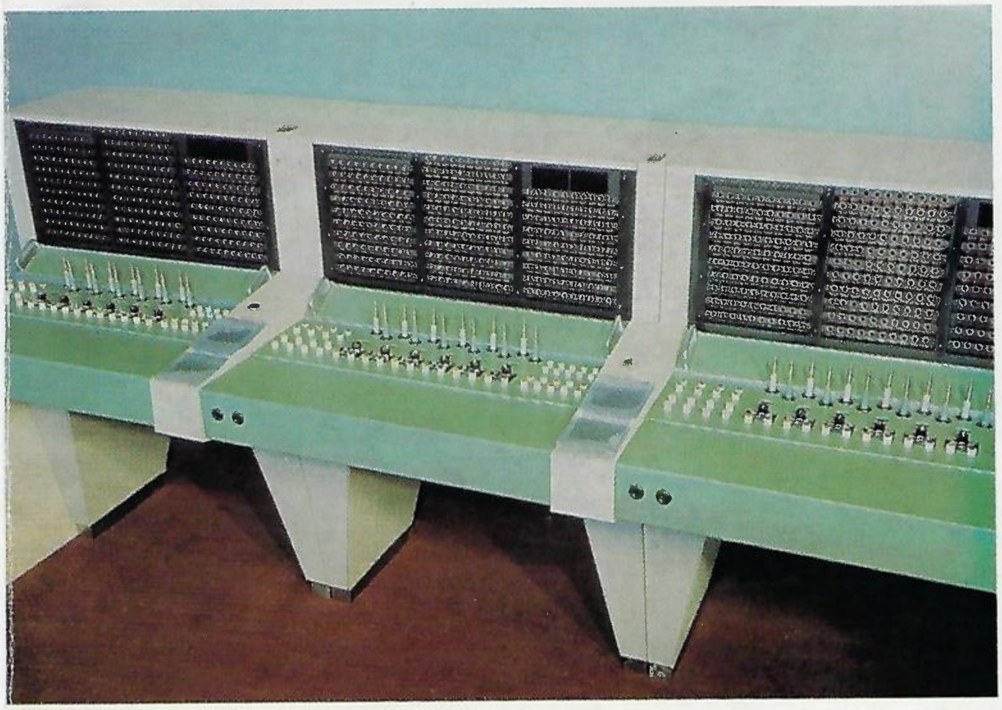
THE

Telecommunication Journal OF AUSTRALIA

IN THIS ISSUE

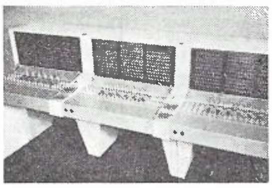


Vol. 19 No. 2 Registered at the General Post Office, Melbourne, for transmission by post as a periodical. JUNE, 1969

THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

VOL. 19 No. 2
JUNE 1969

CONTENTS



COVER
New Cord Type Operating Positions for Trunk Assistance Traffic.

The TELECOMMUNICATION JOURNAL of Australia

The Journal is issued three times a year (in February, June and October) by The Telecommunication Society of Australia. Commencing with Volume 15, each volume has comprised three numbers issued in one calendar year.

The Journal is not an official journal of the Postmaster-General's Department of Australia. The Department and the Board of Editors are not responsible for statements made or opinions expressed by authors.

Residents of Australia may order the Journal from the State Secretary of their State of residence; others should apply to the General Secretary. The subscription fee for Australian subscribers is 1 dollar per year, or 40 cents each for single numbers. For overseas subscribers the fee is 1 dollar and 50 cents per year, or 50 cents for single numbers. All rates are post free. Remittances should be made payable to The Telecommunication Society of Australia.

Editors of other publications are welcome to use not more than one-third of any article, provided credit is given at the beginning or end, thus "The Telecommunication Journal of Australia". Permission to reprint larger extracts or complete articles will normally be granted on application to the General Secretary.

Information on how to prepare manuscripts for the Journal is available from members of the Board of Editors.

Contributions, letters to the editors, and subscription orders may be addressed to:

The State Secretary, Telecommunication Society of Australia.
Box 6026, G.P.O., Sydney, N.S.W. 2001.
Box 1802Q. G.P.O., Melbourne, Vic. 3001.
Box 1489, G.P.O. Brisbane, Qld. 4001.
Box 1069J, G.P.O. Adelaide, S.A. 5001.
Box T1804, G.P.O. Perth, W.A. 6001.
Box 1522, G.P.O. Hobart, Tas. 7001.

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

Agent in Europe: D. McBride, Canberra House, Maltravers St., Strand, London, W.C.2, England.

ADVERTISING

All enquiries to Mr. R. Barrett, Service Publishing Co. Pty. Ltd., Tel. 60-1431. 415 Bourke St., Melbourne, Vic. 3000.

Revenue: The total net advertising revenue is paid to The Telecommunication Society of Australia whose policy is to use such funds for improvements to the Journal.

Contract Rate: Space used in any three consecutive issues: Full page, black and white, $100.80 per issue. Half page, black and white, $62.40 per issue (horizontal only). Quarter page, black and white, $36.00 per issue.

Casual Rate: Contract rate, plus 10%.

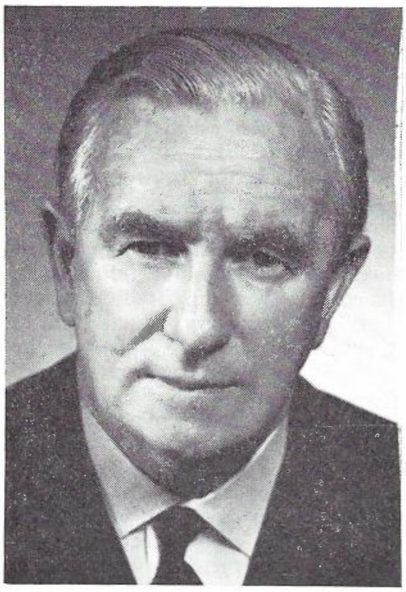
Rate Cards: With full details including colour rates obtainable from: Service Publishing Co. Pty. Ltd.

Copy Deadline: 15th December, 30th April, 30th August.

CAB CIRCULATIONS AUDIT BOARD

Audited average circulation for year ending 31 March, 1968: 5652.

NEW DIRECTOR-GENERAL



J. L. KNOTT, C.B.E.

The appointment of Mr. J. L. Knott, C.B.E. to the position of Director-General, Postmaster-General's Department, was announced by the Minister, the Hon. A. S. Hulme, on 5th December, 1968.

Born on 6th July, 1910, Mr. Knott was educated at Cobram State School and Melbourne University, gaining the Diploma of Commerce. He is a Qualified Accountant, Auditor and Company Secretary, and successfully completed the 1949 course at the Imperial Defence College, London. He was awarded the C.B.E. in 1961.

Mr. Knott brings to his new position a wide experience in management and administration in a variety of areas. He joined the Commonwealth Service in March 1926 as Telegraph Messenger in the Postmaster-General's Department and has served in a number of departments, including Customs and Excise, Munitions, Post-War Reconstruction, Defence Production, and Supply.

From 1935 to 1938 Mr. Knott was Private Secretary to the Minister for Trade Treaties. He attended the Eastern Group Supply Conference in Delhi in 1940 and was Secretary of the Army and Munitions Co-ordination Committee during the war years under the general direction of Sir Essington Lewis. Immediately post war he was Executive Officer of the Secondary Industries Commission, and a member of the Joint War Production Committee. He was thus closely associated with Australia's war production activities and with the efforts of the Division of Industrial Development in the Department of Post-War Reconstruction.

Subsequently, Mr. Knott occupied senior positions concerned with Defence Production Planning; he became Secretary to the Department of Defence Production in 1957.

In 1959, Mr. Knott was appointed Secretary, Department of Supply, becoming responsible for the administration of a large Department concerned with such matters as supply of aircraft and munitions, including management of government factories, operation of storage and transport facilities, and defence research. He became associated with many significant developments in both the scientific and defence fields, including:—

- Production of aircraft —
  the Avon Sabre Fighter,
  Canberra Bomber,
  Mirage Fighter,
  the Jindivick,
  Anti-submarine System Ikara,
- The building and equipping of St. Marys Filling Factory.
- The commercial exploitation overseas of research laboratory developments.
- Formation of the European Launcher Development Organisation.
- The establishment of working facilities in Australia by NASA, U.S.A.
- The development and adminisration of the Industrial Mobilisation Course, Australia.

His work in the Department of Supply brought Mr. Knott into close association with leaders of industry not only in Australia but also overseas in such countries as U.S.A., U.K., France and Japan. He was a member of the Australian Defence Mission to the United States in 1957 and was the leader of the Australian Mission to ELDO Conferences in London in 1961 and Paris in 1965, Rome in 1967 and Bonn in 1968. He was Senior Vice-President, during 1967/68, of the ELDO Council which met regularly in Paris.

Mr. Knott was appointed as Deputy High Commissioner for Australia in the United Kingdom and took up this post in London in March 1966. He has since been closely involved in representation of Australia in Britain and has attended a number of International conferences. He was a member of the Review Committee set up in 1966 by Commonwealth Prime Ministers to report on the operations of the Commonwealth Secretariat in London. He was also active as a member of the Commonwealth Foundation official Sub-Committee of Trustees appointed to deal with out-of-session applications by Commonwealth Countries for financial and professional help by that body. He is a Freeman of the City of London.

Mr. Knott has a wife, three sons, one daughter and one grandson. He is a Member of Rotary and a former Senior Vice-President of the Royal Victorian Bowling Association; his main hobbies are golf and gardening.

The Board of Editors, on behalf of the Telecommunication Society of Australia, congratulates Mr. Knott on his new appointment. We look forward eagerly to the prospect of working with him and feel sure our members would have us offer full support on the many tasks that lie ahead.

LIKELY DEVELOPMENTS IN TELECOMMUNICATIONS

Editorial Note: On 9th December, 1968, Dr. Henri Busignies of the I.T.T., New York, addressed senior staff of the Central and Victorian Administrations on likely developments in telecommunications over the next 20-30 years. The following precis of some of the main points was prepared in consultation with Dr. Busignies, and should be of general interest to readers. The Editors gratefully acknowledge Dr. Busignies' assistance in preparing this precis.

GROWTH IN WORLD TELECOMMUNICATIONS BY THE YEAR 2000

World telephones are expected to increase from 220 million to 1,000 million by the end of the century, i.e., in the next 32 years. This increase will not be in the high density networks like U.S.A., Canada or Sweden, but rather in the low density areas. Some typical densities in telephones per 100 population are:

France	—14
Latin America	—2.5 average
Russia	—3.9
U.S.A.	—52
Australia	—27
Sweden	—50

A major problem for the lower density countries is the rapid rate of growth, which could be equivalent to doubling the network every five years. Generally this is too fast for Administrations to handle, especially in the areas of training, programming and logistics.

There is a similar growth problem in the international traffic area where the present growth rate is around 30% per annum. The nature of this traffic is such that the growth does not seem to present a large problem. It is expected that the number of people employed in telephone companies will rise from two million today to a world total of ten million by the year 2000, and that plant investment will reach U.S. $5 billion by year 2000.

50% of the computers are connected to communication systems today and by the year 2000 the figure is expected to reach 80%. Therefore, data transmission will be a major growth area in general communications, and in educational communications.

The widespread availability of wideband transmission facilities at reasonable rates will permit a big increase in data and educational information transmitted over the communications network. In fact the availability of wide band transmission facilities is a key to the next stage of development in communications services, both in volume and range of services. For instance, the cost of channelling transmission equipment has reduced by a factor of ten in the last 12 years, with no parallel reduction in switching costs per line. A break through in transmission cost reductions can happen in the future, for instance, by the use of fibre optics, or other new techniques, but there is no corresponding reduction in switching costs in sight.

APPLICATION OF SATELLITES AND CABLES

Dr. Busignies reported that a Presidential Task Force had been set up to examine the domestic communications problems of the United States, and particularly the relative fields of use of satellites, microwave systems, coaxial cables, and urban communications. The efficient use of the frequency spectrum is a major problem currently in the U.S.A. especially having regard to future growth expectations. The National Academy of Engineering is attempting to assist the decision makers by designing some process by which the relative values of spectrum uses could be appreciated correctly.

Regarding the relative costs of cables and satellites, multiple access satellite communications are attractive compared with cable facilities when many points are to be interconnected particularly in the international network, but on main point-to-point routes the economics are not clear. In the domestic network it would appear that the economic break-even distance for satellite communications is about 1,300 miles, but it could come down further. The economic field of use of PCM on cable pairs will reduce from 15 miles to a few miles in the next few years.

Satellites

Satellites will find national or regional application where the use of cables or microwave links is difficult. Examples are: Brazil, India, Africa and other Latin American countries. There are two Russian satellite systems —

(i) Molniya satellites in elliptical orbit, each visible over Russia for a period of eight hours and used for TV relay and some communications.

(ii) An experimental synchronous satellite for communication of moderate capacity.

In America there are pressures for educational and normal TV relays to stations via satellite. There is the 'Teleclub' system proposed for developing countries such as India by means of which educational and informative TV programmes would be transmitted over a satellite and received on a cheap antenna of 15 to 20 ft diameter used to operate a group receiver for the village. An experimental installation to prove this 'village receiver' concept has been tested with great and continued interest on the part of the villagers. The receiver output can also be re-transmitted from a low-power transmitter for local reception by standard TV receivers.

Use of Frequency Spectrum

At present some frequency bands are shared between microwave and satellite systems and mutual interference is kept to tolerable levels by some restrictions imposed by agreed regulations and by geographical separation between stations. The frequency bands of 4 GHz and 6 GHz are used for this purpose and will be sufficient for some years into the future. However, this will not last indefinitely and other parts of the spectrum will need to be made available for use by communication satellites.

To connect communication satellite earth stations to the rest of the telecommunications network, microwave feeder systems can be used provided that the feeder system uses different frequency bands from the satellite system. The alternative is to use coaxial entry cable. Interference isolation can be provided by installing the satellite ground station in a valley or between mountains; an example of such an arrangement exists at Hawaii. It is not possible to locate satellite earth stations close to heavy centres of population such as the eastern seaboard of U.S.A. because of the number of microwave systems focussing on such centres.

Intensive studies of propagation of the frequencies above 10 GHz for satellite use are to be undertaken for future satellite applications. In view of the shortage of frequency spectrum within urban areas in the U.S.A. for mobile radio telephone services, consideration will have to be given to releasing one or two UHF channels up to 960 MHz at present held in reserve as TV transmission channels so that these may be made available for mobile radio telecommunications.

Submarine Cables

Cable capacity of up to 2,500 circuits in 1970, growing to 10,000 circuits by 1980 is foreseen. The cost per circuit mile should fall from $30 in 1970 to less than $10 by 1980.

80% of world communications flow between Japan, Europe, U.S.A., and Australia. Therefore having regard to the growth forecasts there is likely to be spectacular development on routes to other parts of the world. Satellite development work has stimulated cable transmission improvements. An example is a project to produce a submerged repeater with a power consumption of only three watts. Isotope power supplies which could be used with each submarine repeater at present cost $50,000 to $80,000 and are very heavy. However, their cost may come down and if this were the case, repeaters could have their own power supply.

SWITCHING SYSTEMS

The Bell system plans envisage no crossbar remaining in the network in the year 2000. However, crossbar will continue to be installed up to 1975, and electronic equipment will be added to crossbar and step to provide new facilities up to this date. There will be no step-by-step in the Bell System network by the year 1990 and all Panel will have been removed by 1980. At present there are about 44 E.S.S. exchanges in service in the civil network.

Switching networks will be developed to handle different bandwidths to allow for data transmission and message switching; the switching equipment will be computer controlled. Bandwidths under consideration are 8, 12, 48 and up to 500 kHz. Computer users would wish to transmit data between computers at computer speed, therefore on large bandwidths, but it could well be that this transmission would be over leased lines.

SUBSCRIBER FACILITIES

The subscribers facilities will increase with push-button (4,000,000 sets in use in the U.S.) and card dialling, data phone, loud speaking telephone, videophone, telemetering, news library and other data bank access facilities and facsimile. In developing equipment to meet the abovementioned needs there is clearly a circular relationship between the technique, its cost, and the use to which it can be put. As long as telephone lines exist the data phone system will find application. In addition rented lines will continue to be used. Several wider band switching systems are in service and the American Government Services Administration network has switches capable of connecting lines with bandwidths of 12, 24, 48 and 60 kHz.

Private users may consider grouping their requirements to obtain economy and efficiency, and the proposed A.P.O. common user message switching network is an example of such a grouping.

PULSE CODE MODULATION

Dr. Busignies opinion is that if a new network was being established today, P.C.M. would be an immediate attractive prospect; however, with the existing investment in F.D.M., which would be controlling, there will be a continued development of conventional systems and P.C.M. will thus take longer to introduce. There are still some essential standardisation problems to solve for P.C.M. transmission facilities including whether 24 or 32 channels should be the standard. In U.S.A. P.C.M. is used widely and the B.P.O. is planning extensive use of P.C.M. 24 channel equipment. In Japan also 24 channel P.C.M. is being produced. The 96 channel group is now available and work is being done all the way to 224 megabits.

P.C.M. Switching

Dr. Busignies confirmed that introducing P.C.M. switching into an F.D.M. environment was difficult. The Russians are looking seriously at P.C.M. switching in view of the low telephone density in their network. There will not be product stabilization from some 10 to 15 years from now. The real economies in P.C.M. switching may be first in tandem switching where many P.C.M. trunks are converging and later in subscribers networks, and therefore I.T.T. are working on an efficient and cheap coder for the subscribers telephone. A study has been made on hybrid switching, a combination of semi-electronic and P.C.M. switches, which seems quite encouraging from a cost standpoint.

BUSIGNIES — Likely Developments

BOOK REVIEW

ATMOSPHERIC ELECTRICITY

(2nd Edition)

J. Alan Chalmers 1967
Pergamon Press pp.515
Australian price $14.50

Chapter Headings: Historical survey — General principles — Clouds, water and ice — Ions and nuclei — The Vertical potential gradient — Space charge — The conductivity of the air — The Air earth conduction current — Point discharge currents — Precipitation currents — The transfer of charges — The Thunder cloud — Non stormy clouds — The lightning discharge — Atmospherics — The separation of charge — Conclusion — Appendices — References — Index.

This book is a revised and updated version of an earlier edition, first published in 1956. It is essentially a reference volume dealing with electrical phenomena in the atmosphere up to a height of about 50 Km. The style and presentation will permit the non-specialist in this subject to gain an understanding, whilst the specialist will obviously want to probe more deeply into the original papers liberally referred to in the text. Mathematics are kept to a minimum and never go beyond simple calculus.

Each subject is briefly introduced and defined, and is then followed by a historical survey of the findings and measurement techniques up to 1965 in summary form, quoting from an extensive reference literature. The chapter of perhaps greatest interest to the Telecommunication engineer is the one dealing with lightning discharges, but such subjects as lightning flash incidence, waveshape and energy distribution are only very briefly dealt with, and the considerable experience accumulated in these matters by various investigators including those at the University of Queensland over the past 10 years get little mention.

The book could have been improved by the inclusion of a list of symbols used, thus preventing the necessity of having to refer back to earlier chapters to find symbol definition. The Greek letter rho is used both for volume charge density (p. 24) and specific resistance (p. 27).

The book achieves its author's aim of presenting a survey of present knowledge in the field of atmospheric electricity. As the book deals with basic physical properties, its contents are equally pertinent to the Australian reader, and constitute a valuable source of reference to both the specialist and those seeking some insight into this subject. — (G.F.)

PERT IN THE LIGHT ENGINEERING FIELD

S. A. HOWARD, A.M.I.I.E. *

Editorial Note: This article is reprinted from 'The Industrial Engineer', February 1969 with the kind permission of The Institute of Industrial Engineers.

INTRODUCTION

General

The introduction of critical path analysis and resource scheduling techniques has resulted in significant savings being achieved in many organisations throughout Australia and overseas. These techniques have particular application to specific work such as telephone exchange installation, and can be extremely helpful in planning and controlling many types of project.

Experienced work project managers and supervisors intuitively recognise those critical factors which ensure the smooth and efficient undertaking of a project such as the installation of a telephone exchange. In an informal way they quickly recognise inefficiencies resulting from lack of material, insufficient instructions, unsuitable tools and insufficient co-ordination with other dependent projects. Critical path analysis and resource scheduling are methods of formalising these intuitive processes so that project managers and supervisors, irrespective of their experience can very considerably improve the effectiveness of project supervision.

The introduction of these new methods of project control into an administration or organisation is not simply a matter of training the staff concerned. In addition to formal training it is necessary for the managers and supervisors to subject themselves to new disciplines which require a more analytical approach to project control than has been used in the past. Experience shows that when people are familiar with the new methods they soon prove them to be indispensable for effective management.

Network planning requires greater effort than would be normal for traditional methods such as bar charting. However, having experienced the benefits of network analysis and planning there is no doubt that the users find the extra effort of little significance when weighed against the saving achieved. The preparation of a network can be described as a feasibility study requiring numerous decisions to be made at the networking stage before commencement of the project. Using traditional planning methods, many of these decisions would probably not be made at this early stage and consequently holdups, which could have been avoided, become inevitable during the course of the project.

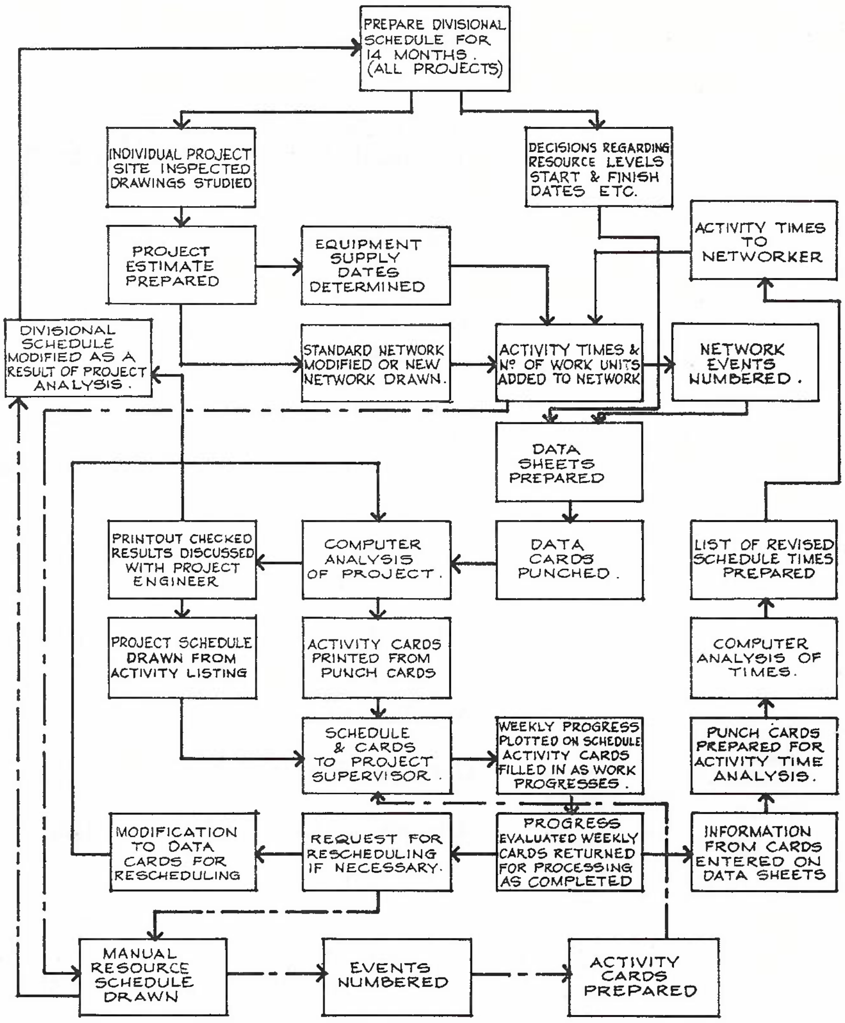
This paper presents the application of networking techniques, resource scheduling and control in the light engineering field of an Exchange Installation Division of the Postmaster-General's Department, Brisbane.

The term PERT (Programme Evaluation Review Technique) will be used from this point on to embrace networking, resource scheduling and control. Definitions of other networking terms used in this paper are given in Appendix I.

Background

A little background information on the extent of the use of PERT in the installation field will provide an indication of how the use of such techniques can provide the basis of a management control system for an organisation concerned with project type work. An installation division undertakes some 10 to 12 major projects at any given time, with the duration time for any project varying from 4 to 12 months. Equipment is supplied from a common pool and availability of many items is limited. A technical staff in the order of 100 persons is available to be allocated to the projects. The resulting situation is one involving the problems of multi-project scheduling and resource allocation.

PERT was introduced into this area in 1963. Since then all major projects have been subjected to PERT analysis and control. During the initial 12 months each project was considered as a separate identity and the indications of the need for multi-project scheduling soon emerged. This was largely a period of gaining exerience with the technique



- – – – – – – VARIATIONS FOR MANUAL PROCESSING.

Fig. 1 — Basic Flow Chart.

* Mr. Howard is a Technical Officer, Grade 2, (Work Study), Metropolitan Branch, Queensland.

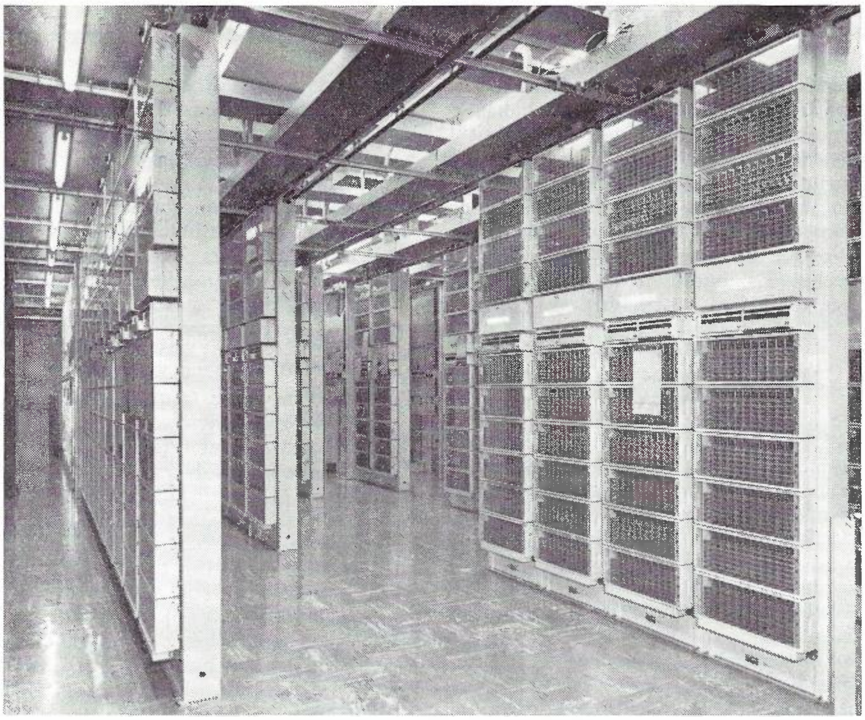


Fig. 2 — A Portion of the Main Equipment Room in a Typical Modern Automatic Telephone Exchange.

and overcoming the many problems associated with implementing a major change in project planning and control. Full implementation of changes such as this is a slow and often difficult task but one that will result in extensive savings through improved planning and control.

Multi-Project Co-ordination

It became evident that co-ordination of a larger area through multi-project planning was desirable and in fact necessary in order to achieve overall divisional control and improved resource utilisation. After the initial 12 month period a divisional scheduling system was evolved. In this overall planning which takes place before network preparation for any project, each project is represented by one activity on a large scheduling board. Broad divisional planning is undertaken on this board to ensure that the available resources are capable of achieving a given programme of work over a period of 14 months.

The flow chart, Fig. 1, illustrates the basic steps involved in this system of scheduling and control for both computer and manual methods.

Since gaining some two years experience using manual methods of computation and resource scheduling, standard computer programs have been utilised to process numerous networks and provide resource limited schedules. Manual methods are still used and will continue to be used on the smaller projects or where minor adjustments to an existing schedule will enable it to be used for another project.

THE APPLICATION OF PERT TO A PROJECT

Selection of Activities

While all major projects are scheduled using PERT techniques, this paper discusses the steps involved in the application of networking and resource scheduling to one project using computer processing. The project is the installation of automatic telephone equipment in a new building. The building houses other equipment areas such as power plant, batteries, air-conditioning plant, testing equipment, etc. A view of the main equipment room in a typical exchange is given in Fig. 2.

When the objective is clearly established, a list of activities to be performed is necessary to enable networking to proceed. Because of the nature of the installation work, it has been possible to prepare a manual which lists most of the activities expected to be encountered during most projects. (See Fig. 3). The preparation of the initial activity list required a careful study of the equipment, floor space restrictions and skills required. Where an activity requires a team effort, e.g. a team to run a group of cables or erect a bulky or heavy item of equipment, it is important to take these practical considerations into account and the activity definitions have been prepared along these lines.

Correct activity definition is most important if practical and acceptable schedules are to be produced. Another important consideration when selecting activities is the way the supervisor sees the work under his control. Each activity must represent to him a distinct and controllable task.

Preparation of the Network

The network is the basis of all further calculations relating to the project, hence it is important to ensure that it is a true representation of relationships, restrictions and decisions. The schedule ultimately produced from the network will be a much more acceptable plan of work if supervisory personnel have been involved in the discussions and decisions associated with the network preparation.

Since the introduction of PERT in the Division, there has been an awareness of the possibility of utilising a series of standard networks to cover a majority of the projects likely to be undertaken. Over the years, a library of networks and schedules have been produced and are used where possible to reduce networking effort. However, in most projects it is necessary to make at least some minor modifications to the standard networks to cope with particular problems. Any project requiring particular technical features or confronted with other than the usual difficulties, usually cannot be successfully related to

Sub-Group	Activity No.	Equipment Type or Operation	Unit	State Unit Time	Notes
G2 D.C. Power Distribution Work in equipment room only, but including connection to discharge or distribution panel	G201	Fit power box and connect suite cabling	Power Box		
	G202	Cable for suite distribution	10 Metres of Cable		
	G203	Connect rack to suite cabling	Rack		
	G204	Cable main distribution. Fit lugs and terminate each end.	Metre of Cable		

Fig. 3 — Extract From Activity Journal.

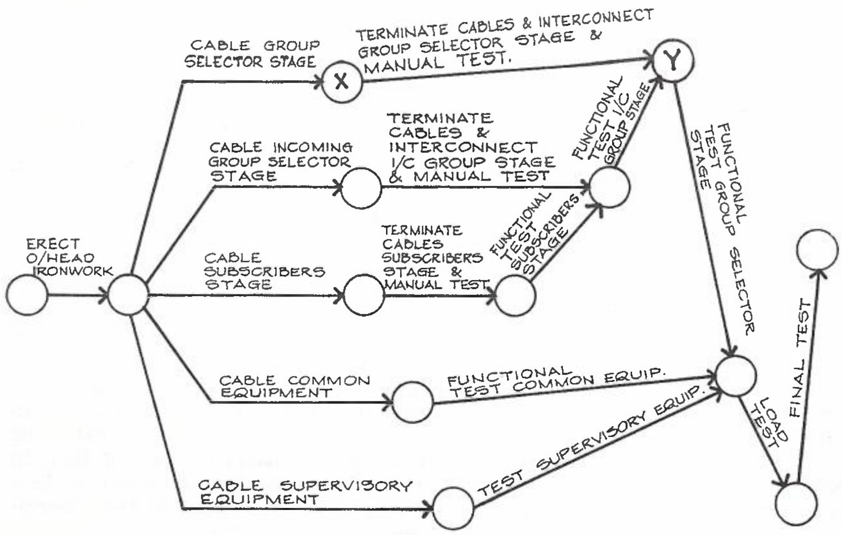


Fig. 4

a standard network and a new network must be drawn.

To determine whether a standard network can be utilised, the following steps are taken:—

(a) A study of the equipment layout, equipment interconnections and equipment quantities.

(b) The site is inspected and any unusual difficulties discussed with the project engineer.

(c) An assessment of the extent of variation from a standard network is made.

Whilst a definite yardstick has not yet been determined, if changes to a standard network in the order of about 30% are necessary, it is usually better to prepare a new network.

Setting the network out on the drawing board is often a problem because of the network size and complexity. Many of the networks range from 220 to 550 activities and can be prepared on a 30 in. x 60 in. sheet. Initially the project details are studied to enable the networker to visualise the broad outline of the project. If this is committed to paper, in simplified form, it may appear as Fig. 4.

Network numbering and activity duration times are not considered in this broad context. Having established an overall impression of the project, the detailed network can be prepared. This process can be completed in stages to some extent, bearing in mind that a network is a working diagram and not an exercise in art. A networker must be prepared to modify his network in the light of new information or decisions.

A segment of the broad network, e.g. activity X-Y of Fig. 4, is taken as a sample in Fig. 5 for finer breakdown into working activities. The delivery times for equipment are shown against the appropriate supply activity. This is essential to build all known delays into the network.

Activity Duration Times

When the network or logic diagram is completed and checked, activity duration times are added. The necessity for fairly accurate duration times is obvious, but the calculation of times for activities encountered in project work presents difficulties as the usual work measurement techniques are often difficult and uneconomical to apply under such conditions.

Initially, to establish duration times for the listed activities, several conferences both formal and informal were conducted to arrive at a set of times which were agreed to and accepted by all concerned. Reasonably accurate estimates were made of most activity times, but for some, only an approximate estimate could be made.

The first PERT schedule introduced was accompanied by a system of information feedback for control purposes and data regarding time taken for each activity. From this data the duration times have been reviewed regularly to maintain realistic planning information. The method of providing feedback information has been revised from time to time, but essentially it consists of the recording of activity times on standard activity cards in the field.

Single time estimates are now used on all activities. In the early stages of implementation three time estimates were used on selected projects for the variable activities associated with equipment testing. This enabled the probability of achieving a target to be calculated, provided that the activities of a more

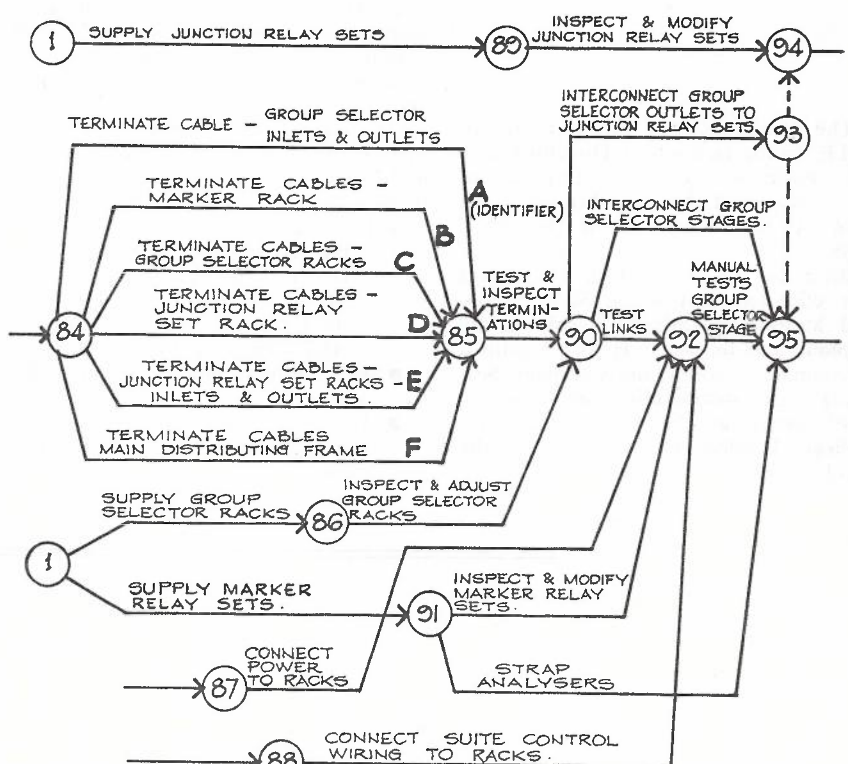


Fig. 5 — Group Selector Stage. Activity definitions are abbreviated in actual practice.

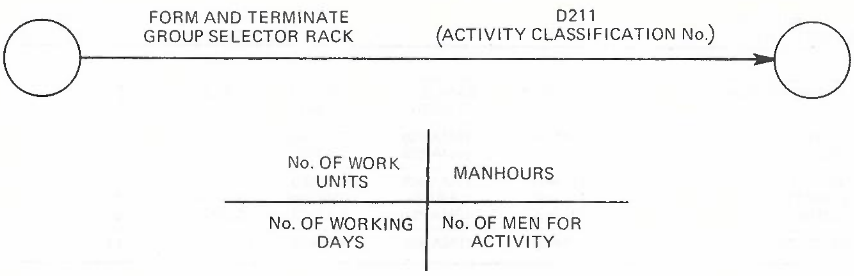


Fig. 6

stable nature were performed as scheduled. As the probability of meeting a target proved acceptable, it was decided that single time estimates would suffice for all activities, provided the recorded times did not disclose a range for any activity beyond specified limits without an assignable cause.

From the activity list the data as in Fig. 6 is added to the network.

COMPUTER PROCESSING

Preparation

As this network processing and resource levelling is to be performed by the computer, all events are numbered to meet the requirements of the computer PERT programme. Random numbering is acceptable and less time consuming than sequential numbering. The identifier used on parallel activities in Fig. 5 is a time saving feature of the programme aimed at reducing the number of dummy activities in the network.

If manual methods are used, the network events would not be numbered until all calculations have been completed and the network extended onto a time scale for resource levelling. When resource levelling is complete, the event numbers are entered on the schedule from the start of the project. This method of numbering produces a set of activity cards numbered in sequence according to activity scheduled start time.

When all data is inserted on the network for computer processing the information is entered on 80 column punch card data sheets. One line of a data sheet represents one activity. The data preparation can be considered in two groups.

Group 1 — Network activity data as in Fig. 7. As far as the computer programme is concerned, the project is the entire division and a sub-project is an individual installation. The activity data includes the division and individual installation identification codes, network event numbers, activity duration time, activity description, classification number, resource types and requirements for the activity.

Transcription from network to data sheets requires considerable care to avoid errors. The type of errors encountered have been:—

(a) Omission of an activity which can result in incorrect logic analysis but not show up as an error.
(b) Omission of an activity resulting in start or finish dangles in the network.
(c) Data entered in incorrect columns or card punching errors.
(d) Duplication of an event number which can produce a network loop.

Group 2 — Control directives regarding the decision table to be used and output format. Also information regarding resource availability, activity costs, holidays and overtime.

In the particular PERT computer programme used, there are nine basic decision tables designed to place restrictions on the computer programme in order to achieve a particular type of processing and result. Examples of the decision tables are:—

Decision Table 4 — The computer process is:—

Attempt to schedule the project in the network time using normal level of resources. If the normal level of resources is inadequate extra **time** is used. This extra time has to be specified as threshold time.

If the extra time is not sufficient, extra resources which have been specified as threshold resources are used.

If the extra time and resources are still insufficient, additional time is used to complete the project.

Decision Table 8 — The computer process is:—

Attempt to schedule the project in the network time using normal level of resources. If the normal level of resources is inadequate extra **resources** are used. The extra resources have to be specified as threshold resources.

If the extra resources are still not sufficient to complete the project, threshold time is used.

If the extra resources and time are still insufficient, additional resources are used to complete the project.

To decide which decision table will be used, the divisional schedule board is studied to enable the following questions to be answered:—

(a) Must this project be completed to meet a firm time commitment?
(b) If the commitment cannot be achieved using the specified resources, will extra resources be made available.
(c) If the answer to (b) is yes, when will the extra resource be available and how much extra?
(d) Must this project be completed as economically as possible using limited resources, irrespective of completion date?

Computer Output

Because of the variety of outputs available from the programme, careful consideration has to be given to this aspect and the desired output selected and specified in the control directives. When considering types of output, one must remember that a scheduling system is actually an information system, the results of which are useless unless they are easily understood and lead to corrective action. The usual output for this type of project is:—

(a) Listing of input data.
(b) Time analysis in which the activities are listed in the order of minimum total float to maximum total float. Earliest and latest start and finish dates, along with total float and

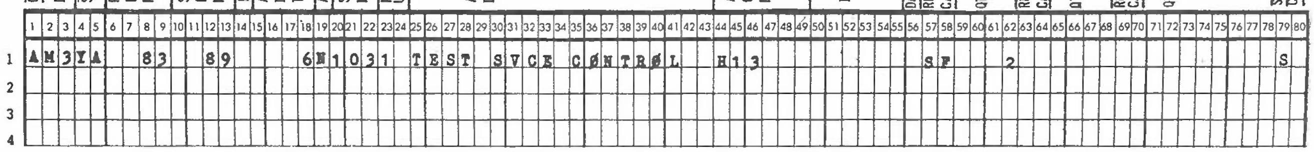


Fig. 7

I.C.L. 1900 SERIES PERT PROJECT M3 20/11/68 **SUB PROJECT TITLE** OUTPUT SHEET NUMBER 13 TIME NOW 25NOV68 PAGE 5

TIME ANALYSIS

S/P CDE	PREC EVENT	SUCC EVENT	REPORT CODE	DESCRIPTION	DUR	EARLIEST START	EARLIEST FINISH	LATEST START	LATEST FINISH	TOT FLOAT	FREE E FLT
YA	83	89	H13	1031 TEST SVCE CONTROL	6	10MAR69	18MAR69	2JUN69	10JUN69	57	57
YA	27	86		DUMMY	0	10MAR69	10MAR69	3JUN69	3JUN69	58	0
YA	86	89		16 1 TEST FACILITIES	5	10MAR69	17MAR69	3JUN69	10JUN69	58	58
YA	161	34		DUMMY	0	10FEB69	10FEB69	9MAY69	9MAY69	61	30
YA	27	85		DUMMY	0	10MAR69	10MAR69	6JUN69	6JUN69	61	0
YA	85	89		16 1 TEST TFC RCDR	2	10MAR69	12MAR69	6JUN69	10JUN69	61	61

Fig. 8

I.C.L. 1900 SERIES PERT PROJECT M3 20/11/68 **SUB PROJECT TITLE** OUTPUT SHEET NUMBER 32 TIME NOW 25NOV68 PAGE 14

ACT SCHED

S/P	PREC EVENT	SUCC EVENT	U I	REPORT CODE	DESCRIPTION	DUR	EARLIEST START	SCHED START	SCHED FINISH	LATEST FINISH	REM FLOAT	RESOURCES R1		R2
YA	83	89		H13	1031 TEST SVCE CONTR OL	6	10MAR69	9MAY69	19MAY69	10JUN69	16	2SF	6	
YA N	86	89			16 1 TEST FACILITIES	5	10MAR69	12MAY69	19MAY69	10JUN69	16	1SF	5	
YA	160	90		H20	2001000 TEST SUBS LI NES	12	1MAY69	3JUN69	20JUN69	17JUN69	-3	2SF	12	
YA	63	91		G70	30 1 FACILITY CHECK CNTE	4	27MAY69	27MAY69	2JUN69	23JUN69	14	1SF	4	

Fig. 9

free float, are given for each activity in this listing as in Fig. 8.

(c) Resource listing, showing the resources required for each day of the project.

(d) Activity schedule, listing all activities in order of scheduled start date. This schedule incorporates the resource restrictions specified in the control directives. The earliest start and latest finish dates are given, in conjunction with the scheduled start and finish dates, and the remaining float and resource requirements for each activity, as in Fig. 9.

(e) Cost histogram. This is a graph which indicates the progressive man-hours (or cost if desired) for each day of the project.

Computer printed bar charts have been used on a few projects but because inter-relationships are not shown, difficulties have been experienced in their use for control purposes.

THE WORKING SCHEDULE

It is most desirable for the working schedule to display the project graphically, showing the inter-relationships between activities. For this reason the information provided by output (d), the activity schedule, is transcribed into a time scaled drawing of the network as in Fig. 10. This becomes the working resource limited schedule for the project. Resource requirements and equipment supply times are entered on the schedule along with any important information regarding the timing of activities associated with other projects. The schedule is used in conjunction with the

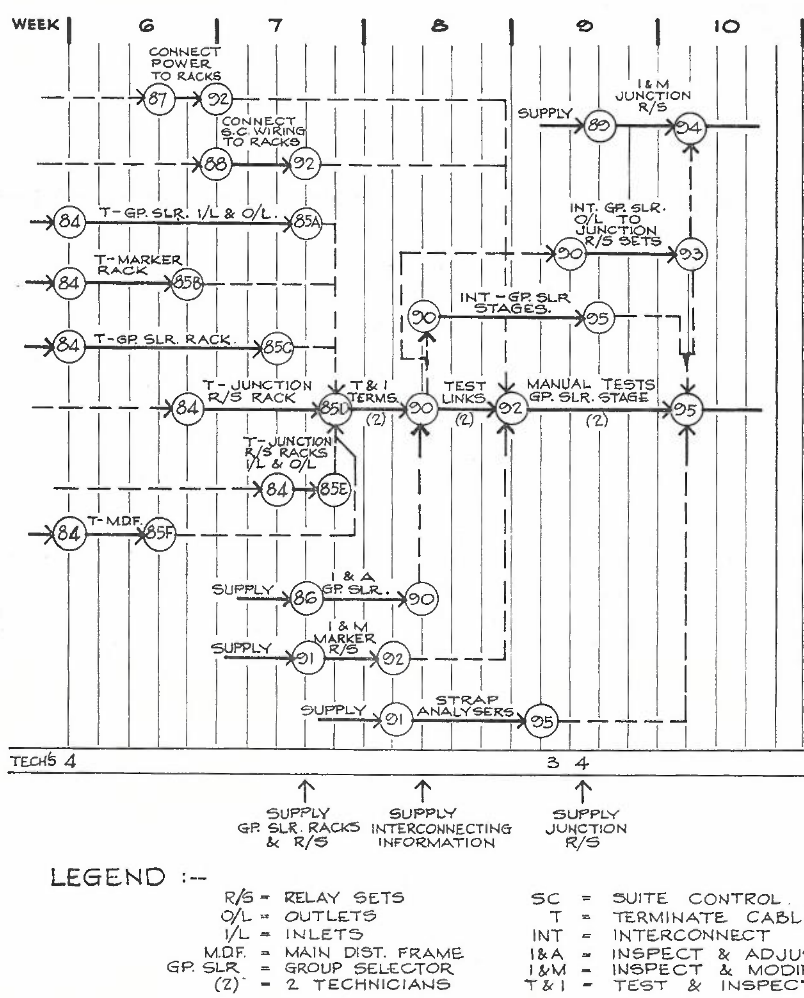


Fig. 10 — Portion of a Working Schedule.

EQ109 (4/68)

TOTAL HOURS WORKED

POSTMASTER GENERAL'S DEPARTMENT

WORK RECORD ACTIVITIES

EXPLAIN WORK VARIATIONS ON BACK OF CARD

CARD ...... OF ...... CARDS

Project or Exch.	NETWORK EVENT No.		CLASSIFIED ACTIVITY No.	SCHED. HOURS	No. OF UNITS	ACTIVITY TITLE	WORK AUTHORITY
E3	1	2	B202	45	30	ERECT THROUGH S11 12	

	DATE	M/HRS WORKED	PROG. TOTAL	ESTIMATED % COMPLETION	% COMPLETION X SCHED. M/HRS.	DATE	M/HRS. WORKED	PROG. TOTAL	ESTIMATED % COMPLETION	% COMPLETION X SCHED. M/HRS.
SCHED. START DATE										
....										
SCHED. FINISH DATE										
....										
SIG. .... SENIOR TECH.										
INIT. .... SUPVG. TECH.										

Fig. 11 — Activity Card.

manhour graph to control the progress of the work.

A copy of the schedule and a set of activity cards are given to the project supervisor prior to commencement of the work and another copy of the schedule is displayed in the engineering office. An activity card is prepared for each activity in the network. (See Fig. 11).

The cards are typed automatically from the punch cards on a machine programmed to select data from the required punch card column and reproduce it on the activity card in specified type spaces. These cards become the job cards and provide a major source of feedback information.

PROJECT CONTROL

When resource levelling has been completed, it is not unusual to find that the critical path time for the network has been extended because of limited resource availability. Under these conditions, the critical path loses some of its significance and the important consideration becomes the overall pattern of the schedule. Every effort must be made to work as closely to this pattern as possible otherwise rescheduling will be necessary.

During the course of the project, the supervisor allocates activities and their associated cards according to the schedule. Each week, progress is plotted on the schedule and an evaluation of progress made. When the pattern of progress deviates from the schedule, the supervisor must take appropriate control action.

When unforeseen holdups or changes occur, as they do from time to time, rescheduling is usually necessary. This may require a new network or simply modification to some of the activity duration times.

CONCLUSION

The PERT system of scheduling and control has been firmly established in the exchange installation area of work and provides a degree of control far superior to that provided by previous methods. Multi-project scheduling and co-ordination has resulted in major savings being achieved through:—

(a) Improved decision making based on network analysis.
(b) More efficient utilisation of men and equipment.
(c) Improved project control.
(d) Improved communication between the various levels of staff concerned and other divisions or sections.

Management and supervisory personnel involved in planning and controlling complex engineering projects requiring co-ordination of men, material, information and time can benefit from the application of network techniques and resource scheduling. The use of these techniques is in an early stage of development in limited areas of the Department and it is envisaged that their use will spread into other areas as the advantages and benefits are realised. Widespread application can only be achieved if management and supervisory personnel are prepared to play an active role in development and operation.

As a result of the experience gained in Queensland and of studying systems in other organisations, the following three factors have emerged as essential to the successful acceptance and operation of a project scheduling and control system:—

(a) The realisation by management of the need to use modern techniques to gain improved control over functional activities.
(b) The need for active participation and co-operation by both mangement and supervisory personnel.
(c) Selection and training of a suitable person to perform the following duties:—
    (i) Co-ordinate the implementation of the scheduling system.
    (ii) Provide the required staff training.
    (iii) Undertake networking and scheduling to ensure smooth and continuous operation of the system.

It is the author's opinion that network based management control systems have wide application in the Department and their implementation in project oriented divisions will result in economic gains and improved operating efficiency.

ACKNOWLEDGMENT

The Author wishes to thank International Computers (Australia) Pty. Ltd. for their approval to publish information regarding the ICL1900 series PERT programme.

APPENDIX I

TERMINOLOGY

Three Time Estimates is the term used to embrace a method of estimating a time for an activity when the work content is of an extremely variable nature. The activity time derived by this method has a 50% probability of being achieved.

Resource Levelling is the process of allocating a specific start and finish date to each activity in the project to ensure that a given target can be achieved without exceeding a limited number of resources such as men.

Events in a network are points in time when an activity or activities commences or finishes. The network symbol for an event is a circle.

Control Directives are a set of computer instructions designed to select the appropriate segments of the programme and produce a desired output format.

Earliest start date is the earliest date on which an activity can commence because of network restrictions.

Latest start date is the latest date on which an activity can commence and not delay the project completion time.

Earliest finish date is the earliest date on which an activity can be completed because of network restrictions.

Latest finish date is the latest date on which an activity can be completed and not delay the project completion time.

Total Float is the maximum amount of free time available to the completion of an activity. It indicates how long the start of an activity can be delayed without causing delays in the project completion date.

Free Float is the part of total float which can be utilised by a particular activity without affecting the amount of float or free time available to any following activities in the network. All activities do not necessarily have free float available to them.

Remaining float is the amount of float remaining when an activity has been scheduled to be completed earlier than its latest finish date.

ERLANG METERS IN ARM CROSSBAR EXCHANGES

T. ALLAN and I. W. LARSSON, A.R.M.I.T., Grad. I.E. Aust.***

INTRODUCTION

In a recent edition of the Journal Rubas and Carroll (Ref. 1) briefly outlined the use of erlang meters as a means of gathering traffic and revenue statistics in automatic exchanges. This paper deals specifically with the use of erlang meters in ARM 201/4 crossbar exchanges and discusses the ARM erlanghour meter survey diagram, erlang meter rack layouts and some of the facilities offered by this equipment.

Direct reading route occupancy indicators (See Fig. 1) are known as erlang meters; in the Australian Post Office, the accumulating erlang meters (See Figs 2 and 3) are known as erlanghour meters. In ARM exchanges the erlanghour meters are to be used for two distinct functions, namely, revenue recording and traffic recording. The types of erlanghour meters to be used will be the Siemens and Halske Company Model Fg69/5012, (Fig. 2), and the Masters Instruments Pty. Ltd. Model ECSQ144, (Fig. 3).

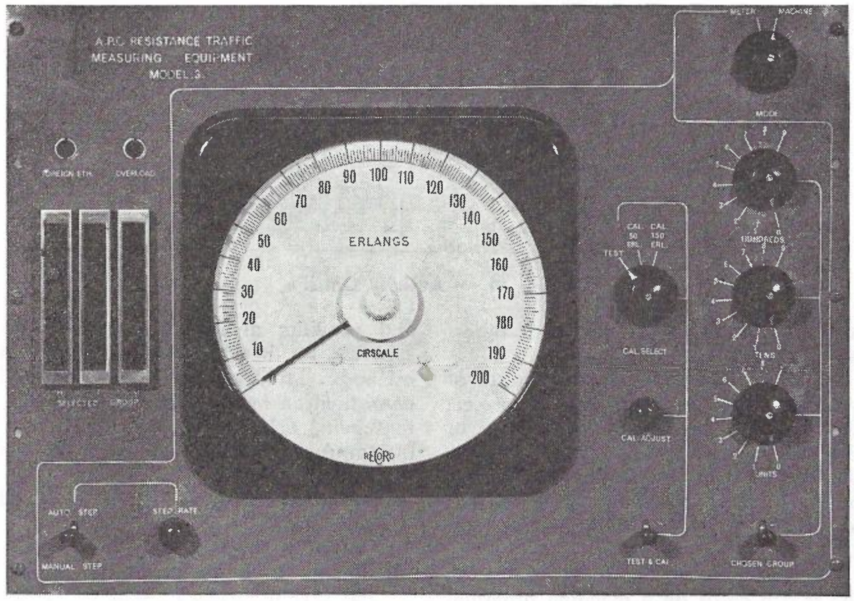


Fig. 1 — Route Occupancy Measurement Control Panel.

REVENUE RECORDING ERLANGHOUR METERS

Revenue recording erlanghour meters are used to record the following statistics.

Tariff Rates A to Y: Fourteen meters are required for this purpose, 7 for recording the day-time tariff rates between 9 a.m. and 6 p.m. and 7 for the night-time tariff rates betwen 6 p.m. and 9 a.m. To provide this facility the 'total metering per tariff' leads 1-7 on all FIR-ZM and FDR-ZM type relay sets are cabled away via an IDF to the erlanghour meters. Fig. 4 shows the details of these connections.

Unit Fee, No Fee and Repeats Remote Multi-metering: Three erlanghour meters are provided, one for each function, and operate continuously. The 'total metering per tariff' leads 9-10 on all FIR-ZM and FDR-ZM type relay sets are cabled away via an IDF and connected to the appropriate erlanghour meter. A facility to allow for the repetition of remote multi-metering signals is being introduced to allow for charging analysis to be carried out for unique network destinations such as New Zealand, United Kingdom and United States of America, at the point of entry to that network. The immediate use of the facility is required for International Subscriber Dialling (I.S.D.) calls, where the Austra-

* Mr. Allan is Supervising Technician, ARM Networks, Victoria.
** Mr. Larsson is Engineer Class 2, ARM Design and Co-ordination, Victoria. See Vol. 19, No. 1, Page 77.

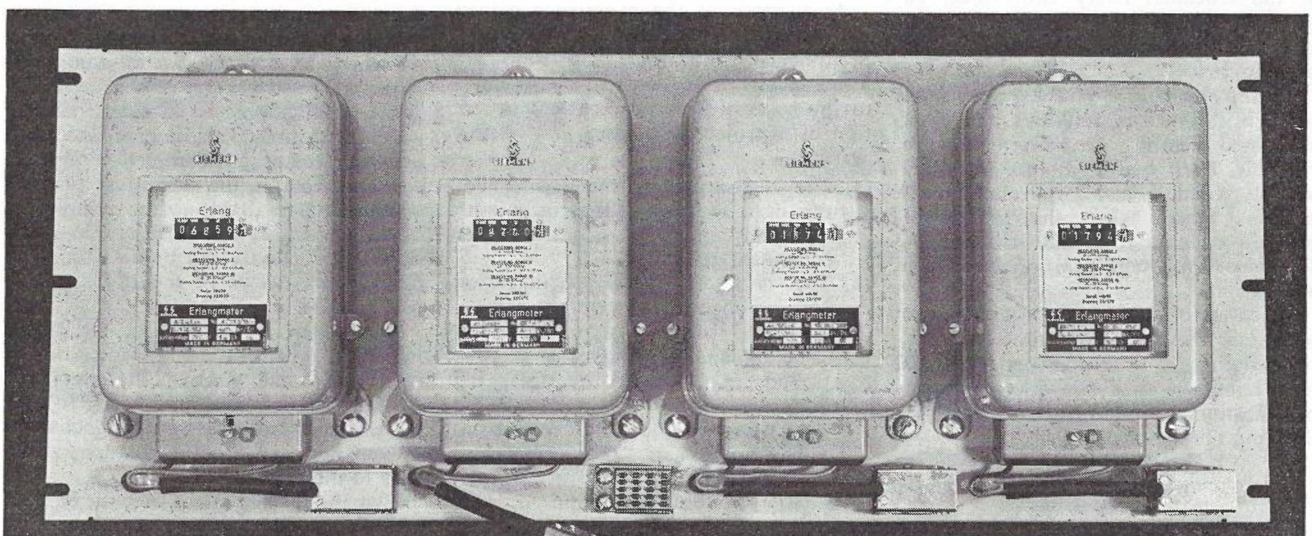


Fig. 2 — Siemens and Halske type Erlang Meters.

Fig. 3 — Master Instruments type Erlang Meter.

lian network tariff setting will be performed by FUR-ZTM-A relay sets at the Haymarket ARM exchange in Sydney. These relay sets will connect to direct links to the Overseas Telecommunications Commission terminal exchange in Sydney.

Total Traffic: A reading of total traffic is required as part of the revenue statistics and the total traffic meter will operate continuously except during the annual traffic recording sessions. This facility of recording the total volume of trunk traffic, paid and unpaid, is provided to obtain an accurate estimate of the total ineffective and unpaid traffic for local area originated calls. To accomplish this all TKTi leads in FIR-ZM and FDR-ZM type relay sets must be extended through to the total traffic erlanghour meter, as shown in Fig. 4.

TRAFFIC RECORDING ERLANGHOUR METERS

Outgoing Routes: For economic reasons it is necessary to restrict continuous traffic flow measurements to final choice (backbone) trunk routes. Some of the important high usage routes may also be observed if their dimensioning is regarded as critical. In this case however, the connection of erlanghour meters need not be permanent, the instrument being transferred to another route after a period of observation. Connection is made to the TKTu leads of FUR and FDR type relay sets which are extended to the I.D.F., all relay sets on a particular route having their TKTu leads commoned.

Incoming Routes: Normally, the erlanghour meters should be installed to record traffic flow at the originating end of the routes. However, for installation and reading convenience, the measurement of traffic on routes between minor switching centres and their parent secondary exchange may be carried out from the secondary exchange. This will avoid the installation of erlanghour meters at minor centres, and allow the meters to be centralised at secondary centres, thus simplifying the recording arrangements.

Seasonal Correction Indicator: Erlanghour meters may also be used to measure the total exchange originating traffic over the year, to provide a more accurate record of seasonal variations than that obtained from battery discharge readings. For this application the daily observation period could be one, two or three hours, but must include the exchange busy hour. In ARM exchanges the total link traffic will be used to indicate seasonal variation, the link groups being commoned and then strapped to an erlanghour meter.

Traffic Erlanghour Meter Control: To confine the recording of traffic flow only to the busy periods of business days, erlanghour meters must be time switched. This time may be arranged as a single 2-hour period, or two one-hour periods (Ref. 2). For recording convenience a single observation period which must include the busy hour, is to be preferred.

THE ERLANGHOUR METER

The erlanghour meter (Ref. 3) is essentially an integrating counter, consisting of an ampere hour meter and a contact mechanism for the emission of pulses. It is used to integrate current flow through traffic recording resistors in telephone equipment. The pulses emitted can be used for remote indication in lieu of visual readings taken at the instrument. In the usual application of measuring the flow of telephone traffic, each traffic carrying device is provided with a 100K ohm resistor, which is connected into the erlanghour meter circuit whenever the device in question is busy. The recording resistors will be connected in parallel between ground and the erlanghour meter, with 50 volt negative battery applied behind the meter. One of the operational requirements set down in A.P.O. Specification 1065, is that the voltage drop across the erlanghour meter terminals at rated current shall not exceed 0.5 volt. Thus, with a nominal battery potential of 50 volts, 0.5 milliamp will flow through the meter for every grounded traffic recording resistor, each grounded resistor representing one occupied circuit in the observed group. Since all traffic recording resistors are connected in parallel, the current flowing through the erlanghour meter at any given time is directly proportional to the total traffic flow during the period concerned.

To obtain the average traffic intensity the erlanghour meter reading must be divided by the elapsed time in hours and then subjected to range scaling factors.

Range Scaling Factors: In order to maintain a linear relationship between the erlanghour meter movement speed and the measuring current driving it, three measuring ranges are provided. The ranges are obtained by connecting different shunt resistors in parallel, or series/parallel, with the meter movement. The range selected is determined by the size of the measuring group, also taking into account the expected traffic density in that group. The scaling factors and impulsing rates for the 3 ranges are shown in Table 2.

TABLE 2: MEASURING RANGES OF ERLANGHOUR METERS.

Range	Number of Circuits in the Route	Counter Reading Scaling Factor	Pulse Count Scaling Factor	Number of Pulses per Erlanghour
I	21 — 100	1	0.1	10
II	101 — 500	5	0.5	2
III	1 — 20	0.2	0.02	50

For example, if the counter of a correctly calibrated meter operating on Range II advances by 42.3 units during one hour, the average intensity of the traffic carried is:

$$a = (42.3 \times 5)/1 = 211.5 \text{ erl.}$$

During the same period 423 pulses would have been emitted from the mercury switch, yielding the same traffic load measurement:

$$a = (423 \times 0.5)/1 = 211.5 \text{ erl.}$$

Accuracy: A.P.O. Specification 1065 states that error in the analogue to digital conversion process shall not exceed 2% when the measuring current is between 20% and 100% of the maximum value on any range. At lower current values a larger error can be tolerated, but it must be always less than 10%. That is, the reading over any given hour shall be within the stated percentages of the current analogue. The same accuracy standards apply also to the pulse output.

TIME SWITCH

The type of switch used is a Venner Time Switch Type TJD2SPS and is an electrically wound, spring driven time switch, carrying spring reserve power sufficient for a minimum of 9 hours running. Winding of the clock spring is effected automatically by a high torque synchronous motor, and once fully wound, the clock has a reserve of 9 hours guaranteed minimum. The clock can also be wound by hand for testing purposes or to prevent the clock stopping during a power failure exceeding the length of spring reserve.

The mechanism is designed for a seven day cycle and allows one or two 'on' and 'off' switchings during each 24 hours. Provision is made for automatic cancellation of the switching action during part of the seven day cycle, e.g., no switching on Saturdays and Sundays. The unit is supplied with a large dial, which gives a visual indication.

SURVEY DESCRIPTION

The survey diagram Fig. 4 indicates the effective circuit elements of the types of line signalling relay sets observed in ARM exchanges. The diagram also shows the manner in which connections are made to the enlanghour meters via the IDF and TM miscellaneous rack.

Revenue Recording: One 100K resistor connected to ground is provided in each FIR-ZM and FDR-ZM type relay set for this function. Depending on the combination of the tariff relay contacts when the called party answers, this resistor will be extended through to one of the TKTr leads 1-11. These leads are commoned at the IDF over all charging type relay sets and jumpered via day-night change over relays (in the case of tariff rate leads 1-7) or directly to their respective erlanghour meters.

During the 6 p.m. to 9 a.m. measuring period the night tariff charging rates are applied to FIR-ZM and FDR-ZM type relay sets. Connection of the 7 night rate erlanghour meters is established via normally released contacts of relays DNE, which are mounted on the erlanghour meter rack. From 9 a.m. to 6 p.m., however, the tariff change relay set CE-15173 is operated, applying the day tariff charging rates to the FIR-ZM and FDR-ZM type relay sets. The DNE relay operates in sympathy with the tariff change relay set, thus facilitating connection of the 7 day rate erlanghour meters to the TKTr groups.

Traffic Recording: One 100K resistor connected to ground is provided in each FIR, FUR and FDR relay set, regardless of type, for this function. This resistor will be extended through to the TKTi lead on FIR and FDR relay sets, or TKTu lead on FUR and FDR relay sets upon seizure. The TKTi or TKTu leads for each route are commoned at the IDF and then taken away as follows:—

(a) Incoming and outgoing routes not connected to erlanghour meters shall be jumpered direct to the route occupancy access switch.

(b) Incoming and outgoing routes connected to erlanghour meters shall be jumpered to the erlanghour meters via erlanghour meter interrupt circuits (initially by programme plugs) located on the TM miscellaneous rack. Connection of the TKT groups to the erlanghour meters will be via the interrupt circuit except during traffic recording sessions, when connection of TKT groups to the route occupancy measuring equipment is required.

(c) Incoming routes using FIR-ZM and FDR-ZM type relay sets, if not already connected to individual erlanghour meters, shall be connected to the total traffic erlanghour meter. This is carried out by individually connecting these TKTi groups to the erlanghour meter interrupt circuits as in (b) above. However, in this case these groups are commoned before connection to the total traffic erlanghour meter. This arrangement will enable individual routes to be connected to route occupancy equipment by the substitution of programme plugs, and later by relay operation in the erlanghour meter interrupt relay set.

If incoming route erlanghour meters are provided, the total traffic reading is obtained by the sum of the readings on both the total traffic and incoming route erlanghour meters. This is facilitated by the provision of change-over contacts on the BH relays used for connection of erlanghour meters during the busy hour. Over the greater part of the day when these relays are normal, the total traffic erlanghour meter will accumulate traffic from the incoming routes via these change-over contacts.

It should be noted that all traffic erlanghour meters are controlled by time switched BH relays to record busy hour traffic only, whilst the total traffic erlanghour meter, which is provided to supplement revenue statistics, operates continuously.

Circuits Free Indicator: One 100K resistor connected to ground is provided in each FUR-TM-C, FUR-T3M-C and FDR-TM-Y1/C relay set for this function. If the relay set is in the released and unblocked condition, this resistor will be extended through to the TKF lead which is cabled to the IDF. The TKF leads for each backbone trunk route are commoned at the IDF and taken away to the 4-wire manual assistance centre. A direct reading erlang meter, Fig. 1, will be provided on the supervisor's position, to indicate the number of circuits that are free on selected backbone routes to trunk distance centres, and which carry both subscriber dialled and operator switched traffic.

Erlanghour Meter Interrupt Circuit: Periodic full scale traffic studies will be carried out using the route occupancy measuring equipment located on the TM rack. This can be in the form of manually controlled measurements using a direct reading route occupancy meter, Fig. 1, or by the use of a portable automatic traffic recorder.

To avoid interference between this equipment and the erlanghour meters, special switching arrangements must be made. It is necessary to interrupt the erlanghour meter for a short time to connect the traffic measuring groups to route occupancy equipment.

Cabling is provided to cater for 10 measuring groups per 80 point knife jack position on the TM miscellaneous rack. Initially, 80 point fork plugs will

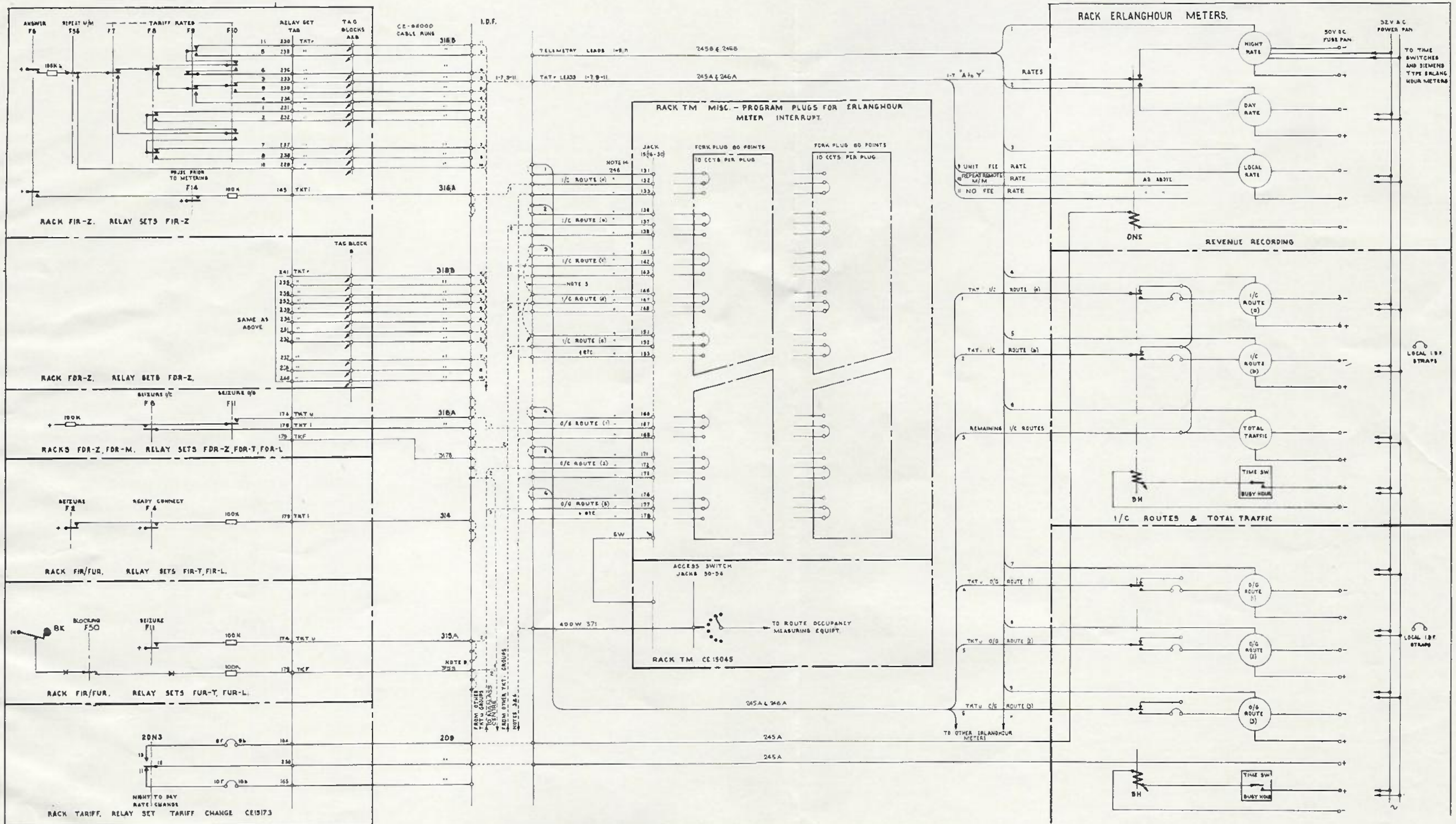


Fig. 4 — Route Occupancy, Erlanghour Meters and TKT Leads Survey Diagram.

be strapped as shown in Fig. 4, to perform the interrupt function, and inserted on the TM miscellaneous rack. One bar relay sets to perform these functions automatically have been designed at the Central Office Circuit Laboratory and when delivered, will replace the 80 point plugs.

MEASURING GROUP SIZE

Total Traffic: The maximum instantaneous capacity of erlanghour meters is 500 erlangs. At 0.7 erlang per incoming line this suggests a maximum measuring group size of approximately 700 measuring leads that can be accommodated by one instrument. At large metropolitan exchanges, where the measuring group size exceeds this figure, it will be necessary to provide more than one erlanghour meter and measuring group for this function.

Revenue: The maximum group size will vary for individual installations depending on the outgoing route provisioning. For example, Haymarket ARM exchange has approximately 2000 FIR-ZM type relay sets connected to revenue recording erlanghour meters. As only 400 outgoing circuits on routes requiring application of the 'Y' rate exist, this dimensioning is satisfactory. It can be seen that an examination of the charging analysis and trunking diagrams is necessary when providing this facility.

Route Occupancy: The maximum instantaneous capacity of route occupancy equipment is 200 erlangs, therefore, measuring groups connected to this equipment should be restricted to 200 TKT leads.

ERLANGHOUR METER RACKS

Type 1 Rack: This rack will be the 'first in' rack and accommodate revenue and traffic erlanghour meters as shown in Fig. 5. Two positions, 19 and 20, have been reserved for future revenue recording facilities. Relays for the control of revenue and traffic erlanghour meters are provided in a BCG relay set mounted in a central position, separating the revenue and traffic erlanghour meter groups.

Type 2 Rack: This rack will accommodate traffic erlanghour meters and associated time switches only, as shown in Fig. 5. Relays for busy hour control are provided in two BCG relay sets at the centre of the rack, relays for the upper half of the rack being mounted on panel 6 and for the lower half on panel 7.

Installation Aspects

The time switches should be mounted on the lowest panel so that erlanghour meters which need to be read frequently, can be placed at a more comfortable height.

Two erlanghour meter mounting plate designs are available, one design providing for 4 Siemens and Halske type erlanghour meters or 4 Venner type TJD 2SPS time switches, and the other design providing for 4 Master Instrument type erlanghour meters. Both panels are the same overall size and thus interchangeable on the one rack. Each erlanghour meter/time switch position on the mounting plate is provided with a 30 point knife jack, see Fig. 6.

The 20 point knife jack provides for:—

(a) complete rack wiring commons and cabling of partially equipped racks,

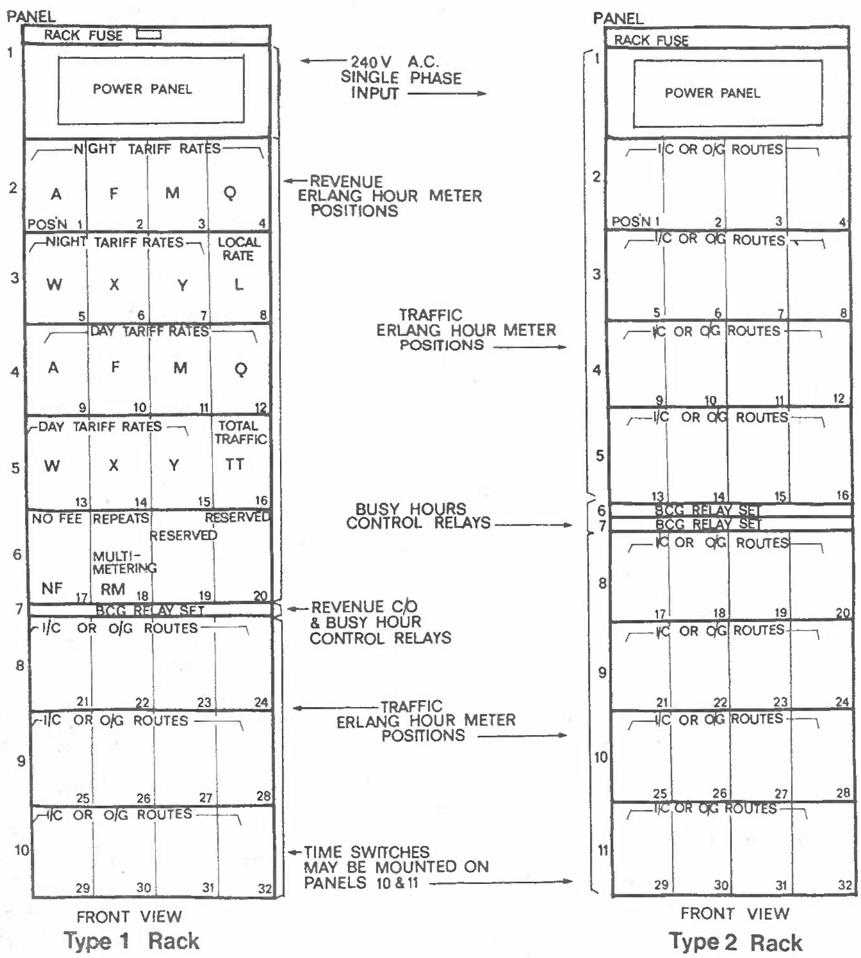


Fig. 5 — Erlanghour Meter Racks.

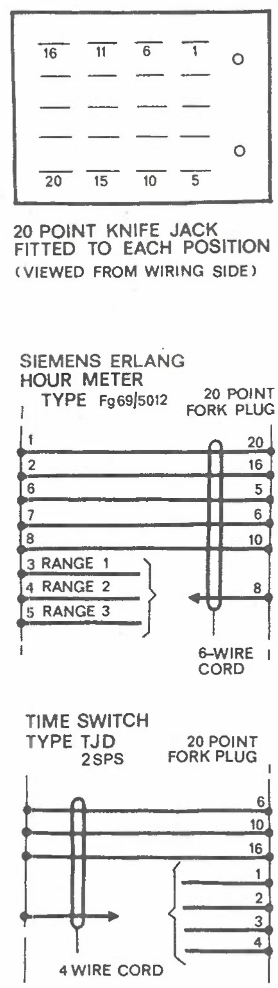


Fig. 6 — Details of 20 Point Knife Jack.

(b) a strapping point for selection of busy hours and connection to total traffic erlanghour meter,
(c) the instruments to be fitted with flexible cords and 20 point fork plugs, thus simplifying replacement and recalibration.

The 50 V d.c./32 V a.c. power panel will be provided on all racks where Siemens and Halske type erlanghour meters are installed. Although the Master Instrument type erlanghour meters do not require 32V a.c. for the telemetry function, there is still a need to provide 32V a.c. for the operation of time switches.

Wiring and Strapping

On the initial rack designs, the method of wiring provides the following facilities:

(a) Outgoing and incoming routes may be connected to erlanghour meters in any position on the rack allocated for traffic requirements.
(b) Four time switch commons are provided in each half rack of traffic erlanghour meters. These commons allow a maximum of four busy hours per half rack and also installation of time switches in any position allocated for traffic requirements although for reasons previously stated, the preferred position is the bottom rack panel.
(c) Terminal Block A is provided on each rack in the BCG relay sets to facilitate connection of time switch commons to the selected BH relays, and also for extending these busy hour control leads, and the total traffic common, between erlanghour meter racks.
(d) Two BH relays are provided per panel of 4 erlanghour meters. These relays will facilitate the use of 2 busy hours on one panel, thus allowing full utilization of the rack. Connection of measuring groups to the erlanghour meters is via straps on the rear of the 20 point knife jacks.

CONCLUSION

The accurate recording of traffic flow and dispersion data provides some of the basic statistics necessary to plan the economic development of the telephone network. The use of erlanghour meters in ARM trunk exchanges, as outlined in this paper, helps to provide some of these statistics. With the ever increasing rate of growth of the A.P.O. STD network, the introduction of this type of equipment as an integral part of the initial installation is highly desirable.

ACKNOWLEDGEMENTS

The authors wish to record their appreciation of the assistance given by Headquarters and Victorian Engineers in the original discussions on the preparation of the survey diagram and rack layouts. The assistance offered by Exchange Installation No. 3 Drafting Section, Victoria, in the preparation of documentation required for the satisfactory manufacture and installation of the erlanghour meters is also acknowledged.

REFERENCES

1. Rubas, J. and Carroll, B. J., 'Supervision of Plant Congestion'; Telecom. Journal of Aust., Feb., 1968, Vol. 18, No. 1, P. 54.
2. A.P.O. Engineering Instruction, PLANNING, Traffic D1310, Venner Time Switch.
3. A.P.O. Engineering Instruction, PLANNING, Traffic D1330, Siemens and Halske Erlanghour Meter.

TECHNICAL NEWS ITEM

TRIALS OF DIGITAL SWITCHING SYSTEMS

With the advent of pulse code modulation (P.C.M.) transmission systems, interest has been intensified in time division multiplexed switching systems. Many telephone manufacturers and administrations are developing model integrated switching and transmission (I.S.T.) systems to switch P.C.M. channels without the need to demodulate and remodulate the digital signals.

An experimental digital switching exchange has been developed by the British Post Office to test the feasibility of this type of switching. Although small, the model exchange contains many of the features of a full size exchange suitable for metropolitan tandem applications. It is now installed in Empress telephone exchange in West London where it will carry live traffic originating from three nearby Strowger exchanges. These three exchanges, Acorn, Ealing and Shepherds Bush serve an area with a common community of interest so that in the normal course much traffic passes over direct audio junctions between them. A proportion of this traffic is automatically directed to P.C.M. transmission systems installed at these exchanges, where the information is converted into P.C.M. form and passed to the experimental switching unit. Each exchange is equipped with two 24-channel P.C.M. systems. In addition there are two P.C.M. multiplexers at Empress exchange but these are used solely for testing and demonstration purposes. Thus, the experimental exchange handles only 144 live channel connections (40 Erlangs of traffic).

Work commenced on the detailed design of the model exchange at the British Post Office Research Station, early in 1965, and on 11th September, 1968, the exchange was opened for live traffic by the Postmaster-General. In his address the Postmaster-General noted the growing experience with P.C.M. transmission systems at home and abroad and said that the particular significance of the Empress exchange was that it was the first example of switching P.C.M. signals carrying live traffic anywhere in the world.

The Australian P.M.G. Research Laboratories are investigating many aspects of future telephone networks, including a current study of the I.S.T. concept. The purpose of this project is to examine under field conditions the effectiveness and applicability of I.S.T. in the Australian telephone network. A laboratory model of a digital switching stage has been constructed. Speech and data transmission tests through this model switching stage were conducted for the first time on 18th October, 1968, with very satisfactory results.

Work is now in progress to construct an experimental digital switching exchange for trial in the Melbourne telephone network. The proposed A.P.O. field trial bears a resemblance to that of the B.P.O. It is planned to install the A.P.O. trial exchange at a tandem switching centre, Windsor, late in 1970. The exchange will switch junctions between Gardenvale (Strowger primary equipment with crossbar first stage switching), South Oakleigh (Strowger), Clayton (crossbar) and the Windsor ARF tandem. Initially, it will have a total of 96 P.C.M. circuits connected, but the basic design allows for considerable expansion limited only by the capacity of the controlling processor. Although the field trial is similar, the A.P.O. digital switching system differs in a number of respects from that being tested in London.

INSTALLATION OF LEAD SHEATHED CABLES ON BRIDGES

*M. F. LETTE, A.S.T.C., M.I.E. Aust.**

INTRODUCTION.

The failure of lead sheathed telephone cables on bridge structures has, in the past, received considerable publicity. The result of this is that over the years, a certain distrust has developed towards this type of construction, based mainly on rumour and contributed to by inadequate installation practices.

This article sets out to investigate whether this distrust is justified, what causes failures on bridges, and what constitutes good installation practices.

CABLE FAILURE MANIFESTATIONS.

The usual mode of failure of lead sheathed cables on bridges is for the integrity of the sheath to be impaired either at one point, or over a considerable area along the length of the cable. Where joints are installed on bridges, failures of the joints have also occurred. For cables not under pressure, sheath or joint failure allows moisture (or even water) to enter the cable destroying the insulating properties of the paper around the conductors. For cables under gas pressure, failure results in loss of pressure which is detected by pressure sensitive alarms so that repairs can usually be effected before moisture entry occurs.

The loss of sheath integrity and joint failures are usually a result of intercrystalline fracture of the lead. Such fractures occur where lead (and other metals) are called upon to withstand many cycles of varying stresses and strains.

Stress Variations in Cables On Bridges

Bridges vibrate in a variety of modes due to the impulsive effect of vehicle and wind loads and are also subject to considerable and often rapid temperature changes. Cables attached to bridges have these temperature changes and vibrations transmitted to them in a greater or lesser degree depending on the design and placement of the cable supports. In addition the cable structure itself, e.g. a rigid pipe supported at intervals, has a natural or resonant vibration frequency and may be subject to additional temperature change by virtue of exposure to the sun, rain or even water from waves or tides.

Both vibrations and temperature changes induce stresses into the cable sheaths and joints but the quantitative assessment of stress from vibration and temperature does not appear possible. However Ref. 1 indicates that the effects of vibration can be assessed adequately by determining, with instruments, the strain and the acceleration to which the cable is subjected. It indicates that provided the strain is below 30 x 10^{-6} and the acceleration is below 0.6 g (where g is the acceleration due to gravity) the cables should be 'safe', i.e. have an acceptable service life.

Other references (Ref. 2 to 6) dealing mainly with structures indicate that designs based on maximum accelerations of about 0.6 g are satisfactory provided a moderately high safety factor is used.

Relation between Vibration and Acceleration

The bridge vibrations and, through them, the cable vibrations, are a damped harmonic motion and therefore, for any cycle of a given amplitude and frequency the classical formulae of simple harmonic motion lead to the expression —

Acceleration $= Aw^2 \operatorname{Sin} w\,t$ where A is the amplitude and w is 2π times the vibration frequency, and the acceleration is expressed in length units per second per second. To express the acceleration in terms of g the expression becomes —

$$a = \frac{4\pi f^2 A}{12\,g} \quad \text{where}$$

a is acceleration (in terms of g)

A is the amplitude in **inches.**

f is the frequency of vibration in cycles per second.

g is 32.2, the acceleration due to gravity in **feet** per sec. per sec.

Thus for any given amplitude and frequency there is a discrete value of 'a' and conversely for a set (or design) value of 'a' a graph of frequency versus amplitude can be plotted. The full line of Fig. 1 is such a graph for 'a' $= 0.15$.

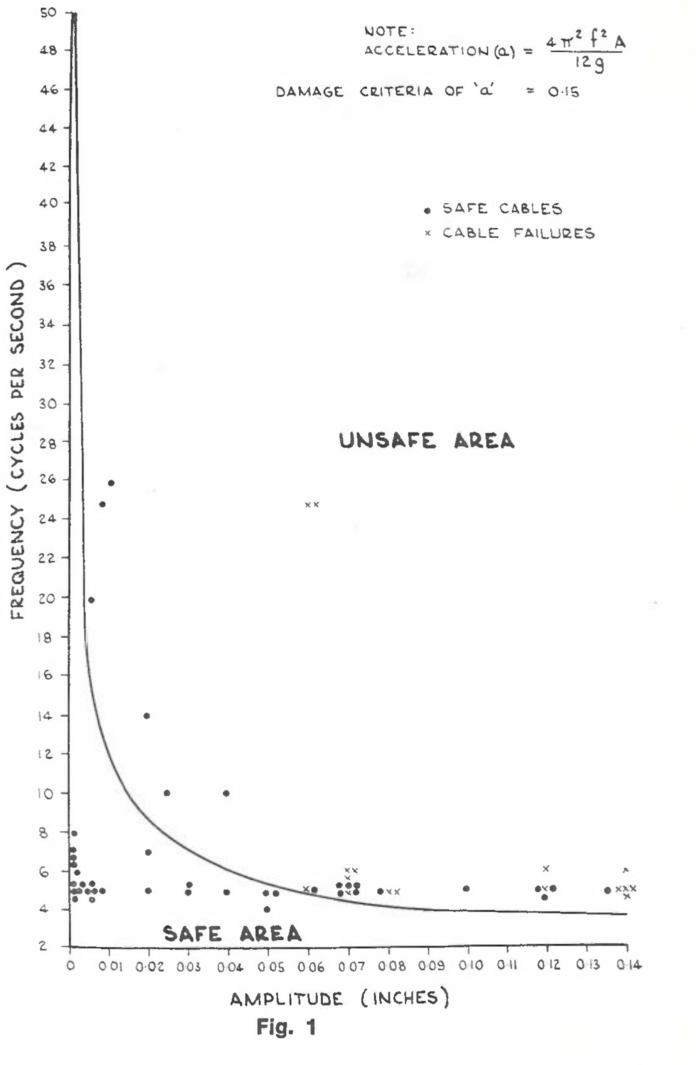


Fig. 1

* Mr. Lette is Engineer Class 2, Primary Works, Sydney.

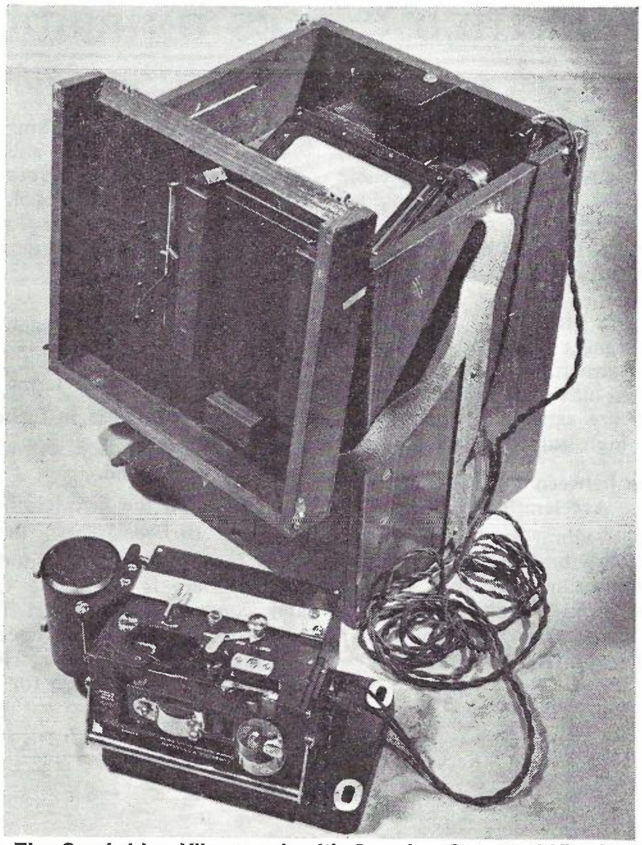


Fig. 2 — The Cambridge Vibrograph with Carrying Case and Viewing Screen.

INVESTIGATION PROCEDURE.

The investigation aimed to determine whether acceleration alone can explain the majority of past cable failures and of successful installations, thus providing a simple guide to future practices.

Instrument Used to Establish Vibration Amplitudes and Frequencies.

The instrument used in the investigation is a Cambridge Universal Vibrograph, which is best described as a stylus-on-celluloid recorder. Figs. 2 and 3 show this machine, while Fig. 4 is a typical recording. This machine can record either horizontal or vertical vibrations. In Fig. 2 it is shown set up to record vertical vibrations, and in Fig. 3 for horizontal vibrations. In all bridges measured, the vertical vibrations were larger than the horizontal vibrations.

RESULTS

Cases Where Cables Failed

Of all the bridges on which cable failures have occurred, only 16 are still in existence and available for vibration measurements. These bridges varied, but 14 of the 16 were of timber construction, and, of these, timber truss types were the most common. Figs. 5 and 6 show typical timber bridges on which these early cables were installed. N.S.W. Department of Main Roads statistics

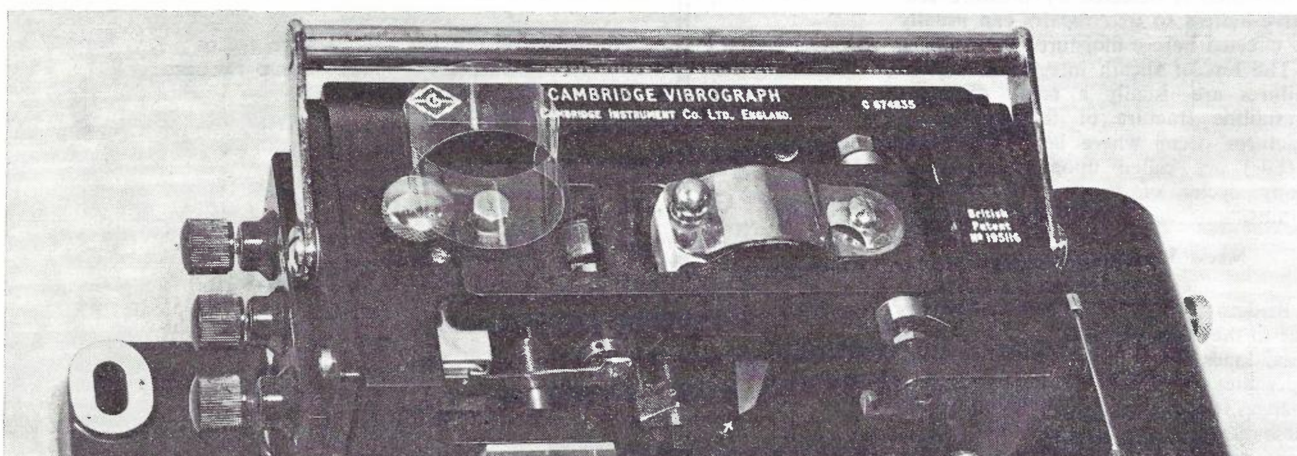


Fig. 3 — Close-up of the Vibrograph set up for Recording Vibrations in the Horizontal Plane.

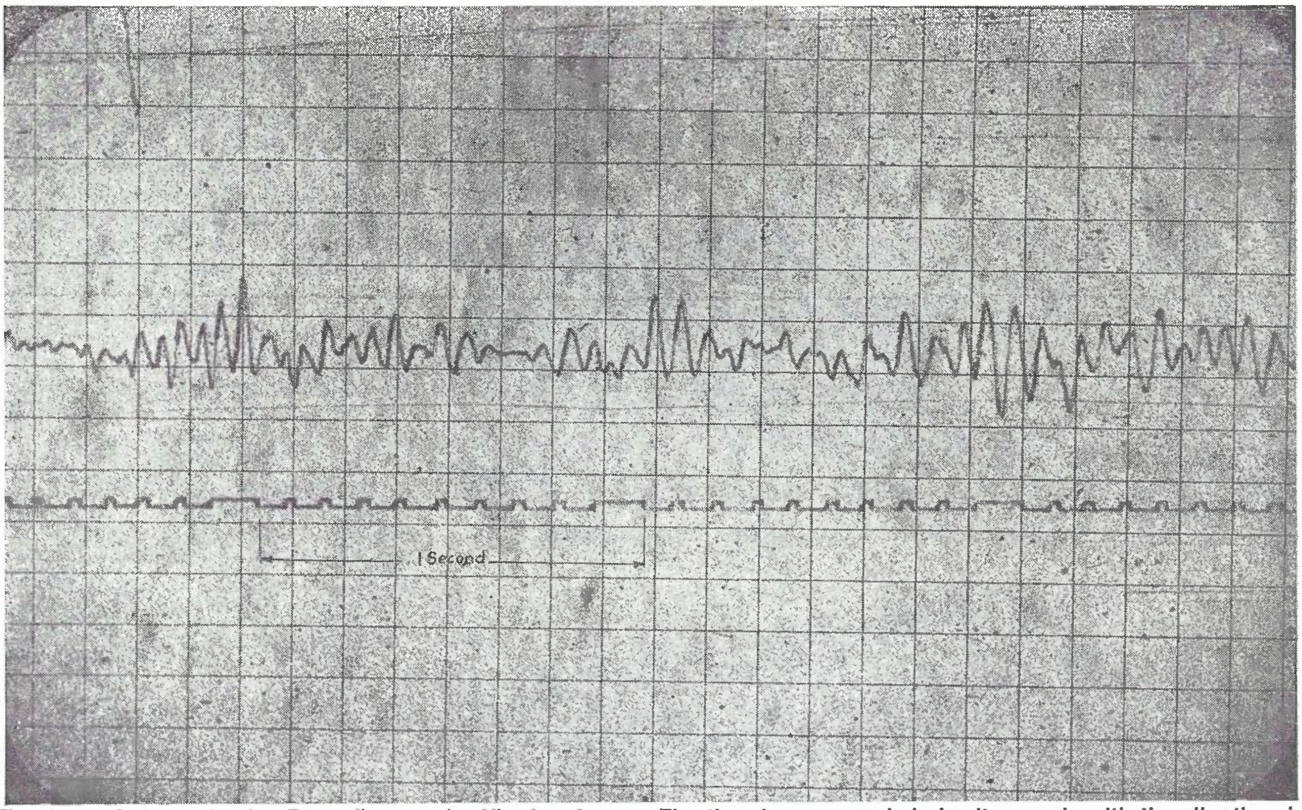


Fig. 4 — Photograph of a Recording on the Viewing Screen. The time base, recorded simultaneously with the vibration, is in tenths of a second. The grid represents 0.004 in.

TABLE 1 — YEARS OF SERVICE BEFORE FAILURE

Type of Construction	Vibration Amplitudes				
	0.060 in	0.070 in.	0.080 in.	0.120 in.	0.140 in.
Armoured Cable			*4 years*	15 years	*4 years* *1 year*
Armoured in Conduit				40 years	
Lead Sheath in Conduit	8 years *20 years* *11 years*	*18 years* *3 years* *23 years*	5 years		*20 years* 1 year *1 year*
Lead Sheath not in Conduits		20 years			

Note: Items in italics are for cables or conduits which are exposed to the sun, and may therefore be subjected to more rapid temperature changes.

show that out of its 4,000 bridges, over two-thirds are of timber construction. Although cables are placed on a very small percentage of these bridges, it is likely that the majority of cables on bridges are on timber bridges. Table 1 shows failure vibrations and types of cable construction.

The table shows that cables exposed to the sun have lasted from 1 to 22 years, and that cables not exposed to the sun have lasted from 1 to 40 years over similar vibration amplitudes.

Table 2 relates the diameter of cables, amplitudes and years of service before

TABLE 2 — DIAMETER OF CABLES AND YEARS OF SERVICE BEFORE FAILURE

Diameter of Cable (in.)	Years before Failure	Vibration Amplitude (in.)	Type of Cable	Exposed to the Sun
0.6	20	0.070	Lead Sheath	Yes
0.7	8	0.060	Lead Sheath in Pipe	No
0.8	18	0.070	,, ,, ,, ,,	Yes
0.8	20	0.140	,, ,, ,, ,,	No
0.8	40	0.120	Armoured in Pipe	No
1.0	15	0.120	Armoured	Yes
1.0	22	0.070	Lead Sheath in Pipe	Yes
1.0	4	0.080	Armoured	Yes
1.11	20	0.060 at 25 cps.	Lead Sheath in Pipe	Yes
1.5	1	0.140	,, ,, ,, ,,	No
2.02	5	0.080	,, ,, ,, ,,	Yes
2.32	11	0.060 at 25 cps.	,, ,, ,, ,,	Yes

Notes: (1) All frequencies are 5-6 cycles per second unless otherwise stated.
(2) Four cables are not listed in this table as their diameters were not recorded on replacement.

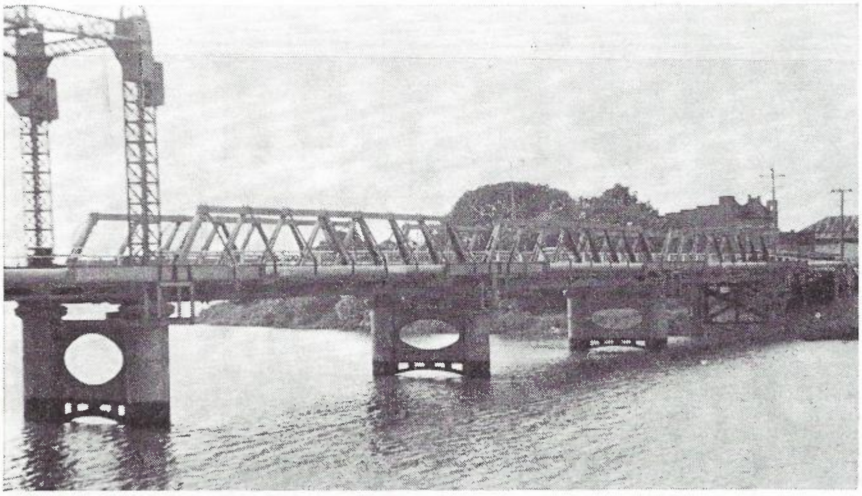


Fig. 5 — Timber Truss Bridge at Murwillumbah, Northern N.S.W.

Fig. 6 — Timber Beam Bridge at Gundagai, Southern N.S.W.

failure. This shows that the smaller diameter cables appear to survive the longest.

Longest Service to Date Before Failure.

The cable which lasted the longest before failure was at Gladstone on the N.S.W. North Coast. The bridge is across the Belmore River on the main road between Kempsey and Gladstone. The cable was wire armoured and was installed in a G.I. pipe well clamped to the underside of the bridge every 8 feet, and consequently was not exposed to the sun. The cable lasted 40 years before failure, and was subjected to vibrations of 0.120 in. at 6 cps. It is significant to note that this cable which lasted so well was armoured, and may have had alloy 'B' lead sheath.

On the graph (Fig. 1), the known failures have been ploted as 'X'. It can be seen at a glance that all the plots full above the $a = 0.15$ line i.e. all failures have occurred on cables subjected to accelerations in excess of 0.15 g. On the same curve, the results from the investigation of 'safe' bridges have been plotted as '•'.

Cases where Cables have not Failed

The safe bridges measured are those on which cables have been in situ for at least nine years, and are still in service without any failures. A total of 48 bridges were examined in various parts of N.S.W. including the Sydney Metropolitan area. The 'safe' bridges were of all types, and included the longest steel truss span in the State (the Pacific Highway Bridge over the Hawkesbury River, 30 miles North of Sydney), which has two main spans of 452 feet each.

Bridge with Longest Cable Life

The cable which has lasted the longest to date (without failure) is at Murrurundi (50 miles South of Tamworth) where the New England Highway is bridged across the Pages River. The cable is a 216/10 installed in a 4 in. iron pipe well supported under the bridge, and consequently not exposed to the sun. The cable was installed in 1931 and is still in service. The bridge is subjected to continuous traffic, the vibration being 0.070 in. at 6 cps on the passage of heavy vehicles.

Table 3 lists the years of service against the type of construction, whether exposed to the sun, and the vibration the cables are experiencing.

It will be noted that many of these cables are subjected to small vibrations (up to 0.006 in.), but are exposed to the sun. The majority of these 'small vibration bridges' are in the Riverina Irrigation Area crossing the numerous canals, some of which are 100 feet wide.

The remainder of the cables listed in Table 3 are on bridges spread over eastern N.S.W., all on highways or main roads; measurements were not taken on bridges on lesser roads where traffic was light. The majority were on three highways, namely Newell, New England and Pacific Highways. Fig. 7 indicates these Highways, and the location of all the measured bridges.

Summary of Vibration Data

Comparing Tables 1 and 3, it is noted that failures occurred between vibration readings of 0.060 in. and 0.140 in. (the limit of the Cambridge Vibrograph) at 5 cps. On the other hand safe bridges recorded vibrations of up to 0.120 in. at 5 cps. Thus it is apparent that factors other than vibration play a significant part. However, most 'safe' cables are subject to accelerations less than 0.15g leading to the tentative conclusion that this may be a safe limit. This limit as shown by Fig. 1 is 0.070 in. at 5 cps. A reservation must be placed on this limit, as the data available has referred mainly to cables less than 1 in. in diameter.

Effect of Temperature

Temperature changes need consideration as they impose stress variations on the lead sheath, which may add to the effects of vibration induced variations to an unknown extent. Failures attributable to temperature change are described below.

Case 1: A cable in a 4 in. G.I. pipe on the approaches to Glebe Island Bridge in Sydney. The conduit was installed only a few inches below the surface of the footpath, which was black bitumen. During the summer months,

TABLE 3 — DIAMETER OF CABLES ON 'SAFE' BRIDGES

Diameter (in.)	Years in Service	Vibration Amp. (in.)	Vibration Freq. (cps)	Whether Exposed to Sun	Type of Construction
0.5	9	0.120	5	No	Lead sheath in iron pipe.
0.5	15	0.006	5	No	,, ,, ,, ,, ,, *
0.5	14	0.100	7	Yes	,, ,, ,, ,, ,,
0.5	11	0.030	5	Yes	Armoured.
0.5	15	0.030	5	Yes	Armoured.
0.5	14	0.006	20	Yes	Lead sheath in iron pipe
0.5	15	0.001	15	Yes	,, ,, ,, ,, ,,
0.5	12	0.001	20	Yes	,, ,, ,, ,, ,,
0.5	8	0.070	5	No	,, ,, ,, ,, ,,
0.6	22	0.040	5	Yes	,, ,, ,, ,, ,,
0.6	17	0.120	5	No	,, ,, ,, ,, ,,
0.6	10	0.020	7	Yes	Armoured.
0.6	15	0.006	5	No	Lead sheath in iron pipe
0.6	10	0.120	5	Yes	,, ,, ,, ,, ,,
0.6	20	0.008	5	No	Armoured.
0.6	10	0.002	15	Yes	Lead sheath in iron pipe
0.6	25	0.009	25	Yes	,, ,, ,, ,, ,,
0.6	11	0.001	5	Yes	,, ,, ,, ,, ,,
0.6	8	0.001	5	Yes	,, ,, ,, ,, ,,
0.7	11	0.070	5	No	Armoured cable in troughing.
0.7	10	0.020	14	Yes	Armoured.
0.7	9	0.060	5	Yes	,,
0.7	16	0.140	5	Yes	,,
0.7	24	0.002	5	Yes	Lead sheath in iron pipe
0.7	15	0.006	5	No	,, ,, ,, ,, ,,
0.9	10	0.020	5	No	,, ,, ,, ,, ,, (4 cables).
0.8	20	0.001	5	Yes	,, ,, ,, ,, ,,
1.0	17	0.025	10	No	,, ,, ,, ,, ,,
1.0	15	0.070	5	No	,, ,, ,, ,, ,,
1.0	25	0.001	5	Yes	,, ,, ,, ,, ,,
1.0	12	0.003	5	Yes	,, ,, ,, ,, ,,
1.1	13	0.050	5	No	,, ,, ,, ,, ,,
1.1	11	0.070	5	No	,, ,, ,, ,, ,,
1.2	15	0.050	4	Yes	Armoured.
1.2	34	0.070	5	No	Lead sheath in iron pipe
1.4	9	0.001	5	Yes	Lead sheath in iron pipe
1.7	15	0.004	5	No	,, ,, ,, ,, ,,
1.7	15	0.004	5	No	,, ,, ,, ,, ,,
1.7	8	0.080	5	No	,, ,, ,, ,, ,,
2.0	15	0.004	5	No	,, ,, ,, ,, ,,
2.0	17	0.040	10	No	,, ,, ,, ,, ,,
2.67	25	0.001	5	Yes	,, ,, ,, ,, ,,
2.67	25	0.001	5	Yes	,, ,, ,, ,, ,,
2.67	25	0.001	5	Yes	,, ,, ,, ,, ,,
2.67	25	0.001	5	Yes	,, ,, ,, ,, ,,

Note: * Bridge at Peats Ferry, Hawkesbury River. The longest truss span road bridge in N.S.W.

the footpath temperature went over 100°F, and it is quite likely that the conduit temperature was similar. When the cable failed, and was withdrawn, the lead sheath where it had been in the pipe was literally falling apart due to inter-crystalline fracture. Vibration readings were taken on the site, but proved to be negligible.

Case 2: This occurred in the foothills of the Blue Mountains, where the Western trunk cable passed through a short exposed length of 4 in. G.I. pipe approximately 10 feet long. After about 8 years service, the cable failed and was withdrawn. On examination it was found to have inter-crystalline fracture, but only over the short section of cable that was in the pipe; the balance of the sheathing was sound. Again, vibration measurements were taken, but were negligible. In this area temperatures drop below freezing in the Winter and rise above 100°F in the Summer, consequently daily variations in temperatures of up to 40°F are not uncommon. The pipe was exposed to the sun for most of the day.

Case 3: This involved a submarine cable across Georges River, Sydney, between Oatley and Como. When the cable failed it was found that the wire armouring had rusted away between the low and high water marks, and over this section the sheathing had inter-crystalline fracture. The sheathing was checked at other locations and was found to be sound. The cable at the water line, after the armouring had rusted away, would be subjected to the cooling effect of the rising tide, and then heating due to the sun after the tide fell. The cable was checked for vibrations, but again the results were negligible.

The question which should now be asked is, "Why haven't cables in other areas failed through temperature cycl-

Fig. 7 — Location Map.

ing?" As considerable data was available for cables installed in the Riverina Irrigation Area, it was decided to compare temperature variations in this area with the greater Sydney area. Griffith was selected as representing the Irrigation Area and Parramatta for the Sydney Area. The Bureau of Meteorology supplied temperature records for the last 30 years. Table 4 shows the average maximum and average minimum for each month.

As shown by Table 4, the temperature variations in the two areas are similar and the two regions are very much alike as regards average maximum and minimum temperatures.

TABLE 4 — TEMPERATURE DIFFERENCE BETWEEN GRIFFITH AND PARRAMATTA IN °F

Month	GRIFFITH			PARRAMATTA		
	Max.	Min.	Diff.	Max.	Min.	Diff.
Jan.	89.2	61.8	27.4	83.2	62.1	21.1
Feb.	89.2	62.2	27.0	82.3	61.4	20.9
March	83.7	57.6	26.1	79.9	58.4	21.5
April	72.9	50.8	22.1	74.7	52.6	22.1
May	65.5	43.3	22.2	69.0	46.7	22.3
June	58.3	39.7	18.6	64.0	42.0	22.0
July	57.8	38.4	19.4	62.7	40.5	22.2
Aug.	61.0	40.0	21.0	66.2	41.6	24.6
Sept.	67.7	43.6	24.1	71.3	46.3	25.0
Oct.	74.7	49.1	25.6	75.4	51.5	23.9
Nov.	81.6	54.7	26.9	78.8	56.3	22.5
Dec.	86.3	59.7	26.6	82.1	60.4	21.7
	Average Difference 23.9			Average Difference 22.5		

A significant difference between the areas could be the rate at which this variation occurs. The Metropolitan area is subjected to very rapid changes in temperature when the cooling Southerlies sweep up the coast. Griffith, however, being surrounded by very large land masses cools slowly during the night, and is not subjected to the cooling Southerly winds so prevalent along the coast. Generally, the Griffith area would start heating from just after sun rise to, say, about 2 p.m., then it would commence cooling, and would cool until about sun rise. In the hottest month, February, the heating would take place over 8 hours, and the cooling over about 16 hours, but as the average difference is only 27°, both the cooling rate and heating rate would be very gradual. In the Sydney area it is not uncommon to have several cold Southerly changes in a week, particularly in the summer months. During these changes the temperature may drop 15 — 20°F in 30 minutes, which would produce stresses in a lead sheath. In addition to this, daily oscillations in temperature occur due to the cooling effect of the sea breezes.

EFFECT OF SHEATH STRESS DUE TO G.P.A. SYSTEMS

When cables are placed under gas pressure alarm (G.P.A.) systems, the sheath is subjected to an additional stress. Data on past cable failures and on successful installations on bridges is not sufficient to allow conclusions to be drawn regarding the importance of the adverse effect on lead sheaths, of the additional stress when superimposed on the stress due to vibration.

EFFECT OF CABLE SIZE

In N.S.W. the cables installed on bridges have been of relatively small size and little data is available in respect of larger cables. Theoretically it appears that the effect of vibration on large cables will be worse than on smaller cables on two counts —

(a) The force required to cause a given acceleration is proportional to the mass being accelerated. Thus force which is transmitted via the cable sheath, is larger for heavier cables.

(b) For a cable to remain in contact with a duct vibrating between two supports, the cable must flex. Such flexing will induce stresses in the sheath and the magnitude of the stresses is proportional to cable diameter.

Of these (b) may control and accordingly Table 5 has been prepared to show suggested design limits (at 5 cps) for cables up to 3 in. diameter.

TABLE 5 — TABLE OF CABLE DIAMETERS AND VIBRATION LIMITS

Cable Diameter (in.)	AMPLITUDE OF VIBRATION LIMITS (in.) (Notes 1 and 2)
0 – 1.0	0 – 0.070
1.0 – 1.5	0 – 0.060
1.5 – 2.0	0 – 0.040 0.040 – 0.070 if split into 2 cables.
2.0 – 2.5	0 – 0.30 0.030 – 0.060 if split into 2 cables.
2.5 – 3.0	0 – 0.20 0.020 – 0.030 if split into 2 cables. 0.030 – 0.050 if split into 3 cables.

Notes: 1. Assuming alloy 'B' sheath and polythene jacket.
2. These limits are for vibration frequencies of up to 5 cps. For bridges which vibrate at higher frequencies, the limits are lowered accordingly.

TABLE 6 — COPPER PAIR CABLES AND COAXIAL CABLE WEIGHTS

Copper Cables		Coaxial Cables (Non Layer Polythene jacket)	
Dia. (in.)	**Av. Weight per Yard (lbs.)**	**Size (No. of Tubes)**	**Weight per Yd. (lbs.)**
1	5.6	4	7.2
1½	9.5	6	11.6
2	17.0	8	14.0
2½	24	12	23.0
3	32.5		

TABLE 7 — TABLE OF VIBRATION LIMITS FOR NON LAYER POLYTHENE JACKET COAXIAL CABLES

Cable Size (No. of Tubes)	Amplitude of Vibration Limits Assuming Alloy 'B' Sheathing (in.)
4	0 – 0.060.
6 & 8	0 – 0.040. 0.040 – 0.060 split into 2 cables.
12	0 – 0.030. 0.030 – 0.040 split into 2 cables. 0.040 – 0.060 split into 3 cables.

Note: These limits are for vibration frequencies of 5 cps. For bridges which vibrate at higher frequencies, these limits are lowered accordingly.

COAXIAL CABLE

Coaxial cables are from 4 to 20% lighter than copper conductor cables of equivalent diameter (Table 6), and therefore if the limits based on Table 5 are applied to them, the design will be slightly more conservative. As this is desirable for such important cables, Table 7 has been prepared accordingly.

NEW DEVELOPMENTS

Cables

Installations of two new types of cables are currently being carried out in the various States. These cables have moisture barrier sheaths and are available with either paper or polyethylene insulated conductors. The moisture barrier sheathing is essentially a polyethylene sheathing with a thin layer of aluminium firmly bonded to its inner surface. This sheathing can withstand much higher vibrations than lead sheathing and is ideally suited for placing on bridges, provided that in the case of paper insulated conductors a suitable gas protection system is available.

The jointing on both these cables is carried out using epoxy resin and auxiliary lead sleeves, which also means that they may be readily plumbed onto existing lead sheathed cables; but special precautions would still be necessary for any joints on the bridge.

Bridges

Many present types of stressed and reinforced concrete bridges being built offer very good platforms for cables. Fig. 8 shows a good example of this type. This is a photograph of the Commonwealth Avenue Bridge across Lake Burley Griffin at Canberra. This bridge consists of five spans varying between 185 feet and 240, and the maximum vibration recorded was 0.010 in. at 5 cps.

Examples of other modern concrete bridges are listed below:

(a) Cook's River Bridge, Princes Highway at Tempe, Sydney, spans of 130 feet, maximum vibration 0.010 in. at 5 cps.
(b) King's Bridge across Lake Burley Griffin at Canberra, 7 spans ranging from 95 feet to 154 feet, maximum vibration 0.006 in at 5 cps.
(c) Captain Cook Bridge across Georges River in Sydney, 7 spans ranging from 184 feet to 250 feet. Maximum vibration 0.005 in at 4 cps.
(d) Gladesville Bridge across the Parramatta River, 1 main span of 1000 feet. Maximum vibration 0.001 in at 4 cps. (This bridge has the roadway on top of a 1000 feet span concrete arch).

CONCLUSION

There is no doubt that more bridges could be used to carry cables, and that Engineers should weigh carefully the following advantages and economies of construction on bridges before deciding on a river crossing:

(a) Expensive excavation in river beds is avoided.
(b) The cable costs less and is more readily available than the armoured cables required for installation in the river bed.
(c) Cables are readily accessible and may be withdrawn.
(d) Cables on a bridge are unlikely to be affected by floods, particularly on the downstream side.
(e) The cable if damaged, may be repaired in situ. or, if this is not possible, can easily be replaced. Actually in some situations it may be more economical to allow for the cable to fail on a bridge, say every 10 years, than to construct an expensive river crossing, particularly if a G.P.A. system is available to ensure that the sheath failure does not cause service interruptions.
(f) Approaches to bridges are generally sound.

The following design and installation practices are recommended:

(a) Bridges should be used in preference to a submarine cable crossing, where the bridge is suitably sited and vibration readings confirm that the amplitudes are lower than the

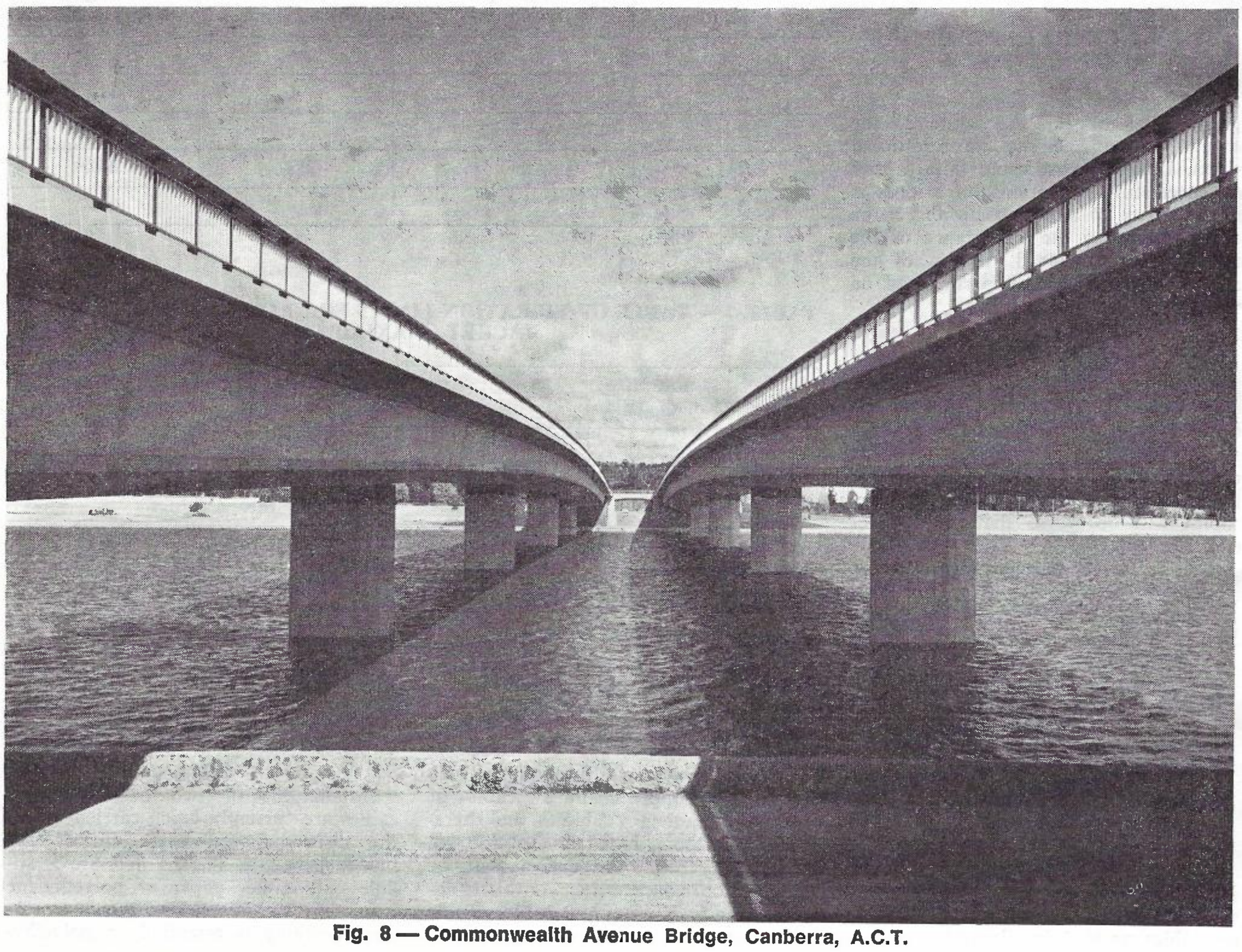


Fig. 8 — Commonwealth Avenue Bridge, Canberra, A.C.T.

limits of Tables 5 and 7 appropriately adjusted for frequency.

(b) All cables installed on bridges should be sheathed using Alloy 'B', and be jacketed with polythene, unless moisture barrier cable is used.

(c) Large size cables should be split into smaller diameter cables in accordance with Tables 5 and 7 if single cable is outside limits.

(d) All cables and conduits should be shaded from the direct rays of the sun. If this is not possible, a sunshade should be installed over the conduits, and painted with aluminium paint.

(e) Special precautions should be taken where duct (or supports) cross expansion joints in the bridge so that stress concentrations do not occur in the cable sheath.

(f) Particular care should be taken with any cable joints on the bridge itself. Ideally these should be at nodes in the bridge vibration pattern, i.e. usually immediately above piers.

ACKNOWLEDGMENT

The Author wishes to acknowledge the assistance of many colleagues in New South Wales who so willingly supplied the information and assistance required to complete the investigatory work.

REFERENCES

1. MASAO Totruku and Takao Koniski 'Anti-Vibration Measures for Cables Fixed to Bridges'; Japan Telecommunication Review 1963.
2. Leonard Obert, Report E-35 No. 3 1960, 'Bureau of Mines, Applied Physics Research Laboratory Maryland'.
3. A. T. Edwards and T. D. Northwood, 'Experimental Studies of Effects of Blasting on Structures'; The Engineer, September, 1960.
4. F. J. Crandell, 'Ground Vibrations and its Effects Upon Structures'; Boston Society of Civil Engineers Publication, 1949.
5. H. Westerberg and B. Kilstrom, 'Ground Vibrations in Blasting'; Water Power, September, October, November, 1958.
6. J. R. Thoenem and S. L. Windes, 'Seismic Effect of Quarry Blasting'; U.S. Bureau of Mines Bulletin 442.

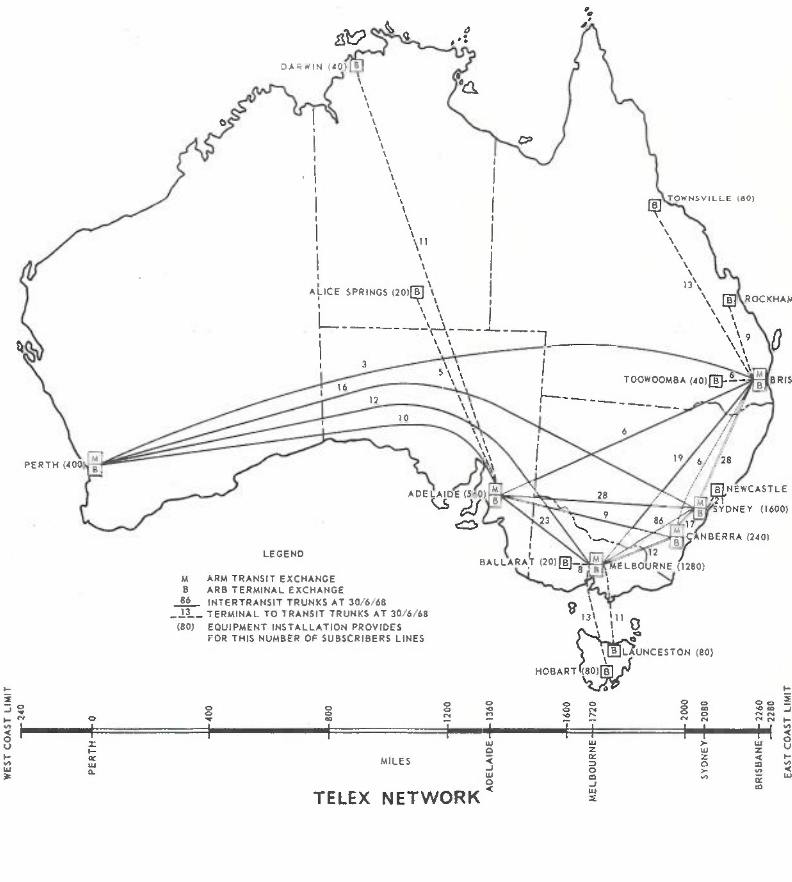
TECHNICAL NEWS ITEM

TELEX SERVICE EXPANSION

Expansion of the Australian Post Office telex system, converted to automatic operation in June 1966, is continuing at a rapid rate. For each year since cutover, the annual subscriber growth rate has been 29%, 900 subscribers having been connected in the financial year ending 30th June, 1968. There are now approximately 4,500 subscribers connected to 16 exchange points, the number of services having doubled since cutover. Australian telex subscribers, operating through the Overseas Telecommunications Commission's international telex exchanges at Sydney, now have access to 108 overseas destinations. Fully automatic operation on telex calls to the U.K. was introduced on 16-9-1968, and it is expected that this facility will be extended to calls to several other overseas destinations within the next few years. The layout of the national network is shown in the attached diagram.

Calls within Australia increased in the last financial year by 51% while international telex calls increased by 42%. The average telex subscriber now originates approximately 1,400 national calls a year, of which some 70% terminate beyond 400 mile radius, emphasising the long-distance nature of telex traffic.

The introduction of on-line, time-shared computer services opens up a likely avenue for further development of the telex network. The conditions for providing access to such a computer service by selected telex subscribers from any point in the network have been established, and several subscribers are at present negotiating with the A.P.O. regarding the introduction of such a facility.



TELEX NETWORK

A.P.O. FOUR WIRE CORD TYPE SYSTEM AFM. 402: THE MANUAL ASSISTANCE CENTRE: PART 2

F. M. SCOTT, A.M.I.R.E.E. (Aust.)

INTRODUCTION

This article is a continuation of Part One which appeared in Volume 19 No. 1 of the Journal. The previous paper dealt with the general aspects of both trunk assistance (T.A.) and special services (S.S.) positions, then followed with a more detailed treatment of the facilities and circuits used on the T.A. positions. Components, signalling, cabling and the design group organisation were also discussed.

The purpose of this part (Part 2) is to provide a description of the line relay sets and the turrets and positional relay sets associated with the miscellaneous service positions, i.e., Special Service, Monitor and Supervisor. The S.S. position being cordless in operation requires an external switching device. A description of the specially designed crossbar line finder is given.

It is current practice in telephony to refer to the more commonly used relay sets by a coded designation. This avoids giving a rather lengthy description of the relay set functions each time a particular relay set is identified in descriptions, catalogues, order forms, drawing titles, etc. The designation codes applied to equipment used in this system are listed for reference.

EQUIPMENT DESIGNATION CODES

Many of the line and positional relay sets are identified by a code comprising three groups of letters. Key panels are also coded in this manner. A typical code for a line relay set would be FUR-LM-MOC. The first group (FUR) describes the general function of the relay set and its direction of operation. The intermediate group indicates the type of signalling employed and the location of the relay set in relation to the first group of letters. Thus in the example quoted —

F indicates a junction relay set
U indicates outgoing at the M (ARM) exchange
R indicates relay set
L indicates local type signalling on the ARM side.

The third group indicates facilities and, if necessary, the type of signalling employed on the other side of the relay set. Thus M in this case refers to a facility, while OC refers to the four-wire cord type exchange. There is a series of codes referring to different types of manual exchanges each commencing with O (for operator), e.g., OA, OB, OC, OD, etc.

Table 5 lists the line relay set designation codes applicable to System AFM. 402.

TABLE 5: DESIGNATION CODES USED IN SYSTEM AFM402 FOR LINE RELAY SETS

Code	Meaning	Code	Meaning	Code	Meaning	Code	Meaning	Code	Meaning
FIR	Junction, trunk, or interexchange i/c relay set.	**L**	Local, connecting two exchanges at the same location.	**F**	ARF Crossbar exchange.	**C**	Repeats decadic pulsing.	**OA**	AFG201
FUR	Junction, trunk, or interexchange o/g relay set.	**L1**	Loop disconnect, two wire, 0-2000 ohm.	**M**	ARM Crossbar exchange.	**L**	Access to Reg-L.	**OB**	Siemens Cordless
FDR	Junction, trunk, or interexchange both-way relay set.	**L2**	Loop disconnect, four wire, 0-2000 ohm.	**OA**	A.P.O. Cordless exchange (System AFG201).	**M**	Seizes forward to manual, with recall.	**OC**	AFM402
		R	17 Hz, two wire, manual to manual.	**OB**	System AFM402.	**N**	Repeats decadic pulsing and recall signal.	**OS**	Sleeve Control
		U	D.C. four wire, manual to manual.	**OS**	Sleeve control.	**P**	Seizes forward to manual, without recall.		
		T	L.M.E. Pulse.			**Y2**	Access to Reg-Y2.		
Function		Signalling		Location		Facility		Works to or from	
First Group		Intermediate Group				Last Group			

The positional relay sets for the operating positions and turrets are coded in a similar manner. Tables 6A, 6B and 6C show a list of the designation codes used for these relay sets.

PULSES

A number of D.C. pulses is required for the operation of the exchange. A description of the pulses is given in Table 7.

LINE RELAY SETS

The line relay sets provide interconnection between System AFM 402 and other systems. Switchboard lines may connect to adjacent local exchanges, e.g., ARM or ARF in the same building or be extended over carrier channels or trunk cables circuits to distant exchanges.

Each line relay set can be considered as two separate halves merged together. The circuit conditions in each half are complementary to those existing at the

TABLE 6A: DESIGNATION CODES USED FOR POSITION RELAY SETS — FIRST GROUP

Code	Meaning
OKR	Key logic relay set
OPI	Position panel for keys, lamps, etc.
OPR	Position switching relay set
OTR	„ telephone „ „
SNOR	Connect circuit „ „
	Manual Exchange Equipment Primary Classification

TABLE 6B: DESIGNATION CODES USED FOR POSITION RELAY SETS — INTERMEDIATE GROUP

Code	Meaning	Code	Meaning	Code	Meaning
Z	Multimetering	**A**	Appointment & reminder	**OA**	4W cordless AFG201
		B	Complaints	**OB**	2W cordless (Siemens)
		C	Supervisor	**OC**	4W Cord (APO System AFM402)
		D	Trunk assistance	**OD**	CB multiple A position
		E	Emergency	**OE**	CB non-multiple position
		F	International	**OM**	Magneto
		G	Supervisor & Monitor (C + M)	**OS**	2W sleeve control (APO)
	(If Z facility is not required the first symbol is omitted)	**I**	Information		
		L	Control		
		M	Monitor		
		P	Pricing		
		R	Routing		
		S	Special Services		
		T	Trunk enquiry & Suspense		
		U	Trunk assistance & Special services D + S)		
		V	Interception		
		X	Observation		
		Y	Switchboard end section		
Special Facilities		Type of Position		Type of Exchange	

distant end of the link. For example, if an outgoing line on the switchboard trunks to a distant exchange and T type line signals are employed then the line side circuitry of the terminating relay sets at each end must interwork with T pattern signalling. These portions of the relay sets are therefore complementary.

Similarly the switchboard side circuitry of the line relay set must be compatible with that of the cord circuit. A conversion within each line relay set occurs to change the signalling conditions on one side to those required on the other. Fig. 15 illustrates the merged half relay set concept.

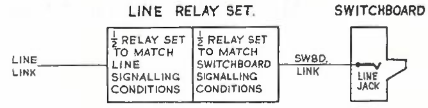


Fig. 15 — Merged Half Relay Set Concept.

Incoming Line Relay Sets

Two line relay sets are designed to provide for inlets to the switchboard from other local exchanges. One interconnects ARM and AFM; the other ARF and AFM. Each relay set may be strapped in a number of ways to control supervisory signals and service tones. Four distinct groups of incoming traffic are recognised (see Table 8).

The incoming from ARF line relay set (FUR-L1F-POC) has a two wire speech circuit on the ARF side and a four wire speech circuit on the switchboard side. It may be trunked directly from the

TABLE 6C: DESIGNATION CODES USED FOR POSITION RELAY SETS — LAST GROUP

Code	Meaning	First Group Classn. Applicable to	Code	Meaning	First Group Classn. Applicable to
A	Demand traffic — i/c & o/g on ANS side, o/g on CALL side.	SNOR	**A**	Access to Reg-OA	OPR
B	Originating traffic — o/g on CALL side.	,,	**C1**	,, ,, ,, -OC1 (m.f.c. output)	,,
C	Revertive traffic — o/g only on ANS & CALL sides.	,,	**C2**	Access to Reg-OC2 (decadic output)	,,
D	Thro' terminating traffic — i/c on ANS side, o/g on CALL side	,,			
E	As for E, but extendable to monitor &/or supervisor.	,,			
G	Misc. traffic — Auto exchange line, Swbd. service line, extend lines from SS positions.	,,			
K0	Key logic relays — position key functions	OKR			
K1	,, ,, ,, — ,, speak & hold functions	,,			
K2	,, ,, ,, — ,, selection for listen & speak	,,			
K3	,, ,, ,, — Exch. management functions	,,			
K4	,, ,, ,, — Route control ,,	,,			
K5	,, ,, ,, — Traffic ,, ,,	,,			
K6	,, ,, ,, — NA ,, ,,	,,			
K7	,, ,, ,, — Eq. alarm control ,,	,,			
K8	,, ,, ,, — Door lock control ,,	,,			
L	Control & Supervision	OPI			
P	Switching functions — Spk., listen, ring, TCO, INF. OW, PA system, dual register coupling.	OPR			
R	Switching functions — Spk listen.	,,			
S	,, ,, — ,, ,, , TCO., Auto-exchange line, swbd. service, lines tech.OW.	,,			
U	Telephone cct. — 2W bi-directional	OTR			
V	,, ,, — 4W directional	,,			
W	,, ,, — 4W bi-directional	,,			
Type of Facility			Type of Register		

TABLE 7: D.C. PULSES USED IN SYSTEM AFM402

Pulse	Source	Periodicity	Use
FL.1	R.M.	0.2 sec on, 0.2 sec off.	Fast flash on lamps.
FL.2	R.M.	0.75 sec on, 0.75 sec off.	Slow flash on lamps.
1 sec	M.C.	0.15 sec on, 0.85 sec off.	Time supervision in REG-OC2.
6 sec	M.C.	0.5 secs on, 5.5 sec off.	Cord circuit timers, time supervision in REG-OC2, used to derive 18 sec pulse in Relay Set Pulse REG-OC2, call monitor gong pulse.
P.T.C.	M.C.	0.15 sec on 0.85 sec off 0.15 sec on 0.85 sec off 0.15 sec on 3.85 sec off	Pip tone control pulse to cord circuit. Connects 3 pips of 900 Hz tone every 3 minutes at 2.8, 5.8 and 8.8 minutes

Notes: 1. RM = Ringing Machine
MC = Pendulum type master clock
2. Suffixes E and B are sometimes affixed to the pulse designations to indicate earth or battery source; e.g. FL.1.E indicates earth backed FL.1 pulse.

GVB selector stage as it provides suitable 'c' and 'd' wire connections. Alternatively it may be approached using only two wires from a FUR-L1F-L relay set after the GVB stage. The same line relay set is suitable for trunking 2,000 type step-by-step exchanges to the switchboard, in which case it can connect either to a selector outlet or to the outgoing side of an auto-to-manual repeater.

The incoming from ARM line relay set (FUR-LM-MOC) is designed to operate from a local ARM exchange. No other relay set is required between the GU stage and the switchboard.

An incoming line relay set with 'T' type signalling (FIR-TOC-MOC) is available for carrier channels having standard E and M leads. T3 type signalling is not required on manual to manual links. For physical four wire trunk circuits an incoming line relay set using L2 type signalling is available. (FIR-L2. OC-POC). A T3 type signalling relay set (FIR-T3.03-MOC) may be required at a later stage for auto-to-manual operation.

Outgoing Line Relay Sets

Relay set FIR-LF-LOC provides access from the switchboard to a local ARF exchange. The line relay set has connections to an ARF local register REG-L and a GVA selector inlet. A four wire to 2 wire speech conversion is provided. Digits are keyed by the operator to REG-OC2 and repeated to REG-L at a sending speed of 20 i.p.s. REG-L converts the decadic digits to an M.F.C. code for sending in the crossbar network, but may revert to 10 i.p.s. decadic sending if the call is to a distant step-by-step exchange. The line relay set provides ringing and battery feed for the 'B' subscriber's telephone on local calls and a loop back bridge with a polarity reversal sensing relay for calls to distant exchanges. The backward M.F.C. signals received by REG-L cause one of three settings to occur in the line relay set prior to register disconnection, viz., B subscriber idle, B subscriber busy, equipment congestion. The idle setting results in through connection and the sending of a register disconnect idle signal to REG-OC2. Busy and congestion are both signalled to REG-OC2 as 'register disconnect busy' but separate audible tones are applied in the line relay set so the telephonist may distinguish between the two conditions.

When a switchboard plug is inserted in the line jack of an outgoing line relay set, the relay set is busied to other operators (the F.L.S. lamp is extinguished, and the 'C' wire engaged) but REG-L is not called. The digits are keyed by the operator and stored in REG-OC2. When all digits have been keyed, the finished key is pressed. REG-OC2 sends a seize forward signal (closure of forward cailho path) to the line relay set which calls for a REG-L. When REG-L is connected and ready to receive digits a proceed-to-send signal (closure of backward cailho path) is sent from the line relay set to REG-OC2. As a further safeguard REG-OC2 times an interdigital pause before transmitting the first digit of the stored number.

Relay set FIR-LM-Y2OC gives outgoing switchboard access to a local ARM exchange. Both sides of the line relay set have four wire directional speech paths. This relay set has access to REG-Y2 in the ARM exchange. Signalling between REG-OC2 and REG-Y2 is on the same system as in the ARF exchange.

As for incoming trunks, outgoing connections are provided to distant exchanges using T type and L2 type signalling. Outgoing line relay sets FUR-TOC-N and FUR-L2OC-C cater for these modes of signalling. In each case REG-OC2 commences sending on the receipt of the proceed-to-send signal which is returned from the line relay set following receipt of the seize forward signal. Digit transmission is at 10 i.p.s. As no back signals are received under non-M.F.C. sending conditions REG-OC2 releases immediately when all digits are sent. If the B subscriber is busy, or congestion is encountered at a further stage in the network, suitable tones will be applied at the distant exchange.

Outgoing line relay set FUR-LOC-NOS is essentially a conversion circuit connecting the AFM switchboard with an outgoing sleeve control type 2VF signalling relay set. As well as a change of signalling mode, the relay set provides for a conversion from four wire directional speech to four wire tail eating as used in the A.P.O. 2VF network. This is the only relay set designed so

TABLE 8

Dialling Code	Service	Special Signalling Requirements
011	Subscriber Trunk Assistance	Answer signal is not passed back to the A subscriber except on calls originating from coin telephones in S x S exchanges. No recall is possible.
010	Operator Trunk Assistance	Full backward supervision is provided. Recall is possible.
0176	Crossbar Coin Telephones	Coin telephone tone is connected in the incoming line relay set. The switchboard operator disconnects the tone by pressing the Tone Cut Off key. Recall is not possible. No backward supervisory signals are applied.
1194	Time of day	Answer signal is sent when the operator answers.

far to interwork with 2VF. Further designs may be necessary to interwork with other types of 2VF line relay sets providing incoming, outgoing or bothway access.

Relay set FUR-LOC-NM satisfies a requirement met frequently at a country centre. It provides for connection to an ARM FDR (of any type) at the point where outgoing access from the ARM GU selectors is normally wired. The distant end of the line terminates at a small country office and provides the office-keeper with outgoing access to the ARM exchange, while incoming traffic is switched by the AFM operator.

Bothway Line Relay Sets

At a country exchange there is frequently a requirement to handle traffic to and from a small group of lines using magneto 17Hz ringing. For various reasons these services cannot be connected to automatic equipment. Typical cases are multi-office trunk lines, subscribers party lines, earth circuit lines, fire lookout points and certain emergency services. Relay set FDR-ROC-MOC/M provides a line circuit termination for two-wire physical lines using 17Hz line signals. It allows for traffic in both directions. Two appearances of each line are required in the switchboard line multiple — one for the incoming line jack and call lamp, and one for the outgoing line jack and busy lamp or F.L.S. lamp. A hybrid transformer and two amplifiers are provided. A delay circuit is included so that inter-party calls may be set up on the line without calling the AFM exchange operator. The delay necessitates a ring exceeding five seconds before a switchboard call is recognised. The delay circuit may be strapped out if not required. When an inter-party call is in progress no busy indication is given at the switchboard so that it is necessary for an operator to make a verbal challenge before ringing. Because of the absence of positive line signals with 17Hz working certain compensation must be made within the line relay set for signals not forthcoming from the line. These are self generated to preserve the correct supervisory conditions on the AFM switchboard. After a telephonist has rung on a line the line relay set generates an artificial answer signal which it applies towards the cord circuit. This occurs after each succeeding ring forward or recall signal. As there is no distinction between ring off and recall signals received from line both conditions are treated by the relay set as recall and it is up to the telephonist to determine which condition applies by speaking and listening on the line.

A four-wire version of the above relay set is available for use on carrier channels and V.F. amplified cable pairs. It provides the same manual-to-manual ring down facility but uses D.C. signals in place of 17Hz A.C. The bothway relay set is coded FDR-UOC-MOC/M. The U type signals may take one of four forms:—

- U1 — has sending and receiving combined on a single wire such as a phantom cailho circuit over two side circuits. An earth backed relay is connected at each end of the circuit. To signal, the relay at one end is removed and replaced with 48V negative potential for the duration of the ring key operation.
- U2 — Current-off-idle normal potential E and M leads. The signal lead terminations are similar to those used on a standard carrier channel. Suitable for use on standard carrier systems.
- U3 — Current-off-idle reversed potential E and M leads. Similar to U2 but with reversed potentials on the E and M wires, i.e., Signal to the M wire is 48V negative, E wire relay is earth backed. This is the most suitable variation for use on four-wire cable circuits.
- U4 — Current-on-idle E and M leads. The potentials used are similar to those in U2 but continuous current flows in both E and M leads in the idle condition. A signal consists of a break in current. Suitable for use on rural carrier systems.

Auxiliary Line Relay Sets

A small group of relay sets are associated with the line relay sets to control or augment their functions. The relay sets have the functions described below.

A four stage gating (Ref. 1) is provided between the incoming line relay sets and the switchboard call lamps. While gating does not ensure that all calls are answered in exactly the order in which they arrive as with a full queueing system it is nevertheless adequate for a small installation with a relatively low calling rate. The more stages there are in the gating, the better the separation of calls and the closer the gating system is to providing full queueing. The main disadvantage of a queue is its high cost. A quite useful facility can be obtained by having a queue with a limited number of seats, which is really what the gating system amounts to. Consider a group of ten lines on an incoming route to the switchboard. In a slack traffic period the calling rate will be low and no delay will be experienced in answering calls as they arrive. In the busy period most of the lines should be carrying traffic. Say six are engaged. In a group of this size it is unlikely that more than two or three calls would be waiting answer at any one time. Even with four calls waiting the four stage gating will adequately separate them in distinctive stages provided that answering of calls is fairly regular and calls are not accumulating in the fourth stage to any great extent. A typical country exchange would have a number of such groups of incoming lines. The basic principle of gating is not to answer all calls in precisely the order in which they arrive, but to give an approximate priority mainly to avoid any particular call waiting appreciably longer than the average. Two gating control relay sets are provided. One controls traffic to the trunk assistance positions while the other gates special services calls.

Calls waiting in each of the four stages of the gating system are timed and should the speed of answer deteriorate so that some calls experience more than the pre-determined delay an alarm is given to the supervisor. The length of this delay may be 10, 20 or 30 seconds as selected by the supervisor. Calls enter the gating circuit at stage 4 and pass progressively through stages 3 and 2 until they reach stage. 1. Only those calls in stage 1 are marked for immediate answer. Optional strappings on the incoming line relay sets provide the following lamp conditions:—

(i) Stage 1 flashing call lamp, stages 2, 3, 4 no call lamp.
(ii) Stage 1 steady call lamp, stages 2, 3, 4 no call lamp.
(iii) Stage 1 flashing call lamp, stages 2, 3, 4 steady call lamp.

In periods of light traffic each call will pass directly to stage 1 and will probably be answered before the next call arrives. As traffic increases the first call will be waiting in stage 1, the second in stage 2, the third in stage 3 and any overflow in stage 4. When the first call is answered, the second call moves from stage 2 to stage 1, the third call from stage 3 to stage 2, and the fourth call from stage 4 to stage 3. This procedure is repeated each time a call or calls in stage 1 is answered — the unanswered calls moving up one stage at a time until they reach stage 1. With a further increase in traffic a point is reached where more than one call enters stage 4 before the call in stage 1 is answered. Stage 4 is normally open to an unlimited number of calls, but if the density is sustained at a level in excess of the answering capacity of the exchange, the supervisor may operate the Restrict Gating key to close off stage 4. Under these conditions the number of calls from the main routes which are awaiting answer is restricted to three (one in each of the stages 1, 2 and 3). Other calls will receive busy tone. Routes without back busying facilities cannot be restricted in this manner. Temporary blocking of traffic under restricted gating conditions is accomplished through the use of Group Busy relay sets. If stage 4 of the gate is open and a number of calls arrive, these will advance stage by stage as other calls ahead are answered. When stage 1 is reached the corresponding number of call lamps will light simultaneously. Once stage 4 is vacated, it will start collecting further calls for answering. The number of calls waiting in each stage during the busy period depends upon the traffic arrival and answering rates. The pattern would tend to produce groups of calls in stage 1 consisting of one, two or three calls, but this depends entirely upon the random arrival rate of calls and the random availability of free operators.

The Group Busy relay sets are merely a collection of individual relays having varying numbers of make contacts. The relay coils and contacts are wired to the I.D.F. where the coils may be jumpered to control devices such as the restrict gating circuit and the contacts to individual line relay set BK leads. They may be used to provide blocking on a route basis or on a carrier system basis.

Free line signalling is normally provided on all outgoing switchboard lines. Should visual engaged signalling (V.E.S.) or busy lamps be required in lieu of free line signalling (F.L.S.), the F.L.S. relay sets are still retained but the I.D.F. strappings are altered. There is an F.L.S. relay for each outgoing line. The relay coils are jumpered on the I.D.F. to the appropriate line relay sets. Lines in the same group would be jumpered to adjacent relays, the contacts of which are wired to adjacent lamps in the switchboard line multiple. A chain circuit through the relay contacts ensures that only one lamp — that corresponding to the first free line in the group — is lit at any one time. When a designated free line is taken into use the associated F.L.S. lamp will go out and another F.L.S. lamp corresponding to the next idle relay set in the group will light. Should a relay set placed earlier in the chain become free its F.L.S. lamp will light and the previous lamp will extinguish.

If all lines in a group are engaged no F.L.S. lamp will be lit. Provision is made for the lamp to the right of the last F.L.S. lamp in the group to function as a congestion lamp. Thus if a group is congested no F.L.S. lamp will be alight but the congestion lamp will be glowing. The multiple jack and lamp to the right of the congestion lamp may be used for delay working.

V.E.S. lamp operation creates a fluctuating demand on the lamp power supply between idle and busy periods. At peak periods when most of the lines are engaged there is a dazzling optical effect. F.L.S. lamps have a constant power requirement which is of particular advantage with six volt D.C. working. The number of lamps glowing remains constant in busy and slack periods. Lamps used in the line multiple are of the standard No. 2 type and may be either six volts 40 mA, or 60 volts 20 mA (for use on 48V). The nominal 60 volt lamp when under-run on 48 volts has long life.

Miscellaneous Line Relay Sets

Service line relay sets are used on intra-exchange links between the T.A. switchboard and the special services position, the monitor's posts, the supervisor's table and the exchange equipment room test jacks. The line connections may be strapped for 2-wire or 4-wire speech. D.C. signalling may be superimposed on the side circuit cailhos or connected on two separate wires.

A conference line relay set provides line circuits and amplifiers for five parties. A maximum of two relay sets may be combined to provide for up to ten parties on the one conference call. To establish a conference call the main party is obtained and extended via a cord circuit to one of the conference line jacks. The other parties are obtained on other cord circuits and extended to the conference line jacks. The timer on the cord circuit used for the main party is started to time the duration of the call.

Lamp supervision is given on each cord circuit.

Each delay tone relay set contains equipment for two routes. A maximum of six routes can be controlled. Five different delay periods in addition to the normal condition of no delay can be set on each route. The Supervisor places a route in delay by manipulating keys on the Supervisor's turret. This causes the route delay lamp to glow in the switchboard line multiple. (Refer back to description of F.L.S. working). A telephonist may determine the length of delay by plugging into the jack below the delay lamp and hearing a recorded announcement or special tone (usually a service tone).

The test tone relay set enables a technician at a distance exchange to perform transmission level measurements on channels terminating on the trunk assistance switchboard, without the aid of technical staff at the switchboard. The technician calls the switchboard over the channel to be tested and requests the operator to extend the cord circuit to the Test Tone relay set. When the call plug is inserted into the Test Tone line jack, answer signal is given and an identifying tone (820Hz) applied for two seconds. The technician then applies low level tone to the forward speech path and gradually increases the sent level until tone is heard on the return speech path. The level of tone being sent at the instant that received tone is heard, is noted. The detector in the Test Tone relay set triggers at –20dBm. The difference between the sent level and –20dBm gives the loss or gain of the channel in the forward direction. A careful reading of the received tone level is made, and the reading compared with the known level at the Test Tone relay set (at present +1dBm). The difference between these two readings gives the channel loss or gain in the return direction. The Test Tone relay set applies the reference tone for six seconds, but a further period of six seconds may be obtained by triggering the detector again, with a pulse of tone in the forward direction. This process may be repeated as often as required.

The cord circuit Test relay set provides a comprehensive series of tests for the cord conductors and the cord circuit functions generally. A full test cycle comprises over 30 manipulations of keys and plugs on the switchboard, but a scaled-down procedure is available for the use of telephonists in the performance of a simple routine test on the cords. One relay set per exchange is provided and wired to a pair of test jacks in the switchboard miscellaneous multiple. A separate lamp box is available for association with the test relay set so that indications of relay operations may be obtained at the switchboard position. This requires a third jack in the switchboard multiple.

THE SPECIAL SERVICES POSITION CIRCUITS

Operating Position

The operating requirements on a Special Services position vary in a number of ways from those on a trunk assistance position. In the first place, the class of traffic is different, requiring an altered handling procedure. The four groups of inlets — enquiry, information, time and complaints each require different answering phrases and handling techniques. Information traffic necessitates access to a large number of metropolitan and country telephone directories which must be within easy reach of the operator. Space must be available on the table in front of the operator to spread an open directory. In slack traffic periods the duties of an operator may include sorting and pricing of trunk line dockets. This also requires the provision of ample table space.

These operating requirements do not favour the use of cords and a horizontal key shelf area occupying table top space.

For this reason it has been the practice in the A.P.O. to make use of turret positions for S.S. traffic. A number of installations are in use employing cordless operation, usually with ratchet drive or motor drive uniselectors as the switching medium. The major differences in the AFM402 system are that the turrets use push button keys (ERGA) in lieu of lever keys and a crossbar marker controlled line finder replaces the uniselector for switching.

Three groups of connect circuits are provided on the S.S. position.

(i) Two connecting circuits (SNOR-SOC-F) are employed for answering terminating type traffic, i.e., enquiries, information and time. Calls on these services have a comparatively short holding time but require the operator's full attention. One connect circuit would therefore be sufficient in these circumstances, but a second is provided for flexibility particularly in the event of a fault placing one of the circuits out of order. Although the traffic is terminating by definition, an extended facility to the supervisor and monitor is available through key operation. The extension is to fixed points and not to the general telephone network. Extended calls would be those requiring lengthy discourse or investigation, information not readily available to the S.S. operator without leaving the position, or calls from subscribers making special requests, e.g., for priority in handling of calls.

(ii) Three connecting circuits (SNOR-SOC-D) are used for answering complaints calls. As a proportion of these calls must be extended to a wanted number, a through switching facility into the general network is required. Holding time is therefore longer. The extension of calls is key controlled and two alternatives are available. Firstly, if a local ARM exchange is installed the Extend Auto. key is used to complete all trunk and local calls which can be obtained via the ARM exchange. The Extend Switchboard key is used to switch calls via the switchboard over direct trunks or to places accessible only by this means. Secondly, if no local ARM exchange is available, the Extend Auto. key gives access to the local ARF or step-by-step exchange which switches local calls for two-wire speech. The route via the switchboard is used for trunk line calls or four wire local traffic.

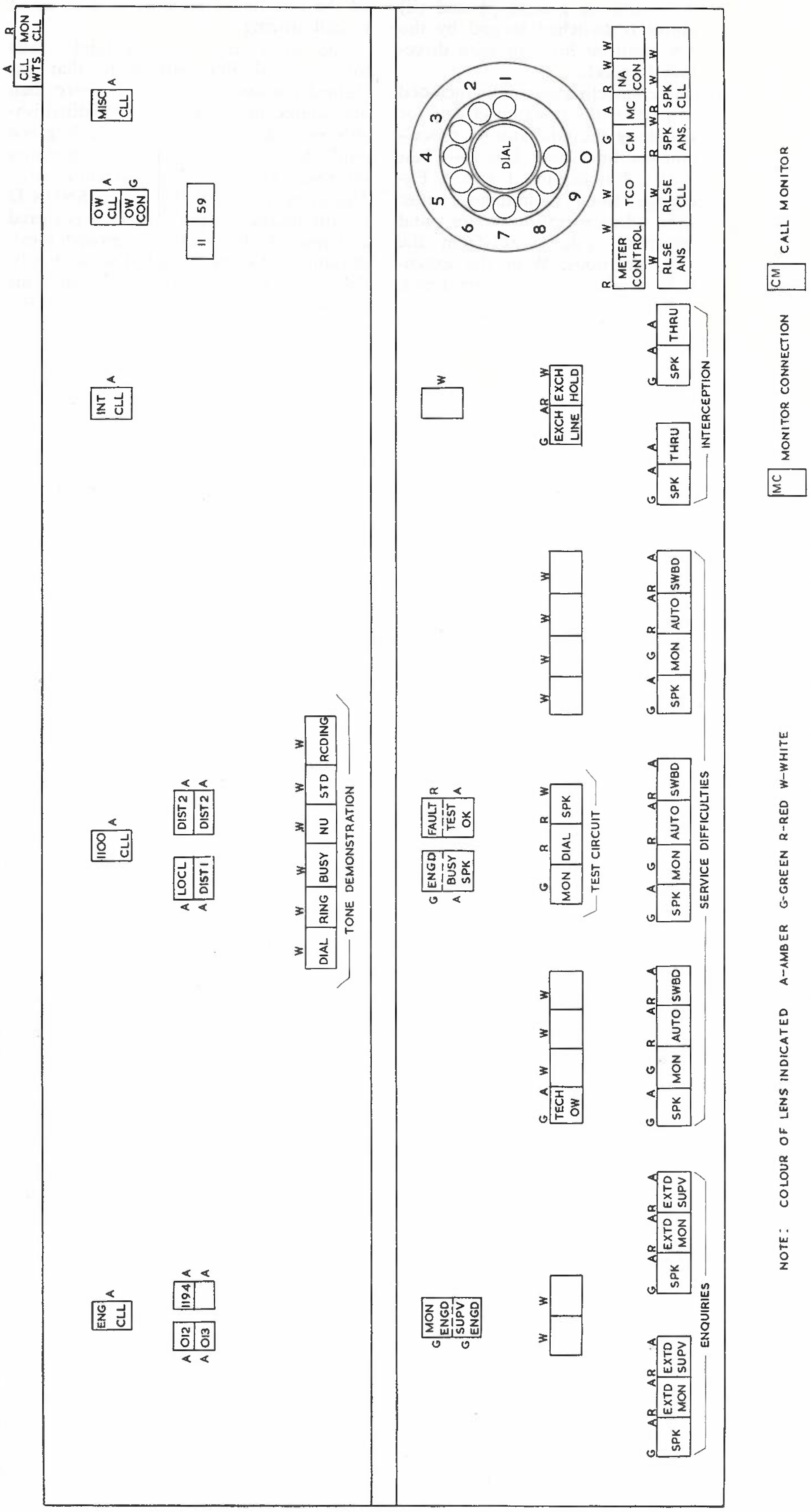


Fig. 16 — Special Services Turret Key Panel Layout.

All traffic in groups (i) and (ii) above is switched to and by the S.S. position for four wire directional speech.

(iii) One connecting circuit is included as part of the position circuit for switching the Operator to miscellaneous lines as follows:— Test access, Interception 1 and 2, Exchange line, Technicians order wire, demonstration tones, and incoming order wire from the T.A. positions. With the exception of the demonstration tones, these services function with two wire speech.

Fig. 16 shows the face layout of the turret key panel.

On the top horizontal surface of the turret on the right hand side two position pilot lamps indicate call waiting and monitor call, respectively. In the top horizontal row of lamps are five call waiting lamps as follows: enquiry, complaints, interception order wire and miscellaneous. Service level calls awaiting answer are divided into two groups according to the type of connect circuit (SNOR-F or SNOR-D) which must be used for answering and one or both of the two call waiting lamps will light. If the call is in the first group (enquiry) the telephonist does not know on which service level (012, 013, 1194) the call is waiting. In fact, calls could be waiting simultaneously on all three levels. A call is answered by pressing the speak key of an idle connect circuit. This gives a start signal to the line finder marker CSM which identifies the connect circuit, selects the call to be answered and switches the call to the operator via a path in the finder relay set C.S. While the marker is working, a by-path is set up to pass category information from the line finder line relay set CRA to the connect circuit SNOR-F where it is stored on relays S11-14. One of the lamps designated 012, 013 and 1194 lights according to the category identified. It is at this stage that the telephonist knows the type of call being switched so that the appropriate answering response may be applied.

The left hand side lamp in each of the connect circuit keys is a Key Operated lamp and lights when the key is pressed. The right hand side lamps are supervisory indicators. It will be noticed that keys which have a switching and lamp function are mounted with the long edge of the key knob horizontal, while those having a lamp function only are mounted vertically. The two keys directly above the enquiry connect keys have no function. The two lamps above these keys are busy lamps associated with the monitor and supervisory extend circuits. Clearing of calls is automatic when the A party restores and the speak key is unoperated. While a speak key is operated the line finder remains held to assist in call tracing.

The answering of complaints calls follows a similar pattern to that explained for enquiry traffic. If more than one source of complaints is distinguishable no indication of the route is given until the call is answered by pressing the speak key of an idle connect circuit. The category signal will reach SNOR-D via the marker by-path where it is stored and one of the lamps designated local, distant 1, distant 2 and distant 3 will light. In practice, these designations would be replaced by the name of the exchange or district. The monitor key is additional in the complaints connect circuit so that the telephonist may check the progress of through switched calls. When the speak key is restored the incoming category lamps extinguish They will re-light each time a speak key is operated.

Through the test access circuit the complaints telephonist may dial subscribers lines for test via the SNPR or a group of FIR-P's. A listening test and busy lamp indication are the normal facilities, but speaking may take place while the speak key (non-locking) is pressed. The Fault and Test O.K. lamps have no function at this stage.

A bothway exchange line is provided to the local ARF or S x S exchange.

Two interception answering circuits are provided. Both re-direction and put-through types of interception can be handled.

The tone demonstration keys enable the various service tones to be connected to a subscriber for his education and in particular to help in the diagnosis of vague complaints such as "When I picked up the 'phone there was a buzzing noise".

The technician's order wire keys may be used to give access to the test desk for the reporting of faults, ordering a line test, or clearing fault dockets. In some exchanges additional order wires to the automatic equipment and long line equipment rooms may be justified.

In the lower right hand corner of Fig. 16 is the positional equipment. The dial is used for impulsing on the exchange line circuit, the test access circuit and in the complaint connect circuits via the Extend Auto. keys. The keys have the following functions:—

Meter control — Associated with the complaints connect circuits. If pressed, causes metering of an extended call.

T.C.O. — Enables operator to disconnect coin telephone tone on calls from coin telephones.

Call Monitor — Similar function to the call monitor key on the T.A. positions. Calls monitor to the position or requests her to speak on the call monitor line.

N.A. Connect — Enables operator to connect N.A. buzzer on her position only. Used when sorting dockets, etc. or when concentration is not directed on the call waiting lamps.

Release Answer — Functions as a forced release key for incoming traffic. Enables a connect circuit to be freed in the event of a subscriber failing to release. Also provides lock-off facility on interception circuits.

Release Call — Associated with the Extend Auto. and Extend Switchboard keys and enables release and reseizure of an outgoing line circuit.

Speak Answer, Speak Call — Speech path divide keys associated with the three complaints connect circuits.

On the initial operation of the Extend Auto. and Extend Switchboard keys the position circuit is divided and the operator is placed in the speak call condition. This is so that the call may be extended without the caller hearing the telephonist making the attempt.

Above the dial, the device designated 11-59 on the face layout is a 24-hour digital time of day clock.

Two telephone jacks are provided on the front edge of the table used for the S.S. turret and these are wired to maintain stable conditions of current, level and impedance termination as on the T.A. positions.

Position Relay Sets

The use of non-locking type pushbutton keys to perform locking functions requires the use of logic circuitry to provide the push-on-push-off control of functions. This is a type of memory circuit. Contacts of the memory relays are used to form chain circuits for the control of 'one only' and 'mutual release' functions. All speak keys are included in a 'one only' and 'mutual release' chain so that the operator can connect to only one speak position at a time and the pressing of a speak key will release any other speak key already operated. A similar chain is wired through each of the monitor keys. In addition, mutual release is provided between speak and monitor keys within each connect circuit. These functions are performed by the Key Logic relay set, OKR-SOC-KO.

The Telephone Circuit relay set OTR-UOC-W is the same type as is used with type 'E' trunk assistance positions. Refer to Fig. 14 in Part One of the article.

The Position Circuit relay set OPR-SOC-S controls the switching of the operators speaking and monitoring commons, and contains the relays associated with the miscellaneous connect functions and the relays controlled by position keys on the turret.

No coupling is provided between positions. If none of the S.S. positions is staffed traffic is automatically diverted to the T.A. positions.

SCOTT — System AFM. 402

THE LINE FINDER

As indicated on the block diagram (Fig. 6 in Part One) the line relay sets used for terminating S.S. traffic are to the same designs as those used for T.A. traffic. In fact, the special services incoming line relay sets are terminated on both the T.A. positions and L.F. banks. Calls may be answered at all times on the S.S. positions, but lighting of the call lamps on the T.A. positions is controlled by the night switching arrangements. A line finder group comprises the following:—

Two line finder line relay sets CRA (20 lines)

Three line finder relay sets CS (30 verticals)

One marker relay set CSM

If used for complaints traffic a CRB relay set must be associated with each CRA relay set.

The twenty incoming lines connect to the 20 horizontal positions (HA and HB switching) in the crossbar selector of the first C.S. and are multipled over the horizontals of the other two C.S. relay sets. The ten verticals on each switch connect to 10 individual connect circuits. Thus 30 connect circuits can be wired to each line finder group. A group may be fitted with one, two or three C.S. relay sets according to traffic requirements. Each through connection via the C.S. is a five wire circuit. The allocation of the conductors is as follows:—

- a1, b1 Forward direction speech pair and backward signalling cailho.
- a2, b2 Backward direction speech pair and forward signalling cailho.
- h Holding of the connection and signalling tone-cut-off with the application of a superimposed positive potential.

Three basic connecting patterns are available to meet the needs of a variety of exchange sizes.

(i) The small exchange. One L.F. group is fitted. All S.S. levels (012, 013, 1194 and 1100) are handled by the one marker and the total number of inlets on all routes must not exceed 20. The number of C.S. relay sets fitted depends upon the number of special service positions required. Each S.S. position has a total of five connect circuits so each C.S. will cater for two S.S. positions. At small exchanges two positions may be adequate. If a third S.S. position is installed then a second C.S. will be needed. With two types of traffic available at the horizontals (enquiry and complaints) and two types of connect circuits (SNOR-F and SNOR-D) available at the verticals the marker must ensure that only the allowable cross-connections are made.

(ii) The medium sized exchange. Two L.F. groups are fitted. Enquiry traffic is handled in one group and complaints in the other. This permits up to 20 lines in each group or a total of 40 for the exchange. The enquiry group if equipped with three C.S. relay sets will serve up to 15 positions each with two connect circuits type SNOR-F. The complaints group with three C.S. relay sets will serve 10 positions each with three connect circuits type SNOR-D.

At this stage of development the special services positions may be divided into two specialised groups each handling exclusively enquiry or complaints traffic. A number of universal positions may be retained for light traffic periods.

(iii) The large exchange. A combination of specialised and universal positions would be used. A minimum of three L.F. groups would be established. Enquiry routes would be arranged in two groups and connected to L.F. groups 1 and 2. The third group (and a fourth if necessary) would switch complaints traffic. This would provide a total of 60-80 inlets and 90-120 connect circuits.

The test leads (T1 and T2) from the 20 inlets on each C.S. are selected for test in the marker by the G1-6 relays.

The 20 inlets are divided into six groups as follows:—

Inlets	1-4	G1
,,	5-6	G2
,,	7-10	G3
,,	11-14	G4
,,	15-16	G5
,,	17-20	G6

Provision is made for up to four category markings to be signalled from the 20 inlets to the connect circuits. These are controlled by the B1-4 relays. A strapping field is provided between contacts of the B relays and the coils of the G relays. For example if inlet 9 is in category 2, then B2 is strapped to G3 as inlet 9 is accessible only through the G3 relay. The vertical to be used is determined by the connect circuit engaged for the call and is identified in the marker by the A1-10 relays. Before switching takes place the marker ensures that only one relay in each of the A and B relay groups is operated. Two preference chains are wired to the A relays and holding preference is given to A1 and A10 on alternate calls. An allotter steps on each call handled by the marker and gives priority to each of the B relays in turn. The functioning of the marker is time supervised and released followed by an alarm to the service control room occurs if calls are not switched within a pre-determined time.

THE MONITORS POST CIRCUITS

Monitor's Turret

Fig. 17 shows the face layout of the monitors turret key panel. Across the top are ten keys giving access to the ten T.A. or S.S. positions for which the monitor is responsible. Two-way calling and speaking is provided and listening one-way from monitor to telephonist. When a telephonist on a T.A. or S.S. position presses the call monitor key the lamp in the right hand side of the appropriate key on the monitor's turret will light. The monitor's pilot lamp on top of the turret will also light. In addition, a pilot lamp on the calling position and a lamp in the annunciator panel will glow. The monitor may acknowledge the call in two ways:—

(i) By walking to the calling position and speaking to the telephonist. The monitor will release the call monitor key, or

(ii) By pressing the Connect key on the monitor's turret. In this case the turret call lamp will extinguish (also all pilot lamps) and the left hand side lamp in the key will light indicating that the key function is operative. The monitor call lamp on the calling position will flash until the telephonist restores all speak keys. When this is done, and the monitor presses the Speak-on Monitor key the two parties may converse. The Call Monitor key on the T.A. or S.S. position (if ERGA type) will restore automatically.

The monitor may listen across each of her 10 telephonists for supervisory purposes by pressing the appropriate position connect key (with the Speak-on-monitor key normal).

Two lines to the trunk assistance switchboard line multiple are provided and separate speak and hold keys are fitted to each. These are bothway lines. The extend circuit from special services positions terminates on speak and hold keys. This line is incoming only to the monitor. A bothway line to the local ARF or S x S exchange is provided and associated with this are dial, speak and hold keys. A night alarm cut off key temporarily disconnects the buzzer until all waiting calls are answered. The buzzer circuit is then reset automatically so that it will function again on the next incoming call. Two telephone jacks are provided on the front of the turret and wired so as to maintain stability of transmitter current, speech level and terminating impedance with one or two handsets plugged in.

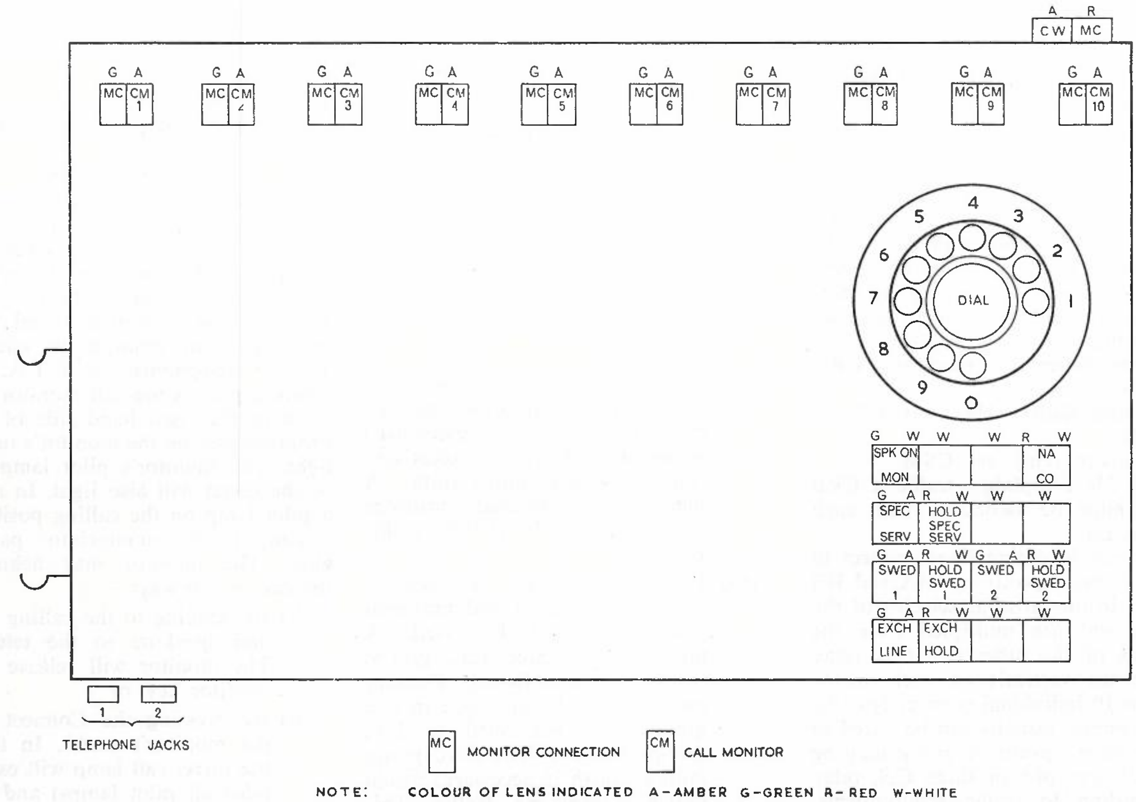


Fig. 17 — Monitors Turret Key Panel Layout.

Position Relay Sets

Key logic relays are required to control the functions associated with the non-locking type push button keys. The relays are divided into two groups and fitted in two separate relay sets OKR-GOC-K1 and OKR-GOC-K2. The OKR-K1 relay set contains the logic relays for the speak and hold functions. "One only" and "mutual release" chains are provided for the speak key functions. There is mutual release between each pair of speak and hold keys and overlapping of functions during switchover.

The OKR-K2 relay set is associated with the ten monitor connect keys. It provides 'one only' and 'mutual release' chains between the ten keys.

The Telephone Circuit relay set OTR-GOC-V may be associated with either a monitor's or supervisor's position. Its design is rather different to the OTR used on trunk assistance and special services positions. The four-wire line connections comprise two speech pairs SA and SB but these provide 600 ohm terminations and convey directional speech only. In the speech condition the circuit functions as an amplified four wire terminating telephone. Fig. 18 shows a simplified diagram of the OTR. Speech signals from the telephone transmitter are amplified and applied to line on the SA pair which is connected to the a1, b1 wires of a switchboard line circuit, e.g., service line relay set. A sample of the output voltage on SA is returned via a 60dB pad to the receive amplifier and telephone receiver where it is heard as side tone. Received speech from line is connected to the SB pair, passed through a 41 dB pad, amplified and supplied to the telephone receiver. Monitored speech on the MA and MB pairs is attenuated by a further 7 dB to produce a lower volume in the telephone receiver. The purpose of the pads is to de-couple the SA, SB, MA and MB leads and thus reduce crosstalk between them.

The Position Circuit relay set OPR-GOC-R is usable on either a monitor's position or supervisor's position. It is a comparatively simple circuit containing mainly the switching functions on the SA, SB, MA and MB leads. A new facility is the six second reminder bell which operates under call monitor conditions. When a telephonists presses a

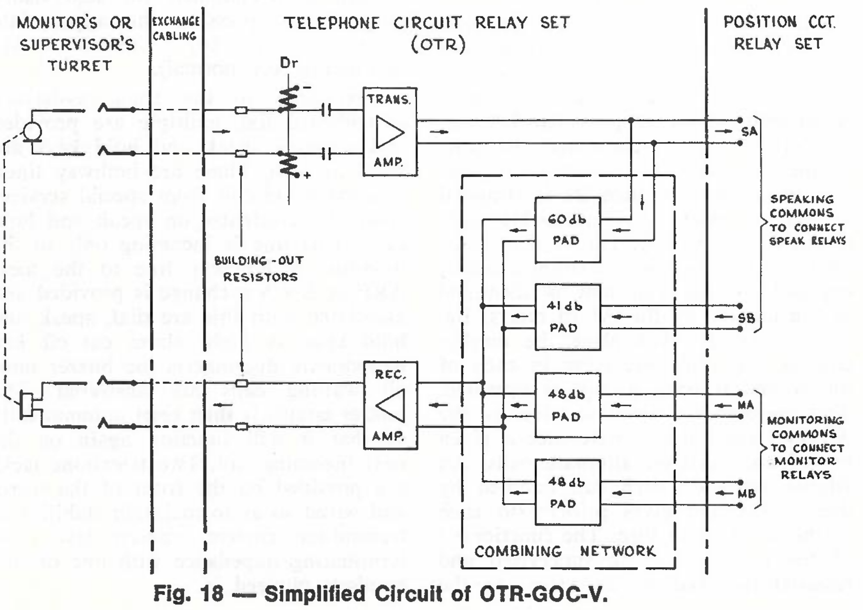


Fig. 18 — Simplified Circuit of OTR-GOC-V.

call monitor key, in addition to the lamp indications mentioned previously, a bell gong in the monitor's turret is struck once. This is followed by reminder 'gongs' every six seconds, until the call is answered. The OPR contains this circuitry.

A miscellaneous connect circuits relay set (SNOR-GOC-G) also usable on a supervisor's position contains terminations for the exchange line circuit, the two service lines, the extend circuit from the S.S. positions and the demonstration tones. The tone circuit is used on the supervisor's turret but not on the monitor's turret.

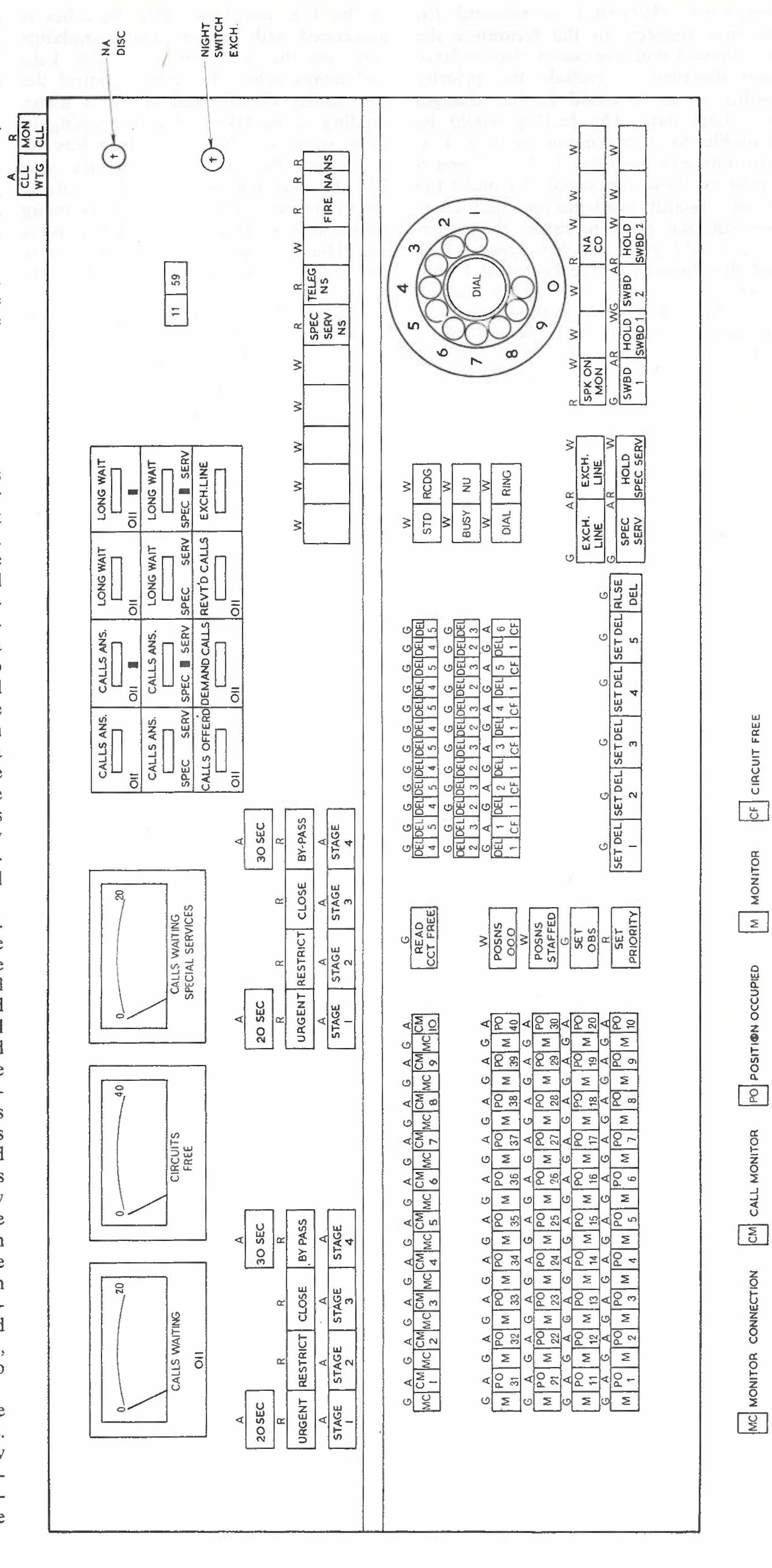
THE SUPERVISOR'S TURRET CIRCUITS

Supervisor's Turret

The so-called supervisor's turret is provided for the in-charge officer whether her status is supervisor or monitor. It is supplied with the initial installation. The facilities of the monitor's turret are duplicated on the supervisor's turret and in addition keys and meters for exchange management functions are included. At a small exchange with a monitor in charge there would be no monitor's turret. The monitor would operate the supervisor's turret. When the exchange grows so that a supervisor in addition to the monitor is justified, a monitor's post would be installed and the call monitor functions transferred to the monitor. As the monitor's turret is equipped for only 10 call circuits any excess over this number could be terminated on the supervisor's turret until a second monitor's turret is installed.

On the left of the key panel (see Fig. 19) are forty keys corresponding to the forty operating positions which is the maximum number the system is designed to handle. The lamps in the right hand side of each key are used for the dual purpose of indicating positions occupied and positions blocked. The appropriate indications are given when the Positions Staffed and Positions O.O.O. keys to the right of the block of forty keys are pressed. To observe across a staffed position the Set Observation key is operated followed by the position key in the 1-40 group. The left hand side lamp in the position key will light when the key function is operative. The supervisor may move from observing on one position to another merely by pressing the key associated with the second position. When she is finished observing, the Set Observation key is pressed to restore the set observation facility.

The priority facility is not available in the present design of System AFM402. Before it can be introduced a new operators register capable of signalling with compelled sequence multifrequency code must be designed. The



NOTE: COLOUR OF LENS INDICATED A-AMBER G-GREEN R-RED W-WHITE

Fig. 19 — Supervisors Turret Key Panel Layout.

designation REG-OC1 is reserved for the new register. In the meantime the switchboard and associated circuits have been designed to include the priority facility so as to avoid further changes at a later date. The facility would be available to a maximum of five T.A. positions and positions 1, 3, 5, 7 and 9 would be those concerned. To make the priority facility available on a particular position, say position three, the supervisor would press the Set Priority key and the Position Three key. The L.H.S. lamp in the position three key flashes until the Telephonist avails herself of the facility when it will extinguish.

The five Set Delay keys, the Release Delay and the Read Circuits Free keys are connected in a logic control chain circuit. These are associated with the six route keys. It is thus possible to cope with up to six major outgoing routes, placing each route independently in one of five delay conditions or connecting the Circuits Free meter to the traffic resistors for a direct reading of idle circuits on these routes. The manipulation of the keys in the 1-40 positions and 1-6 routes blocks are arranged for single finger operation.

There are two calls waiting meters. One is associated with traffic incoming to the T.A. positions while the other is associated with enquiry and complaints calls on the S.S. positions. The keys and lamps below the meters control the two gating circuits and enable a meter reading to be taken of calls waiting in each stage of the gates. The Restrict key closes the fourth stage of the gate limiting the number of calls awaiting answer to three. Blocking of all incoming routes occurs when the Close key is pressed. The By-pass key isolates the gating and allows the call lamps to light immediately calls arrive.

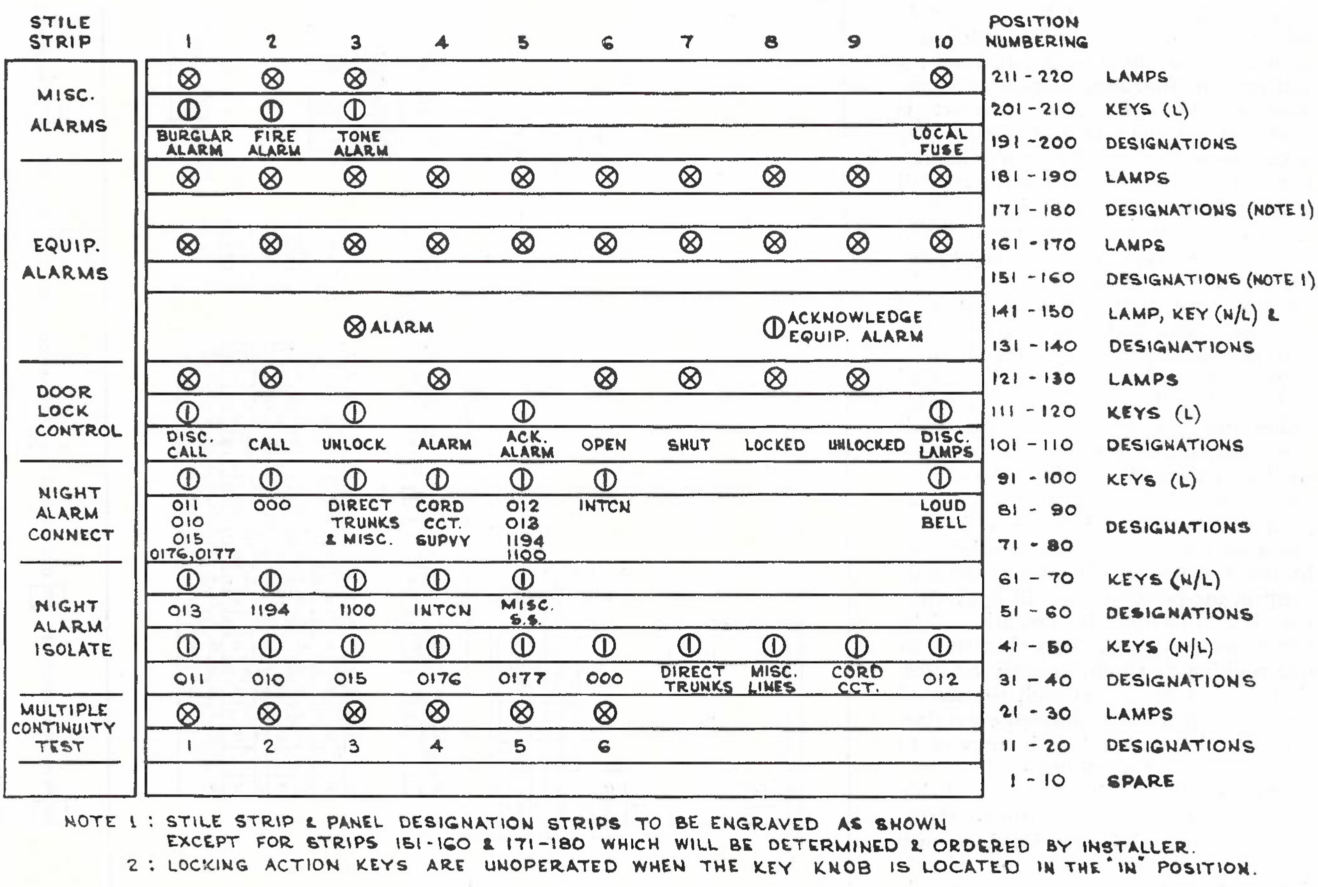
The speed-of-answer objective is normally 10 seconds. If the waiting time of a call in either gating system exceeds this period the urgent lamp will light and call pilot lamps in the exchange will flash. If the traffic increases to a point where the available staff is unable to maintain a 10 second speed-of-answer the supervisor may increase the time by presing either the 20 second or 30 second key.

Twelve cyclometer type meters record traffic data. Seven are associated with the T.A. positions and four with the S.S. positions. Some are resettable. The exchange line meter is wired in parallel with the normal meter associated with the supervisor's bothway exchange line in the local exchange. It is used by the supervisor to check metering on self-dialled S.T.D. calls.

The rectangle displaying the figures 11-59 on this layout represents the face and digit wheels of a 24 hour clock showing the time in hours and minutes.

Automatic diversion of the special services traffic to the T.A. positions occurs when all S.S. positions are unstaffed. The supervisor also has manual control of this function through the key marked Spec. Serv. N.S. When the key is pressed incoming traffic from the special services routes may be answered at either the T.A. or S.S. positions. This facility may be used to improve the speed-of-answer on special services calls during busy periods. A similar facility may be provided on phonogram traffic by using the key designated Teleg. N.S.

The Fire key directly controls a local fire bell used in the practice of fire drill. The key to the right of the Fire key has no function, but the lamps are associated with the two control locks mounted immediately above. The N.S. Disc. control lock is used to disconnect the night alarm in the event of a permanent alarm condition developing when the alarm bell and buzzer are controlled by the synchronous time switch. Once



NOTE 1 : STILE STRIP & PANEL DESIGNATION STRIPS TO BE ENGRAVED AS SHOWN EXCEPT FOR STRIPS 151-160 & 171-180 WHICH WILL BE DETERMINED & ORDERED BY INSTALLER.
2 : LOCKING ACTION KEYS ARE UNOPERATED WHEN THE KEY KNOB IS LOCATED IN THE "IN" POSITION.

Fig. 20 — End Section Key Panel Layout.

operated by the control key, the N.A. lamp remains lit until the reset key on the GOC rack is operated. A lamp indication is given to the service control room also. The Night Switch Exchange control lock is used to close down all operating positions and divert the traffic to a larger manual assistance centre. It would have connections to the common control equipment in the ARF and ARM exchanges. Above the control locks on the top of the turret are two position pilot lamps indicating call waiting and monitor call conditions. Dual telephone jacks are provided as on other positions and these are mounted on the front edge of the table.

Position Relay Sets

The relay sets associated with the supervisor's turret comprise two groups. First is the group associated with speaking, monitoring and line signalling. These are the same family of relay sets as used for the monitors, namely —

OKR-GOC-K1 Key logic for speak and hold functions.

OKR-GOC-K2 Key logic for call monitor functions.

SNOR-GOC-G Miscellaneous connect circuits.

OPR-GOC-R Position switching

OTR-GOC-V Telephone Circuit

The second group is key logic relay sets associated with control functions, as follows:—

OKR-COC-KE Key logic for observation, priority, positions staffed and positions blocked, functions.

OKR-COC-K4 Key logic for route delay and read idle circuits functions.

OKR-COC-K5 Key logic for the control of gating and speed of answer.

MISCELLANEOUS APPARATUS

Switchboard End Section

One panel of line multiple space on the end section is occupied by control keys and lamps. Fig. 20 shows a face layout of this panel. In the night alarm field, twenty non-locking keys are assigned for night alarm isolation. Each key is associated with a separate incoming route so that a permanent alarm fault may be isolated to a particular route The Night Alarm connect keys enable the alarm buzzer to be connected on selected routes in times of light traffic. The Loud Bell key is used for the routine testing of the delay circuit and bell, and for connecting the loud bell during hours when the time switch is not operative.

Equipment alarms are normally signalled to the exchange technicial staff. After hours when the test desk Alarm Extend key is operated, alarms are received by the traffic staff. Up to twenty separate alarms may be received, identified and acknowledged.

Three special alarms terminate on the end section at all times. These are the burglar, fire, and pip tone fail alarms. Each of these alarms must be acknowledged both on receipt and when cleared.

The building entrance door used by the traffic staff may be fitted with a solenoid type lock for remote operation from the End Section. This saves the operating staff leaving the switchboard to admit staff to the building when a change of shift is due. Lamps on the

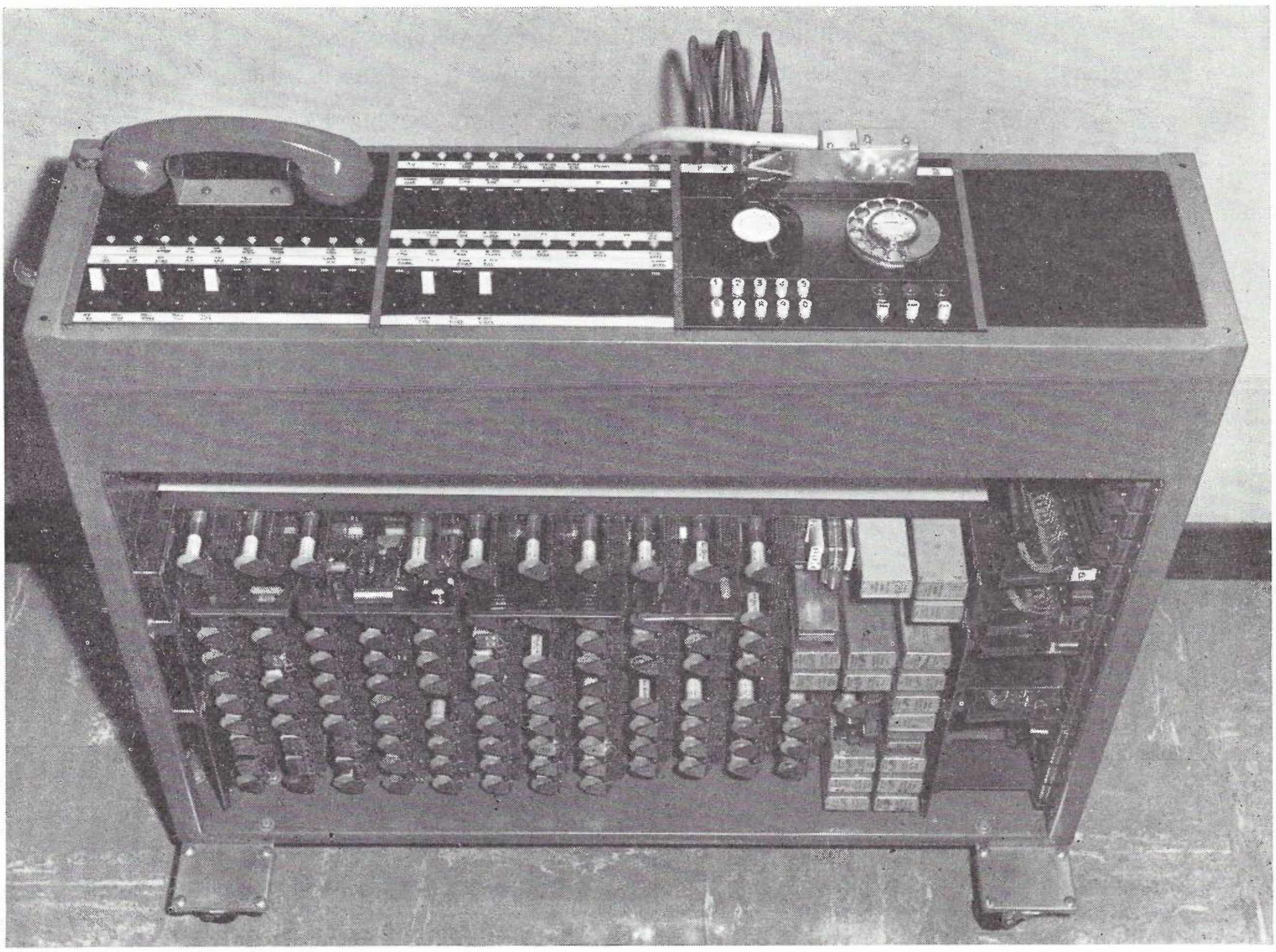


Fig. 21 — The AFM402 Exchange Tester.

panel supervise the door and indicate whether it is open or shut, locked or unlocked. The lock solenoid is normally operated. An alarm is provided in the event of an open circuit in the control pair due to either a fault or manual interference. A person wishing to gain entrance to the building presses the call button outside the door and gives a pre-arranged code of signals. When suitably identified the person may be admitted by pressing the Unlock key on the control panel. This key sounds a buzzer at the door which indicates to the person waiting that the lock has been released. The Disconnect key is used in the event of an unauthorised person indiscriminately pressing the call button and creating a nuisance.

A multiple continuity test set is built into the End Section for point-to-point and end-to-end testing of continuity in the line multiple wiring. Testing is done with local 1.5 volt dry cells and each of the six wires in the jack multiple is tested in turn. The low voltage ensures that high resistance connections will not be broken down and thus will show up as faults. The six lamps on the control panel light in turn as the six wires are tested. The test set is wired to test jacks in the switchboard miscellaneous multiple. Testing is performed by patching from the test jacks to the line jacks of the line under test, using double ended cords.

End Section Relay Sets

Key logic relay sets associated with the end section keys are mounted on Rack GOC in the equipment room. Four relay sets are involved, namely:—

OKR-YOC-K6 Key Logic for night alarm and urgent lamp control

OKR-YOC-K7 Key logic for extended equipment alarms. Each relay set contains ten circuits. Two relay sets may be installed.

OKR-YOC-K8 Key logic for door lock control.

OKR-YOC-K9 Key logic for burglar, fire, and pip tone fail alarms.

Miscellaneous Relay Sets

A Lamp Pulse relay set is required on each GOC and SOC rack. The relay set receives FL.1, FL.2, and six second pulses from the exchange pulse distribution and repeats them to turret lamps and their associated control relay sets.

TABLE 9: PRINTED CIRCUIT BOARDS USED IN SYSTEM AFM402

ROA Number	Name	Essential Characteristics
ROA213A5	Amplifier Type 1	Input level : –13 dBm to +1 dBm Output level : 0 dBm to +4 dBm Gain : 14 dB Used as line amplifier
ROA213A6	Amplifier Type 2	Input level : –38 dBm to –40 dBm Output level : –6 dBm to + 2 dBm Gain : 42 dB Used as receive amplifier in OTR's and in conference relay set.
ROA212A10	Amplifier Type 3	Input level : –8 dBm Output level : +13 dBm Gain : 21 dB Used as transmit amplifier in OTR on T.A. and S.S. positions.
ROA214A4	Amplifier Type 4	Input level : –3 dBm Output : 25 watts into 8 ohm load. Used in P.A. system relay set.
ROA211A4	Attenuator 0-15½ dB	Contains strappable pads having the following attenuations:— ½, 1, 2, 4, 8 dB Used in line relay sets to adjust level.
ROA213A17	Oscillator 900 Hz	Frequency : 900± 10 Hz Output : 3 volts R.M.S. into 600 ohm load. 1.5 volts R.M.S. into 15 ohm load. Used to supply 3-pip tone to cord circuits.
ROA212A15	Oscillator 820 Hz	Frequency : 820± 5 Hz Output : Odbm to + 3dbm into 600 ohms with stability of ±0.1dB. Used for reference tone in Tone Test relay set.
ROA213A13	Combining Network Type 1	Provides for transmitting and receiving speech on two bi-directional pairs forming a four wire circuit. Also has two high impedance tapping paths for monitoring. Used in OTR relay sets on T.A. and S.S. positions.
ROA212A16	Combining Network Type 2	Provides 4 pad combinations for side tone, received speech and monitored speech. Used in OTR relay sets on monitor and supervision positions.

The One Minute Pulse relay set receives a half second (approximately) pulse from the exchange master clock every minute. These are repeated to the digital slave clocks on the operating positions as polarity reversals.

The Exchange Tester

A comprehensive tester for line relay sets is provided in the form of a mobile test trolley (See Fig. 21). It comprises a rack, jack box, and three relay sets designated SPR I, II and III. The SPRI contains circuit elements to simulate the distant end of each of the signalling types used in the exchange line relay sets. These are as follows:—

L1, L2, T, T1, R, U1, U2, U3, U4, GV outlet, GU outlet.

SPRII simulates the answer side of a cord circuit used on the trunk assistance positions and also the essential functions of the OPR-DOC. SPRIII contains the four-wire telephone circuit and speech path switching. The exchange tester may be plugged into the line side and/or switchboard side of any incoming, outgoing or bothway line relay set. An additional 80 point plug on the end of a cord is used to connect the tester to Jack 68 on the line relay set rack. This provides access to battery and earth, an inlet on the RS multiple for connection to REG-OC2, a service line terminating on the trunk assistance positions, and other common services.

To test a particular line relay set, the tester keys are operated in the following groups —

Incoming or outgoing. These keys nominate the direction of the test call with respect to the switchboard.

Signalling type. The type of signalling required on the line side is selected.

Connect line, connect switchboard. Connect the exchange tester to either or both sides of the line relay set under test.

Control keys. These keys apply the various test conditions. There is a group applying distant end conditions in the forward direction, e.g. seize, clear forward, recall; and a group applying supervisory conditions, e.g. answer, clear back. Another group includes speak, monitor, dial, digit keys, etc. associated with the switchboard side.

A large array of lamps indicates the progress of the test and the response to the various control signals applied. Two dials, one delivering 10 i.p.s. and the other 20 i.p.s. are included in addition to the digit keys.

Printed Circuit Boards

All amplifiers, oscillators, attenuators and combining networks used in the line and positional relay sets are mounted on printed circuit boards of the plug-in type. Standard ROA type mountings are used. Table 9 lists the essential characteristics of each ROA board.

Racks

Ten rack types were specially designed for System AFM402. In addition use is made of the ARM rack type FIR-M for mounting line relay set FIR-LM-Y2OC and the ARF RS rack for the register finders. The racks and their functions are listed in Table 10.

TABLE 10: SYSTEM AFM402 RACKS

Designation	Use
SNOR-OC	One per two trunk assistance positions Type 'S'
DOC	One per two trunk assistance positions Type 'E'
REG-OC	One per eight registers Type REG-OC2.
L.R.S.-1 (30)	One per 30 line relay sets of Type BCH121, except FIR-LM-Y2OC.
L.R.S.-2 (20)	One per 20 line relay sets of Type BCH131.
L.R.S.-3 (15)	One per 15 line relay sets of Type BCH141.
OC-MISC.	One per exchange. Mounts the following relay set types: F.L.S., Pulse Distributor, Pulse Alarm, Central Alarm, Gating, Cord Circuit Test, P.A. System, Conference.
LF	One per two line finder groups. Mounts the following relay sets in each group: 2-CRA, 2-CRB, 3-CS, 1-CSM.
SOC	One per two special services positions. Also mounts Test Access, Interception, and Technicians Order Wire Relay Sets on a non-positional basis.
GOC	One per exchange. Contains relay sets for one supervisor, four monitors and the following miscellaneous relay sets: OKR-YOC-K6, OKR-YOC-K7, OKR-YOC-K8, OKR-YOC-K9, Delay Tone and One Minute Pulse.

CONCLUSION

The AFM402 system provides a manual assistance centre designed to meet the present and future needs of the A.P.O. trunk network. It offers a new conception in manual cord type switchboard operation styled to provide a working environment closely allied to that of a modern office. The system emerges as an attractive competitor to the proposed cordless type manual assistance exchange — at least for the smaller sized installations. It combines a contemporary appearance with simple operating procedures, while providing improved transmission performance, better facilities and a wider range of circuit operating limits compared to previous cord type switchboards.

Considerable laboratory work preceeded the adoption of the various circuit elements used in the design. Prototype models of the operating positions, the associated relay sets and also the line relay sets were constructed and subjected to exhaustive laboratory and simulated service tests. No effort has been spared to ensure that the finished design contains the best of facilities provided in a reliable manner consistent with long life and low maintenance.

ACKNOWLEDGMENT

The author would like to express his thanks to the members of the design team for their help and co-operation during the project. Their energetic approach to the work and the valuable suggestions made were particularly stimulating. Many other people — too numerous to name individually — officers of various divisions, sections and subsections have made contributions to the project both large and small and the assistance of these persons is gratefully acknowledged.

REFERENCES

1. E. G. Wormald, "Gating: An approach to call queueing", Telecom. Journal of Aust., June 1958, Vol. 11, No. 4, P. 127.

POLING PATTERNS FOR PEAK VOLTAGE REDUCTION

*S. MINZ, B.E.E., M.I.E.Aust.**

INTRODUCTION

High voltage peaks are caused in wideband carrier systems as a result of additions of sinusoidal signals, if these signals occur in groups with uniform frequency separation and if, at the same time, they originate from a single coherent generating source. (The word coherent used in this context implies that all signals forming the frequency group concerned are produced with the same initial phase).

Well known examples are the 'spikes' observed in systems using continuous out-of-band low level signalling tones. These tones appear as a group of signals, 4 kHz apart; they all usually originate from a single 3.825 kHz oscillator and the peaks which result occur at a repetition frequency of also 4 kHz. Pilot tones, if coherent, could in a similar way be responsible for the formation of voltage peaks. Group pilots for instance, which occur at a frequency displacement of 48 kHz could cause high voltage peaks at a repetition frequency of 48 kHz. A further source of potential trouble could arise due to carrier leaks which, although occurring at low levels, could nevertheless cause substantial resultant peaks if the number of channels in a system is very large.

The load capacity of a carrier system depends, among other things, on the rating of line amplifiers which have to cope with the multiplex signals transmitted. Since the nature of these signals is such that an accurate prediction concerning the variation with time of their voltage waveform is impossible, statistical methods have to be employed to express their characteristics and the load formulas which are currently used for the design of wideband carrier systems (C.C.I.T.T. Recom. G223, Blue Book Vol. III p. 80) are based on the assumption that for $N > 64$, where N is the number of active channels, the distribution of instantaneous voltages is normal. Such an assumption is perfectly reasonable, as has been shown by Holbrook and Dixon (Ref. 1), if the individual communication sources, which combine to form the multiplex signal, consist of speech or other noncoherent signals. If, however, a substantial proportion of the transmitted signal includes coherent tone groups, the application of the conventional design formulae could lead to the systems being grossly underrated. The excessive voltage peaks. formed by such coherent groups, may then cause overload conditions with the incidence of prohibitive distortion products spilling over all channels so that in order to keep the system operative, a drastic reduction in channel capacity will be necessary.

In addition to limiting the system capacity by causing the amplifier overload point to be exceeded and thus generating excessive intermodulation products of low as well as high orders (Ref. 2), the coherent tone groups with uniform frequency spacing are also responsible for another undesirable effect described by Grönberg and Johannesson (Ref. 3).

This effect is a type of 'intelligible crosstalk' which occurs because the difference frequency concerning any two tones of a group with uniform frequency spacing must be an integral multiple of that spacing and therefore some of these difference frequency tones will coincide with tones of the original group. If the signals of this original group are coherent, then the interference tones will add on a voltage basis and reach objectionable magnitudes. If, however, the same signals occur at random phases, the difference products add in accordance to the power addition law. It is on this latter assumption, that the design of repeaters is currently based.

Fortunately methods are available which can be employed to reduce the voltage peak incidence referred to above. The purpose of this paper is to describe these methods in some detail and to explain the underlying principles.

THE NATURE OF THE VOLTAGE PEAKS CAUSED BY COHERENT TONE GROUPS

(Ref. 4, 5)

Let:

$\delta\omega =$ common frequency interval between tones of group

$\omega_1 = 2\pi f_1$, lowest angular frequency in tone group

$N =$ number of tones in group, each of unit peak amplitude

$\omega_n =$ highest angular frequency in tone group

$\Delta\omega =$ frequency range of group $= (\omega_n - \omega_1) + \delta\omega$ or: $N\delta\omega$

$\omega_m =$ mean angular frequency

$T =$ period between successive peaks

The following relationships hold:

The voltage function $F(t) =$

$$= \sum_{k=0}^{N-1} \cos(\omega_1 + k\delta\omega)\, t$$

$$= \sin N\frac{\delta\omega}{2}t / \sin\frac{\delta\omega}{2}t$$

$$\times \cos\left(\omega_1 + \frac{N-1}{2}\delta\omega\right)t \quad \ldots .(1)$$

Since $\omega_1 + \dfrac{N-1}{2}\delta\omega = \omega_m$,

and writing $H(t)$ for $\sin N\dfrac{\delta\omega}{2}t / \sin\dfrac{\delta\omega}{2}t$

(1) can be rewritten:

$$F(t) = H(t)\cos\omega_m t \quad \ldots .(2)$$

This is a function $\cos\omega_m t$ modulated by the envelope $H(t)$.

Also, by inspection,

$H(t)$ max: at $t = 2\pi n/\delta\omega$, $n = 1, 2, 3$, $= N$

A trace of this envelope $H(t)$ is shown in Fig. 1.

Also:

Period of successive peaks:

$$T = \frac{2\pi}{\delta\omega} \ldots\ldots\ldots.(3)$$

Width of main peaks:

$$= 2\frac{2\pi}{\Delta\omega} \ldots\ldots(4)$$

Width of subsidiary peaks:

$$= \frac{2\pi}{\Delta\omega} \ldots\ldots\ldots.(5)$$

Successive zeros between peaks occur at:

$$t = \frac{2\pi n}{\Delta\omega},\ n = 1, 2, 3$$

(where t is measured starting from the commencement of a main peak)

Auxiliary peaks occur at:

$t = 3\pi/\Delta\omega, 5\pi/\Delta\omega, 7\pi/\Delta\omega$, etc.

Height of successive auxiliary peaks:

$2N/3\pi,\ 2N/5\pi,\ 2N/7\pi$

The height of the main peak is N times the common height of the single tone peaks, assuming the single tone peaks are all of the same magnitude.

Since $\Delta\omega = N\delta\omega$, it follows that as N increases, the width of the main peak decreases and in the limit; as $N \to \infty$:

$$\text{Main peak width} = 2\frac{2\pi}{N\delta\omega} \to 0$$

The repetition period $T = \dfrac{2\pi}{\delta\omega}$ is

* Mr. Minz is Engineer Class 3, Transmission and Line Planning, Headquarters.

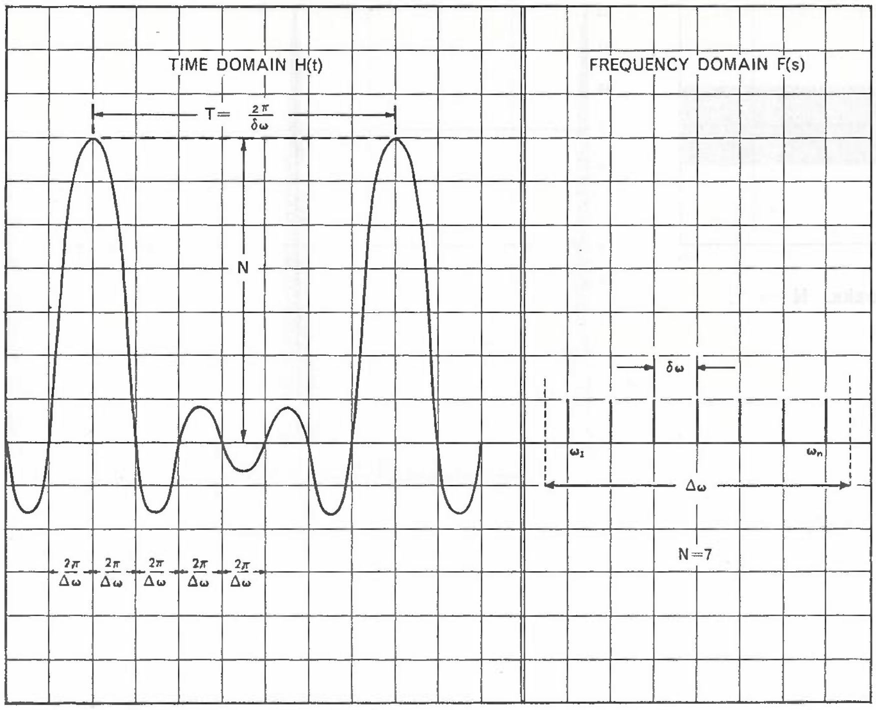


Fig. 1. Left: Trace of Envelope $H(t) = \sin N \frac{\delta\omega}{2} t \Big/ \sin \frac{\delta\omega}{2} t$

Spectrum of7 Coherent Tones with Uniform Frequency Separation.

independent of N and remains unchanged provided the common frequency interval $\delta\omega$ is not changed. It is inversely proportional to $\delta\omega$.

Plotting the Function

The function

$$F(t) = \sum_{k=0}^{N-1} \cos(\omega_1 + k\delta\omega)t$$
$$= H(t) \cos \omega_m t$$

can be plotted with the aid of a computer. Figs. 2 to 6 are a series of such plots for N = 1, 2, 3, 6 and 12. The evolution of the 'spikes' can be clearly seen.

Fig.7 shows a photograph of waveforms actually observed when 3.825 kHz signalling tones were added to a 12 channel group, one at a time and the bottom trace represents the result of adding 60 signalling tones in a supergroup. Note the narrow 'spikes' of this last trace. It is also of interest to observe that in the case of this example of an actual physical circuit, the main peak is shown to be split into three parts. Obviously the coherence is not absolutely rigid as the three channel carrier paths are each subject to different phase delay characteristics.

ESTIMATE OF PEAK VOLTAGE AMPLITUDES

In the last section it has been shown that for N tones of unit magnitude the maximum height of the voltage 'spikes' under conditions of rigid coherence is equal to N. If the phase distribution of the same signal tones is random, then the probability density function p(z) for the resultant instantaneous voltage peaks is gaussian. (Ref. 6). Thus if the individual signalling tones consist of sine waves given by the equation:

$$X_k = A_k \sin \theta_k$$

where k = integer 1 to N for N tones

X_k = instantaneous height of voltage due to the kth tone

A_k = max height of the kth tone

θ_k = random phase angle of kth tone ($-\pi$ to $+\pi$)

It can be shown that the probability density function p(z), where

$$z = \sum_{k=1}^{N} X_k$$

is given by:

$$p(z) = 1/\sigma\sqrt{(2\pi)} \times \exp.(-Z^2/2\sigma^2)$$

where $\sigma^2 = 1/2\,(A_1^2 + A_2^2 + \ldots + A_n^2)$

To estimate the reduction of peaks which is possible if a coherent group of tones is replaced with one which exhibits a completely random distribution of phases as far as the component tones are concerned, we compare the peak factor for coherent tones P(N) with the peak factors for tones with random phases $R(N)_{10}$ and $R(N)_1$, where P(N) is defined as the highest voltage occurring in the wave train due to the addition of N coherent signals, each of unit amplitude, and $R(N)_{10}$ and $R(N)_1$ are the peak voltages with a 10% and 1% probability of being exceeded, respectively, when the same component waves are at random phase.

These estimates are given in Table 1. Both positive and negative voltage peaks are included. In practice, the improvements that can be achieved will be less than the maximum stated, because neither rigid coherence nor perfect randomisation are normally encountered.

TABLE I: ESTIMATE OF PEAK VOLTAGE REDUCTION

No. of Channels	σ	$R(N)_{10}$ ($z = 1.65\sigma$)	$R(N)_1$ ($z = 2.58\sigma$)	P(N)	Maximum Reduction Possible (in dB) 10% probability $= 20\lg(P(N)/R(N)_{10})$	1% probability $= 20\lg(P(N)/R(N)_1)$
1	0.7			1		
12	2.5	4.0	6.3	12	9.5	5.6
60	5.5	9.0	14.1	60	16.5	12.6
240	11.0	18.1	28.2	240	22.5	18.7
300	12.3	20.2	31.5	300	23.4	19.6
960	21.9	36.2	56.4	960	28.5	24.6
2700	36.7	60.6	94.6	2700	33.0	29.1

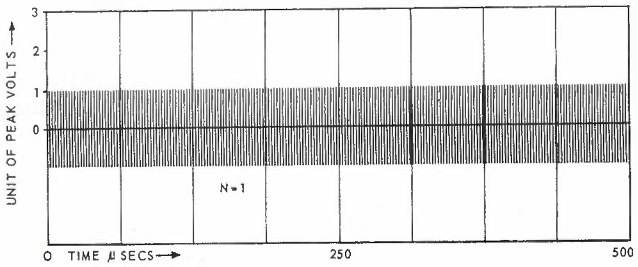


Fig. 2. Evolution of High Voltage Peaks. N = 1.

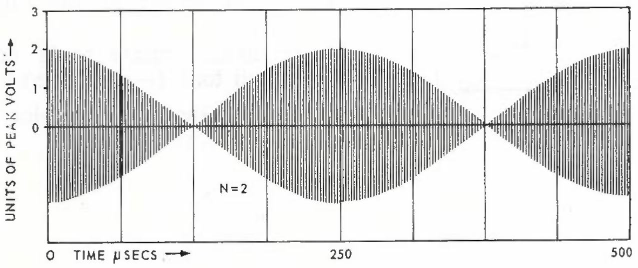


Fig. 3. Evolution of High Voltage Peaks. N = 2.

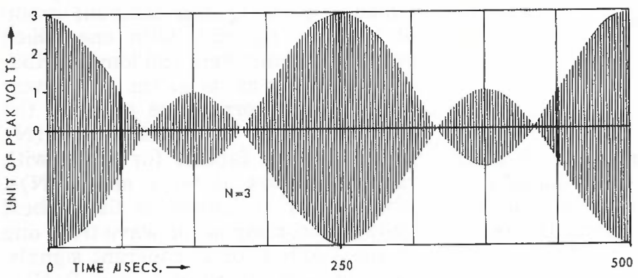


Fig. 4. Evolution of High Voltage Peaks. N = 3.

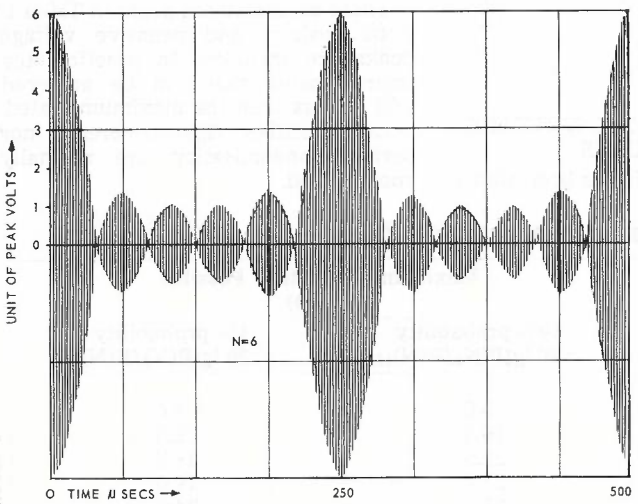


Fig. 5. Evolution of High Voltage Peaks. N = 6.

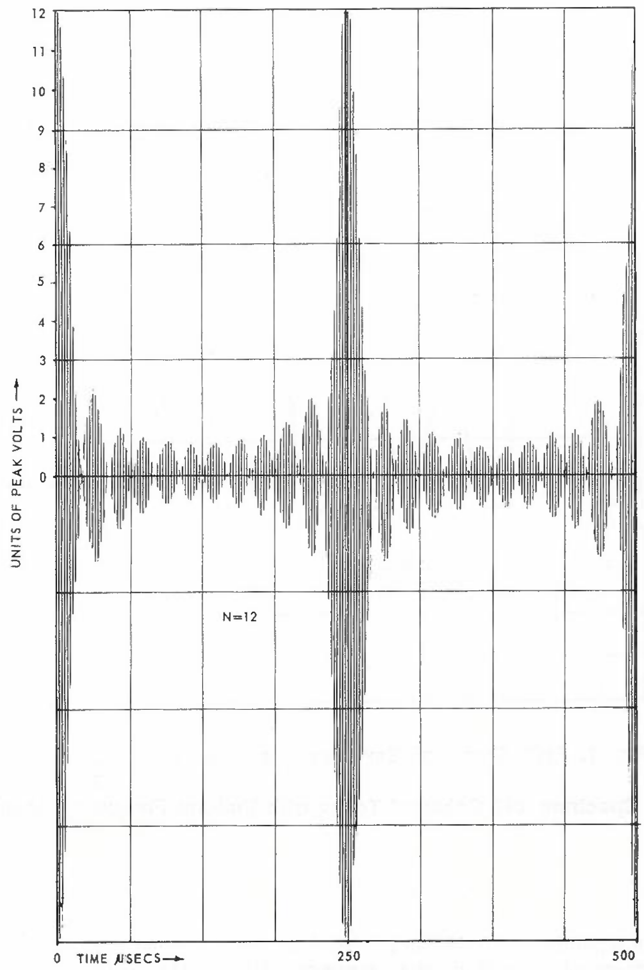


Fig. 6. Evolution of High Voltage Peaks. N = 12.

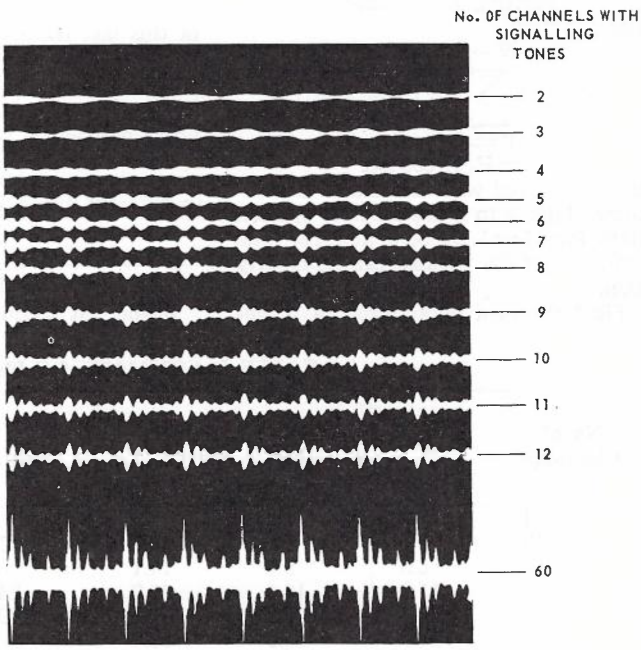


Fig. 7. Photograph of Observed Waveforms.

METHODS TO REDUCE THE VOLTAGE PEAKS

General

As already mentioned, two factors are responsible for the generation of the high voltage peaks under discussion, namely:

(a) The presence of signals forming a group in which each signal is separated from the next by an equal frequency interval; (in the case of low level continuous tone signalling systems, this common frequency interval is 4 kHz).

(b) Coherence of all signals in the group.

The conditions leading to the presence of equal frequency intervals are not easily changed as this would involve extensive modifications to established modulation plans, which clearly is not practical.

The second factor, however, does provide a key for the solution. Any method which can upset the rigid coherence of the tone group and substitute some degree of randomisation, must contribute towards the reduction of the high peak votages.

One method to achieve this aim could be to provide a number of separate oscillators for the generation of the tones involved. A second possibility is to interpose suitable delay networks in the path of the signals. Both these methods, however, suffer from the disadvantage of not only being costly but also of adding to the complexity of the comunication system concerned.

Fortunately, there is a third method, which requires no additional circuit elements for its implementation. It is based on the possibility of causing a phase change of π radians, i.e., a change of poling, by simply transposing the two wires carrying a signal. Such transpositions are relatively easy to apply in practice.

In what follows, the development of useful pole changing patterns is described as well as the principles on which they are based. The examples given are illustrated with traces actually obtained with the aid of computer simulated plots.

Theoretical Considerations

In accordance with the well known shift theorem associated with Fourier Transforms: (Ref. 7).

If $f(t)$ has a Fourier Transform $F(\omega)$ then $f(t - t_0)$ has a Fourier Transform

$$\exp(-j\omega t_0)\, F(\omega) \quad \ldots\ldots (6)$$

Applying this principle to the case of continuous tone signalling systems, which have a discrete frequency spectrum with a unit frequency interval of $\delta\omega$ corresponding to 4kHz and a fundamental period in the time domain of $T = \frac{2\pi}{\delta\omega}$ expression (6) must then be interpreted to imply that the rate of phase change required per unit angular frequency change (in this case $= \delta\omega$), i.e., the phase change from one tone to the next, to cause a shift t_0 in the time domain, is $\delta\omega\, t_0$.

The shift theorem therefore shows that it is possible to manipulate the voltage trace in the time domain and change its form in a predictable manner. How this can be done in practice using transpositions, i.e., phase changes in units of π radians only, is best illustrated with the help of examples.

Example 1:

Object: To shift voltage trace by a half period.

$t_0 = T/2 = \pi/\delta\omega$ (from (3))

Rate of phase change required:

$$\delta\omega t_0 = \pi$$

Let the initial phase of a signal be represented by a line with an arrowhead pointing up the page, and the reverse phase (change by π radians), by one pointing down the page. Then Fig. 8 represents a coherent group of 6 signals.

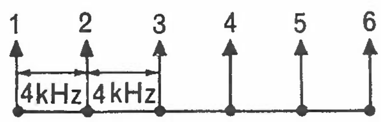


Fig. 8.

This corresponds to the voltage trace shown in Fig. 9.

A group of 6 signals having a rate of phase change of π radians per frequency is represented by Fig. 10.

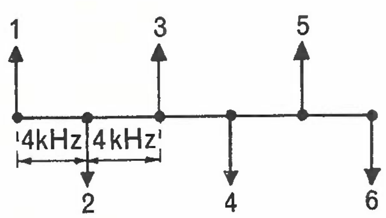


Fig. 10.

This corresponds to the voltage trace shown in Fig. 11. Fig. 12 shows a combination of 12 signals, with 6 in their normal state and 6, transposed to a pattern having a phase change of π radians per tone. Note that the maximum peak of this combination does not exceed 6 units of height. If all 12 tones were coherent, the total peak height would be 12 units as shown in Fig. 6.

Example 2:

Object: To shift voltage trace by a quarter period.

$t_0 = T/4 = \pi/2\delta\omega$

Rate of phase change required:

$$\delta\omega\, t_0 = \pi/2$$

Now a rate of change of $\pi/2$ radians per frequency displacement of $\delta\omega$ corresponding to 4kHz, is equivalent to a rate of change of π radians per frequency displacement of $2\delta\omega$ corresponding to 8kHz.

Thus the configuration of signals will be as shown in Fig. 13.

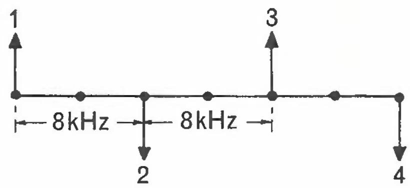


Fig. 13.

The corresponding voltage trace is shown in Fig. 14.

Note, the distance between peaks is halved as the unit frequency displacement is doubled.

Since in actual carrier systems signalling tones are present every 4kHz, the solution is to superimpose 2 trains of the type shown in Fig. 13. The result is shown in Fig. 15 where it can be seen that the first train consists of all odd number signals, and the second train consists of all even number signals. The voltage trace corresponding to this configuration is shown in Fig. 16.

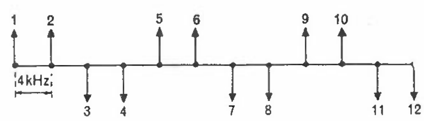


Fig. 15.

Continuing in the same manner, we can obtain a frequency shift of $t_0 = T/6$, requiring a rate of phase change of $\pi/3$ per signal or π every 3 signals. For $t_0 = T/12$, the rate of phase change is $\pi/6$ or π every 6 signals. These cases are illustrated in

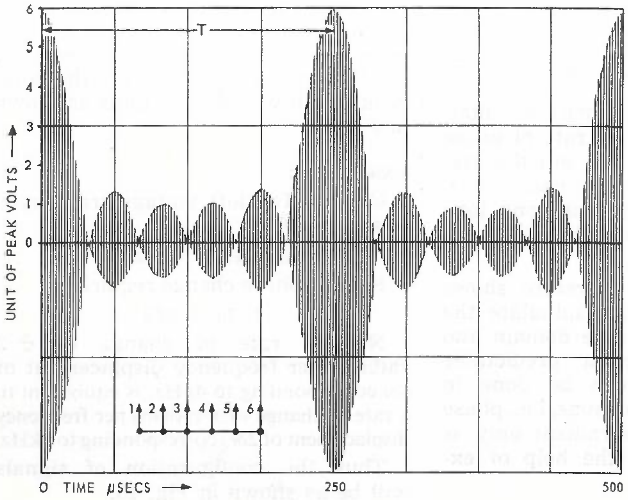


Fig. 9.

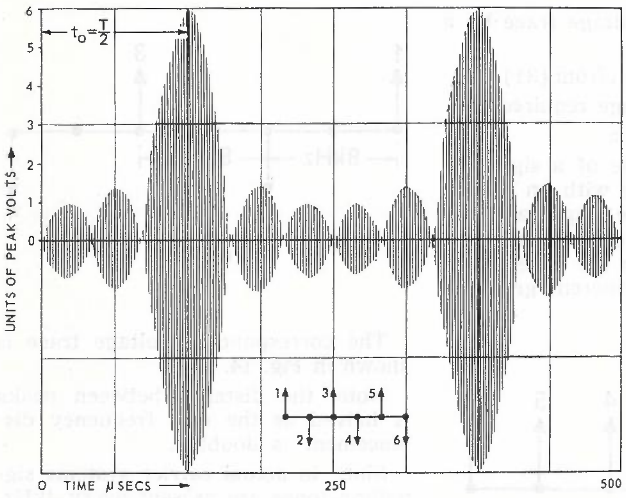


Fig. 11.

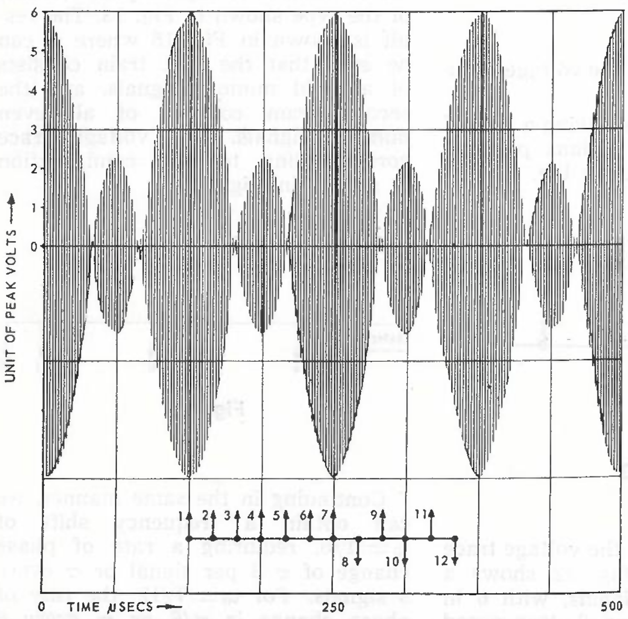


Fig. 12. Combination of Two 6 Tone Groups, One Normal, the Second with a Shift $t_0 = T/2$.

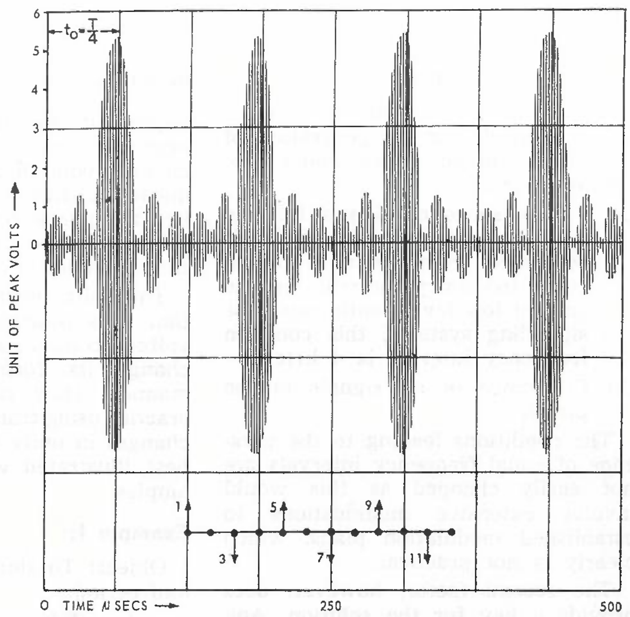


Fig. 14. Voltage Trace for a Rate of Phase Change equal to $\pi/2$ per Tone or π per Two Tones.

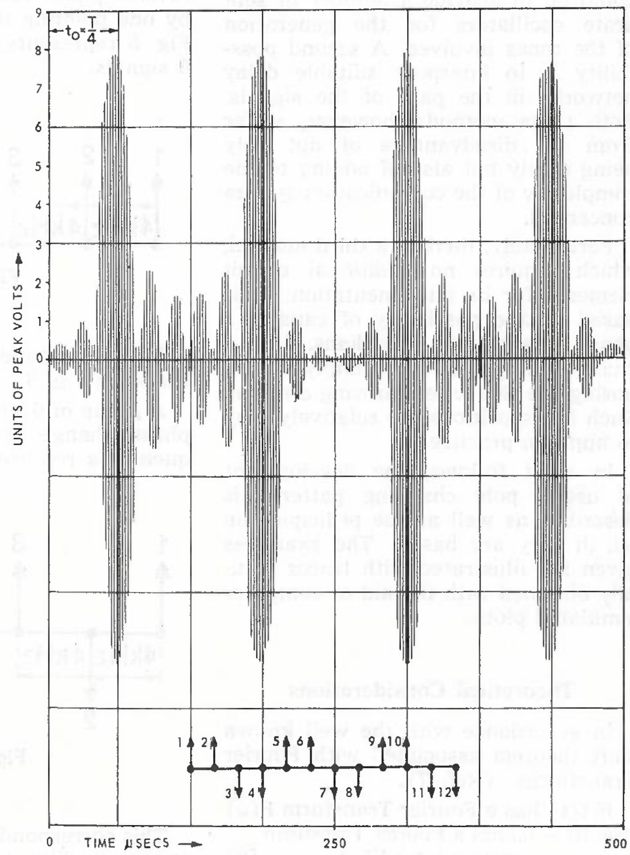


Fig. 16. Superposition of Two Sets of Tone Groups, Such as Shown in Fig. 14, to Account for all Tones Placed 4 kHz Apart.

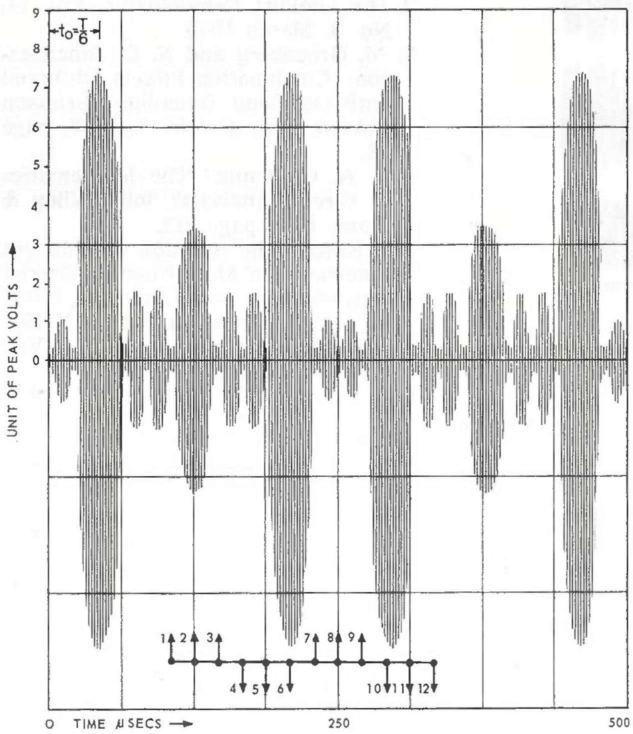


Fig. 17. Voltage Trace for a Rate of Phase Change Equal to $\pi/3$ per Tone or π per Three Tones.

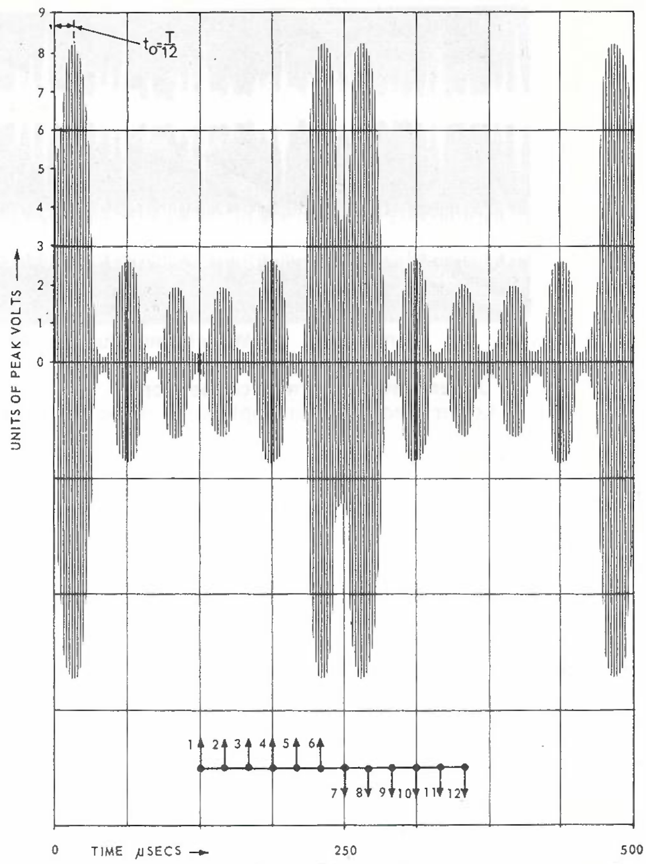


Fig. 18. Voltage Trace for a Rate of Phase Change Equal to $\pi/6$ per Tone, or π per Six Tones.

Figs. 17 and 18 respectively. When these figures are compared with the resultant waveform of the original 12 coherent signals shown in Fig. 6, the main peak which occurs at T=250 microsecs appears to be split.

Practical Application—A Pole Changing Pattern for 12 Channel Groups

The principles illustrated in the previous section may be applied to develop a great variety of poling patterns. A particularly useful pattern, based on 12 channel groups as units for the transposition scheme and achieving a high degree of randomisation has been proposed by Siemens & Halske (Ref. 8).

The relative phase disposition of tones following this pattern is shown in Fig. 19.

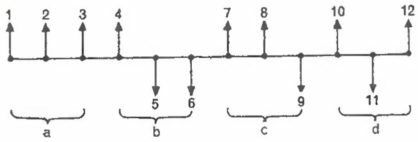


Fig 19.

Note that groups 'a' and 'd' form two 3-tone groups, one having its time domain trace shifted a half period with respect to the other. Group 'b' represents the beginning of a quarter period shift pattern and 'c', with tone 8 reversed when compared with tone 5 of 'b', represents a half period shift with respect to that section.

The combined waveform trace is shown in Fig 20. Note, that this trace is the resultant due to 12 tones and should be compared with Fig. 6 which gives the trace due to the addition of the same number of tones in a coherent mode.

Fig. 21 shows a photograph taken of a supergroup (5 groups) with 60 coherent signalling tones and the same

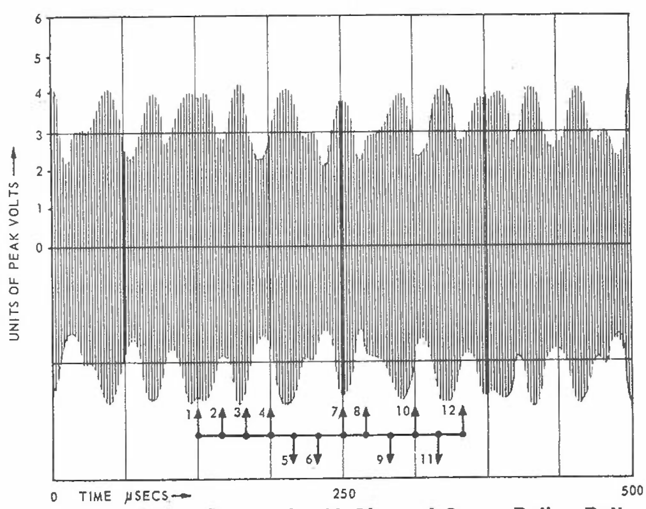


Fig. 20. Resultant Trace Due to the 12-Channel Group Poling Pattern.

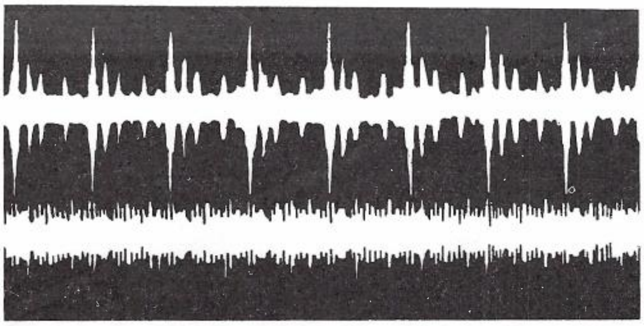


Fig. 21. Comparison of Waveforms due to 60 Signalling Tones.
Upper trace — normal connection
Lower trace — after application of poling pattern.

supergroup after transpositions have been applied to each of the 5 groups in accordance with the pattern outlined above.

Poling Pattern for a Large Number of Channels:

Futher randomisation can be achieved if in addition to the poling in the signal paths of each 12 channel group, phase reversals are carried out in the supply paths of channel carriers and pregroup carriers to the scheme shown in Table 2 (Ref. 8, 9).

CONCLUSION

It has been demonstrated that the high voltage peaks caused in coherent tone groups consisting of signals with uniform frequency separation can be effectively reduced by using pole changing systems.

A very effective method is a scheme based on a pole changing pattern developed for a 12 channel group and complemented with a further system of phase reversals in the supply paths of channel and pre-group carriers.

REFERENCES

1. B. D. Holbrook and J. T. Dixon, 'Load Rating Theory for Multi-Channel Amplifiers'; Bell System Technical Journal Vol. 18, 1939, page 624.
2. The Lenkurt Demodulator, Vol. 14, No. 3, March 1965.
3. M. Groenberg and N. O. Johannesson, 'Combination Effects Observed with Out-Band Signalling'; Ericsson Review, Vol. 44, No. 1, 1967, page 28.
4. E. A. Guillemin, 'The Mathematics of Circuit Analysis'; John Wiley & Sons, 1951, page 512.
5. J. Rasch, 'The Addition of Coherent Sinewaves in Multi-Channel Carrier Systems and their Combined Effect on the Transmission Paths'; NTZ—Communications Journal No. 3, Vol. 6, 1967, page 125.
6. P. F. Panter, 'Modulation. Noise and Spectral Analysis'; McGraw-Hill, 1965, page 129.
7. R. Bracewell, 'The Fourier Transform and its Applications' McGraw-Hill, 1965.
8. Australian Patent Application No. 62,824/65 and unpublished papers by J. Rasch and H. Kagelmann of March 23, 1966 and October 28, 1966.
9. J. Rasch and H. Kagelmann, 'On Measures for Reducing Voltage Peaks . . . etc.' and 'On The Effects of Polarity Reversals . . . etc.'; NTZ-Communications Journal, No. 1, Jan. 1969, pages 24 and 31 resp.

TABLE 2

	Channel Carriers (kHz)			Pregroup Carriers (MHz)			
Group	12	16	20	120	108	96	84
1	●	●	●	●	●	●	●
2	●	●	●	×	●	●	●
3	●	●	●	●	×	●	●
4	●	●	●	●	●	×	●
5	●	●	●	●	●	●	×
6	×	●	●	●	●	●	●
7	×	●	●	×	●	●	●
8	×	●	●	●	×	●	●
9	×	●	●	●	●	×	●
10	×	●	●	●	●	●	×
11	●	×	●	●	●	●	●
12	●	×	●	×	●	●	●
13	●	×	●	●	×	●	●
14	●	×	●	●	●	×	●
15	●	×	●	●	●	●	×
16	●	●	×	●	●	●	●
17	●	●	×	×	●	●	●
18	●	●	×	●	×	●	●
19	●	●	×	●	●	×	●
20	●	●	×	●	●	●	×

× represents phase reversal
● represents no change

C.C.I.T.T. IVth PLENARY ASSEMBLY— MAR DEL PLATA, ARGENTINA, 1968

S. DOSSING, M.Sc.E.E., M.E.E., F.I.E. Aust. *

INTRODUCTION

The International Consultative Committee on Telephony and Telegraphy (C.C.I.T.T.) met for its IVth Plenary Assembly in October, 1968, in the seaside resort of Mar Del Plata in Argentina for a period of two weeks.

Over a period of three weeks immediately prior to the Plenary Assembly meetings, there were meetings of most of the C.C.I.T.T. Study Groups, each Study Group meeting for a few days.

The purpose of this article is to give a brief account of the main events at the Plenary and Study Group meetings and the work done since the IIIrd Plenary Assembly, in Geneva in 1964.

C.C.I.T.T. OBJECTIVES

The organisation of C.C.I.T.T. has been referred to in earlier Telecommunication Journals (Refs. 1 and 2).

The C.C.I.T.T. is a permanent organisation of the International Telecommunications Union (I.T.U.), which itself is the specialised agency of the United Nations (U.N.) in the field of telecommunications. The I.T.U. and the C.C.I.T.T. maintain and extend international co-operation for the improved national and international use of telecommunications. They also have a responsibility for promoting the development of technical facilities with a view to increasing their usefulness to the public and to harmonise the actions of nations. The C.C.I.T.T. is specifically oriented towards public telephone and telegraph telecommunications as well as sound and T.V. broadcast links. Radio matters are dealt with by the C.C.I.R. (International Consultative Committee on Radio) and the I.F.R.B. (International Frequency Registration Board).

The Union had its origin as early as 1865 with the founding of the International Telegraph Union which was later expanded. Its permanent seat and the Secretariat is in Geneva. The present name of C.C.I.T.T. was adopted in 1956, and there have been four Plenary Assemblies, two in Geneva, one in New Delhi and one in Mar Del Plata.

The Australian Delegation to the Mar Del Plata meetings consisted of Mr. E. Sawkins (Leader), Messrs. I. A. Newstead, S. Dossing and R. McKinnon representing the Engineering Divisions of the Postmaster-General's Department, Messrs. D. Rhys-Jones and P. F. Connell representing the Telecommunications Division, Messrs. W. G. Gosewinckel, R. Brown and K. Reid representing the Overseas Telecommunications Commission, and Messrs. J. Scott (S.T.C.) and K. Casey (L.M.E.) representing industry.

VENUE FOR THE MEETINGS

Argentina

Argentina is the second largest country in South America and eighth largest in the world. It has a population of over 24,000,000. Buenos Aires, the Argentine capital, together with its suburbs accounts for nearly 6,400,000 inhabitants. Buenos Aires is the largest city in the southern hemisphere and the most populous 'Latin' city in the world.

Topographically Argentina is usually divided into six main areas, one of which is the pampas; the region of very fertile central plains which extends to the rich forest lands of the subtropical North, known as the Chaco. The pampas, which embraces the province of Buenos Aires (in which Mar Del Plata is situated) and four other provinces, is an immense, unbroken plain. The pampas is mainly agricultural and pastoral, being specially suitable for wheat, rye, corn, oats, barley and linseed and for the breeding and fattening of livestock on alfalfa and other pastures.

The early history of Argentina is that of a Spanish colonial possession for nearly three hundred years. This period began in 1515, when the Spanish navigator, Juan Diaz de Solis, sailed along the coast of the River Plate, and ended with the Revolution of 25th May, 1810, when the first governing council 'Primera Junta de Gobierno' was set up in Buenos Aires. The formal independance of the United Provinces of the River Plate was to be declared six years later on 9th July, 1816, at San Miguel de Tucuman.

The population of the Argentine Republic is 98% of white European race with a predominantly Spanish and European strain. The largest foreign born community is the Italian, followed by the Spanish. There are also Polish, Russian, German, Yugoslav, French and Portuguese migrants.

Argentina is one of the leading producers of grains, wheat, oats, barley, etc., and the world's largest exporter of chilled and canned beef. It also exports by-products such as wool, hides, casein and vegetable oils, dairy products, forest products (chiefly quebracho extract). The good quality of its livestock which includes cattle, dairy cows, sheep, pigs and horses is known the world over. Constant efforts and expenditure have been devoted during the last 30 years towards improvements of livestock, which today is very high grade.

Argentina is also an important producer and exporter of high quality fruit including apples and citrus fruits. The mountain regions in the provinces of Mendoza and San Juan are famous for its vineyards, the Argentine production of wine is the fourth largest in the world. Local wines are cheap and form part of the daily diet.

The electrical industry is in a phase of development (telecommunication equipments, electrical appliances, etc.). This industrial development is being accomplished through the growth of local industries and by the establishment of branches of foreign corporations.

Argentina rates one of the highest cultural levels in Latin America. Illiteracy accounts for 8.5% of the population, and is the lowest in Latin America. The educational system provides free primary and secondary schooling. There are eight State Universities (Buenos Aires, La Plata, Cordoba, Santa Fe, Tucuman, Bahia Blanca, and a Technical University), and a number of provincial and private universities. Private, foreign and religious schools and universities are permitted, but they must conform to a nationally-prescribed pattern of teaching.

Mar Del Plata

Mar Del Plata is Argentina's most fashionable, as well as most popular seaside resort. It is situated on the Atlantic about 400 km (250 miles) south-east of Buenos Aires.

It is an important city as well as a sea port, with magnificent residences, parks, beaches, hotels, restaurants and shops of all kinds. It has a permanent population of 320,000 inhabitants which increases in the summer season to about 2,000,000, tourists coming from all points of the country. It is an attractive place to visit in the summer season and it has the added attraction of a huge Casino. It may be said that everything in Mar Del Plata 'revolves' around the Casino.

The main attraction of the city is its beautiful beaches. Other points of interest include the busy sea port and the fishing centre with its restaurants offering italian style sea-food in a friendly atmosphere.

Climatically speaking, Mar Del Plata is similar to Melbourne. Cold ocean currents from the Falkland Islands cause regular (and usually cold) winds from the sea, and at night the temperature decreases sharply.

Gran Hotel Provincial

The C.C.I.T.T. meetings were held at Gran Hotel Provincial, where, on the first floor, four main and three auxiliary

* Mr. Dossing is Assistant Director-General Systems, P.M.G. Research Laboratories.

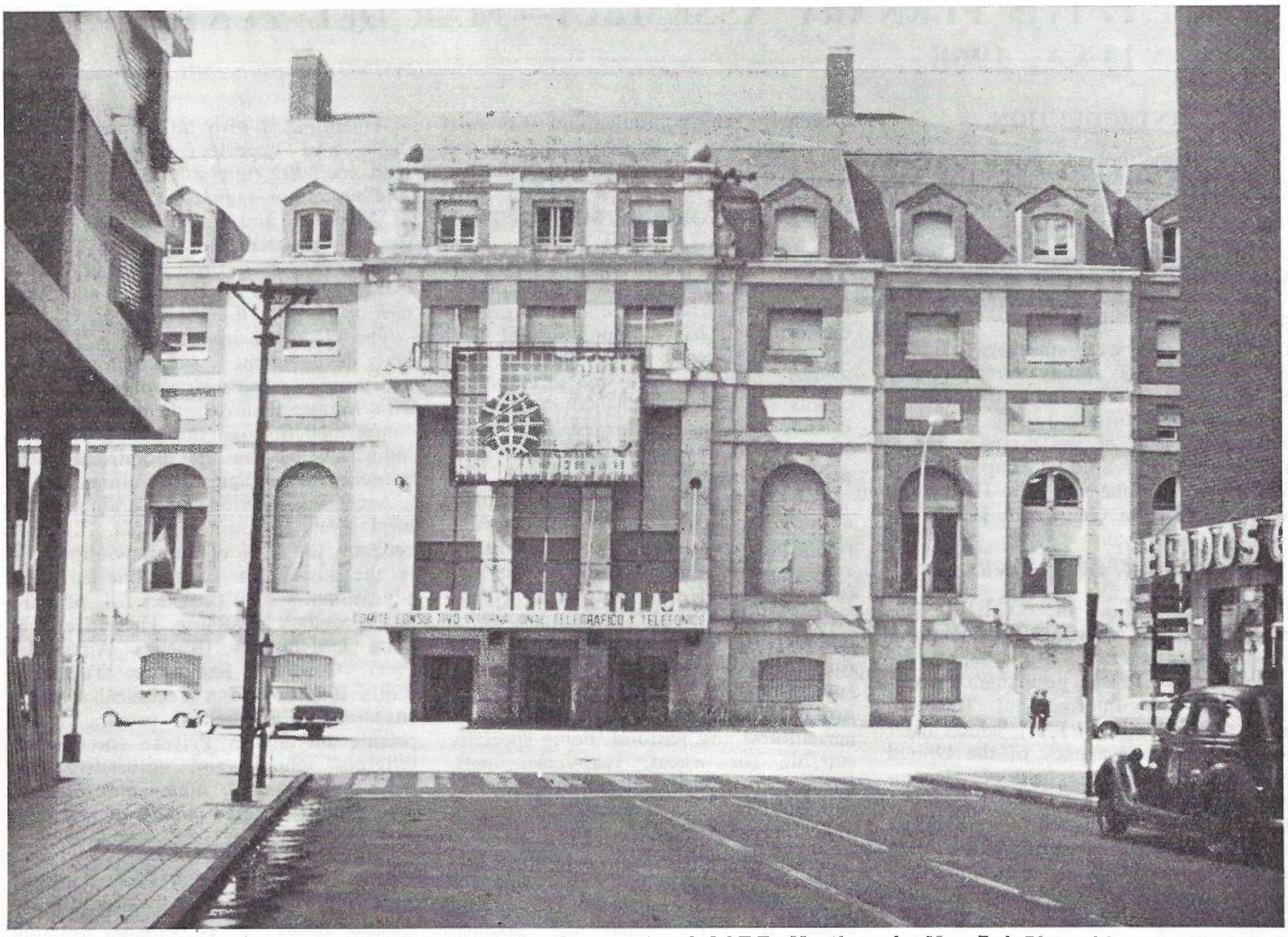


Fig 1 — Frontal View of Gran Hotel Provincial, the Seat of the C.C.I.T.T. Meetings in Mar Del Plata. The view shows a small portion only of the hotel and the casino.

meeting halls were made available as well as restaurant services and offices for the C.C.I.T.T. Secretariat. Other facilities such as typing, document service, post office, tourist office, reception, medical services and accommodation were provided on other floors. The Australian Delegation stayed at this hotel.

Hospitality

On the social side, one of the greatest difficulties encountered was the language problem. Very few Argentinians, even in hotels, shops and public offices, speak English, and all the delegation members by necessity had to learn sufficient Spanish to manage. In spite of this, we were made to feel at home and a considerable amount of hospitality was shown. There were, for instance, organised excursions to a stud farm, a fish canning factory, the port of Mar Del Plata, a satellite earth station under construction, the hills of Sierra de los Padres, an old mission station and a horse rodeo. In addition, there were various special theatre performances, receptions, free access to the Casino, and special stamps were issued to mark the C.C.I.T.T. meetings. The Australian Delegation was mentioned at least three times over the local radio and television stations.

THE WORK OF THE C.C.I.T.T.

General

The highest authority of the C.C.I.T.T. is the Plenary Assembly which met for two weeks to revise, approve and modify as appropriate the work which had been carried out by the individual Study Groups (S.G.'s) during the 1964/1968 period. Almost all of the individual S.G.'s met for some days during the three weeks immediately prior to the Plenary Assembly.

About 600 delegates from some 70 countries attended some or all of the meetings.

A brief description is given in the succeeding paragraphs of the past and future work of each of the individual S.G.'s. The results of this work will in due course be available in the C.C.I.T.T. 'White Book' and other C.C.I.T.T. publications. The White Books will make the present Blue Books obsolete. They will be comparable in size to the Blue Books, that is nine volumes occupying about seven inches of shelf length.

Many of the problems confronting the S.G.'s are in principle the same as they were many years ago, but the rapid advances in technology and world-wide communications demand constant updating of the recommendations resulting from the work of the S.G.'s.

The topics under study are in C.C.I.T.T. terminology referred to as 'Questions'. The answer to each Question is in the form of a 'Recommendation' and being a democratic establishment, these Recommendations are usually unanimously agreed. It is of course a difficult task to ensure unanimous agreement, but the C.C.I.T.T. is to be commended on its achievements in the past, and it is hoped that it will be no less successful in the future.

S.G. I: Telegraph Operation and Tariffs, including Telex

This S.G. is mainly concerned with

Fig 2 — One of the Squares in Mar Del Plata Showing Modern Flats and Offices.

operational procedures and tariffs and is thus basically of a non-engineering nature.

As an example of the type of work done by this S.G. may be mentioned a few of the Questions for the current Plenary period: 'New principles for telegraph tariffs'. 'revision of the telex regulations', 'simultaneous photo telegraph transmission to multiple destinations', 'revision of telegraph regulations' and 'photo telegram rates and telegraph tariffs in the extra European system'.

S.G. II: Telephone Operation and Tariffs

This S.G. has Questions similar to those of S.G. I, but dealing with telephony instead of telegraphy.

Some of the Questions for the current Plenary period are: 'Review of the new accounting procedures for international automatic and semi-automatic telephone traffic', 'standardisation of call tickets', 'arrangements for the payment for public service telephone calls by persons travelling abroad' and 'standardisation of the use and printing of symbols in national and international telephone numbers'.

In addition to these Questions, the S.G. has a number of Questions concerned with human factors in telephony.

S.G. III: General Tariff Principles: Leased Telecommunication Circuits

This S.G. attacks tariff Questions on a broader basis than S.G.'s I and II. Questions for the current Plenary period include: 'Leasing of a wideband transmission facility', 'tariff conditions for replacing faulty leased circuits', 'distribution of rates charged for leased international circuits' and 'study of costs and fixing of basic tariff components for the telephone and telex services'.

S.G. IV: Maintenance of Lines, Circuits and Chains of Circuits

This S.G. is responsible for all maintenance Questions related to the national and international networks. It also studies the transmission performance of these networks based on extensive sample measurements.

It has evolved an organisational pattern for international maintenance centres and international service co-ordination centres. These centres analyse fault reports and generally supervise the performance of the telephone networks. The international service co-ordination centres will work in conjunction with international transmission maintenance centres and international switching maintenance centres.

Another achievement of the S.G. has been the specification of a new model (Mark 2) of automatic transmission measuring equipment, and field trials of this equipment should be made during the current Plenary period. In addition, the S.G. has also prepared performance specifications for transmission measuring equipment of various types.

Some of the Questions to be studied during the current Plenary period are: 'Maintenance of groups, supergroups, etc., not routed over a communication satellite system', 'maintenance of groups, supergroups, etc., routed over a communication satellite system', and 'automatic noise measurement'. The S.G. has a total of 23 Questions.

S.G. V: Protection against Dangers and Disturbances of Electromagnetic Origin

S.G.'s V and VI, and to some extent S.G. VII, are different from most other S.G.'s in so far as they relate to Questions of national practices. They serve as a forum for the exchange of information between countries carrying out work in the fields under consideration.

The Questions entrusted to S.G. V are grouped under the title of 'Protection against Dangers and Disturbances of Electromagnetic Origin'. At the 1964 Plenary Assembly of C.C.I.T.T., a list comprising 26 Questions was allocated for consideration during the ensuing four years.

Attention has been directed to disturbances of ground potential caused by earth fault currents on high voltage transmission systems, in the neighbourhood both of the fault and of the transformer feeding the line on which the fault occurs. A Recommendation relating to separation between telephone cables and earthed parts of power installations has been prepared. Other Questions relate to problems of induction into plastic insulated cable and to earthing problems associated with such cables.

One Question provides for the interchange among Administrations of information on practices of joint use of poles and underground works, and another Question deals with the balance to earth of exchange and repeater equipment, a factor of importance in relation to induced noise, and recommends, provisionally, a balance attenuation of 40 dB minimum.

Methods of calculation relevant to induction problems and general recommendations relating to tolerable values of induced voltage in relation to both danger (under power fault conditions) and noise (under normal working conditions) have been collated and published for general reference in a Handbook entitled 'Directives concerning the Protection of Telecommunication Lines against Harmful Effects from Electricity Lines'. Handbooks are also being prepared embodying information on lightning protection and on the design and construction of earthing systems.

The S.G. has 22 Questions during the current Plenary period.

S.G. VI: Protection and Specifications for Cable Sheaths and Poles

Like S.G. V, S.G. VI is a S.G. in which information regarding national practices is exchanged between the various countries.

The S.G. has 20 Questions for the current Plenary period, and the following Questions serve as an example of its activities: 'Protective covering of aluminium cable sheaths', 'cable sheaths made of metal other than lead or aluminium', 'cable sheaths made entirely of plastic', 'joint cathodic protection of several networks' and 'problems resulting from the use of non-conducting pipes'.

S.G. VII: Definitions and Symbols (Means of Expression)

S.G. VII was not very active during the 1964/68 period, and it is proposed that it be merged with C.C.I.R. (International Radio Consultative Committee) S.G. XIV. Pending agreement on this matter by C.C.I.R. the S.G. has been provisionally retained in its present form but without any detailed assignment of Questions. It is hoped that this combined S.G. may also be able to work closely with the I.E.C. (International Electrotechnical Commission).

S.G. VIII: Telegraph Equipment and Local Connecting Lines

This S.G. has two Questions only for the current Plenary period.

During the past Plenary period the S.G. prepared Recommendations dealing with 100 baud start-stop apparatus using international alphabet No. 2, and one of the two Questions facing it during the current Plenary period is: 'What standards should be set for the characteristics of apparatus working on modulation rates up to 200 bauds and above, with the data oriented international alphabet No. 5'.

S.G. IX: Telegraph Transmission Quality; Specification of Equipment and Rules for the Maintenance of Telegraphy Channels

Mr. R. A. Brown, Overseas Telecommunications Commission (Aust.), was elected as the new Chairman of this S.G. for the current Plenary period.

The S.G. has in the past dealt mainly with conventional 50 to 75 baud voice frequency telegraph systems, but in the new Plenary period, some new and interesting Questions have been set. The first of these deals with the formulation of transmission plans above 50 bauds. The second Question deals with 'time sub-division of a telephone channel or a primary group for telegraph or data transmission', and the third question deals with 'time division of a PCM system for telegraph and data transmission'. The total number of Questions facing this S.G. is 16.

S.G. X: Telegraphy Switching

This S.G. has prepared Recommendations in a number of areas such as in the specification of re-tests for telegraph circuits failing to respond to a signalling sequence; this Question is related to the designs prepared by the Australian Post Office for its telex system. Other matters dealt with are the use of radio telegraph circuits with ARQ equipment for fully automatic telex calls charged on the basis of elapsed time, requirements of synchronous multiplex equipment for telex and gentex operation, amendments to the type 'C' signalling, and automatic tests of transmission quality of telegraph circuits.

The new study programme includes ten Questions, the most interesting of which is the Question: 'New telegraph type network for message and data transmission'. A number of administrations are considering the introduction of such networks; these include the Australian Administration and in particular the German Administration. Other Questions are 'Standardisation of signalling in the telex and gentex services', 'automatic service over intercontinental circuits' and 'world-wide routing plan for telex and gentex services'.

S.G. XI: Telephone Switching and Signalling

International signalling systems currently standardised are the No. 3, No. 4 and No. 5 C.C.I.T.T. Systems. During the last Plenary period and the Mar Del Plata meetings, the 5 bis system was standardised and the Specification for a new 'common channel' signalling system known as the No. 6 System (Ref. 3) was prepared. In addition, the Plenary Assembly adopted the 'Berne MFC' and the 'North American MFC' signalling systems for regional use.

Australia is vitally interested in the C.C.I.T.T. No. 6 Signalling System and has participated in the preparation of the specification for this system. During the current Plenary period, national and international field trials of this system are proposed, and Australia intends to participate. The No. 6 Signalling System is particularly suitable for signalling between the processors of processor controlled exchanges and the Australian trial will be conducted jointly by the P.M.G. Research Laboratories and O.T.C., using processor controlled crossbar switches to be installed at Windsor (Melbourne), and O.T.C. Paddington (Sydney). The No. 6 Signalling System is expected to lead to very substantial savings in network signalling costs, and is the first signalling system specifically being developed for processor controlled switching centres.

S.G. XII: Telephone Transmission Performance and Local Telephone Networks

This S.G. deals with all aspects of transmission performance of an overall connection from subscriber to subscriber.

One of the main points on which a new Recommendation was agreed in Mar Del Plata is that of permissible delay. This point is of particular interest in connection with synchronous communications satellites and the new Recommendation in effect says that one hop, and one hop only, of synchronous satellite should be used in a connection. During the current Plenary period, it is intended to study the effect of two hops of synchronous satellite under the general Question of: 'Users tolerance of echo and propagation time'. Other Questions deal with the permissible loss and noise in national trunk and local networks, network characteristics such as trans-hybrid loss at a 4/2 wire conversion point, and the transmission performance of pulse code modulated transmission and switching systems.

S.G. VII is also in charge of the C.C.I.T.T. Laboratory which has recently established a reference system capable of simulating a complete international connection from subscriber to subscriber including artifically produced propagation delays.

S.G. XIII: Automatic and Semi-automatic Telephone Networks

Mr. I. A. Newstead of the P.M.G.'s Department was elected as the new Chairman of S.G. XIII for the current Plenary period.

S.G. XIII concerns itself mainly with such matters as traffic engineering, world routing plan and with international maintenance aspects as related to the above topics.

The world routing plan has to take account of satellite communications and the associated long propagation delays which are an inherent feature of synchronous satellites. Furthermore, economies can be achieved by making use of the fact that the 'busy hours' in various parts of the world differ by a substantial number of hours. Thus if sufficient flexibility is obtained, groups of circuits can be diverted from one route to another during the 24 hour period as required to meet the busy hour traffic demands.

In the 1964/68 period, S.G. XIII also studied human factors in telephony but these Questions are now being studied by S.G. II.

S.G. XIII is also providing basic material for the specification of the new signalling systems referred to under S.G. XI, particularly Signalling Systems, No. 5, No. 5 bis, and No. 6.

A Joint Working Party (JWP) between S.G.'s XI and XIII has been set up to supervise the field trials of the No. 6 Signalling System.

Another topic to be studied by S.G. XIII is that of planning and operation of network management; network management will be required to an increasing extent as the national and international networks become fully automatic and the 'supervision' hitherto exercised by the telephonists will be reduced in relative terms. It is therefore necessary that technical features be built into the networks to ensure that the network can be 'managed' without the feedback of information from the telephonists.

S.G. XIV: Facsimile Telegraph Transmission and Equipment

This S.G. has a total of 11 Questions under study. These Questions relate to all aspects of facsimile operation. However, it is worth nothing that a new Question regarding the transmission of colour facsimile has been included. This is just one example of the multitude of new tasks which present day transmission systems will have to cope with in the future. Colour facsimile is already in regular service in Japan on a modest scale.

A new facsimile standard test chart was agreed upon with a picture submitted by Argentina being recommended.

S.G. XV: Transmission Systems

The Questions before this S.G. total 44. S.G. XV is traditionally the S.G. dealing with the largest number of Questions. The S.G. endeavours to make specifications about new transmission systems as detailed as possible, and also to specify existing transmission systems in detail to advance international standardisation.

The S.G. has made very considerable progress towards the further standardisation of frequency multiplex carrier systems, including systems operating at frequencies up to 60 MHz. It has also produced fundamental specifications for PCM type transmission systems, and it has specified a number of other transmission equipments notably compandors and echo suppressors.

A fully up-to-date echo suppressor has now been specified representing a major step forward relative to the echo suppressor adopted by the 1964 Plenary Assembly. Further work on the echo suppressor problem is proposed during the next Plenary period because of the realisation that absolute delay is of relatively small concern as long as the mean one-way propagation delay is below 300 to 400 mS; the main disturbing effect as far as the user is concerned is not the absolute delay but mal-operation of echo suppressors due to the fact that, in many practical networks, they are not given operating conditions enabling them to function properly. A new concept known as the 'adaptive echo suppressor', is being examined in a number of laboratories, including the P.M.G. Research Laboratories, and it is hoped that such echo suppressors capable of operating under more adverse conditions than the present specified type, may be approved by the 1972 Plenary Assembly.

The importance of PCM is now considered to be so great that it would not be possible for S.G. XV to cover PCM together with its other normal functions as it has done in the past, and a new S.G. to be known as S.G. Special D (Sp. D) was created to cover all aspects of PCM and IST (Integrated Switching and Transmission).

The S.G. will further deal with a number of Questions which are of very acute interest. As examples of these may be mentioned, transmission of high quality monophonic programmes, transmission of steorophonic programmes, videophone transmission and standards, transmission of data at various bandwidths, and characteristics of wideband signals of various types transmitted on group and supergroup links, etc. Some of the facilities referred to are already established in some countries, and will be demanded by the public in a number of other countries. The problems of accommodating these new services are formidable in so far as mutual interference between these new services and existing (and new) pilot and signalling frequencies must be avoided. As a first step towards the specification of transmission systems to carry these new services, S.G. XV has decided to attempt to specify just what services need to be accommodated and what will be the characteristics of the signals which these services will need to transmit.

S.G. XVI: Telephone Circuits

This S.G. deals with the overall transmission aspects of national and international networks. The main task in front of it is to examine the implications of the new international transmission plan which was agreed at the 1964 Plenary, and which specifies international circuits of nominally O dB loss. The main considerations relate to the control and effects of echo and stability against 'singing'. The importance of the differences in definition of the 'relative levels' used in various countries has furthermore come to be realised, and this will affect many aspects of the work of this S.G. as well as other S.G.'s.

Another important Question under consideration is that of carrier systems for very short distances (notably PCM systems). Suitable specifications for these systems are to be prepared including the important aspect of permissible noise.

The S.G. also proposes to investigate the characteristics of national systems in greater deail, and it is concerned with transmission aspects of circuits routed via communication satellites, including the proper and efficient use of echo suppressors.

S.G. Special A (Sp. A): Data Transmission

This S.G., which has a total of 30 Questions under study, studies all aspects of data transmission at all speeds.

It has already, in co-operation with other international bodies, agreed on the new data-oriented international alphabet No. 5 (seven intelligence bits), and it has also standardised data modems for speeds up to 1,200 bauds on the switched network. It is now working on the standardisation of modems for higher speeds such as 2,400 bits per second and 48 k bits per second. The presently standardised data modems operate with one high speed 'serial' bit stream, but new modems operating with several (slower) bit streams in parallel are being considered for use in the telephone network. The tasks facing Sp. A are very difficult in so far as the interests of the operating administrations and the computer manufacturers have to be reconciled. This has lead to dual standards and in some cases will probably result in more dual standards for the future.

The S.G. co-operates with other S.G.'s, for instance, on such Questions as transmission constraints on wideband data systems with respect to the concentration of energy in a given frequency band and the permissible duration of such concentration. Another point in which co-operation with other S.G.'s has been necessary is that of specifying a disabling frequency for echo suppressors to allow simultaneous bothway data transmission and ensuring that the data signal spectrum contains enough energy near that frequency to retain the echo suppressor in the disabled condition.

Several users are pressing for acoustic coupling of data sending and receiving equipment to the microphone and receiver of the telephone handset, and this problem is being considered. The S.G. is further vitally interested in the new Question: 'Further integrated data networks'.

S.G. Special B (Sp. B): Worldwide Automatic and Semiautomatic Networks

This S.G. was not very active during the 1964/68 period. It has been abolished and replaced by a Family Co-ordination Group consisting of Chairmen and Vice-Chairmen of S.G.'s II, IV, XI and XIII.

The purpose of Sp. B was to co-ordinate and check on the progress made in the various S.G.'s to ensure maximum benefit from their work.

S.G. Special C (Sp. C): Reliability and Noise

This S.G. is a joint C.C.I.R./C.C.I.T.T. S.G. being managed by the C.C.I.T.T. In the past its title has been simply 'Noise', but during the Plenary Assembly at Mar Del Plata, it was given a number of general reliability Questions, and it is now known as 'Reliability and Noise'.

The S.G. has prepared detailed Recommendations regarding permissible circuit noise on various types of circuits, such as tropo-scatter systems, submarine cables and long distance coaxial and microwave links.

It has also been instrumental in specifying instruments and methods for the measurement of impulsive noise on voice-data circuits, and this will be expanded to cover specifications for impulse noise measuring instruments for wideband data circuits.

Other studies have led to the specification of noise on programme circuits and the distribution of overall noise allowances between national and international circuits.

The S.G. will continue to study akin Questions during the current Plenary period in addition to its reliability studies covering all aspects from the reliability of a single component to the reliability of a complete subscriber to subscriber connection.

S.G. Special D (Sp. D): Integrated Switching and Transmission (IST) and Pulse Code Modulation (PCM)

This S.G. is a new S.G. established by the Plenary Assembly at Mar Del Plata. In the field of PCM, it has taken over the work previously done by S.G. XV. It has been charged with the study of all Questions relating to PCM and IST and has therefore, become very important and will have to co-operate with other S.G.'s as necessary. The S.G. is of special importance to the Australian Administration because it is planning to have an experimental IST network designed by the P.M.G. Research Laboratories in operation in the Melbourne network in 1970.

Joint Working Party (JWP)

Fourteen JWP's were set up by the Plenary Assembly. These WP's are under the joint management of two or more S.G.'s and cover fields in which the S.G.'s are interested. They report to the S.G.'s in charge of the JWP.

As mentioned before, one of the JWP's is that set up by S.G.'s XI and XIII for the field trials of the No. 6 Signalling System (JWP; GM FT6). Other JWP's deal with such problems as regional tariffs, use of alphabet No. 5, protection and earthing systems.

Special Autonomous Group No. 1 (GAS 1): National Automatic Networks

GAS 1 has been in existence for eight years under the Chairmanship of Mr. E. R. Banks, P.M.G.'s Department. The tasks of GAS 1 like that of other GAS groups, has been to prepare handbooks for new and developing countries to assist in the development and training in those countries. The handbooks have also been found useful for the training of young engineers in more advanced countries.

The task of GAS 1 had been successfully completed and the group was therefore abolished.

Special Autonomous Group No. 2 (GAS 2): Local Networks

GAS 2, like GAS 1, was faced with the preparation of handbooks. GAS 2 has virtually completed its work, and it was decided that it should be abolished when its handbooks have been fully prepared.

Special Autonomous Group No. 3 (GAS 3): Economic and Technical Comparison of Transmission Systems

GAS 3 estimated that they would need approximately half a year more to complete its handbooks. The Plenary Assembly decided to extend the previous terms of reference of GAS 3, and it is now to make a comprehensive comparative study of satellite systems, submarine cable systems, PCM, IST, and other new systems which may be of interest to administrations. The results of these studies are to be prepared in handbook form for presentation to the 1972 Plenary Assembly.

The GAS 3 handbooks being prepared during the 1964/68 period should be available in print by late 1969.

Special Autonomous Group No. 4 (GAS 4): Primary Power Sources

Approximately half a year's work is needed for completion of the handbooks, and these should be available in print by late 1969. When the handbooks are completed, GAS 4 will be abolished.

Special Autonomous Group No. 5 (GAS 5): Economic Conditions and Development of Telecommunications

GAS 5 has almost completed the handbooks covering its previous terms of reference. However, nine new Questions were adopted for study for the 1968/72 period as a result of pressures from developing countries to broaden the scope of GAS 5 to cover Questions of internal organisation, finance, funding and profitability of administrations. Draft handbooks covering these new topics are to be presented to the Plenary Assembly in 1972.

AUSTRALIAN PARTICIPATION IN C.C.I.T.T. WORK

Until the late 1950's the work of the C.C.I.T.T. had mainly been carried out by the European countries. However, with the advent of submarine cable techniques and the possibility of satellite communications, it was clear that truly global communications would soon materialise and that non-European countries had to increase their participation in the work of the C.C.I.T.T. Thus Australia and a number of other non-European countries became active in C.C.I.T.T. work in the 1950's.

The P.M.G.'s Department is the registered Australian member of the I.T.U., and thus of the C.C.I.T.T. and the C.C.I.R.

In order to discharge its responsibilities, it nominates a small number of officers from Headquarters to participate in the proceedings of individual Study Groups and the Department invites the Overseas Telecommunication Commission, and in some cases industry, to nominate officers as appropriate. The nominated members receive the relevant documentation from C.C.I.T.T. and after study prepare written contributions stating the results of Australian investigations together with appropriate opinions and points of view. These contributions are forwarded to the C.C.I.T.T. for distribution to other member countries.

There are usually a number of meetings of Study Groups in between two Plenary Assemblies, and the more important meetings are attended by an Australian delegate (or in some cases more than one), to ensure that the Australian point of view is appropriately represented and that the decisions of the meetings were taken with due regard to our conditions. The Plenary Assemblies are attended by larger delegations and the Second and Third Plenary Assemblies were attended by delegations of comparable size to that of the delegation attending the Fourth Plenary Assembly in Mar Del Plata.

It is indicative of the Australian activity that in addition to the Chairmanships mentioned previously, Mr. R. D. Kerr of the P.M.G.'s Department was chairman of the Study Group during the 1960/64 period, and that Mr. W. G. Gosewinckel of the Overseas Telecommunication Commission was Chairman of a Joint Working Party during the 1964/68 period. During the Mar Del Plata meetings, Messrs. R. McKinnon and S. Dossing were chosen to chair important ad hoc Working Parties.

A significant number of C.C.I.T.T. Recommendations and other C.C.I.T.T. publications have been influenced by Australian activities.

IMPORTANCE OF C.C.I.T.T. RECOMMENDATIONS

C.C.I.T.T. Recommendations reflect world standards and practices in telecommunications and aim at ensuring that the national networks of the various countries are inter-connectable to form one global automatic network.

The standards implicitly and explicitly embodied in the Recommendations represent the world trend in commercial and engineering practices and in the long term it could have serious consequence for a country to deviate from these standards in so far as at some future date, due to pressure from all other countries, it could be forced to embark on extensive and expensive changes in tariff and technical areas. Furthermore, adherence to C.C.I.T.T. Recommendations ensures that the methods and practices adopted have been subjected to critical examination and approval by world experts, and consequently, there is a greater chance that no unforeseen difficulties will arise immediately or in the future.

CONCLUSION

References to the organisation of the I.T.U. and the C.C.I.T.T. are made in the paper, and attempts have ben made to describe the activities of the C.C.I.T.T. in general terms, but with particular reference to the meetings at Mar Del Plata. A brief indication is given of past and future work and the extent of participation by Australia.

C.C.I.T.T. may be considered as the only truly international body concerned with international and national standards of telephony, telegraphy and all other electrical communications facilities. It is obvious that the days when national networks could be developed independently of each other are rapidly drawing to a close and the paper emphasises the importance of developing national and international networks in accordance with C.C.I.T.T. Recommendations.

C.C.I.T.T. meetings provide an excellent opportunity to make valuable personal contacts with people from other administrations. Such contacts are conducive to good co-operation and understanding between countries and administrations, and also provide the opportunity of obtaining early information as to the thinking in other administrations regarding the probable future developments and standards in electrical communications.

There is no doubt that the C.C.I.T.T. activities are of great practical value to the continuing growth and extension of telecommunications, both at the national and international level. The Mar Del Plata meetings demonstrated the excellent international co-operation achieved through the C.C.I.T.T., and it is hoped that the same degree of understanding and co-operation will be encountered at all future meetings.

REFERENCES

1. E. Sawkins, 'World Automatic Telephone Networks'; Telecom. Journal of Aust. Oct. 1960, Vol. 12, No. 5, P. 363.
2. E. Sawkins and E. R. Banks, 'C.C.I.T.T. Study Group Meetings in Melbourne October, 1963'; Telecom. Journal of Aust. Oct. 1963, Vol. 14, No. 2, P. 87.
3. G. L. Crew, 'C.C.I.T.T. System No. 6 — Common Channel Signalling Scheme'; Telecom. Journal of Aust. Oct. 1968, Vol. 18, No. 3, P. 251.

SPACE SYSTEMS AND RADIO ASTRONOMY: 1968 INTERIM MEETINGS OF C.C.I.R. STUDY GROUP IV

E. R. CRAIG, B.Sc. M.I.E.E.*

INTRODUCTION

From the 18th September to the 8th October, 1968, Study Group IV of the International Radio Consultative Committee (C.C.I.R.) held a series of meetings in Geneva, Switzerland. Study Group IV is responsible for the consideration of space systems (which includes communication satellite services) and radio astronomy.

The C.C.I.R. is that part of the International Telecommunication Union (I.T.U.) which studies technical questions and makes recommendations and reports relating to radio communication. It comprises fourteen study groups and meets in Plenary Assembly every three years to issue formally the results of all studies, as approved C.C.I.R. texts. The study groups normally meet immediately prior to the Plenary Assembly to prepare the texts for which they are responsible but this practice may alter in the future because of the difficulty in providing accommodation and secretariat facilities for the large number of people involved in the total activities of Plenary and Study Groups. This number at Oslo in 1966, where the last Plenary Assembly was held, was about 1,500. Consequently, the next Plenary Assembly which it is planned to hold in New Delhi in January/February 1970 will not immediately follow study group meetings held in the same place. Instead, the study groups will meet separately in September and October of 1969 in Geneva. The timetable of meetings has been arranged to allow discussion between study groups with overlapping interests such as, for instance, between Study Group IV and the Study Group dealing with radio relay systems (Study Group IX).

In addition to the meetings associated with the Plenary Assembly, most study groups hold an 'Interim Meeting' about half-way through the period between Plenary Assemblies. This practice was introduced to allow new draft recommendations and reports and extensive alterations to existing ones to be prepared early enough so that time was available for adequate consideration of new proposals. It was also intended as a means of spreading the secretariat load.

The rate of change of technology has increased to such an extent over recent years that the output from interim meetings is being used in practice in advance of formal approval of the texts in Plenary Assembly. Consequently, it has been found desirable to publish the results of Interim Meetings in special booklets. This has been done since the 1965 Interim Meetings and booklets are available for the 1968 meetings. (Ref. 1).

* Mr. Craig is Engineer Class 4, Transmission Media, P.M.G. Research Laboratories.

The remainder of this article deals with the 1968 Interim Meetings of Study Group IV. These meetings were attended by 197 delegates representing 20 Administrations and about 50 Operating Agencies, International Bodies, etc. The Australian Delegation was made up of the author and Mr. N. S. Feltscheer, Overseas Telecommunications Commission.

Organisation of the Work

The work of Study Group IV is split up into several 'Working Groups' which had been maintained unchanged since 1962. However, in Geneva, the Working Group which dealt with propagation matters was replaced because this subject is more properly the province of Study Group V, to which the propagation questions and study programmes of interest to Study Group IV have been referred. The new function of the Working Group is to consider the problems of service to aircraft and ships. The work of the Study Group is now organised as follows:—

Working Group A: Deals with the technical characteristics of communication satellite systems but excluding sharing problems and telemetry, telecommand, control and silencing.

Working Group B: Deals with the problems raised by the sharing of frequency bands between communication satellite services and other services. This working group must therefore take into account the views of Study Groups dealing with other services such as Study Group IX.

Working Group C: Deals with the technical characteristics of space research systems and of space-to-space communication links and including telemetry, telecommand and control for all spacecraft. This working group deals with sharing problems related to these systems and also includes meteorological satellite systems.

Working Group D: Deals with communication satellite service to aircraft and ships including radionavigation satellites.

Working Group E: Deals with radio astronomy and radar astronomy.

Terminology Working Group: This is a small working group which deals with those definition and terminology matters of particular interest to Study Group IV. There is a specialist Study Group (XIV) to deal with all C.C.I.R. terminology.

HIGHLIGHTS

The 1968 Geneva meetings of Study Group IV reflected the experience built up over the past two or three years with commercial communications satellite systems but in addition have initiated several studies of systems and technological extensions now foreshadowed for future space systems. This is following the trend of C.C.I.R. work on space systems generally which has been characterised by an effort to produce guidelines for systems implementation at the feasibility study stage rather than waiting until a system is in being. The practical need for such an approach is most obvious when one considers that a single satellite transmitter can affect nearly one-third of the surface of the earth; a wise choice of technical characteristics is to the advantage of all. In line with this thought, the C.C.I.R. is addressing itself to the use of the geo-stationary satellite orbit; to the use of frequencies above 10 GHz; direct broadcasting from satellites; integrated systems for communications and navigation for ships and aircraft, and so on. These items and others which are mainly a consolidation of experience over the last few years are outlined below. I am indebted to Mr. Feltscheer for some of the comments on these items.

Utilisation of the Geo-Stationary Satellite Orbit*

A special working party was set up by Working Group B to provide an informal exchange of views between interested Delegations on the specific subject of sharing of the geo-stationary satellite orbit by a number of satellites operating in common frequency bands. This working party made a list of technical factors which were considered to be relevant to the determination of the minimum safe separation between geo-stationary satellites, for systems using frequency modulation. In addition mention was made of the possible use of other modulation systems (such as P.C.M. or Delta) in the future and the probable need for systems to operate in frequency bands above 10 GHz.

These technical factors were incorporated in a Draft Study Programme in Document IV/191 (Rev. 2) which is to

* The geo-stationary satellite orbit is the special case of the class covered by the possibly more familiar 'synchronous orbit'. It is the circular orbit which lies in the plane of the earth's equator at the altitude (about 22,300 miles) at which a satellite turning about the polar axis of the earth in the same direction as the earth's rotation will appear stationary in the sky from a point on earth. 'Synchronous' is now taken to apply to any satellite of period 24 hours irrespective of the orbit inclination.

consider the technical factors influencing the efficiency of use of the geo-stationary satellite orbit by communication satellites sharing the same frequency bands (See Ref. 2). The International Working Party which was set up by a Draft Resolution of Study Group IV (Document IV/201 refers) is intended to facilitate the exchange of views prior to the next meeting of the Study Group later this year. It is to review and consider contributions and report to the Study Group. To carry out this task the International Working Party is to meet in Ottawa in June, 1969.

There are two main reasons which give an urgency to these studies. These are:—

(a) Operating systems have shown that use of the orbit for space services is indeed practicable and its advantages, economical and operational, are such as to preclude other solutions except for special purposes such as coverage of high latitude areas. Satellites must be spaced sufficiently in angular distance to allow antenna beams to discriminate one from its neighbours so early study and planning will help to maximise the total capacity of the orbit.

(b) A conference to consider frequency allocations — the World Administrative Radio Conference (Space) is to be held in late 1970 or early 1971 and C.C.I.R. has a responsibility to study these matters so that it will be in a position to provide technical guidance.

To illustrate Australia's interest in use of the geo-stationary orbit, one might cite the case of satellite communications to Europe. For a one-hop link, the satellite position is quite critical. As the service expands, no doubt more than one satellite will be required and the limit of expansion will be set by the number of satellites which are mutually visible to both terminals. Obviously, the closer the allowable spacing, the greater the expansion possible.

Use of Frequencies Above 10 GHz

There was general recognition that satellite communications will quickly outgrow the presently allocated frequency bands, and that additional spectrum below 10 GHz is virtually unattainable. As a result a new Study Programme has been proposed (Document IV/133) to study the use of frequency bands above 10 GHz.

Apart from equipment problems, rain and cloud can affect system performance and reliability and certain frequency bands in the range suffer extra attenuation due to absorption effects in atmospheric gases and water vapour. The Study Programme directs attention to some of these problems and calls for study of techniques which could be used to overcome them. In addition a study of the sharing problems at frequency bands above 10 GHz is on the Programme.

A Draft Report has already been prepared under the new Study Programme (Document IV/187). It has been accepted as only a first provisional report on the subject but some interesting points are suggested, which are:—

(a) Frequencies above 10 GHz offer some technical advantages particularly when multiple narrow beams from a single satellite are required for regional systems.

(b) The narrow antenna beams readily achievable should allow more satellites in a given arc of the geo-stationary satellite orbit.

(c) The fact that the basic transmission loss over a given path increases with frequency (f) at a rate between about 20 log f and 30 log f means that the difficulties of co-ordination would generally be reduced as the frequency is increased. This means that earth stations may be sited closer to terrestrial radio relay stations and the provisional report takes this to imply that earth stations could be closer to traffic centres.

Direct Broadcasting from Satellites

The use of frequencies above 10 GHz was referred to in other documents from the Study Group meetings. One of some general interest is the document dealing with the feasibility of direct sound and television broadcasting from satellites (IV/199). This document is a major revision of C.C.I.R. Report 215-1 and in the revised tables the examples given for operation at 12 GHz are considerably less pessimistic than in the original report. For a 0.5 kW satellite transmitter power through a 1.4° beamwidth antenna (which would cover an area on the earth about 1000 x 1000 km) a receiving installation using a 1 metre diameter dish and a 7 dB noise factor pre-amplifier would allow high quality television reception (weighted luminance signal-to-noise ratio about 45 dB).

Despite the generally more optimistic note of the draft revision compared with the original report, a cautionary note is still sounded on the problems of heat dissipation and thermal balance in the satellite. There is a statement that, 'For many years the maximum practicable radio-frequency power is likely to be limited to about 5 kW'. From this and the tables of examples, it can be concluded that frequency modulation or some equivalent method of trading bandwidth for signal-to-noise ratio will be required to make satellite broadcasting feasible.

Communications and Navigation for Ships and Aircraft

Prior to the Geneva Meetings, C.C.I.R. had adopted by correspondence a new Study Programme (2 G/IV). The reconstituted Working Group D revised this Programme to clarify the meaning. The salient points of the new programme (Document IV/165) are:—

(a) That satellites could be used to provide communications and navigation services to aircraft and ships of sufficient reliability for general use.

(b) To conserve radio-frequency spectrum and to minimise the equipment which aircraft and ships carry, it might well be advantageous to have joint usage of a frequency band by aircraft and ships for communications either direct or via satellite and to use the same satellites for radio determination (i.e. position or direction fixing) also.

The study programme calls for studies of preferred orbits, frequencies and technical characteristics and of the technical feasibility of systems based on the above premises.

Communication Satellite System Items

Under this general heading, there are two items which may become of increasing importance in the future:—

(a) The present hypothetical reference circuit as defined in C.C.I.R. Recommendation 352 and the accompanying Recommendations 353-1, 354 and 356-1 apply only to intercontinental connections. In the future there will be a need to give special attention to regional systems and it was decided that it would be useful for these problems to be studied.

(b) The definitions relating to circuits with multiple access proposed in C.C.I.T.T. Document COM XIII — No. 76 were discussed by Working Group A and the Terminology Group and some suggestions made to overcome the difficulties seen. The preliminary views on C.C.I.R. usage are presented in Document IV/198 which includes a pictorial representation of Multiple Access Classifications. There are in all seven variations shown from a fixed pre-assignment (all dedicated channels) at one extreme to fully variable (random) assignment at the other. One variation not covered by the C.C.I.T.T. definitions received by C.C.I.R., but of particular interest because of its application to the INTELSAT system, is that proposed for use with the 'multi-destination carrier' technique. In this case the transmitting ends of the channels are pre-assigned and received by several stations only one of which uses a particular channel for traffic at any one time so that the receive end is variably assigned.

Receiver System Performance

The performance of present day communication satellite systems is critically dependent on the characteristics of the receiver installation at the earth station. There is thus a great deal of interest in the exchange of information and at the Geneva meetings papers were produced concerning two key aspects. These were:—

(a) The overall figure of merit of the radio frequency portion of a receiving installation is commonly given in terms of G/T where G is the antenna gain and T is the effective receiving system equivalent noise temperature. It would be desirable to establish a practical method of measuring this ratio directly with high accuracy because of the errors which often arise when the ratio is inferred from separate measurements of the quantities G and T. Methods have now been evolved to measure the ratio directly using radio stars as signal sources. (The use of radio sources for antenna measurements and a table of suitable radio stars will be dealt with in an article by Wielebinski to be published in this Journal.)
Volume IV(2) of the C.C.I.R. 'Green Book' (Oslo 1966) contains report 390 dealing with 'Earth Station Antennae for the Communication Satellite Service'. Major revisions of this report were proposed at the Geneva Meetings in Documents IV/132 and IV/182. The former document modifies the main text in some respects but the main change is to remove the five annexes giving details of particular antennae that have been built. A new Annex is put forward in Document IV/182 concerning G/T Measurements with the aid of radio stars.

(b) In F.M. systems, threshold extension demodulators permit the use of lower carrier-to-noise ratios than is possible by conventional limiter/discriminator demodulators. Proposed modifications to Report 211-1 on the Comparative Study of Possible Methods of Modulation and Multiple Access are given in Document IV/181 and in this a section is devoted to threshold extension demodulators. One point of some substance concerns what is meant by 'threshold'. It has been defined as the point at which the curve of signal-to-noise ratio as a function of the carrier-to-noise ratio, for the top channel, departs by 1 dB from linearity; some difficulty has been found in applying this definition. A new definition, which has had some use, is now proposed, which is, 'The input carrier to noise temperature ratio (C/T) at which the weighted noise in the worst channel is 50,000 pWop'. An empirical formula is given to describe the threshold in terms of available demodulators. The formula is:—

Threshold C/T (in dBw per °K) $= -171.7 + 8.7 \log n$
where n = number of channels

It is of interest to note that the demodulators at the O.T.C. earth station at Moree come very close to this performance.

Frequency Sharing Problems

The problems arising from the sharing of frequencies between space services and terrestrial services have been the subject of continuing study; refinements have been proposed to existing methods of calculation to ease the co-ordination procedure and allow closer spacing between Earth and terrestrial stations. The impetus of this work was maintained at Geneva in view of the forthcoming Space Conference.

So far as communication satellite services are concerned, a draft revision of Report 382 on the Determination of Co-ordination Distance was prepared as Document IV/180 (Rev. 1). This revision does not alter any principles but clarifies the methods used for calculation and suggests that specific paremeters be used when known, even for initial co-ordination negotiations. In addition, a draft New Report entitled 'Calculation of Interference Probability Between Earth Stations and Terrestrial Radio-Relay Systems' has been prepared as Document IV/178 (Rev. 1) and some subjects have been referred in Doc. IV/204 (Rev. 1) to Study Group V (Tropospheric Propagation) for examination. The overall trend of the work in Study Group IV on sharing problems is to interrelate the technical data for the consideration of 'co-ordination distance' (which is an administrative concept) with the purely technical problem of controlling mutual interference.

The problems of frequency sharing between stations in the space research service and with other services were discussed in Working Group C who produced a draft Annex to Report 218 concerning radio frequency powers required (Document IV/148). A noteworthy conclusion is that deep-space exploration of the four nearest planets requires radiation of equivalent isotropically radiated powers (e.i.r.p's.) up to 1,000 GW, or more from Earth Stations with the result that in horizontal directions the e.i.r.p's. of these transmissions may be of the order of 100 MW. Such powers could require separation distances between deep-space earth stations of 500 km or more and raise formidable problems for sharing with other services. It was recognised that further quantitative study is needed.

General Comment and Conclusion

The delegates to the Study Group IV meetings in Geneva included representatives from Administrations and Operating Agencies who have been responsible in some degree for the implementation of the INTELSAT communications satellite system. These included, in the U.S. Delegation, members of Comsat Corporation staff. As a consequence, the output from the meetings reflects the experience and the problems arising from INTELSAT activity. A typical example of this is the importance attached to the use of the geo-stationary satellite orbit.

The next meetings of C.C.I.R. Study Group IV are to be held in September/October 1969 and these are to be followed by the XIIth Plenary Assembly in January/February 1970. The results of the work at Geneva in 1968 have pointed to several subjects that require study in preparation for these meetings. The main points have already been covered in this article so will not be further elaborated here, but the preparatory work will be of importance not only for the C.C.I.R. meetings but also for the World Administrative Radio Conference (Space) which will follow in late 1970 or early 1971. Such activities are of real practical significance because system development and equipment design now takes full account of C.C.I.R. recommendations. Thus it is in Australia's interest to participate in the work of C.C.I.R. to ensure that Recommendations are acceptable and our point of view put forward in time to influence results. In this connection, documentary contributions provide an effective vehicle of influence.

REFERENCES

1. 'Conclusions of the Interim Meeting of Study Group IV (Space Systems and Radioastronomy)' Parts 1 and 2; The International Radio Consultative Committee (C.C.I.R.), Geneva, 1968.

2. Technical News Item, 'International Working Party to Study Use of Geo-Stationary Satellite Orbit'; Telecom. Journal of Aust., Feb. 1969, Vol. 19, No. 1, P. 60.

CONDUCTOR JOINTING IN PART PRIVATELY ERECTED TELEPHONE LINES

K. E. KEIR and N. J. SADLER, B.Sc.***

INTRODUCTION

High resistance joints in part privately erected (P.P.E.) lines (Ref. 1) are the cause of many faults and complaints of poor service. When these lines are connected to a magneto-signalling exchange, the voltage produced by the magneto may be sufficient to break down high resistance films and thus permit conversation until such time as the high resistance films re-form. Such a situation can at best be marginally satisfactory, but before a magneto-signalling exchange is converted to common battery or automatic working, it is essential that high resistance joints in the associated lines be permanently removed.

In order to be able to suggest methods of obtaining the necessary improvement in existing lines and develop satisfactory practice for new ones, a large number of jointing techniques was assessed by the Postmaster-General's Research Laboratories (Refs. 2, 3 and 4). Emphasis has been placed on the evaluation of existing jointing techniques whilst at the same time giving attention to the design and development of a new type of compression sleeve for making joints in rusty 200lb/mile galvanised iron (G.I.) wire.

TABLE 1 — APPROXIMATE CLEANING TIMES

Joint	Length of Wire to be cleaned (ins)	Approximate Time Required (minutes)
Twist	2 x 12 = 24*	32* (10)
Britannia	2 x 3 = 6	8
Crimp (Using currently available sleeves)	2 x 1½ = 3	4
Crimp (Using developmental spring-sleeve)	0	0

* Actually, these figures are too pessimistic. In practice, it is only necessary to clean thoroughly those portions of wire which will be soldered together (see Fig. 1). The remainder of the wire contributes to the mechanical strength of the joint but it is not required that there should be high grade electrical contact under the tightly wound sections at either end of the joint. The figure shown in brackets, 10 minutes, is more appropriate.

JOINT REQUIREMENTS

The fundamental (and obvious) electrical problem is to obtain a low, reliable resistance between the two lengths of wire. This is effected by bringing two clean metal surfaces into direct physical and electrical contact, or by bringing one clean metal surface from each wire into direct physical and electrical contact with a third low resistance metallic path. It can be shown (Ref. 2) that stable resistances of up to 2.2 ohm/joint for 200lb/mile G.I. wire, and up to 0.55ohm/joint for 400lb/mile G.I. wire are acceptable. In practice, the resistance of a well made joint is very much less than these values. Most joints produced by acceptable techniques have a joint resistance less than the resistance of an equal length of line wire.

It is shown in Ref. 2 that an electrically clean surface is essential if a reliable joint is to be made. The cleaning of rusted G.I. wire in the field is not an easy process. Experiment has shown (Ref. 2) that vigorous rubbing with coarse emery paper does not always produce a surface which is electrically conducting over its entire area. For example, when one sample of corroded 200lb/mile G.I. wire was rubbed vigorously with very coarse emery paper for five minutes, over a distance of one and a half inches from the end of the sample, most, but not all, of the corrosion was removed, and electrical measurements showed that the exposed surface had a high surface resistance over some portions. Further rubbing with a fresh piece of emery would have eventually produced a bright, clean, conducting surface, but five minutes was regarded as a long time to spend in cleaning one piece of wire. The use of a file turns out to be more satisfactory than emery paper. On the average, a piece of rusty 200lb/ mile G.I. wire may be cleaned over a one and a half inch length in about two minutes to give an exposed surface which is clean and bright and electrically conducting over its entire area. It is important, however, to continually rotate the wire as the filing proceeds in order not to produce flat areas of too great a width. If this technique is used, Table 1 gives the approximate average times required to clean the curved surface areas of badly corroded wires:

It is quite understandable that an operator would find the cleaning process irksome and try to speed it up by making only a perfunctory attempt at cleaning the wire. It would, however, be difficult to lay too much emphasis on the importance of having a clean metallic surface available.

EVALUATION OF EXISTING TECHNIQUES

The making of soldered twist joints (Fig. 1) in wire heavier than 200lb/mile is physically quite strenuous. For heavier wires, e.g., 400lb/mile, the use of a Britannia joint (Fig. 2) provides a less arduous construction procedure. In Ref. 1, the Britannia joint is recommended as the most effective alternative to the sleeve joint for copper wire. It is shown in Ref. 2, however, that it is quite suitable for jointing G.I. wires if the solder-

Fig. 1 — Twist Joint.

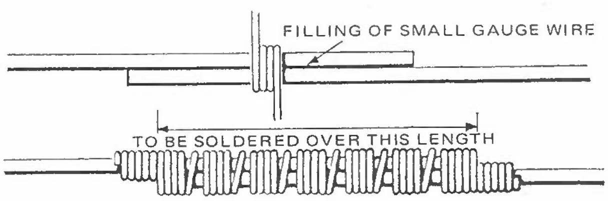


Fig. 2 — Britannia Joint.

* Mr. Keir is Metallurgist Class 2, P.M.G. Research Laboratories.
** Mr. Sadler is Physicist Class 2, P.M.G. Research Laboratories.

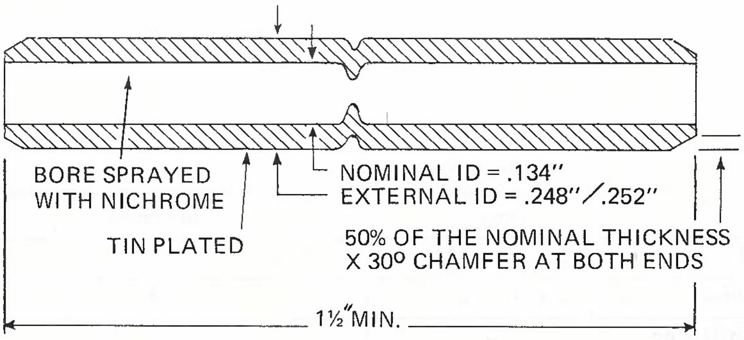


Fig. 3 — Press type Jointing Sleeve for 200lb/mile G.I. Wire.

ing is done carefully. When making Britannia or twist joints, or using a soldered by-pass, some attention should be given to the soldering process. The surfaces to be soldered would have already been cleaned. The next step is to apply a suitable soldering flux (e.g. Baker's Solution) to the joint. The soldering iron should be of large thermal capacity and hot enough to allow the solder to flow freely into the whole of the space between the wires. At the same time, especially if copper wire is being soldered, care must be taken to guard against 'burning' the wire by using an excessively hot soldering iron. This weakens the wire at the joint and could later result in a broken wire. After the solder has solidified, it is important to wash off any surplus flux, as this may corrode the wire. If the wires are not adequately cleaned and the soldering is not properly performed, it may mean that the outside of the joint only is covered with solder and that there is no firm metallic connection between the two wires. In this case, the joint will be only equal in performance to an unsoldered or dry joint and will cause faults. The soldering of cleaned copper wire is quite straightforward. New galvanised iron wire can be soldered with only slightly more trouble, but care and perseverance is necessary to get a good soldered joint in G.I. wire from which the galvanised surface has been removed.

It is recommended (Ref. 2) that all future P.P.E. lines using new clean 200lb/mile wire be jointed using currently available crimping sleeves (Fig. 3). Such joints are reliable, of low, stable resistance, low cost and easily made. This method is also recommended for the upgrading of existing lines in 200lb/mile wire when cleaning off the insulating film does not decrease the diameter of the wire to such an extent that it is impossible to obtain a crimped joint of adequate strength. When it is necessary to joint wires of different diameters, Britannia or soldered twist joints should be used as illustrated in Figs. 1 and 2 and described in detail in Ref. 1. To improve existing lines in which joints are mechanically sound but have high resistance, the soldered by-pass (Ref. 1) is suitable if it is desired not to cut the existing line. The commonly encountered use of knots as a jointing technique is entirely unsatisfactory.

COMPRESSION SPRING SLEEVE JOINT

A joint specifically designed for repairing rusty 200lb/mile galvanised P.P.E. telephone lines is shown in Fig. 4 and has been fully described in Refs. 3 and 4. This method of jointing utilises a sleeve containing an internal compression spring. To make a joint, the ends of the wire to be joined are wiped free of loose rust and dirt, and are then cut with pliers to expose a small but clean surface or edge. The wire ends are then inserted into the sleeve, fully compressing the spring, whereupon the ends of the sleeve are crimped onto the wire. Relaxation effects that can occur when contact is made by crimping alone are virtually eliminated by this technique due to the length of compression of the spring. The use of this type of joint also eliminates soldering which, in the field, is a difficult and uncertain practice when dealing with heavily rusted wire, and is also time consuming.

Tests were conducted (Ref. 3) with wire cut by two methods, one giving pinched ends on the wire as would be obtained with ordinary pliers or side cutters, and the other method giving a square cut end by shearing in slots such as are provided in many pliers. Whilst from an electrical point of view there was no difference between the two types of cut, physically it is much easier to cut 200lb/mile wire with slotted pliers, and for this reason the sheared type of cut would be recommended.

Loose rust is wiped off the wire to make sure that it does not get between the ends of the wire and the spring thus creating a high resistance, but it is most important that firmly adhering rust remains, because this is what gives the joint sufficient mechanical strength, particularly when old wires have become considerably reduced in size. The

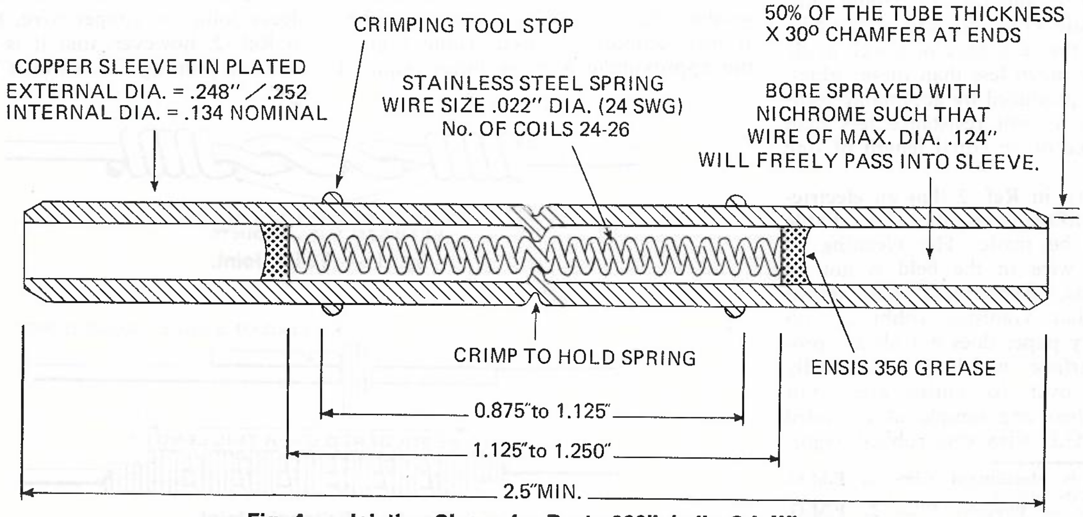


Fig. 4 — Jointing Sleeve for Rusty 200lb/mile G.I. Wire.

nominal size of 200lb/mile G.I. line wire is 0.121 ins. diameter but tests (Ref. 3) on two wires each of diameter 0.090 ins. showed that when crimped into a sleeve, the rusty wire joint held a load 3½ times that of a cleaned wire joint before the wire pulled out of the sleeve.

This compression spring joint is not a heavy current type of joint due to the small area of contact, but tests have proved the stability of the joint under severe environmental (tropical cycling) conditions. In actual fact, the joints prepared for testing were made on wire with more than 0.005 ins. thickness of rust and where no conduction at all occurred between the crimped sleeve and the wire. This represented the worst possible conditions that could exist, whereby the electrical connection depended wholly on contact between the freshly cut ends of the rusty wire and the internal spring. One connector manufacturer was approached and indicated his willingness and ability to manufacture this type of sleeve. Some prototypes were made by him and have been tested (Ref. 4). After a period of 18 weeks exposure in a tropical cycling cabinet, the final resistances of these joints were actually lower than the initial values.

In the most extreme case which could occur where the conduction through this type of joint would consist of the two end contact resistances, plus the resistance of the full length of stainless steel wire used in forming the spring, the total resistance of the joint would be in the vicinity of 750 milliohms. In practice, however, when the spring is compressed, shorting will occur between various coils of the spring and the spring will also make side contact onto the sleeve wall. It can be thus seen that joints will vary quite widely in initial values. In the case of the prototypes (Ref. 4), initial values varied from 15-212 milliohms, and these dropped to 13-140 milliohms after the tropical cycling treatment. In many cases where the rust would be less severe than on the wire used for testing, the crimping of the sleeve would crush the rust sufficiently to cause conduction onto the line wire and this would lower the overall resistance considerably, but relaxation of the crimp and further possible corrosion may cause this conduction path to subsequently rise in resistance. The new joint described does not rely on any conduction path between the line wire and sleeve.

This type of joint requires two persons, one to hold the wire ends in the sleeve, compressing the spring, whilst the other crimps the sleeve onto the wire, but despite this, compression spring jointing would require less man-hours of labour than soldered jointing. Where extensive jointing would be required, a clamp designed to enable single handed operation would no doubt be used.

Compression spring sleeve jointing would be a simple and effective means of upgrading rusty 200lb per mile galvanised iron P.P.E. telephone lines, but as yet the method requires to be tested in the field.

REFERENCES

1. 'How to Construct and Maintain your Telephone Line', published by the Australian Post Office.
2. Sadler, N. J., 'Conductor Joints in Part Privately Erected Lines'; Interim Report, P.M.G. Research Laboratory Report No. 6162. 1966.
3. Keir, K. E., 'Part Privately Erected Telephone Lines'; A Method of Jointing Rusty 200lb G.I. Line Wire, P.M.G. Research Laboratory Report No. 6231. 1967.
4. Keir, K. E., 'Part Privately Erected Telephone Lines'; A Method of Jointing Rusty 200lb/G.I. Line Wire. P.M.G. Research Laboratory Report No. 6231, Addendum No. 1, 1968.

ACTIVITIES OF THE SOCIETY

The following extracts from the Annual Report of the Council of Control of the Australian Telecommunication Society of Australia will be of interest to members.

Council Activities

Decisions were taken on the following
- reciprocal advertisements with the Institution of Post Office Electrical Engineers (U.K.) were arranged;
- participation in exhibitions and conventions as an exhibitor was rejected;
- advertising rates in T.J.A. were increased;
- experimental changes were made in the typesetting and paper quality of T.J.A. and readers' opinions obtained, with a view to possible changes in format for 1969;
- as from 1969 individual off-prints of T.J.A. articles would be provided (as for A.T.R.);
- $5,000 was transferred to interest-bearing deposits, to obtain a higher rate of interest;
- payments for casual secreterial assistance were authorized.

Activities started, but incomplete at 31 December 1968 were:
- design of seal and badge for the T.S.A.;
- review of further assistance which might be requested from the Department;
- a review of costs, subscription rates, and membership activities.

Telecommunication Journal of Australia

Journals ordered by State Committees for distribution by agents are shown below. They include a small margin for stock.

State	Average Journals per issue 1968	1967
N.S.W.	2500	1567
Vic. (inc. H.Q.)	1733	1700
Qld.	840	807
S.A.	667	553
W.A.	537	473
Tas.	222	213
National	6499	5313

Penetration of T.J.A. per 100 engineering staff (Engineers, Technicians (all grades), Technical Officers and Technicians' Assistants) is shown below.

	1968	1967
N.S.W.	41.7	27.34
Vic.	36	36.12
Qld.	37.8	37.5
S.A.	40.9	34.71
W.A.	42.9	41.97
Tas.	38.8	37.11
National	39.5	33.5

Australian Telecommunication Research

Average paid circulation for 1968 was as follows:—

N.S.W.	114
Vic.	121
Qld.	55
S.A.	32
W.A.	26
Tas.	4
Overseas	97
Director-General	280
Total	729

KEIR and SADLER — Conductor Jointing

SAFETY ASPECTS OF VOLTAGES APPLIED TO TELEPHONE LINES

*G. BYASS, B.E. * and T. G. PIMM, Grad. I.E. Aust. ***

INTRODUCTION

Telephone lines, as well as carrying speech signals, low level signalling tones and data information, are also required in some cases to carry voltages for signalling purposes and for feeding power to remote equipment. These voltages are usually considerably higher than those employed for the carrying of information, and there is a trend to use even higher voltages to gain economies from the use of lighter gauge conductors, to improve signalling, and to increase the distance between power injection points for power feeding of remote equipment. But increased line voltages make working conditions less comfortable for technical staff, and increase the hazards resulting from electric shocks.

Therefore, the maximum voltages allowable are necessarily a compromise between the limits desirable for comfort and possibly safety and the higher values desirable for economic and technical reasons. Safety must of necessity be the major consideration, but the limits should be realistic within the range of present knowledge.

This article presents a summary of previously published papers on electrical safety and deals with the various aspects of electric shock; the main purpose is to provide a guide to the determination of the most suitable approach to safety in any particular case. In addition the results of some measurements of human body and skin resistances carried out by the authors are discussed. The article indicates voltages that may be considered safe under most circumstances but the figures given have not been adopted as A.P.O. standards.

ELECTRIC SHOCK

General

Early experimenters in the field of electrical safety attempted to relate the applied voltage to the severity of an electric shock but were unable to obtain any conclusive results. Then in 1936, the experimental work of Ferris, (Ref. 1) and of Kuowenhoven (Ref. 2) established a relationship between the current flowing through the body and the effect on the heart. Since then a number of further observations have been made, correlating the current flow and duration with such effects on the victim as sensation, muscular contraction, respiration and heart action.

It has been established that there are four basic categories of electric shock. In order of increasing severity these are the threshold of perception, the 'let-go' value, the fibrillation value and the paralysis value.

The Threshold of Perception

This is the value of current through the body which first becomes perceptible. Dalziel and Mansfield (Refs. 3 and 4) showed that the average threshold of perception through the body of males for 60 Hz sine-wave a.c. is about 1 mA and for d.c. is about 5 mA. They further determined that the peak current and not the r.m.s. value is the controlling factor for nerve stimulation and that the perception threshold increases with increasing frequency. Fig. 1, which is taken from Ref. 4, presents these results as three curves. The 0.5% curve shows the current value at which 0.5% (1 in 200) of the subjects would just be able to detect the current flow through their body. Similarly the 50% and 99.5% curves show current which would be detected by 100 and 199 out of 200 persons. These values are for perception by the hand holding a small copper wire. Tests with different electrode areas show variations in the threshold as some areas of the body are more sensitive than others. For example, on the tongue 45 micro-amperes d.c. is perceptible to 50% of persons.

'Let-go' Value

For a.c., as the current flow is increased above the perception threshold, the effect on the muscles becomes more severe with pain increasing and the muscles tending to contract. Eventually muscular control is lost and a person, who is **firmly holding** terminals or electrodes, may be unable to release himself from the circuit. The current at which this occurs is referred to as the 'let-go' value. The value is also known as the threshold of decontrol and as the 'can't let-go' value.

For d.c., Ref. 5 indicates that the 'let-go' value is related to the voluntary endurance of pain rather than loss of muscular control. D.C. produces sensations of heating rather than muscular contractions and the reaction and shock produced by the sudden change in cur-

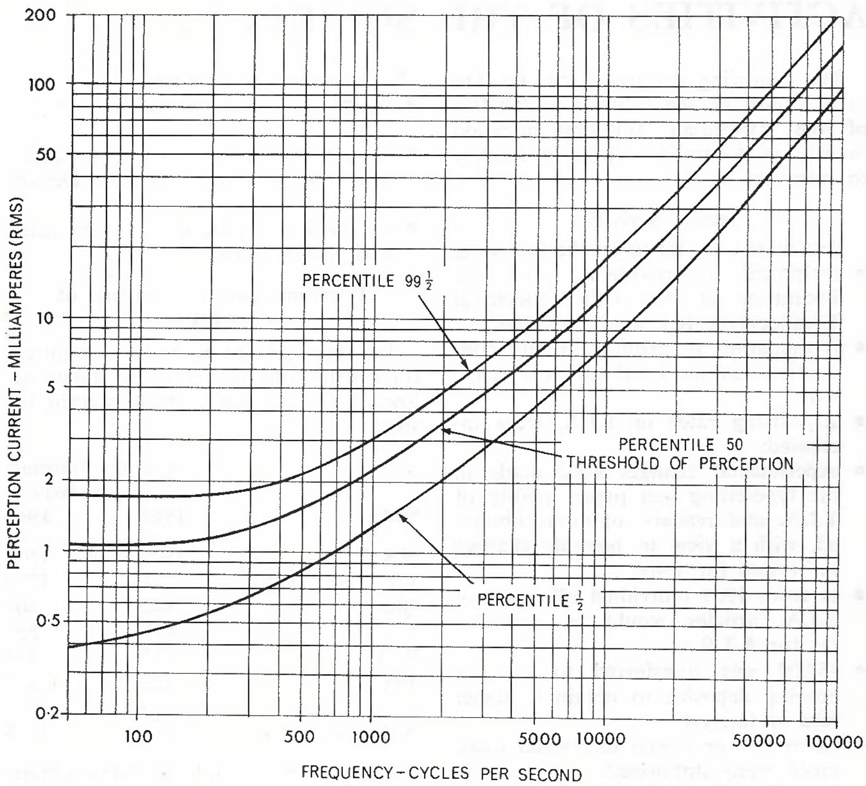


Fig. 1.

* Mr. Pimm is Engineer Class 2, Kempsey, N.S.W. See Vol. 16, No. 1, Page 87.
* Mr. Byass is Engineer Class 2, Country Section, W.A.

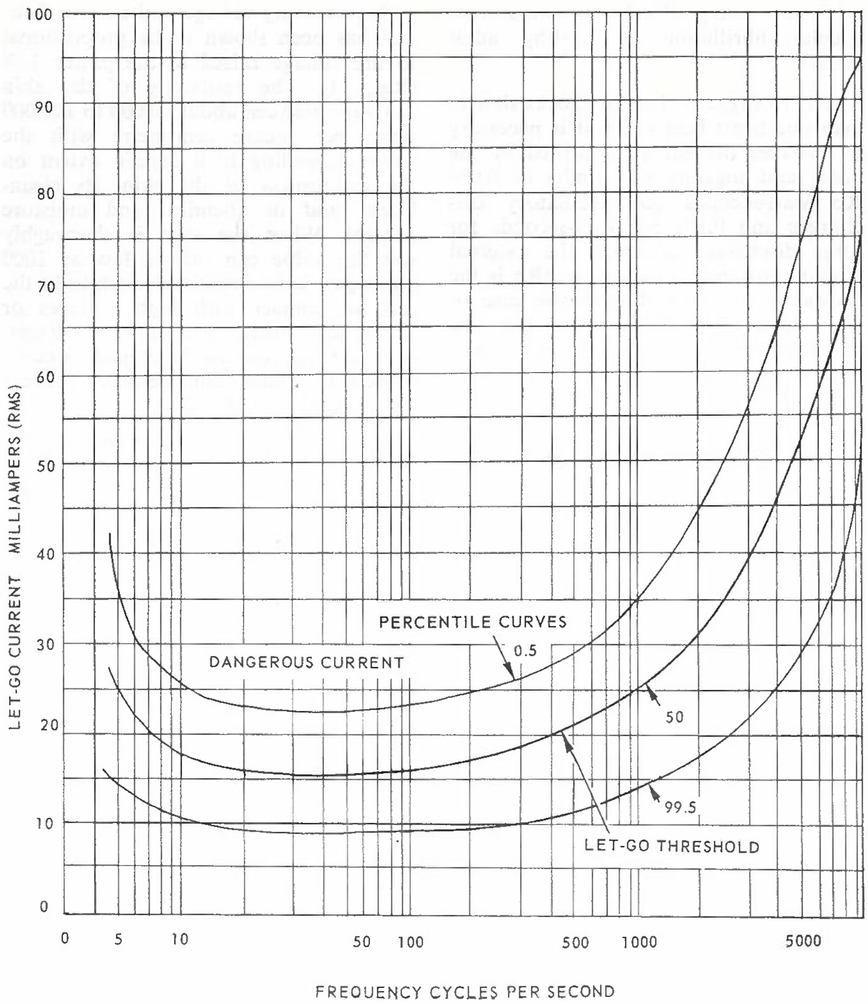


Fig. 2.

rent when releasing the test electrode causes the subjects to decline releasing at higher current values.

The danger in currents at or just above 'let-go' currents is that they may cause fibrillation (see next section) within a few seconds. If not, the continued contact will cause blisters which lower the contact resistance and result in the current rising and perhaps reaching fibrillation values.

Considerable experimental work has been carried out on human subjects to determine 'let-go' values for current flow through the body (Ref. 5). Owing to the wide variations between the responses of different subjects it is not possible to define a current that is safe for all persons, however, for practical purposes the value at which 99.5% of healthy adults can still 'let-go' is usually regarded as being safe. Graphs of 'let-go' values are shown in Figs. 2 and 3 (taken from Ref. 5). The two important points are the d.c. maximum safe current of 62 mA and the a.c. maximum safe current of 12.5 mA (crest value). Before using Fig. 3 for combined a.c. and d.c. currents, Ref. 5 should be consulted.

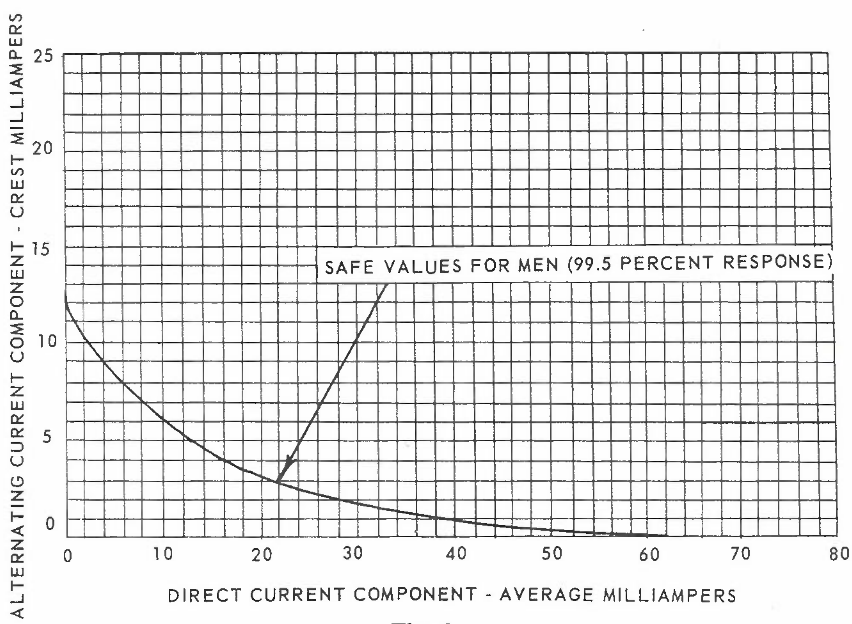


Fig. 3.

The Fibrillation Value

In some electric shocks, a heart condition known as ventricular fibrillation occurs. This is an unco-ordinated action of the muscle fibres in the ventricles of the heart, in contrast to their normal co-ordinated and rythmic contractions. The heart seems to quiver rather than beat, its pumping action ceases and the failure of blood circulation results in death in a few minutes. It is also stated (Ref. 1) that once ventricular fibrillation is started it is unlikely to cease naturally. However, external heart massage can keep a victim alive pending defibrillation at a hospital.

Because of the dangers involved, experimental work (Refs. 1 and 6) was carried out on animals of various types and the results form the basis for estimating the corresponding danger values for humans.

The fibrillation value varies with the duration of the shock and with the body weight. For a.c., Ref. 6 indicates that currents as low as 7.4 mA and 5.4 mA may result in fibrillation in shocks exceeding 5 seconds in duration for body weights of 70 Kg (154 lb.) and 50 Kg (110 lb.) respectively. These values, of course, apply to currents flowing on a path, for example, through the chest cavity, that takes them close to the heart. Published data of fibrillation values for d.c. were not reviewed by the authors.

The Paralysis Value

When the body is subjected to electric currents in excess of about 10 amps for a few seconds the chances of the victim surviving may be greater than for more moderate shocks. The reason for this apparent anomaly is that while lower currents may cause ventricular fibrillation, a large current produces paralysis involving severe contraction of the body muscles, including those of the heart. If the duration of the current flow is brief, the heart will usually automatically resume its normal action. However, the passage of large currents has severe secondary effects such as severe tissue burns and temporary paralysis of varying severity due to disruption of the nervous system.

Intermittent Shocks

When electric shock is caused by a series of individual short pulses or bursts of current through the body, the magnitude of the individual shocks and the time interval between them are important. If the time interval between the current bursts is very short the victim may not be able to release the circuit before the next current pulse and the effect is similar to a continuous current. Tests carried out by Dalziel (Ref. 5) using 60 Hz current 2 to 4 mA above the individual's 'let-go' current, indicate that the 'let-go' time is about 0.4 seconds.

When the time interval between shocks with current in excess of the 'let-go' value, allows the circuit to be released during off time the possibility of fibrillation after the initial shock is critical. Work in this field is described in Ref. 1, 6, 7, 8 and 9, but there is no general agreement among researchers as to the current levels and durations that should be considered dangerous. In particular the effects of duration relative to the heart beat period are in dispute.

Examples of intermittent voltage in use are electric fence controllers which employ a repetitive capacitor discharge with off times of between 0.75 and 1.0 seconds and interrupted ringing voltage in telephone systems which have off times of 2 seconds.

Shocks Caused by Single Pulses

Single pulse shocks can be caused by lightning, discharge of high voltage capacitors or by power circuits protected by fast acting circuit breakers.

When the current pathway is through the chest, a far greater shock than is required to produce venticular fibrillation is necessary to cause respiratory inhibition and damage to the nervous system. Thus the danger criterion is the minimum energy likely to cause ventricular fibrillation in healthy adult males.

Ref. 10 suggests that for shocks shorter than one heart beat cycle, it is necessary to consider the energy absorbed by the body, and suggests safe limits of 0.054 Rb watt-seconds for oscillatory discharges and 0.108 Rb watt-seconds for surge discharges assuming the external circuit resistance is negligible. (Rb is the resistance of the body). In the case of high voltage discharges, Rb may be taken as 500 ohms since the skin resistance breaks down to an insignificant value. Thus it can be assumed that for short high voltage discharges, the limits are 27 watt-seconds for oscillatory discharges and 54 watt-seconds for surge discharges.

Other researchers however favour criteria based on currents and suggest that currents up to one amp may be safe if the duration is less than about half a heart beat cycle.

Analysis of known cases of high voltage accidents indicate that some victims have lived after receiving energy from surge discharges of up to 25,000 watt-seconds although in one fatal accident the energy absorbed from an oscillatory discharge was only 23.5 watt-seconds. Hence it can be seen that, at this stage, limits for pulse shock, must be regarded as tentative only.

RELATION BETWEEN CURRENT AND VOLTAGE

General

The foregoing has served to indicate the importance of current rather than voltage as the main criterion in electric shock. However, the voltage must be considered; frequently it is the only known parameter and the current has to be calculated from it.

The current flowing depends on the applied voltage and the total circuit resistance and hence before a voltage can be regarded as safe, an estimate must be made of the total resistance of the circuit. In a practical case the internal impedance of the voltage source and other fixed circuit parameters are usually known, but the resistance of the current path through the body is not. This resistance is affected by internal body resistance, skin resistivity and area of contact.

The internal resistance of the body, i.e. underneath the skin, is relatively low because body fluids due to their salinity are good conductors. An internal resistance of 500 ohms between any two limbs is typical. The resistance decreases with increasing voltage and current flow, and has been shown to be proportional to the voltage raised to the power 1.98 (Ref. 11). The resistivity of dry skin can vary between about 70,000 to 100,000 ohms per square centimetre with the value depending to a certain extent on the callousness of the skin, its cleanliness, and its chemical and moisture content. When the skin is thoroughly wet the value can fall as low as 1000 ohms per square centimetre while in the case of contact with high voltages or prolonged contact with lower voltages, sufficient heat can be developed to cause blistering which considerably reduces the resistivity of the skin.

Thus with dry skin and a contact area of 10 sq. cms. the skin would contribute about 7,000 ohms to the 7,500 ohms resistance of the path through the body, but the contributions could fall to as little as 100 ohms for the same contact area of wet or blistered skin, leading to total resistance of only 600 ohms.

A.P.O. Tests

A series of measurements, intended as a pilot study, were carried out by the authors to test the relationship between current and voltage, and to determine the range of body resistances to be expected in work on telephone lines. The subjects were a group of 33 Australian Post Office Engineers of various ages and the measurements were made under controlled conditions of temperature (70°) and humidity (45%).

The tests simulated two extremes of skin contact area. In the first (Test 1) the subject was required to hold a wire between the thumb and forefingers of each hand thereby completing a circuit through the body. In the second, (Test 2) the subject held an aluminium tube (1 in. diam.) with one hand and completed the circuit with a firm grip on a pair of pliers.

The tests were conducted with d.c. starting at 10 volts and increasing in steps of 10 volts to 60 volts. The subject resistance in the first test varied from about 20,000 ohms to 400,000 ohms; in the second test, with a greater contact area, resistances ranging from 3,000 ohms to 10,000 ohms were recorded. A feature of the results was the variation of resistance with voltage throughout the tests. Fig. 4 shows the average of all results obtained.

The subjects also commented on the degree of discomfort experienced. No subjects experienced discomfort in Test 1 and most experienced some discomfort in Test 2; five subjects were unable, or unwilling, to proceed beyond 50 volts. The current flow in these five either equalled, or exceeded, the value for other subjects at 60 volts.

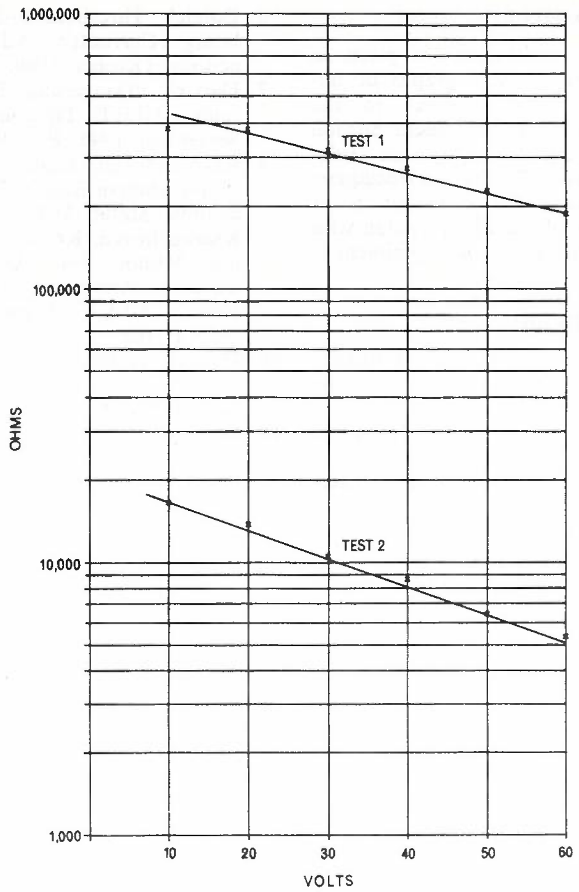


Fig. 4.

VOLTAGES PERMITTED BY A.P.O.

There are a wide range of voltages used in the A.P.O., determined to a large extent by the technical requirements of the particular circuits. These range from magneto local battery requirements of 3 volts d.c. up to 150 volts d.c. for 'charge over trunk' circuits to remote country exchanges and even higher a.c. and d.c. supplies for some special purposes, e.g. up to 1,500 V for coaxial cable power feeding system. Some A.P.O. specifications have specified maximum a.c. voltages ranging upwards from 40 volts (r.m.s.) (Refs. 12, 13, 14 and 15). The standard d.c. voltage for C.B. and automatic exchanges is a nominal 50 volts but in special cases higher d.c. voltages are used, e.g. 100 volts for signalling repeaters over high resistance junctions and trunks.

The alternating voltage for ringing purposes has an r.m.s. value ranging from 75 volts to 100 volts, but is interrupted having a maximum break of 2 seconds.

In each case the hazard to field staff of the voltages used has been considered and special safety precautions have been applied.

For example, the power supplied for remote repeaters on coaxial cables is removed before staff are allowed to work on the cables or associated equipment; stringent precautions are taken to ensure that the supply cannot be reconnected during work.

Impulse voltages are also applied to lines e.g. dialling impulses and telegraph signals. Oscillographs taken for typical circuit configurations show that the voltage between lines during dialling reaches almost 200 volts for about 10 milliseconds and is around 50 volts for the remaining period of each impulse. Between the battery leg and earth the peak voltage is about 150 volts for 10 milliseconds. In telegraph work, the tests showed that voltage did not exceed 50 volts.

BASIS FOR SAFETY STANDARDS

The determination of voltage standards for safety purposes is difficult as shock hazard is more directly related to current than to voltage. The current although a function of the voltage is far more dependent on the surface contact area and the condition of the skin. The current is also dependent on the impedance of the voltage source.

Standards for safety may be determined in several ways. Firstly, the voltage may be limited to a value which has been accepted and used without accident for a long period of time. This approach however, also limits possible technical developments and thereby hinders progress and mitigates against cost reduction. The second method, arising from the dependence of shock hazard on current flow, imposes a current limitation by circuit design (impedance of voltage source) thereby allowing a higher line voltage than would otherwise be safe. A third method, used with a.c. power supplies, employs a relay to remove power when the earth leakage current of a superimposed d.c. exceeds a given value (Ref. 16). It may be desirable in some cases to deny access to high voltage circuits until all power has been removed. This approach is used on coaxial cables and associated equipment.

Each of the foregoing implies that no special training is needed of staff required to work on the associated line or equipment. The alternative to all of these is to thoroughly train staff in the precautions required to safely maintain lines and equipment when operating at high voltages.

SUMMARY

There is no voltage (a.c. or d.c.) which can be said to be unconditionally safe for all people or even for all adult males.

The difficulty in determining a safe voltage arises from the variability of the resistance of the current path through the body and of the 'let-go' current of individuals. Conservative values must be placed on these to obtain a reasonably safe voltage. During normal A.P.O. activities, this resistance is rarely lower than 2000 ohms. Using this value and the currents at which 99.5% of subjects can let-go, i.e. 62 mA d.c. and 12.5 mA crest value for a.c., the safe voltages would be:—

D.C.	– 120 volts
A.C. (Sinusoidal)	– 18 volts r.m.s.
A.C. (Other waveforms)	– 25 volts peak.

These values may be conservative, because the skin contact area with wires or terminals is usually much smaller. However, these voltages although considered safe, may cause mild to painful shock, depending on the particular skin conditions. It should be realized that even the present exchange battery voltages applied to auto and C.B. lines may cause similar painful shocks in some conditions but the incidence of such shock would rise considerably if significantly higher, but still safe, voltages were used extensively in the local cable network.

Safe conditions may be obtained by current limiting devices and some present specifications provide that circuit design shall be such that no more than 10 mA a.c. or 60 mA d.c. can flow continuously through a resistance of 2000 ohms placed across the power feeding terminal. Frequently 50 mA d.c. is specified.

Under current limited conditions, the total circuit voltage is less important and may be quite high. The voltage limit will then be determined by the capacitance of the line and the maximum energy which may be stored. This may then be related to the maximum energy which can be discharged through the body without causing ventricular fibrillation. As an example, the high voltage test on coaxial cable is applied with a current limited device capable of charging the line to 2kV but limited in continuous current to some hundreds of microamps. Calculations show that a repeater length (approximately 6 miles) of coaxial cable charged to 2kV would probably cause heart fibrillation if discharged across the chest.

High voltage from non-limited current sources must be restricted to those applications where power is removed before access to the high voltage conductors is permitted, unless special staff training and equipment can be shown to be effective.

ACKNOWLEDGMENT

Considerable assistance was given in the preparation of oscillographs of impulse voltages by colleagues in the Telephone Exchange Equipment Section and the Subscribers Equipment Telegraphs and Power Section at Headquarters. In addition the contribution of those engineers of the Lines Section who submitted to the resistance experiment is gratefully acknowledged.

REFERENCES

1. Ferris, King, Spence, Williams, 'Effect of Electric Shock on the Heart'; A.I.E.E. Transactions (Electrical Engineering), Vol. 55, 1936, P. 498.
2. Kuowenhoven, Hooker, Lotz, 'Electric Shock, Effects of Frequency'; A.I.E.E. Transactions, Vol. 55, 1936, P. 384.
3. Dalziel, Mansfield, 'Perception of Electric Currents'; A.I.E.E. Transactions, September 1950, P. 794.
4. Dalziel, 'The Threshold of Perception Currents'; A.I.E.E. Transactions, July 1954. P. 625.
5. Dalziel, Massoglia, 'Let-go Currents and Voltages'; A.I.E.E. Transactions, May, 1956, P. 49.
6. Dalziel, 'Threshold 60-Cycles Fibrillating Currents'; A.I.E.E. Transactions, October 1960, P. 667.
7. Dalziel, 'Dangerous Electric Currents'; A.I.E.E. Transactions August-September 1946, P. 579.
8. Kuowenhoven, 'Effects of Electricity on the Human Body'; A.I.E.E. Transactions, March 1949, P. 199.
9. Kuowenhoven, Knickerbocker, Chesnut, Milnor, Sass 'A.C. Shocks of Varying Parameters Affecting the Heart'; A.I.E.E. Transactions, May 1959, P. 163.
10. Dalziel, 'A study of the Hazards of Impulse Currents'; A.I.E.E. Transactions, October 1953, P. 1032.
11. Westerman, 'The Mechanism of Death in Electrocution'.
12. P.M.G. Research Lab. Report No. 3729, 'Use of Cable Pairs by Outside Bodies'.
13. A.P.O. Engineering Instruction, Telephone Substation A.0012 (1957).
14. A.P.O. Information Bulletin No. 16. 'Facilities for Data Transmission'.
15. A.P.O. Specification No. 1002 'Power Supplies for Line Transmission Equipment'.
16. Superior Cable Corporation, 'Power-Trip Circuit for CM4 — Electronic Distribution System'.

TECHNICAL NEWS ITEM

EXTENSION OF OPERATING FREQUENCY OF OPEN WIRE LINES

Consideration is being given to the possibility of utilising the frequency spectrum of open wire pairs of wires above the conventional 12 channel open wire frequency of 143kHz. A new 48 channel open wire carrier system which operates in the frequency range from 312-808kHz developed in France by Telecommunications Radioelectriques et Telephoniques (TRT), provides C.C.I.-T.T. quality circuits and offers a possibility of exploiting the vast asset in open wire lines available in Australia.

The exploitation of higher frequency capabilities of open wire lines to provide substantially increased capacity per pair is dependent on being able to reduce the mutual pair couplings between pairs to a very low level when more than one system is to be installed on a route. It may in fact be possible to install one system only on a suitably transposed pair of wires on any existing pole route. For the installation of two 48 channel systems on a route plus two standard 12 channel systems, two possible special wire configurations are being examined:—

(i) Using two pairs of wires with wire to wire spacing of 8 in. and between pair spacings of 93 in., with the wires arranged in a parallelogram formation resulting in zero mutual couplings between pairs. Two pairs of wires on any existing route with pole spacings up to 4 chains could be readily converted to the correct geometrical configuration.

(ii) For new construction a special route configuration development by TRT for 48 channel open wire systems employs two pairs of insulated copper-clad steel wires with wire to wire spacing of 2 in. and at least 24 in. between pairs. Very frequent relative transpositions are installed using light polythene, inspan, roll type transposing devices on long span (8-10 chain pole spacing) construction.

While it is too early to draw positive conclusions as to the future role of the 48 channel open wire systems, preliminary economic studies indicate that there could be a sizeable field of application in Australia.

OUR CONTRIBUTORS

M. F. LETTE

S. S. MINZ

G. S. BYASS

M. F. LETTE, author of the article, 'Installation of Lead Sheathed Cables on Bridges', joined the Department in 1947 as a Cadet Draftsman. After qualifying as a Draftsman in 1951 he spent five years in the Equipment and Survey Sections. In 1956 he qualified as an Electrical Engineer and took up an appointment as Grade 1 Engineer, No. 2 Primary Works in 1957. He was promoted in 1958 to the position of Group Engineer, District Works and was later transferred as Group Engineer, Primary Works.

In 1961 when installing ducts and cables for the COMPAC Cables project Mr. Lette became interested in the problem of damage as a result of blasting operations in built up areas and undertook formal studies in this field at the Sydney Technical College in 1962.

Mr. Lette is a Member of the Institution of Engineers, Australia.

★

S. S. MINZ, author of the article, 'Poling Patterns for Peak Voltage Reduction', was in charge of production planning in one of Tata's engineering works which was manufacturing communication equipment under the control of the R.A.F. in Bombay during the last war. He obtained a B.E.E. degree from Melbourne University in 1952 and joined the Postmaster-General's Department as an Engineer in the Traffic and Trunking Division, Victoria, in 1953. He transferred to the Radio Section where he was appointed a Class 2 Engineer in charge of Lyndhurst H.F. Radio Station. He was responsible for the installation of radio transmitters, and took part in the construction of a novel high power h.f. line switching system at this station. From 1957 he was in charge of installation of radio telephone systems in Victoria and later joined the Engineering Studies Division where he was working on problems of engineering management and industrial engineering. In 1966 he joined the Long Line Equipment Section, Headquarters, where he has been engaged in transmission testing of signalling equipment, the installation of a Data Logging System for the automatic recording of transmission levels, and in studies of broadband carrier loading problems.

★

E. R. CRAIG, author of the article, 'Space Systems and Radio Astronomy — 1968 Interim Meetings of C.C.I.R. Study Group IV', joined the P.M.G.'s Department as an Engineer Grade 1 in November 1949. He served in the Radio Section, Headquarters, and then in the South Australian Administration where he was concerned with radio-telephone and broadcasting equipment design, installation and maintenance. In 1954 he was promoted to the Research Laboratories, as Divisional Engineer and for the three years 1961 to 1964 was on loan to the British Post Office for work on the satellite communication projects 'Telstar' and 'Relay'. On his return from the U.K., Mr. Craig took charge of the Transmission Media Sub-Section in the Research Laboratories and was appointed Sectional Engineer in 1965. This sub-section is responsible for research in radio propagation, transmission lines, computational techniques and satellite communications.

E. R. CRAIG

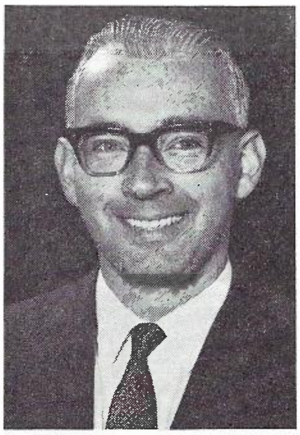
★

G. S. BYASS, co-author of the article, 'Safety Aspects of Voltages Applied to Telephone Lines', commenced with the Postmaster-General's Department in Western Australia as a Cadet Engineer in 1958. He graduated Bachelor of Engineering, from the University of W.A. in 1961. After appointment as Engineer, Class 1 in 1962, he served in Country Workshops and Equipment Service Divisions in W.A., before going to Headquarters, Lines Section, on temporary transfer for two years as Acting Engineer, Class 2 with the Service and Maintenance Sub-Section. During this period special investigations into the potential safety hazards of electrical voltages in use in the telephone network were carried out.

★

K. E. KEIR, co-author of the article, 'Conductor Jointing in Part Privately Erected Telephone Lines,' studied Metallurgy at the Melbourne Technical College, and after a period of employment in private industry joined the P.M.G. Research Laboratories in 1963. He is at present a Metallurgist Class 2 in the Chemistry and Metallurgy Sub-section of the Laboratories.

S. DOSSING



T. ALLAN

S. A. HOWARD

S. DOSSING, author of the article, 'C.C.I.T.T. IVth Plenary Assembly — Mar Del Plata, Argentina, 1968', received his M.Sc.E.E. Degree with Honours from the Technical University of Denmark in 1945. After a period as assistant to the Professor of Telecommunications he joined the Engineering Sales Division of Philips in Copenhagen transferring later to Messrs. H. Buch and Company, Copenhagen, where he was responsible for sales, installation and service of a wide range of telecommunications equipment, radar equipment and scientific instruments.

He was employed by the P.M.G.'s Department in 1949 and spent the period from 1949 to May, 1964, in the Long Line Equipment Section where he advanced to Sectional Engineer, Design. Throughout this period, he was concerned with type approval of new equipment and overall network aspects. In May, 1964, Mr. Dossing was promoted to Assistant Director-General, Systems, P.M.G. Research Laboratories.

Mr. Dossing has been actively associated with C.C.I.T.T. work and participated in meetings in Montreal in 1962 for a period of four weeks, Plenary Assembly and Study Group meetings in Geneva in 1964, and also in the Plenary Assembly and Study Group meetings in Mar Del Plata, Argentina for five weeks.

Mr. Dossing has contributed a number of articles to Danish, English and Australian Journals, the present article being his seventh published in this Journal.

★

T. ALLAN, co-author of the article, 'Erlang Meters in ARM Exchanges', joined the Postmaster-General's Department in Melbourne as a Technician-in-Training in 1952, qualifying as a Technician in 1957 and later as a Senior Technician. Following completion of his training he was employed in the Country Installation, No. 2 Division, Victoria, and was engaged on the installation of magneto, sleeve control, 2VF and Step-by-Step Equipment. Mr. Allan constructed the initial model ARK 521 Crossbar Exchange in Victoria, which provided training facilities for Technicians and Senior Technicians in the early stages of the ARK installation programme. In July, 1964, he was promoted to Acting Supervising Technician, Grade 1 in Country Installation, No. 5 Division, where he supervised the installation of Step-by-Step, S.T.D. and coaxial carrier equipment.

For the past 3½ years he has been associated with the Victorian ARM Design and Co-ordination Group and assisted with the establishment of the Geelong ARM Exchange network, preparing installation and testing instructions. Mr. Allan took an active part in prototype and commissioning tests for the Geelong network. Since the Geelong ARM cutover, he has been carrying out special investigations in connection with the documentation of outstanding miscellaneous service control equipment for ARM exchanges. It was during this period that an investigation was made into the provisioning of erlanghour meters in ARM Exchanges, this work culminating in the issue of a survey diagram, Erlang Meter Rack appropriation and wiring details, together with a comprehensive instruction on the installation of erlanghour meters in ARM exchanges.

Mr. Allan is currently occupying the position of Supervising Technician, Grade 2, Special Investigations.

★

S. A. HOWARD, author of the article, 'PERT in the Light Engineering Field', joined the Postmaster-General's Department as a Junior Postal Officer in 1948. He transferred to Exchange Installation in 1954 and qualified as a Senior Technician in 1959. In 1962 he moved into the position of Technical Officer Grade 2 (Work Study Officer) and participated in a seven weeks full time Work Study Course with Central Office. As Work Study Officer, he introduced PERT to Exchange Installations in Queensland and has implemented the project scheduling and control system used by the Brisbane Exchange Installation Divisions.

He completed a Work Study Certificate Course at the Brisbane Technical College in 1964 and has presented numerous lectures and training courses on Project Management, with particular reference to PERT/CPM and resource utilisation. These included lectures and courses for the Institute of Industrial Engineers, the Commonwealth Public Service Board Regional Management conference, Work Study Certificate students, senior staff of the Ipswich City Council, and numerous Departmental personnel.

For the past two years he has been on the Queensland Divisional Council of the Institute of Industrial Engineers, and is an Associate Member of the Institute of Industrial Engineers.

★

N. J. SADLER, co-author of the article, 'Conductor Jointing in Part Privately Erected Telephone Lines', completed a B.Sc. in Physics at Melbourne University in 1956 and part-time studies at Melbourne University Electrical Engineering School during 1957. From 1958 to 1959 he was employed as an Engineer Grade I by the Laboratory Equipment Division of the P.M.G. Research Laboratories and was admitted to Fellowship of the Royal Astronomical Society in 1958. During 1959 and 1960 he was employed as a Geophysicist Grade I by the Bureau of Mineral Resources, Geology and Geophysics and as a Technical Officer by the Radio Branch of N.Z.P.O. in Wellington. Mr. Sadler has been a Physicist in the Physics Division of the P.M.G. Research Laboratories since 1961.

ANSWERS TO EXAMINATION QUESTIONS

Examination No. 5789, 26th June, 1969, and subsequent dates, to gain part of the qualifications for promotion or transfer as Senior Technician (Telecommunications) Telegraphs, Postmaster-General's Department.

TELEGRAPH EQUIPMENT.

QUESTION 1 (a):

Describe with the aid of Fig. 1 the transmission from a Siemens Model 100 keyboard of:
(i) current.

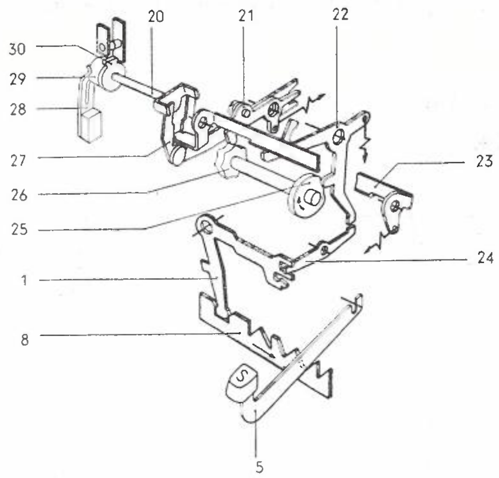


Fig. 1

(ii) no current signals.

ANSWER 1 (a):

(i) When code bar 8 is moved to the right it causes bell-crank 1 to move setting lever 24 out of the path of code lever 22. This allows the code lever to follow the surface of cam 25, and raise the bail 23. The bail swings the rocker 27 under the right arm of the switching shaft 20. When the rocker cam peak 26 raises the rocker lever 21 the switching shaft 20 is turned counter clockwise, turning the switching plate 30 away from the lever spring, allowing the contacts to close.

(ii) Code bar 8 moved to the left causes the bellcrank to place the setting lever in the path of the lower extension of the code lever. The code lever cannot follow the cam surface and does not raise the bail. Spring tension on the bail holds the rocker under the left arm of the switching shaft. When the rocker cam raises the rocker, the switching shaft is turned clockwise, and the switching plate opens the contacts.

QUESTION 1 (b):

Describe the Teletype Model 15 keyboard transmitter and indicate what advantages the Siemens Model 100 system may have over it.

ANSWER 1 (b):

The M15 KT has six signalling contacts each cam-controlled by a contact lever. Five contacts and associated locking levers are assigned to the variable elements of the five unit code, and the sixth cam controls the transmission of start and stop elements. Operation of the transmitter cam sleeve is controlled by a one-revolution clutch tripped at the time the code-bars are set to the combination selected. The M100 has only one transmitter contact which is adjustable by means of a locking screw, the transmitter shaft has a zero-setting and anti-bounce facility, and the unit is of such a design that an answerback facility can be associated with the transmitter.

QUESTION 2:

An inverse neutral hub circuit is in full conference connection to a single current machine loop. Relay PRA accepts signals from the hub and repeats them to the machine loop and repeats them to the hub.

QUESTION 2 (a):

Sketch the basic circuit needed to arrange this signalling conversion. Component values may be omitted but designations or notes to explain the relay conditions for mark and space should be included.

ANSWER 2 (a):

See Fig. 2.

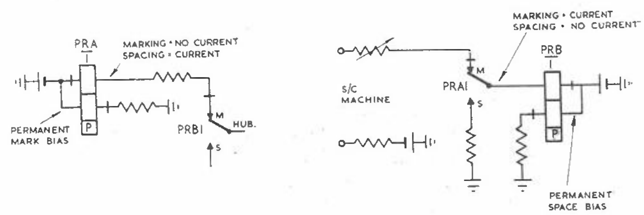


Fig. 2

(i) When there is current in the hub, it is approximately double bias current, and controls PRA to space.

(ii) When there is current in PRB line coil, it is approximately double bias current, and controls PRB to mark.

QUESTION 2 (b):

Discuss the possible sources of bias being introduced in the signalling in the hub.

ANSWER 2 (b):

The transit times M-S and S-M both add to the no-current period in hub relays and introduce space distortion. CR networks added to the hub correct the space bias by prolonging the current period after the signalling tongue lifts off space. If too much capacity is employed, for instance when the number of connections is variable, the overcorrection can introduce mark distortion.

QUESTION 3:

A Creed Model 7 teleprinter is installed at a metropolitan Tress outstation, and distortion measurements are to be made on

Answers

incoming signals on line at the outstation. A B.A.T.E. T.D.M.S. type 6 with the following controls is to be used:

Speed Range
Fine Speed
Signal (Mode and Polarity)
Unit Code
Cont./Start-Stop
High/Low Sensitivity
Display

QUESTION 3 (a):

Describe the procedure to set up the instrument and read incoming text from the exchange.

ANSWER 3 (a):

Speed Range—50 bauds.
Fine Speed—adjusted to known correct setting or by fork if not known.
Signal mode—D.C. -ve M.
Unit Code—7.
Cont-Start Stop—Start Stop.
High-Low Sensitivity—Low.
Display—M.S. & S.M.
Connect Input 1 or 2 to receive side of line and select correct input by switch.

QUESTION 3 (b):

What is implied if the incoming signals were said to be isochronous? How should the degree of isochronous distortion be measured and how would this differ from the degree of start-stop distortion?

ANSWER 3 (b):

Isochronous signals are signals in which transitions are separated by unit element intervals or whole number multiples of unit element intervals. It is implied they are not hand sent, and not sent by start-stop apparatus.
Isochronous distortion should be measured on the Continuous setting, and after observation over a specified period, the maximum difference between the earliest and latest transitions quoted as a single reading. It differs from start-stop distortion in that it does not separate "early" and "late" distortion, but lumps them together as the sum.

QUESTION 4 (a):

Draw current and voltage waveforms you would expect to see at the tongue of a 4H39 relay sending polar signals into an artificial wholly resistive line.

ANSWER 4 (a):

See Fig. 3.

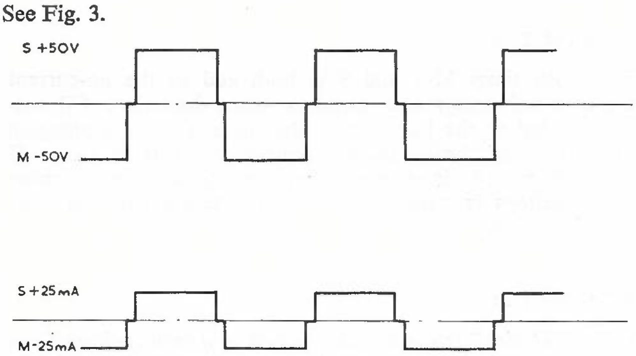


Fig. 3

Answers

QUESTION 4 (b):

Discuss why this signal should not be transmitted into telephone cable.

ANSWER 4 (b):

It contains considerable energy in the audible spectrum, and would cause audible interference in other circuits in the cable.

QUESTION 4 (c):

Show in a circuit the standard filter section included to modify the send waveform and sketch the modified current waveform. What has happened to the waveform in terms of its frequency spectrum?

ANSWER 4 (c):

See Fig. 4.

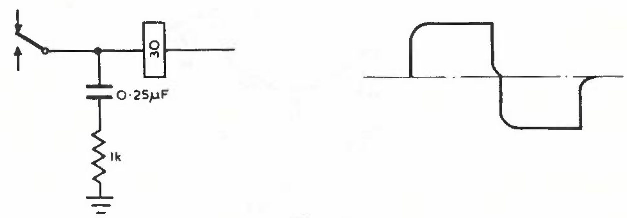


Fig. 4

The higher frequency components have been removed. These contribute to the square edge on the leading edge of the waveform. The rounding is the result of their removal.

QUESTION 5 (a):

Show in simplified or block diagram form the method of deriving:
(i) a single telegraph circuit on a physical speech pair;
(ii) a number of telegraph channels from a speech channel.

ANSWER 5 (a):

(i) See Fig. 5.

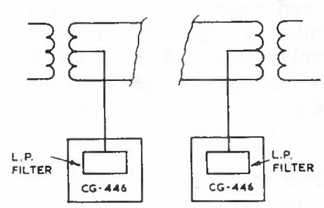


Fig. 5

(ii) See Fig. 6.

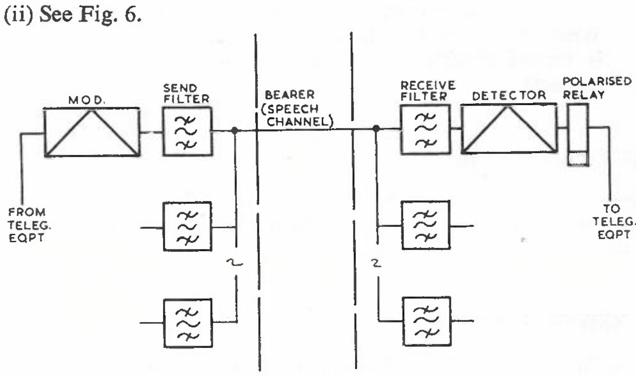


Fig. 6

QUESTION 5 (b):

Explain, for each of the cases above, how the telegraph signalling does not interfere with other circuit on the same bearer.

ANSWER 5 (b):

(i) Each transformer has balanced centre-tapped coils, and the lines are of equal resistance, shunt capacitance and leakage. D.C. signals divide equally in the transformer line winding halves and there are equal currents in each leg of the line. These currents produce cancelling flux fields in the transformer coils at both ends of the line.

(ii) This is referred to as frequency division multiplex. The energy from each channel is assembled into its own band in the spectrum. Filters at the send end ensure that no components outside the band are injected, and at the receive end, no components outside the band are accepted. In practice, the filter rejection is not infinite, but interference is avoided by keeping the filter characteristics sharp enough to avoid trouble.

QUESTION 6 (a):

Draw the magnetic circuit and explain the operation of:
(i) the Carpenter type 4 each side stable polarised relay;
(ii) the Clare HGS5000 series each side stable polarised relay.

ANSWER 6 (a):

(i) See Fig. 7.

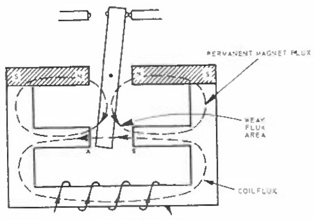


Fig. 7

When current flows in the relay coil as shown, the electromagnet flux aids the permanent magnet flux in gap A and opposes it in gap B, so that the armature is attracted at A as this is the area of greater flux. This results in the right hand contact making. When current direction is reversed the permanent magnet flux is weakened at A by the electromagnetic flux and strengthened at B. The armature movement is dependent upon the direction of current in the coil, and is each side stable.

(ii) See Fig. 8.

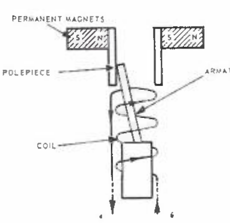


Fig. 8

When current flows in the coil, the top end of the armature becomes either N or S polarity, depending on the direction of current, and reacts with the fields of the permanent magnets. Suppose that when terminal 4 is negative, the armature assumes a south polarity at the contact end. As the poleface of the permanent magnet on the left is north polarity, the armature does not move.

However, when terminal 6 becomes negative, the contact end of the armature assumes a north polarity and is repelled from the north pole of the permanent magnet on the left, and is attracted to the south pole on the right.

QUESTION 6 (b):

Describe the action of the motor uniselector in driving and tripping, by reference to the explanatory diagram of Fig. 9.

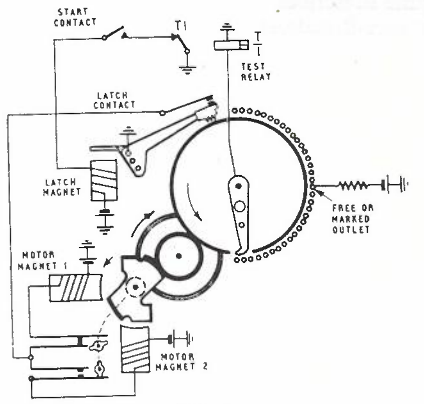


Fig. 9

ANSWER 6 (b):

An outlet is marked and the start contact closed. The latch magnet operates and its off-normal contact closes the motor circuit. Only one magnet will energise at a time, under control of the rotor shaft cams. The energised magnet attracts the rotor, and when the rotor pole face is opposite magnet 1 the cams change the circuit to energise magnet 2, which then attracts the rotor and the sequence repeats. When the marked outlet is reached, high-speed relay T is energised and releases the latch, stopping the rotor and wiper movement at the correct outlet.

QUESTION 7 (a):

A Telex subscriber 30150 calls subscriber number 20153. The originating subscriber T and K characters are combination number 14 (N) and combination number 17 (Q) and the Z character is combination number 10 (J).
List for —
(i) the originating register; and
(ii) the terminating register
in the correct sequence the 5 unit start-stop International No. 2 Alphabet combinations received and transmitted during the establishment of the call. Indicate the origin or destination of each signal.

ANSWER 7 (a):

See Fig. 10.

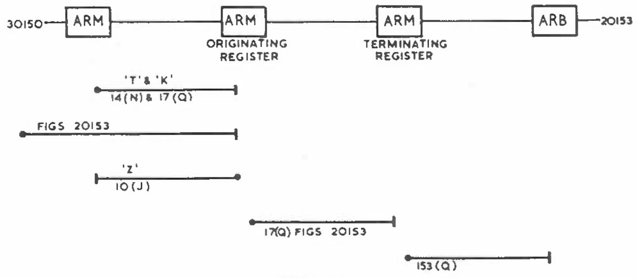


Fig. 10

Answers

QUESTION 7 (b):

What 'class of service' originating subscriber classifications are at present defined for private subscribers connected to the Telex exchanges?

ANSWER 7 (b):

K2—Ordinary subscriber
K3—Part time subscriber
K4—Conference-Broadcast

ANSWER 8 (b):

Free line	—Space, both directions.
Call	—Mark forward.
Call Confirmation	—25mS Mark backward.
Proceed to select	—25mS Mark backward.
Selection signals	—Figs. and digits in five unit code forward.

QUESTION 9:

Fig. 11 shows the ARB111 'A' Marker circuitry associated with the 'c wire' test on calls incoming to a subscriber.

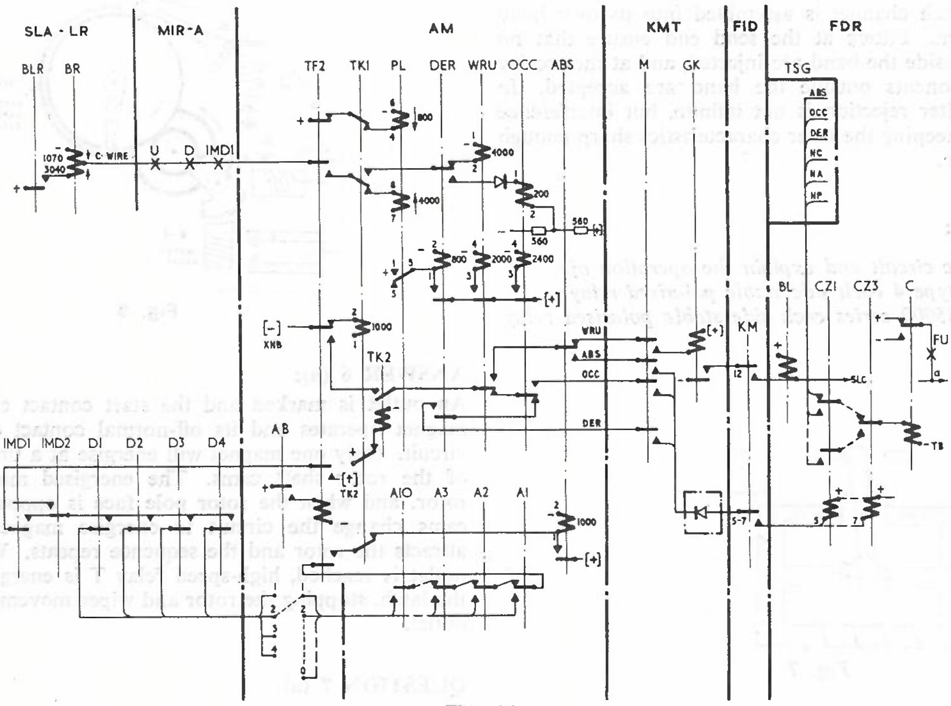


Fig. 11

QUESTION 8 (a):

Define the following terms associated with signalling in a telegraph system:

ANSWER 8 (a):

Free line. Circuit not seized but available for traffic.
Calling signal. The signal transmitted over the forward signalling path to indicate seizure for a call.
Call confirmation signal. The signal transmitted over the backward signalling path following the initiation of a call, to prove the continuity of the line and the response of the distant terminal equipment.
Proceed-to-select signal. The signal transmitted over the backward signalling path after the call confirmation signal, to indicate that the selection information may be sent.
Selection signals. The signals transmitted over the forward signalling path to indicate the number required.

QUESTION 8 (b):

Indicate how these apply in the Automatic Telex system by describing this sequence in an ARM to ARM trunk.

Answers

QUESTION 9 (a):

Describe the circuit operation in the case where the called subscriber is free and the call proceeds.

ANSWER 9 (a):

When the call sub is free there is -50V on the 'c' wire. Reception of the A and B digits operates AB, which operates TF2. TF2 releases TK1 which releases TK2. During the release of TK1, PL samples the 'c' wire potential and does not change over. When TK1 has released, WRU operates. WRU operates GK in KMT. GK operates BL in FDR.

QUESTION 9 (b):

Indicate briefly the operation of the circuit in the case where:
(i) called subscriber is busy;
(ii) the called subscriber has ABS condition.
TWO—ds 2/5/69

ANSWER 9 (b):

When the sub is busy, the 'c' wire has earth on it, so PL changes over when it samples the 'c' wire potential. PL operates

DER, which connects OCC to the 'c' wire. Relay OCC causes OCC service code to be transmitted to the calling subscriber.

An absent subscriber is one who temporarily closes down his telex service over holiday breaks, etc. In such a case a strapping is provided between A contacts in AM, and D contacts in MIR-A. When TF2 is operated, ABS operates and causes ABS service code to be transmitted to the calling subscriber.

QUESTION 10:

Describe, with reference to CG1004 sheet 3, the circuit operation when a call from a line finder Tress outstation occurs when all perforators are busy.

Commence the description with the allotter resting on the 25th contact and relay LS in the line relay set just operated.

ANSWER 10:

Positive battery on R wire operates LS. LS5 connects earth to TR which operates. TR operates TRA. TRA1 cuts the drive circuit of UAL. TRA2 connects earth to UOC, which drives to calling outlet. T relay operates to 560Ω negative battery from LS4. T operates H. H1 connects 'S' pulse to BS and H2 prepares BS hold circuit. H3 operates HA, H5 operates K, and H4 extends the OCC signalling path to PRS via K3 to BS2.

HA1 starts the code generator, HA2 completes the line alarm circuit via K5, HA3 opens the UOC drive circuit, and HA4 connects LA to the R wire via K2. K1 busies the selector multiple outlet and K4 disconnects B from the 'P' wire. K6 releases LS and K7 opens the call lead.

The S pulse from the code generator operates BS, and BS1 holds BS. BS3 prepares BZ for the Z pulse. After 'OCC' is transmitted to the outstation, Z pulse operates BZ. BZ1 releases H and HA, and BZ2 releases BS. The circuit restores to normal when H5 releases K.

QUESTION 11:

The parts of this question refer to CG1004 Sheet 3.

QUESTION 11 (a):

Describe the events in the cross office circuits that immediately precede and lead to the operation of the NA relay.

ANSWER 11 (a):

When the line relay set is free, H relay operates to the Sequential Start test pulse, and causes B in the Line Relay Set and HA in the Cross Office relay set to operate. HA releases NS in the Sequential Start relay set, which stops the hunting action.

B1 completes the 'B' wire lead to start the Auto. Numbering, and operates NA.

QUESTION 11 (b):

Describe the automatic numbering unit operation following the operation of relay NA.

ANSWER 11 (b):

NA1 operates P and energises USU. NA2 prepares to energise USP, and NA4 starts the Character Generator.

The cadence pulse operates NB and NB energises USP. USP steps at the end of each cadence pulse. USP1 steps around the programmed bank and the character generator output leads are connected in turn to control PRN in the line relay set. PRN repeats the programme to PRS and the Number Bulletin Printer. After USP2 releases NA, it steps to the 25th contact and earths the B wire. The Reperforator is then identified if necessary before transmission proceeds from tape.

QUESTION 11 (c):

When an automatic numbering unit is to be used on an outgoing interstate channel what wiring change is necessary on USP?

ANSWER 11 (c):

The destination state letter is wired to the programme bank USP4 and 200Ω positive battery is wired to USP2. USP2 wiper applies this to the B wire to allow the transmitter clutch to be operated for 160mS. The two characters following the interstate letter are transmitted from the tape to the N.B.P. and to the outgoing reperforator.

QUESTION 12:

A Siemens Model 100 Teleprinter is fitted with a tape transmitter attachment which has tape in the gate and the tape transmitter running.

Describe with the aid of Fig. 12.

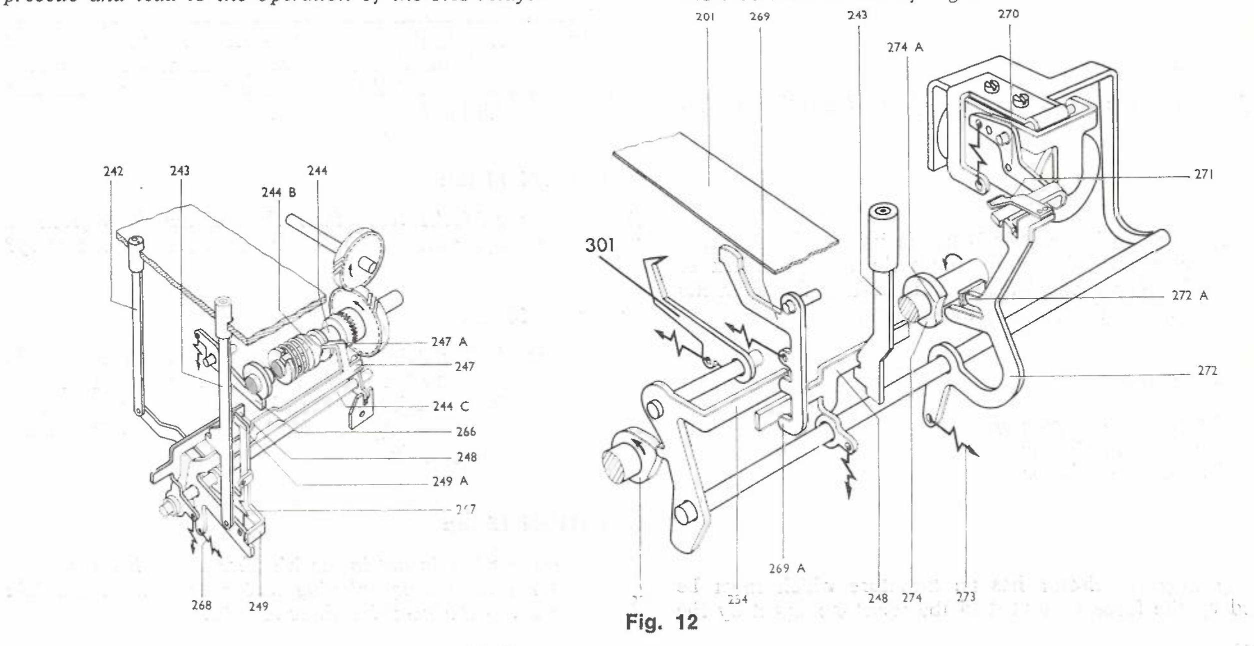


Fig. 12

Answers

QUESTION 12 (a):

The stopping of the TD by operation of the OFF key.

ANSWER 12 (a):

242 pushed down turns 249A counter-clockwise, which disengages 248 from 2. Springs 9 and 267 restore ON key 2 and bail 247. Throwout cam 3a bearing on 247A disengages the clutch driven member 244, whose abutment stops against 247A. 266 accurately locates the rest position of the transmitter cam sleeve.

QUESTION 12 (b):

Two other means by which the TD may be stopped without operator intervention.

ANSWER 12 (b):

End of Tape. Cam 255 offers 269 via 254 to sense the presence of tape each cam shaft cycle. When the tape is fed clear of the sensing nose, 269 is drawn clockwise by a spring and disengages bail 248 from ON key 243. Spring 9 controls the arresting action already described.
Remote Control by Distant Operator. To stop an incoming tape transmission from this transmitter the distant operator repeatedly hits T key. When the spacing elements of the T character coincide with the tape transmitter's stop pulse, the GM armature 270 is released. This allows spring 273 to draw 272 into depression 274A. 272A disengages bail 248 from ON key 243 and the transmitter is again arrested.

QUESTION 12 (c):

The purpose of the part numbered 301.

ANSWER 12 (c):

301 is the feed pawl, controlled by cam 255 via feed lever 254. At the beginning of each cycle it slips behind the next tooth on the feed ratchet, and at the end of each cycle is drawn forward, feeding the tape one character space.

QUESTION 13 (a):

What function in a teleprinter is performed by the receiver selector mechanism?

ANSWER 13 (a):

The selector mechanism responds to the information in serial mode in the receive circuit, mechanically stores a mark or space condition for each element, and presents the character in parallel form to the printing mechanism.

QUESTION 13 (b):

Describe briefly the operation of:
(i) a pulling magnet Selector;
(ii) a holding magnet Selector.

ANSWER 13 (b):

A pulling magnet selector has an armature which must be attracted by the force generated in the selector magnet by the received signal, to select a mark condition. If the armature is not attracted, a space condition is selected.
A holding magnet selector has its armature offered to the receive magnet pole face under the control of timing cams on the receiver shaft. The armature is then freed to sense the condition of the magnet before being locked in either marking (held) or spacing (released) condition.

QUESTION 13 (c):

How could you explain an improved range in a machine fitted with the holding magnet selector?

ANSWER 13 (c):

Less current is required to hold the armature than is required to attract the pulling magnet selector armature. On a given circuit, the time during mark elements for which the current remains above the value necessary to hold the armature could be greater than the time between the operate value and the release value of the same signal in the pulling type magnet. This would increase the possibility of selecting mark elements.

QUESTION 14 (a):

The transmitter shaft clutch in both the Siemens Model 100 and the Teletype Model 15 teleprinters is engaged following the depression of a key on the keyboard.
Describe for each of these machines the principle of this clutch mechanism and its engagement.

ANSWER 14 (a):

The clutch of a Model 100 has 3 pawls arranged around a star wheel located within a driving drum whose circumference has a number of internal teeth. The pawls are disengaged when the star wheel projection is held. When the projection is released, the pawl springs cause a pivoting action of the star wheel, which offers the pawls to the drum teeth. To reduce clutch take-up time the pawls are displaced relative to each other by 1/3 of the drum tooth pitch, and only one pawl engages to drive the shaft.
The Model 15 has two clutch members with equally-spaced radial teeth. The clutch members are disengaged by a clutch throwout lever. Withdrawal of the clutch throwout lever allows the driven clutch member to move (under the control of a compressed spring) axially along the transmitter shaft into engagement with the driving member.

QUESTION 14 (b):

How does the Model 100 printer shaft clutch differ from its transmitter shaft clutch and why is the difference necessary?

ANSWER 14 (b):

The printer shaft clutch has a fourth pawl which engages in the opposite sense to the driving pawls. The purpose of the fourth pawl is to maintain the driving and driven clutch members in mesh during the load variations which occur within the printing cycle.

QUESTION 15 (a):

Facsimile recorders in use in the Weather network incorporate circuits for level setting, phasing and synchronism. Explain these terms and the need for these circuits.

Answers

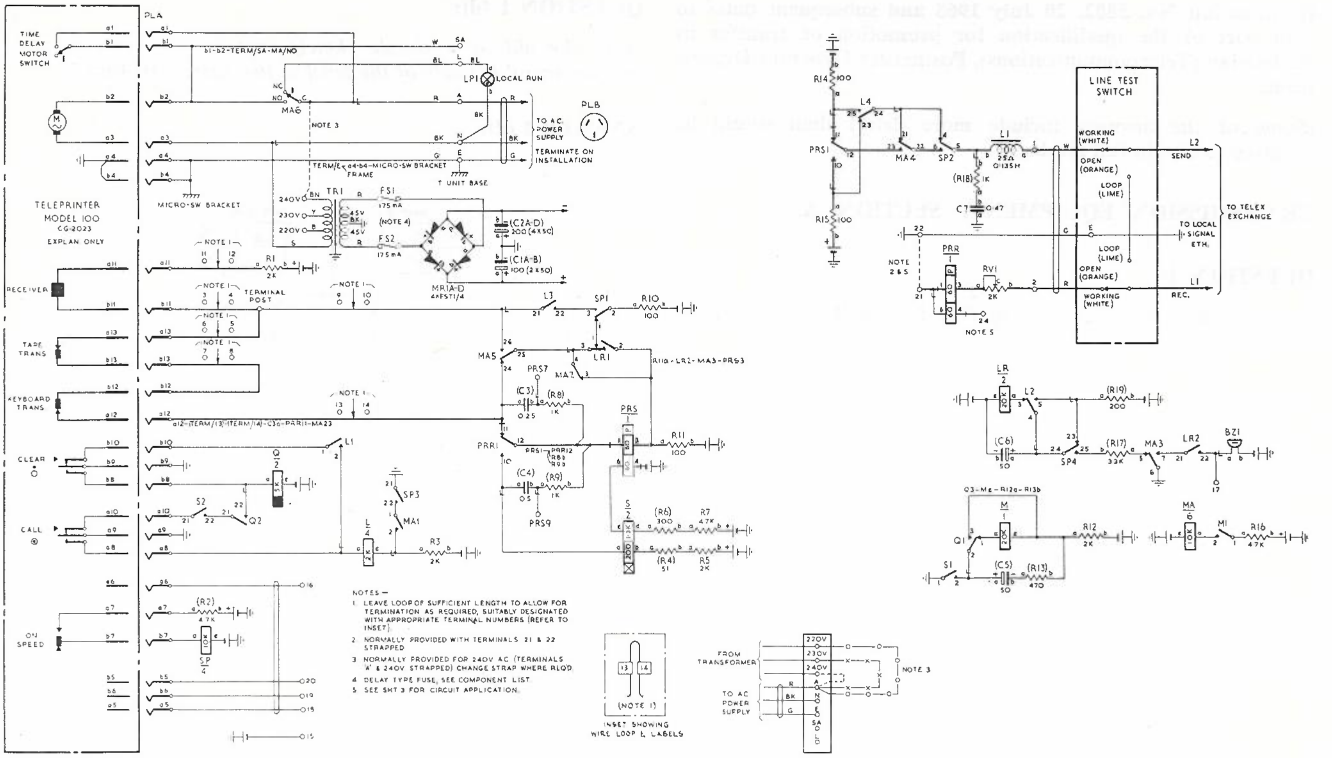


Fig. 13

ANSWER 15 (a):

Level Setting. The adjustment within the recorder of the amplifier gain so that the signal is offered to the marking circuit at a set level irrespective of the received level (provided the received level is within the adjustment range). Its function is to ensure that Marking Power gives the correct degree of marking on the chart.

Phasing. The release of the helix drum at the point on the incoming signal corresponding to the point at which the transmit drum was released. Its function is to ensure that the chart is not divided, but placed correctly on the paper.

Synchronism. The phased condition, once achieved, is maintained over the duration of the whole chart. Its function is to ensure that the chart does not drift out of shape.

QUESTION 15 (b):

Describe the techniques used in the D-649 type Mufax Chart Recorders to achieve these functions.

ANSWER 15 (b):

Level Setting. The received amplified level is compared with a reference level, and the voltage difference generated is used to control a motor which drives an input level adjustment potentiometer.

Phasing is achieved by transmission of phasing pulses before transmission of the chart commences. The recorder's response to one of these pulses trips the helix drum drive at the right instant.

Synchronism. Both the transmitter and recorder drums are driven from local highly stable tuning-fork controlled oscillators.

QUESTION 16 (a):

Describe the operation of the circuit in Fig. 13 when a call from the exchange arrives while the motor is running.

ANSWER 16 (a):

The 'on speed' contacts have operated SP, and SP4 has operated LR. An incoming call controls PRR to mark and S operates. S1 operates M which operates MA. MA3 opens the circuit of LR which has a release delay of 3 seconds. During this time MA3 and LR2 operate the buzzer which warns the operator a call is incoming, and PRS 1-3 coil and both sets of transmitter contacts are short-circuited by MA5 and LR1. PRS1 sends space to the exchange until LR is released. MA6 extinguishes the Local Run lamp and puts the motor under the control of the line circuit instead of the time delay motor switch. When LR releases, LR1 removes the short circuit from the transmission circuit, and PRS1 sends mark to the exchange. LR2 releases the buzzer.

QUESTION 16 (b):

The circuit as shown is not suitable for operation with the automatic telex exchange. For the calling condition of Section (a), how does the circuit malfunction?

ANSWER 16 (b):

MA5 normal short-circuits PRS 1-3 coil, and PRS is controlled to space by the bias coil. During the changeover of MA5, PRS is momentarily controlled to mark, which is interpreted by the exchange as an indication that the sub is ready to receive the call.

Answers

Examination No. 5802, 20 July 1968 and subsequent dates to gain part of the qualification for promotion or transfer as Technician (Telecommunications), Postmaster-General's Department.

(Some of the answers include more detail than would be required to obtain full marks.)

TRANSMISSION EQUIPMENT. SECTION A.

QUESTION 1:

The output of the oscillator in Fig. 1 is 2mW, and the level at the termination at the distant end is 0dBm.

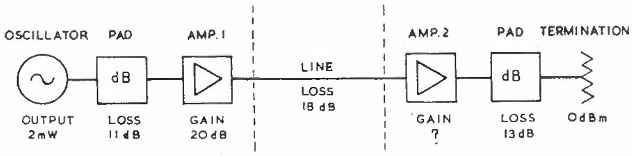


Fig. 1

QUESTION 1 (a):

Calculate the gain required in Amp. 2.
Given that log 20 = 1.30, log 18 = 1.26,
log 2 = 0.30, log 13 = 1.11,
log 11 = 1.04, log 42 = 1.62.

ANSWER 1 (a):

(i) Convert oscillator output level to dBm.

$$\text{dBm} = 10 \log_{10} \frac{P1}{1\text{mW}}$$

$$= 10 \log_{10} \frac{2}{1}$$

$$= 10 \times 0.3$$

$\therefore$ Oscillator output = + 3dBm

(ii) Calculate gain of amplifier 2.
Overall circuit loss = 3dB (+ 3dBm input, 0dBm output)
$\therefore$ Total circuit gain is 3dB less than total circuit loss.
Total circuit loss = 11 + 18 + 13 = 42dB.
Total circuit gain = 42 − 3 = 39dB.
$\therefore$ Gain of amplifier 2 = 39 − 20 = 19dB.
Answer 1 (a) = 19dB.

QUESTION 1 (b):

What is the level in dBm at the input to the line?

ANSWER 1 (b):

Overall gain to input of line = 20 − 11 = 9dB.
Oscillator output level = +3dBm.
$\therefore$ Input level to line = 9 + 3 = +12 dBm.
Answer 1 (b) = +12 dBm.

QUESTION 1 (c):

What type of testing instrument would be used to measure levels in the circuit?

ANSWER 1 (c):

Transmission Measuring Set (T.M.S.) or Level meter.

Answers

QUESTION 1 (d):

With the aid of a simple sketch explain how a 'terminated measurement' is made of the level at the output of Amp 2.

ANSWER 1 (d):

See Fig. 2.

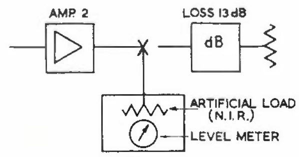


Fig. 2

To make a terminated measurement it is necessary to break the circuit at the output of Amp. 2, and replace the normal circuit load with an artificial load or reference load (N.I.R.). The level is then measured across this reference load with a high impedance level meter.

QUESTION 2:

Multiconductor cable pairs are often 'lumped loaded':

QUESTION 2 (a):

With the aid of a sketch show the principles of lumped loading.

ANSWER 2 (a):

See Fig. 3.

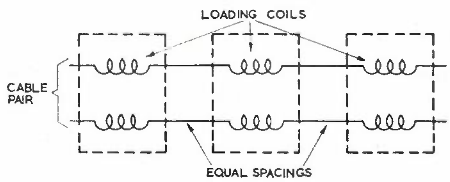


Fig. 3

QUESTION 2 (b):

State the advantages gained by lumped loading.

ANSWER 2 (b):

Within the limits of a particular frequency range (which is largely dependent on coil values and spacings), the following advantages are gained:
Decrease in attenuation constant.
Decrease in frequency and delay distortion.
Characteristic impedance increase.

QUESTION 2 (c):

What is the main reason for:
(i) V.F. loading?
(ii) Carrier frequency loading?

ANSWER 2 (c):

(i) V.F. loading is introduced mainly to reduce cable pair attenuation. For example, the loading of junction pairs reduces attenuation and allows increased operating lengths.
(ii) Carrier frequency loaded pairs have a characteristic impedance similar to that of open wire pairs. For this reason carrier frequency loading is mainly used on trunk entrance

pairs to enable matching of open wire to cable pairs with a minimum of reflection, particularly in the lower frequency range.

QUESTION 2 (d):

What restriction does lumped loading place on the use of a loaded cable pair?

ANSWER 2 (d):

The addition of loading coils at intervals along a cable pair produces a low pass filter effect. The actual cut-off frequency depends on the coil values and spacings, but all lumped loaded pairs have a high frequency limitation to their use.

QUESTION 3:

A number of measurements are made on an audio amplifier to check its performance.

QUESTION 3 (a):

List three of these measurement and briefly explain the purpose of each.

ANSWER 3 (a):

Any three of the following:
Gain versus frequency.
Amplifier overload (Power handling capacity).
Harmonic distortion.
Noise.

QUESTION 3 (b):

With the aid of a sketch, briefly describe how to perform one of these measurements.

ANSWER 3 (b):

Any one of the following measurements.
Gain versus frequency. This can be measured by either a direct method or a comparison method. A simplified test set-up for a direct measurement is shown in Fig. 4.

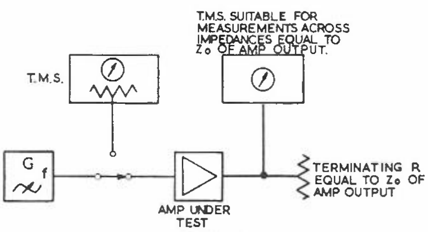


Fig. 4

An audio test oscillator of the required impedance is connected to the input of the amplifier under test, and the amplifier output level is measured with a T.M.S. The input level is measured across a reference resistance before application to the amplifier. The input level should be relatively low to prevent overload of the amplifier. The gain of the amplifier is equal to the difference in dB between the measured input and output levels.
This measurement is repeated at various frequencies in the audio range to obtain the frequency versus gain characteristic. A simplified test set-up for a comparison measurement is shown in Fig. 5. The output of an audio oscillator of the required impedance is connected to a 'comparison set' which, when switched to the 'adjust' position, includes a calibrated attenuator and the amplifier under test between the test oscillator and an indicating device (level meter). In the 'compare' position, zero loss exists between the oscillator and the level meter. By switching from 'compare' to 'adjust', and setting the calibrated attenuator to obtain the same meter deflection for each position, the amplifier gain is obtained. When the same meter deflection is obtained for both switch positions the amplifier gain is equal to the calibrated attenuator loss and can be read directly.

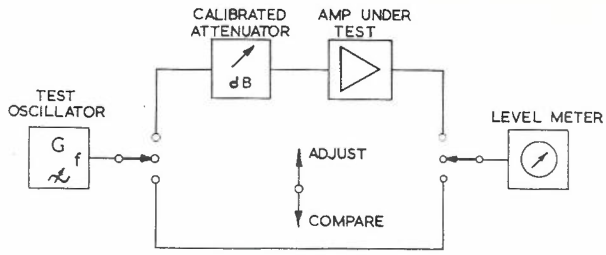


Fig. 5

Amplifier Overload. Overload of an amplifier occurs at the point when the input level is sufficiently high to cause one or more of the electron tubes or transistors to drive into the non-linear portion of their characteristics. A number of methods can be used to determine this point. Fig. 6 shows a simple arrangement to measure overload. This test set-up makes use of the fact that the gain of an overloaded amplifier is reduced.
A frequency about the middle of the amplifier working frequency range is applied via a calibrated attenuator to the amplifier input. The output is taken to a T.M.S. via a calibrated attenuator similar to the one in the input. Attenuation is removed from the input attenuator in steps and at the same time attenuation of the same value is added in the output attenuator. When the overload point is reached, the amplifier gain decreases and a unit increase in input level does not give a unit increase in output level and the meter deflection decreases.

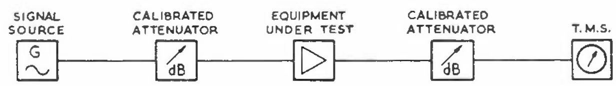


Fig. 6

Harmonic Distortion is a form of non-linear distortion. The basic test arrangement to measure harmonic distortion is shown in Fig. 7. A pure sine wave signal is applied to the amplifier, and the amplifier output is taken to the noise and distortion (N and D) measuring set. With the function switch in the 'calibrate' position the meter is adjusted to give full scale deflection (100%). The function switch is next switched to the 'distortion' position and a frequency selective circuit is adjusted to remove the fundamental frequency (the applied signal frequency). The harmonic frequencies produced in the amplifier, plus noise frequencies, are applied to the meter. The meter deflection indicates percentage distortion. When the noise requirement for the amplifier is satisfactory, the noise frequencies are ignored in the measurement of % distortion.
The fundamental test signal should be low enough in frequency to allow sufficient harmonics to be received to make the test realistic. For example, 400 Hz is suitable for most audio amplifiers. The test signal level should be suitable to test the amplifier under peak operating conditions.

Answers

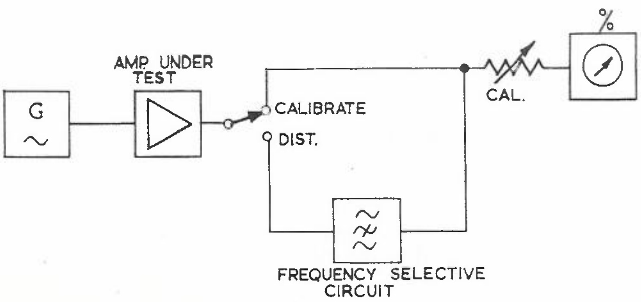


Fig. 7

Noise. The calibrate procedure for a noise measurement is the same as that for harmonic distortion. (100% distortion and 0dB noise are both represented by full scale deflection.) Referring to Fig. 7, the second stage of the noise measurement is to switch the function switch to the 'noise' position, remove the test signal from the amplifier input, and terminate the amplifier input in its characteristic impedance. The only frequencies present are noise frequencies and the level of these are recorded on the meter in dB below the reference point. The second stage of the test arrangement to measure noise is shown in Fig. 8.

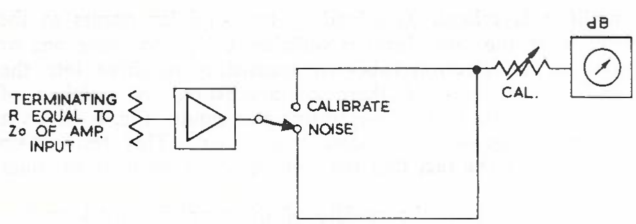


Fig. 8

QUESTION 4:

Unsatisfactory reception of radio signals is sometimes due to 'fading':

QUESTION 4 (a):

Define the term 'fading'.

ANSWER 4 (a):

The term fading is used to define the variation of received radio field strength, caused by the transmission medium.

QUESTION 4 (b):

List three types of 'fading' that occur in the Very High Frequency range and briefly describe each type.

ANSWER 4 (b):

(Only three of the four types are required.)

Two-ray or two-path fading. As indicated in Fig. 9 a direct wave and a ground reflected wave reach a receiving aerial. The received signal strength is the vector sum of the two signals; that is, it depends on their relative amplitudes and phases. The amplitude relationship depends on the reflecting ability of the ground surface at the reflecting point, and the phase relationship depends on the relative length of the two paths. The length of the direct path is fixed but the length of the reflected path changes with variations in the refractive index of the air. This is indicated in Fig. 9a where the standard refractive index of air is regarded at 4/3. Under these conditions the two signals should be in phase at the receiving aerial but, as indicated in Figs. 9b and 9c, with changes in refractive index the reflected path decreases or increases and the phase relationship changes.

The change can be sufficient to cause cancellation and therefore severe reduction of signal strength at the receiving aerial occurs. (A change in refractive index causes a change in the bending of the electromagnetic wave but this can be represented by showing an apparent change in the radius of the earth.)

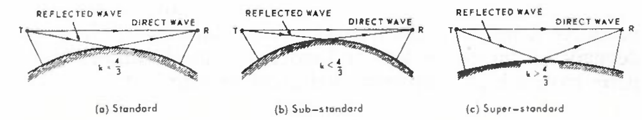


Fig. 9

Multi-ray or multi-path fading. This is similar to two-ray fading but in addition to the ground reflected path, other reflected paths, for example from cloud masses, exist. This is illustrated in Fig. 10. The received signal strength is equal to the vector sum of the received waves. The phase relationship of these waves depends on the refractive index of the air and also the position of the cloud masses or other reflecting items.

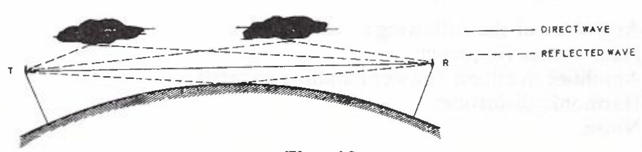


Fig. 10

Duct fading. Large air masses having different refractive indexes may lie one above the other in the troposphere. These layers form a duct which traps the electromagnetic waves and takes them beyond the receiving aerial. Ducting can also occur between the earths surface and a heavy air layer above the surface; this is called ground ducting.

Obstruction fading. This occurs when the value of the refractive index of air becomes so small that the electromagnetic wave bends into some ground obstruction before reaching the receiving aerial. This is shown in Fig. 11 where for simplicity the change in refractive index is considered to have increased the earth's radius.

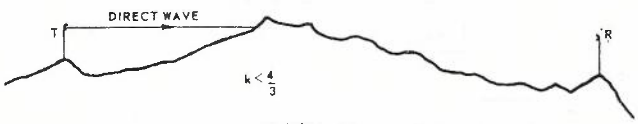


Fig. 11

QUESTION 4 (c):

Briefly describe the principles of 'diversity reception' and explain how diversity reception is used to reduce the effect of 'fading'.

ANSWER 4 (c):

The principle of a diversity system is the simultaneous reception of two signals; these signals may be of different frequencies or signals of the same frequency but with different path lengths. The stronger of the two signals, at any time, is selected by a diversity combining unit.

The first method (frequency diversity) is illustrated in Fig. 12. Two independent frequencies are transmitted on a common path. Because of the difference in wavelength of the two frequencies it is unlikely that simultaneous deep fades will occur.

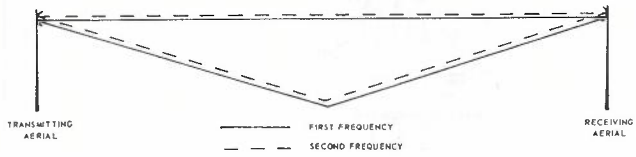


Fig. 12

The second method (space diversity) is illustrated in Fig. 13 where a common frequency is transmitted on different paths. When cancellation of the direct and reflected waves occurs at one receiving aerial, no cancellation should occur at the other.

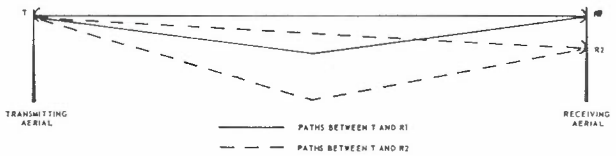


Fig. 13

QUESTION 5:

With regard to radiotelephone systems, answer the following questions:

QUESTION 5 (a):

What is meant by the term 'line-of-sight' transmission?

ANSWER 5 (a):

'Line-of-sight' transmission is the term used when a transmitting aerial is just above the horizon when viewed from its receiving aerial.

QUESTION 5 (b):

What is the approximate spacing of repeaters on S.H.F. radiotelephone routes?

ANSWER 5 (b):

About 30 miles.

QUESTION 5 (c):

State the frequency ranges and approximate channel capacities of radiotelephone systems in the following frequency bands.

ANSWER 5 (c):

Bands	Frequency Range	Approximate Channel Capacity of System
V.H.F.	30-300 MHz	1 and 4
U.H.F.	300-3,000 MHz	12, 24, 120
S.H.F.	3-30 GHz	Broadband 300-1,800

QUESTION 5 (d):

An electromagnetic space wave commonly consists of two components. These are:

ANSWER 5 (d):

(i) Direct wave.
(ii) Ground reflected wave.

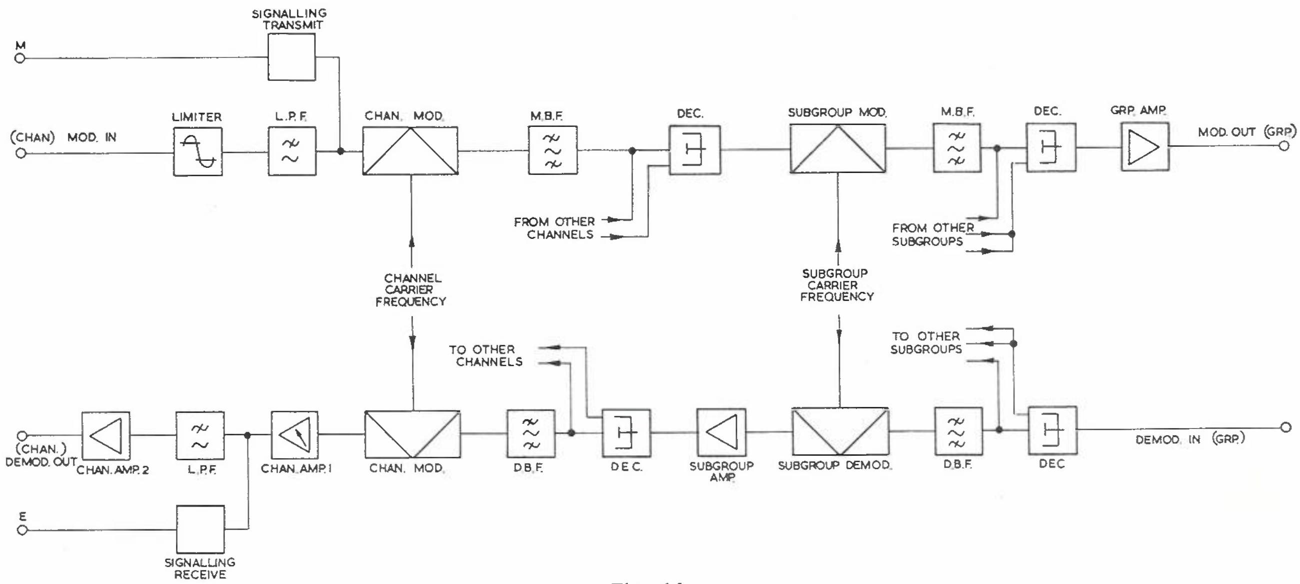


Fig. 14

Answers

SECTION B

QUESTION 1:

Draw and label a block diagram of typical twelve channel modem equipment using two stages of modulation. Briefly explain the function of each block shown.

ANSWER 1:

A suitable diagram is shown in Fig. 14. The basic functions of the blocks are:

Limiter. Attenuates voltage peaks in excess of a predetermined value.

Low Pass Filter. Helps separate the voice frequencies from the signalling frequencies and establishes an upper limit of 3.4kHz for the voice.

Channel Modulator. Translates the input voice frequencies to the required channel frequency band.

Modulator Band Pass Filter. Selects the required sideband and rejects all other frequencies.

Decoupler (Hybrid). Combines sidebands from a number of channels into a subgroup (pregroup) or isolates M.B.F.'s adjacent to one another in the frequency spectrum.

Subgroup Modulator. Translates the subgroup frequencies into the required section of the basic group frequency range.

Subgroup Modulator Band Pass Filter. Selects the required sideband and rejects all other frequencies.

Decoupler and Group Amplifier. The decoupler combines the sidebands of the four subgroups but isolates filters adjacent to one another in the frequency spectrum. The group amplifier obtains the required level at the MOD. OUT (GRP) point.

Decoupler (Subgroup). Isolates subgroup D.B.F.'s adjacent to one another in the frequency spectrum. Helps to separate subgroup frequencies from the received basic group.

Subgroup Demodulator Band Pass Filter. Selects a subgroup from the basic group frequencies and directs them to the appropriate subgroup demodulator.

Subgroup Demodulator. Translates the received sideband into the appropriate subgroup frequency range.

Subgroup Amplifier. Raises the power level of the subgroup frequencies before channel demodulation. Helps maintain suitable signal to noise ratio.

Decoupler (Hybrid). Isolates D.B.F.'s adjacent to one another in the frequency spectrum or helps to separate channel frequencies of the received subgroup.

Demodulator Band Pass Filter. Selects the appropriate channel frequencies.

Channel Demodulator. Translates the received channel frequencies back to the voice frequency range.

Low Pass Filter. Selects the voice frequencies and rejects all other frequencies.

Channel Amplifier (1). Amplifies voice and signalling frequencies. Used to adjust channel level.

Channel Amplifier (2). Amplifies voice frequencies.

Signalling (Transmit). Converts signalling pulses to pulses of 3.825 kHz for transmission with the channel frequencies.

Signalling (Receive). Selects 3.825 kHz signalling pulses and converts them to signalling pulses suitable for application to the exchange equipment.

QUESTION 2:

A simplified block diagram of a pulse echo tester is shown in Fig. 15.

Answers

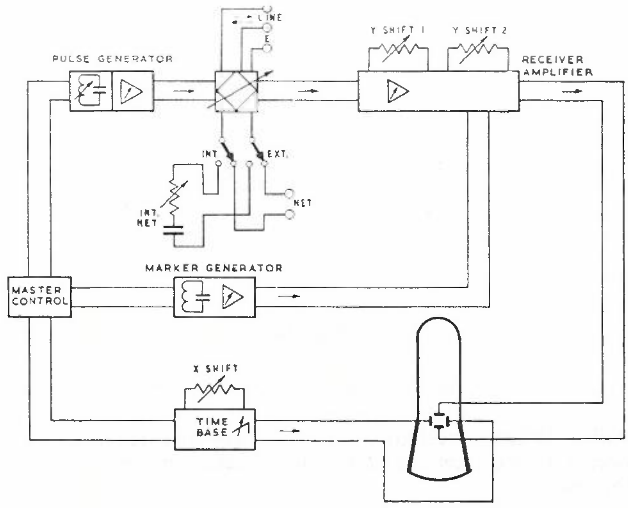


Fig. 15

QUESTION 2 (a):

Briefly explain the function of each component (assuming that the instrument is connected to a faulty line).

ANSWER 2 (a):

Pulse Generator. Produces 'sine squared' (raised cosine) pulses which are transmitted to line.

Hybrid. Separates the transmit and receive circuits; that is, it directs pulses to line without materially affecting the receive circuit.

Marker Generator. Generates positive marker pulses for the time scale.

Receiver Amplifier. Amplifies received echoes and marker pulses and applies them to the cathode ray tube.

Time Base. Generates a sawtooth wave to move marker and test trace across the screen at a uniform rate.

Cathode Ray Tube. Displays separate marker and test traces.

Master Control. Synchronises pulse generator, marker generator and time base.

QUESTION 2 (b):

Sketch the typical marker and test patterns appearing on the screen if the line under test is open circuit. Assume that the line has a pulse echo time of 11 microseconds per mile and the fault is situated 20 miles from the testing point.

ANSWER 2 (b):

See Fig. 16.

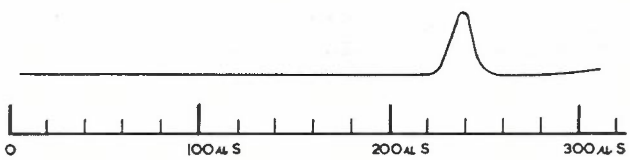


Fig. 16

QUESTION 3

The simplified circuit of a typical oscillator-modulator used in F.M. V.F. carrier telegraph systems is shown in Fig. 17.

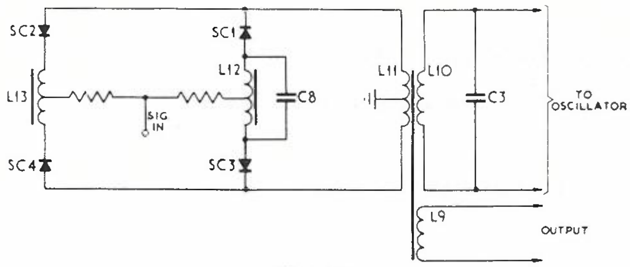


Fig. 17

QUESTION 3 (a):

What is the function of the oscillator-modulator?

ANSWER 3 (a):

To change the double current telegraph signal into the V.F. frequency range.

QUESTION 3 (b):

Briefly describe its operation.

ANSWER 3 (b):

With no telegraph signal applied to the modulator, it would produce a 'rest' frequency determined by the resonant circuit L10 and C3. (This is not a normal operating condition for the modulator because either a positive or negative telegraph signal would be applied to the input at any time).
With a negative signal applied at SIG. IN the diodes SC1 and SC3 are biased non-conducting and diodes SC2 and SC4 are biased conducting. L12 and C8 are removed from the circuit and L13 is connected across L11. The oscillator tuned circuit is effectively altered and the frequency is shifted by 30Hz.
With a positive signal applied at SIG. IN, the diodes SC2 and SC4 become non-conducting and SC1 and SC3 conduct. L13 is removed from the circuit and L12 and C8 are connected across L11. The oscillator tuned circuit is again effectively altered and the frequency is shifted by 30Hz from the rest frequency. The shift for the positive signal is in the reverse direction to that for the negative signal.

QUESTION 4:

Some carrier telephone systems employ automatic pilot regulation:

QUESTION 4 (a):

State the advantages gained by using automatic pilot regulation.

ANSWER 4 (a):

Automatically maintains correct levels over a long period of time.
Reduces time out of traffic for maintenance purpose.
Gives an alarm when the degree of level variation indicates a possible fault condition.

QUESTION 4 (b):

Why are two pilot frequencies used in some open-wire carrier telephone systems?

ANSWER 4 (b):

A relatively wide range of frequencies is transmitted to line and changing weather conditions have greater effect on the higher frequencies than the lower frequencies. One pilot, located at the centre of the band, could not cater for the changes at either end of the band so two pilots are used — one at each end of the frequency range. One pilot controls a variable flat gain amplifier and the other controls a variable equaliser. The two combined obtain the required level and an overall flat response.

QUESTION 4 (c):

Draw and label a block diagram of the group equipment of a typical twelve channel open-wire carrier telephone system. On the diagram show clearly the pilot injection and pilot pick-off points.

ANSWER 4 (c):

See Fig. 18.

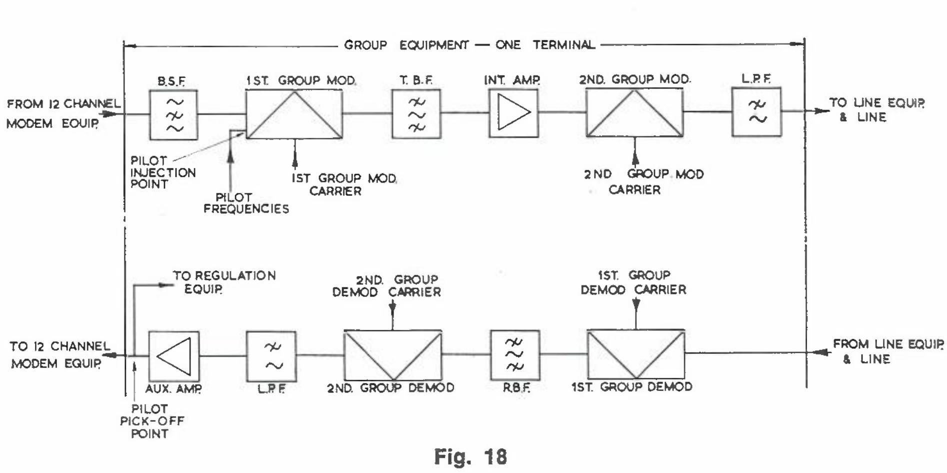


Fig. 18

Answers

QUESTION 5:

An audio programme channel should meet certain fundamental requirements to ensure the satisfactory transmission of programmes:

QUESTION 5 (a):

List these fundamental requirements.

ANSWER 5 (a):

Adequate frequency range.
Minimum frequency distortion.
Minimum non-linear distortion.
Minimum delay distortion.
Adequate volume range and minimum noise.

QUESTION 5 (b):

Briefly describe each of these requirements and state their limits.

ANSWER 5 (b):

Frequency Range. The average human ear can detect sounds in the range from about 30Hz to 15kHz but suitable audio programme transmission can be made using more restricted ranges. Typical limits are:—
50Hz-10kHz (Carrier programme)
50Hz- 7kHz (Carrier programme)
50Hz- 5kHz (Physical lines)
Frequency Distortion. All frequencies in the required range should be transmitted with equal efficiency; that is the frequency response of the channel should be substantially independent of frequency. The limit for distortion is a variation of ± 2dB from the level received at 1kHz within the limits of the frequency range to be transmitted.
Non-linear Distortion is the production of new frequencies and is caused by over-loaded amplifiers, transformers, etc. It has two undesirable effects:—
(i) Harmonies of the various frequencies present are produced.
(ii) Intermodulation occurs between the various frequencies present and new frequencies are produced.
Harmonic distortion only is measured and total harmonic distortion should not exceed 4%. This test is normally made with a 400 Hz sine wave frequency at a level 8dB above the nominal line-up level.
Delay Distortion. The velocity of propagation of an electromagnetic wave through most lines and equipment varies with frequency. Some frequencies are delayed more than others, and when this delay is excessive it becomes noticeable in the reproduced sound. Delay is not a normal routine measurement but the limits are expressed, over the frequency range, with respect to the frequency with the lowest velocity of propagation.
Volume Range and Noise. These features are considered jointly because one affects the other. The volume range of a programme channel is the difference, expressed in dB, between the lowest and highest signals that can be satisfactorily transmitted. The lowest signal is limited by the noise factor; a margin of about 10dB should be maintained between the noise and the lowest signal level transmitted. The highest signal is limited by the power handling capacity of the equipment and by the possibility of crosstalk into adjacent circuits. In practice, occasional programme peaks up to about 10dB above the line-up level, should not cause overload of amplifiers or crosstalk problems.
Noise should be kept to a minimum and a signal to weighted noise ratio of 49dB should not be exceeded.

Answers

QUESTION 6:

Some carrier stations are supplied with A.C. power from A.C. no-break sets.

QUESTION 6 (a):

Draw a block diagram of an all electric A.C. no-break set.

ANSWER 6 (a):

Either of the diagrams shown in Fig. 19 is satisfactory.

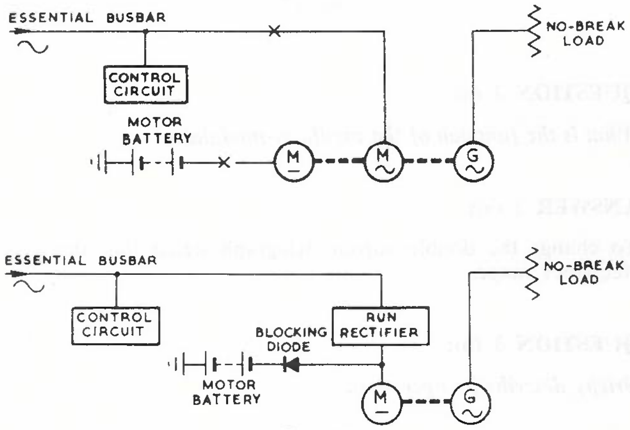


Fig. 19

QUESTION 6 (b):

Draw a simple diagram showing how power from an A.C. no-break station is fed to a remote station over coaxial tubes.

ANSWER 6 (b):

See Fig. 20.

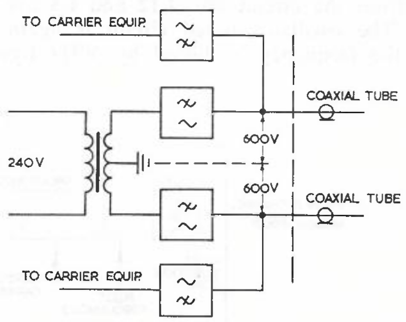


Fig. 20

QUESTION 7:

Draw a block diagram showing the various stages of a typical V.H.F. radio-telephone terminal and state briefly the function of each block shown. (Order-wire and supervisory equipment need not be shown.)

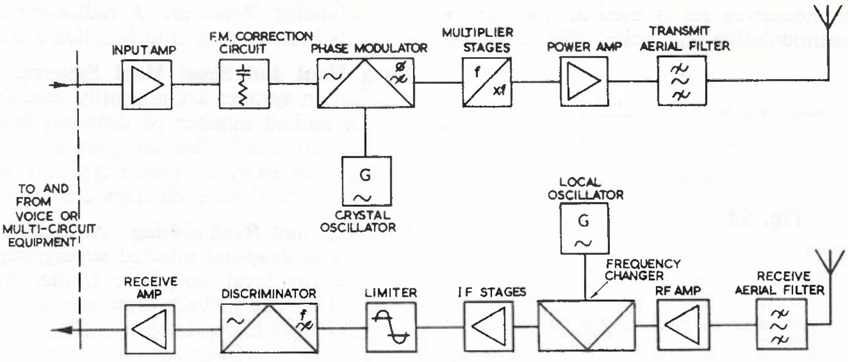


Fig. 21

ANSWER 7:

See Fig. 21.

Input Amplifier. Amplifies input signal (voice or output of carrier equipment) to the required level for application to the phase modulator.

F.M. Correction Circuit. A frequency modulated output is obtained from the phase modulator by modifying the input signal before application to the modulator. This modification is achieved in the R.C. network in the F.M. correction circuit.

Crystal Oscillator. Produces the original carrier frequency; normally a relatively low frequency, for example, 4.5MHz.

Phase Modulator. Phase modulates the incoming signal but in conjunction with the F.M. correction circuit, an F.M. output is obtained; or translates the incoming modulating frequencies to another section of the frequency spectrum.

Multipliers. Multiply the frequency and frequency deviation to the required values for transmission. For example, 160MHz ± 300kHz. A number of multiplier stages are used.

Power Amplifier. Amplifies the R.F. signal to the required power level for connection to the transmitting aerial.

Transmit Aerial Filter. Eliminates unwanted frequencies; that is, limits the frequencies transmitted to the required frequency range.

Transmit Aerial. Directs the transmitted R.F. signals to the distant receive aerial.

Receive Aerial. Receives R.F. signal beamed from transmit aerial and applies it via the aerial feeder to the receive filter.

Receive Aerial Filter. Limits the received frequencies to the required frequency range.

R.F. Amplifier. Amplifies the received signals before frequency conversion to help maintain the required signal-to-noise ratio at the output of the frequency changer.

Frequency Changer. Translates the received R.F. to an intermediate frequency, for example, 21MHz, before amplification. The carrier frequency is supplied from a local oscillator.

I.F. Stages. Amplify intermediate frequencies to a suitable level before detection.

Limiter. Removes any A.M. and helps improve signal-to-noise ratio.

Discriminator. Converts the received frequencies back to the original modulating signals.

Receive Amplifier. Amplifies received signals (voice or carrier equipment frequencies) to the required level for application to the local equipment.

QUESTION 8:

Standing Wave Ratio (S.W.R.) tests and White Noise tests are made on radio-telephone systems or associated equipment:

QUESTION 8 (a):

What do the results of these tests indicate?
(i) S.W.R.;
(ii) White Noise.

ANSWER 8 (a):

(i) The S.W.R. test gives an indication of the power reflected from a poor termination or a discontinuity. The test is performed on waveguides, antennas and filters.

(ii) The white noise measurement gives the intermodulation and thermal noise performance of telephone channels when a radiotelephone system is fully loaded. (The white noise simulates the fully loaded condition.)

QUESTION 8 (b):

Briefly describe how one of these tests is performed.

ANSWER 8 (b):

A description of one test only was required.

Standing Wave Ratio. Fig. 22 shows a test set-up to measure the S.W.R. of a waveguide. The output of a swept microwave oscillator is applied to the waveguide under test, via a directional coupler. If the waveguide presents a perfect termination over the swept frequency band, no power will be reflected. When a mismatch is present some of the power is returned to the launching circuit where it is measured and compared with the forward power. This comparison can be made with a C.R.O.; the S.W.R. (ratio of forward power to reflected power) is given on the vertical axis and the frequency is given on the horizontal axis.

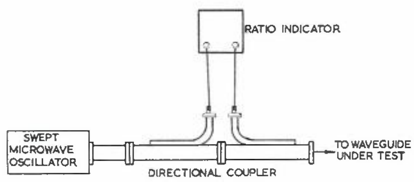


Fig. 22

White Noise consists ideally of a signal having a uniform level at all frequencies in a band to be considered. For radiotelephone bearer systems this represents the band occupied by the frequency multiplexed telephone traffic. To measure the intermodulation in one telephone channel, due to all others, white noise is sent over the system, but with the output eliminated over the band of frequencies occupied by one channel. At the receive terminal any signal present in this frequency slot is either due to intermodulation or thermal

Answers

noise. A selective level measuring set is used at the receive terminal to measure intermodulation and noise. Fig. 23 shows a typical test set-up.

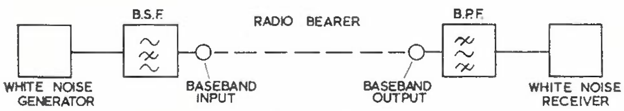


Fig. 23

QUESTION 9:

Microwave radio systems are used as bearers for telephone or television channels.

QUESTION 9 (a):

With the aid of a simple diagram show how 300 telephone channels are assembled before application to a radiotelephone system.

ANSWER 9 (a):

See Fig. 24.

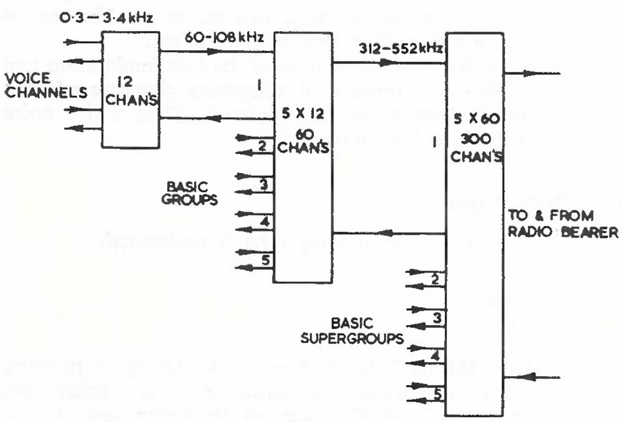


Fig. 24

QUESTION 9 (b):

What frequency bandwidth is occupied by a standard 625 line television channel?

ANSWER 9 (b):

7 MHz.

QUESTION 9 (c):

Briefly explain the following terms as applied to microwave radiotelephone systems:
(i) Baseband.
(ii) Demodulating Repeater.
(iii) Long Haul and Short Haul Systems.
(iv) Drop-out and Replenishing.
(v) Intermediate frequency.

ANSWER 9 (c):

Baseband. In broadband radiocommunication the term baseband is used to describe the overall supergroup frequency range, that is, the output and input frequency range of the broadband carrier telephone system.

Demodulating Repeater. A radiocommunication repeater that converts back to baseband is called a demodulating repeater.

Long Haul and Short Haul Systems. Long haul radiocommunication systems are primarily used for long distance routes with a limited number of drop-out requirements. Short haul systems are much less complex and less expensive and are suitable for short distances; typically with hops up to about 30 miles with three such hops a maximum for one system.

Drop-out and Replenishing. At a demodulating repeater it is possible to drop-out selected supergroups, from the baseband, for use for local telephone traffic. When a supergroup is dropped for use in both directions at a repeater this is known as dropping and replenishing of the supergroup. Supergroups 1 and 2 only can be dropped and replenished.

Intermediate Frequency. In radiocommunication receivers, amplification of the radio signals takes place at an intermediate frequency. Typically the incoming U.H.F. or S.H.F. radio signals are converted to the intermediate frequency of 70 MHz.

QUESTION 10 (a):

What advantages are gained by single sideband transmission as used by some radiotelephone systems?

ANSWER 10 (a):

Compared with double sideband, single sideband operation has several advantages. These are:—

An economy in frequency space. For the same audio signal, single sideband transmission takes up half of the bandwidth taken by double sideband transmission.

An improvement in signal to noise ratio. A total improvement of 9dB in the signal to noise ratio can be achieved by single sideband transmission.

A reduction in transmitter power consumption. During periods of no modulation the transmitter emits low level pilot carrier only.

Selective fading and wave interference due to multi-path fading is reduced.

QUESTION 10 (b):

With the aid of a simple diagram explain how two voice channels are obtained in an Independent Sideband (I.S.B.) System.

ANSWER 10 (b):

A simplified diagram of the drive unit of an I.S.B. system is shown in Fig. 25. Two separate audio frequency channels, each with an effective frequency range of 0.1-6kHz are applied to separate balanced modulators with a common 100kHz carrier supply. The output of one modulator is applied to a 94-99.9kHz band pass filter and the lower sideband is selected. The output of the other modulator is applied to 100.1-106kHz band pass filter and the upper sideband selected. These two separate sidebands are combined and applied via a 100kHz band stop filter to a modulator, with a 1.7MHz carrier frequency, where they are converted to a 1.6MHz input for the transmitter. The 100kHz band stop filter rejects carrier leak from the two balanced modulators. The carrier frequency (pilot carrier) is injected at a controlled level at the input to the common modulator.

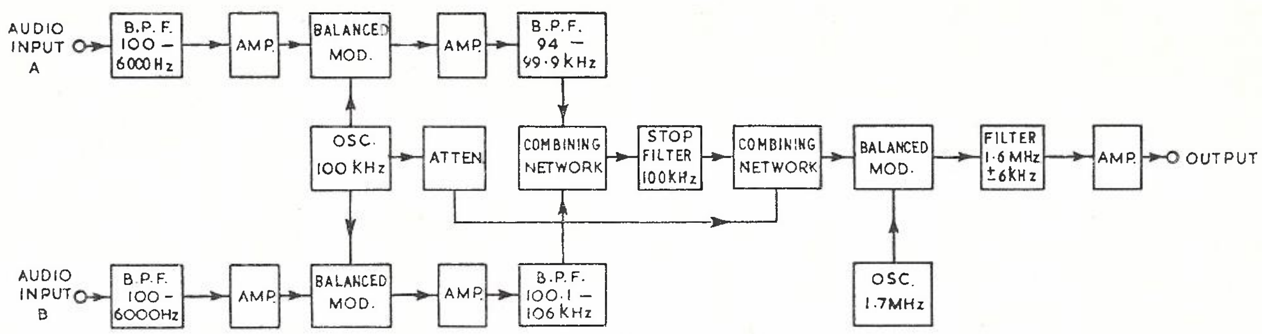


Fig. 25

QUESTION 10 (c):

Why is a pilot carrier frequency transmitted by an Independent Sideband system?

ANSWER 10 (c):

The pilot carrier frequency is continuously monitored at the receive terminal and any variation of more than ±3dB in pilot level brings in an alarm.

Ahead of its generation

• *Wide range* • *Accurate* • *Solid-state reliability*

THE NEW
Wandel u. Goltermann
SIGNAL GENERATOR
MG-164

- Frequency range: 10 Hz to 40 MHz.
- 5 overlapping bands selected by illuminated push-buttons.
- Effective scale length 2.5 metres for each band.
- 2000 crystal check points.
- Resetting accuracy: 1 part in 10^3
- Frequency or amplitude modulation internally or externally derived.
- Maximum output 5 volts.
- 70dB attenuation in step and continuous control.
- Impedance: Switchable 50, 60, 65, 75, 135 and 150 ohms.
- Integrated circuitry—completely solid-state.

The MG-164, with all its qualities has a wide range of application in measurements in the fields of audio, R.F., television and telecommunication. A complete instrument for the engineer in all spheres.

For full technical information, contact the Australian agents.

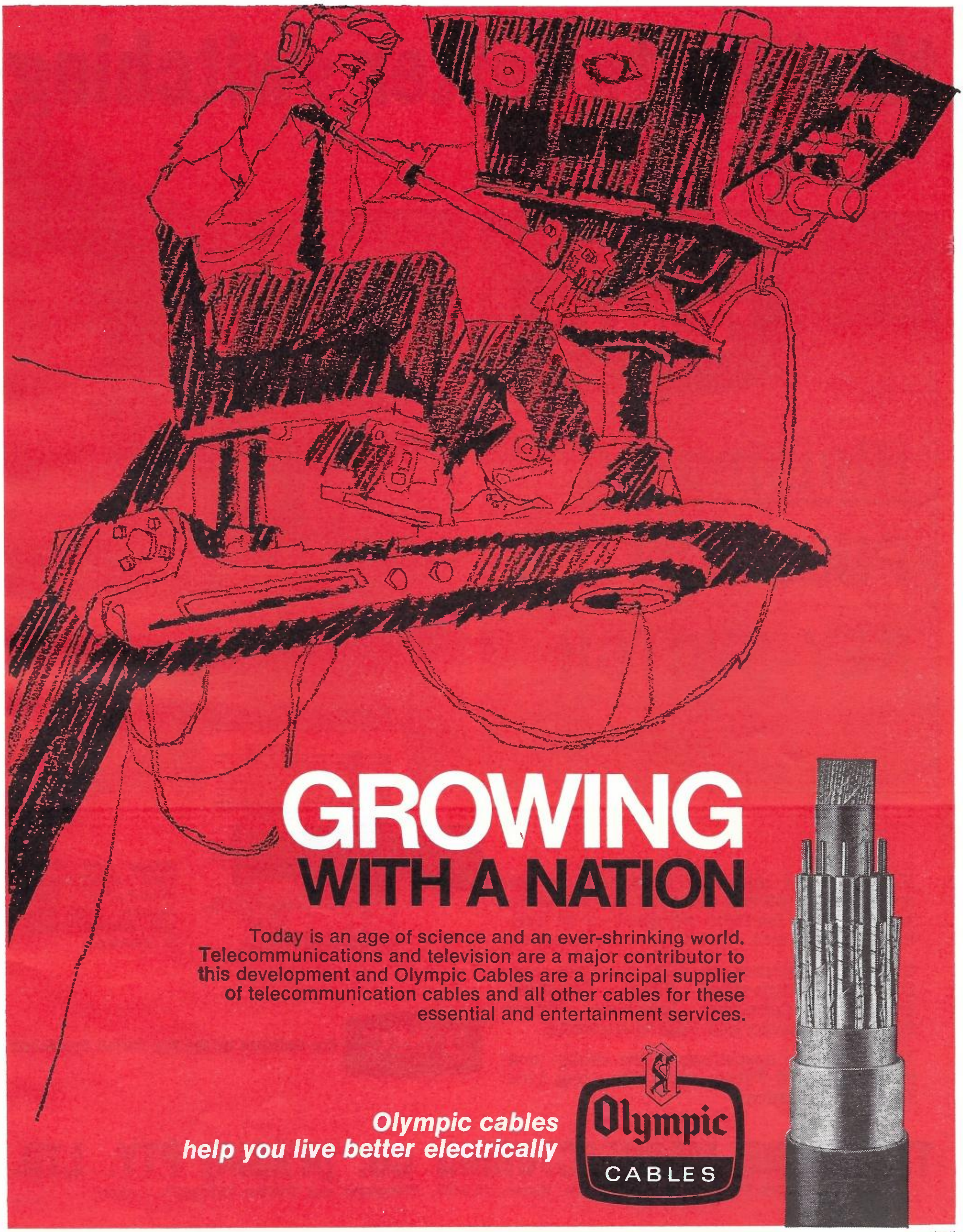
Distributed by— **jacoby, mitchell & co. pty. ltd.**

469-475 Kent Street, Sydney. 26-2651

MELBOURNE	ADELAIDE	BRISBANE	PERTH	LAUNCESTON
30-2491/2	53-6117	2-6467	28-1102	2-5322

JM/12-68


components with a purpose *
Magnetic Reed Switches
HAMLIN
Neon Indicator Lamps
Telite
Cordless Programming Boards
Sealectro
Solenoids
MAGNETIC DEVICES LIMITED
Toggle Switches
NKK
Potentiometers
CTS
Relays
Micro Switches
Mulon
Type 650
Type 500
Trimming Potentiometers
Precision Film Resistors
Soldering Irons
SCOPE
IRC AUSTRALIA
Wirewound Resistors
Power Rheostats
Matrix Boards and Kit-sets Vector
* your complete satisfaction
INTERSTATE AGENTS & REPRESENTATIVES
MELBOURNE
I R H Components Pty. Ltd.,
Phone 489-1088
BRISBANE
K.H. Dore & Sons
Phone 2-1391 (except Magnetic Devices)
PERTH
Simon Holman & Co.
Phone 8-2271
HOBART & LAUNCESTON
W.P. Martin Pty. Ltd.,
Phone 34-2811 22-844
ALSO
Underhill Day & Co.
Phone 70-2141 (Magnetic Devices only)
ADELAIDE
Collett & Cant Pty. Ltd.
Phone 23-1971
IRH
COMPONENTS PTY. LIMITED
THE CRESCENT,
KINGSGROVE,
N.S.W. 2208.
TEL. 50 0111


GROWING
WITH A NATION
Today is an age of science and an ever-shrinking world. Telecommunications and television are a major contributor to this development and Olympic Cables are a principal supplier of telecommunication cables and all other cables for these essential and entertainment services.
Olympic cables
help you live better electrically
Olympic
CABLES

SIEMENS

Speed your Data by Telephone

A modem is required at the beginning and end of each telephone circuit established for data transmission. Siemens modems cover the entire range of data transmission by telephone for any speed, tailored to your requirements. They are of advanced design and conform to all relevant CCITT recommendations.

These are the advantages you gain: You pay only for the electronics required for the application in question. Whatever your choice — a modern desk model or a rack mounting model — whenever you choose a Siemens modem you choose the latest technology and highest reliability.

Modem 8332 2400/1800/1200/600 bits/s (selectable). Synchronous operation. Suitable for operation over switched lines as well as 2-wire or 4-wire point-to-point circuits. Adjustable line equalizer. Also available in special housing for mobile service.

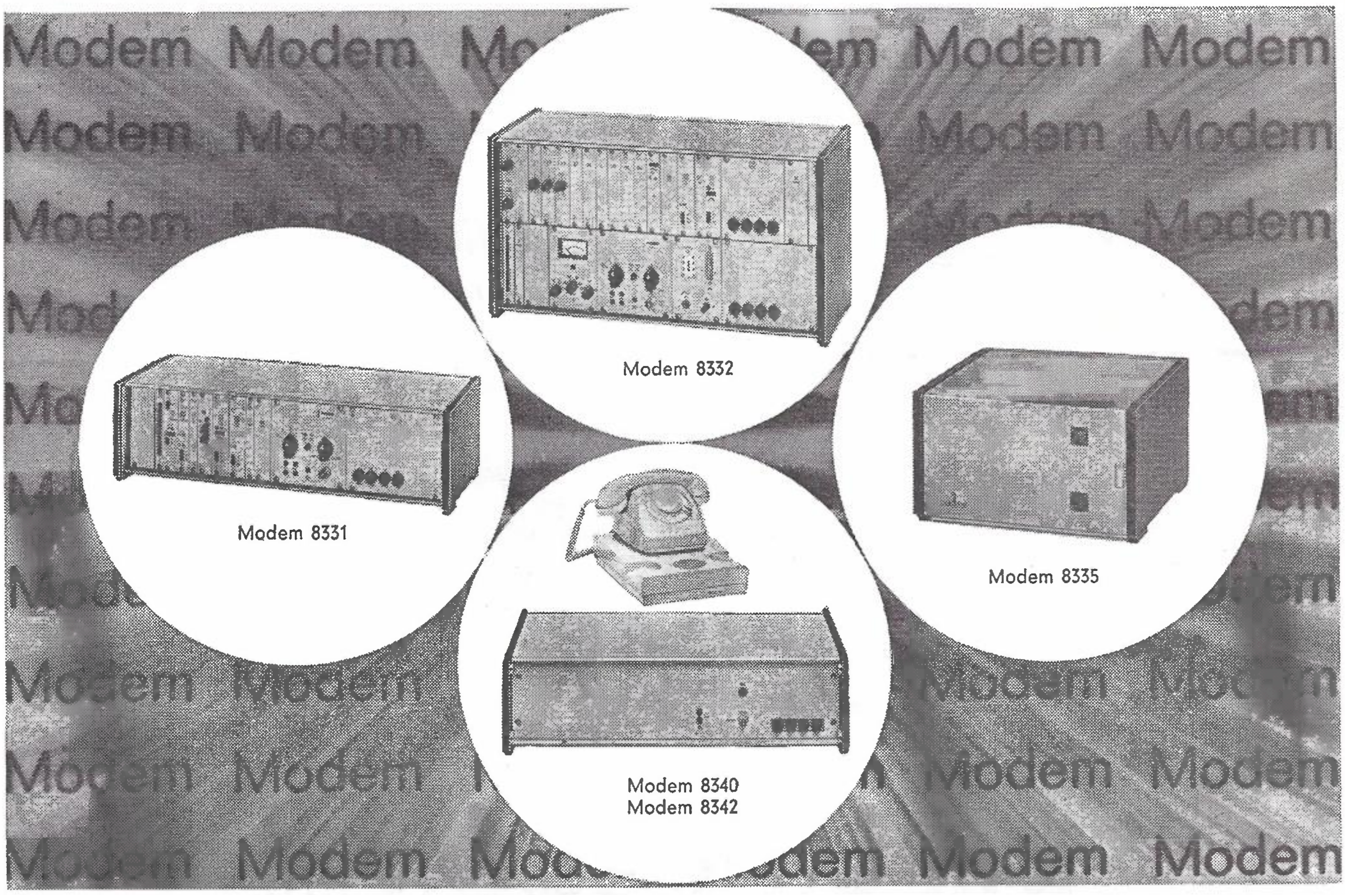
Modem 8331 600/1200 bits/s (selectable). Synchronous or start-stop operation. Clock and synchronous receiver incorporated for synchronous operation. Adaptable to operation over switched lines as well as 2-wire or 4-wire point-to-point circuits.

Modem 8335 2 x 200 bits/s. Synchronous and start-stop operation. Adaptable to operation over switched lines as well as 2-wire or 4-wire point-to-point circuits.

Modem 8340 (outstation).

Modem 8342 (central station).
Parallel modem, 20 or 40 characters/s for data acquisition or information systems. Operation over switched lines, digital or speech return signal.

Siemens Industries Limited
544 Church Street, Richmond, Victoria. 42 0291
Also at:
Sydney, Brisbane and Newcastle.



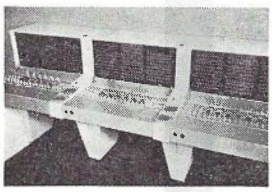
Siemens Data Systems

SH353

THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

VOL. 19 No. 2
JUNE 1969

CONTENTS



COVER
New Cord Type Operating Positions for Trunk Assistance Traffic.

The TELECOMMUNICATION JOURNAL of Australia

ABSTRACTS: Vol. 19, No. 2

ALLAN, T. & LARSSON, I. W.: 'Erlang Meters in ARM Crossbar Exchanges': Telecom. Journal of Aust., June 1969 page 120.

A brief summary of the use of erlang meters in ARM 201/4 crossbar exchanges to provide revenue and traffic statistics is given. The types of erlang meters to be used are discussed together with a general description of the erlang hour meter survey diagram. Some installation aspects, and the types of racks used to mount the equipment are also discussed.

BYASS, G. and PIMM, T. G.: 'Safety Aspects of Voltages Applied to Telephone Lines'; Telecom. Journal of Aust., June 1969, page 170.

This article presents a summary of previously published papers on electrical safety and deals with the various aspects of electric shock pertinent to the determination of the most suitable approach to safety in any particular case. The result of some measurements of human body and skin resistances are discussed.

CRAIG, E. R.: 'Space Systems and Radio Astronomy — 1968 Interim Meetings of C.C.I.R. Study Group IV'; Telecom. Journal of Aust., June 1969, page 164.

Interim meetings of C.C.I.R. Study Group IV were held in Geneva in September/October, 1968, and this paper describes generally the scope of the subjects covered and a selection of the more important results are treated in more detail. Among the highlights of interest in the field of communication satellites are consideration of use of the geo-stationary satellite orbit, use of frequencies above 10 GHz, direct broadcasting from satellites and the measurement of receiver system performance.

DOSSING, S.: 'C.C.I.T.T. IVth Plenary Assembly — Mar Del Plata, Argentina, 1968'; Telecom. Journal of Aust., June 1969, page 157.

The Plenary Assembly, which is the highest authority of the International Consultative Committee on Telephony and Telegraphy (C.C.I.T.T.), meets every three to four years usually preceded by meetings of the individual C.C.I.T.T. Study Groups. The last such meetings were held in Mar Del Plata during September/October, 1968. The paper gives a brief summary of these meetings which were held over a period of five weeks and attended by a number of officers from the P.M.G.'s Department, Overseas Telecommunications Commission and industry.

HOWARD, S. A.: 'PERT in the light Engineering Field'; Telecom. Journal of Aust., June 1969, page 114.

This paper briefly outlines a system of project planning, scheduling and control which has been implemented in the Exchange Installation Divisions, Brisbane. The system is based on networking techniques (PERT/CPM) utilising both manual and computer methods of processing. Some of the difficulties encountered during the implementation and development of the system are discussed.

KEIR, K. E. and SADLER, N. J.: 'Conductor Jointing in Part Privately Erected Lines'; Telecom. Journal of Aust., June 1969, page 167.

Existing jointing techniques for galvanised iron wires are reviewed. A new type of compression sleeve incorporating an internal compression spring is described.

LETTE, M. F.: 'Installation of Lead Sheathed Cables on Bridges'; Telecom. Journal of Aust., June 1969, page 127.

This paper describes investigations of the performance of lead sheathed cables installed on bridges in N.S.W. and the associated vibration and exposure environment provided by the bridge installation. The effects of temperature variation, cable type and cable size are discussed and recommended practices for successful and economical installations on bridges are given.

MINZ, S.: 'Poling Patterns for Peak Voltage Reduction'; Telecom. Journal of Aust., June 1969, page 150.

The paper describes methods of reducing peak voltages in coherent tone groups in wideband carrier systems. In particular the principles of a method based on phase changes by systematic wire transpositions are developed. A practical application is described.

SCOTT, F. M.: 'System AFM 402: The A.P.O. Four Wire Cord Type Manual Assistance Centre'; Telecom. Journal of Aust., Feb. 1969, page 41, and June 1969, page 136.

This paper describes the general electrical design features of A.P.O. System ARM 402, which comprises a cord-type operating position for manual assistance traffic, a cordless type operating position for special services traffic, monitors and supervisors' turrets, positions and line relay sets, and a marker-controlled crossbar switching stage. The manual assistance position is described in detail.

PRINTED BY HEDGES & BELL LTD., MARYBOROUGH, VICTORIA