The question of: To find a leak, or not to find it (but feed it with dry gas) is not clear cut. A cable network may be in relatively good condition (say one leak per sheath mile) and many have been thus improved for example, by clearance of sheath perforations located over perhaps 10 years by incipient insulation loss fault practices, as has been the case in Queensland. Alternatively, perhaps 80% of an exchange main cable network is under five years old and has been jointed uniformly by jointers trained to sleeve cables with pressure-resisting sleeves and using pressure equipment made available in more recent years to ensure sound installations. The temptation, if it can be thus termed, is then strong to eradicate all leaks and start with a "tight" system.

If a cable network is old, complicated, difficult of access, has few spare ducts for replacement of faulty sections and these of doubtful alignment and condition, the temptation may be to try, in the first instance to feed it with machine dried air and clear sufficient leaks to obtain perhaps 2 p.s.i.g. at the distant ends. Also, replacement of odd cable sections complicates the succeeding relief cable duct occupancy. The capital cost of fitting pressure contactors on all extremities plus cable pairs to each at perhaps $60/mile is not particularly attractive, but is essential if a reasonably fully protective system is to be achieved.

LEAK LOCATION

Some indefinite point may be adopted between the two foregoing extremes. At this point, when this is either decided, or as can happen, decides itself on the availability of machines or staff, the position obtains whereby the cable is protected to some degree. In this condition, sooner or later, irrespective of the principles adopted, an air leak, beyond the capacities of machine, or sufficient to cause uncertainty about the security of the system, will occur. Even if the fully gas tight system has been adopted on all networks, as is the case in Queensland, some machines will generally be in use to avoid the supply problems and labour costs associated with cylinders for filling or topping-up the cable network. The prime consideration in this type of use of machines is to defer leak location until staff can conveniently deal with it. In any case, there remains the problem of finding air leaks.

Now the physical properties associated with gas leaks give rise to a number of possible means of location. Gas is compressible, unlike a liquid, but must obey the laws of flow (in particular, flow from high pressure points to low pressure areas). The flow may be either lamellar or turbulent depending, in the case of telephone cables, largely on local pressure differences. The former is the almost universal condition. Thus, any pressure or differential pressure indicating system will show the direction to a fault. Multiple faults, further confused by gas injection for safety reasons, from a local cylinder or from a distant machine, will complicate the overall pressure pattern. However, as time elapses and steady state conditions obtain, the leak(s) must be at the lowest pressure point(s).

This principle is so basic that it is occasionally overlooked when more sophisticated means of leak location are available. All leak locations may well then start with a pressure gauge. At least two series of pressure versus

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distance readings along the leaking cable must be made to determine both the severity of the gradient and hence the urgency of the fault and also whether steady state conditions exist or are still being approached.

At this stage, statistics prove that some 90% of leaks are in manholes or pits, usually in sleeves. Also, the gas loss is in a jet shaped stream, causing drawing in and entrapment of atmospheric air with local turbulence. This property can be used to form foam or bubbles with a variety of soaps and detergents. As this principle lends itself to the simple practice of swabbing or squirting soaps or detergents over the sleeves, it is too obvious a follow-up not to use. As might be expected, several different substances have been found effective by local trials in different States. It is probably significant though that most of these substances are similar, in that they are now liquid-detergent-based. Some extremely tenacious foaming agents have been used to pick up the fine high-speed air jets from hairline cracks, which do not cause much turbulence and ebullition. These foams are usually too persistent, with consequent subsequent confusion looking for a secondary leak, for general use.

Gas escaping from an orifice makes a spectrum of sounds ranging through the audible range, up to about 50 kc/s. A very pronounced peak in the range occurs due to molecular interaction in the 40-44 kc/s range, the exact peaks depending on pressure difference orifice dimensions and other related factors. This noise spectrum of a gas leak has given rise to the production and use of commercially produced portable transistor-powered "ultrasonic leak detectors". These instruments usually consist of a suitable pressure/voltage transducer, band pass filter and heterodyne frequency band converter and amplifier. The unit is highly directional and is useful in finding the odd very fine crack in a cable sheath which is missed by a foaming agent.

The remaining 10% or so of leaks — in sections and in directly buried cables-comprises the "hard" part. It was found that location of these leaks was taking 80% of the total man-hours spent on leak location! No doubt this fact has led to the early favouring of desiccator machines and continuous gas flow systems by some authorities.

Nevertheless, it was obvious in the late 1950's that existing methods to find leaks in buried or conduit sections, especially in complicated subscribers' networks, were not good enough.

By extending the properties of gas flow to extremes, using exceedingly sensitive manometers, aneroid type pressure gauges, jewelled-bearing precision gauges, precision flow meters and the like, the limit of useful sensitivity was reached to the point where gas temperature difference errors and other factors were limitations. Ammonia/sensitised paper gas flow indicators and other methods did not extend the flow location methods reliably. Very occasionally, due to limitations of flow and pressure measurements, sound cable sections were condemned. Needless to say, this engendered a feeling of caution in condemning a cable section, until it could be proved by sealing it off or other not particularly attractive (in cost) means.

DEVELOPMENT OF A HALIDE LEAK DETECTOR

Overseas, various tracer techniques had been tried, with varying degrees of success. It was fairly obvious that a foolproof tracer technique would be an enormous help in two ways. Firstly, that it could be applied early in the leak location operation, when the approximate location (to within-200 yards) was found fairly quickly by pressure methods; secondly, it would give the operator the confidence, lacking up to this time, that the leak was indicated absolutely, requiring no further extensive checking that the apparent location was indeed correct.

There are a number of requirements of a tracer technique. The tracer substance must be an inert (to cable materials) gas, relatively cheap and readily obtainable. It must be distinctive, and able to be positively identified in considerable dilution in air. It must be suitable for use by cable jointers, following reasonable instruction and training.

Possible tracer materials which were considered are shown in Table 1.

It will be noted that combustible and corrosive gases, which could be detected in small quantities are not included.

Of the gases considered, carbon dioxide appears attractive at first sight as it is not difficult to produce a sensitive thermal conductivity detector. But it is not distinctive enough among gases found underground to avoid spurious indications for telecommunication purposes. It has been used as a tracer in some industrial applications.

Nitrous oxide detectors have been used in a few applications notably in fluid carrying pipes but it has not been attractive on account of its cost and availability.

Radon is effective, but poses supply and handling problems, also it does not exist as a large volume tracer source, for deeply buried, slow leaks.

The halide compounds — in particular the widely available refrigerants — do appeal as a suitable substance. In particular Refrigerant 12 (Dichloro Difluoro Methane) often known popularly by the commercial name "Freon", is relatively cheap, safe and freely available. Further, the detectors developed for refrigeration system leakage are in well distributed use in that industry. It is, however, necessary to purge the halide gas from the cables, to avoid chemical breakdown to noxious acid substances at plumbing temperatures.

With this background, a number of refrigeration leak detectors were obtained in about 1958 for trial use in several States. This followed similar practice on the Continent. Using Refrigerant 12 the tracer technique proved most effective. However, almost immediately it became apparent that a great amount of flexibility was lost by the need to power the unit with about 0.2 kW of 240 volts single phase 50 cycle power. While this can be and was, supplied by a portable petrol-engine-driven alternator, it was not very satisfactory as the refrigeration type detector is somewhat frequency (of supply) sensitive and, to a lesser extent, voltage sensitive. In addition, long trailing 240 volt leads and the not inconsiderable weight and bulk of the equipment, greatly detracted from its usefulness.

An attempt was made, unsuccessfully, in 1960, to locate a supplier in Australia or overseas of a fully portable high gain transistorised unit, still utilising the same principles. Following this, it was decided to develop a suitable unit, aimed solely at telecommunication needs and usage.

The operational premises and components available with which to design this equipment were initially considered. A suitable halide sensitive element or ozotron was available as used in refrigeration type detectors. This element which is about the size and shape of a good-sized hen's egg is a three element open-ended tube. It has a 35 watt (5 volts 7 amps) heater, which indirectly heats a plat-

TABLE 1

Gas	Distinctive and Detectable Property in Small Concentration
Nitrous Oxide	Relatively opaque to infra-red light.
Radon	Radio-activity.
Carbon Dioxide	Thermal conductivity greatly different to air.
Halide Compounds (containing combined fluorine, chlorine, bromine or iodine).	Thermally ionisable. Also flame colouring.

inum cylinder about 2 cm. long and about 7 mm. diameter. A similar outer electrode is spaced about 0.5 mm. radially from the inner cylinder. In operation, the outer cylinder is polarised with about 270 volt D.C. from the inner cylinder (reverse to a vacuum tube). Under the temperature (800°C)/electrical gradient condition, portion of the halide-combined gas is ionised. Some thermionic current also flows with a net result that, in free air, with an air sample being drawn through it at about 2 inches/second, a standing current of between one and 15 microamps D.C. appears between the electrodes. This current, surprisingly, can be quite different for different new ozotrons, even from the same batch and with identical heater currents and air flow rates. No satisfactory explanation is available to account for this.

When a trace of halide gas is passed through the ozotron, the ionisation current rises — the increase often being quite different also between new and apparently identical tubes. For a concentration of about one part in a million of halide gas in air, the increase in current on an "average" ozotron would be between 0.1 and 0.01 microamp. With halide gas in high concentration (one part in 10) this rise in current may be as high as 100 microamp. In general, an increase in inner cylinder temperature increases both the standing current and also the sensitivity, but reduces element life and decreases stability.

The operator requires a visual signal for comparison and also an audible signal, proportional in some way to the gas concentration to draw his attention to the presence (and concentration change) of the gas as a search head is used as described below.

Thus a "front-end" of a halide detector based on transistors partly suggests itself. The requirement is for a D.C. amplifier of perhaps 70 dB gain up to an indicating meter, stable, but with a zero set facility to manually accommodate the initial standing current of the ozotron. The ozotron can be heated by a portable 30 lb. 64 AH. accumulator for about eight hours' use. Power to run the unit may be derived from this battery via a transistor inverter or internal dry batteries, the former being preferable.

A sound source, controlled also by the D.C. amplifier plus suitable amplifier stages and a loudspeaker follows as a reasonable "rear" end.

In 1961, construction of an experimental model was begun on a project basis. The detailed design of the prototype unit centred around two oscillators — in the 15-30 kc/s region —one manually adjustable to a frequency to match the second one which would be frequency controlled by the D.C. amplifier. This control, incidentally, was effected using voltage sensitive capacitors.

The field prototype using dry cells for the transistor stages and utilising germanium transistors, was completed in the Brisbane Postal Workshops later in 1961. Field trials were begun immediately. The instrument was successful, but was very sensitive to case temperature variations due to sunlight. Design improvements were then considered, the major change effected being that the circuit was adjusted to suit silicon transistors. About this time, a transistor inverter was developed to provide three ancillary voltages from the 6 volt input in lieu of dry cells. Among various suggestions offered, a significant one adopted about 24 months later was the replacement of the heterodyne sound system by a D.C. controlled unijunction oscillator which is simpler, cheaper and more stable.

The first fully effective field unit of the heterodyne type was then placed in service in February, 1962. After very gratifying results during the next few months, further instruments were manufactured and distributed to Queensland Country Divisions with fully satisfactory results. It was found, though, that informed verbal instruction to operators was essential. Further instruments were manufactured and distributed to other States.

The total number of instruments in use at the time of writing, together with those under manufacture, exceeds 100.

An estimated saving of some tens of thousands of manhours has been made by the use of these instruments in Queensland with the total number of leaks located in Queensland by this method being about 1,000.

The extent of the sensitivity and effectiveness of the system may be gauged from one of the more spectacular results. A slow leak — 0.1 standard cubic feet/hour — existed in a buried section of coaxial cable six feet deep. F12 gas was injected for a week, then a search made and a plot of concentration on the surface of the ground — taking an hour or so of search time in all. The leak was located to within six inches.

It has been found not uncommon for a fault patrol of two cable jointers to return from a halide detector-leak location before lunch, with the mission completed — either the conduit section indentified or the buried cable leak located, dug up and repaired.

ELECTRICAL FUNCTIONING

Fig. 1 shows the current design. It will be noticed that all semi-conductors are silicon type and, for the most part, of recent introduction.

The circuit functions as follows:— Free air is drawn through the ozotron by a 5,000 r.p.m. precision motor and centrifugal fan at about 2 inches/second. The ozotron and fan are set up in a search head, shaped somewhat like a bulky pistol, with a 4 core connecting flex. A potential of about 270V (D.C.) is supplied to the ozotron cylinders from an inverter stage (VT11). The inner cylinder is at a temperature of approximately 800° from the heat supplied to its heater by a 6 volt accumulator, taking some 10 minutes to attain full temperature at final steady state heater current of 7 amps.

The resultant thermionic and conducting current passing between the ozotron cylinders passes also through R27, R1 and R3. R1 is merely a protective resistor, R27 a metering resistor (see below) and R3 is the resistor across which a potential is set up to be fed to the first transistor VT1. The first part of a two section set zero potentiometer (RV3) allows manual adjustment of the input conditions to the base of the first stage, via the "earthy" end of R3.

When a trace of F12 gas is sampled, a small ionisation current passes between the ozotron cylinders in addition to the standing current. This raises the voltage on the base of VT1. VT1, VT2 and VT3 are direct coupled amplifiers (NPN, PNP, NPN) with supply voltage of +18 supplied also from the inverter stage VT11. The third stage is metered with an auxiliary zero set (RV1) control, ganged to the input potentiometer (RV3) between the second and third stages. This extends the range over which the meter and subsequent stages can be zeroed, without applying excessive voltage or current to the input stage (VT1). The meter is 0-50 uA shunted to 1 mA in the normal-operate position. The use of the more sensitive movement allows a check on the standing current of the element by switching it across R27 (mentioned above) to determine the cause of irregular operation, should (as happens) the ozotron become contaminated with conducting material.

VT4 is a current control stage, supplying power from the 18V supply to the unijunction oscillator R-C circuit (VT5, R8 and C2). The rate at which the unijunction can switch is thus controlled by the voltage appearing at the base of VT4.

As the unijunction switches from one mode to another, the pulse is inverted by VT6 and VT7 and re-injected to restore the original non-conducting mode of VT5 to await the next R-C controlled voltage rise to "fire" it again.

The pulses, being controlled in rate by the input signal change, are then picked off VT7 and converted by three direct coupled stages (VT8, 9, 10) to the approximate pulse impedance of a 3.5 ohm speaker. A simple volume control is fitted after the last stage.

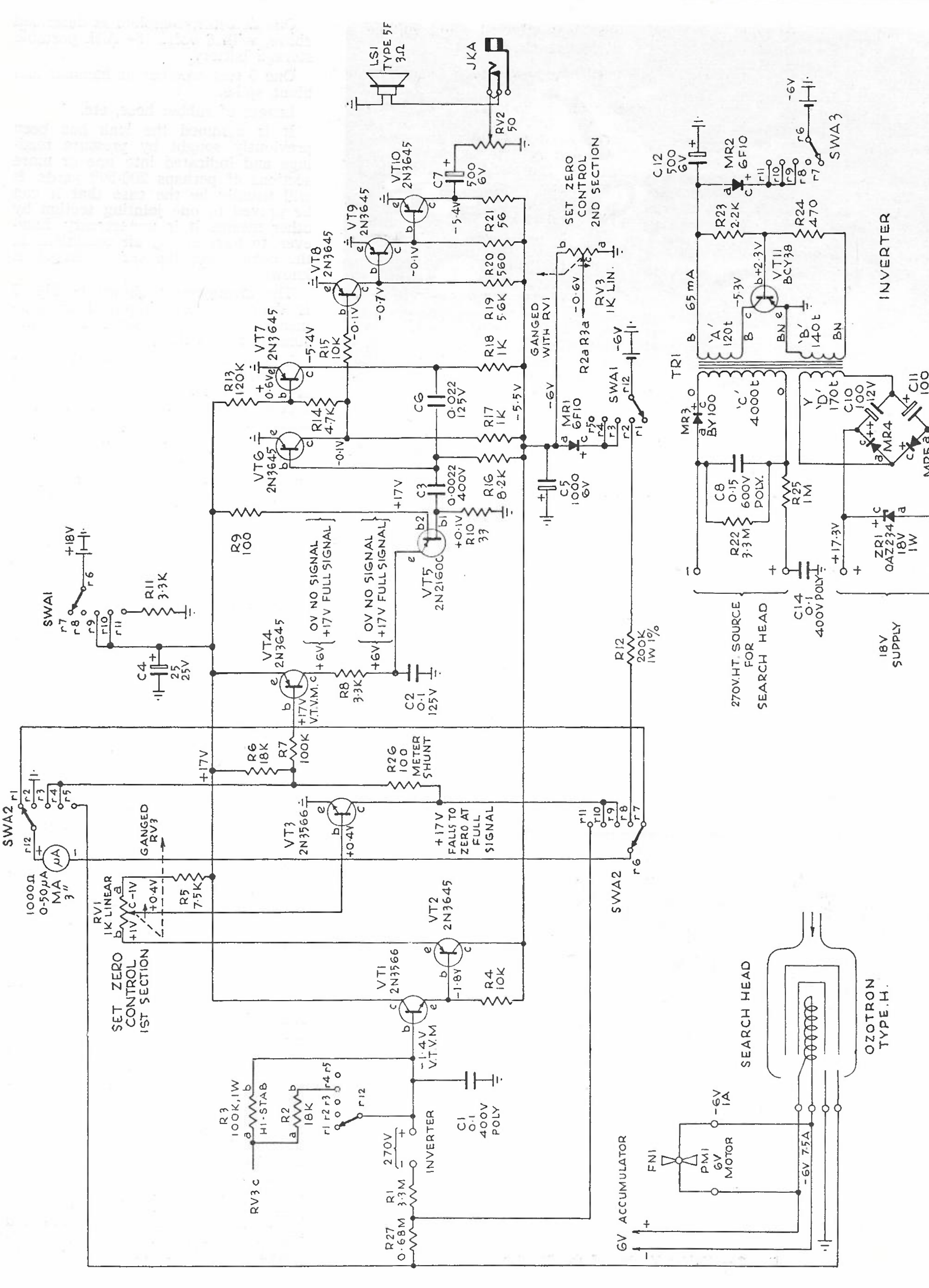

Fig. 1 — Simplified Schematic Circuit.

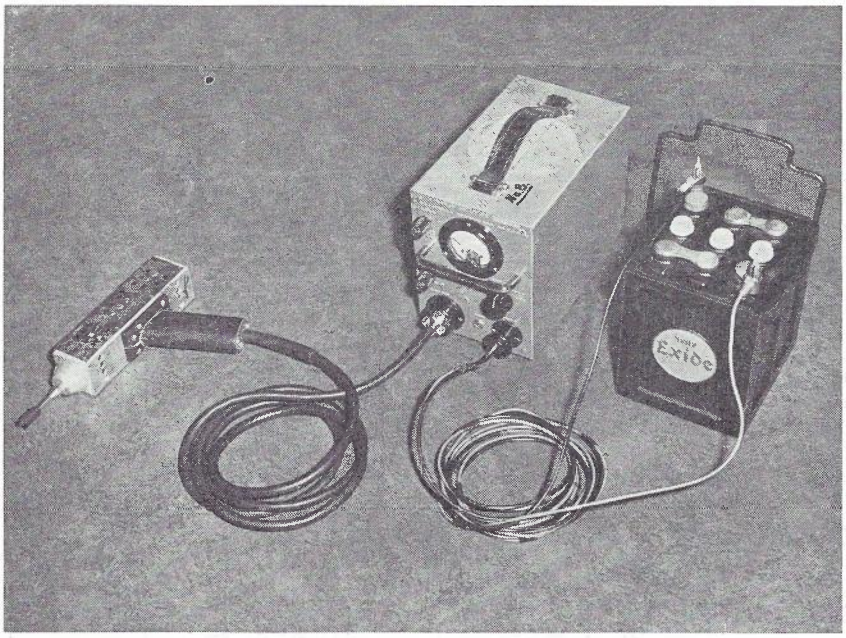

Fig. 2 — The Detector Complete with Accessories.

METHOD OF USE OF THE HALIDE GAS LEAK DETECTOR

Fig. 2 shows the detector complete with accessories as used in the field by a cable jointer. An alternative arrangement has been produced (Fig. 3) which is lighter and more convenient for some applications. This is fitted in a commercially available bakelite case. Fig. 4 shows an F12 (Dichloro Difluoro Methane) cylinder with automatic expansion valve and pressure gauge and hoses, set up for injection of halide tracer gas to a telecommunication cable.

Leak Location in Buried Cables

Equipment: One F12 cylinder of 20 lb. or 40 lb. capacity charged with F12 gas with appropriate regulator, hose and gas fittings.

Two air cylinders and regulators with appropriate hoses and gas fittings.

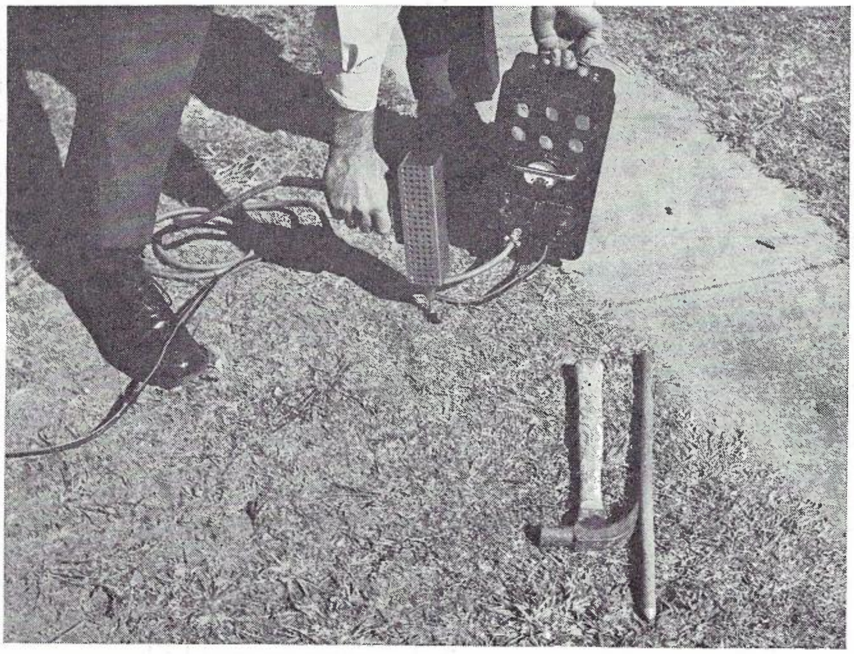

Fig. 3 — Lighter Version of the Detector.

One detector, complete as described above, with 6 volt x 64 A.H. portable storage battery.

One 5 feet crowbar or hammer and blunt spike.

Length of rubber hose, etc.

It is assumed the leak has been previously sought by pressure readings and indicated into one or more sections of perhaps 200-500 yards. It will usually be the case that it can be proved to one jointing section by other means. It is unnecessary, however, to have steady air conditions in the cable, once the section length is known.

The arrangement shown in Fig. 5 is then set up. (Simplified arrangements, suitable for some cases are sometimes possible.)

The air cylinders are used to maintain cable pressure temporarily and also to restrict the F12 flow to the section concerned. Otherwise there is difficulty in removing large quantities of F12 from the cable later.

Sufficient instructions for adjusting the detector are engraved on its front panel. These are (in the current production model)—

MARK II

First: Plug-in 6V battery and head. Turn switch to "on normal". Allow 15 minutes to warm up.

Second: Set sound and meter to near zero. (This control needs reasonably careful adjustment as it is easy to "overshoot" the setting.)

Third: Volume (normally full on).

The procedure is next thus:—

(i) Air regulator on cylinder A is opened to deliver about 3 p.s.i. higher pressure than the existing cable pressure.

(ii) Air hose D is opened well away from top of the manhole.

(iii) F12 cylinder regulator C is opened to deliver pressure just marginally less than the air cylinder A regulator setting.

(iv) Presence of F12 at the air hose D is sought with the detector. As soon as it has appeared —
   (a) Air hose D is closed off.
   (b) F12 cylinder is shut off.
   (c) Cylinder B regulator is opened to deliver air at same pressure as air cylinder A.

The cable section in which the leak exists in now filled with F12 and the search with the detector may now begin. The two air cylinders will normally hold the F12 gas pocket in the cable steady for a few hours. For a large leak about a quarter of an hour should be allowed for F12 gas to escape through the ground. For a tiny leak, about 24 hours should be allowed before searching, for each week it has taken to empty a 110 cubic foot air cylinder at constant pressure. The search is best preceded by a cable location to ensure the buried cable track is correctly followed, using an electronic pipe finder.

A crowbar or hammer and gad are used to make small holes, about four inches deep, about four feet apart, in the ground over the cable track. The detector head is then introduced into these holes. The F12 presence is registered on the detector. In most cases a plot of concentration may be made in the early stages before ground saturation with gas occurs to allow a precise location. It is essential that the holes be tested when freshly punched, as surface diffusion is rapid.

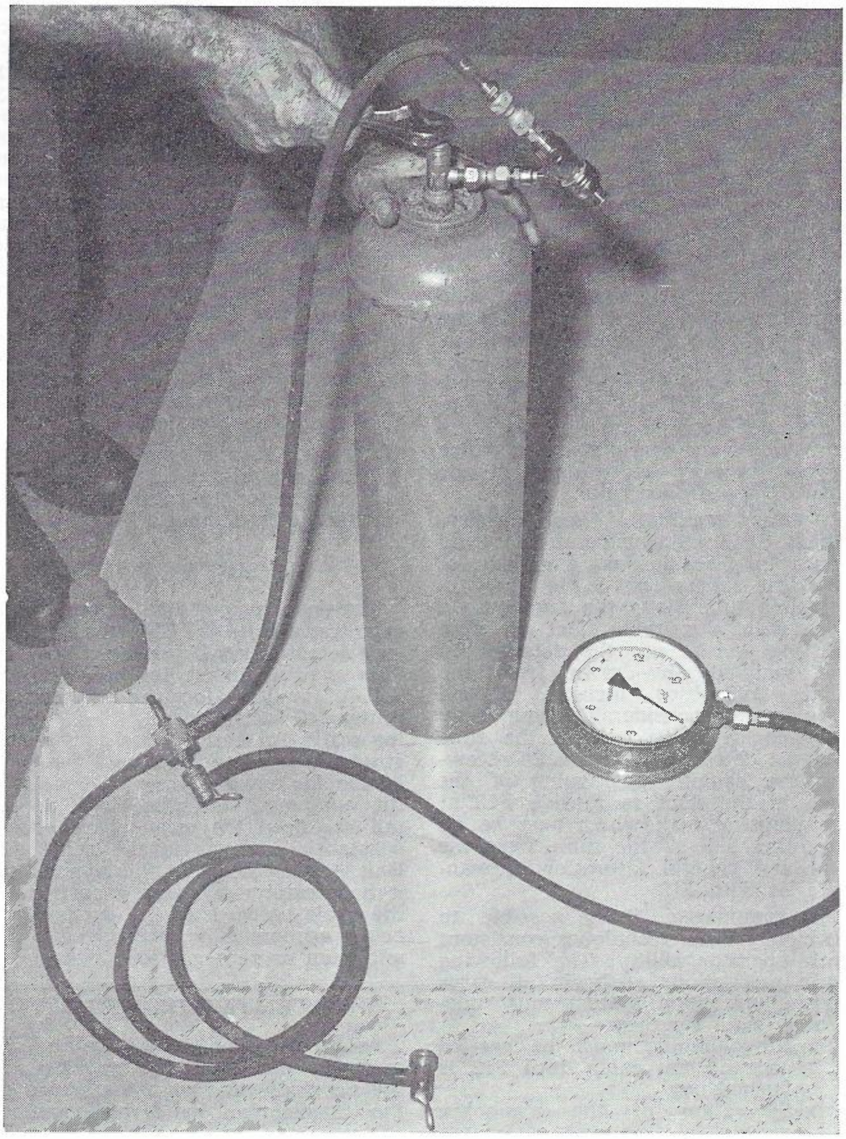

Fig. 4 — The F12 Cylinder and Attachments.

Armouring materials will sometimes take the gas stream away from the leak along the cable before releasing it. Likewise, newly reinstated trenching can have this effect. Plastic jacketing may have to be sectionalised.

A simplification of the preceding set-up is sometimes possible. Where a cable can be sealed off, or where there is no objection to filling a whole cable with F12, the air cylinder may be dispensed with. The main difficulty in this condition is that much more time and quantity of air is required to flush the cable before plumbing operations may be started to repair the leak. Flushing with air is necessary to avoid breakdown of F12 to acid gases at cable plumbing temperature.

Flushing the cable is carried out by driving air from the cylinder through the F12 gassed section until the detector shows no further F12 escaping. In the set-up depicted earlier, it is sufficient to drive from Cylinder A to the valve holder where Cylinder B was attached; but where an indefinite length of cable has been filled, it is usually necessary to flush the whole cable. Often small traces of F12 will remain, but these will not normally cause any difficulties.

It must be kept in mind that even in the controlled condition, F12 gas may have penetrated further along the cable than is needed for leak detection, particularly when the gas pocket is left in the cable for some time.

Leak Location in Conduit

Equipment: As for armoured cable, excluding a crowbar but including caulking compound. In conduit the prime function of F12 location is to determine which conduit section is leaking, rather than to locate the distance along the conduit. There are several ways by which an approximate leak location within a section may be attempted, but the benefits of the F12 location system are mainly in being able to positively distinguish which of several successive sections is leaking.

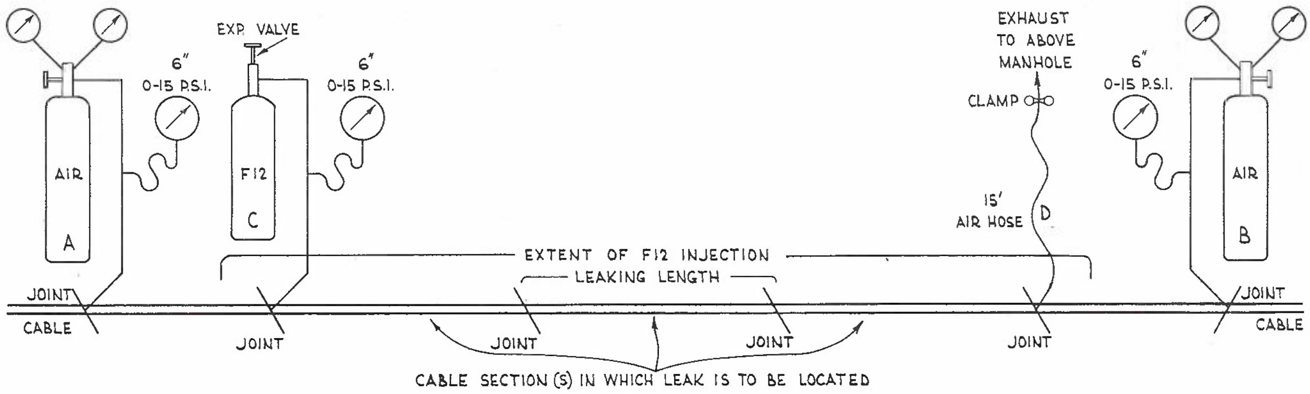

Fig. 5 — Typical Testing Arrangements.

The set-up of F12 and air cylinders is made as for the armoured cable arrangement. In addition, caulking compound is used to block all ducts each end of each suspected section. If there are three possible leaking sections in a six-way conduit run for example, this will mean six blocks of six ducts, which would require perhaps 28 lb. of compound. (About 90% of this may usually later be recovered.) The reason for blocking all conduits is to prevent by-pass leakage from the leaking section through cracked or imperfect pipe joints to other pipes. It is essential to keep F12 out of the manholes until the leak is proven, otherwise the gas remains in the manholes for some days and causes confusion of test results. It is not toxic, however, unless heated to about 500°F in which case the fumes are pungently unpleasant and easily recognisable before they become a hazard.

The leak location procedure involves the injection of F12 as for the buried cable arrangement described above. Air is caused to flow through the suspected sections of conduit by inserting an air hose, attached to a gas cylinder, and the flow rate adjusted by a regulator to about 50 s.c.f.h., the easiest method being by observation of the fall in pressure of the H.P. gauge on the cylinder regulator. This gauge records in effect, both cylinder pressure and contents in cubic feet (110 cubic feet for small cylinder and 220 cubic feet for large). The gas flow is allowed to escape through a finger hole poked in the compound at the other end of the section. The detector is used to sample the escaping air from this hole. If no indication is received in an hour (with 50 s.c.f.h. flowing) it may be assumed that either the conduit is blocked or the leak is elsewhere. After some experience in the technique it will be found convenient to test two consecutive conduit sections simultaneously — preferably driving air towards the common manhole for convenience in handling the detector.

When a duct is blocked it will usually be found that F12 escapes into the soil through imperfect pipe joints and a reasonably reliable test may be made on the ground above as for armoured cable. This aspect, however, may cause erroneous tests in an area adjacent to recent (2-3 days) previous tests.

An approximate location of the leak within the section is possible if conditions are favourable — moderate leak rate, relatively clear conduits and conduits in good condition. In general, the economics of the need for location should be weighed carefully before commencing, as it is not a precise location and may take several days or longer to clear F12 between tests from conduits. One method is to set up the system as for the initial test and adjust the air flow rate through the conduit before injecting F12 gas. F12 is then injected and the time taken for it to appear at the end of the conduit is recorded. Both cable and ducts (about 50 cubic feet air required) must then be cleared of F12 and the process is repeated, end for end. By taking into account the time for the F12 to flow along the duct and cable (usually fairly negligible compared to duct flow rate) an approximate distance proportion may be attained in the time of appearance ratio.

Another method of leak location, which at first consideration would appear precise, but has a number of practical difficulties, is to draw a sampling tube along the duct with a wire with a suitable duct air flow existing and to use the detector on the sampled air drawn from the tube. Difficulties include blocked tube intake, considerable time delay between sampling end of the tube and the detector sensing head receiving the sample, positioning of the tube in the duct to receive F12 at the point of leak which may be on the other side of the cable from the tube and general saturation of manhole air with F12.

To summarise, it is possible to develop various techniques consistent with operator ability. The following basic precautions apply in all cases and any location system must adequately cater for these:—

(i) No plumbing must be carried out on the cable until F12 is flushed out.

(ii) Saturation of the manholes, ground, clothes and equipment with F12 must be avoided. It makes the testing (subsequently) suspect or useless.

(iii) Contamination of the detector head with more F12 than necessary should be avoided. It should be allowed to recover in free air after it has received gas. Above all, it must not be tested with cigarette smoke or other of the gases or fumes which will cause it to register signal as this may greatly reduce the ozotron (sensitive element) life. This usually is only several hundred hours in any case. If a test system is necessary, two bottles half full of chlorbutol solution in water, one made 1/10,000 and one 1/100,000 will adequately indicate the sensitivity of the head. The vapour above the former solution should drive the meter to near full scale and the latter somewhere between 10% and full scale, depending on battery voltage, individual transistor gain of the units and ozotron sensitivity. These solutions will deteriorate if not kept sealed.

(iv) After testing, the head should be allowed to clear itself and the meter to return to normal before switching off.

SUMMARY

The development of a portable high gain transistorised halide (tracer) gas leak detector was commenced in 1961. This was intended for use in the A.P.O. for leak locating or section-proving of faulty cable by cable jointing staff. An entirely satisfactory instrument was developed and has been in use for several years. The use of this equipment, described in some detail has been the means of effecting substantial savings in the cable gas leak location field. In this application it has restored a marked portion of the cable network to the category of being economically maintained as a minimum or zero gas loss system.

ACKNOWLEDGMENTS

Acknowledgment is gratefully made to the assistance provided in the development and manufacture of the transistorised halide by a number of persons within the A.P.O. in Queensland and in particular to Mr. G. P. Kidd, Mr. P. J. Reed, the Brisbane Postal Workshops, and staff of the Queensland Cable Protection Division.

SOME RECENT DEVELOPMENTS IN ENGINEERING ADMINISTRATIVE PRACTICES AT BENDIGO, VICTORIA

*J. E. RUFFIN, A.M.I.E.Aust.**

INTRODUCTION

The past two years have seen the introduction of some striking changes in the administrative practices and the organisational arrangements in the Engineering District Works Division at Bendigo, Victoria. This article outlines the nature of these changes in the works programming, works scheduling and material supply areas, as well as in the form of the clerical organisation, developed as a result of O. & M. and limited Industrial Engineering studies between two and five years ago. The majority of the procedures described in this article have been, and still are, under trial. However, from experience to date, it is apparent that their introduction has given a substantial improvement in the degree of control over Divisional activity with a resultant increase in efficiency.

The present approach in the Engineering Division of the Australian Post Office is towards more fully integrated management systems embracing programming, scheduling and control as envisaged in current Industrial Engineering thought. This article does not include references to these applications, which will no doubt be described in future issues of the *Journal.*

Background

In the Australian Post Office, the basic organisational unit responsible for the technical direction and management of the public telecommunications network in country areas is the Country Engineering Division of which there are 53 throughout Australia. These divisions are essentially territorial in nature and hence the field operations cover a very wide range of activities, equipment and plant.

The purpose of a Country Engineering Division can be stated as the provision and maintenance of exchange, long line, radio and subscribers telephone equipment and associated external plant within its boundaries in accordance with sound business practices and Departmental policy. However, in many instances, the provision of exchange, long line and radio equipment would be of a relatively minor nature only as there exist State-wide specialist groups to perform the larger installations. A typical organisation chart for a Country Division is shown in Fig. 1.

A Divisional Engineer is responsible for the efficient management of each division and he is assisted in this task by several engineers and a clerical group. The District Engineers under the direction of the Divisional Engineer, have control of both Lines and Technical staff within a region of the Division. In rapidly growing areas the number of engineers may be more than that shown. Alternatively an engineer may take charge of all large installation works leaving the District Engineers responsible for maintenance and small works. The field staff are likewise organised on an area basis with groups of linemen and groups of technicians stationed at suitable locations throughout the Division.

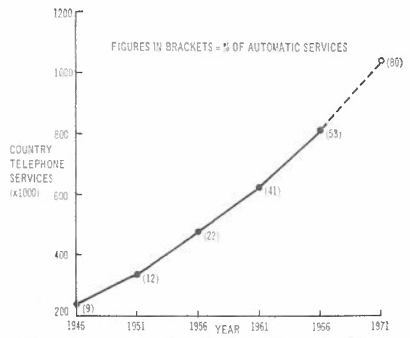

Fig. 2 — Growth of Country Telephone Services.

Fig. 2 shows the growth of country telephone service in recent years and that expected by 1971. A notable component of this growth is the extension of automatic services, which is expected to reach 80% by 1971. The number of country Trunk Line channels is also expected to increase significantly, from approximately 36,600 in 1966 to 48,200 in 1969. In 1960 the number of channels was only 18,000. It is estimated that by 1969 there will be 257 country S.T.D. routes, and some 441,000 subscribers will have access to them, three times the present figure. Furthermore other authorities such as those responsible for rural electrification are also expanding and this again adds to the task of providing service and improving telephone facilities.

Because of these changing circumstances there has been a marked increase in the Divisional workload and its complexity. A greater engineering and administrative effort is required which in turn imposes additional strain on the resources of the Division. From the foregoing figures, it is evident that this increased effort will need to continue or even expand further. Therefore it appears opportune to examine the current organisation and procedures employed in country Divisional offices to determine their efficiency under these new conditions and to alter them as appropriate.

In the Bendigo Division certain key administrative activities have been the subject of two separate, but inter-related, exercises. The first investigation was confined to the development of a more appropriate clerical organisation, while the second was mainly devoted to the examination of administrative arrangements in Country Engineering Divisions. These two investigations are here outlined under the headings of "The Office Organisation" and "Review of Administrative Arrangements".

THE OFFICE ORGANISATION

The Integrated Clerical Organisation.

The clerical organisation at Bendigo prior to the trial period was as shown in Fig. 3. This type of organisation is typical of other Country Divisions today although the numbers of staff may differ. A poor feature is the existence of two distinct groups, one being responsible to the Divisional Engineer and the other being responsible to a Costing Officer remotely situated in the Metropolitan area. The functions of the administrative and clerical group are to:—

* Mr. Ruffin is Engineer Class 3, Bendigo, Victoria.

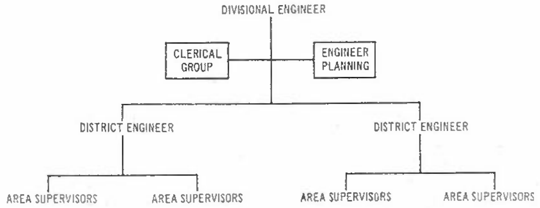

Fig. 1 — Organization of a Typical Country Division.

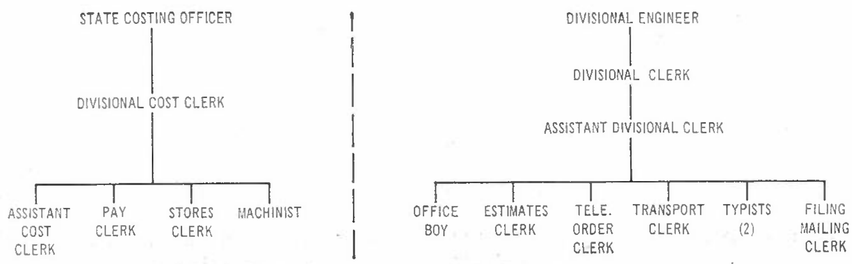

Fig. 3 — Previous Segregated Clerical Organization.

(i) record the operations of the Division to meet the requirements of both engineering management and Government financial control;
(ii) provide clerical services to the professional staff and the field staff; and
(iii) administer staff and industrial relations.

This type of Divisional organisation has remained relatively stable for the past twenty years, as have many clerical and administrative procedures associated with it, despite the major technological developments, improved field methods and policy changes which have affected country areas in recent years.

The work of the administrative group covers staff and transport records, processing of works estimates, filing, typing and other clerical services. The Divisional clerk in charge also renders personal assistance to the Divisional Engineer on non-technical functions and oversights the discipline of the Divisional costing group.

The Divisional costing group carries out duties relating to the costing of materials, labor and incidentals, the preparation of wages and allowances, audit control of stores and tool kits as well as providing financial data for the Departmental accounting system.

In early 1964, analysts from the Victorian Personnel Branch and W. D. Scott and Co., Management Consultants undertook a "Clerical Methods and Measurements Programme Survey" in the Divisional Engineer's office at Dandenong Victoria. This survey, which covered the work of both the administrative and costing groups, had as its aims:—

(i) the elimination of unnecessary clerical work, improved efficiency and reduced costs;
(ii) the provision of data to determine the number of clerical employees needed for the current work load and varying work loads;
(iii) the provision of job descriptions to facilitate employee training; and
(iv) the provision of control data for management.

The analysts used the Mulligan Manuals of Standard Time Data to determine the times taken for individual clerical operations. These standards represent the times that a fully trained clerk working at a normal level of skill and speed would take to do each job and they include a 16 2/3% allowance for personal needs, etc. Allowances were also made by the analysts for interruption and query time. In cases where application of the Mulligan Standard was not warranted, estimated times were struck with the agreement of those responsible for the operation.

One important result of this study was the recommendation that the two clerical groups be integrated and placed under a senior officer to be called the Divisional Administrative Officer. The organisation of this integrated unit is shown in Fig. 4 and it will be noted that the clerical staff was reduced from 14 to 10.

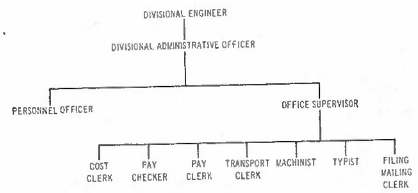

Fig. 4 — Initial Integrated Clerical Organization.

Apart from reduced staff and improved methods, further advantages claimed by the analysts for the integrated unit included:—

(i) the most effective utilisation of clerical resources;
(ii) maximum flexibility in the clerical structure allowing local interchange of duties and more avenues of promotion;
(iii) co-ordinated office services e.g. typing, machining, filing, etc., available as common facilities to all;
(iv) the clerical organisation represented to field employees and others as one unit; and
(v) the organisation is self-relieving for recreation leave, illness or other short-term absences.

In the latter part of 1964 the recommended organisation was introduced on trial in the Bendigo Division. This trial was oversighted by a Steering Committee consisting of representatives of the Methods, Personnel and Engineering sections at Headquarters and the Victorian Personnel and Engineering Administration Branches.

With the reduction in staff numbers and the re-arrangement of some duties it was necessary to re-train staff accordingly but even after allowing a reasonable familiarization period it became increasingly obvious that a staff of 10 was not adequate for efficient operation and the clerical service gradually deteriorated. There were several reasons for this deterioration. Firstly the new procedures recommended by the analysts envisaged the abolition of checks on tool kits and store bin tally cards. However, to satisfy Treasury and Audit requirements these checks could not be terminated. Secondly, the duties of the Divisional Administrative Officer, Office Supervisor and Personnel Officer were not measured by the Mulligan Technique as the higher type of clerical work undertaken by these officers is of a less routine nature. Furthermore, the volume of staff and industrial work generated by the Divisional staff of about 300 proved to be too great for one Personnel Officer. Accordingly the position was reviewed, the staff increased to 12 and a further re-organisation of activities undertaken.

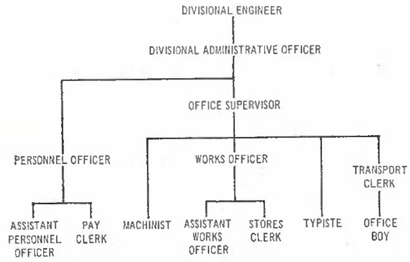

Fig. 5 — Final Integrated Clerical Organization.

Fig. 5 shows the final organisation adopted at Bendigo in which the pay and allowance functions were incorporated into a more appropriate Personnel unit, whilst the activities relating to the production, costing and finalisation of work authorities were further consolidated.

This final clerical grouping has proved most efficient. Not only is the number of staff employed less than that prior to the commencement of the trial, but the new system frees at the highest level, a clerical officer (Divisional Administrative Officer) with completely new functions designed to assist the engineers and to partake actively as a member of the Divisional management team. The expected advantages of the integrated structure have been fully realised and many procedures simplified. The centralisation of staff and pay functions has enabled a better service to be given to the field staff with less margin for error. The centralisation of Works Authority activities has considerably reduced the amount of paper circulating in the office and has reduced the number of copies of authorities etc., needed. A further important advantage is that the duties of the Divisional Administrative Officer relating to programming and productivity, which will be described in detail later, are also greatly facilitated. As a result of these favorable findings the organisation was approved by the Steering Committee extended to all other Country and it is intended that it be eventually Divisions. However, because of the variations of work load and field staff which occur between Divisions, the staff will not necessarily number 12 as at Bendigo.

The Divisional Administrative Officer

Another important recommendation of the analysts following their Dandenong survey was for the introduction of a Divisional Administrative Officer (D.A.O.). They envisaged that this officer would have little routine day-to-day duties, apart from generally oversighting the work of the clerical group. He would thus be free to handle special investigations and to assist the Divisional Engineer in the preparation, analysis and interpretation of control data necessary for the efficient operation of the Division. The concept of the senior clerical officer taking a more active part in the affairs of the Division and providing greater assistance to the professional staff was not altogether a new one. In 1961 a joint Public Service Board—Post Office Organisation and Methods report on Engineering Administrative practices had recommended that the Divisional Clerk in the segregated organisation (Fig. 3) should have greater responsibilities particularly in relation to material supply and works programming. Appropriate items were subsequently included in the duty statements for the position of Divisional Clerk.

In practice however, these new functions were not realised to any degree, even though the increasing complexity and expansion of the work-load made the concept of a more active clerical officer a most attractive one to engineers endeavouring to rid themselves of unwanted routine and administrative work. The ideal condition envisaged in the 1961 O & M Report was when the Divisional Management Team as a whole comprised:—

(i) engineers who shed the maximum amount of clerical and semi-technical work; and
(ii) clerks who had both the experience and the initiative to perform the work.

Nevertheless the report appeared to limit the Divisional Clerk to a more active supporting role rather than one of direct involvement in the managerial process.

The concepts contained in the 1961 report were not realised because of:—

(i) the very general terms of the recommendations;
(ii) the non-existance of formal procedures for works programming and review; and
(iii) the pressure of day-to-day routine work which prevented the individual development of the new activities.

As already stated the role expected of the D.A.O. was a more involved one than that of the Divisional Clerk, yet strangely enough both duty statements were practically identical. Consequently during the reorganisation at Bendigo it was found that the D.A.O. was not free as expected. There was still too much time devoted to routine work and the assistance to the Engineers was not forthcoming. To coincide with the introduction of the organisation shown in Fig. 5, the duties of the D.A.O. were completely reassessed to allow full development of the position along the lines originally intended with the result that the D.A.O. is now a new position, bearing little relationship to that of the former Divisional Clerk. In fact the office supervisor in the new organisation would now be the nearest equivalent to the Divisional Clerk in the previous organisation.

The duties of the D.A.O. may be summarised as:—

(i) non-professional executive and administrative assistance in the management of the Division, particularly in the areas of:—
   (a) works programming and review;
   (b) assessment of resources and supply;
   (c) evaluation of achievement and productivity;
(ii) administrative advice and assistance to the Divisional Engineer;
(iii) performance of special investigations, analysis and interpretation of control data as required.

Procedures have been developed at Bendigo to facilitate the work of the D.A.O. enabling this officer to become a valuable acquisition to the Divisional management team. In particular, there has been improved co-ordination of the Divisional resources and at the same time engineers have been relieved of much clerical and administrative effort.

Although it is most desirable for each engineer to divest himself of all possible routine administrative work to allow sufficient time for his more important professional duties, he must nevertheless retain and perform certain administrative tasks if he is to adequately discharge his duty and maintain his authority over, and the respect of, his staff. It is considered that the inclusion of the D.A.O. in the Divisional management team enables the ideal situation to be more readily attained. The procedures evolved at Bendigo emphasise the valuable assistance and co-ordinating functions which the D.A.O. can perform. Control is still with the Divisional Engineer and his Engineers and of course must remain there.

A factor which could reduce the usefulness of the D.A.O. to the engineer is that higher administration mav tend to add other extraneous duties as these arise. Unless such moves are resisted, the nature of the duties could easily alter so that the primary role of assistance is eventually lost.

The 1961 O & M Report recognised the lack of suitable training given to clerks in the Engineering Division and recommended the introduction of a formal training course for future Divisional Clerks. It was pointed out that Divisional Clerks were required to have knowledge and experience to varying degrees in the following aspects of work:—

(i) types of equipment and plant used in field;
(ii) material supply;
(iii) personnel administration;
(iv) financial management;
(v) human relations;
(vi) motor vehicle maintenance;
(vii) accommodation.

It was further considered that such training was necessary even if the scope of clerical functions were not widened. The 1964 report on Dandenong also stressed the need for suitable training of the D.A.O.

To date no formal training courses exist but further consideration of their introduction would appear to be timely. If the position of D.A.O. is to be successful, careful consideration must be given both to the choice of occupant and his training. If this is not done there will be no real or lasting benefits, but there will be a very real danger that the position will degenerate into a means of promotion for Divisional Clerks who, either due to a lack of training or initiative may not be suitable in any way for the increased responsibilities and requirements of the D.A.O. position.

REVIEW OF ADMINISTRATIVE ARRANGEMENTS

The second investigation was aimed at the development of suitable techniques to enable the clerical organisation and the D.A.O., in particular, to become more actively involved in the non-technical administration of the Division. This exercise was controlled by a working party comprising, the then Divisional Clerk, Bendigo, and two representatives of the Headquarters Administration and was co-ordinated with the changed administrative arrangements already described.

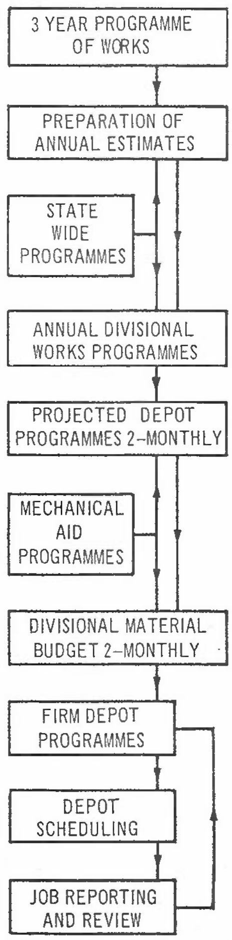

Fig. 6 — Country Engineering Division Management Plan.

As a result, a set of control documentation was developed which formed the basis for the preparation of the several works programmes and allied activities for which a country Division is responsible. It also included provision for co-ordination with all external plant programmes likely to affect the Division's operations, and these procedures have now been published as a Country Administrative Manual. Fig 6 shows the scheme of operation. In particular the investigation disclosed a real need for improved programming of minor works on a depot basis.

Depot Works Programming

Unlike the long term three-yearly and annual works programmes which have well established procedures for their production, the programming of works for periods of shorter duration is not subject to any formal method. Consequently short term works programming is not performed in all country Divisions even though if properly prepared and utilised, such programmes can be a valuable aid to management.

For external plant activities a short term Depot works programme has been used in Victoria for many years. With the lack of a formal procedure the method of production has varied between Divisions and even within the Division itself with resultant varying degrees of effectiveness. Depot Works Programming can be defined as the allotment of separate jobs to each depot in priority order after taking into account all relevant factors for the period concerned. A typical programme is shown in Fig. 7.

The advantages of factual Depot Works Programming include:—

(i) control and review of minor works. These constitute substantially more than half of a Country Division's activities and without such programming they are virtually uncontrolled;

(ii) improved forward ordering of material. The supply of materials should be commensurate with the labor capacity to consume them so that capital is not idle in the form of excess or unwanted stores. Conversely when material is in short supply, labor and plant can be diverted to other work with a minimum loss of effort;

(iii) improved efficiency in the field. The resources of labor, material, mechanical aids, transport and tools are co-ordinated. In turn, these resources are further co-ordinated with local priorities of work and the policies and programmes which originate from outside the Division; and

(iv) improved utilisation of resources. The Area supervisors are relieved of much organisational work and therefore have greater time to devote to effectively supervise the efficient performance of the work.

The assessment of works priorities for each depot is the concern of the appropriate District Engineer. The effectiveness of programming depends upon the state of the engineer's forward planning and the time he has available for, or is prepared to devote to, the preparation of each programme. With the pressures of day-to-day work it is probably true that most engineers seldom found time for the clerical effort needed in the preparation and documentation of the necessary data to the desired detail or in a uniform manner. Effectiveness further depends upon the degree of liaison maintained with the other District Engineers of the Division. If an engineer produces depot programmes quite unrelated to the needs of the other engineers, then field supervisors may well have to vie amongst themselves for the material or mechanical aids vital to the successful completion of the several programmes.

Unco-ordinated work can also result in staff at one depot being engaged on relatively unproductive maintenance work whilst at another depot the demand for service can not be met. When either type of situation

STATION: KERANG. **PARTY: ALL STAFF.**

MANHOURS AVAILABLE:—

1. LOCAL	**2172**	(A. J. Brown, 12 Days R/L).
2. OUTSIDE ASSISTANCE	**672**	Bendigo Aerial Party 22.8.66 to 28.9.66
TOTAL:	**2844**	3rd Aug. 1966 to 28th Sep. 1966.

Authority No. (In Priority Order).	BRIEF DESCRIPTION	Man-Hours Jtg.	Man-Hours Other	Remarks
84847	Murrabit-Benjeroop: Channel Crossing.		224	
84845	Murrabit-Benjeroop Tk: Erect 2/24 poles = Lay 10/10 cable	63	90	Ditchwitch.
84801	Gonn Crossing: Lay 54/10 P.J.	27	173	V.30 Ditcher.
84843	Kerang: Lay ducts Vaughan St. between Albert & Boundary Sts.		164	Back Actor.
	Pole Renewals		1123	Bendigo. Party Assist.
	Subs Faults	320	350	
	Trunk Faults		60	
	Telephone Orders	200	50	
		610	2234	
	Tentative October — November.			
84843	Kerang: Lay ducts Vaughan St. between Albert & Boundary Sts.		308	Completion.
69459	Benjeroop-Murrabit Tk: Provide slavey cable, dismantle idle plant		494	
84849	Lake Meran: 54/20 cable, Potters Lane.	32	132	Mole Plough.
69871	Dingwall: Eliminate P.P.E. subs	56	172	Mole Plough.

Fig. 7 — Typical Depot Works Programme.

arises, the area supervisor concerned is thrown into confusion with the result that the programme may be ignored completely and the wishes of higher management may not be carried out. It is, of course, the responsibility of the Divisional Engineer to ensure that the programmes are realistic, co-ordinated, and in accordance with overall policy.

With the re-organised clerical staffing at Bendigo the opportunity was taken to develop formal procedures for Depot Works Programming which would result in more accurate and therefore more effective programming. The D.A.O. is now responsible for the co-ordination of all preparatory information necessary to assemble a programme thus relieving the engineers of considerable clerical effort. Once the programmes are finalised and approved by the Divisional Engineer it is the duty of the D.A.O. to arrange for their production and distribution. The centralisation of all relevant information with the D.A.O. facilitates liaison between engineers, and improves the effectiveness of the Divisional Engineer's overall control. This is a significant contribution, as previously the Divisional Engineer had to develop and maintain his own rough control documentation.

A period of four months is covered by each Depot Works Programme. For the first two-month period the firm programme is listed for the use of the Field Foreman. This is based on the priorities of works and the availability of resources. The second two-month period consists of a tentative list of work and is used by the Divisional Storekeeper for the advance ordering of material. The two-monthly period is the minimum necessary to ensure that sufficient time is available for the supply of material and auxiliary services. The four-monthly programme is prepared every two months with the previous tentative programme forming the basis of the next firm programme. Following receipt of the tentative programme the Divisional Storekeeper prepares the material budget, which is processed and the material supplied to the Division prior to the preparation of the next firm programme. In this way the firm programme is prepared with the full knowledge of the material that is available.

For the preparation of each Depot Programme, the D.A.O. assembles the following data which covers the firm two-monthly period only:—

(i) the depot labor capacity. This is prepared in the Personnel group;

(ii) a list of proposed or projected works. This is available from the Works group who now keep a separate register of works for each depot in lieu of a Divisional Register;

(iii) a list of works partly completed and details of manhours needed for their completion. This information is supplied by the area Line Inspector;

(iv) details of field conditions and other factors which could influence the type of work to be undertaken. This is also obtained from the Line Inspector although it may already be known to the Engineer; and

(v) the material supply position from the Divisional Storekeeper.

With the presentation of the information in this form the engineer can, by discussion with the D.A.O. indicate the work he requires to be carried out during the period and its priority order. This is done after taking into consideration the conditions throughout the Division and not just his particular District. In this manner the preparation of a realistic co-ordinated programme of works is obtained with a minimum of effort on the part of the engineer.

At Bendigo it has been found beneficial to consider depot labor capacity in the primary categories of jointing, digging and aerial work. At depots with a small staff the amount of specialist manpower e.g. cable jointers is strictly limited and outside assistance from another depot is often required. Analysis of labor capacity in this manner facilitates recognition of the type of assistance required and its duration. For the larger depots such as Bendigo itself where up to 70 men are employed and defined groups are continuously engaged on work relative to these primary categories, the break-up enables separate simple works programmes to be prepared for each group. The number of manhours in each category for each particular work is assessed when the work estimate is prepared. The use of broad units for estimating readily allows this to be done and the result is considered well worthwhile.

Table 1 shows the percentage of lines staff manhours lost each month due to unforeseen leave in the Bendigo Division. Altogether this totals some 12,000 manhours per year and the influence of this on the works programme is taken into account, as is the average time required for fault clearance per month per depot.

TABLE 1:
PERCENTAGE OF TOTAL TIME LOST DUE TO UNFORESEEN LEAVE
BENDIGO LINES STAFF

Month	%
JANUARY	1.5
FEBRUARY	3.0
MARCH	3.0
APRIL	2.0
MAY	3.0
JUNE	4.5
JULY	5.0
AUGUST	4.5
SEPTEMBER	4.0
OCTOBER	4.0
NOVEMBER	3.0
DECEMBER	2.0

With careful preparation it has been found possible to prepare Depot Works Programmes with a firm expectation of 90 — 95% fulfilment. It is realised that there will be alterations or interruptions to the programme due to bad weather or unforeseen urgent works. However, accurate programming assists in reducing the effect of these alterations to a minimum as resources necessary to meet the emergency are considered on a Divisional basis and not necessarily restricted to those at the particular depot concerned. Works of low priority simply become deferred and appear as a carry over in the next programming period.

Experience at Bendigo indicates that most Field Supervisors appreciate receiving detailed factual programmes as they are relieved of organisational work and therefore have more time to devote to their supervision function. The supervision of works is of course as important as programming in reaching acceptable standards of efficiency. An important further advantage of accurate detailed programming is that it allows a comparison of the predicted programme to be more readily made with actual depot achievement for the period, thus giving a measure of the efficiency of management in the field.

The comparison can be made, quite simply, by the D.A.O. from an analysis of the way in which the depot labor resources were utilised during the programme period and comparing this analysis with the predicted manhour consumption as per the programme. This can be further facilitated if costing months are used for programming instead of calendar months. Should an unreasonable number of manhours remain unexplained after all known factors are brought to account, the engineer is in a position to investigate and to pinpoint the inefficiency. Subsequent reviews will enable an assessment to be made of the corrective action taken.

At the present time field supervisors, Line Foremen and Line Inspectors are not given formal training in either management or supervision even though their task is becoming a more and more complex one. Furthermore it is doubtful whether many field supervisors really regard themselves as a part of the management team as in the main they are geographically isolated from the Divisional headquarters. The individual abilities of supervisors vary extensively and this system of comparing programme with performance can highlight weaknesses in "foremanship" and allow on-the-job training to be given.

Factual Works Programmes also facilitate accurate estimating. The comparison between performance and prediction not only checks the accuracy of the estimator but it also permits the opportunity for the development and review of local estimating rates.

Depot Scheduling

In May 1964, the Engineering Studies Division, Victoria, published a report (No. 65/1) entitled District Works Depot Management. This report covered a number of key activities relating to the organisation of work in line depots and resulted from investigations and trials conducted in the Melbourne Metropolitan area. The report recommended the introduction of the following:—

(i) a revised method of depot works programming;
(ii) a system for scheduling work at Line Depots;
(iii) a new labor reporting system;
(iv) a revised stores issue procedure; and
(v) a procedure to assess labor productivity in the field.

These recommendations had been successfully introduced into the Metropolitan area and it was desired to ascertain whether they would be suitable for the country situation and, if so, to what extent modifications would be needed. As Bendigo had been committed to the trials previously described, it was logical to extend their scope to include recommendations of the Engineering Studies Division as they likewise affected costing, programming and productivity.

Scheduling is the advance allocation of the programmed work in detail at the depot. Each particular job is assigned to a specific party or member of the staff with a definite starting time being indicated. In the proposed system a scheduling period of two weeks was chosen to reduce the number of jobs being handled at any one time. The Engineering Studies Report further recommended the use of a scheduling board to provide a convenient visual display of the distribution and the timing of jobs ahead. The type of board used in the Bendigo Division was the same as that recommended in the report and is shown in Fig. 8. The third week is provided to allow for carry over from the second week.

The field units are listed on the left hand side of the board. A label showing authority, location and estimated manhours is prepared for each category of the job and placed on the board under the day the work is to commence and opposite the appropriate field unit. The manhours shown divided by the daily hours worked by the field unit gives a guide to the starting time of the following job. Different colored labels are used for different types of work, whilst special tags can be used to remind the Foreman of liaison required with other authorities, etc. Color codes can also be used against the field units to indicate special qualifications such as motor driver or compressor operator, etc.

Initially the use of scheduling boards was limited to two at the Bendigo Depot where there were Depot Linemen to assist each Foreman in the preparation and up-dating of the boards and where the large number of field units indicated that scheduling could be used to advantage. From the introduction of scheduling boards several benefits soon became apparent. These were:—

(i) the display enabled the Foremen to approach their work in a more orderly fashion. Knowing that a job is about to commence the Foreman can arrange pre-inspection, decide whether any special instructions are needed, check material, liaise with other authorities etc., so that when the team goes to the job everything is in order and no delays occur;

(ii) the board made it possible to display and schedule each new telephone installation individually im-

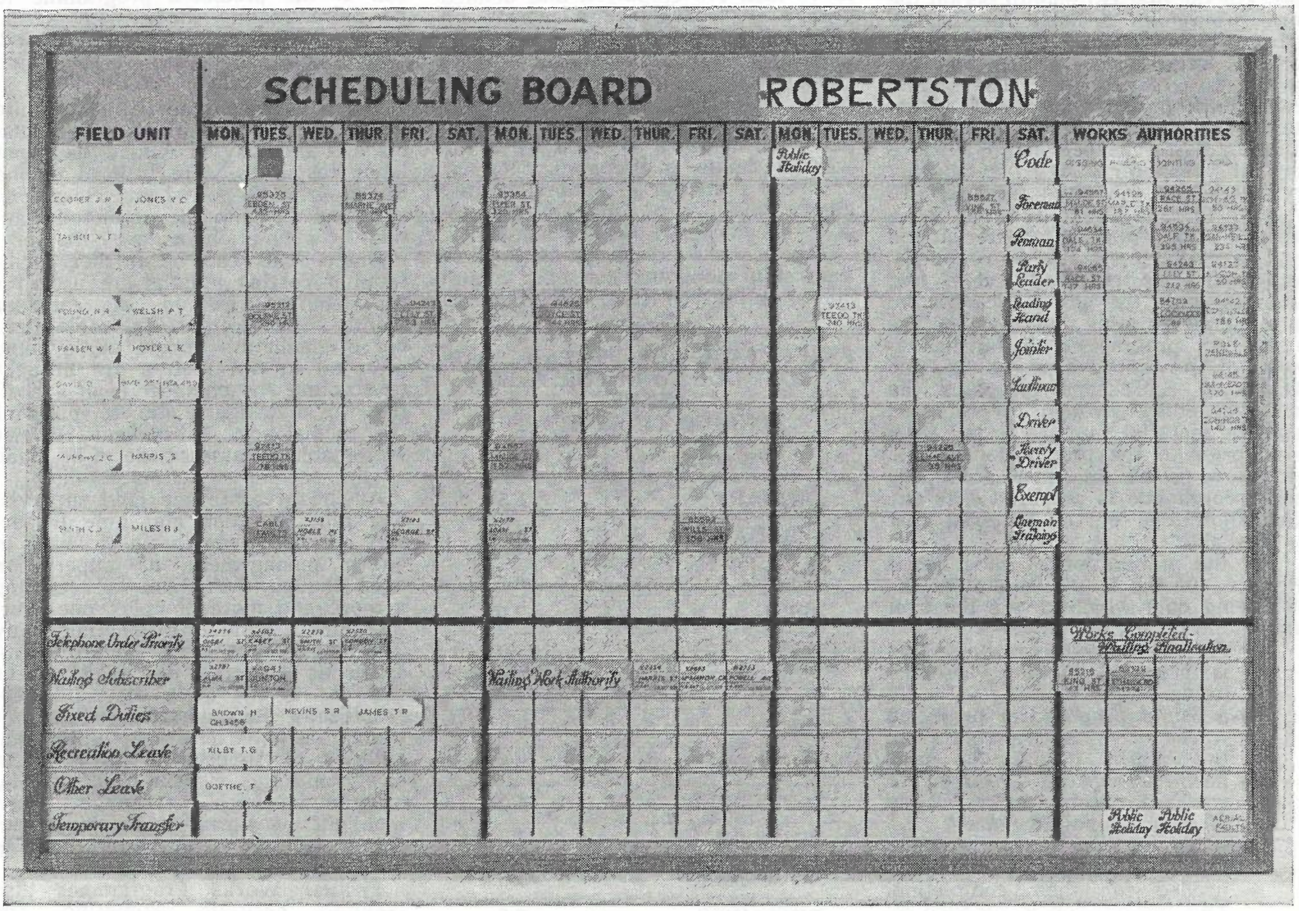

Fig. 8 — Depot Scheduling Board.

mediately upon receipt of the order in the depot. Furthermore this was done in a systematic manner with due regard to the priority of each as well as economy of installation. In the past there was always the tendency to handle telephone orders in a "top of the heap" fashion as they can only be indicated in bulk on the depot works programme;

(iii) the boards proved of considerable assistance to the District Engineer and the Line Inspector. With all current jobs prominently displayed as well as the location of the various parties, the District Engineer and the Line Inspector are materially assisted in their duties of overall control;

(iv) the field staff appreciated the facility of being able to know their daily movements in advance.

In view of these benefits the use of Scheduling boards was subsequently extended to smaller depots with a total staff of 10 or more and this move also proved successful. It has been found that the Foremen appreciate the facilities of the board as an aid to organisation and memory. Each Foreman developed its use in some fashion to suit the requirements of his particular area. It is significant that the boards have not fallen into disuse at any depot even though at the smaller ones their preparation must be done by the Foreman without the aid of a Depot Lineman. It is apparent that the small amount of time taken in their preparation and updating is considered well worthwhile due to the savings that can be made in other directions.

Group Working Reports

Possibly the most significant procedural alteration recommended in the Engineering Studies Report was the introduction of new types of working reports for the recording of labor usage. Information regarding manhour costs is, of course, an essential requirement of audit which stipulates that all expenditure must be brought to account. This recording also provides statistics from which labor rates can be derived for use in estimating and budgeting procedures. Ideally a labor costing system should also enable the production of performance statistics for the measurement and control of the efficiency of the engineering effort.

The existing system of preparing labor cost returns based on fortnightly working reports prepared by each individual workman was found to have two main defects. Firstly accuracy was suspect. Although the working reports should be prepared daily, this is impossible to enforce in practice, and consequently many entries are made in bulk. Due to the time lapse and the ease with which the entries can be manipulated, little regard need be paid to accuracy except for those statements pertaining to pay and allowances. Secondly, the processing of a great volume of individual reports is most time consuming and laborious with inherent time delays and thus the checking of irregularities, inefficiencies etc., becomes a difficult task.

A new procedure for the recording of manhours was therefore developed to overcome these defects and to facilitate the production of accurate performance statistics for management purposes. At Bendigo these procedures were further developed to allow their application in the country situation and are now used by the lines staff throughout the Division. A summary of the procedure is as follows:—

(i) each field unit is given two small exercise books, one red and the other blue for easy recognition. The books are used on alternate days to record in an informal fashion details of the work performed during the day. Plant accounts, authority numbers etc., as well as details of irregular allowance claims are entered. The books are forwarded to the Line Foreman at the end of each working day;

(ii) the foreman or the Depot Lineman prepares in detail from the primary data in the field books the following returns:—

(a) a pay and allowance statement;
(b) a work statement sheet 1;
(c) a work statement sheet 2.

Each of the above is a group return covering all staff at the depot for a period of two weeks. All entries are made daily as is a cross balance of total hours between the pay and allowance statement and the sum of both work statements.

The pay and allowance statement records all the information required for the payment of wages and allowances to each staff member. It is prepared in duplicate. One copy is filed in the depot for reference whilst the remaining one is forwarded fortnightly to the Divisional office. This copy is processed in the pay subsection and used by the staff clerk as a leave journal. The Works Statements are prepared in duplicate and one copy of each is forwarded to the Divisional office fortnightly. The Works Statement Sheet 1 records in total for the station, the daily manhour details of non-specific charges, e.g. telephone orders, faults, supervision etc., whilst Sheet 2 records details of daily manhours debited to specific works authorities. The works statements are processed in the Divisional office to fulfil the costing and audit requirement. Information for the production of productivity analysis, etc., is also available and can be assembled with little effort.

The advantages of such a system are:—

(i) higher degree of accuracy particularly in manhours due to the daily recording checking and reconciliation. However, as referred to later, plant accounts still can be incorrect due to the ignorance of staff in these matters;

(ii) up-to-date costing information concerning each job is readily obtainable. The District Engineer and the Line Inspector are now in a position to be informed regarding possible over or under expenditure whilst the job is still current and to take appropriate action. Previously, such knowledge was not generally available for some months following the completion of the job;

(iii) the field staff are relieved of clerical effort. The system of daily recording, checking and reconciliation takes less effort than the earlier fortnightly assembly and scrutiny of individual reports. Similarly the use of the book is less time consuming. Field staff are therefore favorably disposed to group working reports;

(iv) there is less effort required to handle group working reports in the Divisional office. The amount of paper is reduced and certain functions essential when handling individual reports are eliminated; and

(v) source documents are available for the compilation of productivity statistics as already stated.

Productivity Analyses

Although productivity can be very simply defined as the efficiency with which goods and services are produced it is, nevertheless, an extremely complex concept to measure. In Country Divisions the factors influencing production are numerous and at the present time techniques to enable all of them to be measured do not exist. However, of the three factors i.e. men, materials and equipment, that play a major role in the production process, it is the human element which often has the greatest influence. This is particularly true in field work where there is a high percentage of manual content. For these reasons the Bendigo trials, like those undertaken by the Engineering Studies Division, concentrated on the "Productivity of Labor" i.e. the number of manhours consumed for each unit produced. Use was made of the information conveniently presented by means of the group working reports to effect improvements in work organisation and methods.

One form of depot labor productivity analysis using the completed Works Programmes has already been described. However, for works programming purposes the activities of connecting new telephone services and fault clearance on existing services can only appear on the programme as an estimated total number of hours based on past performance (See Fig. 7.). Yet for the Bendigo Division the manhours utilised for these two activities represent approximately one third of the total labor capacity. Furthermore, this work directly affects the customer and it is mainly by the performance of the field staff in these two areas that the telephone service as a whole is judged. Therefore, there is a need for critical examination of fault clearance and telephone order organisation so that the engineer can define accept-

LABOUR ANALYSIS	STATION BENDIGO	P.E. 14-9-66	TOTAL HOURS* 4164

NEW WORKS HRS. 1388 % TOTAL 33%	Hours	% Total
TELEPHONE ORDERS	635	15
WORK AUTHORITIES	753	18

OTHER HRS. 1074 % TOTAL 26%	Hours	% Total
LEAVE	508	12
SUPERVISION	387	9
MISCELLANEOUS	179	5

MAINTENANCE HRS. 1702 % TOTAL 41%	UNDERGROUND		AERIAL	
	Hours	% Total	Hours	% Total
FAULTS	481	12	200	5
WORK AUTHORITIES	279	5	256	6
TELEPHONE ORDERS	190	5	10	–
UNSPECIFIED	266	6	80	2
TOTAL	1156	28	546	13

TELEPHONE ORDER ANALYSIS	Hours	% Total	No. Orders	Hrs/Order
A. UNDERGROUND EXTN.	216	5	2	108
B. DIRECT LEAD	196	5	16	12
C. AERIAL EXTN.	98	2·5	8	12
D. DROP WIRE	100	2·5	13	8
E. TEST ONLY	1	–	5	0·2
F. LINEMAN INSTLR (X.I.P.)	24	–	11	2
TOTAL	635	15	55	11·5

FAULT ANALYSIS	Hours	% Total	No. Faults	Hrs/Flt
A. SUBS UNDERGROUND	481	12	75	6·5
B. TRUNK UNDERGROUND	–	–	–	–
C. SUBS AERIAL	102	2·5	36	3
D. TRUNKS AERIAL	98	2·5	5	20
TOTAL	681	17	116	6

* THIS TOTAL MUST AGREE WITH TOTAL MANHOURS ON THE PAY AND ALLOWANCES STATEMENT

Fig. 9 — Depot Labour Analysis.

able standards and have them achieved.

Fig. 9 depicts a depot labor analysis report developed at Bendigo. It can be prepared fortnightly i.e. per costing period, in the works section directly from the group working reports with the Depot Foreman providing the statistics of telephone connections and faults. The analysis gives the percentage of labor employed on new works and maintenance and further subdivides these sections for telephone orders and faults as shown. The use of this type of analysis is restricted to the larger depots which employ staff regularly on these activities and where the greatest gains can be made, e.g. at the Bendigo Depot it has been found possible by simple re-arrangements of staff and transport to reduce the time taken for direct lead telephone orders from an excessive 18 hours to a more reasonable figure of 10-12 hours.

The use of the depot labor analysis also has other advantages. Firstly it provides a check on whether the staff are recording their time to the correct account and this check can be performed by the D.A.O. In the Bendigo Division the results in this area have been somewhat surprising. Experienced linemen of many years standing, including some supervisors, have been found lacking in a basic appreciation of plant accounts and their purpose. In one period some 500 manhours of maintenance work was incorrectly debited to new work because of this lack of knowledge. The first use of the depot labor analysis was therefore to assist the training of field staff in the use of correct plant accounts. A second advantage of the analysis is that it highlights the percentage of labor consumed on unspecified maintenance. This type of work is inherently inefficient and is often of doubtful value. The analysis provides a means of control and ensures that unspecified work is kept to an absolute minimum. In the example of Fig. 9 the 6% of unspecified maintenance represents essential work on cables under gas pressure.

If required, the basic information of the analysis sheets can be extracted monthly on to a yearly summary sheet for each depot. This is of assistance is displaying long-term trends or other significant changes which in turn may require a complete re-assessment of the depot organisation. Group Working Reports can also be readily used to extract further productivity information concerning the installation rate of plant, e.g. that for underground cable laid directly in the ground could be expressed in yards/manhour. These figures can be extracted either for each depot or for certain Works Authorities as specified by the engineer or both. This line of approach has not been fully pursued at Bendigo but it would appear to have value, particularly following the introduction of a new machine or some other circumstance from which a significant change of rate could reasonably be expected.

Centralisation of Stores

A further re-organisation undertaken in the Bendigo Division was the centralisation of all stores activities. Although internal plant operations are not subject to programming procedures, the demand for material can, nevertheless, be closely anticipated by an analysis of past issues and other known factors. Prior to the trial period there were eleven technicians' stores operating throughout the Division. Material was ordered directly from the Melbourne main store by each Supervising Technician individually as and when the need arose.

The first stage of this particular trial was to close each of these technicians' stores and to transfer the provisioning of internal plant items to the Divisional Store in Bendigo. In lieu of a store each Supervising Technician was given an approved maintenance holding individually assessed for his station and based on past needs. This holding is approved by the Divisional Engineer and is quite flexible. It is replenished by means of a simple budgeting procedure on the Divisional Store. Material for other works is sent by the Divisional Store on a scheduled delivery basis and is debited directly to the job. Divisional Store supplies of internal plant material are obtained by means of a two-monthly budget on the main store which is prepared by the Divisional Storekeeper and designed to maintain the Divisional Store stocks at a predetermined figure.

This revised system proved successful from its inception despite the fact that the Supervising Technicians needed time to become familiar with the new routine. Immediate benefits were:—

(i) a 25% reduction in the volume of stores vouchers and hence less work in the Divisional office and the field.

(ii) the value of internal plant stores holding was reduced from \$22,000 to \$10,000. The average maintenance holding at each station is only \$100;

(iii) elimination of costly stores inspection procedures; and

(iv) the reduced clerical effort both in the field and the office lessened the risk of documentary errors.

Because of these advantages, the fourteen line depot stores in the Division were also closed and similar arrangements made. However, in this case the value of the average maintenance holding is \$160. With the introduction of effective works programming the closure of out-posted lines stores is a logical step. As already described the material budget is based on the tentative works programme and phased one month ahead of the firm one. The firm programme is thus prepared with full knowledge of the material available. Hence it should be possible for outlying depots to order material from the Divisional Store, have it delivered at a suitable time and debited directly to the job. To book the material through a local store under these conditions only results in a significant amount of unnecessary paper work.

With the closure of all stores the Divisional Storekeeper became responsible for the complete storage, distribution and accounting arrangements. This centralisation gives a better overall control of material usage and allows a greater flexibility of distribution. In the Bendigo Division, 21 of the 25 stores closed were within a 60-mile radius of the Bendigo Divisional Store. However, the area of a Division of the geographic location of depots should not make any fundamental difference to the principle of centralisation. In some Divisions due to the distances involved more than one store may be necessary. In Divisions with a different workload it may be preferable to maintain two separate centralised stores, one for external and the other for internal plant. The procedures devised are flexible enough to cater for these changed circumstances although some operational and control advantages could be lost. The transfer of these stores activities to the Divisional Storekeeper at Bendigo did not result in the need for additional store staff. One Lineman, however, was replaced by a Clerical Assistant to facilitate the accounting side of the stores activities. The need for the store staff to handle technical equipment gave rise to very few problems and it took only a short time for them to become fully conversant with the main items in common use.

TABLE 2: COMPARISON OF STORES OPERATING COSTS

Financial Year	Stores Handling Manhours	Stock Value at 30th June \$	Value of Material Used in Year \$
1963/64	18,000	73,200	305,000
1965/66	11,000	68,600	442,000

The trial arrangements have proved acceptable to field staff, Divisional Store staff and Office staff alike, providing better service with less effort and at a considerably reduced cost (see Table 2.).

In Table 2, 1963/64 represents the last full year of operation under the old system while 1965/66 covers the first year of operation for the centralised store. The total manhours devoted to stores activities has decreased significantly whilst the value of material used has increased. Approximately 20% of the 1965/66 material value represents rises in prices during the interim period. However, after taking these rises into account there is still a 17% increase in material turnover and a 25% reduction in stock holdings.

CONCLUSION

The changes introduced in the Bendigo Division during the past two years have overcome many of the defects of the former methods and in each case the objectives of the trials were met. However it is appreciated that each Country Division is not identical and that there are often basic differences, even between neighboring Divisions. Hence to gain the maximum benefits from the introduction of these new methods it may well be necessary for local management to make certain modifications. The procedures have been designed to be flexible and should meet this requirement.

It is also considered that not all of these new procedures should be made mandatory. In particular, those relating to productivity are designed as an aid to local management and, as such, the conditions governing their use should rest with the controlling Divisional Engineer. There is ample scope for further development in this area and this should be allowed to continue.

It was found that the need to satisfy the legal requirements of Governmental control in the financial and staffing areas often dominated procedures, etc., whilst detrimental side-effects on the field staff, their operations and the Divisional management, tended to become secondary in nature. Unless severe, these effects were tolerated. Also Governmental control does make it difficult to effect rapid changes in staff and methods even though these may become necessary due to technical developments and the ever-increasing workload. These factors can readily make management the slave to an outmoded system which gives little managerial assistance in return; whereas, for efficiency, the system should be an aid to management.

The need for this governmental control is recognised and of course it must remain in some form or another. Nevertheless the experiments at Bendigo indicate that it is possible to utilise some of the legal requirements to give valuable assistance to the needs of local management and at the same time achieve a desirable increase in operational efficiency. From the foregoing it will be realised that, so far, only a limited number of inter-related aspects of the work of a Country Division have been subject to investigation but on the basis of the results already obtained, there appear to be many other activities which would benefit from a similar approach.

ACKNOWLEDGMENTS

The very nature of the Bendigo Trials involved the co-operation of a great number of people from various sections of the Australian Post Office, both at a Victorian and at a Headquarters level, in addition to the Steering Committee Members responsible for the overall control. However special mention must be made of the Bendigo staff both in the office and in the field. Their co-operation, enthusiasm and patience at all times ensured the success of the efforts. In fact many suggestions made by the Bendigo staff have been incorporated into the final procedures. Special mention must also be made of Mr. R. D. McRae, D.A.O. Bendigo, who had the unenviable task of taking the raw ideas and developing them into workable procedures, acceptable to all concerned.

CALL RECORD PRINTING EQUIPMENT

R. W. CUPIT, A.M.I.E.Aust. and V. HOLLIDAY***

INTRODUCTION

The Call Record Printing equipment is designed for connection to individual subscribers' line equipment e.g. Uniselector — Final Selector in step equipment, and LR/BR in crossbar equipment. It produces a printed record (Fig. 1) showing the digits

		WEEK	DAY	HR.	MIN.	SEC.	
–		08	4	10	59	22	LOOP O/G CALL
I		08	4	10	59	35	SWITCH HOOK FLICK
6		08	4	10	59	40	
2		08	4	10	59	41	
9		08	4	10	59	43	DIALLED PULSES
4		08	4	10	59	44	
2		08	4	10	59	45	
9		08	4	10	59	48	
	M	08	4	11	00	00	METER PULSE
–		08	4	11	00	11	END O/G CALL
I/C		08	4	11	00	44	I/C CALL RECVD.
		08	4	11	00	53	RING TRIP.
I/C		08	4	11	01	00	END OF CALL
I/C		08	4	11	01	15	LOOP O/G CALL
I/C		08	4	11	01	26	END OF UNANSWERED CALL
–		08	4	11	02	24	LOOP O/G CALL
0		08	4	11	02	27	
1		08	4	11	02	28	DIALLED PULSES
1		08	4	11	02	30	
–		08	4	11	02	41	END NON METERED CALL
		08	4	11	03	09	LOOP O/G CALL
0		08	4	11	03	12	
2		08	4	11	03	14	
2		08	4	11	03	15	DIALLED PULSES
0		08	4	11	03	17	
7		08	4	11	03	18	
4		08	4	11	03	21	
	M	08	4	11	03	25	
	M	08	4	11	03	31	STD. METER PULSES
	M	08	4	11	03	35	
	M	08	4	11	03	39	
–		08	4	11	03	41	END OF CALL

Fig. 1 — Typical Tape Record.

dialled and the number of meter pulses recorded on outgoing calls and the seizure and ring trip on incoming calls. The printed record includes the time to the nearest second that each event occurs.

Information is made available without loss of secrecy in conversation and this equipment has proved of great assistance in cases of disputed accounts since call details can be compared with subscriber records or recollections. In this way the subscriber is made aware of the calling habits on his lines which may differ from his preconceived ideas.

A number of miscellaneous uses have been found for the equipment as a whole, and the line bridging element has been incorporated into the Centralised Service Assessment equipment in Melbourne.

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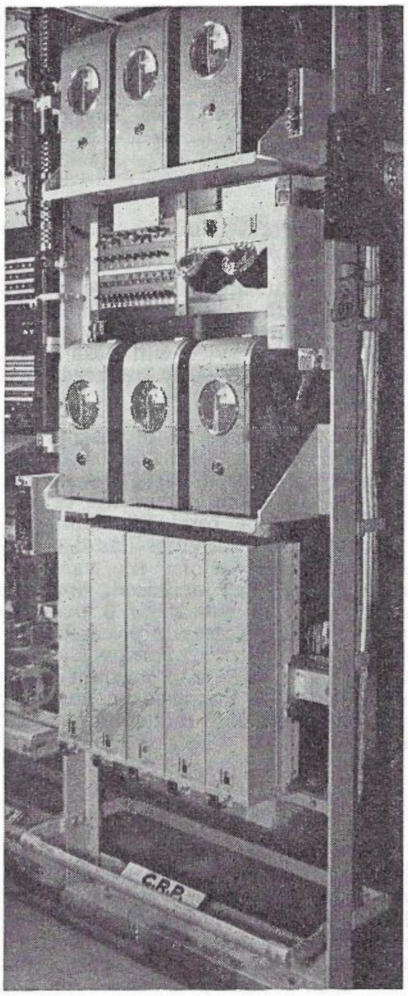

Fig. 2 — Rack Mounted Call Record Printer Equipment.

GENERAL DESCRIPTION OF EQUIPMENT

There are two types of equipment at present in use — rack mounted (Fig. 2.) with nine units per rack, and individual portable units (Fig. 3.)

The line bridging and monitoring elements and the control circuitry for the printing mechanism are contained in a relay set with the printing mechanism as a separate unit. (See Fig. 4).

The circuitry of both fixed and portable units is basically the same; Fig. 5 is a block diagram showing the main circuit elements.

Modifications

A number of modifications have been made to the equipment to suit local conditions. These fall into two groups, those required to permit operation on crossbar equipment and those made so that operation over junctions is possible. Minor modifications to the meter pulse detection element were also necessary to cover some Australian metering systems. A time clock has been added to the portable units to provide one second pulses, which are not always available. The method of connection to these units has been changed to screw terminals in place of the plug and jack arrangement supplied. This latter change is necessary because of the different I.D.F. arrangements encountered in Australian exchanges.

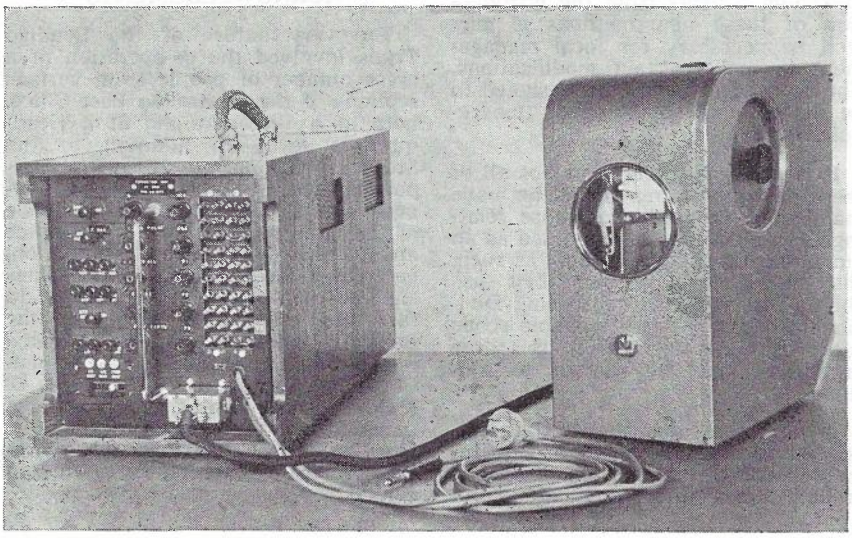

Fig. 3 — Portable Call Record Printer Equipment

EQUIPMENT OPERATION

Step Equipment

Connections are made to the —ve, +ve and the meter wires at the I.D.F. and connections are made to the Final Selector and Uniselector private wires after removal of the I.D.F. strap.

Outgoing call: Earth on the Uniselector P wire is applied to a transistor switch and relay P releases following which relays OC and CT operate. Relay OC busies the Final Selector private and CT connects the line bridging unit to the —ve and +ve wires, operating relay A. At the same time a dash is printed on the tape to signify the start of an outgoing call.

Relay A responds to subsequent dialled digits which are printed on the tape together with the time. The line bridging and monitoring unit consists of an oscillator which is triggered when a minimum negative potential of 1.5 volts is present on the +ve line in the looped condition. This oscillator is followed by amplification, detection and DC amplification stages. A guard circuit is connected to the —ve wire which prevents spurious operation due to line surges or short open circuits during switching. A more detailed explanation of these elements is contained in Ref. 1.

When the called subscriber answers, the meter pulse of whatever type e.g. +ve battery, booster, —ve battery etc. causes relay MP to respond by operation of a transistor voltage detector. Depending on the type of metering, various alternative strapping is required and in some cases e.g. +ve battery, a two-stage transistor switch is used, while in fourth wire —ve battery metering, the second stage only is used. In both cases the pulses are recorded on the meter pulse magnet of the printer mechanism. On S.T.D. calls each meter pulse is recorded separately together with the time.

The end of a call is signified by a further dash on the tape following release of relays A and CE when the loop is broken.

Incoming call: Relay CI is operated from the Final Selector private. CI earths the Uniselector private to operate the subscribers K relay (or equiv.) I/C is printed on the tape at this time.

When the subscriber answers, the DC loop is detected by a transistor voltage detector, which is triggered when the voltage on the earthy side of the line falls towards —50v.

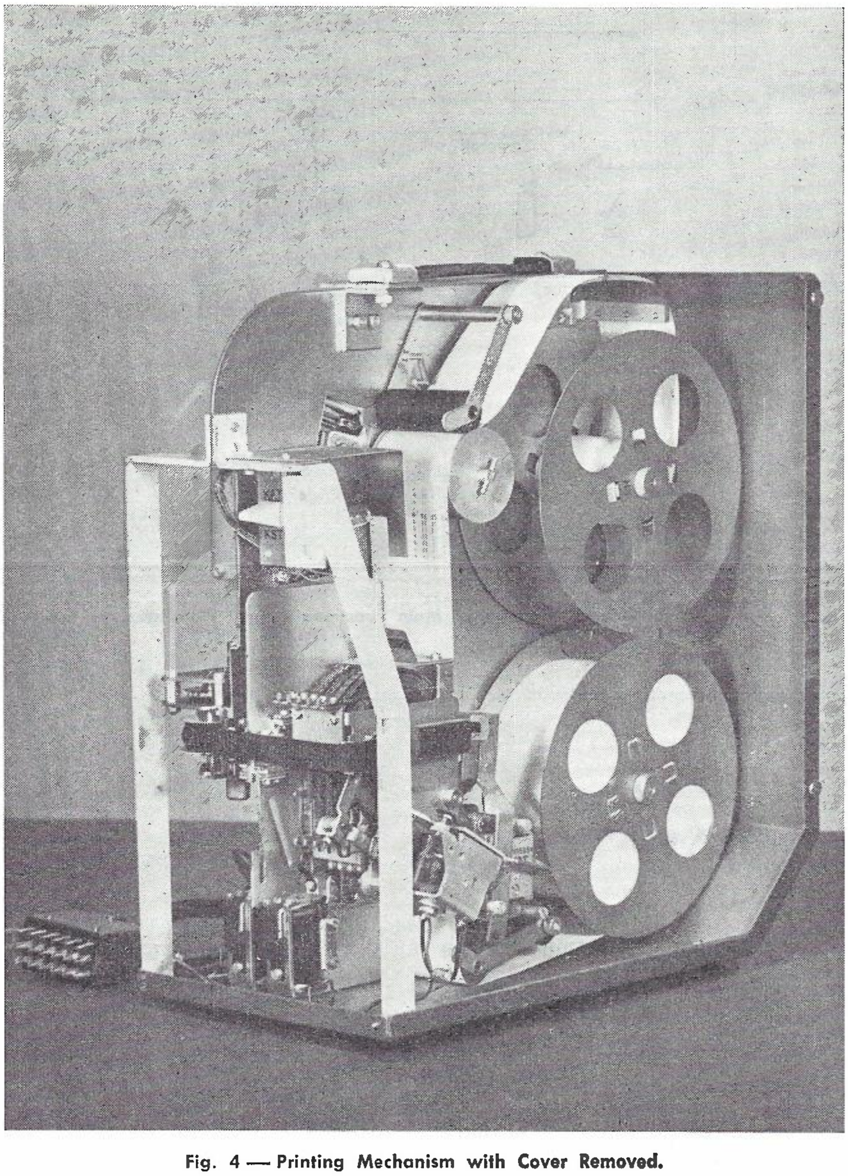

Fig. 4 — Printing Mechanism with Cover Removed.

Relay F operates and causes the time only to be printed. At the end of an incoming call I/C is printed once more on release of relay CI.

Crossbar Equipment

Auxiliary relays XC and IC were fitted to all units to permit operation on crossbar equipment.

Connections are made to the a, b wires at the M.D.F., to the c wire at the PBX rack and to the subscriber's meter. In addition a connection is made to the category analyser (KAN) which is strapped for incoming call classification. This gives a short pulse to operate relay IC on incoming calls followed by relay XC when the earth appears on the c wire. Relay IC must hold over this period hence the large capacitor on the second winding. On outgoing calls relay XC only operates from the c wire. Relays XC and IC are arranged to simulate the calling earth conditions on the P wires of step equipment. All subsequent operation is the same as in step equipment except for the meter pulse which occurs at the end of a normal call.

The voltage detector ring trip unit was included to cover the crossbar case in which no DC polarity change occurs on the a and b wires following ring trip.

Operation Over Junctions

The first delivery of C.R.P. equipment was of the rack mounted type and to permit it to be used throughout the metropolitan area it was connected over junctions radiating from a central installation.

Difficulties were encountered with the line bridging and monitoring circuit due to differences in earth potential causing false operation. Modifications were made so that the oscillator and guard circuits were connected to the earth at the distant exchange over a junction wire. The operation of the test relays in final selectors was also improved by changing the coil of relay CI to a lower resistance value to permit operation over junction loops up to 2000 ohms. Introduction of a transistor detector for ring trip also helped eliminate a difficulty which would have been encountered in working over junctions. The other transistor detector units operate satisfactorily over junctions of 2000 ohms loop.

FUTURE USE OF EQUIPMENT

Deliveries of individual relay sets and printers will make it possible to have one or more C.R.P. units in each exchange above say 1000 lines. It is proposed to cable for up to three relay sets but provide only one. Requirements for more than one observation at the same exchange will then be met by transferring relay sets and printers from other exchanges. Requirements which cannot be met by this semi permanent arrangement will be filled by the small number of portable units available. These portable units will also be used in small exchanges in which a permanent installation is not warranted.

PRACTICAL APPLICATION

Experience since mid 1964 has confirmed the early promise and this equipment has enabled the great majority of complaints of overcharging to be proved groundless. However, a number of cases of faulty registration due to technical causes have been encountered.

The equipment has been used for a number of special investigations which have included:—

1. Intermittent metering on a CE. 11251 S.T.D. access relay set.
2. PT coin service complaints, in an attempt to see whether conversation times prior to calls to complaint centres indicated successful calls.
3. Call dispersion on junctions in small country exchanges.
4. Checking output of Traffic Route Testers.

EXTENDED USE OF BRIDGING CIRCUIT

The transistorised line bridging circuit has been used to replace the bridging circuit in the Melbourne Service Assessment equipment. This has been successful and has eliminated a long standing problem which arose due to the use of a high resistance polarised relay which was difficult to keep in adjustment. In particular the high impedance was essential in making possible observation on S.T.D. outgoing routes.

CONCLUSION

The Call Record Printing equipment has proved a valuable aid in dealing with complaints of overcharging.

The ability of the equipment to detect digits dialled and meter pulses on any equipment has been used to advantage in a number of cases.

Extended use of the bridging circuit on Service Assessment equipment has resulted in significant improvement in reliability and reduced maintenance on that equipment.

REFERENCE

1. B. A. Green and H. Blakey "A Printing Recorder for use with Observation Equipment"; Post Office Elect. Engineers Journal, Vol. 53, July 1960, Page 118.

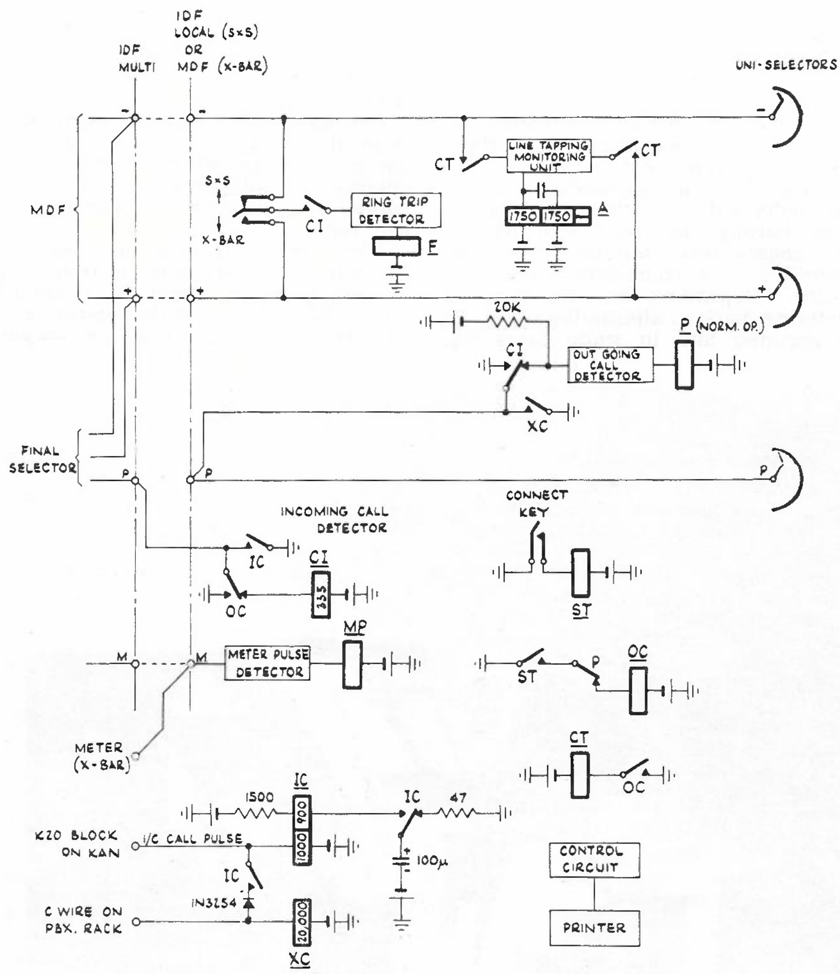

Fig. 5 — Block Diagram of Main Functional Circuit Elements.

BACK NUMBERS AND INDEXES

Some back numbers of the *Journal* are still in stock and are available on application to State Secretaries (for Australian residents), or the General Secretary (overseas residents). Prices for orders received during 1967 are as follows (post free Australian currency):—

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Vol. 16 (1966). No. 3.*

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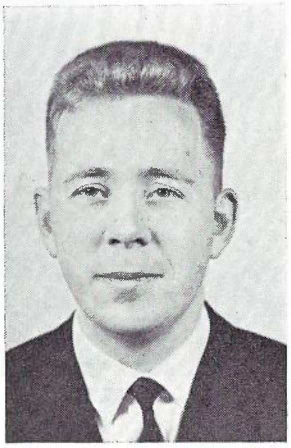

G. P. E. SVENSSON

H. S. WRAGGE, author of the article, "Recent Developments in Electronic Exchanges", joined the Research Laboratories in 1955 after completing a Departmental Cadetship, during which he obtained the degrees of Bachelor of Electrical Engineering (including the Exhibition at the final examination) and Master of Engineering Science at the University of Melbourne. He occupied the position of Divisional Engineer, VF Transmission from 1956, and was mainly interested in the introduction of transistors into Departmental plant. During 1961 he was responsible for the development of an experimental model electronic exchange (SCATS Mk I) which was put into service as a P.A.B.X. for a trial period in the Research Laboratories. In 1962 he undertook a three-month world-wide trip to investigate developments in electronic switching, later that year he was appointed Sectional Engineer, Principles and Standards; this group included the switching activities of the laboratories together with various other more theoretical activities. During 1965 he transferred to the position of Sectional Engineer, Switching with responsibilities only in the switching field. In 1966 he attended the International Conference of Electronic Switching in Paris, at which he delivered a paper. During his return, he visited Japan to discuss latest developments there in electronic switching.

Mr. Wragge is a Member of the Institution of Electrical Engineers, an Associate Member of the Institution of Engineers, Australia and an Editor of this Journal.

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L. CHAMBERLAIN, author of the article "Development of Cordless Manual Trunk Assistance Equipment", and co-author of the article "Operating Facilities for Manual Assistance Centres", is an Engineer Class 3 in the Switching and Facilities Section, Postmaster-General's Department. He joined the Department in Brisbane as a Junior Mechanic in 1944 and was appointed Engineer in 1952. He was employed as Group Engineer in the Brisbane Telephone Equipment Service Divisions, and in the Metropolitan and Country Exchange Installation Divisions. He acted as Divisional Engineer in the Country Installation, Training, and Subscribers Equipment Installation Divisions in Queensland before being appointed to his present position in the Headquarters Planning Branch in 1963. He holds a Diploma in Public Administration and is an Associate Member of the Institution of Engineers, Australia.

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J. H. ELLIOTT

G. P. E. SVENSSON, co-author of the article "The A.P.O. Three-Stage Group Selector — Detailed Description", graduated as an electrical engineer from the Institute of Technology in Stockholm in 1959. Since 1956 he has been employed by L. M. Ericsson in Sweden, where his current position is Group Leader, Circuit Design and Laboratory Section, Telephone Exchange Division. He was temporarily transferred to L. M. Ericsson Pty. Ltd., Melbourne, in January 1966 and returned to Sweden in January 1967, following completion of the Group Selector design.

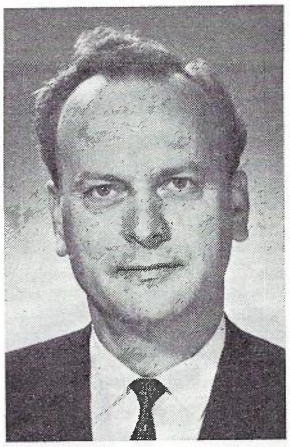
★

J. H. ELLIOTT, co-author of the article, "Operating Facilities for Manual Assistance Centres", joined the Postmaster-General's Department in 1936 as Telegraph Messenger in Melbourne. After various appointments in the Telegraph and Mail Branch areas, he served during World War II, in the Australian Military Forces and in the R.A.A.F. On resumption in the Commonwealth Public Service after the war in 1945, he was employed as Clerk, Commonwealth Serum Laboratories, Melbourne, before being accepted as trainee Traffic Officer, Telephone Branch, in 1949. Since then he has performed most of the duties of Traffic Officer in the Telephone Branch, and for the last 10 years has been mainly associated with the Works and Equipment Section (now Telecommunications Division) both in the Victorian and Headquarters Administrations. Mr. Elliott was promoted Senior Traffic Officer, Headquarters in 1964.

A. G. ELLIS

A. G. ELLIS, author of the article, "SEACOM—Radio Bearer Service Organization", graduated Bachelor of Science from the University of Melbourne in 1952 with honours in Physics, and Associate Diploma of Management from Royal Melbourne Institute of Technology in 1966. From 1949 to 1952, he was employed in the Radio Laboratory of the Victorian State Electricity Commission, transferring to the Design Establishment, Department of Supply, in 1953, where his main interest lay in the development and production of portable HF transceivers. In 1957, he joined the Postmaster - General's Department where for several years he was a member of the Design, Planning and Standards Group, Engineering Division Headquarters. Mr. Ellis is now Divisional Engineer Radio Communication Service Division.

★



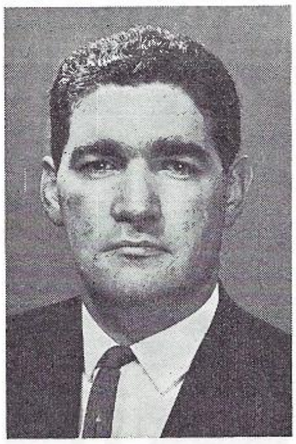
C. A. SPONGBERG

C. A. SPONGBERG, author of the article, "Establishing L. M. Ericsson Crossbar Production in Australia", is Factory Manager of L. M. Ericsson Pty. Ltd., Broadmeadows, Victoria. He graduated in 1943 from Stockholm Institute of Technology, Sweden, in Mechanical Engineering and completed a Diploma in Electrical Engineering four years later. He has been employed by L. M. Ericsson since 1945 as Test Engineer, Circuit Designer, and in 1957 became Chief Engineer for the Crossbar Engineering Department at North Electric Company, Ohio, U.S.A., an affiliate to L. M. Ericsson. After having spent some time in Australia during 1962 to provide technical assistance to L. M. Ericsson's Australian manufacturing licensees of Crossbar Equipment, he was appointed Technical Manager in 1963 to L. M. Ericsson's new establishment in Victoria. In this capacity he was responsible for the implementation of the Company's techniques and controls particularly in the field of production documentation and quality assurance. In 1966 he became Factory Manager responsible for the production and deliveries of Crossbar Equipment to the Australian Post Office and the private P.A.B.X. market. Mr. Spongberg is a Member of the American Institute of Electrical Engineers.

★

C. S. LAVERY

C. S. LAVERY, author of the article, "Commissioning of Crossbar Exchanges", was formerly a technician in the P.M.G.'s Department. He graduated from the University of Adelaide in March, 1960, securing his Bachelor of Engineering degree. In 1960 Mr. Lavery was appointed Engineer Grade 1 in Metropolitan Exchange Installation in Adelaide and subsequently was appointed as an Engineer Class 2 in the same group in 1961. He took up duty with L. M. Ericsson, as a Senior Design Engineer in September, 1966.



M. FARDOULY

M. FARDOULY, author of the article "The A.P.O. Three-Stage Group Selector-Initial Planning", joined the Postmaster-General's Department as a Cadet Engineer after qualifying as a Bachelor of Science at Sydney University. On graduation as a Bachelor of Engineering in 1955, he spent eight years with Long Line and Country Installation, Sydney, on the installation of carrier systems and most forms of telephone switching equipment.

In 1963 he was appointed Engineer Class 3 Switching and Facilities Planning in Central Office and was responsible for carrying out feasibility studies, preparing specifications, etc., for new telephone and telegraph switching equipment. He recently transferred to the position of Divisional Engineer, Metropolitan Exchange Installation, Sydney.

★

B. M. BYRNE

B. M. BYRNE, author of the article, "A Transistorised Halide Gas Leak Detector for Cable Gas Pressure Alarm Systems", was appointed Engineer in the Queensland Administration of the Postmaster-General's Department in 1952, following completion of an Electrical Engineering Degree course at the Queensland University. Since that time he has been engaged in all phases of external plant activities, particularly maintenance. He has retained an interest in electronic developments and their applications to line plant practices and problems. Since 1959, he has controlled the activities of the Cable Protection Division in Queensland and currently occupies this position. Mr. Byrne is a Member of the Institution of Electrical Engineers.

★

J. E. RUFFIN

J. E. RUFFIN, author of the article, "Some Recent Developments in Engineering Administrative Practices at Bendigo, Victoria", joined the Postmaster-General's Department in 1944 as a Technician-in-Training. After completing this course and a Departmental Cadetship he was appointed Engineer in 1954. Following periods in the Country Installation and Metropolitan District Works Sections, Melbourne, he transferred to the Colac Division in 1956 where he worked as a Group Engineer. Whilst at Colac he acted as Divisional Engineer for a period of twelve months. In 1961 he was transferred to the Bendigo Division as acting Divisional Engineer and was subsequently permanently appointed to this position. Mr. Ruffin is an Associate Member of the Institution of Engineers, Australia, and an Associate of the Australian Institute of Management.

★

V. HOLLIDAY

V. HOLLIDAY, co-author of the article, "Call Record Printing Equipment", joined the Postmaster-General's Department as a Technician's Assistant in 1946 after four years service in the R.A.A.F. He qualified as Senior Technician in 1953 whilst on Melbourne city exchange maintenance. As Supervising Technician he spent three years on acceptance testing of contractor-installed P.A.B.X.'s. In 1961 when the Metro. Service Laboratory was established he was appointed to the position of Supervising Technician in-charge. The modifications to the Call Record Printing Equipment for Australian conditions as described in the article, were developed in the Laboratory which is now part of the Melbourne Network Performance Division.

ANSWERS TO EXAMINATION QUESTIONS

Examination No. 5483 — 2nd July, 1966, and subsequent dates. To gain part of the qualifications for promotion or transfer as Senior Technician (Telecommunications), Telegraphs, Postmaster-General's Department.

SECTION 2. TELEGRAPH EQUIPMENT

QUESTION 1. (a)

The Teletype Model 14 Transmitter/Distributor and the Siemens & Halske T Send 77f Transmitter/Distributor have three major operating sub-systems in common.

List these three sub-sys'ems and briefly state the purpose of each. (Approximately 10 words should be sufficient statement for each one.)

ANSWER 1. (a)

(i) Power assembly — motor plus gearing to provide drive to cams and contact assembly.
(ii) Transmitter — converts perforated coding on tape to electrical condition (current or no current).
(iii) Distributor — converts electrical condition of transmitter assembly into correct form for line transmission.

QUESTION 1. (b)

Two of the sub-systems in 1 (a) interoperate to convert the information, contained physically as perforations on paper tape, into electrical signals.

Describe for the two types of transmitter/distributor in 1 (a) how these sub-systems operate and how it is ensured that correct relationship is maintained between the two sub-systems so that proper signals are sent to line.

ANSWER 1. (b)

The transmitter and distributor of the model 14 are driven from the one shaft, while the magnets controlling the transmitter and distributor of the T Send 77 are tripped simultaneously for clutch engagement.

In both machines, the tape sensing pins are offered to the tape during the time the distributor is sending the start pulse. The combination sensed is set on the transmitter contacts under the control of the tape-sensing levers. The Transmitter Tongue remains in the spacing condition if no hole is detected in the tape and changes over to the mark condition if a hole is detected in the tape. The distributor then reads code elements 1, 2, 3, 4 and 5 from the transmitter contacts before inserting the stop element.

The tape sensing pins of the Model 14 are withdrawn from the tape just after the distributor begins to send the stop pulse.

The sensing levers associated with code elements 3, 4, 5 of the T Send 77 are coupled to storing levers which are held in the marking condition if such exists on the tape. This allows the sensing levers to be withdrawn much earlier in the cycle of the character being sent. In both machines, once the pins have been withdrawn, tape feed takes place, advancing the next code above the sensing pins during the time the stop pulse is being sent from the distributor.

QUESTION 1. (c)

How does the tape transmitter attachment for the Siemens & Halske M 100 Teleprinter vary from the two machines in 1 (a)?

(Restrict your answer to principles — mechanical detail is not required.)

ANSWER 1. (c)

The M 100 Tape Transmitter is not associated with a distributor. The correct timing and sequence of impulses is controlled by cam-operated code levers which sense the code condition of the sensing levers, and govern the transmitting contact operation by means of a code bail and a contact operating rocker. Only the fifth code impulse condition is stored, again to allow tape feed to begin a little earlier in the character cycle than in the T/T Model 14 TD. No separate power unit is required, as it is driven from the M 100.

QUESTION 1. (d)

The tape transmitter attachment for the Siemens & Halske M 100 has one feature not integrally included in the T Send 77f and the M14 TD.

What is this feature and why is it a desirable inclusion?

ANSWER 1. (d)

The GM magnet, which is operated by the stop pulse being transmitted. The operator receiving transmission from this tape transmitter can stop the transmitter remotely by transmitting preferably the T character such that at the time the tape transmitter is sending stop pulse, the space condition from the "receiving" machine opens the GM magnet circuit, causing the tape transmitter to switch off.

QUESTION 2. (a)

Describe, with reference to Fig. 1, the mechanical operations involved in switching ON a reperforator attachment fitted to a Siemens & Halske M 100 Teleprinter.

ANSWER 2. (a)

Operation of the "On" key turns 221 forward under the latching surface of 223 to lock in the "On" condition. 221 is coupled to a shaft, crank and lever to withdraw 219 so that its face 217 releases clutch member 195 and its upper projection moves clear of plate 218. Dog 195 will engage in the driving collar 220 when the printer shaft is stationary.

Shaft 194 will then turn with the printer shaft.

QUESTION 2. (b)

How does the tape feed mechanism on a reperforator attachment for a Siemens & Halske M 100 Teleprinter vary from other reperforators outside the Siemens' range of machines?

ANSWER 2. (b)

The M 100 reperforator tape feed mechanism incorporates a tape puller which strikes the tape in the track at the time the feed punch is through the tape. This pulls a little tape forward off the supply reel, so the roller type friction feed mechanism feeds a free length of tape.

QUESTION 2. (c)

When fitting a reperforator attachment to a M100 Teleprinter certain "connections" have to be made to the Teleprinter machine.

List these and state their purpose.

ANSWER 2. (c)

Transfer shaft and driving sleeve must be provided. No wiring changes are needed. The reperforator must be fitted so that the suppression bail is located above the release lever, and a stop plate must be adjusted so that marking function code bars clear the reperforator transfer bars.

Once this plate has been adjusted and the three mounting screws tightened, the driving sleeve must be adjusted to give the transfer shaft a little end play.

QUESTION 2. (d)

An operator, while using a Siemens & Halske M 100 Teleprinter, with reperforator attachment, for tape preparation in the "local run" condition, accidentally depresses the "WHO ARE YOU" key while in "Figures" case.

Describe, without mechanical detail, how this code is prevented from being transmitted when the taped information is sent to line, and give reasons for this being necessary.

ANSWER 2. (d)

The 1st and 4th code holes will be punched in the tape, but selection of the Answerback pullbar suppresses tape feed. This combination will remain above the punches. The operator may then select "Figures" once more, which will overpunch the previous code, converting it to 1, 2, 4, 5, obliterating the error, but retaining the machine in Figures shift. Tape transmission of a 1st and 4th in figures condition would trip the answerbacks of sending and receiving machines, garbling the text and stopping the tape.

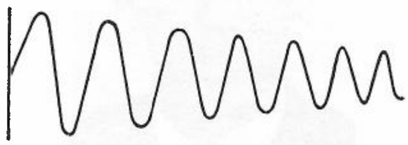
QUESTION 3. (a)

The BATE Type 6 Telegraph Distortion Measuring Set diplays on the screen of a C.R.O. a series of do's, superimposed on either a circular or spiral trace, which by their position indicate the degree of distortion being measured in signals passing through a telegraph line.

Write, with simple explanatory sketches, a brief description of how the following displays are achieved:

ANSWER 3. (a)

(i) **Spiral trace.** The oscillator gain is reduced to slightly less than unity, producing damped oscillation at the X and Y inputs of the C.R.O. tube.



(ii) **Circular trace.** The oscillator output is fed to the X and Y inputs through a 90° phase shift network. (See Fig. 3.)

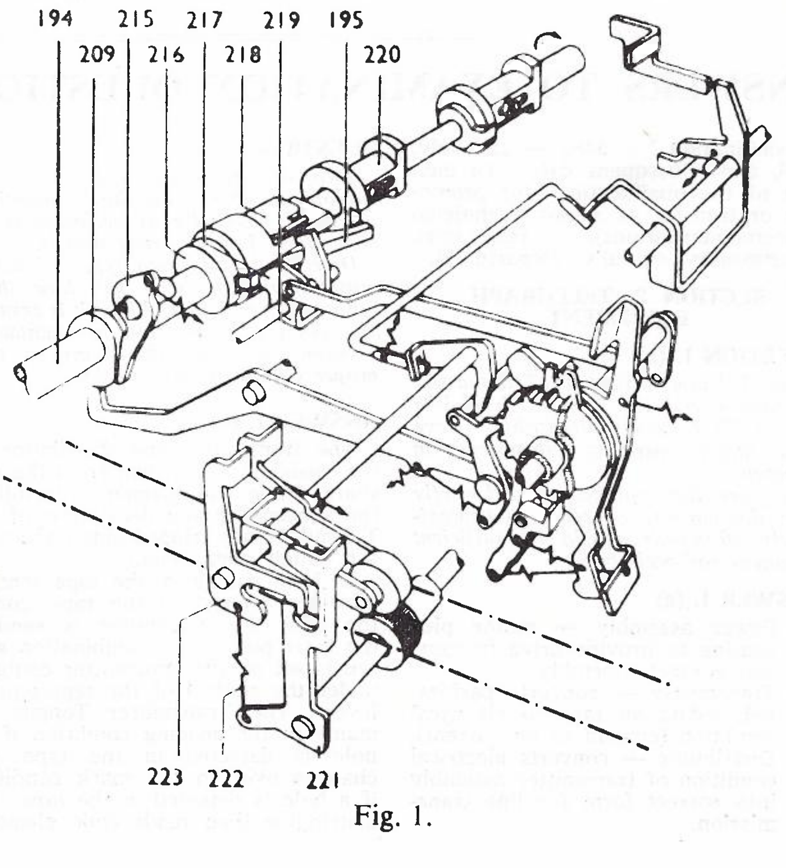


Fig. 1.

(iii) **Brightening Dots Indicating Signal Transitions.** Short duration pulses coinciding with the observed telegraph signal transitions are applied to the grid of the C.R.O. tube to drive it positive, momentarily increasing the brilliance of the trace at that time. (See Fig. 4.)

QUESTION 3. (b)

How would you check that the time-base oscillator frequency (and therefore the speed of trace) of a BATE 6 was correct for a telegraph speed of 50 bauds, before attempting to measure distortion on telegraph signals?

ANSWER 3. (b)

Observe the speed indicator neon lamp through a vibrating 100 c/s tuning fork for 50 baud working and adjust the fine speed control until the lamp seems to remain either on or off.

QUESTION 3. (c)

If you wished to check distortion with a BATE 6 T.D.M.S. firstly at 50 bauds and then at 75 bauds, what alterations would you make to the BATE 6?

Would it be necessary to check the speed again at 75 bauds? (Give reasons for your answer.)

ANSWER 3. (c)

For 50 bauds — select 50 on the range switch and adjust fine speed control as in 3 (b).

For 75 bauds — select 70 or 75 on the range switch according to the model in use and adjust fine speed control using a 150 c/s tuning fork, as the fine speed control designations may not be absolutely accurate.

QUESTION 4. (a)

Describe with the aid of sketches the principles of signal formation in a Telegraph Character Generator suitable for the production of "service codes" in a Telegraph Switching Centre.

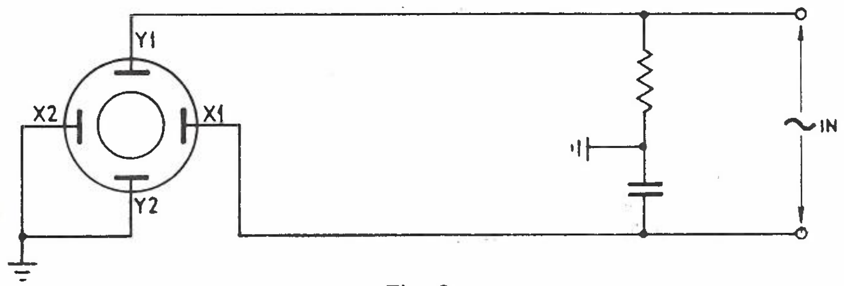


Fig. 3.

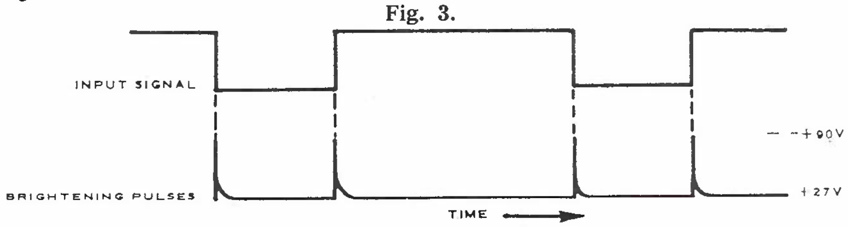
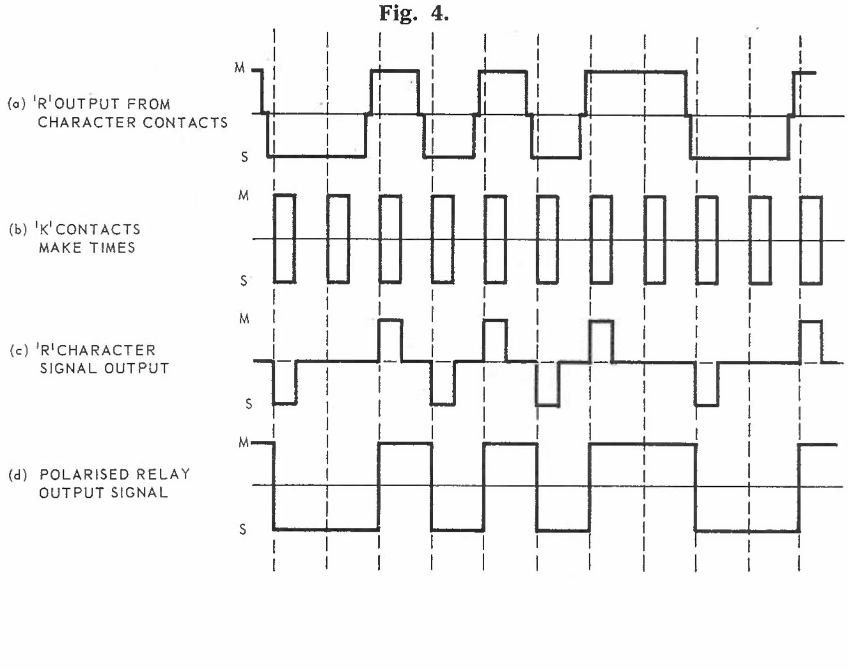


Fig. 4.



ANSWER 4. (a)

With reference to the T send 73a Character Generator: the code cam contacts are designed to close earlier and open later than the transition times of the signal generated (graph (c)), eliminating arcing at these contacts. Timing contacts K, each controlled by an accurately cut single-lobe cam, close at precisely the correct time of each transition possible, and determine the leading and trailing edges of the character elements.

These timing cams turn at eight times the speed of the character cams, so the character output of the generator is an 8-unit code rather than the normal 7.5 unit code. The stop pulse in this case is 40mS or two units long instead of the normal 30mS or $1\frac{1}{2}$ units.

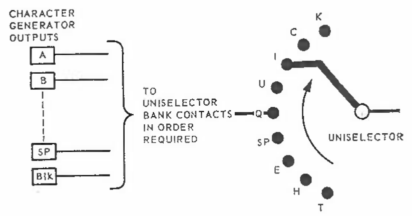
The timing diagram shows at (a) an 'R' character being generated, at (b) the 'K' contacts' make times, at (c) the resultant output from the 'K' contacts, and at (d) the ultimate output from a polarised relay controlled by the 'K' contacts. The dotted lines across the diagram represent the correct transition times of the signal generated.

QUESTION 4. (b)

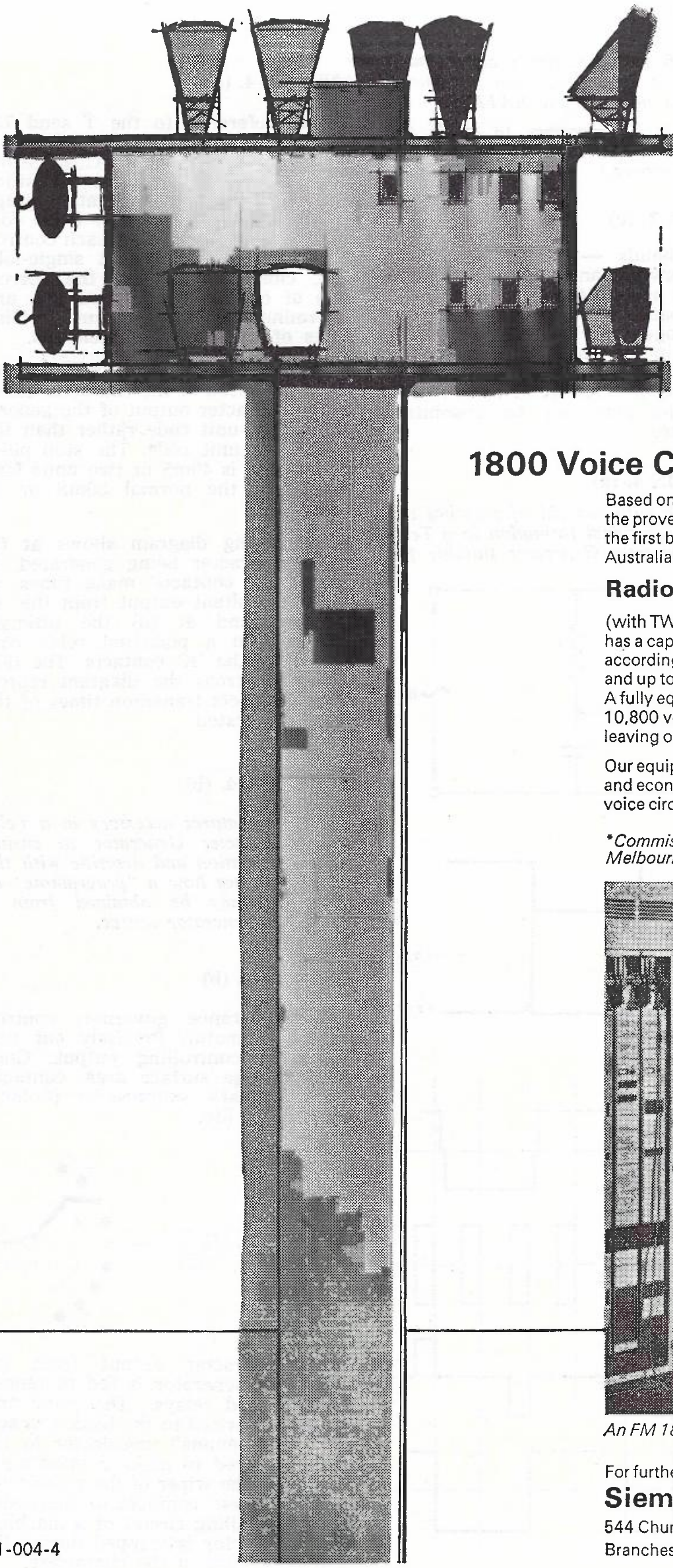
List the features necessary in a Telegraph Character Generator to ensure reliable operation and describe with the aid of sketches how a "programme" of characters may be obtained from a Character Generator source.

ANSWER 4. (b)

Close-tolerance governor, controlling drive motor. Precisely cut timing cams controlling output. Good quality, large surface area, contacts. Efficient spark suppression prolonging contact life.



The character output from the Character Generator is fed to repeating polarised relays. The relay output is then wired to the bank contacts of a "programme" uniselector in the order required to make a meaningful text when the wiper of the uniselector connects these contacts in succession to the signalling circuit of a machine. The uniselector is stepped during the stop pulse time of the characters.



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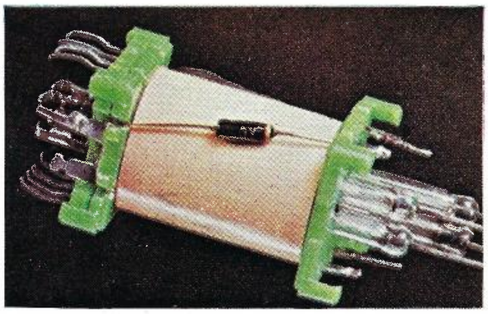
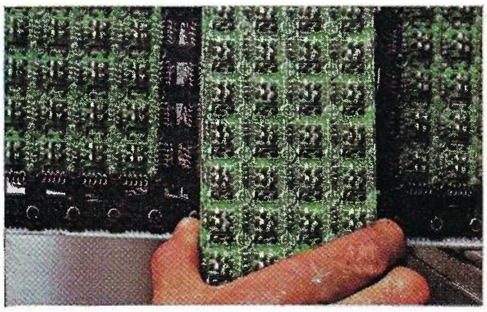


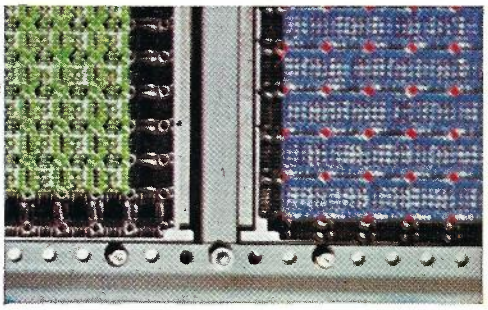
THE REX SWITCHING ELEMENT

The basis of the REX system is this reed relay crosspoint switching element. It contains only nine components, compared with 200 in a bimotional selector, and its very simplicity makes it uniquely reliable. It gives highest quality transmission paths with gold at the point of connection, requires no routine maintenance, generates no vibration and therefore no microphonic noise. There's nothing to wear out and it is sealed completely to be immune to interference by dust or atmospheric pollution.



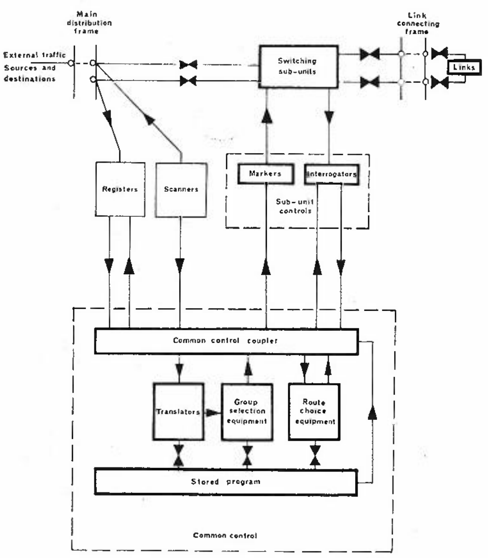
THE REX SWITCHING MATRIX

Since multiple wiring across the end-caps is inherent in the reed relay crosspoint design, switching matrices can be built up in any form simply by clipping reed relay crosspoints together. Matrices may be enlarged in any ordinate simply by the addition of rows and columns of reed relay crosspoints to cater for any switching requirements. This means that unlimited provision for the growth of lines and links is built into the REX system.



THE REX SWITCHING UNIT

Basic switching arrays (normally called sections) are built up out of matrices and assembled in parallel to form a REX switching unit. The number of sections supplied depends on the anticipated originating traffic per line. Typically, a 1000-line four-section unit would serve a community with an average calling rate of 150 call seconds per line in the busy hour; other calling rates can be accommodated by varying the number of sections.



THE MULTI-UNIT REX EXCHANGE

Switching and linking arrangements are provided for all sections of each unit so that complete crosspoint path interconnection is made between all lines of the REX exchange. For purposes of security of service and simplicity of electronic control the units are divided into self-contained basic switching blocks termed 'sub-units'. Each sub-unit is linked only to adjacent sub-units, a linking pattern which provides for every traffic pattern and retains simplicity of control.

THE REX ELECTRONIC CONTROL

Closely related in its simplicity to the 'building block' structure of REX switching equipment, the REX electronic control system has three main areas of activity:

SCANNERS AND REGISTERS
These determine the source and final destination of a call.

MARKERS AND INTERROGATORS
Provided on a per-sub-unit basis, these controls are concerned with interrogating the state of crosspoint paths and marking these paths through the switching sub-units.

COMMON CONTROL
The control processes the necessary call setting data in accordance with instructions from the stored programme control in such a way that the calls are routed with maximum utilisation of the switching network.

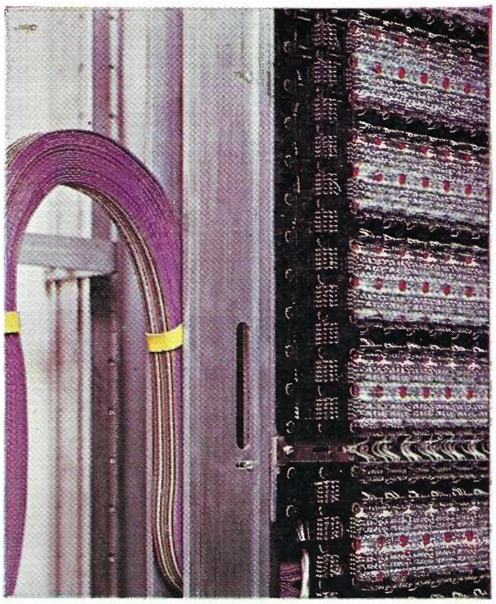
REX®

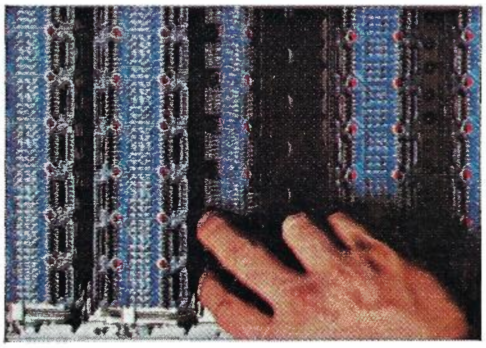
THE REED ELECTRONIC EXCHANGE

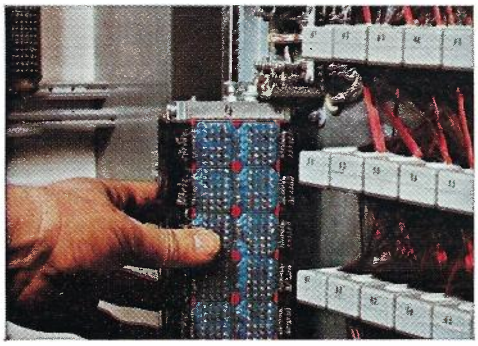
serves a much greater area in far less space than a conventional exchange: every part accessible – every part replaceable!

The REX subscriber's line circuit tolerates substantially wider line conditions enabling a REX exchange to serve an area much larger than that of a conventional exchange, permitting big reductions in line plant investment.

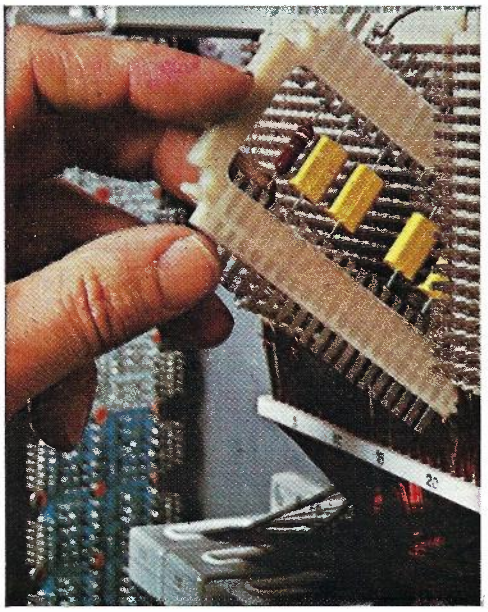
AEI engineers have devised the entirely new Reed & Electronic Modular Apparatus practice (REMA) for the REX exchange providing completely compatible mounting of reed relays and electronic circuit components. Combined with a new sliding frame installation system, the REMA practice allows more than 20,000 lines of REX equipment to be accommodated in the space normally required by a 10,000 line electromechanical exchange. In existing buildings this means more space for future expansion: in new exchanges it makes possible great savings in construction and installation costs.

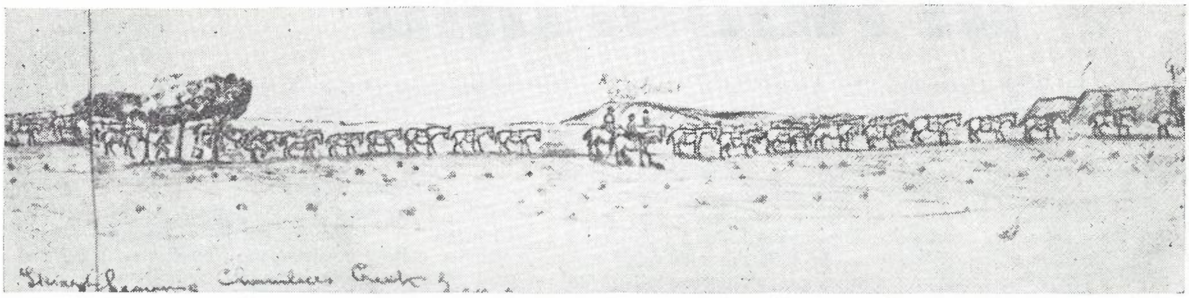






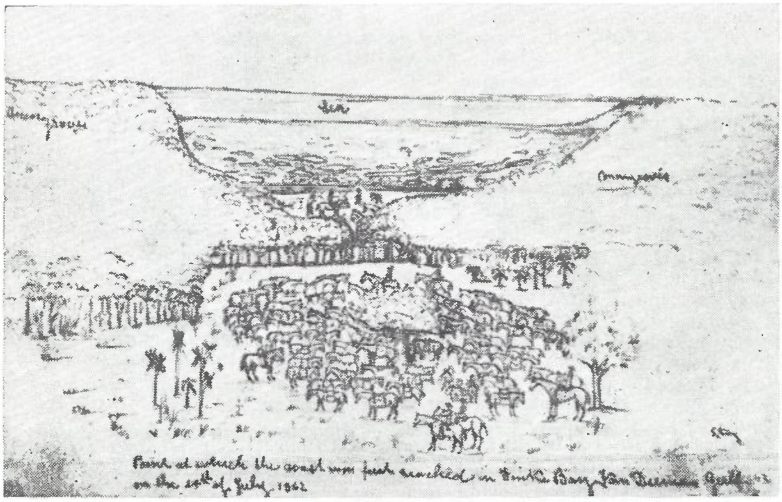
(TOP LEFT) Part of a cross-point switching frame also showing associated electronic modules.
(TOP RIGHT) A sub frame withdrawn for inspection showing the method of tape wiring.
(AT LEFT) Electronic modules can be arranged to revolve horizontally or swing down for inspection and maintenance.
(BOTTOM LEFT) Terminal wafers may be easily withdrawn from the main block to reveal circuit components mounted within the wafer.
(BOTTOM RIGHT) Frame assembly illustrating the wiring gutters used to accommodate the tape wiring.





The expedition, under the command of John McDouall Stuart, leaving Chambers Creek on 8th January 1862.

From originals held in the Archives Department of the Public Library of South Australia.



Point Stuart, where the coast was first reached on 24th July 1862.

£2,000 REWARD

Over 100 years ago, the South Australian government offered £2,000 to the first person to cross to the Northern part of the continent. One of the main reasons for doing so was to bring about the proposed link with the cable and telegraph line to Europe.

The reward was eventually won by John McDouall Stuart, who succeeded in finding a route across the centre of Australia on his sixth and final expedition.

More than a century later, a new £3,200,000 transcontinental microwave communications system, linking eastern and western Australia, is to be supplied by G.E.C. (Telecommunications) Ltd., of Coventry, England. The system, one of the longest civil microwave links in the world, will be in service in 1969. By this date, telephone traffic over the 1500 mile route linking Perth and Adelaide—as far apart as London and Moscow—will amount to about one million calls a year.

Initially, the system will provide two bothway radio bearer circuits, one main and one standby, with a capacity of 600 telephone circuits. The standby circuit may also be used to provide a television link giving a nationwide T.V. network. In addition a separate T.V. link will be provided between Northam, near Perth, and Kalgoorlie.

Completely semiconductored equipment, operating in the 2000 Mc/s frequency band, will ensure maximum reliability and minimum maintenance of the equipment throughout the mainly virgin country which it will traverse. Over a hundred years after John McDouall Stuart's achievement, G.E.C. (Telecommunications) Ltd. will forge new links across the continent.

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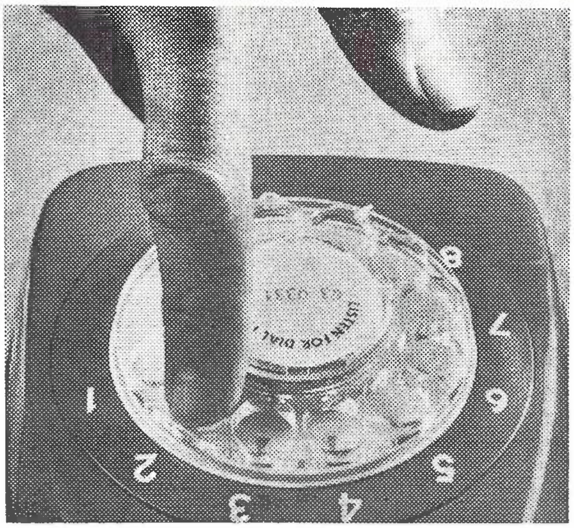

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For further information on these and other kits, please phone 27 4318 in Sydney, 94 0491 in Melbourne, or 23 1922 in Adelaide.

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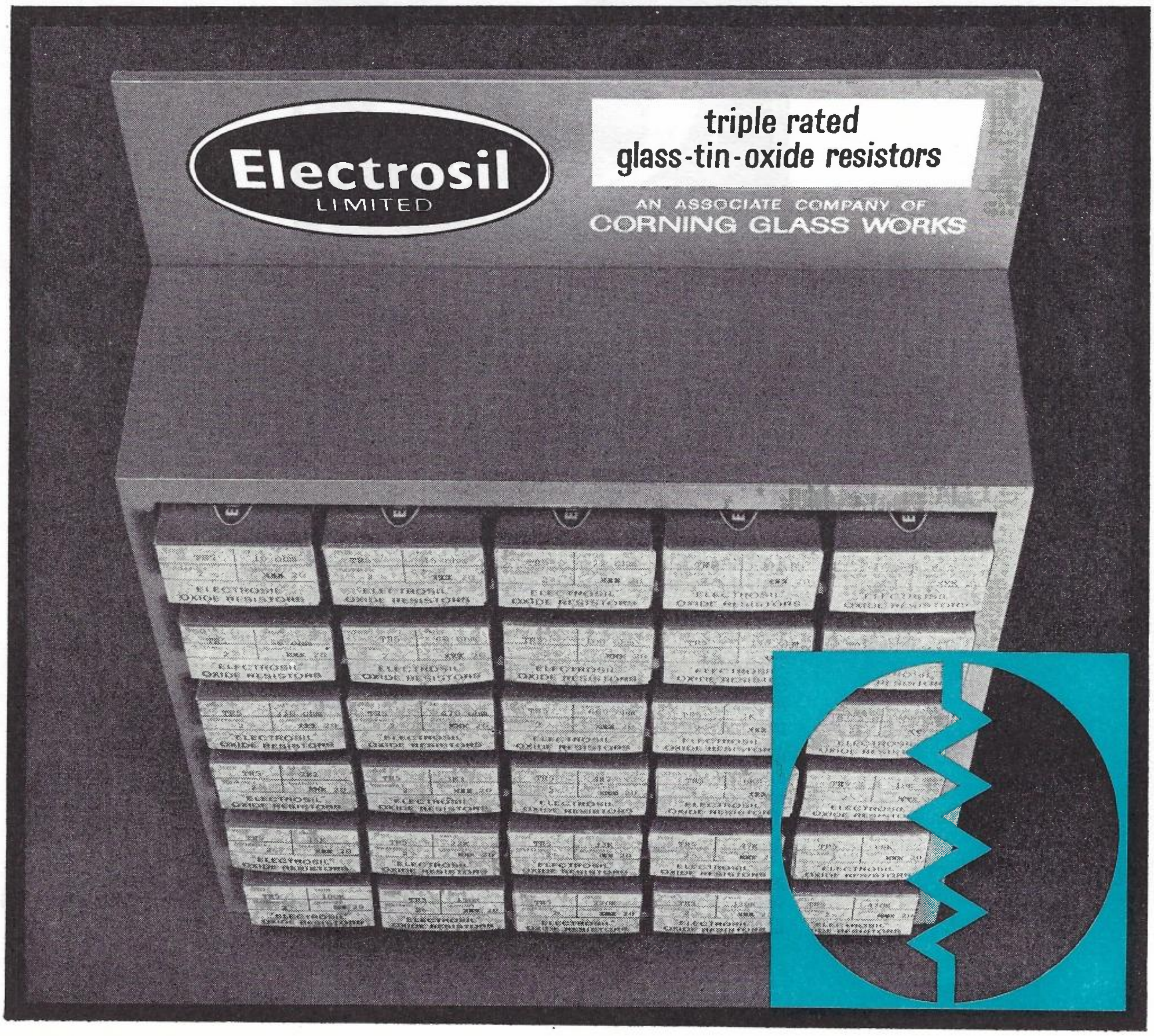
ELECTRONICS

Type	DEF 5115-1 Style	RATING (Watts) 70°C Semi Precision	High Stability	General Purpose	Length ins	Dia. ins
TR 4	RFG5–F RFG2–0.25	1/16	1/8	1/4 1/4	.281	.098
TR 5	RFG5–E RFG2–0.5	1/8	1/4	1/2 1/2	.375	.15
TR 6	RFG5–D RFG2–1.0	1/4	1/2	1 1	.593	.19
TR 8	RFG5–C RFG2–2.0	1/2	1	2 2	.728	.336
25,000 hour max. drift		1%	2%	3%		



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